EE204: Analog Circuits
Dept. of Electrical Engineering
IIT Bombay
Autumn Semester 2023

Assignment 3
Total Marks: 10
Submission Deadline: 11:59 p.m., 09-09-2023
Mode of Submission: Scan your assignment and upload on Moodle as a single pdf file.

Q-1. In the circuit shown in Fig. 1: R4 = R2 = 10K Ohm, R3 = R1 = 5K Ohm, Vdd = 5V, Vo_{min} = 0V, Vo_{max} = 5V for all Op-Amps

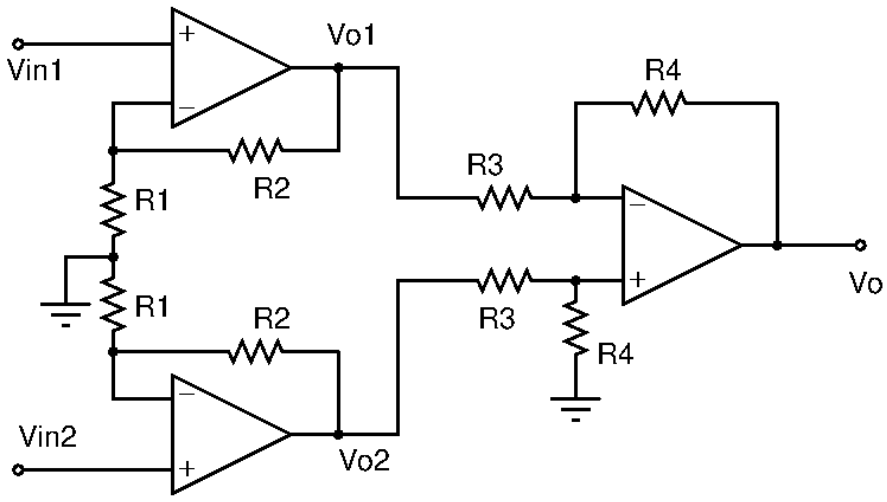

Fig. 1

a. For the inputs: $V_{in1} = V_{cm} - V_{id} * sin(\omega t), V_{in2} = V_{cm} + V_{id} * sin(\omega t)$, find expressions for outputs of all Op-Amps, i.e, V_{o1}, V_{o2}, V_o. (1.5 marks)
b. Assuming the Op-Amps are ideal, given $V_{cm} = 1.8V, V_{id} = 0.3V$, plot all three Op-Amp output waveforms for at least two cycles. (1.5 marks)
c. Assume the output of all Op-Amps saturates at 4V. Plot all three output waveforms once again for at least two cycles. Other parameters of Op-Amps and other elements remain unchanged. (1.5 marks)

Label all the voltage levels properly in the plots.

Q-2. In the circuit shown in Fig. 2, the NMOS is biased at Vb = 0.8 V, Vdd = 1.8V, W/L = 9/0.36, $\mu_n C_{ox} = 260\mu A/V^2$, V_{TH} = 0.4 V

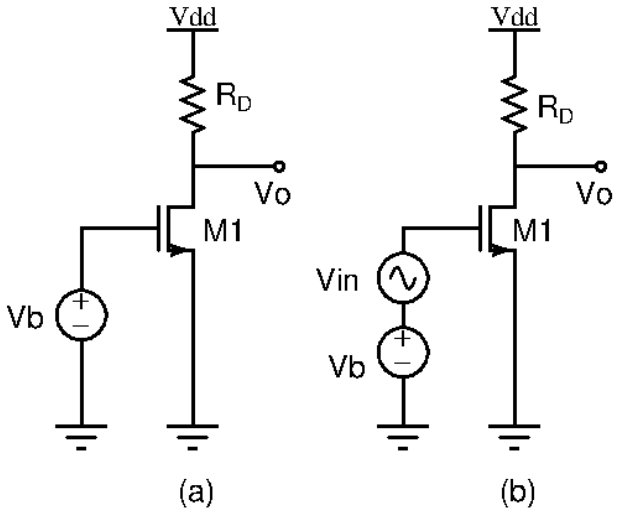

Fig. 2

a. Find the biasing current I_D, and Vo for R_D = 0.8K Ohm. Report the region of operation of M1. (0.5 marks)
b. Draw the small signal model of the given circuit and find the small signal gain. (1 mark)
c. A small signal with pk-pk input of 20mV is applied, as shown in Fig. 2b. Find the absolute value of incremental pk-pk output - input gain. Is the gain inverting or non-inverting? (2 marks)
d. If R_D is increased by two times, calculate the new value of incremental gain for the same pk-pk input of 20mV. Find the maximum value of R_D, that can be used such that M1 stays in saturation. (2 marks)