

# PCB's made with kitchen appliances by VK5JST/TR - Page 1

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, a genuine Scotchbrite pad, an ordinary clothes iron, A4 clay surfaced paper, a soft nail brush, plain paper kitchen wipes or an 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 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 or Paint Shop Pro. 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 photo-processing software may not be necessary.

## The PCB Printing Master

Whichever 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. See more information at the end of this document.

## The Paper

The PCB pattern is transferred to the copper by re-melting the finely ground PVC toner on the surface of the **Clay Based Mat Photo Paper** or better still **Toner Transfer Paper** with a clothes iron so that it sticks to the copper. The paper behind the toner therefore has to be removed to allow chemical etching of the copper. This is accomplished when using the clay based photo paper by a process of soaking and gentle rubbing.

**Ordinary A4 printing 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

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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.

In May 2011 I 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 Aisinc 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 up to now, 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"

**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, WHICH WILL WRECK IT. 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.**

**A note from Jim 2<sup>nd</sup> December 2014 to Phil Storr:**

**“Thought I would pass this one on to you, as another builder of worthwhile items. May Mii Ltd sells an alternative paper on Ebay. The paper is dextrin coated and at around \$16/100 A4 sheets posted and it looks like a winner. I bought a \$1.50 sample to check it out. It arrived badly folded but still worked well with the nasty high melting point toner Brother uses in their laser printers. Should go better with the lower melting point HP toner. Use a clothes iron set towards the upper end of the temperature range. Do an Ebay search for toner transfer paper.”**

**Note from Phil - I found this material at these Ebay stores: [getinsunny](#) and [jiangjc\\_store](#)**



A4 100Pcs Sheets Heat Toner Transfer Paper For DIY PCB

### 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 firmly rubbing the surface of the copper using a small amount of detergent and a genuine Scotchbrite pad 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 plain paper kitchen wipe

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(just plain paper-no perfumes or additives of any sort!!) or 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. The use of genuine Scotchbrite kitchen pads is highly recommended as they are flexible enough to reach to the bottom of the indentations created in the copper surface by the criss-cross patterns of glass fibres under the copper surface. Further, the real pads contain finely ground pumice, which really cuts through the surface contamination on the copper. In summary, 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 ground pumice and wetting agents) to get the scrupulously clean surface needed. Lastly, whatever you use to dry the surface, make sure there are no traces of oil in it. 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 clean piece of flat 16mm thick Craftwood or chipboard 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.)

**Note:** Use a laser printer only, you cannot use an inkjet printer.

### Removing the Paper and Clean up

When using the **clay base photo paper** when the assembly has cooled, soak it in water for 5 minutes. 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 or tooth 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.

**Note from Phil.** When using the Toner Transfer material I have found there is no need to soak the board in water, the backing will just peel off if you peel it at an acute angle, double it back on itself and pull slowly. I have found that soaking the assembly in water for a minute or two does help this process.

### Etching

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

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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 computer motherboard stand-offs. It will be found that toner is an extraordinarily good resist and that it will tolerate brutal over etching. When etching is finished, the toner is removed with lacquer thinners or methylated spirits and a scrubbing pad.

### **Another note from Phil.**

I use Ammonium Persulphate available from Jaycar and Altronics as a powder and mix it one to five in hot water (65 to 75C) by volume in a glass measuring jug appropriated from the kitchen. I etch the PCB face up and gently rock the glass etching dish (also appropriated from the kitchen) from side to side. This enables me to keep an eye on the etching progress and if an area is not etching as fast as the rest of the board I gently brush that area with a soft paint brush. I put the etching dish on a Hot Plate to make sure the etchant is at a temperature of at least 65C but do not get the solution hot enough to steam.

### **"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.

### **Producing a Ground-plane**

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 ground-plane by counter drilling the copper ground-plane surface with a 3.2mm (1/8") diameter drill, using the holes just drilled as a guide. The trick is to just break through the copper ground-plane surface without drilling right through the PCB (a disaster), and a drill sharpened with a sheet metal point helps greatly.

**The original version of this article is from the "ODDS AND ENDS FOR THE RADIO AMATEUR" page on the home page of VK5JST/VK5TR**

**<http://www.users.on.net/~endsodds/pcb.htm>**

**Edited by Phil Storr (VK5SRP) after a lot of experimentation and also a lot of failures. When I started out I had failure rates as high as 50 to 60 %, now it is rare to have a failure and when I do it is usually a dirty patch on the copper or a finger print on the copper or artwork.**

**\* Jim has a lot of good information and projects for Hams who like to make equipment.**

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## Additional notes and observations by Phil - updated March 2015.

After Jim sent me the note about the Toner Transfer Paper December 2014 I ordered a pack of 100 sheets on Ebay and it arrived in reasonable condition. It had been folded but only a few outer sheets were unusable. A friend asked me to help him make 150 little interface boards for his signal system on his vast model railway empire and I was not looking forward to the mess in the shed from scrubbing all that clay based paper off.

