print | close

Factor Time And Money Before Using A Simulator

Electronic Design
Jerry Twomey
Jerry Twomey, Contributing Technical Expert
Fri, 2014-05-02 16:18

Anyone who has been a regular reader of *Electronic Design* over the years knows that when it comes to simulation, the late Bob Pease believed that Spice lies *(see "What's All This Spicey Stuff, Anyhow? (Part 1)")*. He also felt that the most reliable way to get a working device was to actually build the circuit.

In addition, many designers have successfully spent a lot of effort earning their existence while pumping out a multitude of chips that were entirely designed and developed on a simulator and never touched a soldering iron in the process *(see "Simulation Vs. Silicon: Avoid Costly Mistakes With Accurate Models")*.

You can do many things to help you get reasonably good simulation results that correlate pretty closely to real-world devices. Remember, though, that the simulation results are only as good as the model being simulated. Garbage in yields garbage out. It really is that simple. Anybody can produce nonsense results with a simulator.

Related Articles

- What's All This Spicey Stuff, Anyhow? (Part II)
- What's All This Spicey Stuff, Anyhow? (Part 2.5)
- What's The Difference Between Pre-Layout And Post-Layout Simulation?

For example, you could get perfect current and voltage sources that can produce megawatts without a blink. Or, you could produce the ideal op amp with perfect common-mode rejection of a 1000-V common-mode signal, with no offset or additive noise. Or, my favorite, you could put three logic inverters in a closed loop for a circuit that does not oscillate. The misleading and incorrect results you can create with a simulator are pretty much infinite.

In all of these examples, you can point at something in the model that is assumed to be but in reality is not. Does Spice lie? No. You just have to be very careful about the questions you ask and look at the answers with a skeptical mind. Spice is like a clever lawyer who only answers the question you ask and does not point out that it might not be the right question to ask. When you create your simulation model, then, assume nothing and include a complete set of questions, limitations, and conditionals in your model.

Smart Planning

Most simulators provide a ready collection of ideal devices, none of which exist in reality. Everything has impedance, parasitic coupling, variance, limitations, and non-ideal characteristics. Without those, you can quickly dig a fantasy hole and watch all kinds of interesting events as people jump in, venture capital dumps in money, and the inevitable happens.

"Well, the simulations worked" seems to be the final line of defense for a failed design. Personally, I don't want to say "I told you so" at the end. I would rather get a design team to realize what the limitations are and account for them in the design cycle. However, I must confess a bit of smug satisfaction in seeing some inflated egos deflated like a popped balloon when silicon is turned on for the first time.

Simulated designs have a long history of success as well. Modern EDA and IC design lives and dies through the use of simulators to get products out. The early days of semiconductor design used a large amount of breadboard development, building the devices up at the discrete component level and then transferring the designs onto a chip.

Today with the complexity of designs with low-power and high-frequency needs, the breadboard method is largely dead, since the complexity or board-level parasitics aren't comparable to an integrated device. Anybody who thinks they can design and build an RF front end on a board and then get comparable results in a chip is in for a rude awakening.

However, a capable RF IC designer can create a complete model on a simulator and get similar results when the chip comes back from the wafer foundry. The "complete model" includes a huge effort associated with semiconductor models, corner simulations, layout parasitic extraction, Monte Carlo testing of process variance, package/port models, and many other factors.

What about a board-level design? Is there a need to simulate there? Generally, no. I'm now wrapping up a rather complex board-level design with a lot of analog, mixed-signal controls, and power conversion circuitry. Certain things have never been done before, so I needed to do some transistor-level design on the printed-circuit board (PCB) as well, so it's not all module assembly. For this, my design tools never included a simulator or designing a Spice model. Instead, my approach is a pad of paper and a calculator.

For the devices being used, I need the design specifications, any available application notes, and some basic math. Most of the math will involve things like signal amplitudes, device gains, approximate bandwidths, RC time constants, and the expected power consumption issues of selected power path components. There's no need to waste time putting this on a simulator. When I have a PCB, I will adjust some values in the lab and it should be good to go. Knock on wood, right?

Time And Money

Why the two distinctly different approaches? It largely comes down to time and money. Nothing technical steers the two different approaches here. Let's take an example and put some numbers on it to see why each method is valuable in its own right.

First, let's take the case of an IC design. The complexity of a chip can vary from simple devices that are designed by one to three people to system-on-chip (SoC) devices that require 100 or more designers. If we try to stay with a simple design—let's say five designers for three months for something simple. The money spent to do the design breaks into two big piles: labor and fabrication costs.

Semiconductor fabrication is an expensive process. Mask and wafer fabrication expenses are the elephant in the room. A dedicated mask set for cutting-edge silicon easily costs over a $1 million for a single trip to the foundry. Older generations of silicon cost less. But even with multi-project wafers to spread the costs around, spending at least $100,000 to get test silicon is to be expected.

So, we know that fabricating chips are expensive. But what about the time spent doing so? A trip through a foundry will take a minimum of a month. With some processes, it's closer to two months. There is no way around that. It's pure semiconductor fabrication process issues, and no amount of money for rush fees will speed up physics. Depending on how busy the foundry is, getting the mask reticules made plus “in the pipeline” wait times to get the foundry line started can be another month. Expect anywhere from one to four months to get a chip fabricated and available to test.

“Learning experiences” while fabricating chips are expensive. When you go to the foundry, you better be very close to the final result. Also, the capability to adjust things post-fabrication is very limited. A clever designer will include a number of digital controls to adjust parameters internally, but the capability to make changes is very limited and rather expensive.

What about the time and money of getting a PCB done? Again, we have two big expenses, labor and fabrication, but the numbers are totally different. For the sake of argument, we can say the labor is roughly the same. Getting a moderate sized prototype PCB into the lab? It’s roughly $1000 a board to get it built. That can vary by size and complexity, but it is a good rule of thumb. Also, you can send out a PCB for fabrication and have it back fully assembled in a week or less.

With a PCB in hand, you have lots of freedom to swap out components, make adjustments, and fully access all nodes of the circuit. And, if need be, Xacto knives and 30AWG wire gives you the freedom to make some extensive changes.

For a chip, the time and money comes down to months and millions. For a board, the time and money are days and thousands. It makes sense to simulate in one case and “just build it” in the other.

In both cases, the strategy needs to be the quickest path with the lowest cost to a successful product. In both cases, the time and money questions steer designers in two very different directions. If it’s a chip, I will be on a simulator. If it’s a board, I’ll do a hand design with some basic design skills and get the design onto the bench for testing. Both methods are correct, and both methods yield accurate and successful products.

Jerry Twomey *has been involved in IC and PCB design since 1979. He has designed multiple consumer, commercial, and medical products including data communication, satellite systems, video, medical instrumentation, disk drives, cell phones, RF transmitters and receivers, and many others. Mixed-signal systems and design are his primary focus with a special interest in things not easily defined or solved. In addition to design, he teaches in both industry and academia and is a Senior Member of the IEEE. He holds an MSEE from Worcester Polytechnic Institute. He can be reached at jerry@effectiveelectrons.com*.

Source URL: http://electronicdesign.com/analog/factor-time-and-money-using-simulator