

Etching Your Own PC boards

Need just one or two printed circuit boards, for a magazine project or a prototype for your latest design? It's not too hard to etch your own single-sided or even double-sided boards, especially if you have access to a photocopier, or a PC and laser printer. In this Tech Update we tell you all you need to know.

NOWADAYS JUST ABOUT every piece of electronic equipment is built up on one or more printed circuit or 'PC' boards. Each board not only supports the smaller components, but also supplies the wiring which links them all together. This makes assembly and construction much easier, and also results in a product with greater reliability.

As you're no doubt aware, most simple PC boards consist of a thin sheet of insulating material with thin copper connection pads and tracks or 'traces' attached to one or both sides. (More complex multi-layer boards are made from a number of even thinner boards sandwiched together under heat and pressure, so they have copper pads and tracks **inside** the insulating material as well.)

The first PC boards had the basic insulating 'substrate' made from a laminate of paper and synthetic resin, bonded under heat and pressure to form **SRBP** (synthetic resin bonded paper) material. This is still used for PC boards in some mass produced consumer equipment, because of its low cost. However SRBP is fairly brittle and has a tendency to absorb moisture, so most modern boards for higher-quality equipment use a laminate made from sheets of woven glass cloth bonded with epoxy resin, again under heat and pressure. This is known as **epoxy fibreglass** laminate material, and it's not only strong and flexible, but has excellent electrical insulating properties as well.

How are the conducting pads and tracks added to one or both sides of this laminate? Well, there are a variety of possible ways of doing this, including printing them directly on the surface in conducting metallic inks. It's also possible to get small pads and thin strips punched out of thin copper foil, which can be cemented onto the surface(s) of the substrate sheet. But the most common approach is to laminate thin sheets of pure copper metal foil to one or both sides of the substrate sheets as they're being made, and then remove the unwanted metal later to leave just the wanted pattern of conducting pads and tracks.

So the starting place for most PC boards is a sheet of epoxy fibreglass laminate complete with thin copper foil covering either one side ('single sided laminate') or both sides ('double sided laminate').

Most common boards are made from epoxy laminate approximately 1.5mm thick, with copper foil about .035mm thick. This is usually called '1-ounce' foil, because one square foot (304.8 x 304.8mm, or 92,903 square mm) of foil weighs one ounce (28.35g). However boards where the tracks must carry relatively heavy current can be made from laminate with '2-ounce' foil, which is about .07mm thick. On the other hand boards which must have extremely thin tracks can be made from laminate with foil only .02mm, or .01mm thick.

The epoxy laminate board material is also available in a thickness of 3mm, for applications which need greater physical or electrical strength.

Whichever grades of board material and foil are used,

though, it's still necessary to remove some of the copper from the outside foil(s), in order to create the desired pattern of pads and tracks. This is where there's a range of possibilities.

One way of removing the unwanted metal is to use a computer-controlled end milling/routing machine. This can be fairly quick, as it generally isn't necessary to remove ALL of the unwanted copper — just a narrow strip or 'outline trench' around each wanted pad and track, to insulate them from each other. The rest of the copper foil is simply left there, because it doesn't interfere with circuit operation. (See Fig.1)

Nowadays most PC board patterns are designed on a computer anyway, so this milling/routing approach can be very convenient. With the right software, the PC board CAD file can be used to drive the router directly, producing a useable board within an hour or so. The only real disadvantage of this approach is that computer-controlled milling/routing machines are quite expensive (about \$15,000) — making them really only suitable for commercial production firms or large R&D labs.

Because of this, most PC boards are still made by using a chemical etching process to remove the unwanted copper. In broad terms this involves applying a masking pattern of etch-resistant material ('**resist**') to the surface of the copper foil(s), and then placing the board into an etching bath which chemically removes all of the copper foil which isn't protected by the resist. After etching and washing the resist itself is then removed, leaving just the desired pattern of pads and tracks. (See Fig.2)

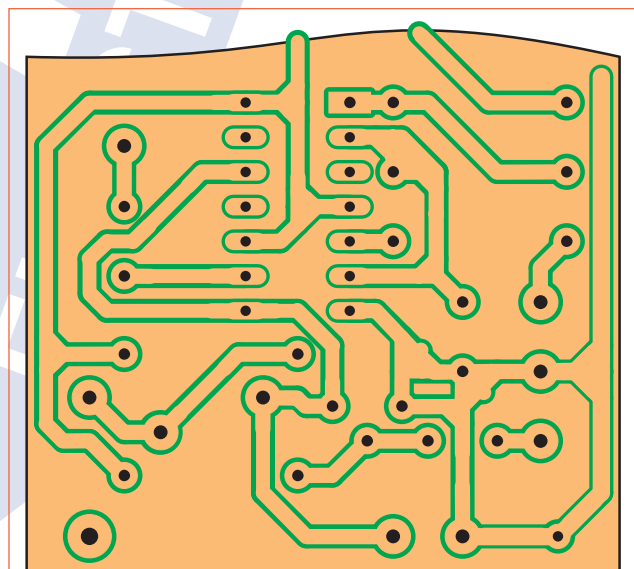
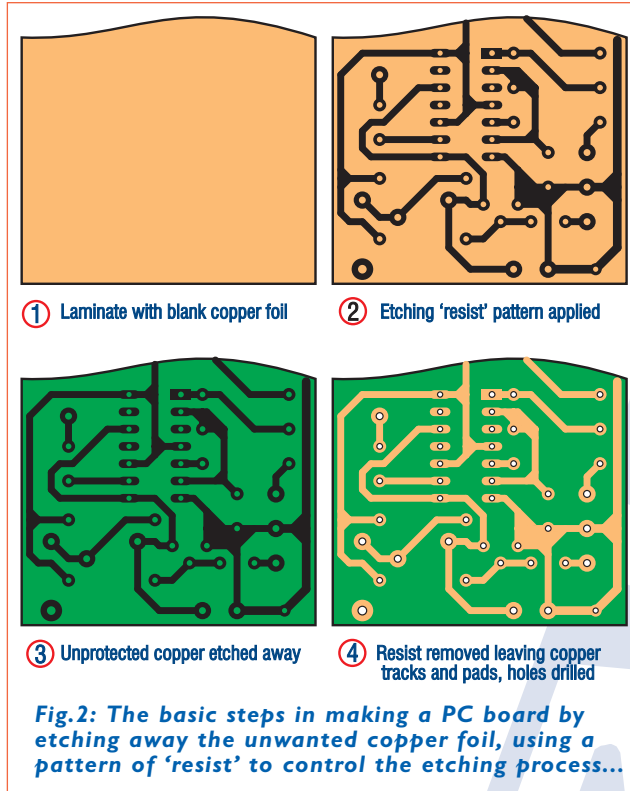


