EC201-ANALOG CIRCUITS : PROBLEM SET 1

shanthi@ee.iitm.ac.in

Problem 1

The following two circuits are identical as far as the 2 ports are concerned. Determine y_1, y_2, y_3 in terms of y_{ie}, y_{re}, y_{fe}, y_{oe}.
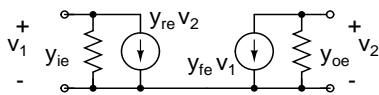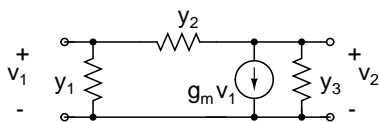

Figure 1: Problem 1

Figure 2: Problem 1

Problem 2

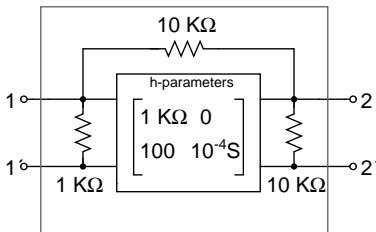Determine the composite y-parameters of the block within the dotted lines.

Figure 3: Circuit for Problem 2.

Problem 3

The operational amplifier shown in Figure 4 is ideal. Determine the signs on the input terminals of the opamp for negative feedback operation. Assuming negative feedback operation, find $\frac{v_{out}}{v_{in}}$.

Problem 4

For the circuit of Figure 5, assume that v_i is an incremental voltage source. Determine the operating point of the network. Find also the small signal voltage across the $1\,\mathrm{k}\Omega$ resistor.

Problem 5

In this problem, we delve deeper into the notion of "small signal". Consider two nonlinear amplifiers, with input-output characteristics given by $V_{out} = \frac{V_{in}^2}{V_A}$ and $V_{out} = V_A \exp(\frac{V_{in}}{V_A})$.

- An incremental gain of 10 is desired of both amplifiers. Determine the operating points so that this gain may be achieved.
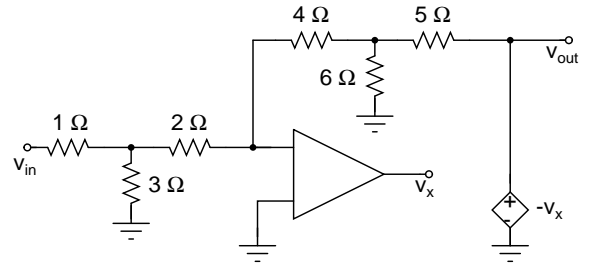

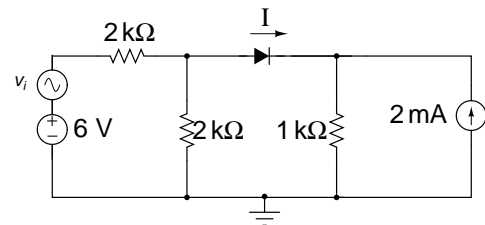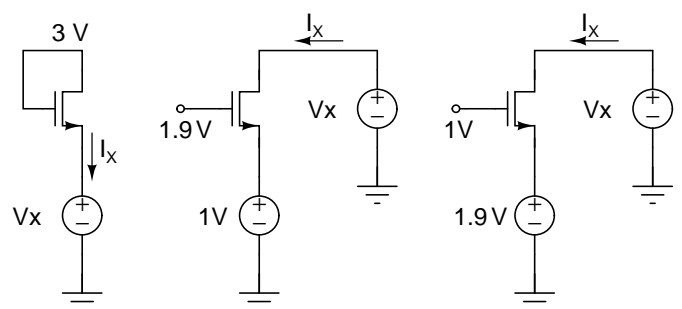Figure 4: Circuit for Problem 3

Figure 5: Circuit for Problem 4

- We saw in class that the "small signal" approximation is valid only when the higher order terms in the Taylor series can be safely neglected in relation to the linear term. Compare the second order derivative of the two amplifers around the operating point. What can you say about the relative magnitudes of the incremental inputs for each of the amplifiers which qualify as small signals ?
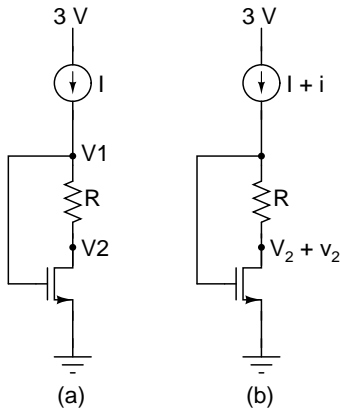
Problem 6

$k = 100\,\mu\mathrm{A/V}^2$, (W/L) = 10, $V_T = 0.7$ V, $\lambda = 0$

Figure 6: Circuit for Problem 6

For each of the circuits shown above, plot I_x as V_x varies from 0-3 V.

