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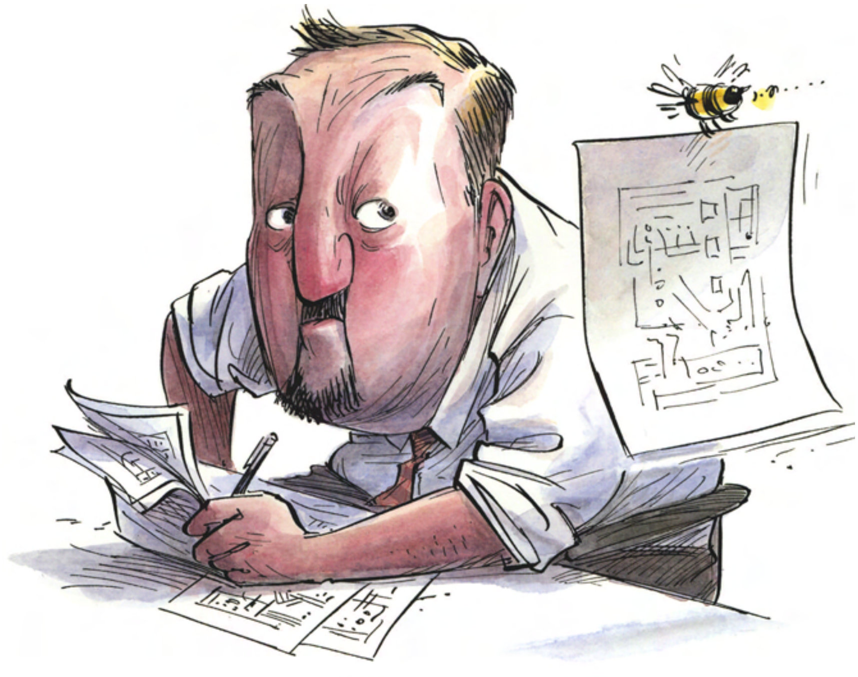
Sting like a bee



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As a design engineer some years ago, I "inherited" a design that was moving from the realm of university research into commercial production. The design worked on paper, but I had an inkling that it wouldn't work in the real world. The objective was to measure the surface charge of an electret. The method of accomplishing this goal was to place the electret a small distance from a capacitive plate that connected to a standard integrator. As the plate charged up, the integral of the required current would be proportional to the surface voltage. This idea is simple, but any stray leakage would scuttle the circuit.

Before handing off the design to me, its designer had demonstrated it as workable. I was naive enough to not ask any questions, and we went into production. Although there were some minor problems, the production units seemed to perform well enough that the design remained in place for almost 20 years. So, like the bumble bee that doesn't know it can't fly but continues to do it, this circuit didn't know it shouldn't work but kept on going.

With the passing of time, it became necessary to change manufacturers. I was no longer with that company but now on my own, and the company asked me to assist in updating the design. With some trepidation about the change, I forged ahead and breathed a sigh of relief when the new units performed slightly better than the original. I didn't understand why but was willing to accept it.

For various reasons, it was necessary to change the PCB (printed-circuit-board) fabricator. I didn't anticipate any changes, but my heart sank when all of the first five boards failed the basic tests. The only indication I had was that the leakage was too high.

After much thought and some trial and error, I determined that the preimpregnated PCB material itself might be the culprit. Some basic research showed that all the manufacturer had specified was that it should be FR (fiberglass-reinforced)-4. Some phone calls and e-mails led to the specifications for the material the manufacturer used in this batch. At 7×10^7-MΩ/cm volume resistivity, this batch was within specification. At this point, I questioned whether I was looking at the right figure and asked whether I could measure this parameter in a working system.

Because the design is a simple integrator, observing the discharge rate of the capacitor allowed me to deduce the total leakage for the circuit, a portion of which would be due to the volume resistivity of the board. Measuring a good board, I saw that the total leakage was on the order of 10^6 MΩ. Using one of the failing boards, I measured slightly less than 10^5 MΩ. This finding supported the idea that I was on the right track.

After some research, I found that a minimum required volume resistivity was 10^8 MΩ. Knowing this fact, I asked the PCB fabricator to make a new batch of boards. I was greatly relieved when the boards performed as I expected. PCB requirements now have a line that stipulates the minimum volume resistivity for the material!

Two key lessons for me emerged during this exercise: First, challenge the assumptions. The manufacturer assumed that a specification of FR-4 was sufficient. It turned out that the manufacturers had for all these years unknowingly exceeded the specifications and thus met the unstated requirement. Second, even though it may be essentially a dc circuit, a PCB is more than a holder of the components. It is a component in itself. EDN

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