Etch a Circuit Board With Kitchen Supplies

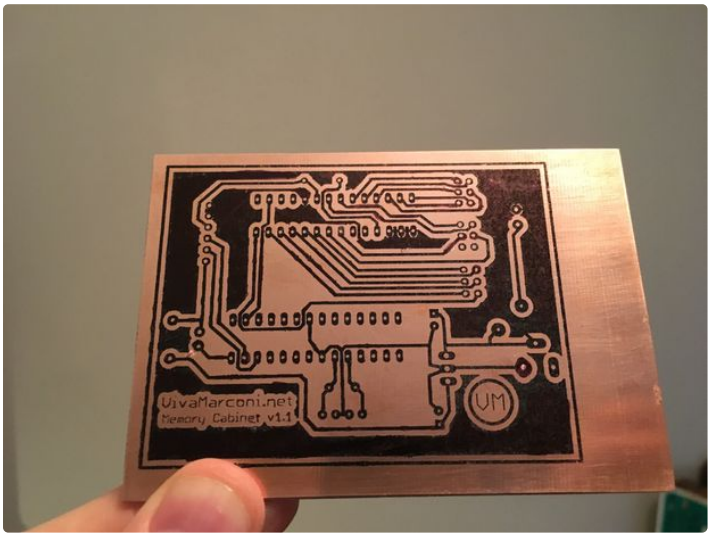
by videoschmideo

As you tinker with electronics projects, you'll quickly realize that the more complex they are, the more difficult they are to solder together. It usually means creating a rat's nest of individual wires, which can be bulky and hard to troubleshoot. Time to try making your own circuit boards at home! They're a great way to test new circuit designs, and make assembling your project a lot simpler later on—just add parts.

There's a catch, though: most of the existing kits out there use really nasty chemicals like ferric chloride or hydrochloric acid to etch the copper... so In this instructable, I'll show you a way to do it with stuff in your kitchen. Call it high-tech-low-tech circuit making, if you will..

You'll need:

- 1 copy of Autodesk Eagle (or another board design software)
- 1 package copper clad board (single-sided blank PCB)
- 1 package sticker paper (important: sure backing comes off in ONE BIG PIECE - no premade cuts)
- 1 clothes iron
- 1 office laser printer
- 1 bottle Acetone or nail polish
- 1 bottle of white vinegar
- 1 bottle hydrogen peroxide
- 1 box cooking salt (finely ground is best)
- 1 box Aluminum foil
- Gloves and eye protection



1. etching fluid just before removing the board - all the blue stuff is copper chloride, which is poisonous. Put little handfuls of aluminum foil in here to turn it into a form you can safely throw away.
1. etching fluid just before removing the board - all the blue stuff is copper chloride, which is poisonous. Put little handfuls of aluminum foil in here to turn it into a form you can safely throw away.

Step 1: Prepare Your PCB Design

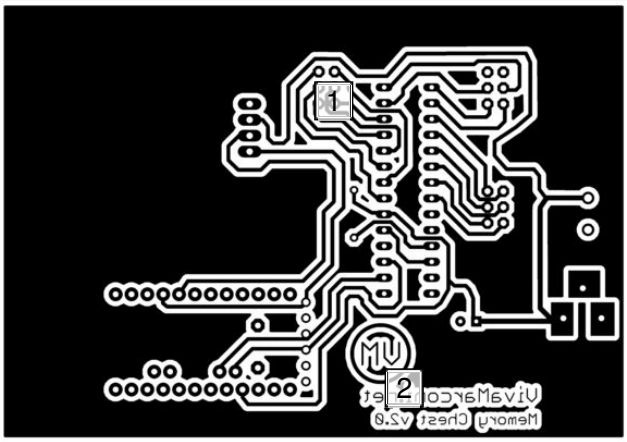
Once you've tested your circuit on a breadboard, you can start to lay out your components in software. There are lots of ways to do it - I used Autodesk Eagle, which is free, but very powerful. I won't explain how to use it here—that's way outside the scope of one Instructable. If you want to learn, though, Sparkfun.com has some really great t utorials.

No matter what software you choose, you'll need to save or export the design as a PNG file in order to etch at home. (If you used Eagle, I wrote a quick how-to below).

