Analog Circuits (EE3002/EE5310) : Problem Set 7

shanthi@ee.iitm.ac.in

For all transistors, use $\mu_n C_{ox} = 200\,\mu$A/V^2, $\mu_p C_{ox} = 50\,\mu$A/V^2, $V_{TN} = V_{TP} = 1$ V. Use $\lambda = 0$ unless otherwise mentioned. The (W/L)s of the devices are marked next to them.

Problem 1

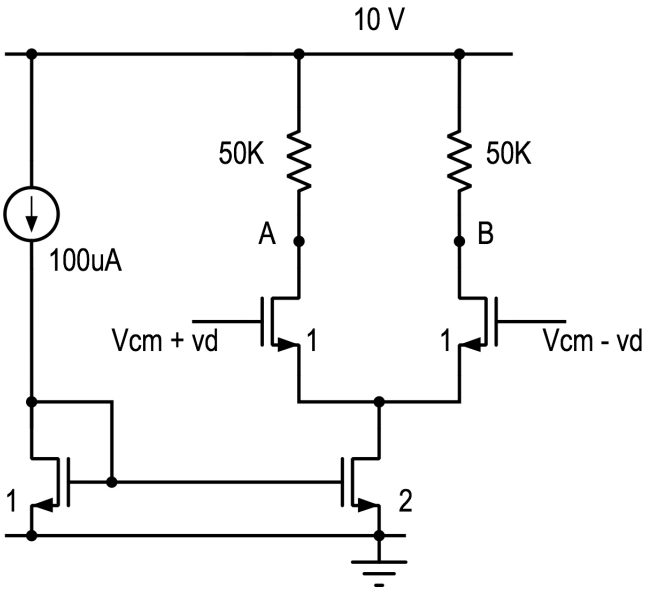

Figure 1: Circuit for problem 1.

In the amplifier of Fig. 1, Vcm=6 V, and vd is a small signal.

- Determine the operating points of all the devices in the circuit.
- Determine the incremental voltages at A and B.
- What is the range over which Vcm can vary, while keeping all devices in saturation?
- It is desired to increase the incremental gain by increasing the resistors, and by using the lowest Vcm possible. Determine the maximum achievable incremental gain at node B.

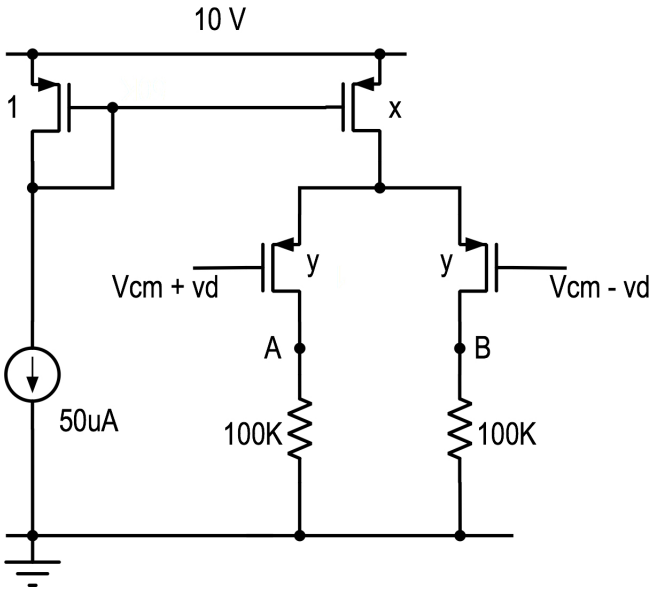

Figure 2: Circuit for problem 2.

Problem 2

In the circuit of Fig. 2, Vcm = 6 V and vd is a small signal. Determine the aspect ratios x and y so that

a. the quiescent voltages at A and B are the same as in the previous problem, and

b. the incremental gain is the same as that in the previous problem.

c. With the calculated x and y, find the input common-mode range.