A good opportunity to try this new material out. In one morning I made 56 little interface boards, four at a time, that included a through hole RJ45 connector and a tiny little surface mount nine pin connector. I had a 98% success rate, the one failure I suspect was caused by a spot on the piece of PCB material that was not clean enough. At first I started to soak the boards in water before peeling the backing paper off but after doing a few I discovered the backing paper was just peeling off anyway. Oh and do not do what I did the first time I tried to use this material, I printed on the yellow paper side, not the shiny side. The paper is the backing, the shiny stuff is the Dextron coating

## Designing PCB's

If you are designing your PCB's from the component side it is a good idea to include some writing on the copper side so once you have produced the resist image on the copper clad material you can be sure you have the board the correct way round. This also helps you to identify your board several years later when you find it in your "junk box". The default method of laying out a PCB in the software I use is to work from the component side and lettering is automatically put on the copper side in reverse so it will be right way round when you have transferred the artwork to the copper clad board.

I use **Sprint-Layout 6.0** (<http://www.abacom-online.de/uk/default.html>)

Sprint-Layout is a simple but powerful tool to create layouts for single-sided and double-sided PCBs (Printed Circuit Boards). The software comes along with all functions that are necessary for board design. Even professional features, like export of Gerber-files (for professional manufacturing) or HPGL (for isolation-milling with CNC machines) are included, while the handling of Sprint-Layout was kept self-explaining.

This is a low cost easy to use PCB design package and if you want to commercialise your design later on you can produce suitable files to email to one of the many PCB manufacturers.

## Summary of the process:

- Produce a horizontally flipped laser image on Clay Paper or Toner Transfer Paper
- Prepare the PCB copper surface: Use small circular strokes with a genuine Scotchbrite kitchen scouring pad and very dilute detergent until the surface is absolutely clean and there are no "water breaks" anywhere on the copper. Dry carefully with plain paper kitchen wipes or clean (oil and lint free) cotton towel. I finish off the cleaning process by dousing the boards in methylated sprits and standing them up to dry
- Fold the clay paper or Toner Transfer Paper around the PCB so no movement can occur and fix it on the back of the board with masking tape.
- Carefully iron the paper onto the boards using medium pressure until you achieve a light to medium yellow colour over the whole surface of the paper. Keep the paper flat and pay particular attention to the corners. This may take from 30 seconds to a couple of minutes depending on the size of the PCB. Note the bulging which occurs when everything has cooled. This indicates excellent adhesion.

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- If using Clay Based Paper, soak everything for around 5 minutes in very dilute detergent and water, GENTLY scrub rear of paper with laundry soap and a soft nail or toothbrush.
- Stop using the nail/toothbrush and then rub gently with your fingers to remove the remaining paper.
- Note a little bit of clay will remain attached to the toner resist. Don't worry about this as the etch will chop through clay this thin.
- **If using Toner Transfer Paper, soak in water for a minute or so and then peel the backing off at 180 degree to the surface of the board. No scrubbing, no mess.**
- Etch the board using your preferred etching solution. I use **Ammonium Persulphate** as it is clean and you do not look like a heavy smoker as you will with Ferric Chloride.

### The description of the May Mii Toner Transfer material from the web site:

I could not resist adding this, in spite of the “Jinglish”, I am sure you will get the idea.

#### Features:

- Remove the white paper, laser printer (or copier) to the PCB map, hit the smooth side, apply to the copper, and iron into the machine or rapid transfer to plate.
- DIY Transfer Paper (fan-made high-precision electronic circuit board must have the material).
- Heat transfer law making circuit boards, circuit board is drawn graphics, laser printers print in thermal transfer paper, transfer paper and then covered in Bonded Copper, after heating, the melting of the toner completely adsorbed on the deposited copper, and other cool tear off transfer paper, you can see the graphics board has to transfer to the Bonded Copper on the black anti-corrosion layers, that is, we want to map the PCB, and finally to corrosion, and that we want to obtain the PCB board.
- The process of making iron tools used in heating or over-presses. We serve the transfer paper for the production of circuit boards dedicated thermal transfer paper, with its production of circuit board has the following advantages:
  1. plate with high precision.
  2. plate cost.
  3. plate-making speed.
  4. can produce double-sided.

#### Usage:

- Circuit board with a laser printer to print to the circuit diagram of the smooth thermal transfer paper.
- Raised with the laminator between 150-180 degrees Celsius, the heat transfer printed circuit side of the paper deposited in the Bonded Copper on the transfer; the system can also be used instead of iron plate machine, hand transfer.
- Remove the transfer paper after printing, the Bonded into the ferric chloride solution to corrosion.
- Finally, remove the circuit board using toner gasoline.