INSTRUCTIONS FOR MAKING PRINTED CIRCUIT BOARDS (PCBS)

Objective

The purpose of this instruction sheet is to provide the necessary information to make printed circuit boards using a PCB etching process with materials and supplies that are readily available and relatively inexpensive to obtain.

Materials required

Table 1 Materials and Supplies needed

Double Sided Copper Clad Board (1oz copper/ sq ft) (Gil Laminate, dimensions 12" x 18" serial# 11220b R33 → inscribed on the bottom)
Cotton T-shirt with no printed design (for drying off boards)
Press and Peel Wet Paper (on which the circuit pattern and ground plane will be printed)
Rectangular flat bottomed tray bigger than boards being etched (used to soak off Press and Peel Wet Paper)
Clothes iron (for transferring toner mask onto board)
Circuit Board Cutter
Scissors
3m abrasive pads (to clean copper board and scrub off toner)
Tongs
Non-metal container (for etching solution) + lid + tray with slots (for lowering boards into soln)
Electric heater
Air pump agitator (speeds up the etching process)
Black Permanent Marker (to fill in dropouts)
Latex gloves (to protect hands from etching solution)
Safety Goggles (to protect eyes from etching solution)
Etching Solution of Sodium Persulphate (to remove excess copper from the boards)
Distilled Water
Paper Towels
Acetone → nail polish remover
Scale → up to 250g x 1g

Procedure

(I) Setup.

- First prepare the etching solution. Note that it may already be in the etching tank. If not, take a gallon of distilled water and pour it into the white plastic etching tank. Then, using the electronic scale provided, weigh out 225 grams of Sodium Persulphate and add it to the water. Then, turn on the agitator.
- Turn on electric heater and at least 30 minutes prior to etching. Turn the dial of the heater to the maximum level indicated. In this case, that would number 9. ***DO NOT remove the electric heater from the solution while the heater is on. This will permanently damage the heating element (and make a mess).***
- Fill the horizontal tray with approximately 1 inch of water.
- Turn the iron on and set it to the highest temperature so that it will be at a stable temperature when required. (linen setting)

(II) Print circuit pattern on Press and Peel Wet (PNPW) Paper.

To use the PNPW paper, **laser** print or copy circuit design and ground plane onto the paper using the layout feature in HPADS. Inkjet printers will NOT work, since their ink will not mask the copper surface properly. Here is an example of a filter circuit and ground plane are shown below.

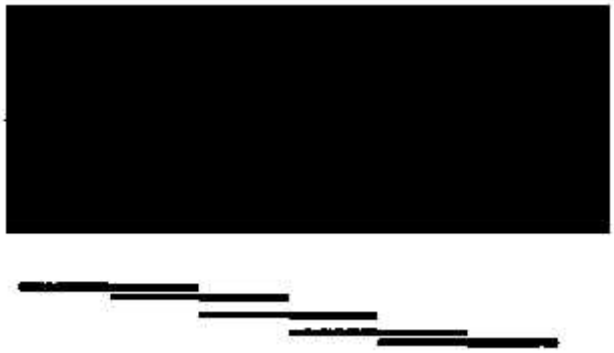

Figure 1 **A band-pass filter circuit layout and ground plane**

- Always check the circuit layout by printing it on regular paper first and checking the dimensions and scale thoroughly.
- Use the darkest print setting on your printer because the thicker the toner the better it will protect the copper.
- Print on the glossy side of the PNPW.
- Choose a paper path through the printer that is the most straight to prevent PNPW paper from curling in the printer.

(III) Prepare the copper clad board.

After the circuit pattern and ground plane are printed on the PNPW paper, the copper board must be prepared. This is necessary because the copper will tarnish over time due to its exposure to air. Any oxidation and dirt on the copper must be removed in order to prepare a good surface for the toner to adhere.