Fig.1: A PC board can be made quickly by using a computer-controlled router or end mill to remove a small 'outline trench' from around each wanted track and pad. The machines are pricey, though.



There are various types of resist, and as a result various ways of making boards using the etching approach. Some of these are really only suitable for mass production, while others are suitable for making single prototype boards. We'll now look at these approaches in turn.

Resist ink pens

The simplest and lowest cost way to apply resist is by applying it manually in the form of liquid 'ink', using a special felt-tip pen. The resist ink is quick drying, and when dry it's resistant to the usual copper etching solutions.

Because this approach involves 'drawing' the pads and tracks in freehand fashion directly on the PC board laminate's copper foil, it's a bit tedious except for very small and relatively simple boards. However if that's the kind of board you happen to need, it can be a very practical approach because the special felt-tip pens filled with resist ink are readily available at low cost. (Jaycar stores have them as Cat. No. TM-3000)

Incidentally these resist-ink felt tip pens are often called 'Dalo' pens, because the first of them to become available carried the Dalo brand name.

Even if you don't intend using a resist-ink pen to make your own boards, it's still worthwhile getting one because they're very handy for making 'touch-up' repairs to resist patterns which you have applied to a board using one of the higher-tech methods, before you etch.



Here's a felt-tip pen of the type used to draw pads and tracks directly on the copper foil, in resist ink. This is the Jaycar TM-3000 (see above).

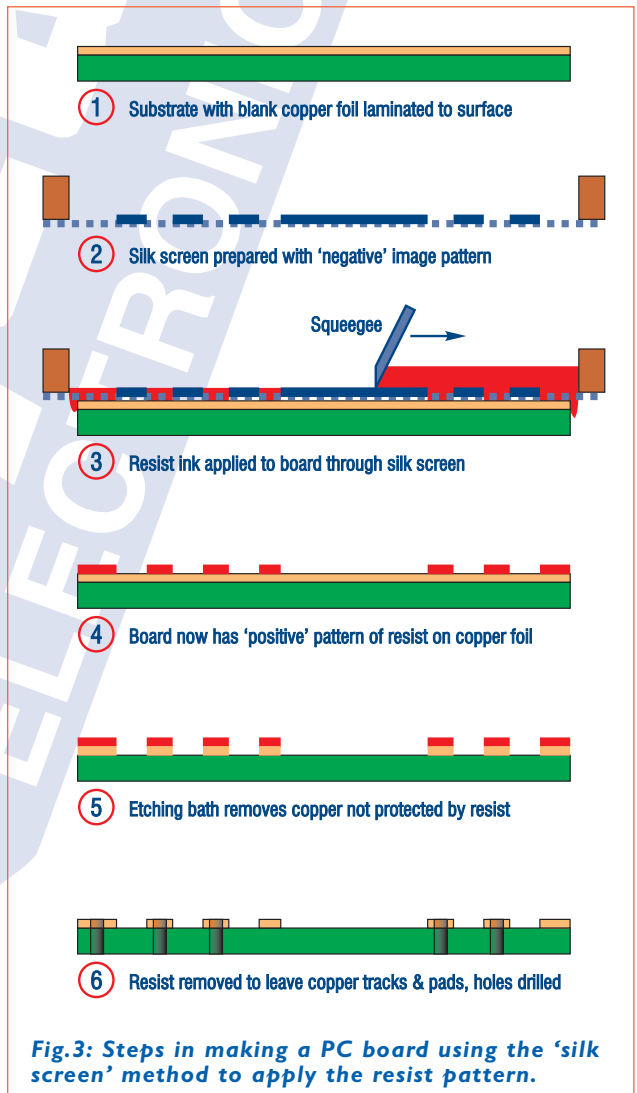
Silk screening

The time-honoured way to apply a resist pattern to PC boards for mass production is by using *silk screen printing*. Here an impervious 'negative' image of the desired board pattern is produced on a sheet of fine silk or nylon fabric, stretched tightly on a frame. The frame is then placed over each cleaned blank PC board laminate, and liquid resist ink applied to the copper foil from the top of the screen using a brush or squeegee. The ink can only pass through the open pores of the screen fabric, so it produces a 'positive' image of the desired board pattern. When this pattern dries the board can then be etched. (See Fig.3)

Silk screen printing of the resist is very cost effective when you're making large quantities of boards. But it's not really practical for small quantities because making the silk screen masks is fairly complex and expensive. In any case the pattern resolution is limited, making it not really suitable for boards with a lot of very fine and closely spaced tracks and pads.

