# EASY PCB's MADE WITH KITCHEN APPLIANCES

For years I have looked for a cheap and relatively easy way of making professional quality printed circuit boards at home. The method outlined below works very well if ALL the steps are carefully followed, and can produce PCB's with 20 thou (0.5mm) track widths. It is a very simple technique and operates by transferring the black plastic toner from the surface of either a laser print or a photocopy of a PCB artwork to the copper surface of a printed circuit board. This plastic toner is then used as the resist during etching of the copper. The only secrets to the process are keeping the surface of both the printing paper and the PCB copper absolutely clean, and using a special type of printing paper.

Equipment

For the electronic hobbyist, the most common source for a PCB artwork is the pattern printed for a particular project in a technical magazine. To produce a PCB from such a source you will need access to a good photocopier, 600 grit silicon carbide wet and dry abrasive paper, an ordinary clothes iron, A4 clay based paper, a soft nail brush, a clean old cotton tea towel and a bar of ordinary Velvet Soap (for those outside Australia this is ordinary unscented hard milled laundry bar soap which is very slightly alkaline).

To generate your own PCB's you will also need a computer, PC artwork software (e.g. Protel Autotrax- download this industry standard package FREE from the Altium site at http://www.protel.com/downloads/eula_autotrax.htm) and a printer. If this is a laser printer then so much the better as you can directly print the PCB pattern on to the special clay paper. Very useful additions to such a computer system include a scanner and a photo processing package such as Adobe Photoshop. The scanner will allow you to scan a magazine artwork into the computer, while the photo processing package will allow you to horizontally flip (mirror image) the PCB pattern, a step which is almost always necessary if this method of PCB manufacture is used. However, many photocopiers and laser printers also include the ability to do horizontal flips (and negatives of an artwork) in their operating menus and so the photoprocessing software may not be necessary.

The PCB Printing Master

Which ever way you choose to generate the PCB track pattern, the end result must be a piece of special clay paper with a mirror image on its surface of the image you wish to produce on the PCB copper. The image produced by the toner on this paper must be very dense and black with NO pinholes. The special clay paper must be handled by its edges only, to avoid contaminating its surface with finger skin oils, which will ruin the adhesion of the plastic toner to the copper surface of the PCB.

The Paper

The PCB pattern is transferred to the copper by re-melting the toner on the surface of the clay paper with a clothes iron so that it sticks to the copper. The paper behind the toner therefore has to be removed and this is accomplished by a process of soaking and gentle rubbing. Standard A4 paper will not work because during printing, the finely ground PVC toner particles have been melted into the wood fibres which form the paper surface. When the paper backing is scrubbed away to leave just the toner protecting the copper surface, the wood fibres pull some of the toner off the copper, completely destroying any etch protection.

The paper which is used to produce photo quality prints on your inkjet printer is a very different animal to the paper normally used for text printing. This type of paper has very few wood fibres in it, and these few fibres are used to form a central supporting core. The surface of this paper is made from pure very finely ground white china clay, and when viewed with a magnifying glass, appears totally smooth with the appearance of fine unglazed china. When this sort of paper is moistened and gently rubbed, the toner is released from the smooth clay surface without damage.

Using the preceding criteria, I went to my local stationer and bought a ream of clay paper with a weight of 90 GSM which went under the wonderful title "Impress Matte" for around $50 (10-20 cents per A4 sheet) And this is about what you should be prepared to pay for bulk quantities of a matte finish "economy" clay paper with a weight in the 90-100GSM range. In Australia, Celcast market such a paper with the code number IJ84. But such data is not helpful to someone outside Oz, and I would suggest that you carefully examine and test your inkjet photo printing paper - you might not have to spend a cent.

Very recently (May 2011), I have located another excellent paper which Aussies can use. It is a single sided paper, sold by "Officeworks" and has the following identification on the packet ....Ausinc matte inkjet photo paper- 100 sheets of A4 100gsm - part number AUOW410- bar code 9 318418 220936. This is the best paper I have ever used, simply because the water penetrates the backing very easily, making it very easy to remove without damage to the track pattern. Someone at "Officeworks" cannot spell because to find it on their homepage for remote ordering, you will have to search for "Ausink matt" :-(

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NOTE THAT GLOSS PHOTO PAPERS SHOULD NOT BE USED. THE GLOSS COATING MAY MELT AND ADHERE TO THE FUSING ROLLERS WITHIN YOUR LASER PRINTER OR PHOTO COPIER. IF YOU HAVE ANY DOUBTS ABOUT YOUR CHOSEN PAPER, FIRST TRY IRONING IT WITH A DRY CLOTHES IRON SET TO 'LINEN' AND SEE IF ANYTHING STICKS OR MELTS!!!!!

PCB Preparation

The surface of the copper must be absolutely clean and completely free of oils, oxides, stains and finger salts. This is achieved by gently rubbing the surface of the copper using a small amount of detergent and 600 grit wet and dry paper with a circular scrubbing motion. This will actually remove a very slight amount of copper, but don't worry because this is exactly the process the professionals use in commercial photo processing. The appearance of the copper surface when this process is finished will be uniformly dull all over, with tens of thousands of fine circular scratches which form a 'key' on the copper surface to which the toner can bond. When this surface appearance has been achieved, the board surface is carefully rinsed off and then dried using a freshly laundered (no oils!) lint free (old!) cotton tea towel. Do not touch the board surface after it has been dried. If you do finger oils will destroy toner adhesion. It really doesn't matter how you get the copper surface clean, but spotlessly clean it must be!! Those in the business of electroplating have a quick test for a clean metal surface, and this is the NO WATERBREAKS test. After the board has been cleaned and washed, the thin film of water remaining should entirely and smoothly cover the copper surface with no breaks visible in the film. If the copper surface is very badly contaminated with oil, I sometimes use a kitchen Scotchbrite pad together with Ajax cleanser (a mixture of finely ground pumice and wetting agents) to get this clean surface. Lastly, whatever you use to dry the surface, make sure there are no traces of oil in it. Instead of a tea towel, I sometimes use plain paper kitchen wipes as another alternative. If you have adhesion problems, it will be due to contamination of the copper surface!!!!

