Testing our reliance on testing

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In the late 1980s, my company was in the market for its first CAE (computer-aided-engineering) system. Because we did a lot of mixed-signal design, we were particularly interested in being able to simulate those kinds of circuits. We developed a series of benchmark tests that included pure-digital circuits, pure-analog circuits, and one mixed-signal circuit. We based all of these circuits on real-life designs that we had recently worked with.

We were particularly careful when choosing the mixed-signal circuit. We wanted to have a realistic test but one that would also challenge the simulator. The circuit we chose, a microprocessor-controlled 4- to 20-mA converter, was ideal. We had thoroughly wrung out the design, through both analysis and testing, so we knew exactly how it worked. The circuit was in production and working flawlessly. We could control the simulations to drive the simulator to any circuit condition we wanted. We could control data to check response times and compare transient responses between the simulation and the real world. My team was ready for anything!

The first companies to get our test-bench couldn't even begin to simulate the mixed-signal circuit. The output never got close to 20 mA. We gave each other smug looks and muttered: "Another case of marketing hype."

The last company to get the circuit was having trouble, too. The company's field-applications engineer called us up one day to talk about his problems.

"You say this is a working design?" he asked.

"Yes," we replied. "It is in production and working perfectly."

"Well, my simulations can't get the circuit to drive up to 20 mA; it stops well below that." Again, my team members and I gave each other knowing looks. "But, when I changed the op-amp model from worst case to nominal, it started working." You could hear a pin drop in the room.

It turns out that the simulator's model assumed a worst-case supply-rail-to-output drop, resulting in less output swing than we needed. That worst-case drop prevented a pass transistor from fully turning on. Our vaunted circuit design was a dud! Despite exhaustive testing, we had never encountered an op amp with that much output drop. The analysis had missed it. It turns out that the designer felt that a worst-case analysis of the circuit was too difficult, so he ran "lots of tests." This situation was another example of why not to rely on testing to determine a design's limits: You will rarely encounter worst-case parts.

Epilogue: We quietly implemented an engineering-change notice to change resistor values in the circuit so that it would work at worst-case conditions. We also bought that company's simulator and showed the designer how to run worst-case and Monte Carlo analyses. EDN

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