
MAKING PRINTED CIRCUIT BOARDS

**Don't give in
to perfboard
just yet!**

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There are many ways to produce your own printed circuit boards. Small boards for DC switching circuits are easy to make because neither the size nor the shape of the copper foil traces is critical. Boards containing many digital ICs are considerably harder to lay out and etch. There are also some double-sided digital board designs with plated-through holes. These types of boards aren't reproducible and you're better off buying them from the source.

Many articles have been published on the use of stencils and rubyliths in conjunction with sensitized pc boards and light tables. These techniques are good for the more complicated boards or for making multiple boards. The process involves making a positive or negative artwork, exposing and developing the light sensitive board, and then etching the board. Most homebrewers don't have access to light tables, developing solutions, and darkroom facilities. I use light sensitive methods for many of my pc boards — mostly for digital IC boards or multiple boards of the same design. What follows are some pc board techniques you can use instead of these facilities.

There are ways to produce RF microstrip and small DC pc boards in minutes without light tables, some without the etching process. Basically, there are four methods. Each method has its own variations, depending on the board material.

- X-ACTO™ knife method
- X-ACTO etch method
- Drafting tape method
- Dremmel method

These methods involve the use of an X-ACTO knife and other procedures that require safety glasses or goggles. The tip of an X-ACTO blade can snap off when used to cut copper foil. I purposely snap off a very small portion of each new

blade before starting. This way I'm sure that the small blade tip will end up in the trash can and not on my workbench.

X-ACTO knife method

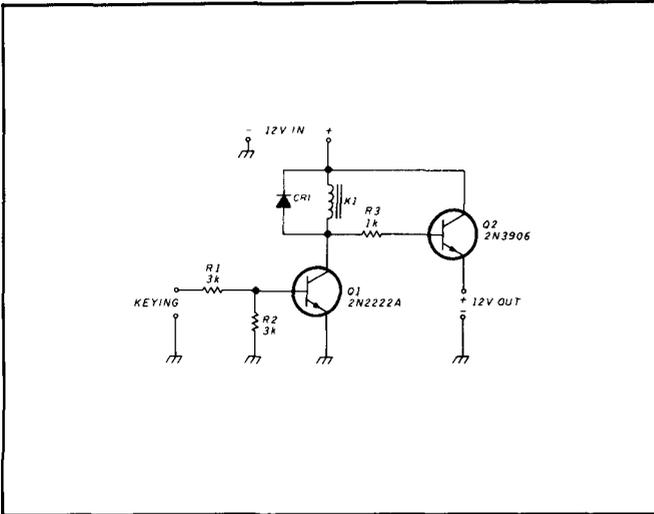
This type of pc board construction can be used on standard G-10 fiber glass board or Teflon™ dielectric boards. It involves cutting away strips of copper, leaving isolated pads to which components are soldered. This is a non-etch process for making pc boards quickly. A working project board can be completed in a quarter of the time it takes to make just the pc board using light sensitive methods. A pencil soldering iron with a pointed tip is required.

Figure 1 shows a small DC switching circuit to be made on G-10 board. Parts placement isn't critical on a simple non-RF board, and the parts layout can follow the schematic directly. Islands of copper are needed at all junctions of the individual components. Ground connections are common using the main copper foil portion of the board.

Figure 2 shows the pc board layout for the circuit in **Figure 1**. Using a pencil, draw small rectangular pads on the copper foil for each component connection. Draw a second outline slightly larger than the first. This small strip of copper around each pad will be removed later. You can draw symbols for each component on the board to make layout easier and ensure correct spacing for leads.

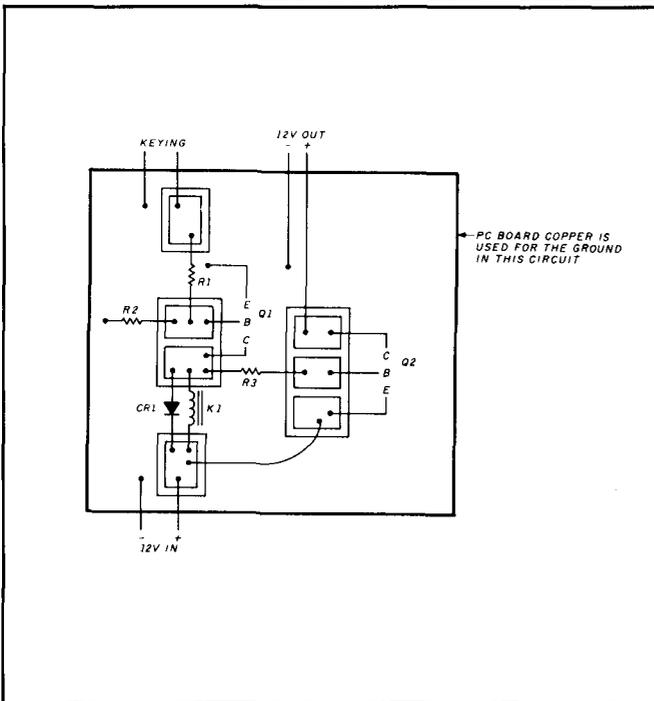
After drawing all the pads, mark and drill component mounting holes. Now, while wearing safety glasses, use the X-ACTO knife to cut along the pencil lines. Use a straight edge if you wish. Heat up the small strips of copper by dragging the tip of your soldering iron back and forth along the strip. The copper foil will pull away from the fiber glass board easily. You can remove very narrow strips with the soldering iron tip. Make the strips just wide enough to isolate the

FIGURE 1



Simple DC switching circuit.