Problem 7

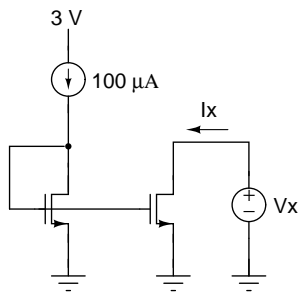For the circuit (a) shown above, determine the minimum value of I required to make the MOSFET operate at the edge

k = 100 μA/V^2, (W/L) = 10, V$_T$ = 0.7 V, λ = 0

Figure 7: Circuit for Problem 7

of the active region. In the circuit (b) shown above, determine the incremental voltage v_2 in terms of the incremental current i, assuming the device is in saturation. How will you choose R to make v_2 independent of i ?
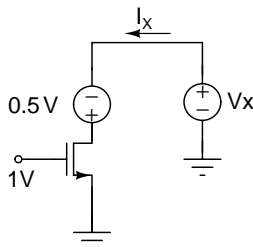
Problem 8

k = 100 μA/V^2, (W/L) = 10, V$_T$ = 0.7 V, λ = 0.1V^{-1}

Figure 8: Circuit for Problem 8

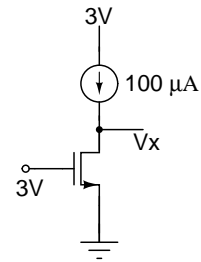For the circuit shown above, sketch I_x as V_x varies in the range 1-3 V.

Problem 9

k = 100 μA/V^2, (W/L) = 10, V$_T$ = 0.7 V, λ = 0

Figure 9: Circuit for Problem 9

For the circuit shown above, sketch I_x as V_x varies in the range -0.5-3 V.

k = 100 μA/V^2, (W/L) = 10, V$_T$ = 0.7 V, λ = 0

Figure 10: Circuit for Problem 10

Problem 10

For the circuit shown above, determine the region of operation of the transistor. Find Vx.
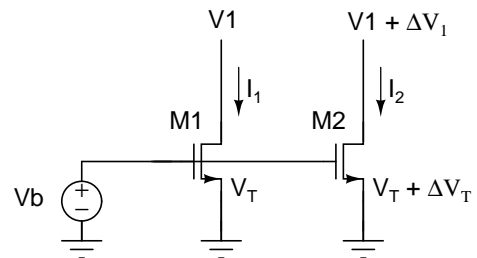
Problem 11

Figure 11: Circuit for Problem 11

In the circuit shown above, it is known that both M1 & M2 operate in saturation. Further, k, $λ$ and W/L for both transistors is the same. The threshold voltage of M2 is *slightly* larger than that of M1, by an amount ΔV_T. Determine I_2. Assume $\Delta V_1 \ll V_1$.
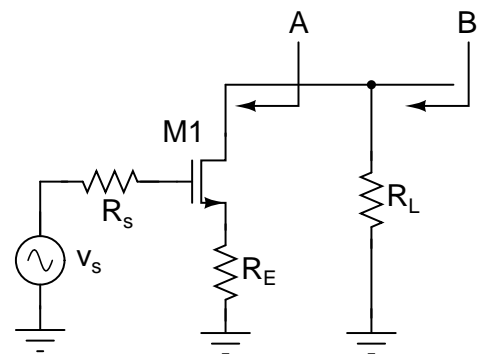
Problem 12

Figure 12: Circuit for Problem 11

The small signal equivalent circuit of an amplifier is shown above. M1 is assumed to be in saturation, with transconductance g_m and output conductance g_o. Determine the Norton equivalent looking in at A, as well as the Thevenin equivalent looking in at B. What happens to these equivalents when $g_m \to \infty$?