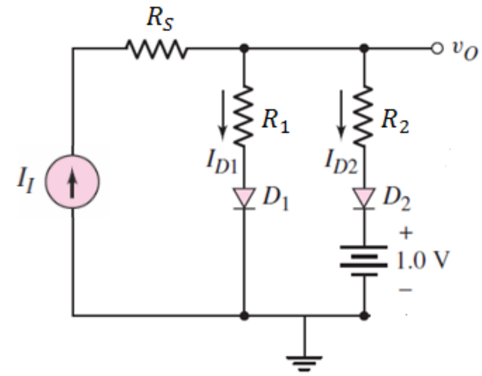
CMPE 314 Midterm Exam-I Solutions 2021 Spring

Problem 1



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

KVL $\quad R_1 I_{D1} + V_{D1} = R_2 I_{D2} + V_{D2} + V_B$

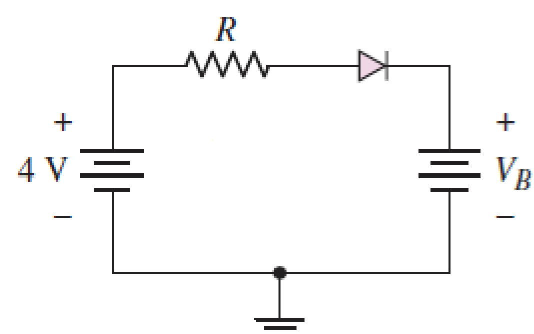
Diode device laws

$$I_{D1} = I_{s1}\left(e^{V_{D1}/V_T} - 1\right)$$

$$I_{D2} = I_{s2}\left(e^{V_{D2}/V_T} - 1\right)$$

No requirement on I_I, since the accurate diode model is used.

Problem 2



In piece-wise linear model,

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

KVL $\quad -4 + RI_D + V_D + V_B = 0$

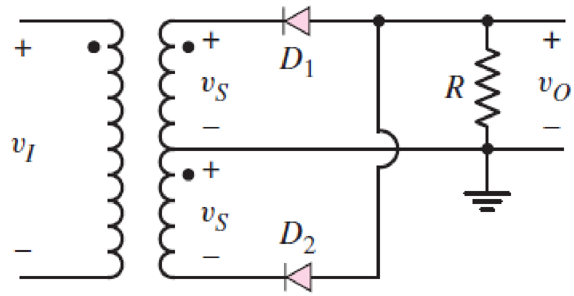
$$V_B = 4 - RI_D - (V_\gamma + r_f I_D)$$

$$V_B = 4 - 0.7 - (100 + 10) \times 50mA = -2.2\ V$$

$$V_D = V_\gamma + r_f I_D = 1.2\ V$$

$$P_D = V_D I_D = (1.2\ V)(50\ mA) = 60\ mW$$

Problem 3



(a) Near diode threshold, $i_D \approx 0$ $\quad v_{D1} \approx -v_S \quad v_{D2} \approx v_S$

- $v_S > 0$

  $v_S > V_{\gamma 2}$ $\quad$ D_2 on, D_1 off.

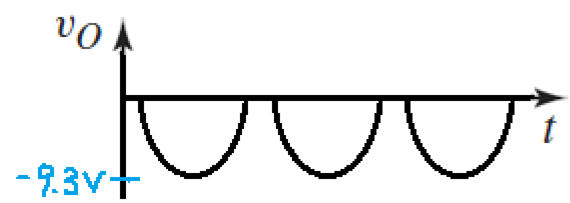
  $v_O(t) = -v_S(t) + V_{\gamma 2}$

- $v_S < 0$

  $v_S < V_{\gamma 1}$ $\quad$ D_1 on, D_2 off.

  $v_O(t) = v_s(t) + V_{\gamma 1}$

(b)



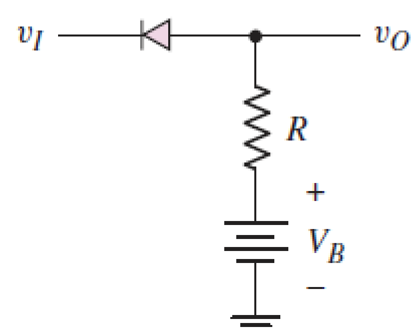
$v_O(peak) = -10 + 0.7 = -9.3\ V$

Diode PIV rating

$PIV > v_{D,Rev}(peak) = 2v_S(peak) - V_\gamma = 20 - 0.7 = 19.3\ V$

Problem 4

(a) $v_D \approx V_B - v_I$ $\quad$ near threshold $i_D \approx 0$



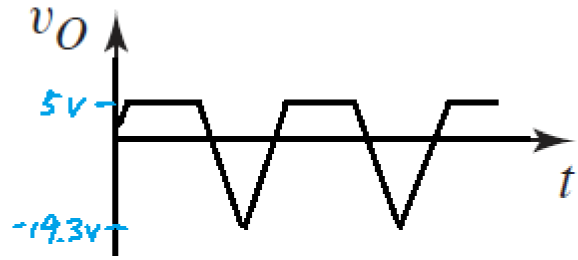
- $V_B - v_I > V_\gamma$ or $v_I < V_B - V_\gamma$ diode on