FIGURE 2



Board layout showing pads made by removing copper strips around each square using X-ACTO knife methods. A "score knife" could also be used to cut away the copper, leaving the isolated pads.

pads. Wider foil strips can be tinned with solder first, then removed using the X-ACTO knife along with the soldering tip. After all the pads are isolated from ground, use steel wool to smooth the board and remove any oxidation that would hinder soldering the components in place.

You can remove copper to make mounting pads in another way — with a "score" knife. Roofing and siding people use this type of knife to cut aluminum siding. The blade makes a "V" cut in the aluminum, making it easy to bend and break. The blade will also cut a V-shaped groove in the fiber glass pc board. Using this knife is sometimes much easier

than using an X-ACTO knife because you need to make only one cut. Dragging the knife along a straight edge allows you to remove long strips of copper for long rectangular pads. With this knife and a straight edge, you can cut pads with 0.1-inch spacing to accommodate ICs, computer-type connectors, or header plugs. I made a board with seven ICs, two LED readouts, and three header plugs using the score knife. Making pads with IC spacing using this knife, in conjunction with some wire wrapping, is a simple way to make an otherwise complicated pc board. After cutting the board to the proper layout, drill component and IC holes and use steel wool to smooth out the knife cuts.

You can use a double-sided pc board (copper foil on both sides) on larger boards with many grounding points. On double-sided boards, the non-etched or non-patterned side of the board is referred to as the ground plane side. All grounds are connected to the ground plane side of the board by holes drilled for each ground lead. Isolate the non-ground leads on the ground plane side of the board by clearing the holes with an oversized drill bit. Drill and clear all non-ground holes first to eliminate the confusion of which holes get cleared.

The X-ACTO knife method can also be used on Teflon pc boards for very basic microstrip designs. **Figure 3** shows a simple RF amplifier. A pc board for the amplifier with a 50-ohm microstrip is shown in **Figure 4**. This board can be produced using the X-ACTO knife method because all lines are straight. Basically, you need remove only two strips of copper. A working amplifier of this type can be completed in 15 minutes using X-ACTO etch.

The copper on a Teflon pc board won't peel when heated with a soldering iron as it does on G-10 board. Peel off the copper using the knife and good needle nose pliers. After drawing the design on the board with a pencil, cut along the lines with the knife. Cut just deep enough to go through the copper foil. Now use the X-ACTO knife and needle nose pliers to pull up the foil strips. After doing a few boards this way, you'll learn to remove the foil without cutting into the Teflon dielectric. Use other techniques for more complicated boards.

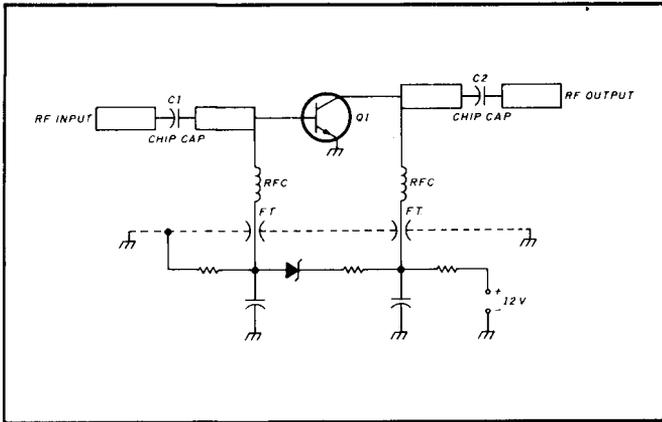
An X-ACTO knife is all you need to make microstrip-type boards on Epsilam 10-type board material (dielectric constant of 10). You can cut the foil with the knife and peel it off with a small pair of needle nose pliers. It's easy to remove the copper foil from this type of board material.

X-ACTO etch method

This process is used for making microstrip-type pc boards. The technique takes little time, doesn't require photo-type artwork, and eliminates the exposure/developing processes. With X-ACTO etch, you prepare your pc board for etching by cutting "clear tape resist" to the desired pattern with an X-ACTO knife. You can purchase clear tape on a 4-inch wide roll at most stationery stores. Although light sensitive methods would normally be used for producing multiple boards, I often use X-ACTO etch because it's faster. It takes less time to X-ACTO etch two or three boards than it does to use light sensitive methods. Making the rubylith artwork for light sensitive methods can be very time consuming.

