CMPE 314 Midterm Exam-1 Solutions

spring 2018

P1

(a) For p-region

Dopant type : acceptor, group III atoms

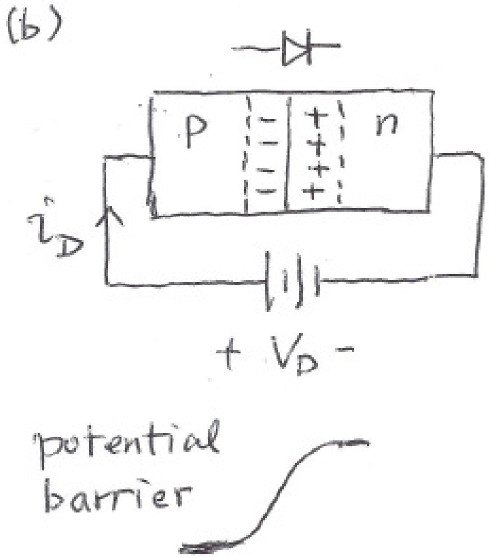
Dopant concentration : $N_a = p_o = 8 \times 10^{14} \frac{1}{cm^3}$

For n-region

Dopant type : donor, group V atoms

Dopant concentration : $N_d = n_o = 2 \times 10^{15} \frac{1}{cm^3}$

(b)



- Forward bias $V_D > 0$
  potential barrier decreases
  electrons moving from n-region to p-region
  holes moving from p-region to n-region
  diffusion current
- Reverse bias $V_D < 0$
  potential barrier increases
  holes moving from n-region to p-region
  electrons moving from p-region to n-region
  drift current

P2

KCL $\quad I_I = I_{D1} + I_{D2}$

KVL $\quad V_{D1} = V_{D2} + R I_{D2} + V^-$

diode-1 $\quad I_{D1} = I_{S1}(e^{V_{D1}/V_T} - 1)$

diode-2 $\quad I_{D2} = I_{S2}(e^{V_{D2}/V_T} - 1)$

4 equations for 4 unknowns $(I_{D1}, I_{D2}, V_{D1}, V_{D2})$

Since diode full models are used, there are no requirements on minimum V^+, V^-, I_I.

P3

① $v_s > V_{\gamma 3} + V_{\gamma 4}$, D3 and D4 on, D_1 and D_2 off

$$v_o(t) = -[v_s(t) - V_{\gamma 3} - V_{\gamma 4}] = -v_s(t) + 2V_\gamma$$

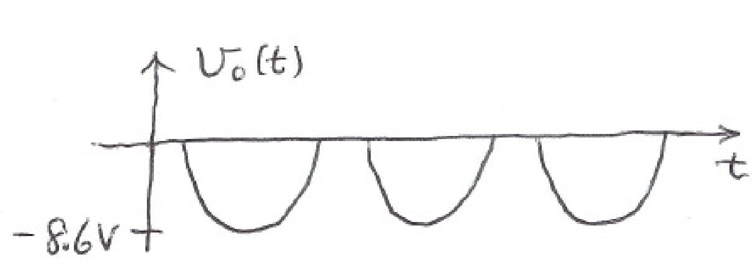
$$v_o(\text{peak}) = -10 + 1.4 = -8.6\text{ V}$$

