Background and Motivation

Certain electronic circuits can be seen as the commonly used building blocks for larger systems. However, there exist a number of parameters that must be configured for each application, as the desired behavior of the circuit will differ. Often configuring these parameters is done manually by experts—a time-consuming process. We enumerate the tunable parameters and desired objective function for a circuit, and then use methods of optimization to search for a solution or to refine an existing solution.

Visualization tools help circuit designers understand and troubleshoot a chosen solution. Below, a transient analysis with an added axis for resistor value $R_{ss}$ points out that while increasing $R_{ss}$ increases the gain, it also flattens the output waveform.

Example Circuit

The Common Source-Common Gate Cascode is a two-transistor MOSFET amplifier. It was chosen as a first example to investigate. The schematic is shown on the right. Tunable parameters include supply voltage, transistor channel widths and lengths, bias voltages, and resistive element values. $V_{i}$ indicates the input signal; $V_{o}$ indicates the output signal.

Typically the circuit designer selects an objective function $f : \mathbb{R}^{n} \rightarrow \mathbb{R}$. This is the function we aim to maximize, where $x$ in $\mathbb{R}^{n}$ is the vector of tunable parameters. Each $M_{i}(x)$ represents a measure such as bandwidth, power dissipation, maximum gain. The form of a typical objective function is shown below:

$$f(x) = \alpha_{1}M_{1}(x) + \alpha_{2}M_{2}(x) + \ldots + \alpha_{n}M_{n}(x)$$

Software and Tools

Visualization and analysis tools were written in Python with the matplotlib library, available at matplotlib.sourceforge.net. Simulations were done in MacSpice, a free variant of Berkeley SPICE. Additional trials are planned with SPICE Opus, specifically designed for use in optimization loops.

Ongoing Work

The Nelder-Mead Simplex algorithm was applied to the problem for varying initial input vectors and for several simple objective functions involving a weighted sum of maximum gain and power dissipation. The solutions found by the algorithm appear to be local optima; however it is not clear if a global optimum was found. Additional tests involving other methods of optimization are planned.