Photo resist

In the 1960's, chemical engineers developed *photopolymers* or light-sensitive plastic materials. Some of these turned out to be excellent as copper-etchant resists, providing a very practical way to apply resist patterns to PC boards.



The most common photoresist material is **Riston**, developed and marketed by the E.I. du Pont de Nemours company ('du Pont'). Luckily for those of us who need to produce small numbers of PC boards, Riston is sold in dry film form, already applied at the factory to blank PC board laminate (and supplied in light-tight bags).

Making a board using this Riston-coated PC board laminate is fairly straightforward, but you *do* need an actual-size photographic negative transparency of the desired board pattern. The negative is usually made using a PC-controlled photoplotter, using a CAD file of the board pattern. However it's also possible to make suitable negatives by printing a negative image of the PCB pattern to transparency film in a laser printer.

Where you want to make a board from a negative pattern printed in a magazine, it's also possible to do this using a photocopier and making the copy on transparency film.

After the negative is prepared by one of these approaches, it is applied as an optical mask to the top of the Riston-coated PC board laminate, in a darkroom. Then the board/Riston/negative 'sandwich' is exposed to UV (ultraviolet) light, with a wavelength in the range 350 - 380nm (nanometres).

Where the Riston film is exposed to the UV light through the clear parts of the negative, it changes in chemical composition. On the other hand the film under the 'dark' parts of the negative image is not changed, because the UV light doesn't reach it.

After exposure the boards are placed in a bath of Riston 'developer' liquid, which is basically a chemical which dissolves the unexposed and unchanged Riston film. This leaves the *exposed* Riston on the board's copper foil, as a positive image of the desired pattern. And the exposed Riston is not only unable to be dissolved by the developer, but is also insoluble to copper foil etchants — so it's a good resist. As a result the board can then be etched, to remove all of the copper that wasn't protected by the Riston resist image.

After etching, the remaining Riston can be removed by rubbing it gently with Riston 'stripper' solution — basically a chemical which can dissolve the UV-exposed



The main resources needed for making PC boards using Riston photopolymer resist: Riston coated blank PC board laminate, Riston CRD30 Developer and Riston CRS-40/5 Stripper solution. All three are available from Jaycar stores, as explained in the text at right...

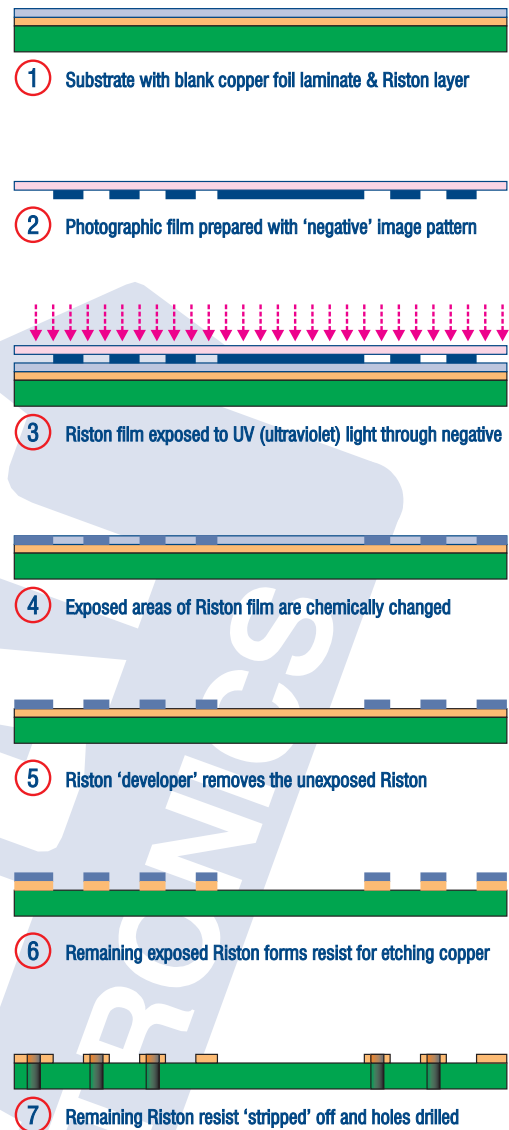


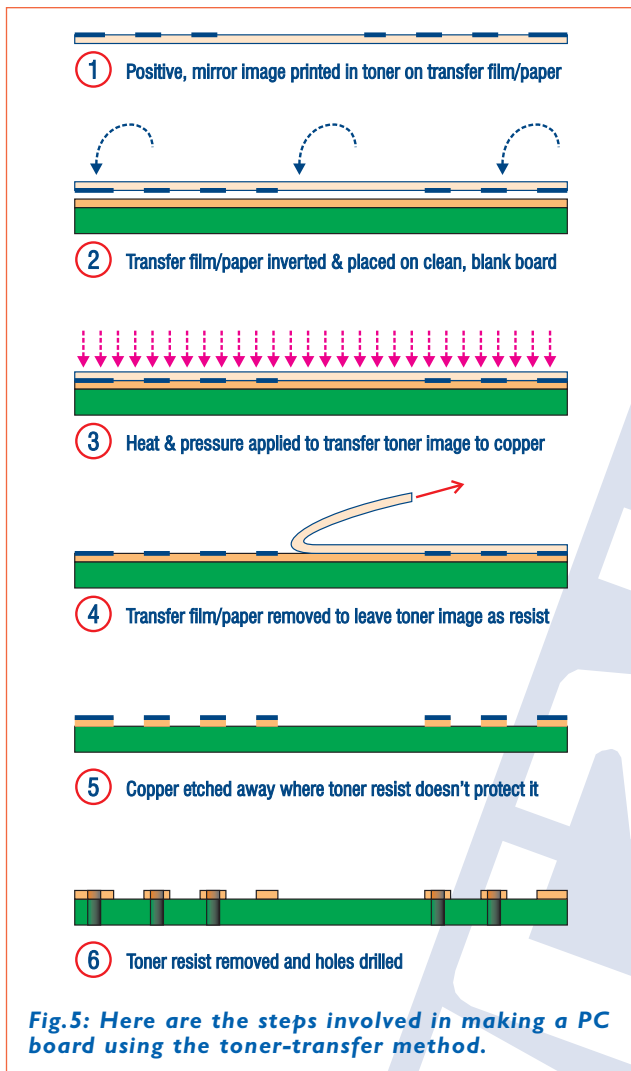
Fig.4: The steps in making a PC board using the Riston photopolymer resist technique.