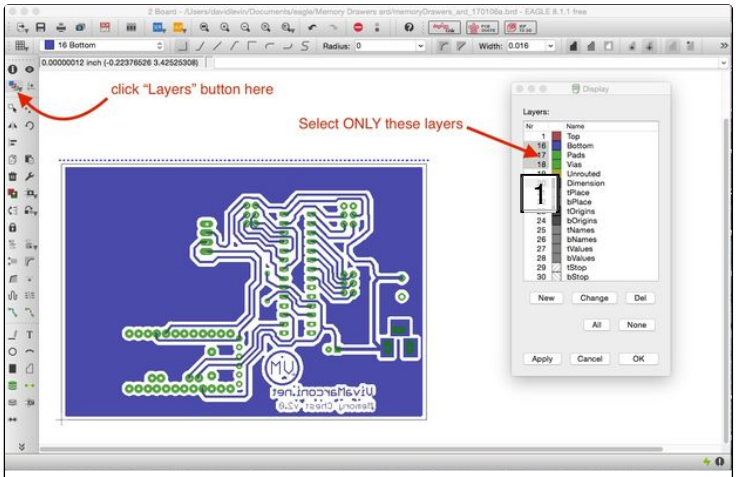
When you're done, use image editing software like Gimp (or even iPhoto) to flip it and make a **MIRROR IMAGE**. If you don't, your final PCB will come out backwards.

Getting a board image out of Eagle:

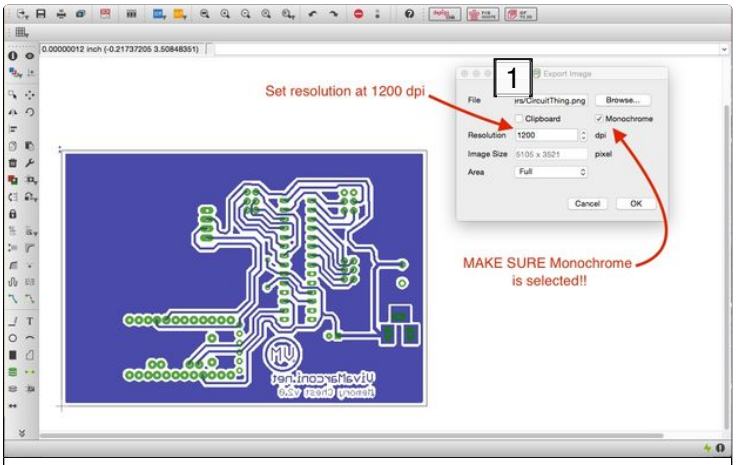
- *Click on the "layer settings" button. (looks like three multicolor squares).*
- *Make sure that ONLY the traces and pads on bottom of the board are displayed. This is the stuff that you want to physically see etched on your board. Usually this will be layer 16 ("Bottom"), 17 ("Pads"), 18 ("Vias"), and 20 ("Dimension)".*
- *Under the "file" menu, select "export", then "image".*
- *Set resolution to 1200 dpi, and BE SURE to select "monochrome."*
- *Give the file a name and save it.*



1. Exported monochrome image of your board. You'll use this to transfer the image to your PCB copper.
2. Make sure you export your board as a MIRROR IMAGE (backwards)! Once it's on the PCB, it'll be in the right orientation.



1. selecting only one side of the board (top or bottom) and the vias/pads lets you see what you're ultimately going to etch onto the copper PCB.



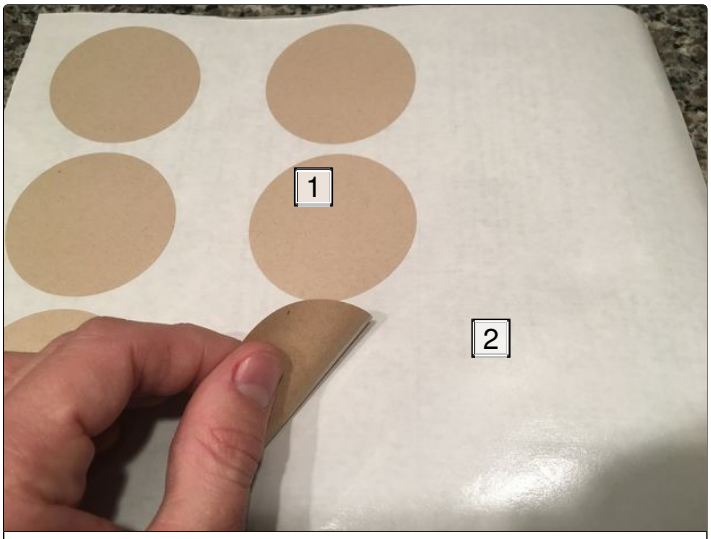
1. Resolution should be 1200. Be sure to select Monochrome so the image comes out in black and white instead of color!

