Rules of Thumb #0: Using Rules of Thumb Wisely

Eric Bogatin - November 19, 2013

Eric Bogatin, Signal Integrity Evangelist, Teledyne LeCroy, embarks on a mission to spell out some common rules of thumb and challenge you in a new series of columns. This column kicks off the series by outlining Rules of Thumb "Do" and "Don't" suggestions.

A key skill for every engineer
I think the most wonderful feature of the real world is that it is predictable. That we can (metaphorically) sit at our desk with pencil and paper and predict the outcome of a measurement of a relatively complex system is the most remarkable achievement of science and engineering.

In this context, I think one of the most important skills for every engineer is be able to "put in the numbers" using analysis tools.

It's what makes us engineers. It's how we separate myth from reality. It's how we gain confidence we have the correct explanation for a possible root cause. It's how we anticipate what to expect before we do any measurement or simulation. And, it's how we explore design space, to get to an acceptable design or answer faster.

I classify analysis tools into three categories: rules of thumb, analytical approximations and numerical simulations. They each have a different balance between the effort required to use them and the potential accuracy of the result returned. Figure 1 illustrates this fundamental trade off: the more accuracy you want (the higher the value), the more it will cost you.

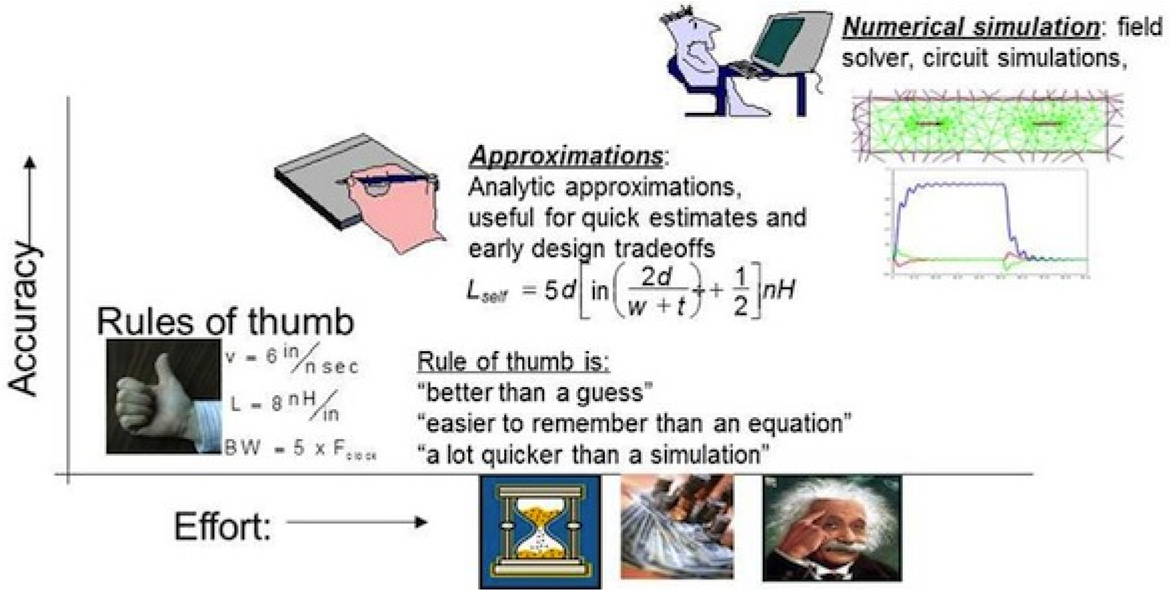

Figure 1. The three analysis tools mapped into "cost" and "value" space.

All three of these tools are equally important and should be in the toolbox of every practicing engineer. They each have their appropriate time and place for use.

Three types of analysis tools
A rule of thumb is meant to give you an answer fast, be easy to remember and give just a “ball park” result. It’s from rules of thumb that we calibrate our intuition and develop a “feel” for what to expect. It’s the ideal tool to use when “an ok answer NOW! is better than a good answer, late.”

Analytical approximations are formulas; they are equations that we can put in a calculator or spreadsheet. They identify what variables are important and how they relate together. We can quickly sweep the terms, optimize values, and explore design space with either pencil and paper or a simple spreadsheet.

With only three exceptions, a formula, no matter how complicated it looks, is either a definition or an approximation. Its complexity is no measure of its accuracy.

A numerical simulation tool can help us perform more complicated calculations, either solving complex circuit networks for the voltages or currents in time or frequency or solving for the electric and magnetic fields in space or time or frequency, or just calculating new signals from transformational operations.

While some numerical simulation tools are free and easy to use, most of them are typically expensive to buy, require a considerable level of expertise to use and take a long time to reach a result. But in many applications, it’s worth it.

If you want to have confidence in the performance of a complex system, sometimes even a first pass result can only be obtained with a numerical simulation tool.

But, the worst thing you can do as an engineer is approach all problems by immediately reaching for your 3D full wave simulator. Equally bad is signing off on a design based on the results from a rule of thumb. It’s about the appropriate type of tool for the appropriated application--how much value you require and how much you are willing and able to pay.

Start all problems with a rule of thumb
When you are up at a white board exploring possibilities, you want to leverage a simple rule of thumb to help give you a ballpark estimate. When you are listening to a design review, a rule of thumb can give you a sanity check, is the design reasonable? When you are thinking you found the root cause of a problem, a rule of thumb will help you get an estimate to see if the effect could really cause the magnitude you are seeing.

But, if you are concerned about the difference between 50 Ohms and 60 Ohms, don’t use a rule of thumb. If you have to use a calculator, don’t use a rule of thumb. If you want confidence in the answer, don’t use a rule of thumb. If you ask too many questions about the assumptions, don’t use a rule of thumb.

Sometimes, to use a rule of thumb, we have to make some gross approximations about the problem. It’s like the old phrase, “if all you have is a hammer, everything looks like a nail.” If all you have is one rule of thumb to estimate inductance for two parallel wires with a space equal to their width, for example, then every geometry will have to be approximated as this simple structure to use the rule of thumb.

Figure 2. The most important principle for the basis of using a rule of thumb.

Why do such gross approximations? Because sometimes an ok answer NOW! is more important than a good answer late.

A new EDN PCB DesignCenter series on rules of thumb
In this series of short posts, a wide variety of rules of thumb will be introduced with a little background of where they came from and some of their underlying assumptions. We will offer a few examples to show the value of the rule of thumb and an exercise or two for you to try.

We encourage you to leave your answers in the comments section and maybe offer your own examples. Maybe you have your own rules of thumb you’d like to share.

Remember, no calculators allowed.

Use these rules of thumb wisely.

Also See:
[Rule of Thumb #1: The bandwidth of a signal from its rise time]