Intelligent Design
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Lee throws down the gauntlet to laminate manufacturers: come up with a weave style that eliminates the non-uniformity in glass cloth. Can it be done?

Bridging the Gap: A Challenge to Laminate Manufacturers

For most of the history of PCB material, concerns have focused on low cost, impedance and the ability of materials to withstand soldering and rework temperatures.

With the advent of gigabit and higher data rates, processors with clocks over 1GHz and rise times faster than 200 picoseconds (which are the characteristics of almost any modern electronic product), concentrating on the afore-mentioned material concerns is not enough.

With very high data rates, the frequency dependent nature of dielectrics and traces has begun to play a major role in the quality of signals that are delivered. The three pieces of the puzzle are:

- 1. The quality of the copper.
- 2. The quality of the resin system.
- 3. The quality of weave of the glass cloth.

It has been shown that the roughness of the finish of the copper foil has a direct effect on losses such as skin effect loss. In order to make the copper adhere well to the resin, the usual approach has been to make the copper very rough. This in turn leads to very high skin effect loss. Experienced fabricators have found a way to bond copper to resin without making the surface rough (a detailed description of this solution can be found in two articles: "The State of Copper," Hilburn, Wang, Clouser and Bergstresser, PCD&M, May 2005; "Non-Classical Conductor Losses Due to Copper Foil Roughness and Treatment," Brist, Hall, Clouser and Liang, CircuiTree, May, 2005). Going forward, the solution described in these two articles needs to become the industry standard.

The loss in the dielectric used to build a board can also play a major role in transmission signal quality. This too has been documented in a number of places (including the book published by Speeding Edge, Right The First Time, A Practical Handbook on High Speed PCB and System Design). The longer the signal path gets, the worse the problem becomes and the higher the frequency of the signal, the larger the losses are.

This problem has been dealt with in two ways. Manufacturers of resin systems have developed resin formulations that are low in loss and they

have also used a variety of fillers in the resin systems that further reduce the loss. In one special case, a laminate manufacturer has gone one step further by using a specially formulated glass in the cloth that has a lower loss. (The problem with this solution is that it is a single-sourced item.) These approaches have helped but for very high data rates this is still not enough.

Even when loss has been lowered with the foregoing methods there is one more trick needed. Electronic pre-emphasis can make up for high frequency losses. In electronic pre-emphasis, as new data bits are sent down a line, the first bit is made larger than the ones that follow and this has the effect of adding back some of the high frequencies that are lost in the dielectric.

In the case of very high data rate paths, all of the above elements--low loss resin formulations; varieties of fillers and electronic pre-emphasis--are required. But, many times when all of these elements have been incorporated into a design, there still remains one more electronic hurdle--excessive jitter. This problem is traceable to the glass weave used in laminates. And, it is the most elusive problem to solve. The phenomenon at work is that glass is woven from threads and as the signal travels across the surface, sometimes it will travel on top of one thread and sometimes it travels between two threads. This results in substantial variation in dielectric constant. This translates into large variations in impedance as well as velocity. The result is jitter and ISI (Intersymbol interference). This problem has been studied and presentations about it have been made (see "The Impact of PCB Laminate Weave on The Electrical Performance of Differential Signaling at Multi-gigabit Data Rates," McMorrow and Heard, DesignCon 2005 proceedings).

There are two approaches to deal with the glass weave problem. The extreme solution is to use laminate that has no glass cloth in it. The problem is that when trying to make large, high layer count boards, with laminate that has no glass cloth in it, there are dimensional stability problems. So for large PCBs, like those used in big Internet products, the problem has to be solved using glass cloth. And, that is the purpose of this column. I want to challenge the laminate manufacturers to come up with a weave style that eliminates the non-uniformity in glass cloth. Until such a product exists, the industry at large will continue to have problems in producing the stable, electronically reliable high-speed boards that we all need. CT

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