Step 2: Prepare the Transfer Paper

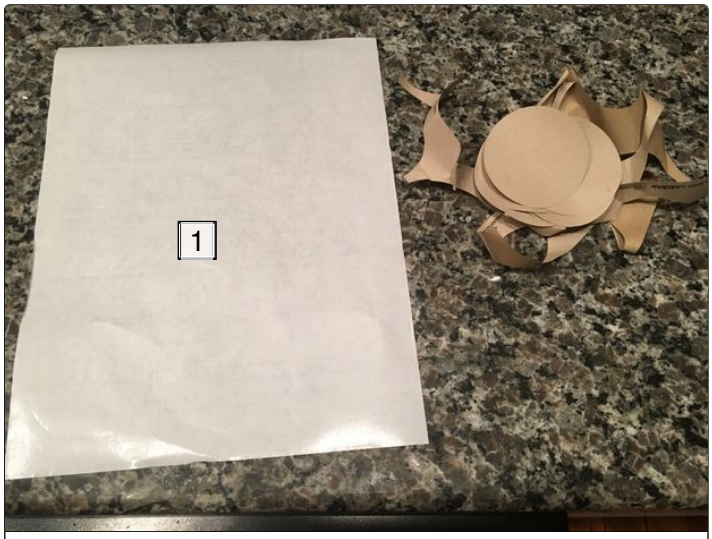
Time to transfer your design to the copper PCB. To do this. you'll need to print it onto the sticker backing paper.

Why? By laser printing the design onto this non-stick paper, we'll be able to easily iron the toner onto the blank copper. Once it's stuck on, it forms a really nice mask—whatever copper is left exposed will be etched away; whatever is covered by printer toner will remain solid metal, forming your circuit.

First, prep the paper. Peel off all the stickers, and wipe the waxy side of the backing with some acetone. Be sure to let it dry. This will remove any oils from your fingers (or the stickers) and give you much more uniform results when you try print onto it.



