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November 2007

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CIRCUITREE MAGAZINE

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A bnp media PUBLICATION

By Mark Finstad

Improving Flexibility With Cross Hatching

Q: ***I've heard that cross hatching plane layers on a flex circuit can improve flexibility. Is this true, and how much more flexible will the circuit become if I use cross hatching?***

A: The amount of flexibility gained when cross hatching planes is directly related to the percentage of copper removed. For instance, if your application has four conductive layers and only one plane, and the cross hatch pattern is only removing 30 percent of the copper on the plane layer, there will be very little flexibility gain. However, if you have several planes that are going to be cross hatched, and the hatch pattern removes 70 percent of the copper in those planes, there will be a noticeable improvement in flexibility. There are other concerns that must be weighed before specifying a cross hatch plane on a flex circuit. If your application requires impedance control, the cross hatch plane will have a significant impact on the impedance value. Without going through all of the gory impedance formulas and calculations, know that impedance is directly affected by the capacitance that is created between the transmission line and its return path (the copper plane). As capacitance decreases, impedance increases. Because capacitance is driven by the area and distance between the two conductors, decreasing the amount of copper in the return path (cross hatched plane) decreases the capacitance. This serves to increase the characteristic impedance of the transmission line. Sounds like a great way to increase impedance without making the flex circuit any thicker, right? Not really. First, we are not aware of an impedance calculator that takes into account a cross hatched plane. All assume a solid fill on plane layers. The reason is that, for the most part, only the flex circuit industry uses cross hatched planes. This is done almost exclusively to make a flex circuit more flexible. Rigid PCB users are not concerned with flexibility, so there is no reason to use anything but a solid shield. While the flex circuit industry is growing, it still does not represent a large enough market for anyone to do the monumental amount of testing required to develop a calculator that includes a variable for cross hatched planes. Also, the path the transmission line follows under the cross hatch pattern can vary wildly depending on the pattern and orientation. Two conductors running side by side may have significantly different characteristic impedances depending on how much of the plane copper they can couple. It would be virtually impossible to include all of the possible variations of cross hatch patterns and signal trace orientations in an impedance calculator program. If you believe your design may be too stiff to function properly, and you have impedance control issues, you may need to consider selectively bonding substrates in the flexing area. Selectively bonding—or "unbonding" portions of the flexing area—will have a much bigger impact on the flexibility than a cross hatch plane. Remember, when a selectively bonded circuit is flexed, the unbonded areas will buckle, creating a space between substrates. Therefore, the designer must carefully select which substrates will be unbonded to ensure that all signal and return path planes are bonded to each other. If a signal layer is not bonded to its plane layer(s), the space created when the circuit buckles will result in an impedance mismatch in that area. When done properly, selective bonding can significantly increase flexibility without affecting electrical performance.

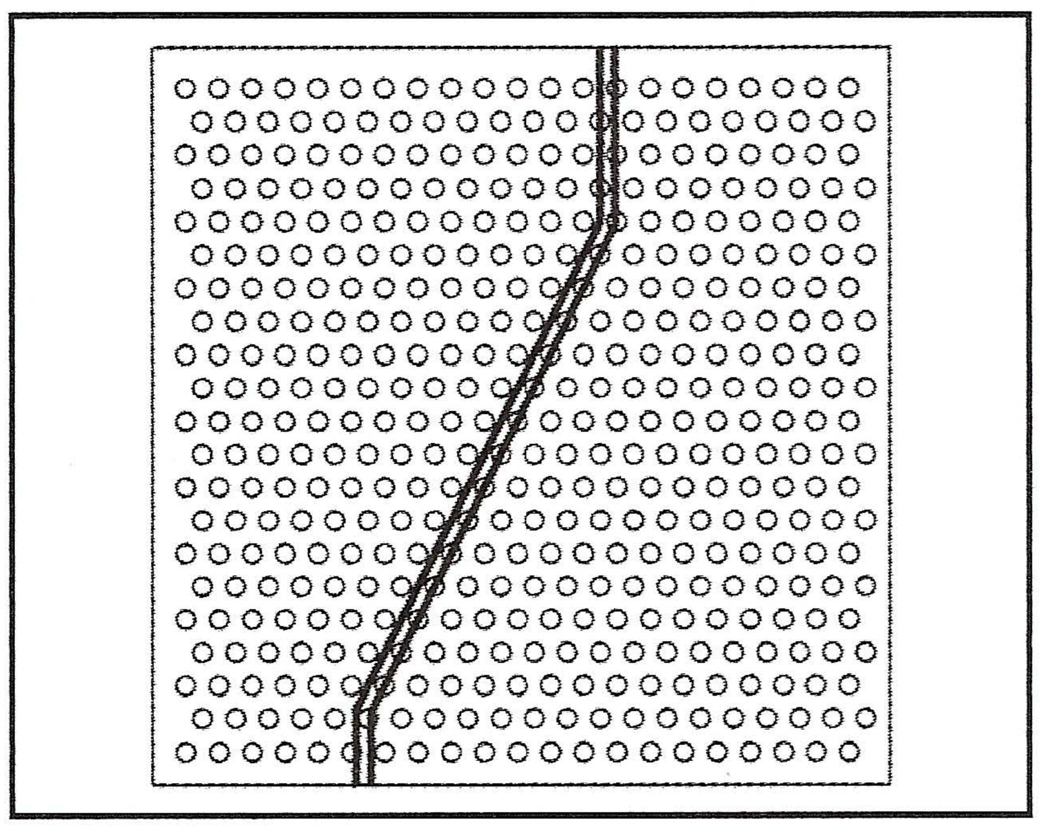

Figure 1 Plane Layer Hatched With Dot Pattern. Left Trace Has Nearly Uninterrupted Coverage By the Plane Because of Its Path Between the Holes in the Plane. Although the Right Trace Runs Immediately Adjacent to the Left Trace, There Are Numerous Discontinuities Along Its Path As It Crosses Under the Holes in the Plane

If your planes are only used as a return path for slower signals or for noise control, cross hatching alone can be used effectively to increase flexibility. There are other benefits to using a cross hatch pattern on plane layers. While it may not have a huge effect on the flexibility of the circuit, it may have a big impact on how the circuit performs when bent or flexed. The neutral bending axis of the circuit (the region of the circuit that does not experience stretching or compressing forces) tends to shift toward a solid plane because a solid plane resists these forces more than most other materials in the circuit. A significant shift in the neutral axis can cause undue stress on fragile conductors on the outside of sharp bends. A cross hatched plane with 30 percent or more of the copper removed will act more like a normal trace layer when the circuit is formed. By reducing or eliminating the neutral axis shift associated with a solid plane, you can make your circuit more tolerant to bending and flexing. If flexibility is key, you may also want to consider a screened conductive epoxy as your shield layer. While this can significantly increase flexibility, it does increase cost.

Remember that hatching reduces the shielding effect and that, depending on the size of the hatch openings and the operating frequency (or circuit sensitivity), it may open the door to some EMI concerns. It is not likely to be a big concern for most applications today, but as frequencies continue to rise, it might be worth keeping an eye out for the effect to surface at some point.

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