EE210A: Microelectronics I

Problem Set 1

Instructor: Imon Mondal, imon@iitk.ac.in

1) : Consider the circuit in Fig. 1. Assume that the forward biased voltage of the diode is 650 mV for finding the quiescent points. Consider $I_B = 2.65mA$, $V_{in} = 0$, $R_1 = 2k\Omega$, $R_2 = 2k\Omega$.

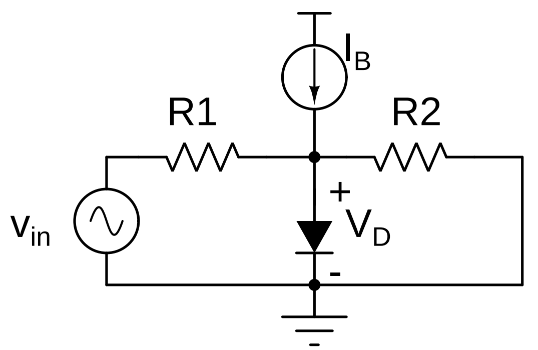

Fig. 1. Problem 1

a) : Find the quiescent current through all the elements in the network.

b) : Now assume $I_B = 2.65mA + 0.5mA\sin(\omega t)$. Using the small signal analysis taught in the class, find the incremental and the total voltage across the diode.

c) : Assume $I_B = 2.65mA + 0.5mA\sin(\omega t)$ and $V_{in} = 100mV\sin(\omega t)$. Find the total voltage across the diode. (*Hint: You can use superposition when network is linear.*)

d) : Assume $I_B = 2.65mA + 0.5mA\sin(\omega t)$ and $V_{in} = 1.65V + 100mV\sin(\omega t)$. Find the total voltage across the diode. (*Careful: You cannot use superposition when a network is non-linear.*)

2) : Consider the circuit in Fig. 2(a). Assume that the forward biased voltage of the diode is 650 mV for finding the quiescent points. $R = 1k\Omega$.

a) : If $I_A = 0$, sketch the small signal equivalent circuit of the given network. Express the small signal parameters in terms of V_{DD}

b) : If $V_{DD} = 2.3V$, and $I_A = 0.1mA\sin(\omega t)$ find the total voltage at V_0.

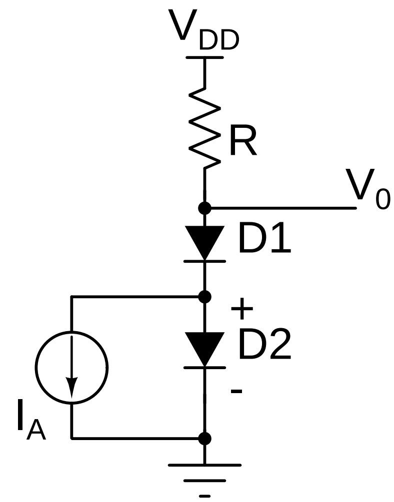

Fig. 2. Problem 2

3) : Consider the circuit in Fig. 3. $I_B = 2mA$, $V_{in} = 0$, $R_1 = 2k\Omega$, $R_2 = 2k\Omega$. The I-V characteristics of the non-linear element is given by $I_N = \alpha {V_N}^2$, for $V_N \geq 0$, and $I_N = 0$ for $V_N < 0$, where $\alpha = 1mA/V^2$.

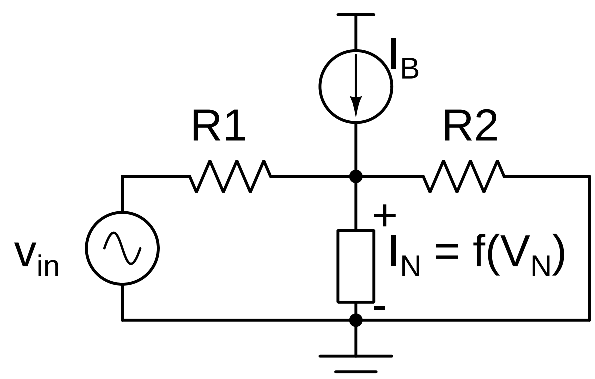

Fig. 3. Problem 3

a) : Find the quiescent current through all the elements in the network.

b) : Now assume $I_B = 2mA + 0.1mA\sin(\omega t)$. Using the small signal analysis taught in the class, find the incremental and the total voltage across the non-linear element.

c) : Assume $I_B = 2mA + 0.1mA\sin(\omega t)$ and $V_{in} = 10mV\sin(\omega t)$. Find the total voltage across the non-linear element.