1. Don't need these.
2. Save this awesome backing paper! You'll need it for the transfer.

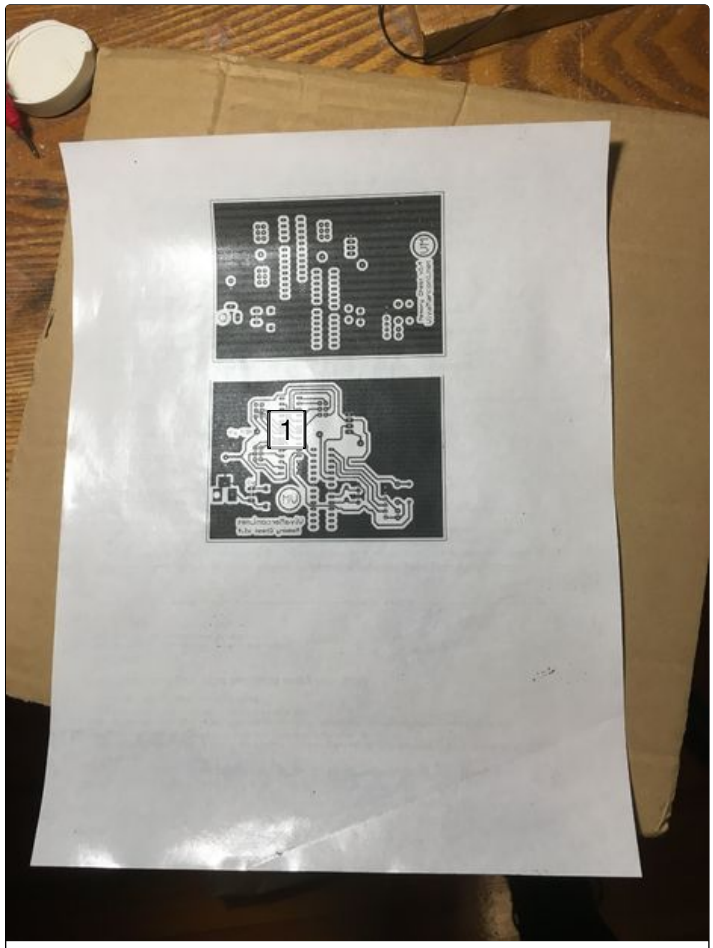


1. Clean sticker backing paper

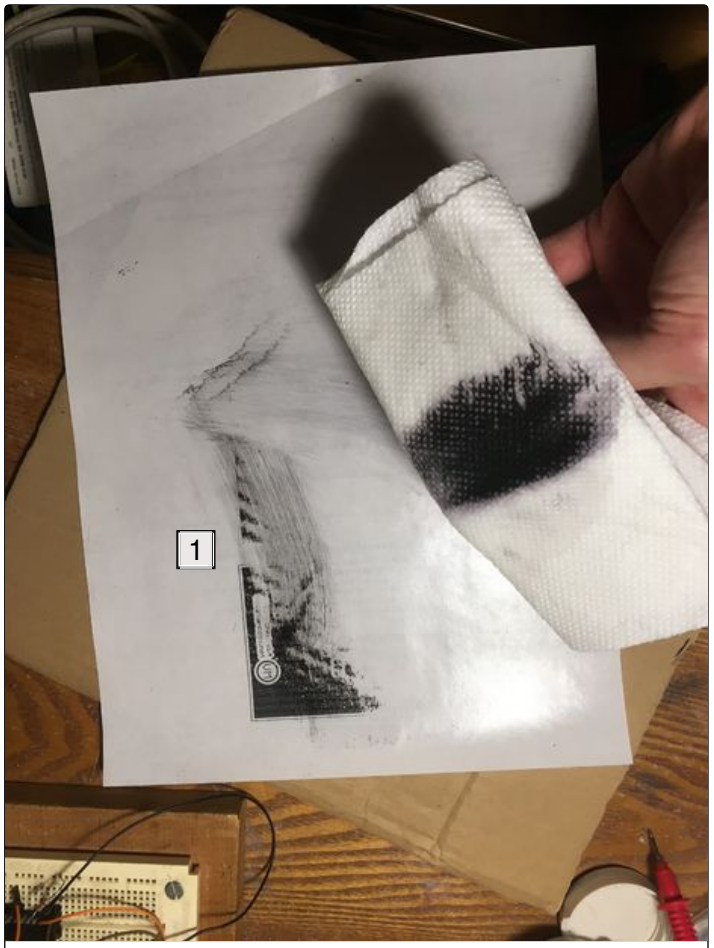
Step 3: Print Your Transfer

Once the paper is ready, slide it into the "single sheet" tray of your laser printer (usually the one that folds down to accept things like envelopes). Make sure you're printing on the shiny, waxy side!!

If all goes well, you should have a print like the one shown above. If not, no worries - just wipe it off with acetone and try it again! You can usually get 2-3 uses out of a sheet before it starts getting too fragile to use.



1. A good print, once transferred onto the sticker backing paper, should look like this. Black lines/fields are clear and solid.



1. bad print? No problem. Wipe with acetone or nailpolish remover and let dry. You can reuse a few times before the paper gets too damaged.

Step 4: Transfer Design to PCB

Got a good print? Awesome. Now prep your blank copper board for the transfer.

- Wipe it with acetone and let it dry. DO NOT touch the surface again before the next step! Oil from your fingers will prevent the design from sticking to the copper.

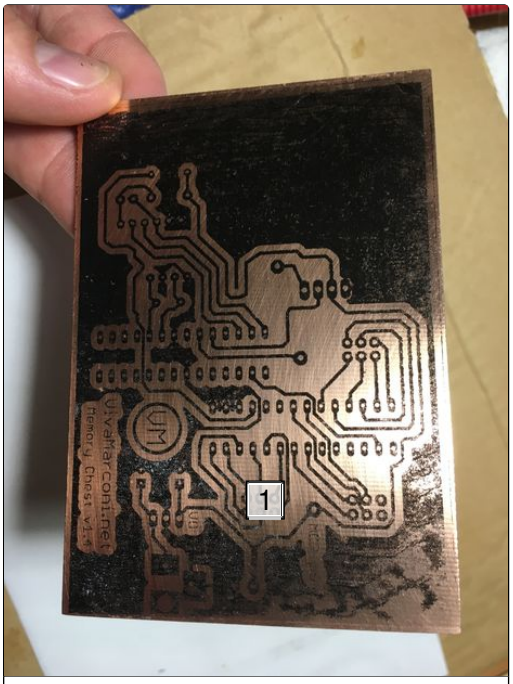
- Attach the blank copper board face-up on a piece of cardboard or scrap wood. Some double-sided tape is helpful to keep it from moving.

- Lay your newly-printed PCB design over the copper board. You can tape the edges in place to keep the sheet from sliding around.

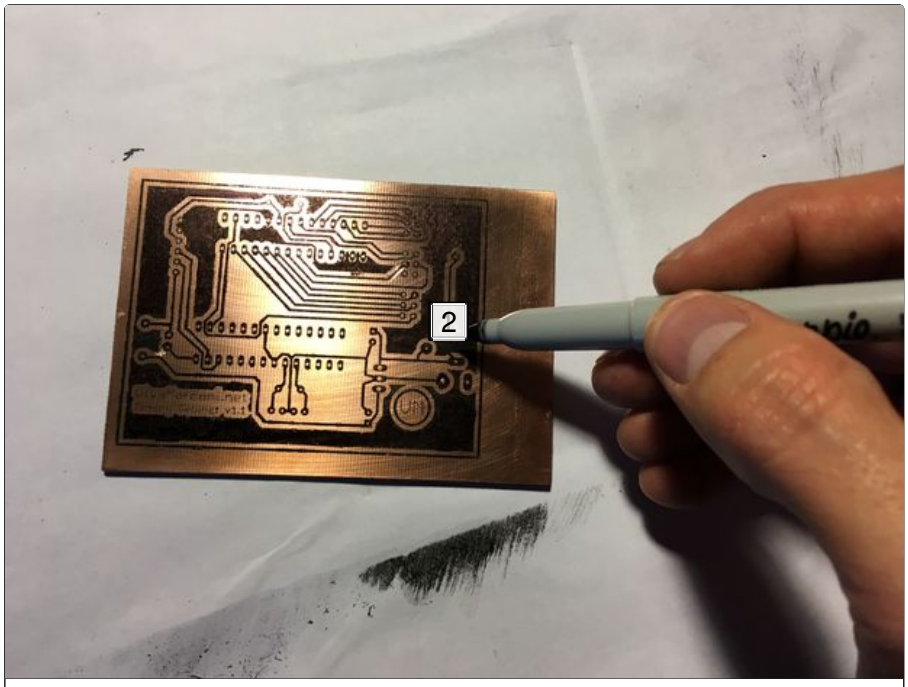
- Set an iron to high (Linen setting), and press down on the sticker paper covering the copper plate. Hold the iron in place, covering the whole board. NOTE: if your edges are coming out jagged or look runny, it means the toner is melting too much. Try putting the iron on a lower setting and just pressing for longer.

