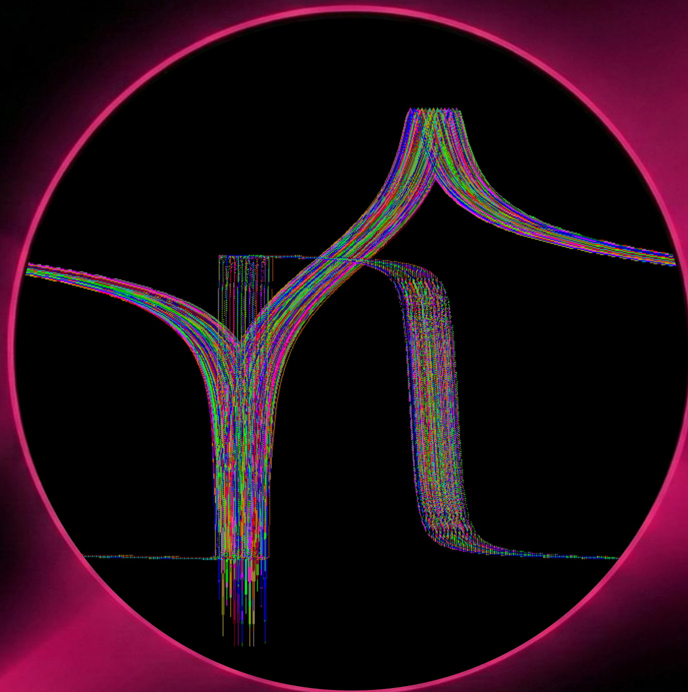

Monte Carlo

Analysis Exploration with A Band-Pass Filter

01 – Simulation

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Introduction

For the first day of the journey, while learning more about LT-Spice, I stumbled upon the Monte Carlo Simulation. The name seems fancy, but in reality, it turned out to be a really important tool in the electrical engineer's toolbox.

The Problem

In an undergrad's early engineering days, the professors' main concern was teaching the students the main concepts and physics behind what we'll be dealing with. While dealing with simulations first, the concept of tolerance wasn't our main study scope. In real life, nothing is ideal. Engineers work daily with nonidealities and must account for tolerance, so the design doesn't fail. Here comes Monte Carlo's purpose.

What is Monte Carlo?

Monte Carlo is a type of computational algorithm that uses randomness and a great number of iterations to evaluate the impact of the tolerance on the design created. Using Monte Carlo while simulating exposes you to your circuit's limitation, with respect to tolerance. It allows you to make sure that your circuit will be reliable in real world applications. Other than tolerance, the analysis could be used for different variation types.

My Application

To see and learn about this simulation, I decided to use a bandpass filter circuit. The main concern is not the circuit itself but the simulation. *Figure 1* shows the result of the simulation. Each element had a 5% tolerance which led to slightly different results.