4) : Consider the circuit in Fig. 4. $I_B = 2mA$, $R = 1k\Omega$. The I-V characteristics of the non-linear element is given by $I_N = \alpha(V_N - 1)^2$, for $V_N \geq 1$, and $I_N = 0$ for $V_N < 1$, where $\alpha = 1mA/V^2$.

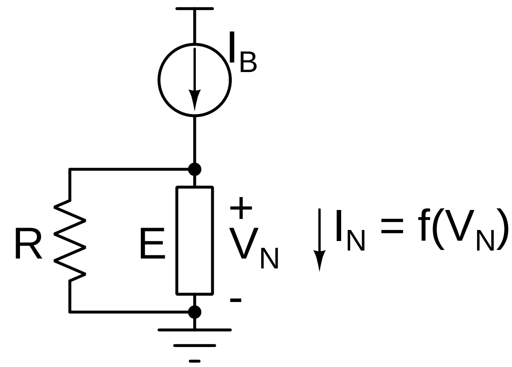

Fig. 4. Problem 4

a) : Find the quiescent current through all the elements in the network. Find the total quiescent power dissipated in R and E.

b) : Now assume $I_B = 2mA + 0.1mA\sin(\omega t)$. Using the small signal analysis taught in the class, find the incremental and the total voltage across the non-linear element.

c) : Find the total average power dissipated in R and E under the condition of (b). (*Note: Average power = time-average of $(I \times V)$, where I and V are the total currents and voltages respectively.*)

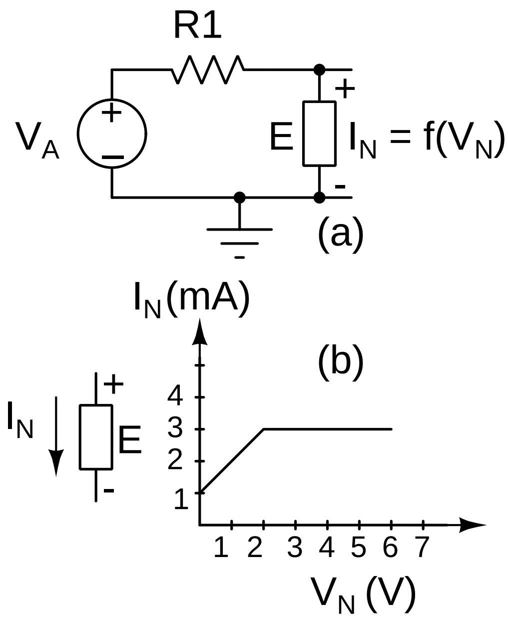

Fig. 5. Problem 5

5) : Consider the circuit in Fig. 5(a). The $I - V$ characteristic of the non-linear element E is shown in Fig. 6(b). $R1 = 1k\Omega$.

a) : Find the ranges of V_A such that $0 < V_N < 2V$ and $V_N > 2V$.

b) : Sketch the incremental network for the circuit shown in the figure for the ranges you evaluated in part a).

c) : Find total V_N if $V_A = 6V + 0.2V\sin(\omega t)$.

d) : Find total V_N if $V_A = 3V + 0.2V\sin(\omega t)$.

6) : Consider the circuit in Fig. 6(a). $R1 = 1k\Omega$. The $I-V$ characteristic of the non-linear element E is shown in Fig. 6(b).

a) : Find V_A such that $V_N = 3V$. Let us call this value V_{AQ}.

b) : In $V_A = V_{AQ} + 10mV\sin(\omega t)$, find the total V_N.

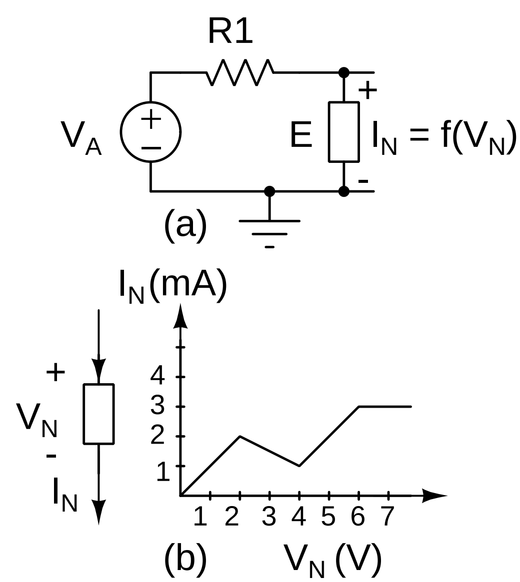

Fig. 6. Problem 6