- Press hard for 60 seconds, then slowly move the iron while pressing for 3-4 minutes. I found it helpful to press gently on detailed areas with the tip of the iron to make sure they fully transfer.
- Remove heat and wait for board to cool a few minutes. While still warm (but not hot), gently peel off the transfer paper. If you did it right, your design will be stuck to the copper!

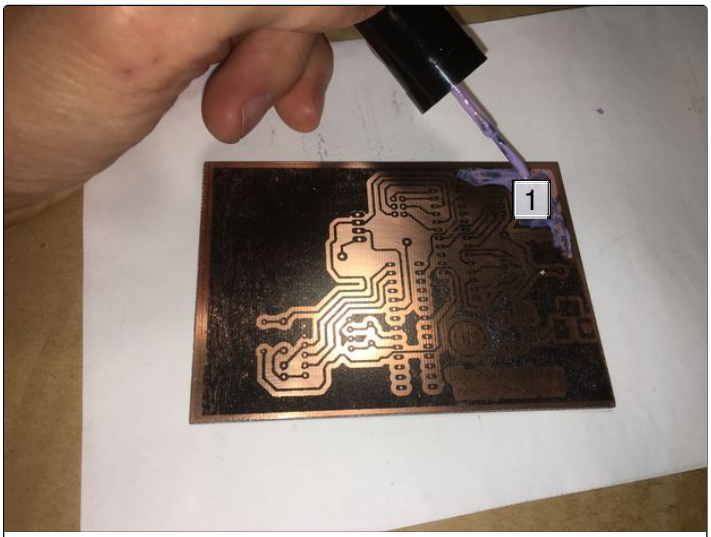
- Use a sharpie or nail polish to fill in any areas that didn't fully transfer, or came out faintly. If any traces are too close together, you can also scrape away some of the toner with an X-acto blade or needle.



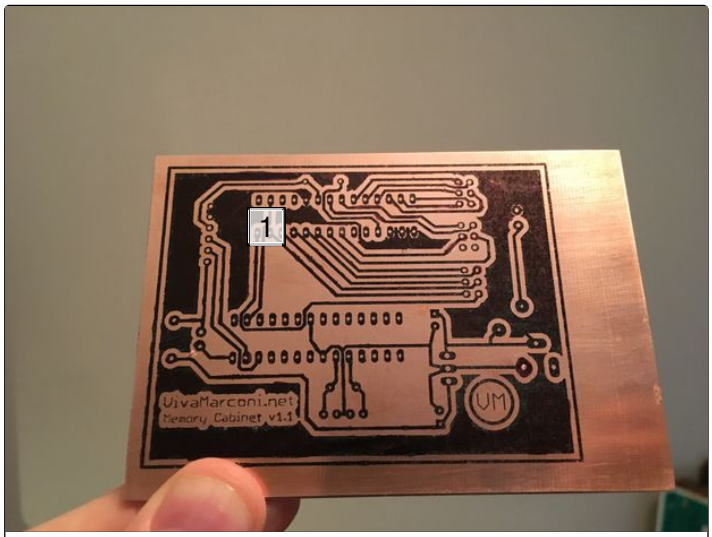
1. The end result. This one wasn't an awesome transfer - you can see some areas of black missing. If this happens, you can either wipe it clean with acetone and start over, or try to touch it up with a sharpie and a lot of patience. Your milage may vary if you do the latter, though.



