More FLEX DESIGN Tips

If you can design rigid circuit boards, there's no reason you can't design flexible circuitry too. If you do your homework, that is. by TOM WOZNICKI

Flexible circuits are a lot like rigid boards, but designing flex can give the most experienced PCB designer fits. What lulls many very good board designers into complacency is the fact that flex circuits typically are electrically simple but mechanically complex. When you've designed boards with thousands of components and schematics that are ten pages long, how hard can it be to create a flex circuit that has only two connectors on it? Well, the design may pass the netlist check but if the flex tears when you try to install it, no one is going to be very happy.

The first rule of flex designing is to make a "paper doll" to make sure you have the correct shape. It may seem hard to believe that engineers still cut shapes out of paper or plastic in this day of high-powered CAD systems, but a humongous amount of time and money can be saved by creating a mock-up. It's a great way to make sure that the flex circuit is long enough to reach all the places it's supposed to and has enough extra length to allow for easy assembly and disassembly.

FIGURE 1 and FIGURE 2 are from a flex design I recently worked on that illustrates this point perfectly. The engineer plotted the flex outline on clear plastic, cut up some old PCBs and rigid plastic and created a beautiful model of the circuit assembly. He discovered that while the shape looked perfect in his CAD model, there was not enough slack for inserting and removing the connectors. Worse yet, if there were any misalignment of the panel to the PCB, the flex circuit would be severely torqued and very likely tear. He then changed the path of the flex and added three inches of length, and now (Figure 2) the flex fits better and the connectors can be installed and removed reliably.

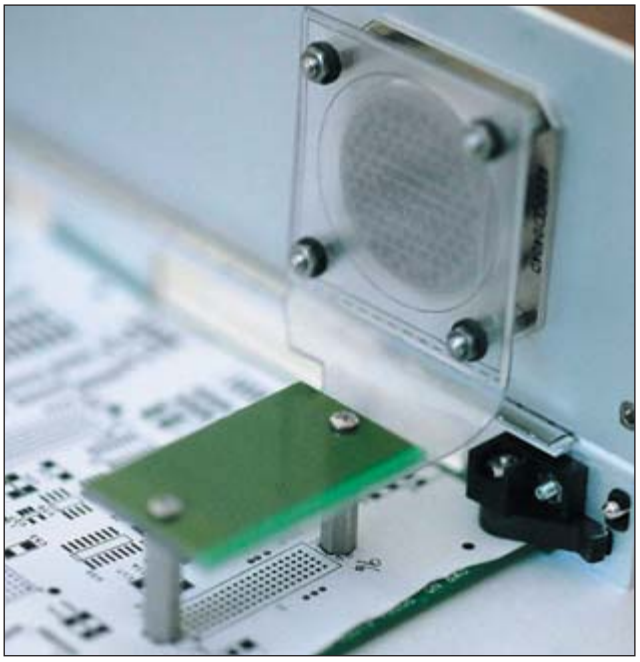

FIGURE 1. This "paper doll" mock-up shows the design as originally conveived ...

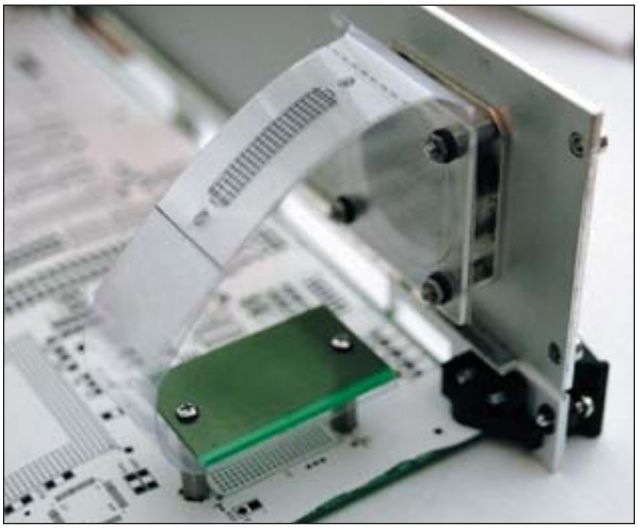

FIGURE 2. ... and the new, shape after modeling. Three inches were added to the total length.

I realize that models are hard to create if you are working on very tiny products. Just remember to consider the ergonomics of installation, misalignment and servicing as you create your flex design.

Another common area where first-timers go wrong is in the creation of pad patterns. Flex circuit pad patterns are usually larger than their rigid board counterparts to allow for things that are unique to flex manufacturing, such as adhesive "squeezeout," pad capture and cover film misregistration.

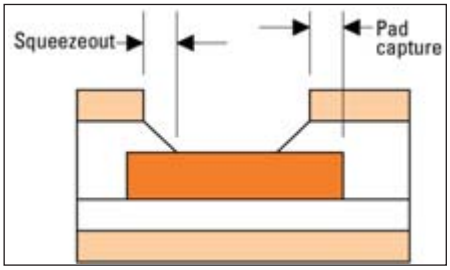

FIGURE 3. This edge view shows pad capture and adhesive squeezeout.

FIGURE 4. Photo shows a properly captured solder pad.

In a flex circuit, the copper trace is affixed to the base film by a layer of adhesive. At elevated temperatures this adhesive softens and loses bond strength. During the soldering process the adhesive can weaken to the point that solder pads lift away from the film. If this happens, the flex circuit is scrap. To prevent lifting, the pads are made larger so that they tuck up under the coverfilm on opposite ends. The distance the copper extends under the coverfilm is called pad capture.

