Optimization-Based Modeling and Design of Electronic Circuits
Some Suggested Final Projects

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1. Implement in Matlab a Trust-Region optimization method; test the algorithm with mathematical functions (for instance, those used in assignment 2), and with a circuit design example.
2. Illustrate the non-uniqueness problem of the parameter extraction process with two simple electronic circuits: one with 2 optimization variables and the other one with 1 optimization variable. Show graphically how the parameter extraction objective function changes when the number of independent variable points (frequency or time points) increases. Also show graphically how the uniqueness of the parameter extraction process changes when the complete set of characterizing responses are matched versus the case where only the optimizable response is matched. If possible, formulate an initial strategy or criterion to choose the number of independent variable samples (frequency or time) to improve the parameter extraction objective function.
3. Make an experimental study on the effects of using Shanon entropy theory for parameter extraction. Using simple circuits (one and two dimensional problems), illustrate a parameter extraction problem using metrics from Shannon information theory, and make a comparison versus conventional parameter extraction formulation (using p-norms).
4. Study the effects of the independent variable in Minimax objective functions. Illustrate the effects of the number of independent variable samples (frequency or time) in the minimax objective function value. Generate contour plots of the maximum error (minimax objective function) for 2 examples with 2 optimization variables, for different values of frequency/time samples. Generate x-y plots of the maximum error (minimax objective function) for 2 examples with 1 optimization variable, for different values of frequency/time samples. Propose examples of circuits with only 2 optimization variables, such as the 10:1 two-section impedance transformer.
5. Design by numerical optimization a Telescopic Cascode OTA, a Two-Stage Miller OTA, or a Folded Cascode OTA, to satisfy some suitable bounds for the following performance parameters: a) small signal transconductance; b) small signal voltage gain; c) Gain-bandwidth product; d) phase margin; e) slew-rate; f) noise level; g) CMRR; h) PSRR; i) minimum power consumption. Do the design for a given capacitor load (for instance, C_L = 0.5pF). The optimization variables must be physical transistor sizes (length/width), and perhaps capacitor areas. The OTA should be designed using a conventional CMOS technology process (AMI Semiconductor 1.50µm or 0.5µm ABN Process, or any other similar technology).
6. Optimize the design of a relatively simple CMOS active filter. Given some design specifications, apply either a minimax or constrained formulation to optimize an already available initial design. The optimization variables must be some suitable physical dimensions of the layout (transistor sizes, capacitor areas, etc.). The filter must be designed using a conventional CMOS technology process.
7. Using optimization methods, formulate and solve the problem of designing a Common Gate Buffer to enhance the signal integrity in a high-speed interconnect circuit. The interconnect can be a typical PCB trace or a microstrip line, and can be simulated in Matlab, SPICE or APLAC (most recommended). The interconnect must be terminated with a Common Gate Buffer. Find by optimization the MOSFET dimensions (W and L) such that reflections on the interconnect are

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minimized and the voltage gain is maximized.

8. Implement in Matlab a global optimization algorithm to optimize the design of some electronic circuit. The suggested global optimization strategies are: a) Genetic Algorithm (GA), b) Particle Swarm Optimization (PSO), and c) Simulated Annealing. Illustrate the performance of the design optimization using GA, PSO or SA, and make a comparison versus the Nelder-Mead method on the same circuit problem.
9. Implement in Matlab a parameter extraction (PE) algorithm using a global optimization method. The suggested global optimization strategies are: a) Genetic Algorithm (GA), b) Particle Swarm Optimization (PSO), and c) Simulated Annealing. Illustrate the performance of the PE algorithm using GA, PSO or SA, by solving a PE problem with many local minima.
10. Study the Genetic Algorithm (GA) method and implement it in Matlab to solve the parameter extraction (PE) sub-problem in the Broyden-based Input Space Mapping algorithm. Apply the GA-based PE method to show how convergence of the Broyden-based Input Space Mapping algorithm is enhanced. Illustrate the case using a synthetic example with many local minima in the PE objective function.
11. Illustrate the Broyden-based Input Space Mapping algorithm by designing an electronic circuit. The electronic circuit can be low-frequency (Matlab-SPICE), high-frequency (Matlab-Aplac, or Matlab-ADS, or Aplac-Sonnet, or ADS-Sonnet, or ADS-Momentum), or transient domain (Matlab-SPICE, or Matlab-Aplac, or Matlab-ADS).
12. Implement a Matlab algorithm for neuromodeling electronic circuits. As a neural network paradigm use a 3-layer perceptron with hyperbolic tangents as activation functions for the hidden layer. Train the neural network by optimization methods. Illustrate the algorithm with a simple circuit.
13. Study and implement in Matlab the Implicit Space Mapping algorithm. Apply it to design an electronic circuit. The coarse and fine models of the electronic circuit can be low-frequency (Matlab-SPICE), high-frequency (Matlab-Aplac, or Matlab-ADS, or Aplac-Sonnet, or ADS-Sonnet, or ADS-Momentum), or transient domain (Matlab-SPICE, or Matlab-Aplac, or Matlab-ADS).

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