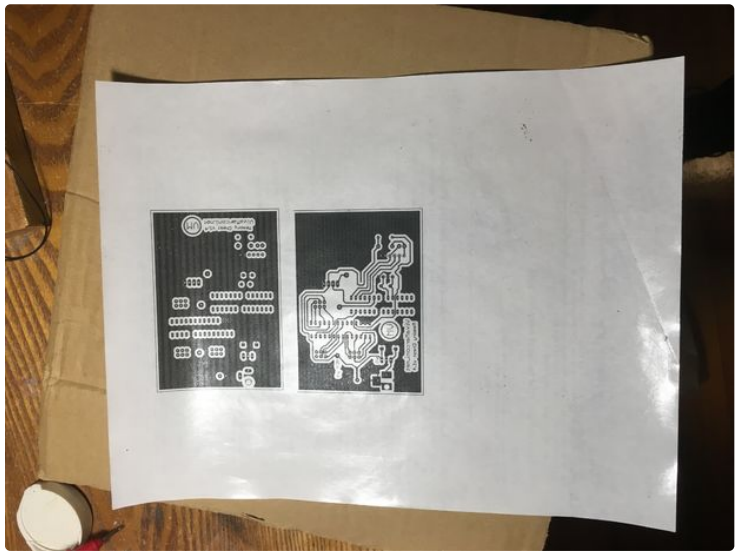
1. A thin-point Sharpie works best for going over fine traces to make sure they're totally masked before you etch.
2. if a trace doesn't fully transfer onto the copper, try going over it with a fine-tipped sharpie.



1. If you need to cover up large areas of your mask that didn't fully transfer, try nail polish. Covers a lot of ground quickly, but isn't so great for detailed touch-up work, though.



1. If any traces are too close, scrape some of the toner between them away with an X-acto blade.



Step 5: Etch Your Board!

The moment of truth. Put on your gloves and eye protection, and get ready to etch! Before you do though, a word of caution:

DO NOT, I repeat, DO NOT pour any acetone into the etching solution. Acetone and hydrogen peroxide can react to cause a highly flammable and possibly explosive chemical.Given the low concentrations of hydrogen peroxide we're using (3% solution), that's unlikely, you're still better safe than sorry. Now on with the show!

- Mix together a 1:1 ratio of vinegar and peroxide in a small tupperware container. I found it helpful to heat it in the microwave to speed up the chemical reaction.

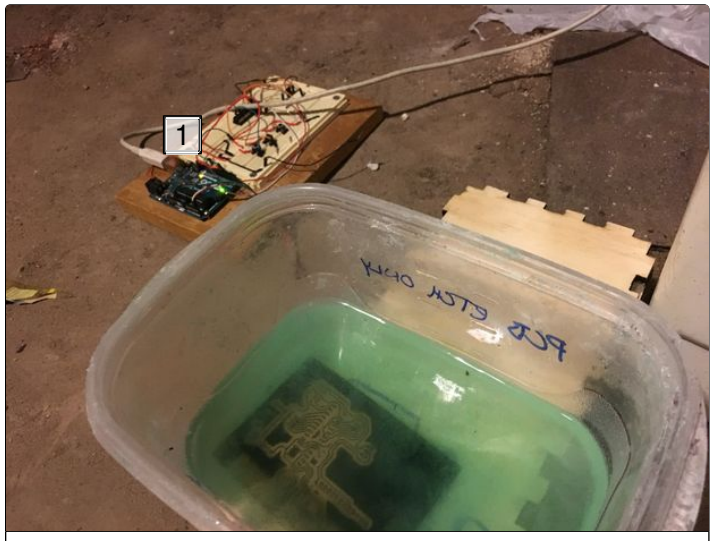
- Add as much salt as the solution will hold.
- Lay the PCB with your newly-transferred design in the bin. You should hear a fizzing sound as the reaction starts to work.

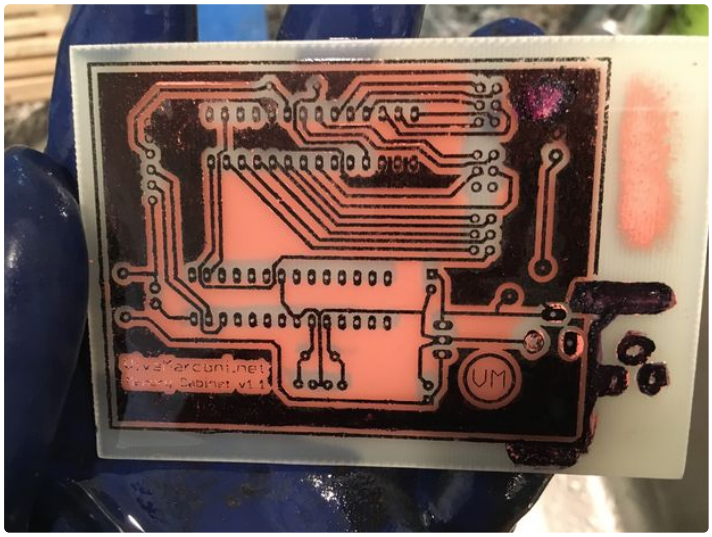
- Occasionally stir the mixture, and add more salt and peroxide as needed. Some crud will form on the surface of the copper board as it dissolves - you can speed the process by wiping it off gently with a sponge or brush.

