Circuit Optimization and Visualization

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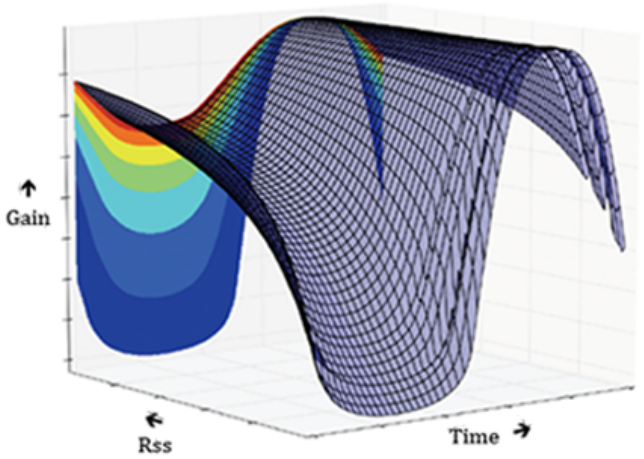
Background and Motivation

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.

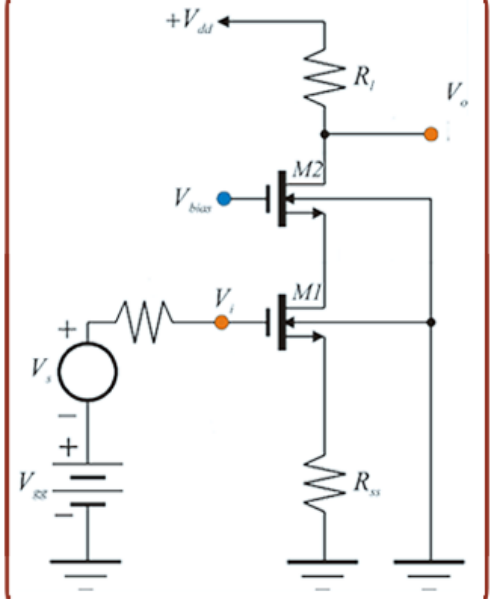


Example Circuit

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: $\mathbf{R}^n \rightarrow \mathbf{R}^1$. This is the function we aim to maximize, where $\mathbf{x}$ in $\mathbf{R}^n$ is the vector of tunable parameters. Each $M_k(\mathbf{x})$ represents a measure such as bandwidth, power dissipation , maximum gain. The form of a typical objective function is shown below.

$$f(\mathbf{x}) = \alpha_1 M_1(\mathbf{x}) + \alpha_2 M_2(\mathbf{x}) + \ldots + \alpha_n M_n(\mathbf{x})$$



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.