Riston. The board is then ready for having the holes drilled and being put to use. (See Fig.4)

Thanks to Riston, the photoresist approach is quite practical for producing both one-off PC boards and very small quantities. The pattern resolution can also be excellent, making it very suitable for making boards with a lot of fine and closely-spaced tracks.

However you do need a negative transparency of your board pattern, which can make the technique a bit difficult for hobbyists. The Riston-coated PC board laminate also isn't cheap, and can also change its behaviour if stored for a long time before use — making it hard to determine the optimum exposure and development times if you've stored it for a while.

If you *do* want to make boards using the Riston photopolymer approach, though, Jaycar Electronics stores can certainly provide everything you need: Riston coated blank board (152 x 152mm single sided, Cat. No. HG-9970; 152 x 305mm single sided, Cat. No. HG-9972), Riston CRD-30 Developer solution (500mL, HG-9964) and Riston CRS-40/5 Stripper solution



(500mL, HG-9968). Plus etching materials, of course.

Toner transfer methods

Luckily there's yet another way to apply a resist pattern to the PC board laminate, which proves even more suitable for prototyping and hobby use. This is the **toner transfer method**, which relies on the fact that the toner powders used in xerographic copiers and laser printers contain various plastics — which after fusing (melting) make an excellent etch resist.

The only catch with using toners as our etch resist is that you can't print a toner pattern *directly* onto a blank PC board laminate using a copier or laser printer, because the laminate has a conducting copper foil on its surface — and both copiers and laser printers need to 'spray' a pattern of electric charge onto the surface, to attract the toner particles before fusing. The copper allows any charge pattern to dissipate away, so you can't get a toner image.

So how *is* the toner pattern created? As the name 'toner transfer' suggests, we get around the problem by using the laser printer or photocopier to print the toner image first onto a non-conducting paper or plastic film. Then we apply this paper or film to the surface of the blank PC board copper — image side down — and apply heat and pressure to this sandwich, using a hotplate or domestic iron. The heat causes the toner image to melt again (re-fuse), and the pressure causes

most of the molten toner to *transfer* from the paper or film over to the copper surface.

When the sandwich is then placed in water, the transfer paper or film can be peeled off, leaving the toner image on the copper surface — ready to serve as the resist for etching. (See Fig.5)

As you can see, the toner transfer method doesn't need a photographic negative of your board pattern. It also doesn't need any developer or stripping chemicals, because after the board is etched the toner image can be removed from the copper tracks and pads using fine steel wool and a mild cleaning paste.

All that is needed to make boards using the toner transfer resist system is access to a PC with a laser printer — or a photocopier — and some of the special 'toner transfer' paper or plastic film. Plus, of course, a hotplate or iron to use for the actual toner transfer process, and some fine steel wool and cleaning paste.

By the way, there **is** one important point to note about the toner image which you print on the transfer paper or film: it needs to be a *positive* image, of course, and it also has to be **laterally reversed** — i.e., a 'mirror image' of the final pattern. That's because when it's transferred from the transfer paper/film to the copper foil, it gets laterally reversed again in the process.

Luckily most PC graphics and board design programs can print a laterally reversed image, so this usually isn't a problem.

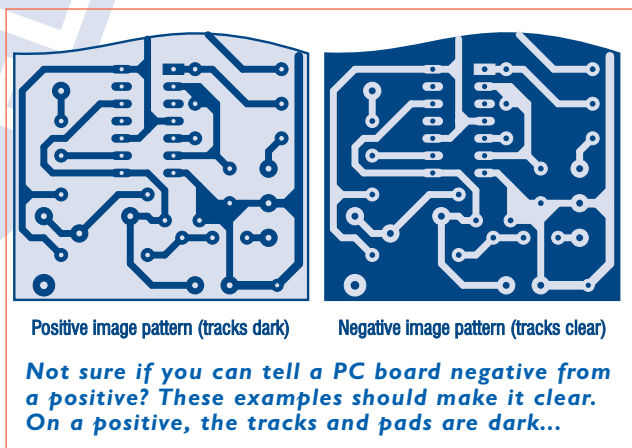
But where do you get the special toner transfer paper or film? That's an easy one. Jaycar Electronics stores stock the excellent **Press-n-Peel** PC board transfer film, made by US firm Techniks Inc. This is sold in packs of five A4-sized sheets (Cat. No. HG-9980), which should be sufficient for about 10 average sized boards.

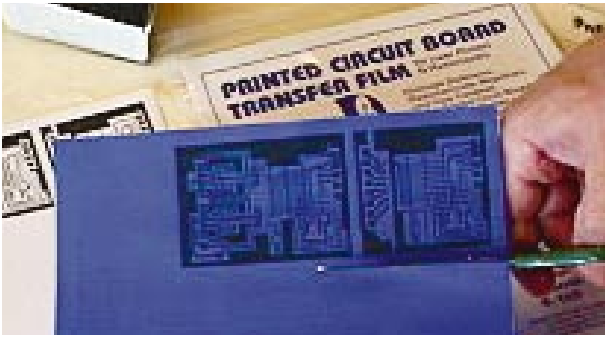
One more general point: occasionally during the transfer process, the toner image may not transfer over to the copper perfectly in all areas. This can happen if you're using a domestic iron to provide the heat and pressure, and you don't provide quite enough of either over the full area. There's no great harm done though, because you can always use one of the resist-ink pens to 'touch up' the pattern before you etch the board...