Problem 3

In the circuit of Fig. 3, Vcm = 6 V and vd is a small signal. Determine the aspect ratio x, so that the incremental voltage between A and B is 4 vd. For this value of x, determine the quiescent voltage at A.

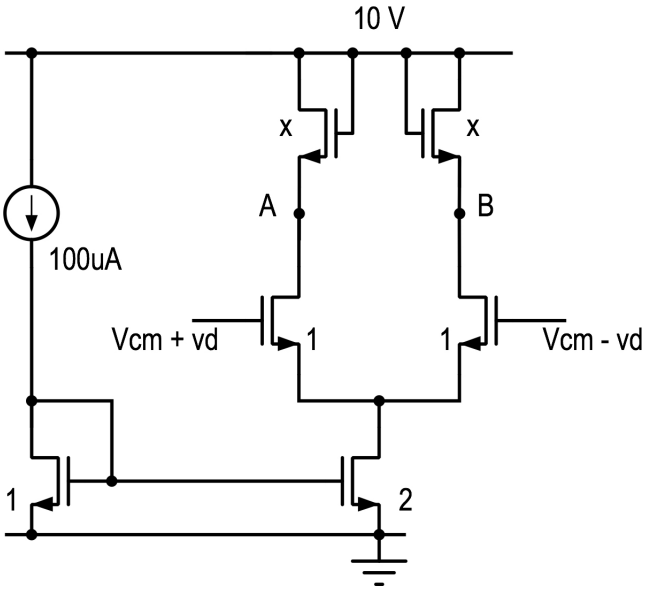

Figure 3: Circuit for problem 3.

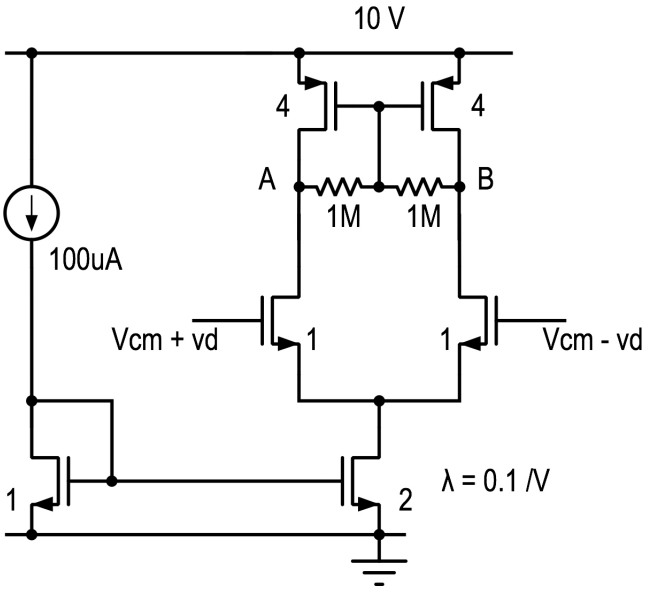

Figure 5: Circuit for problem 5.

Problem 4

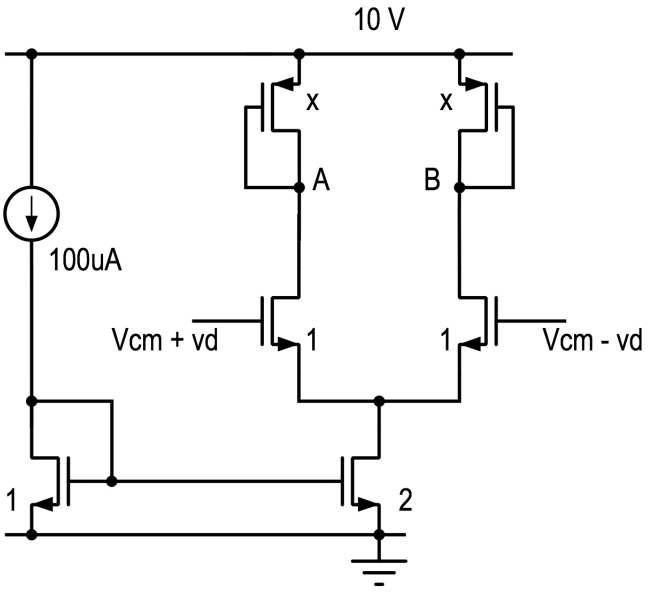

Figure 4: Circuit for problem 4.