- After about an hour or so, your board should be done! Be sure to **RINSE THE BOARD WITH WATER,** then wipe the remaining toner off with acetone and let it dry.

- Next, drill holes in the component pads with tiny bits like these (a drill press or a steady hand helps - they break really easily).

You're almost ready to start soldering! The last thing to do (and this is important), is safely clean up your mess.





1. I got lazy about stirring the etching container, so I hacked together a little "mixing" device with an arduino and a spare servo. It basically just raises one end of the plywood the etch is sitting on every few seconds, then lowers it again so the fluid keeps mixing. Your mileage may vary.

1. When the etch is done, wipe the board down with acetone to get rid of the toner. Shiny new circuit traces are underneath!

1. A drill press really helps get clean holes without breaking the tiny, tiny bits (which is super easy to do)

Step 6: Safely Dispose of the Etchant

When you're done etching, the liquid will look blue-green. That's because the process created copper (II) acetate, which is poisonous. It's not awesome to flush it down the drain, so we're going to neutralize it.

- Cut up about a square foot of aluminum foil into small pieces. Stir the pieces into the blue-green etch liquid, and leave outside for a few hours.
- The liquid will turn purple, and you'll see little brown specks settling to the bottom. Congrats: you just turned that copper chloride into harmless aluminum salts and elemental copper (the brown specks).
- Now you can dispose of it safely in your drain.

Final notes: Don't be discouraged if your board doesn't come out right the first time. It took a bit of trial and error to get mine the way I wanted them - but it's way faster and more satisfying than ordering boards from overseas!

Also: I am NOT a chemist - if you are, please weigh in on the disposal methods! For more info on this etching technique (and on disposal), there's a great discussion at Blondihacks.com. Happy building!

******

UPDATE: a few folks pointed out in the comments that my chemistry might be slightly off - with enough salt in the mix, the solution could turn green, meaning it's copper (II) chloride—the same stuff in some root killers. In that case, adding aluminum foil would just make another poisonous chemical, aluminum (II) chloride, and shouldn't be put down the drain. See discussion on stackexchange for more details.

if there's any doubt on whether or not it's safe to flush the liquid, though, you can always mix it with plaster of paris, wait for it to harden, and throw the whole thing away.

1. first etch didn't go so well, but I quickly got the hang of it on the 2nd attempt. You can see I went through a few iterations until I got to the final version. Best part about doing this at home is that it's FAST - you can make a board in about an hour, so tweaking your design is pretty easy.
2. the final board!

Wow, I'm an artist and this process works perfectly for me. Thanks you so much. Much less expensive than the process I was using.

That's awesome - so glad this will work for you!

I highly recommend printing the images out on regular paper first to make sure the scale is correct. I have made many boards and have had many times where scaling occurred - sometimes caught before etching and sometimes afterwards. Don't waste time and materials! Adding a border to the images in double sided boards will help a lot in alignment. Printing should be done on the darkest setting possible to get a good layer of plastic on the board and avoid broken traces. Also, if you can get ahold of a laminator (I use a modded AL13P) it is much easier to transfer a complete image with even heat and pressure.

These are great ideas. DEFINITELY print the circuit out on regular paper first! That'll save a lot of headaches. The border sounds really helpful, too. I originally tried to do double-sided boards with this technique, but it was just too hard to get the alignment right... with a laminator, though, it might be possible to sandwich the PCB between two printouts at the same time (one for the top side, one for the bottom) - to make sure they stay aligned? If you try it, would love to hear how it turns out.

I have done it many times and it creates very accurate alignment. I use overhead projector film to transfer and use masking tape to hold it in place, place the board in a sheet of paper folded in half and trim it so there is still some overhang to grab onto when the board gets really hot.

Hmm - I'll have to try that - thanks for the tip!

Hi thanks for this instructable I have been looking for a less expensive way of doing this

awesome - glad you liked it!

It's really great to see someone has come up with an acid/peroxide etchant using easily available and cheap white vinegar, instead of expensive and hard to obtain hydrochloric acid. Nice tip with the sticker backing paper there too!
I'm surprised the etchant is only good for one board - the versions I have read about using hcl and peroxide will etch many boards - since this is similar stuff will it not do the same?
I'd like to raise a couple of caveats if I may, lessons I learned early on:
Acetone can contain dissolved grease, which can end up being left as a residue on the thing you are trying to clean. I found this out the hard way and wasted many hours. Fine aluminium oxide paper (around 400 grit) and water and a tiny bit of detergent works really well for cleaning. Isopropanol is useful too.
The highest temperature of your iron will be too hot for a lot of people, causing the toner to turn runny and make wobbly edges. I would suggest experimenting and using the lowest temperature that will fuse the toner to the board, no more.

