UltraCAD Design, Inc.

DESIGN NOTE

TOOLS AND MODELS

We are strong advocates of the use of tools and advanced modeling software as aids in any design process. But we also believe that the tools are only as good as the people using them. We become concerned when we hear people (and even some salespeople) suggest that a new tool can solve, by itself, some difficult problems. And we respectfully point out that throughout history capable people have been able to solve some very difficult problems with some very rudimentary tools! This note summarizes our concerns about some people's reactions to the new modeling tools and our recommendations for how to proceed with your design process with maximum success.

TOOLS VS OPERATORS: I have a consultant friend who teaches people to be better managers through better mental preparedness. He provides immediate credibility for his seminars by using the very same techniques to teach these same managers how to play better golf. He, himself, plays with the worst clubs imaginable --- hardly any two clubs in his bag match and his set is not complete --- yet he holds and plays to a three handicap! He is living proof of the adage that IT AIN'T THE TOOLS, IT'S THE OPERATOR!

A skilled carpenter can frame a house better and faster with a hammer and hand saw than can an inexperienced person with a radial arm saw and a stable full of power tools. IT AIN'T THE TOOLS, IT'S THE OPERATOR!

Sometimes people ask us why we use the particular design system we use. It's not facetious to say that the answer is "Because we always have." There are several excellent design systems available today. But we are good at what we do --- not because we use a particularly good design system (which, of course, we do) --- but because we have assembled a team of exceptional design system OPERATORS who know how to use the tools that are available. They would be good on any system.

So we become concerned when people begin talking as if the TOOLS can solve problems.

NEW MODELING TOOLS: Some people have recently begun asking us about some of the several, good, analytical and modeling tools that have become available. Some of these tools are excellent. And we, as a company, are strong proponents of **any** tool that helps people do their job better. But some people talk as if the TOOLS themselves will SOLVE their EMI/RFI and critical timing problems. The purpose of this Note is to help put some issues into perspective.

OUR CONCERN about the potential weaknesses of some of these tools lies in two areas. First, they may not be able to bring into consideration and discriminate between the creative intelligence that a good designer uses and true design faults. And secondly, they necessarily depend on formulas, some of which are so complex that their very complexity disguises their most troublesome weakness --- their significant sensitivity to parameters that are usually not controlled very well.

DESIGNER CREATIVITY: Consider the situation where the designer intentionally places two traces close together because he knows that in the application (a) signals cannot be present on both traces at the same time, or even (b) he knows that when one trace is active the other is held at ground through a low impedance gate. Will the modeling software inaccurately say that there is a cross-talk *problem* because these traces are too close together, or will it identify the fact that the designer used good creativity in *optimizing* his design? (The salesman's answer is, "Well you can always tell the model about these special cases." But the value of a tool is in *its* telling *you* what you *don't know*, not in *you* telling *it* what you already *do know*!)

FORMULA COMPLEXITY --- Z_O: The sales promotion for the modeling software often emphasizes control over impedance, even to the point of accounting for the minute edge effects on traces. But consider the following. On a 12 in. trace, 8 mils wide and 1 mil thick in FR-4 microstrip, the intrinsic impedance will change by:

- .4 Ω for every .1 mil in width
- .5 Ω for every .1 mil in thickness, but
- .7 Ω for an uncertainty of ε_r of just +/- .1, and a whopping
- 1.6 Ω for **each** pf by which logic gates on the trace are mis-characterized.

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FORMULA COMPLEXITY --- T_{pd}: The rule of thumb is that the propagation time for a 12 in. trace in FR-4 microstrip is 2.0 nsec. A good designer can easily trim that to within +/- .01 in, or 1.6 Psecs! But if the anticipated ε_r is off by .2 (from 4.0 to 4.2), the trace propagation time will change by 50 Psecs ----- 30 TIMES more error from ε_r uncertainty than from our ability to trim the trace!

BY FAR the **greatest source of error** in these models is the imprecise quantification of ε_r and the ability to **exactly** characterize the devices that will be used along the line. The fundamental problem in the designer's ability to "hit" Z_0 or to trim propagation delay is in the board fabricators' inability to specify ahead of time --- WITH PRECISION --- what the board's technical parameters will be. Then, add to this some other considerations: Most always (there are a very few exceptions) it is not the absolute magnitude of Z that is important anyway. Devices are relatively tolerant of the absolute value of the intrinsic impedance. And circuit designers often select line matching and termination resisters at the prototype stage. What is REALLY important is that Z, and relative propagation time, --- **and therefore ε_r** --- remain CONSTANT at whatever it is as a trace moves around the board and between layers.

BEST STRATEGY: If you are concerned enough about your design to justify the purchase of, and training required for, some of the new analytical models, you should **ALSO** put the best board fabricator around on your team from the beginning. Since their ANSWERS ARE PART OF THE DESIGN PROCESS, don't wait until the end of the process to talk with them! But choose wisely! We routinely talk to fabricators about impedance control and propagation time issues, and are saddened by the fact that 80% don't even understand the questions! It is the rare house that can talk intelligently about these issues, and then DELIVER on them.

The best results are obtained when customers commit to a **team** (customer, designer, and board house) **up front**, and then the three team members work through the design together. Some customers fear that this will lead to higher prices; and the prices will be higher than the "low bid." Unless, of course, you consider TOTAL COST, the **benefits** from the finest design possible, and the pleasure of getting it right the first time.

Note: This note was written by, and reflects the views of, Doug Brooks, President of *UltraCAD*. Brooks has 29 years experience in high technology industries and has a Master's Degree in Electronics from Stanford University.