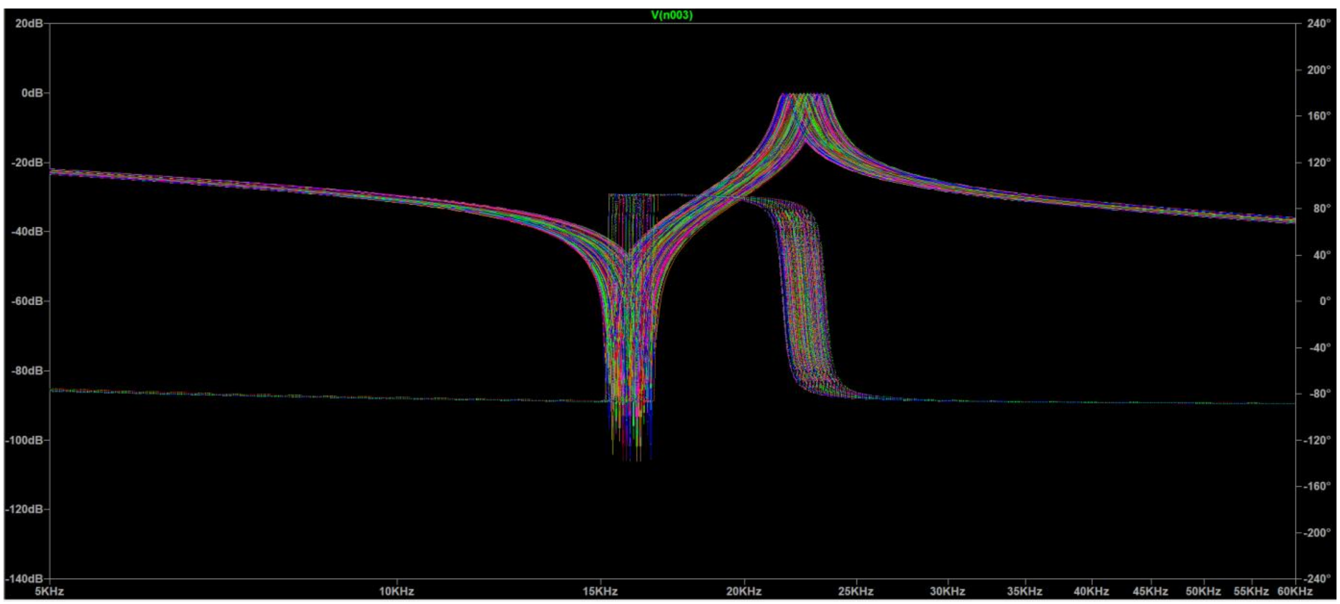

Figure 1 Monte Carlo Frequency Simulation

On the other hand, *Figure 2* shows the circuit and the directives. A variable ***tol*** was set in order to unify the tolerance percentage for all elements and be easily changeable. It was then set to run 1000 times, each with a random value. Frequency range was between 5 kHz and 75kHz, sufficient to show effects and roll off frequencies.

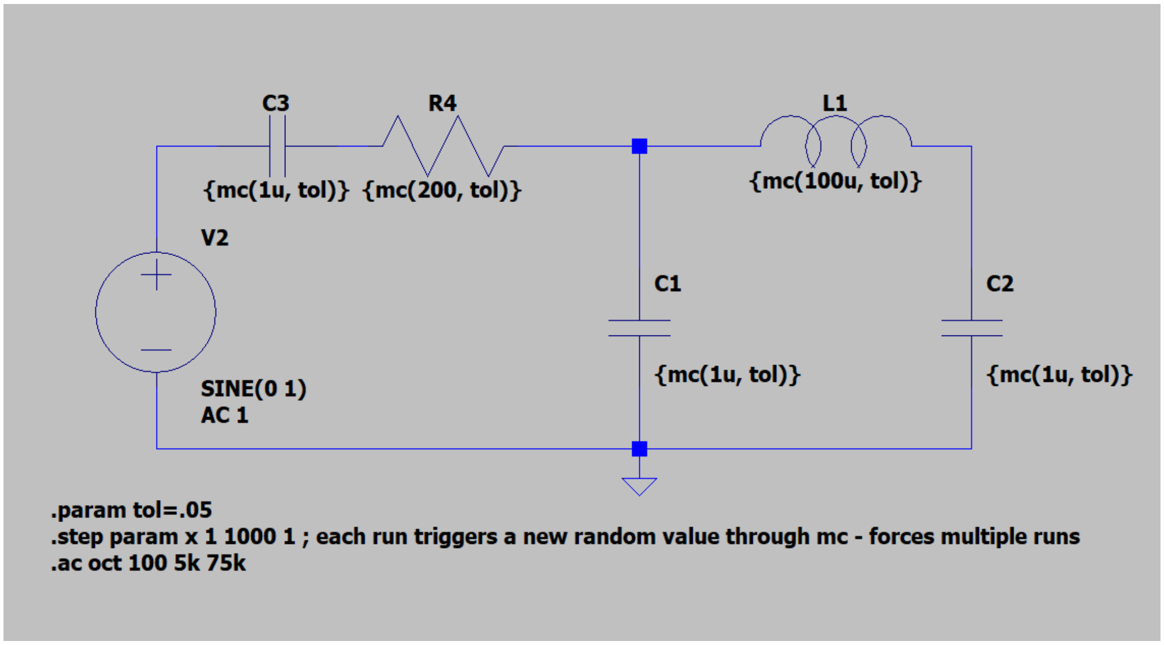

Figure 2 Circuit and Directives

Observation

Other than the filter's main purpose, two points were observed. The first point, between 15-20 kHz, a **transmission zero** was present. At this point the gain drops to a very low value, determined by C3-R4. Another observation is between 20-25 kHz. At this point a **resonant pole** is present, the circuit's impedance is very low causing the gain to peak.

Conclusion

Monte Carlo is a powerful and important tool for realistic circuit design. Without seeing a range and accounting for tolerance, a single simulation would've shown one value, or maybe none, for points where the circuit is sensitive. This simulation showed that even with a small tolerance percentage of 5%, there was a relatively significant variation in performance. Engineers must incorporate Monte Carlo or similar analysis to ensure reliable manufacturable circuits.