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Which Comes First, the Simulation or the Real Circuit?

Gary Breed
Editorial Director

Consider this: "...a senior in a well-funded EE program: he knows exactly what he's doing because he's learned all of the accepted ways to solve the assigned problems; and he has a lab full of expensive measurement equipment and a computer full of expensive software. Even the hardware he builds by soldering parts on a PC board has been carefully designed (often by the unsung hero of engineering education—the department engineer) so that the measurements and simulations agree. What happens when he graduates?

1. All that expensive stuff stays at the university so he loses all his tools.
2. The first circuit he tries to design doesn't behave the way the simulator said it would."

This is just one of several observations made in a recent note I received from Dr. Rick Campbell. Rick is a Principal Engineer in the Advanced Development Group at Cascade Microtech, which has loaned him out for a few hours a week as Adjunct Professor at Portland State University. He is teaching Microwave Engineering and developing a High Frequency Electronics program (his terminology, not mine!).

So, what is Rick's approach to remedy the situation he describes above? Make the students build stuff—from scratch—by soldering components to each other and to an unetched circuit board ground plane (aka "ugly construction"). Then the problem-solving process begins. According to Rick, you "...get it working, measure it, and then see if you can get the simulator to agree with your measurement. The hardware is working reality (even when it doesn't work, it's real), the simulation is the experiment."

I've always been a proponent of hands-on learning, but Rick finally expressed the concept in a way that should make sense to any engineer: the circuit is what's real; the simulation is its virtual representation. It is not the other way around, although many (most?) engineers try to reverse the procedure, attempting make the circuit match the simulation—which is usually an exercise in futility.

OK, not always futility. After gaining lots of experience, both hands-on and virtual, an engineer can minimize the differences between simulation and hardware. At some point, you call it "close enough" and move on to the next step. This is why advanced EDA tool suppliers have created methods for replacing part of a simulated system with the measured data obtained from its real hardware.

There is a lot more to Rick's ideas for teaching RF design and he promises to write an article for a future issue of *High Frequency Electronics*.

Changes in the Profession

Why is it necessary to re-think how engineers are taught? At the core, RF engineering is no different than in the past (I use "RF" as a blanket term to cover all high frequency effects). But even though the principles are the same, the working environment of the engineer is very different today.

- There is more multi-tasking and integration with other branches of design. This represents a broader approach to design that includes circuits, systems, manufacturing, test—even field installation, testing and repair.
- Increasingly, circuit engineering has extended into both the "micro" and "macro" realms—a few electrons at a semiconductor junction affects the bit-error-rate on a trans-Pacific fiber optic cable! And many "components" are not assembled on a pc board, but laid down on the wafer during a chip's fabrication process.
- Compliance with system specifications has become more important, with most high-volume product design driven by standards for the various wireless systems. Often, those systems rely on a level of performance and reliability that has only recently become part of consumer electronics.
- The EDA tools that support modern design are complex and powerful. It is easy to understand why an engineer is willing to let the software do the design. After all, those tools have "bottled" a lot of engineering talent and made it accessible to all users.

All these things have added to the scope of an engineer's work. Sure, there are specialists who are expert in the various specific areas, but some degree of competence is required in more areas than ever. This can foster greater interest in an engineer's job if he or she is stimulated by the challenge. It can also be daunting, especially to a student or a new engineer.

Ultimately, the job (and the joy) of engineering is all about building things, whether as a student in the lab or as a seasoned engineer on a major project. Rick has it right—engineering education should begin by building something!

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