Making your own

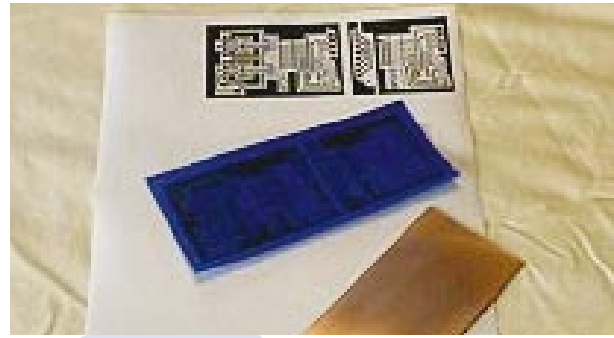
Right, we've explained the various ways of putting a resist image onto the blank PC board laminate, and also explained why the toner transfer method is probably the one most suited for making prototype and hobby boards. So now it's time to take you through the steps of making your own boards, using this approach.

First up, you need to obtain a piece of blank PC





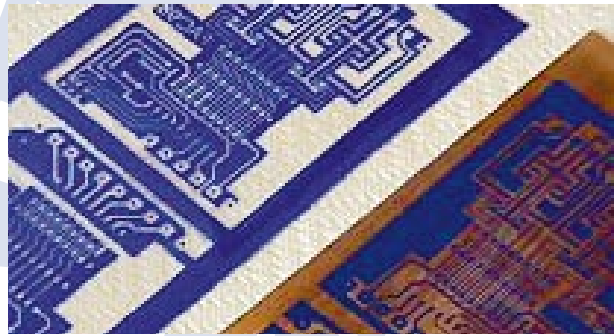
1. Cut transfer film to size, larger than PC pattern.



2. Print pattern on emulsion side of transfer film.



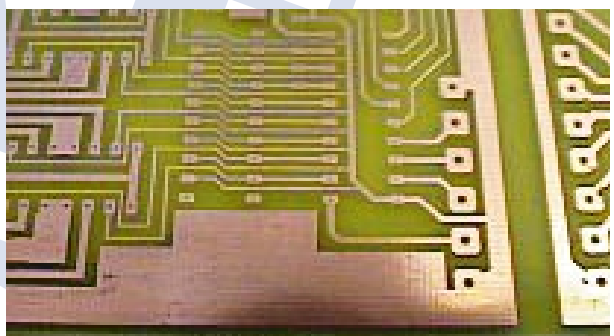
3. Place film emulsion down on blank board, then 'iron' to melt and transfer toner. Dunk in water...



4. Then peel off film, which should leave toner image on copper ready for etching.



5. After etching, remove toner with fine steel wool.



6. Finally drill holes and spray with lacquer.

Here are the main steps involved in making a PC board using Press-n-Peel toner transfer film, as suggested by the manufacturer Techniks Inc. The text gives more detail.

laminates about 40mm larger than the board you want to produce, in both directions. If you have to cut it to size from a larger sheet, make sure that you file off any burrs from the cut edges — these can cause problems later, during the toner transfer process.

The copper surface of the board should be very clean — if it isn't, give it a light rub all over with a fine steel wool pad, using water and a small amount of very mild cleaning paste. It's a good idea to rub it in both the horizontal and vertical directions, to leave an array of very fine scratches. These provide a good surface for the toner to adhere to later, in the transfer process.

Finally wash the piece of board thoroughly and dry the surface with some clean paper towel or lint-free cloth towel. **Don't touch the surface again with your fingers before the board is etched**, because this will tend to leave finger oils which can again prevent proper toner transfer.

Now you're ready to prepare the toner image, ready

for transfer. To do this with your PC and laser printer, set your PC board design software or graphics editing software to print out the board pattern at exactly 100% scale, but laterally reversed (mirrored). If you're using a photocopier instead, you'll have to adjust it to obtain the same result.

Either way, print or copy the image first in the centre of a normal sheet of A4 paper. This will let you check first that it's printing at exactly the right size, and also as a mirror image. It also makes it easy to cut a piece of the blue Press-n-Peel film to a size which will leave about 10mm margin all around the printed image.

Now place this piece of film squarely over the printed image, with the margin all around and with the **dull side of the film uppermost**. This is the 'emulsion' side, which is designed to accept the toner image and allow it to be transferred to the copper later.

With the film in position, use a single length of heat stable (i.e., laser copier safe) sticky tape to stick the

film to the paper, **right along the film's top edge**. This is to attach the film securely to the paper so we can put them both through the printer or copier again, this time to print the image on the film. As the top edge of the film will be the first part to enter the printer or copier, we tape it to the paper right along this 'leading edge' to prevent them jamming inside.

To make extra sure that you don't get a jam, you might also want to place another strip of tape along the bottom edge of the film as well. That's usually OK, but just be aware that this sometimes causes problems, because the film and paper don't expand and contract in the same way when they're heated in the printer or copier's fuser.

With the film taped to the paper, the next step is to put the combination through the printer or copier again, to print the toner image on the film. Then you can remove the film from the paper, and you're ready for the toner transfer process itself.