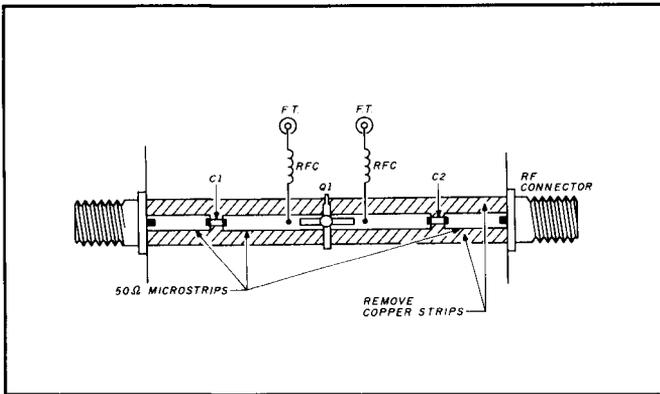
Select a pc board of the proper size. You must use double-sided board for all microstrip designs. Draw the desired pattern on the board with a pencil and straight edge. You can use a dial caliper to accurately lay out a

FIGURE 3



RF amplifier using 50-ohm microstrip.

FIGURE 4



Layout of RF amplifier showing two strips of copper to be removed with an X-ACTO knife to produce a microstrip pc board. Cut away copper to mount DC blocking chip caps C1 and C2.

design from full scale artwork in a magazine. Most microstrip designs have trimmer capacitors for optimization, anyway.

Cover both sides of the board with clear tape. Cut the tape along the penciled lines, using a straight edge as needed. Remove the tape where the copper is to be etched. The remaining tape will serve as the resist for etching the board. Press the resist tape firmly to the board to reduce the "under etching" effects of the ferric chloride. You can add any additional pads to the board later with pieces of tape. Etch the board and remove the resist tape. Clean the board with steel wool and trim to size if necessary.

Another variation of X-ACTO etch involves using a photocopy of the full-scale artwork as a pattern from which to cut the tape resist. Attach the board to the reverse side of the photocopy with tape. Cut the resist tape with your knife, following the artwork copy. You may find this technique difficult to use on some designs because, depending on the number of cuts, the artwork copy will fall apart before the last cuts are made. The last few cuts can usually be made by taking measurements with a dial caliper. After the tape pattern is cut, continue by using the procedures mentioned earlier.

Drafting tape method

You can make many DC switching and small IC projects on single-sided pc boards with this technique. Drafting supplies for making light table artworks are used as the actual resist for etching a board. Drafting tapes are available in many different widths. "Donuts" and other pad shapes are used to mark drill holes. Transistor and IC patterns are also available. Use clear tape to make your own special patterns. Then use these patterns in conjunction with drafting tapes to create circuit resist patterns on the copper side of the board.

Press the patterns and tape lines to the board firmly. Some under etching will occur, but this isn't a problem on DC-type boards. Making the lines a little wider initially will help. Now etch the board, remove the resist tape, and clean the board with steel wool.

Dremmel method

A dremmel tool or small drill press can be used to cut away the copper foil to produce small pads of copper on G-10 fiber glass board. Instead of using the X-ACTO knife and soldering iron, use a small dremmel bit to cut isolating pads on the board. You can do this freehand on boards that don't require a neat appearance.

I use small dental drills in a drill press to cut some of my boards. The worktable is raised up close to the drill bit and set so the bit cuts only through the copper foil. Mark the copper side of the board with a pencil. Move the pc board along the worktable, following the penciled lines. A straight edge clamped to the worktable acts as a guide, letting you make straight cuts on the pc board.

Etching boards

You can etch boards in several ways. The easiest method is to use a spray etching tank. If you don't have access to a tank, the method that follows can be used for basement or garage etching. Conventional methods involving plastic trays with agitating motors and heat lamps work too.

Place the board to be etched in a Tupperware® or other sealed plastic container with sufficient etching solution. Ferric chloride works best at higher temperatures. The etching solution should be less than half the volume of the container to allow for air expansion. Put the plastic container in a bucket of hot water and agitate until the board is etched.

Another etching container that works well is the ceramic "crock pot." I got the idea of using the crock pot from Phil, WA3NUF. Pour about 1 inch of ferric chloride into the pot. Put your board in the pot and replace the cover. Set on the low heat position. Your board will be done in 30 minutes. You can etch several small boards at the same time, providing they aren't stacked on top of each other. The ferric chloride fumes stay in the pot; this is an advantage over using a plastic tray for etching. This type of etching can be used for all resist methods. Even in the high heat position, the clear tape resist works just fine.

Conclusion

I hope these methods will encourage you to build projects requiring a pc board. A double-sided board with plated-through holes is nice, but isn't always necessary. Next time you think about a perfboard project, try it on a pc board using the X-ACTO knife method. I think you'll find it's easier.