Repeat problem 3 for the circuit of Fig. 4.

Problem 5

For this problem, use Vcm = 5 V. Though not shown, the common-mode portion of the input has a small signal component denoted by v_{cm}. Determine the quiescent voltages at A and B. Determine the incremental voltage at node B, and the common-mode rejection ratio. What is the common-mode range?

Problem 6

For this problem, use Vcm = 5 V. Determine x so that the quiescent voltage at A and B is 5 V. Next, for the value of x you just determined, find the range of VM over which all devices remain in saturation.

For VM=3 V, determine the range of Vcm that will keep all devices in saturation.

Finally, determine the incremental gain, which we define in this case to be $v_{AB}/2v_d$.

Problem 7

For this problem, use Vcm = 5 V. Determine the incremental gain from the input to the output at node A. Over what range of Vcm is this gain maintained?

Problem 8

For this problem and the next, use Vcm = 5 V, $\lambda_p = 0$ and $\lambda_n = 0.1$/V.

Determine the quiescent operating point at the output node. What is the incremental voltage at the output?

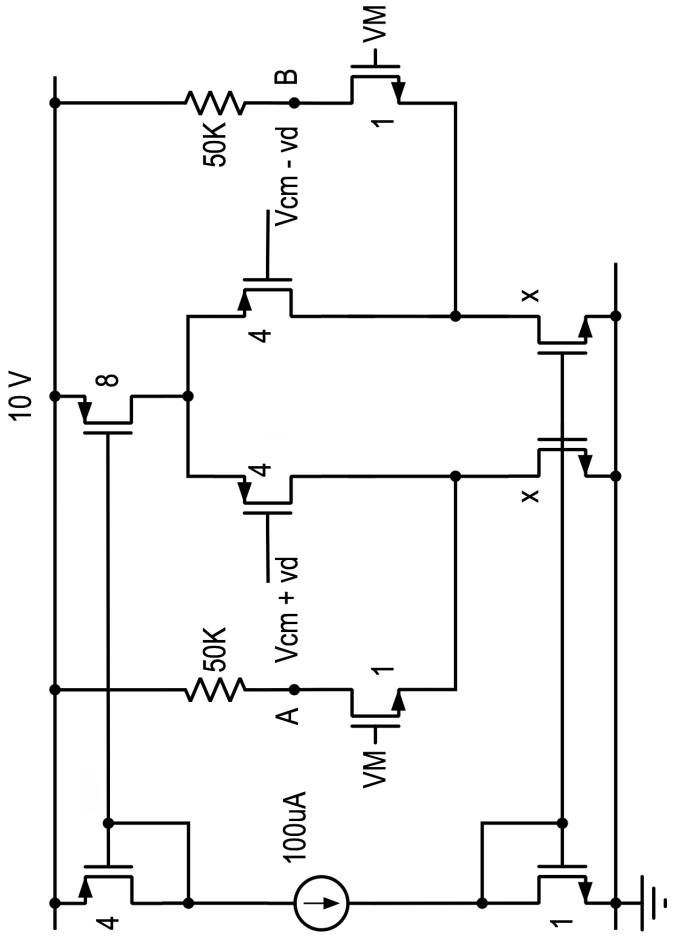

Figure 6: Circuit for problem 6.