  $v_O(t) = v_I(t) + V_\gamma$

- $V_B - v_I < V_\gamma$ or $v_I > V_B - V_\gamma$ diode off

  $v_O(t) = V_B$

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



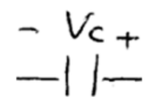
- $v_I < 5 - 0.7 = 4.3\ V$

  $v_O(t) = v_I(t) + 0.7\ V$

  $v_O(min) = -20 + 0.7 = -19.3\ V$
- $v_I > 4.3\ V$

  $v_O(t) = v_O(max) = 5\ V$

Problem 5



(a) Initial $v_C(0) = 0$, $\quad v_D \approx V_B - v_I$

- when $V_B - v_I > V_\gamma$

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

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

  $v_C(peak) = V_B - V_\gamma - v_I(min)$
- When $v_I > v_I(min)$, diode off, capacitor discharging slowly

  $v_C(t) \cong v_C(peak)$
- In steady state

  $v_O(t) = v_I(t) + v_C(peak)$

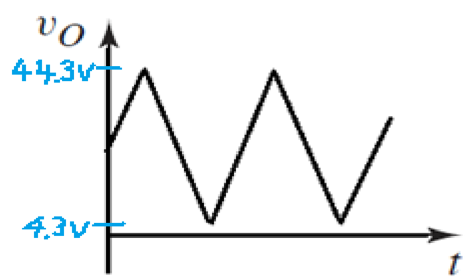
(b) $v_I(min) = -20\ V$

$v_O(peak) = 5 - 0.7 - (-20) = 24.3\ V$

$v_O(t) = v_I(t) + 24.3\ V$

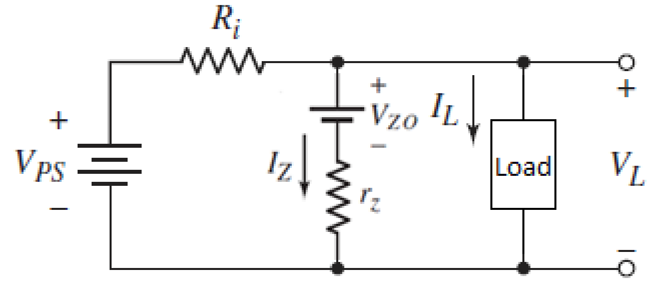
$v_O(max) = 44.3\ V$

$v_O(min) = 4.3\ V$



Problem 6

(a) $V_{PS} > V_{Z0}$, Zener diode is reverse breakdown.



$$V_L = V_Z = V_{Z0} + r_Z I_Z$$

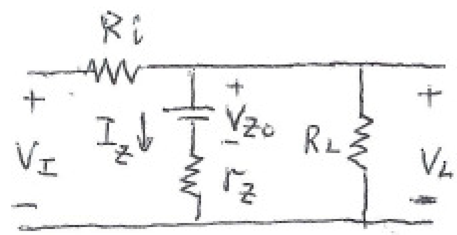
$$\frac{V_L - V_{PS}}{R_i} + \frac{V_L - V_{Z0}}{r_Z} + I_L = 0$$

Under variation of I_L

$$\Delta V_L \left(\frac{1}{R_i} + \frac{1}{r_Z}\right) + \Delta I_L = 0$$

$$\Delta V_L = -\frac{R_i r_Z}{R_i + r_Z} \Delta I_L$$

(b) $R_L = 2\ k\Omega$



$$\frac{V_L - V_{PS}}{R_i} + \frac{V_L - V_{Z0}}{r_Z} + \frac{V_L}{R_L} = 0$$

$$\frac{V_L - 10}{500} + \frac{V_L - 5}{10} + \frac{V_L}{2000} = 0$$

→ $V_L = V_Z = 5.073\ V$

$$I_Z = \frac{V_Z - V_{Z0}}{r_Z} = \frac{5.073 - 5}{10} = 7.3\ mA$$

$$P_Z = V_Z I_Z = (V_{Z0} + r_Z I_Z) I_Z = (5.073\ V)(7.3\ mA) = 37\ mW$$