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Success Through Failures, p. 18

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Unsupported Fingers

Three primary methods can be used, each with its pros and cons.

THE QUESTION FOR this month's column came from a conference call for an upcoming revision of IPC-2223, the flex circuit design standard. The discussion centered on sculptured conductors versus other methods of manufacturing unsupported fingers. It was soon apparent that many of the participants were not entirely clear on the differences among the variations. If there is confusion on this type of design from those who are fluent with flex circuitry, I have to believe that designers with less familiarity are even more stumped. This month I discuss the general concept of unsupported fingers, methods of manufacturing, and pros and cons of each flavor.

To begin, let's review the general concept of unsupported fingers and the manufacturing methods used to create these circuits. An unsupported finger is a feature unique to flex circuitry. FIGURE 1 shows a flex circuit with unsupported copper fingers extending beyond the dielectric materials. These fingers can be used flat or formed, and can be soldered into plated through-holes or hot bar-soldered to a matching conductor pattern on a rigid PCB. There are three distinct manufacturing methods used to construct these circuits.

Method 1. The first method is to use pre-punched or laser-ablated widows in base and cover dielectrics. While the manufacturing processes are different for these two variations, the net result is the same. The oldest method of fabricating this variation is by pre-punching windows in the base dielectric prior to laminating copper foil. Identical openings are also punched in the top covers. After the circuitry is etched and covers laminated in place, any conductor crossing a window area will be unsupported.

The other way to construct this variant is to build the circuit as a normal flex, then laser-ablate the dielectric material from the window areas on both sides of the circuit, thereby leaving unsupported conductors. This type of circuit is the most cost-effective to manufacture, but can be a nightmare to ship, handle and assemble. Because the unsupported conductors will be the same thickness as the rest of the circuit (usually 1 or 2 oz.), they will be extremely fragile and easy to break. Designers will usually specify a "tie bar" of dielectric material be left along the outside end of the unsupported conductors. This tie bar will act to keep off the fingers aligned, and can be removed or left in place after connecting to the PCB. The most common method of connecting this type of circuit to a PCB is lap soldering to a matching conductor pattern on a PCB. It is imperative that the soldered area be over-coated with an epoxy because any mechanical force exerted on the circuit once soldered will break the fragile unsupported conductors.

Method 2. The second method for constructing this type of circuit is called sculpturing (shown in Figure 1). In this method, the manufacturer will start with a thick sheet of plain copper (typically 10 mil one-quarter or one-half hard copper). The copper sheet is selectively surface-etched to reduce the copper thickness by approximately 80% everywhere except the finger areas. The finger areas will remain full thickness. The balance of the processing is very similar to Method 1. The areas of the circuit that need to flex will be about 2 mils thick, but the fingers will be 10 mils thick, making them stronger than the first version. The downside is that the copper in the areas that need to flex will be one-fourth or half-hard rather than fully annealed. Using this type of copper will make the unsupported fingers stronger, but the circuit will not be able to withstand flexing, as well as one constructed from fully annealed copper. While the fingers in a sculptured circuit will be more robust than fingers made from 1 or 2 oz. copper, they will still be fragile and can be damaged easily if not handled properly.

FIGURE 1. A typical flex with sculptured fingers. Fingers can be supplied flat or formed (as shown).

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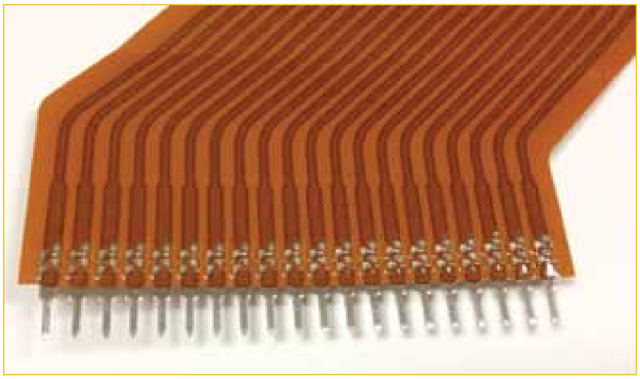

FIGURE 2. Insulation displacement contacts as shown above can offer a robust unsupported conductor in many available pin styles.

Method 3. The final method of creating unsupported conductors involves adding fingers constructed from material such as nickel or full hard copper, and then welding or brazing the fingers to the flexible PCB. With this method, the circuitry is processed normally through etching, at which time windows are punched in the areas that will have the unsupported conductors. The fingers or tabs are then attached by welding or brazing the fingers to the matching pattern on the flex PCB. The balance of the processing is standard. This results in a flex circuit with fully annealed copper in the flexible areas and rigid fingers extending from the edge of the circuit. While this construction is the most robust of the three, it is also significantly more expensive and far from bulletproof when it comes to handling and assembly.

I would be remiss if I did not also discuss a variation on this theme that is well-established and popular. In this variation, insulation displacement contacts are crimped to the flex circuit at the very end of the fabrication. Insulation displacement contacts are very robust and tolerate handling better than any of the aforementioned types. They are also available from multiple vendors and can be ordered in a wide variety of terminal styles (FIGURE 2). The downside is that they add cost and limit contact pitch.

Assembling to a rigid PCB. The most common methods of joining the circuits described above with a rigid PCB are lap or through-hole soldering. Lap soldering can be accomplished either by hand or with a hot bar process. Unsupported fingers are simply positioned over a matching conductor pattern on a rigid PCB and then soldered individually (when done by hand) or all at one time (hot bar). When connecting flex to rigid using through-holes, the unsupported fingers are inserted into the matching hole pattern on the rigid PCB and soldered in place.

Each of these variations has its pros and cons, and designers should carefully weigh cost versus performance issues. As always, it is a good idea to discuss the options with your flex manufacturer. PCD&F