Transferring the Image

To transfer the image, fold the paper around the PCB material so that no relative movement between the two is possible. The back of the paper is then ironed on a hard flat surface (an ironing board will not do as it is too soft - a flat kitchen chopping board is ideal). The iron temperature is adjusted so that after about 20 seconds of ironing the back surface of the clay paper has been uniformly discoloured to a light yellow. Typically the iron temperature setting used will be towards the upper end of scale (cotton or linen) and the iron is of course used DRY. The clay paper surface should remain flat during ironing and particular attention should be paid to the corners of the PCB pattern with the iron tip. The paper/PCB assembly is then allowed to cool for about 5 minutes until it is near room temperature. (Do not throw the PCB/paper assembly into water while it is hot as this will destroy the toner/copper adhesion.) When the assembly has cooled, soak it in water for 5 minutes.

Removing the Paper, Etching, and Cleanup

When the paper/PCB is removed from the water it will be noticed that where there is no toner the paper has bubbled outward (which indicates good toner adhesion to the copper). Take a very soft nail brush, coat its surface with Velvet soap, and gently scrub the rear of the paper, keeping everything wet. The objective here is to reduce about 70% of the paper thickness to pulp but not to break through to the copper surface. The Velvet soap assists in wetting the junction between the clay backing and the toner and assuring its damage-free release. The last part of the backing is removed using the finger tips only with a gentle circular rubbing motion. Be patient and use only light pressure. If you have done everything correctly the undamaged toner track pattern should now appear on the surface of the copper. If there are minor defects, repair them with a DALO pen or similar. The PCB is then etched in one of the standard etching solutions such as 43% ferric chloride (known as 43 Baume), or ammonium persulphate. In an unstirred etch tank, etch the board face downwards. This allows the chemical products of etching to fall away from the copper surface, exposing fresh copper and minimising etch times. Damage to the toner resist can be prevented by drilling 3 or 4 holes in the waste areas of the PCB and fitting plastic stand-offs. It will be found that toner is an extraordinarily good resist and that it will tolerate brutal overetching. When etching is finished, the toner is removed with lacquer thinners or a hydrocarbon such as petrol.

"Double sided" PCB's

Like everything else in this world, it is possible to make a true double sided PCB using the above method if you are sufficiently painstaking and determined, but you have REALLY got to want to do it (and probably be stupid and/or desperate as well).

Here is an alternative, which serves very nicely for most electronics work at home, and only involves a little extra trouble.

Essentially, all the tracks are laid out on one side of the pcb, while the other side is simply a solid copper ground plane to which everything that is "earthed" is connected. This is great RF technique, providing an earth return of absolutely minimum impedance, and some interstage screening, both of which assist enormously in the design and construction of stable circuits. It allows the construction of transmission line sections on the pcb, and 50 ohm lines are particularly simple to do. Routing of power to circuits becomes simpler, and the laying out of circuitry which has two or three power supply rails becomes fairly easy.

How to do it? Simple- create the etch resist for the track pattern as detailed above. During etching, protect the copper ground plane from attack by covering it with the stick on plastic film kids use to protect their school books (In Oz this goes under names such as Fablon,Contact etc). After etching, remove all copper protection and then drill all holes. Turn the board over, and insulate all component leads from the groundplane by counterdrilling the copper groundplane surface with a 3.2mm (1/8") dia drill, using the holes just drilled as a guide. The trick is to just break through the copper groundplane surface without drilling right through the pcb (a disaster), and a drill sharpened with a sheet metal point helps greatly.

The photo of the assembled Q meter pcb in that section of this home page shows the finished result of this technique.

## PROCESS SUMMARY AND PHOTOS

Download photos showing all the warts!

- [The horizontally flipped laser image on clay paper](#)

- [The prepared PCB copper surface- continue small circular abrasive strokes with 600 Silicon Carbide paper and very dilute detergent until the surface is clean and there are no "waterbreaks" anywhere on the copper. Dry carefully with a clean (oil free) lint free cotton towel.](#)

- [Fold the clay paper around the PCB so no movement can occur.](#)

- [Carefully iron the paper for about 30 seconds, keeping the paper flat and paying particular attention to the corners. Note the colour of the paper and the bulging which occurs when everything is cool. The bulging here indicates excellent adhesion.](#)

- [Soak everything for around 5 minutes in very dilute detergent and water.](#)

- [GENTLY scrub rear of paper with laundry soap and a soft nailbrush.](#)

- [Stop using the nailbrush here!](#)

- [Rub gently with your fingers to remove the remaining paper.](#)

- [The finished track pattern ready to etch. Note the little bit of clay remaining attached to the toner resist. Don't worry about this as the etch will chop through clay this thin.](#)

- [The PCB after etching. Note the computer motherboard standoffs to aid rapid etching and prevent damage during handling.The lettering is 0.005 inch while the PCB border is 0.003 inch. 20 thou tracks are easy!!](#)

- [The finished power supply (bottom view).](#)

- [The finished power supply (top view).](#)

PCB with kitchen appliances by dxzone.com