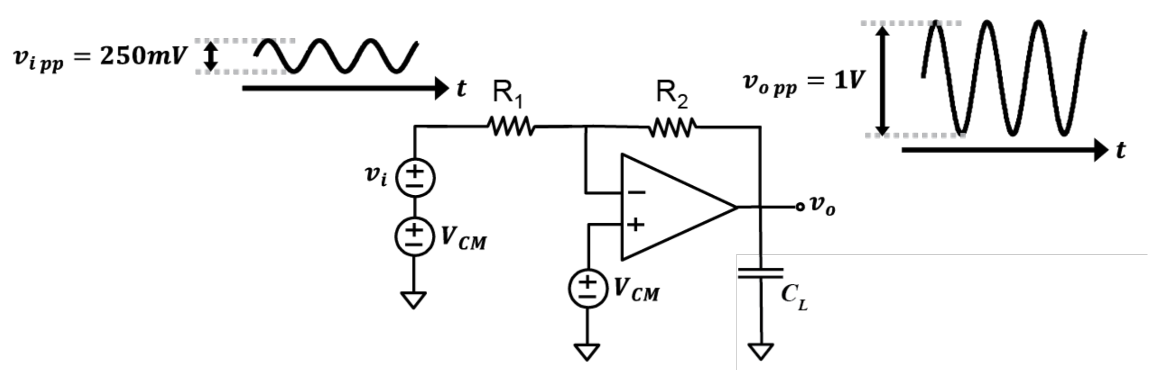
EE 332 Class Project Autumn 2022

Title: Differential Amplifier Design

Due Date: Report is due ***Sunday, Dec 18th 11:59pm***. Please submit electronically on Canvas.

Description: Design a single-ended amplifier (for example a 5-Transistor OTA) that meets the following specifications:

- A low-frequency gain of 10V/V. (Run a proper AC-simulation to validate this and include the result in your report)
- Maximize output swing to support 1V peak-to-peak.
- The amplifier must run off of a 1.5V supply all your devices must have a $100mV \leq (V_{GS} - V_{th})$
- Once you completed your amplifier design, please hook it up as an inverting amplifier as shown below. Design the resistors to give a closed-loop voltage gain of 4 (Don't forget to take the limited gain of amplifier into account!) Once the common-mode voltage has been correctly selected, apply a 250mV peak-to-peak input signal (sinewave) and show the output of your amplifier can produce, without distortion, a 1V peak-to-peak output signal. To minimize any distortion on your output signal, you need to make sure that all the devices in your amplifier remain in the saturation region for the entire swing of the output voltage.
- When running a time domain simulation using a sinewave, please show the amplifier has an output swing of 1V with a 100MHz signal. Output should be loaded with a 2pF Capacitor (C_L). Simulate the frequency response of the closed-loop amplifier using AC-sim and find the 3-dB bandwidth and gain-bandwidth product. Include estimated calculated 3db-bandwidth and unity-gain bandwidth in your report as well and compare with simulation results.
- Minimize the power consumption of amplifier.
- For biasing, you have access to a reference current source of 10uA, VDD of 1.5V, and another DC voltage source of your choice for V_{CM} at input. (i.e. your tail current should be generated via a current-mirror from this reference current source)



Technology: You should use devices from ***gpdk045*** library. You should estimate main parameters including $V_{th}, \mu C_{ox}, \lambda$ of NMOS and PMOS devices from DC simulations/sweeps before starting your design (similar to what we did in Lab X). Include your estimates in a table in your report and use these values for your calculations.

Project deliverables and Report:

- Project report clearly describing your analysis and design. Describe design decisions, tradeoffs, how you optimized gain vs. power, etc. Also describe anything you struggled with in completing the project.
- Complete amplifier schematic. Also, show the amplifier Cadence schematic. Run a DC operating point analysis and annotate all the node voltages and as well as the $(V_{GS} - V_{TN})$ of all the transistors, to prove the devices are in the saturation region with a normal DC bias.
- Table of the operating points of all transistors (W, L, I_D, V_{od}, V_{DS}, g_m).
- Any other plots you find useful in demonstrating that your amplifier meets all specifications. Make sure to plot the input and output voltages.
- Table listing the specifications and your simulated results.
- Reports are recommended to be typed in Word or LATEX. Incorporate figures into the document, not added as appendices. Clearly label all figures with the appropriate axis labels and units.
- Reports can be up to 12 pages of text and figures (including all the supplementary material such as screen captures of schematics, plots, and generally material related to simulation results).

Project grades will be given based on:

- Meeting the project specifications
- Completeness and clarity of project report
- Optimization of your power dissipation