وَمَا أُوتِيتُمْ مِنَ الْعِلْمِ إِلَّا قَلِيلًا

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Analog/Mixed-Signal Simulation and Modeling
Lab 05
Analog Design Optimization

Objectives

1. Learn how to systematically design analog circuits using the gm/ID design methodology and precomputed LUTs.
2. Create a knowledge-based synthesis script that automates OTA design using LUTs.

Instructions

1. Use MATLAB or Octave to write your codes.
2. Use LTSpice for design entry and simulation. You may use Notepad++ to write your netlist (it has SPICE highlight mode). Do NOT use a schematic entry GUI.
3. Download Murmann's gm/ID Starter Kit (https://web.stanford.edu/~murmann/gmid).
   - Read the documentation and the help of the lookup function.
   - Use the 180 nm SPICE model and the LUTs included in Murmann's gm/ID starter kit.
   - You may need to edit Murmann's code if you will use Octave.
4. Download ADT:
   - Go to https://adt.master-micro.com
   - Register using your university or corporate email address. If you are a student or fresh grad, select academia as your organization type. If you don't have a university or corporate email address then register as unemployed and include your LinkedIn profile URL, but your account may take some time to get reviewed and approved.
   - Read ADT readme file. Visit ADT website again and generate a free personal license.
   - **Use the LTspice example LUTs included in ADT. Do NOT generate new LUTs.**
5. Watch the following playlist:
   https://youtube.com/playlist?list=PLMSBalys69ywdpmcih1yP4hboBLY4-iCr
6. Watch Lecture 14 in the Analog IC Design (1) Course:
   https://youtube.com/playlist?list=PLMSBalys69yzp1vrmnYAmpRFiptbuGuaj
7. **Optional:** Read the following paper:
   https://www.sciencedirect.com/science/article/pii/S0026269217307905.

Part 1

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1.	Use ADT Design Xplore to design an NMOS-input 5T-OTA with the following specs: • VDD = 1.8 V, AVDC = 34 dB, GBW = 100 MHz, CL = 500 fF • Minimize power consumption Use the assumptions used in the previous lab to get reasonable ranges for your design database (DDB). Use ADT Tune and sensitivity analysis to optimize your OTA. Report the design charts you used and use cursors to clearly show your design points.

2.	Use ADT Verify to verify your circuit. Report the results.
3.	Repeat the previous problem using ADT Design Cockpit. Report the results.
4.	Repeat the previous problem using ADT Optimize. Report the results.
5.	Complete the function “loptOTA.m”. This is a function that performs local optimization of the power consumption of an NMOS-input 5T-OTA using a non-linear gradient based optimizer (fmincon). The function takes a single structure (SPEC) as input. SPEC has the following fields: VDD, DC gain (AVDC), gain-bandwidth product (GBW), and load capacitance (CL). The function returns a single structure OTA that contains the minimum bias current and the sizing (W and L) of the OTA transistors. Use the assumptions used in the previous lab as initial guess. Report your MATLAB function.
6.	Complete the function “goptOTA.m”. This is a function that performs global optimization of the power consumption of an NMOS-input 5T-OTA using the genetic algorithm. The function takes a single structure (SPEC) as input. SPEC has the following fields: VDD, DC gain (AVDC), gain-bandwidth product (GBW), and load capacitance (CL). The function returns a single structure OTA that contains the minimum bias current and the sizing (W and L) of the OTA transistors. Report your MATLAB function.
7.	Complete the script “optOTA_test.m”. This is a script that calls your local and global optimization function and prints the output clearly in the command window. Use this script to design the OTA you designed using ADT. Report your script. Report the output of the command window. Compare all the results from ADT and Matlab in a table. Comment on the results.
8.	Complete the netlist “ota_tb.cir” to simulate your synthesized OTA. Simulate the differential gain vs frequency (annotate DC gain and GBW) and compare the simulator output with the required specifications. Report your netlist, the simulation results, and the comparison table. Comment on the results.

Part 2

Repeat Part 1 across three corners, where the two additional corners model +/- 10% change in the nominal bias current.

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1.	ADT Design Xplore.
2.	ADT Design Cockpit
3.	ADT Optimize
4.	ADT Verify
5.	[Optional] Matlab local optimization (fmincon).
6.	[Optional] Matlab genetic optimization.

Thanks to all who contributed to these labs. If you find any errors or have suggestions concerning these labs, please contact Hesham.omran@eng.asu.edu.eg.