② $v_s < -(V_{\gamma 1} + V_{\gamma 2})$, D_1 and D_2 on, D_3 and D_4 off

$$v_o(t) = -[-v_s(t) - V_{\gamma 1} - V_{\gamma 2}] = v_s(t) + 2V_\gamma$$

$$v_o(\text{peak}) = -10 + 1.4 = -8.6\text{ V}$$

$$\text{PIN} > v_s(\text{peak}) - V_\gamma = 9.3\text{ V}$$



P4

(a) ① $v_I > V_{\gamma 1} + V_{Z1}$, D_1 on, D_{Z1} reverse break down, D_2 off

$$v_o(t) = V_{\gamma 1} + V_{Z1}$$

② $v_I < -(V_{\gamma 2} + V_{Z2})$, D_2 on, D_{Z2} reverse break down, D_1 off

$$v_o(t) = -(V_{\gamma 2} + V_{Z2})$$

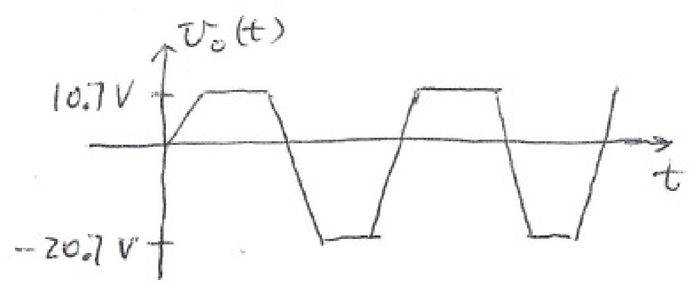
③ $-(V_{\gamma 2} + V_{Z2}) < v_I < V_{\gamma 1} + V_{Z1}$. D_1 and D_2 off

$$v_o(t) = v_I(t)$$

(b)

$$v_o(max) = V_{\gamma 1} + V_{Z1} = 0.7 + 10 = 10.7 \text{ V}$$

$$v_o(min) = -(V_{\gamma 2} + V_{Z2}) = -(0.7 + 20) = -20.7 \text{ V}$$

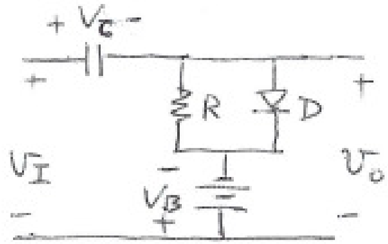


It is a double clipper circuit.

P5

(a) Let $v_C(0) = 0$

$v_D = v_I - (-V_B) = v_I + V_B$



When $v_I(t) + V_B > V_\gamma$, diode on, capacitor charging

$$v_C(t) = v_I(t) - (V_\gamma - V_B)$$

$$v_C(max) = V_I(max) - V_\gamma + V_B$$

When $v_I(t) < V_I(max)$, diode off, capacitor discharging very slowly.

$$v_C \doteq v_C(max)$$

In the steady state

$$v_o(t) = v_I(t) - v_C$$

$$= v_I(t) - v_I(max) + V_\gamma - V_B$$

Diode voltage

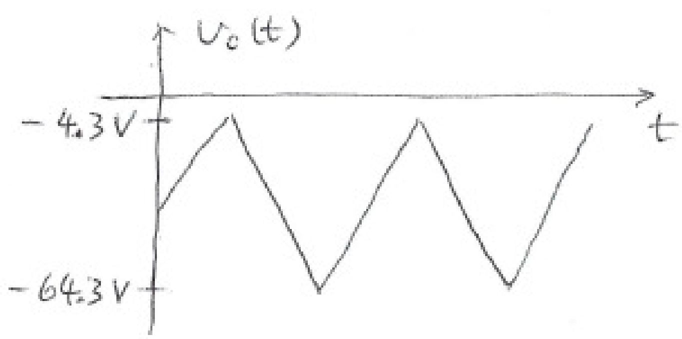
$$v_D(t) = v_o(t) - (-V_B)$$

$$= v_I(t) - v_I(max) + V_\gamma < V_\gamma \quad \text{diode is off.}$$

(b) $v_C(max) = v_I(max) - V_\gamma + V_B$

$$= 30 - 0.7 + 5 = 34.3\ V$$

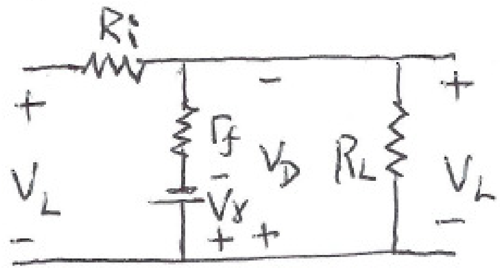
$v_o(t) = v_I(t) - 34.3\ V$



It is a clamper circuit.

P6

$V_Z = -5V$, diode is in forward bias.



$$V_D = V_\gamma + r_f I_D$$

$$\frac{V_L - V_I}{R_i} + \frac{V_L - (-V_\gamma)}{r_f} + \frac{V_L}{R_L} = 0$$

$$\frac{V_L + 5}{100} + \frac{V_L + 0.7}{5} + \frac{V_L}{200} = 0$$

$$\rightarrow V_L = -0.884V = -V_D$$

$$I_D = \frac{V_D - V_\gamma}{r_f} = \frac{0.884 - 0.7}{5} = 0.037\ A$$

$$P_D = V_D I_D = 0.033\ W$$