When the coverfilm is laminated over the etched copper traces, the coverfilm adhesive layer flows out onto the exposed copper pad, thus reducing the amount of solderable area. This encroachment of the adhesive onto the copper pad is called squeezeout. **FIGURE 3** is an edge view of a surface mount pad showing both pad capture and squeezeout. **FIGURE 4** shows a solder pad on a flex circuit that is properly captured on both ends.

Properly created pad patterns for flex circuits are critical for high-yield flex assemblies. I have seen some PCB designers use a quick-and-dirty method in which they take a rigid PCB pad pattern for a component and "flip" the copper pad and the soldermask openings, making the coverfilm opening the size of the copper pad and the new copper pad the size of the soldermask opening.

But this method can lead to poor assembly yields because it does not account for adhesive squeezeout and coverfilm misregistration. **FIGURE 5** depicts a 14-pin SMT component mounted on flex, with a flipped pad pattern. Note that the solder pads are much too small; the assembly vendor had a very difficult time soldering this component to the flex. **FIGURE 6** shows the redesigned circuit with a proper flex circuit pad pattern. It uses large coverfilm openings instead of little individual openings, and this time the assembly vendor had no problem soldering the component to the flex circuit.

Unfortunately there is no published library of pad patterns for flex circuits. If you need help, contact the flex manufacturer or contract assembly vendor you intend to use for some guidance.

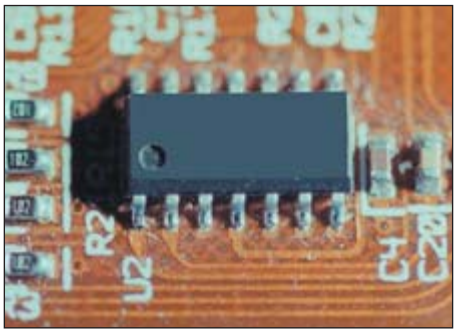

FIGURE 5. This is the result of a "flipped" rigid board pattern.

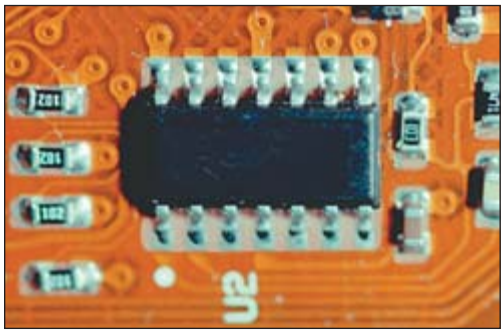

FIGURE 6. Photo shows a properly designed flex pad pattern.

Rigid-flex Design

Rigid-flex, the oxymoron of the flex world, is very popular these days. Once found exclusively in military and aerospace applications, rigid-flex circuits are now made by the tens of millions for cell phones and digital cameras. These commercial rigid-flex circuits are very simple in construction, usually no more than two circuit layers in the flexible sections and four layers in the multilayer rigid sections.

From a design standpoint, I find a rigid-flex circuit is easier to design than a "pure" flex circuit. While you still have to follow good flex design practices on the flex circuit layers, the issues of squeezeout and coverfilm misregistration go away, and the pad patterns are the same as those used in rigid PCB design.

While it is possible to have rigid sections with different layer counts and thicknesses, it is important that all the multilayer rigid sections have the same construction for high-volume, commercial rigid-flex circuits. Different layer counts and thicknesses in the rigid sections will seriously complicate the manufacturing process and increase cost. Circuits with dissimilar layer counts are more typically found in low-volume applications such as military, aerospace or other high-reliability applications.

It's important to pay attention to the area where the transition is made from flex to multilayer rigid construction. Rather than have coverfilm material extend completely through the entire circuit, manufacturers prefer to use what's called a "bikini" coverfilm. Just as a bikini swimsuit only covers the essentials, the bikini coverfilm extends just far enough into the multilayer area to provide reliable adhesion. The prepreg sheet is pre-cut to nest with the coverfilm. FIGURE 7 shows how the coverfilm layer barely encroaches into the multilayer section, being replaced by prepreg in the rigid area.

Why is this bikini coverfilm/prepreg construction important? Well, combined with an adhesiveless base flex material, this construction makes the plated holes more reliable, because now there is no adhesive in the multilayer stackup – the vias are more likely to survive temperature cycling.

More importantly, the designer must make sure that no vias are placed in this area. As shown in Figure 7, the plated holes should be far enough away from the transition area so that they don't travel through the coverfilm. The distance that the coverfilm extends into the multilayer area varies with different manufacturers, but a good rule of thumb is to place via pads no closer than within .050″ from the edge of the multilayer area. PCD&M

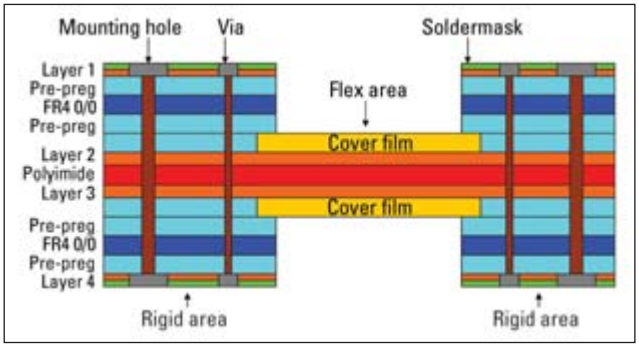

FIGURE 7. Four-layer rigid-flex is shown with "bikini" coverfilm. (Courtesy of Victor Llanes at Tyco Santa Clara.)

TOM WOZNICKI is president of Flex Circuit Design Co., an engineering consulting company that specializes in designing flex circuits. He also publishes *The Flex Circuit News,* an industry newsletter about the flex circuit industry, available at www.flexdude.com. Woznicki can be reached at Tom@Flexdude.com; 408-629-8343.