Transferring the toner

Now place the PC board blank — copper side up — on a flat horizontal surface, preferably of heat resistant wood. Then put the piece of toner transfer film carefully in the centre, this time with the dull side carrying the toner image *underneath* and directly against the copper. Finally place a piece of plain paper over the top of the film, taking care not to disturb the film in the process. This sheet of 'cover paper' is to allow you to 'iron' the board and film sandwich, without accidentally catching the edge of the film with the iron and moving it.

The next step is to heat up your iron, to a temperature of about 135 - 163°C (275 - 325°F). This is a fairly low setting, roughly in between those used for ironing acrylic and polyester fabrics. (By the way, you'll be using the iron in 'dry' mode — DO NOT use steam or a water spray.)

Once the iron has stabilised to the correct temperature, use it to iron the board/toner transfer film sandwich — through the cover paper. Rub it steadily but evenly all over, for between two and four minutes. It's important to make sure that the whole board/film area receives much the same amount of heat, so that all of the toner image will be transferred to the copper.

At the end of the ironing/transfer time, take the board/film sandwich (careful — it'll be hot!) and dunk it in a bowl of cold water. This should dissolve the



Press-n-Peel toner transfer film comes in A4 sheets. Packs of five sheets are available from Jaycar stores as Cat. No. HG-9980.

The most popular PC board etchant in Australia is ammonium persulphate, which is somewhat easier to use than ferric chloride as it's a clear solution and doesn't stain. Jaycar sells it in 400 gram jars (NC-4254), which make up 1.5 litres of etchant.



emulsion off the film, and you should then be able to peel the film off, leaving a clean toner image attached to the copper.

Sometimes a small amount of the film's emulsion may stay on the copper, between closely-spaced tracks and/or in the 'holes' of pads. If so, apply some clear packing tape to the areas concerned and then peel it off again. This should 'lift' the remaining emulsion off...

Your board should now be cleaned gently with soap and water, rubbing lightly with a soft cloth so that you don't damage the toner image. After a final wash it should then be ready for etching.

Etching

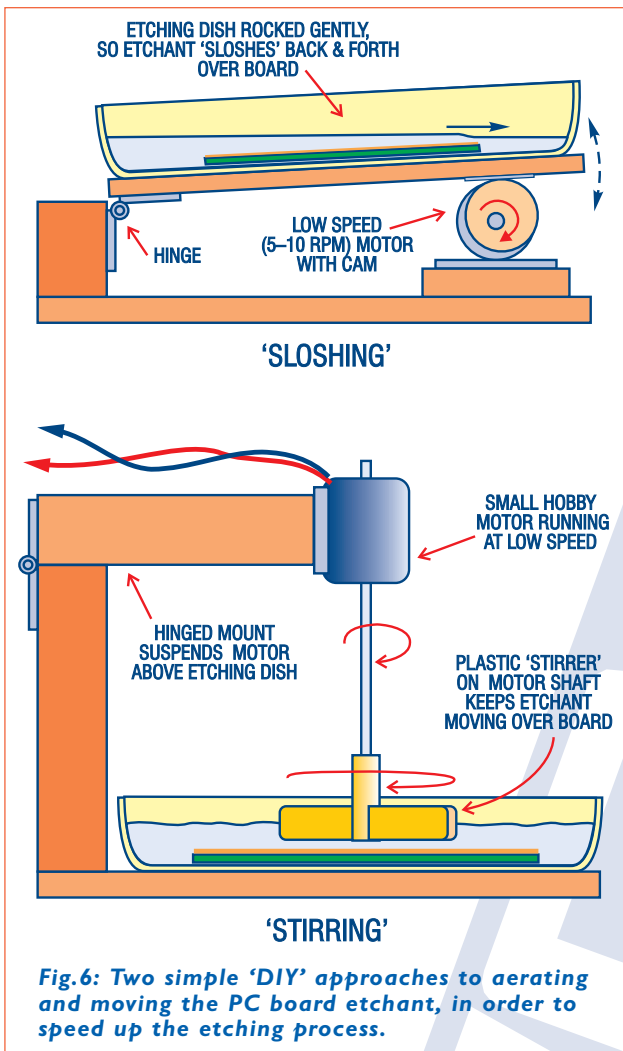
In principle, etching a PC board is relatively straightforward: you simply place the blank board with its resist image in a solution capable of dissolving copper, and wait until it dissolves all of the copper that isn't protected by the resist. Then you wash the board thoroughly and your board is ready for drilling and use.

In practice there's more to etching than you might think. For example it's desirable to etch the unwanted copper away fairly quickly, because slower etching tends to result in 'undercutting' — where copper is removed from under the edges of the resist areas as well, narrowing the copper tracks and pads and weakening their attachment to the substrate. This can cause problems with boards having many fine and closely-spaced tracks.

There are various ways to achieve reasonably fast etching, as we'll see shortly. However another complication is that copper etchant solutions are fairly corrosive, and also present a health hazard. So when you're working with them you should always wear goggles or other eye protection, and also rubber gloves to prevent skin contact. The etchant solutions should also be used in glass or plastic containers — not metal, because they tend to react with many metals.

There's also a choice to be made in terms of the etchant you use. In Australia two main copper etchants tend to be used, each with their own pros and cons.

The etchant that has been used for many years is **ferric chloride**, which is cheap and doesn't require heating. However it forms a dark and 'soupy' etching solution, which makes it hard to see when etching is complete. It's also very messy, and produces dark and virtually unremovable stains on almost any surface — quite apart from its corrosive action on clothes, etc. Containers of ferric chloride cannot be legally sent through the mail because of these problems.



print development. Then you only need a relatively small amount of etching solution — sufficient to fill the dish to about 8-10mm over the board.