It might be possible to use it for more than one board, but I wouldn't recommend it - the solution really slows down its etching ability as more copper is dissolved into it. HCl is a much more powerful acid, so likely would last a lot longer.

Good point on the acetone/grease problem! I hadn't considered that. And yes, a lower temp might be a better idea. I'll make a note in the instructable. Thanks!

Unfortunately, the "bad lads" or urban bomb-makers, have made many of these ingredients hard to get. Any sniff off hydrogen peroxide and acetone are likely to arouse the attention of MI5. Some devastating terrorist incidents have had seemingly harmless beginnings in someone buying up large quantities of peroxide from hairdressers then go on to create lethal weapons.It's a great shame that innocent pursuits like PCB etching could get dragged into into an early morning knock on the door.

Yikes. Hopefully with the small amounts of each chemical needed, this won't raise any eyebrows! Definitely wouldn't want FBI or MI5 at my door.

you note to mirror the image before transfer.
ONLY mirror the "Top layer" or the bottom layer will be backwards

That's why I stick with one sided boards on this technique - mirroring different sides and getting them all lined up makes my head hurt...

Hi
****
That's because the process created copper chloride
****
How can you get copper chloride using vinegar and hydrogen peroxyde on copper ?

TIP: You can etch in a minute or so using concentrated H^2O^2 (130vol) and concentrated Hcl.....
In that case you do obtain $CuCl^2$
RECIPE: 1 part HCl; 1 part fresh water; 10% of all in H^2O^2
(speed increase if water qty decrease,/ Speed increase with H^2O^2 concentration)
BUT wear protections (clothes, glasses, gloves) and always have fresh water to rince whatever needs to be rinced.
In case of large printed circuits, act outside because of the large amount of Hydrogen and Oxygen produced.($4H^2 + 2 O^2 => 2 H^2O$ + boooom!!!!)

You're right - it actually more likely creates copper acetate, which would explain the bluish color (copper chloride would be more green). If you put enough salt (NaCl) into the mix, though, you could definitely wind up with some copper chloride. I did a little more digging and found a good discussion here:

https://chemistry.stackexchange.com/questions/1021...

Based on this, it looks like I had mostly copper acetate, which is poisonous, but can be remediated with aluminum. If it was pure copper chloride (green liquid), the link above mentions that my method would just create aluminum chloride, which is also not so great health-wise.

Anyway - I am BY NO MEANS a chemist - this is all based on just basic chemistry knowledge and some web searches. Other folks that have training in this should definitely weigh in! I'll edit the instructable accordingly.

I think you're forgetting the addition of the salt otherwise known as Sodium Chloride

You can buy 12% Hydrogen Peroxide quite easily.
I bought some from a seller on Ebay, it's food grade but works just as well. I've not tried it for etching.

I bet that would work really well - I imagine you'd have to tweak the ratio of vinegar, though? If you try it, let us know how it turned out!

Awesome thanks, especially how to dispose of the chemicals. Very responsible.

Thanks very much! Glad you liked it.

Great article. I will link it to my web page. Just one thing. I use inkjet photographic paper (yes) in my old HP laserjet. I never had an issue.

Thanks, Stew! And yeah, I've heard some folks have good results with photo paper as well. Do you find it sticks to the board when you iron it, though? I've seen other projects that called for soaking the stuck paper in water and rubbing it off to leave the ink layer behind. (Either way, as long as it

gives you decent results on the etch, it shouldn’t matter how you get the mask onto the copper!)

They do stick and you need to soak the board in water. Still it's OK. I have bought a ton of photographic paper at give away prices. People bought the paper think that it was a great idea to print pictures at home until the discovered the costs involved. So fto the Salvation army, Good will and yard sales.

Haha - never underestimate a good yard sale. :)

good idea! The heat on those is way more even than an iron.

A really nice instructable. I’ll definitely be giving that a go next time I need a small board in a hurry. I usually prototype direct to vero (I hate breadboard, too many lousy connections) but vero isn’t always great with non-std pin spacing.

Thank you again, I knew there was something I should use that damn iron for!

thanks - much appreciated! Hope it comes in handy!

TSJWang - Good call! Thanks for bringing this up. I did a little research on it—with 3% Hydrogen Peroxide (the standard dilution sold in drug stores), and trace acetone residue on the boards, it's not really an issue, especially if you rinse the board with water between etching and wiping with acetone.

But you're absolutely right: you should **definitely not** mix any substantial amount of acetone with hydrogen peroxide, ESPECIALLY in the presence of an acid, since that can form flammable and possibly explosive byproducts. I've updated the Instructable with some warning language along those lines.

If anyone is interested, there's a nice discussion of this in an academic paper from 2011 (link below)... seems this is a potential problem in chemistry labs, where both substances are used to clean glassware.
http://energetics.chm.uri.edu/system/files/TATP+pu...