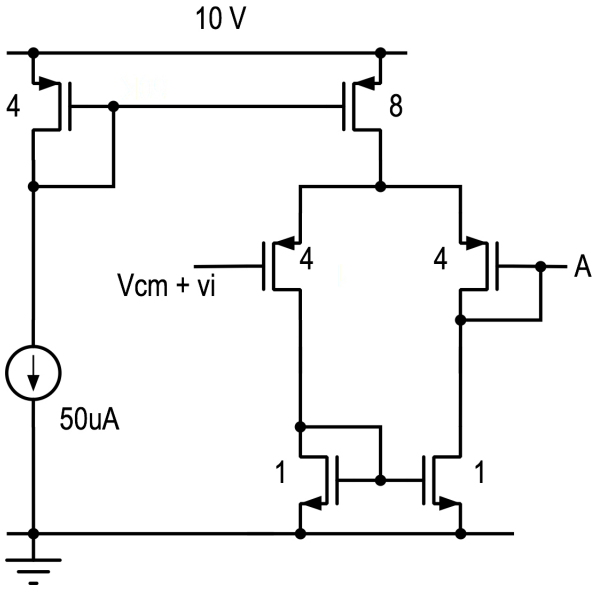

Figure 7: Circuit for problem 7.

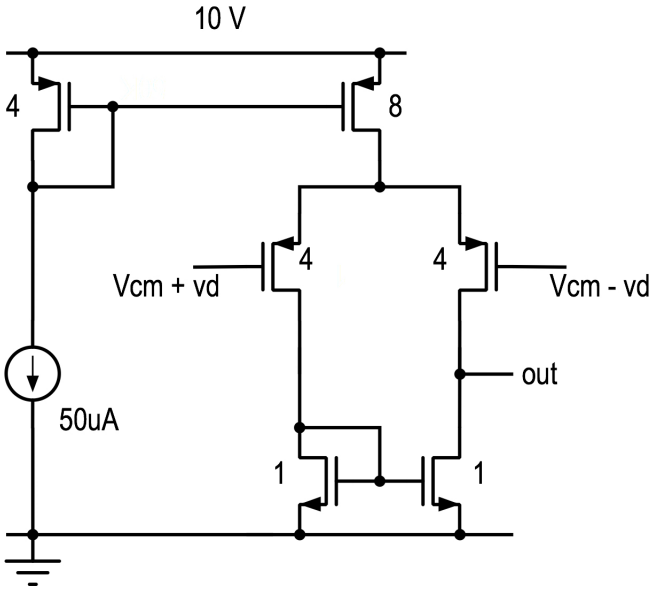

Figure 8: Circuit for problem 8.

Problem 9

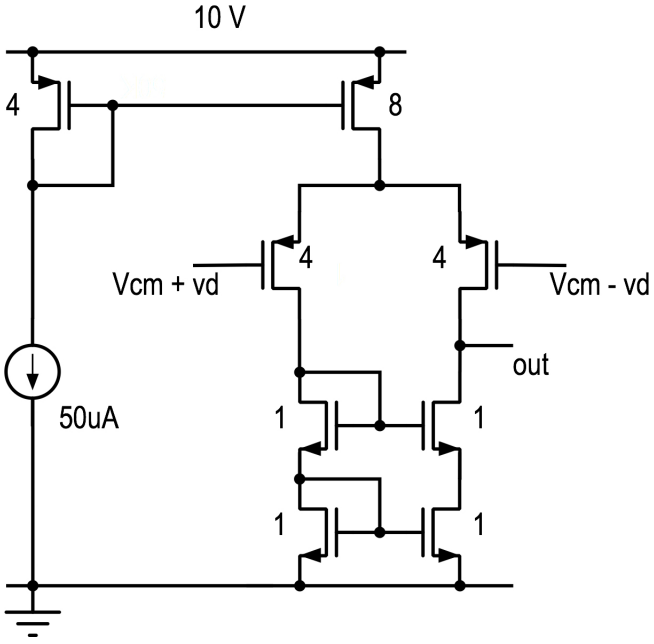

Figure 9: Circuit for problem 9.

Repeat problem 8 for the circuit of Fig. 9.