To speed up the etching, you can gently raise and lower one end of the dish every few seconds, to keep the etchant moving back and forth over the copper. This gentle 'sloshing' wave action also keeps the etchant aerated, which helps the etching process as well. In addition, the moving solution tends to wash away the copper as it's dissolved, allowing you to monitor progress and stop as soon as all of the unwanted copper has been removed.

An alternative to rocking the dish itself is to suspend a small DC hobby motor over the dish, with a plastic stirring paddle attached to its shaft. The motor can be driven via a speed control, so that the paddle gently keeps the etchant solution on the move. (Fig.6 shows simple sloshing and stirring setups.)

These techniques are generally fine for etching small hobby PC boards, but for larger boards there's a better approach. This is to suspend the board in a vertical etching tank, which is a bit like a small fish tank except that it's much narrower — only 30mm or so. This again allows you to cover the board with a relatively small amount of etchant solution. The tanks are also made out of either glass or clear plastic, so it's still easy to keep an eye on the etching process.

Jaycar stores now stock a well-made vertical etching tank of plastic, measuring 210 x 280 x 30mm (Cat.No. HP-9530). This is very suitable for etching boards up to about 200 x 250mm. It comes with special clips and wire hooks to suspend boards in the etching solution, and also boasts a special air channel around the sides and bottom, with tiny holes along the bottom so you can blow air bubbles through the etchant to keep it moving and aerated. The easiest way to do this is with a small air pump of the type used for aerating fish tanks. The pump can be hooked up to the tank's air inlet using a length of PVC tubing (see Fig.7).

If you plan to etch fairly large boards you might also want to get a fish tank heater, of the type that is sealed in glass or plastic and designed to be suspended in the tank. These are quite suitable for heating up the etchant (allowing it to be re-used), and also for keeping its temperature at the optimum level for fast etching.

The main alternative to ferric chloride is **ammonium persulphate**, which forms a clear solution. This makes it much easier to monitor etching progress, and there's also much less risk of staining clothes. As a result it can be sent through the mail, and is usually preferred for school and college use.

However ammonium persulphate does produce ammonia vapour during etching, and this can irritate nasal passages and cause eye watering. Because of this it's usually recommended that etching is done outdoors, or at least where there is good ventilation.

Another small complication with ammonium persulphate is that for faster etching, it should be heated to about 50 - 60°C. For hobby use this means that the etching solution needs to be either made up freshly each time with hot water, or heated up using a fish tank heater dedicated to the task. (You'd poison your fish if you borrowed the one from the fish tank!)

For hobby use then, the preferred etchant is ammonium persulphate. This is readily available from Jaycar Electronics stores in 400g jars (Cat. No. NC-4254), which is sufficient to make up 1.5 litres of etching solution.

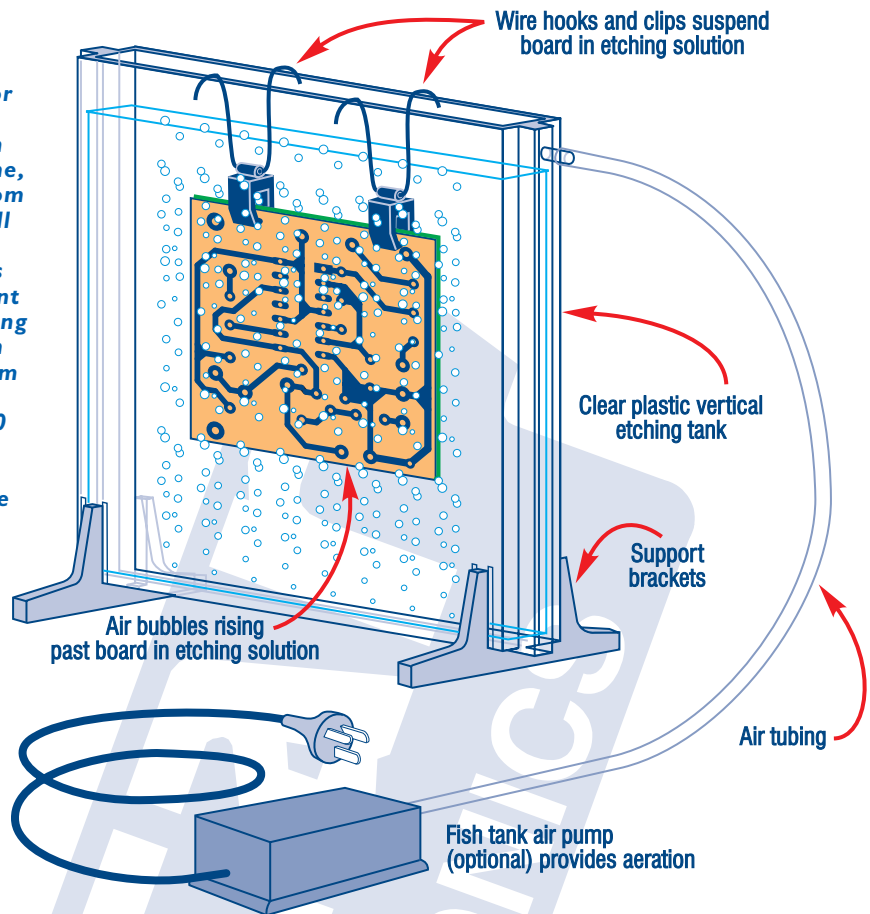
Dish or tank?

The actual etching process can be carried out in a number of ways. The simplest approach with small boards is to place them copper side up in a shallow plastic or glass dish, like those used for photographic

Once your PC board is etched, the toner resist removed and the holes drilled, it's a good idea to give it a thin coat of protective lacquer to prevent the copper pads from oxidising. Jaycar stores can provide this 'solder through' protective lacquer in a spray can, as Cat. No. NA-1002. It's quick drying and makes the job easy.