- Using the PCB cutter, cut off a rectangular section of double sided copper laminate (labeled 11220b R33 on the bottom). It should be significantly bigger than your design, but please be conservative
- Use the abrasive pad to scrub the entire surface (both sides) of the board using a circular motion in the middle and strokes parallel to the edges on the sides.
- Make sure that the entire surface has a relatively even shine; do not be discouraged by scratches because this to be expected. Also, notice that scrubbing motion in different directions will reflect light accordingly. This is acceptable.
- Handle the board by its edges when cleaning. Be careful not to put fingerprints on it because the oils from your skin can prevent the toner from adhering properly.
- Moisten a paper towel with acetone. Use it to clean both sides of the board thoroughly. Keep switching to clean areas of the paper towel. Do this until (almost) no discoloration is observed on the towel
- Allow to dry. This should only take a few seconds.

(IV) Transfer circuit pattern and ground plane onto copper board.

Successful transfer of the toner is dependent on temperature, pressure and time. It is important to evenly heat the entire copper board. Do not assume that if the iron is larger than the board, leaving the iron in one place will heat it evenly. Slight pressure can be applied by leaning over the iron while heating the board to help in transferring the toner.

- Cut out the ground plane from your printout. Make it the size of your copper board.
- Place it on a heat resistant surface (located on the metal cart) with the toner pointing up.
- Cover it with the copper board. Line both items up as well as you can. If you made your PCB large enough, this shouldn't be a problem
- Cut out your circuit, and place it toner down on the copper board. Line them up carefully. If the paper is bent, straighten it out as well as you can. This is to prevent the mask from shifting as you apply the iron for the first time
- Gently, cover the entire setup with a cotton shirt.
- Place iron on top of paper for about 2 minutes. First 30 seconds need to be under moderate pressure. Make sure to keep the iron still during this time. That's when the toner will adhere to the copper, so any movement can ruin the mask. Your first design will be roughly the width of the iron, but keep in mind that the steam holes in it will cause uneven heating. Pick up the iron and move it around a bit every 30 seconds. As your circuits grow in size, you might have to spend more time, and plan out your ironing pattern efficiently.
- After about 2 minutes, remove the cotton shirt and flip the 'sandwich'. Cover it again with cotton shirt, and using moderate pressure heat it up for another 30 seconds or so.
- Place board and paper into water bath in the tray. Careful, it will be hot!!!
- Wait for paper to float freely in the water. Use tongs to stir the water occasionally.
- Grab the board by the edges and pull out of the water. You might notice that the ground plane has a few missing chunks, especially around the edges. This is rather hard to prevent. Your microstrip mask however, needs to be perfect. If it isn't, repeat the process until you get it right.

(V) Check for dropouts in the toner mask.

If there are holes in the toner mask in the ground plane, these dropouts must be filled in before etching.

- Locate areas where toner is missing.
- Fill in such areas completely, with extra permanent black marker and let it dry completely before proceeding to the next step.

(VI) Etch the board.

After dropouts have been fixed, the board has to be etched.

- Place the board into slots on the tray and lower into heated etching solution using the gloves, tongs and goggles for safety and cover with the lid.
- Periodically check board until all unwanted copper has been etched off. This should take approximately 20 to 30 minutes. You might notice that the board develops unevenly. Rotate it to account for that.
- ***Do not remove the electric heater from the etching solution.***
- Once all the copper has been etched off, remove board using tongs and rinse under cool tap water.
- Shut off heater and disconnect rubber tubing to prevent the solution from corroding the agitator.

(VII) Clean the etched board.
Clean the toner off the copper using an abrasive pad to scrub off the toner and rinse the board occasionally under cool tap water.

(VIII) Check board for breaks in ground plane.
If breaks are found in the copper, they will have to be fixed before testing. On the ground plane, if large areas are bare, copper tape should be applied over the area and this can repair open circuit patches. There isn't much you can do with the copper traces. If they don't come out perfect, you are likely to run into problems. Every discontinuity will likely cause a reflection, and lower the quality of your device.

You are now ready to solder on the connectors and/or components and test your circuit.