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Success Requires Both Knowledge and Experience

Gary Breed
Editorial Director

From time to time I get the same interesting question from a younger engineer. It gets asked many different ways, but it's usually something like, "How does [insert a senior engineer's name here] know how to [insert design task here] off the top of his head, without any math?" The follow-up is usually, "How long will it take before I can do that, too?" My answer is always, "It depends," and I continue to explain why the answer isn't so easy.

First, like all things in life, there is no substitute for making mistakes, repeating them a few times, then finally learning not to repeat them. With engineering, this eliminates many wrong answers to a design problem, dramatically shortening the time it takes to find the right answer. This process of trial-and-error...and more error...takes time, but all of us eventually benefit from such lessons (some more than others, of course!).

Sometimes the question is prefaced with, "I was a straight-A student and had a really solid Senior Project [or Master's Thesis topic]." This is when I explain why engineering at high frequencies is unique, and that an intuitive understanding is every bit as essential as the ability to analyze a problem and solve the design equations. I also like to stress that the best way to acquire an intuitive understanding is *hands-on*. Build things. Learn to solder. Adjust pots and trimmers. Make something you can use personally. Do a science project with your kids (or a niece, nephew or the neighbor's kids). In short, live with the technology in a way that is completely down-to-earth.

Since I am a firm believer in what I just wrote, it may be a surprise when I say that some of the hands-on work can be accomplished at the computer keyboard, by exploring simulation. The EDA tools we have now are good enough to partially replace a breadboard. You can tune, rearrange, and play with component values and different circuit topologies and see what happens. Just remember that you will need a whole different mind set than just picking a common circuit layout and invoking the "OPTIMIZE" command. Don't forget that engineers design, computers just compute. Many of the things you are doing at the computer were done years ago with hand calculations, maybe a slide rule. They can still be done that way, when you have the experience.

Now, back to the "building things" approach. Why is this so important?

One reason is that it is, in today's terminology, *multi-media*. It has been proven that we learn better and retain knowledge longer if it is reinforced with several of the senses. For example, anyone can cook up a recipe out of a cookbook, but a great chef can turn it into a masterpiece because he or she can smell the aromas, feel the textures, see the colors and hear the sizzle of the ingredients—and knows what each one means.

It's really not much different with engineering design. We just have different recipes and a different package of ingredients to choose from!

The Flip Side

If experience is so great, why do some engineers never achieve the level of others? It would be easy to say that all minds are not created equal, but there is usually more to the story. Sometimes the difference between excellence and mediocrity is intelligence, or even ambition, but more often it is the "fun factor." (If you're having fun, you're probably going to do a better job.)

The principles that govern circuits and systems at high frequencies are unique. Frequency dependent effects, transmission line behavior, radiation, and generally imperfect components make high frequency engineering a challenging, but always interesting job.

After gaining some experience and getting exposure to other specialization areas in electronics, most RF/microwave/lightwave engineers realize that they are different. Few other disciplines require the same combination of book knowledge and hands-on experience. There is still plenty of what looks like "black magic" to the rest of the engineering community.

And that's fun!

(Don't forget — February is Engineering Month)

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