Fig.7: How the Jaycar HP-9530 vertical etching tank is used for etching your own PC boards. This tank has a air distribution channel moulded into the frame, with tiny holes along the bottom of the tank. So by using a small air pump like those sold for aerating fish tanks, air bubbles can be used to keep the etchant moving and speed up the etching process. A fish tank heater can also be used to keep ammonium persulphate etchant at the optimum temperature of 50–60 degrees C. Just don't put the heater back into the fish tank afterwards, or you'll poison the fish!



Using these techniques you should be able to etch away the unwanted copper from most typical boards in about 10 to 15 minutes. When you can see that it has all been removed, remove the board from the etchant and wash it thoroughly in running water.

Drilling the holes

After etching and washing, you'll probably find it convenient to drill the holes in the board for the component leads, PC terminal pins etc. It's very easy to drill them at this stage because the toner resist is still on the remaining copper, but there will be tiny holes etched in the centre of each pad to act as pilot holes for the drill.

Most component lead holes are usually drilled with a 0.8mm (1/32") diameter drill, while those for larger components and PC terminal pins are usually either 1mm or 1.2mm. Holes used for mounting the PC board are usually either 3mm or 3.5mm.

Resist removal

With the holes drilled, the next step is to remove the toner resist from the copper tracks and pads, so they will accept solder readily.

Most guides to PC board making using the toner resist method suggest removing it by rubbing with either acetone or methyl-ethyl ketone (MEK). These certainly work, but they're rather nasty chemicals that are not very environmentally friendly. If you do decide to use one of these, make sure you wear rubber gloves so they don't contact your skin. Also use them out in the open, where you won't inhale their fumes.

Because of the drawbacks of these chemicals, you

might well prefer to use the old fashioned approach: removing the toner by gentle rubbing with fine steel wool plus a little paste cleaner and warm water. This works almost as well, and you have the warm glow of knowing that you're doing less harm to the environment.

Final trim and spray

The final steps after removing the toner resist is to trim the board to its correct size, and then spraying it with a protective lacquer.

It's usually easy to cut the board to final size at this stage, because the etched copper pattern is now available as a guide. You can use a foot-powered guillotine if you have access to one, or otherwise use a hacksaw followed by a fine-pitch file to remove burrs.

It's not absolutely essential to follow this step with a protective lacquer spray, especially if you're going to be wiring up the board straight away. But if you have to leave it for a while, spraying the copper will prevent it from oxidising and make it much easier to solder to when you do have to add the components.

Jaycar Electronics stores carry a very suitable PC Board Lacquer spray pack (Cat. No. NA-1002), which not only protects the copper from oxidising but also allows the board itself to resist the ingress of moisture. The lacquer doesn't have to be removed for soldering, either — it's of the 'solder through' type, so a quick spray with this lacquer is the best way to give your boards a professional finish.

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(Glossary of terms on next page)

Glossary of terms

Acetone: An organic solvent, which can be used for removing toner resist from a PC board after etching.

Aeration: The process of keeping a small amount of air dissolved in a liquid. Aeration of PC board copper etchants helps speed up the etching process.

Ammonium Persulphate: One of the two main etchants used for removal of unwanted copper from PC boards. It gives a clear etchant solution, which doesn't stain clothes and also makes it easier to watch the etching process.

Developer: A solvent used to remove unexposed photopolymer resist materials like Riston, after exposure to ultraviolet light. This leaves the exposed Riston as an etching resist.

Epoxy fibreglass: The insulating material used to make most higher quality PC boards. It consists of a laminate of layers of woven glass cloth with epoxy resin, bonded together under heat and pressure.

Etchant: A solution which is used to dissolve, and therefore etch away, unwanted material. In making PC boards, etching is used to remove the unwanted copper foil material.

Ferric Chloride: The other main etchant used for removing the unwanted copper from PC boards. A very effective etchant at room temperature, but is also a dark and corrosive 'soup' which stains clothing and almost everything else. It also makes visual inspection of the etching process harder.

Laminate: A 'sandwich' of many layers of materials. Epoxy fibreglass PC board material is a laminate of layers of glass cloth, bonded together using epoxy resin under heat and pressure.

MEK: Methyl-ethyl ketone, a solvent which can be used like acetone to remove toner resist from PC boards after etching.

Negative transparency: A transparent version of a PC board pattern, with clear emulsion where the copper is to be left to form tracks and pads, and dark areas where the copper is to be removed. This type of transparency is needed for the photopolymer resist (e.g., Riston) method of making boards.

Photopolymer: A polymer material which changes its chemical characteristics after exposure to UV (ultraviolet) or other light.

Resist: A material which resists the action of an etchant, in dissolving and removing material. Resists are used to retain the desired copper pattern on a PC board, when etching is used to remove the unwanted copper.

Riston: A dry film photopolymer resist material, developed and marketed by the du Pont company. Available pre-coated onto blank PC board laminate.

Sloshing: Rocking a dish of etchant solution gently, so that the etchant 'sloshes' back and forth over a PC board being etched. This keeps the etchant moving and aerated, which hastens the etching process.

SRBP: Synthetic resin bonded paper laminate, used as the insulating substrate for lower-cost PC boards. More brittle than epoxy fibreglass, and not as resistant to the ingress of moisture.

Stripper: A solvent used to remove the remaining photopolymer resist (e.g., Riston) after a PC board has been etched.

Toner transfer: The system of using a xerographic toner image as an etching resist for making PC boards, by printing it first onto a special film or paper, and then transferring it to the copper foil of a blank PC board using heat and pressure.

UV exposure: Exposing a PC board coated with photopolymer resist to ultraviolet (UV) light, through a negative transparency.

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