CMPE 314 Midterm Exam - I Solutions Fall 2016

P1

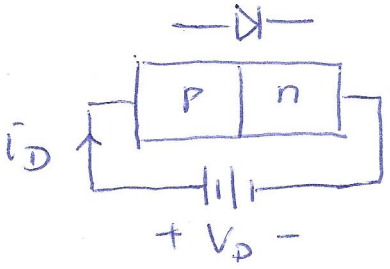
(a) Dopant requirements:

type: acceptor, group III atoms

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

minority carriers are electrons.

(b)



Carrier contributions to current:

holes from p to n regions

electrons from n to p regions

Current is diffusion type.

P2

$$V_I = R_1 I_{D2} + V_{D2} + V_{D3} + V_{D1}$$

$$V_{D1} = R_2 I_{R_2} = R_2 (I_{D_2} - I_{D_1})$$

$$I_{D_1} = I_s (e^{V_{D1}/V_T} - 1)$$

$$I_{D_2} = I_{D_3} = I_s (e^{V_{D2}/V_T} - 1)$$

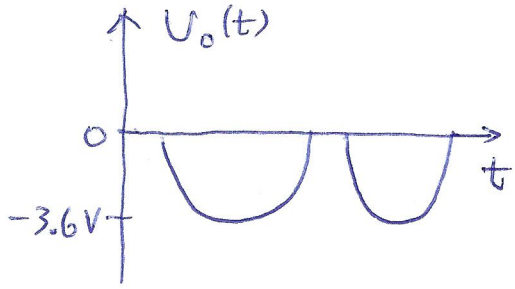
$$V_{D_2} = V_{D_3}$$

P3

(a) $U_s > 2V_\gamma$, D_3 and D_4 on

$U_o = -U_s + V_\gamma$

$U_{o,peak} = -5 + 1.4 = -3.6\,V$



$U_s < -2V_\gamma$, D_1 and D_2 on

$U_o = U_s + 2V_\gamma$

$U_{o,peak} = -5 + 1.4 = -3.6\,V$

(b) Capacitor is connected in paralled to R_L

$$V_{ripple} \doteq V_M \frac{T_P}{R_L C} = \frac{V_M}{2f R_L C}$$

P4

(a) $U_I - V_B < -V_\gamma$

or $U_I < V_B - V_\gamma$ diode on

$U_o(t) = -V_\gamma$

$U_I > V_B - V_\gamma$ diode off

$U_o(t) = U_I(t) - V_B$

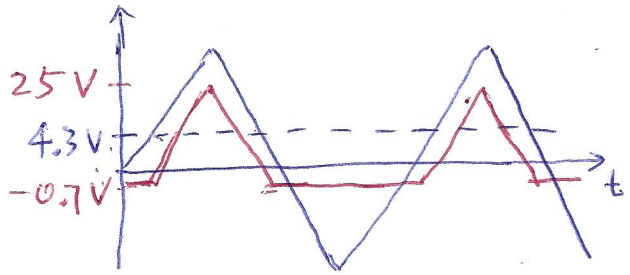
(b) $V_B = 5\,V$, $V_\gamma = 0.7\,V$

$U_I < 5 - 0.7 = 4.3\,V$

$U_o = -0.7\,V$

$U_I > 4.3\,V$

$U_o(t) = U_I(t) - 5$



P5

(a) Initial $v_c(0) = 0$

When $v_B - v_I > V_\gamma$

or $v_I < V_B - V_\gamma$, diode on

capacitor charging

$$v_c = V_B - V_\gamma - v_I$$

$$v_{c,max} = V_B - V_\gamma - v_{I,min}$$

When $v_I > v_{I,min}$, diode off, capacitor discharging slowly

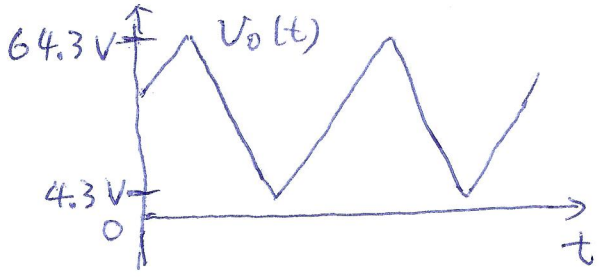
$$v_c \doteq v_{c,max} \quad \text{and in steady state}$$

$$v_o(t) = v_I(t) + v_{c,max}$$

(b) $v_{I,min} = -30\ V$

$$v_{c,max} = V_B - V_\gamma - v_{I,min} = 5 - 0.7 - (-30) = 34.3\ V$$

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



P6

$$V_z = V_{z0} + r_z I_z$$

$$\frac{V_z - V_I}{R_i} + \frac{V_z - V_{z0}}{r_z} + \frac{V_z}{R_L} = 0$$

$$\frac{V_z - 20}{100} + \frac{V_z - 10}{10} + \frac{V_z}{200} = 0$$

$$\rightarrow \quad V_z = \frac{240}{23} \text{ V}$$

$$I_z = \frac{V_z - V_{z0}}{r_\pi} = \frac{1}{23} \text{ A}$$

$$P_z = V_z I_z = (V_{z0} + r_z I_z) I_z$$

$$= 0.454 \text{ V}$$