CMPE 314 Midterm Exam 1

(March 10, 2011)

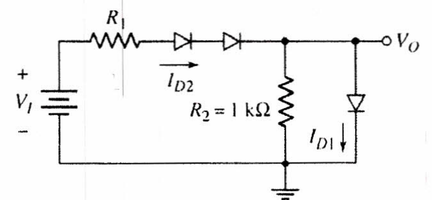
Problem 1. (15 points)

(a) Sketch the pn-junction diode's current and voltage characteristic, including the breakdown effect (indicate the current direction and voltage polarity).

(b) For a forward-biased diode, draw the equivalent circuit for the following piecewise linear models: with turn-on voltage V_γ and forward resistance r_f; with turn-on voltage V_γ and zero forward resistance; with zero turn-on voltage and zero forward resistance.

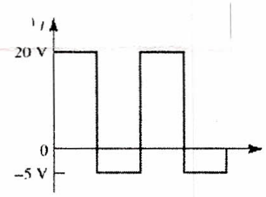
Problem 2. (25 points)

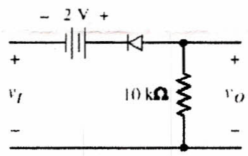
Assume all diodes in the circuit shown have the same reverse-saturation current I_s (full model). Write down the full set of equations that lead to solving v_o, I_{D1} and I_{D2}.



Problem 3. (20 points)

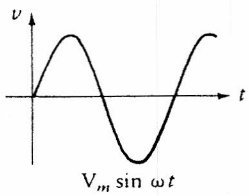
Find and plot v_o for the circuit and input shown. Assume $r_f = 0$, $V_\gamma = 0$.



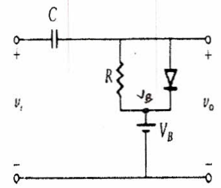


Problem 4. (20 points)

Find v_o for the circuit and input shown. Assume $r_f = 0$, $V_\gamma = 0$, and the RC time constant is large.

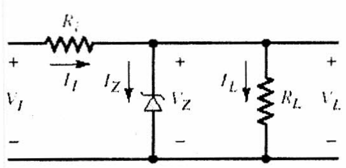


$V_m \sin \omega t$



Problem 5. (20 points)

In the circuit shown, $V_Z = 10$ V, $V_I = 20$ V, $R_i = 200\ \Omega$. Determine the range of R_L so that the power dissipated by the zener diode will not exceed $P_Z(\text{max}) = 400$ mW. (Bonus 5 points if $r_z = 10\ \Omega$ is taken into account.)

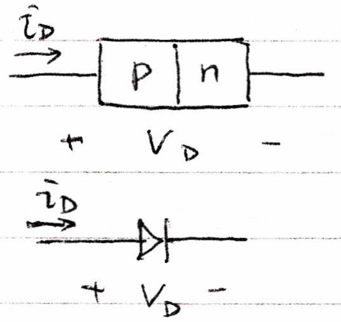


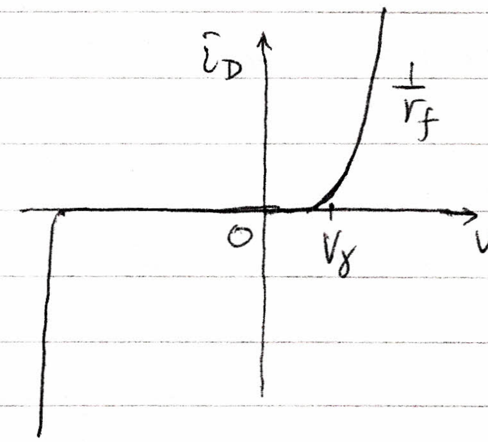
Solutions to Midterm Exam I

CMPE 314
Spring 2011

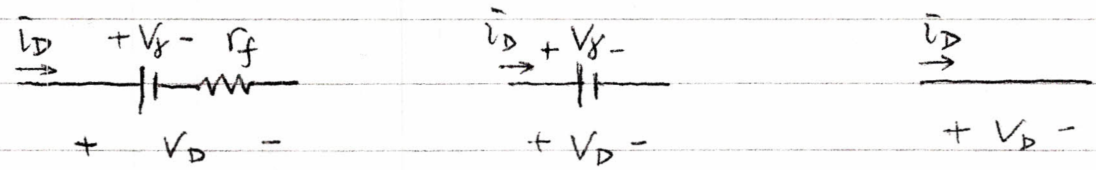
Problem 1

(a)

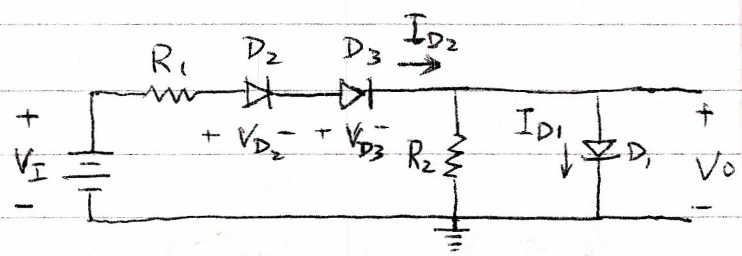




(b) Under forward bias



Problem 2



$V_I = 5\,V$

D_1, D_2, D_3 all are on.

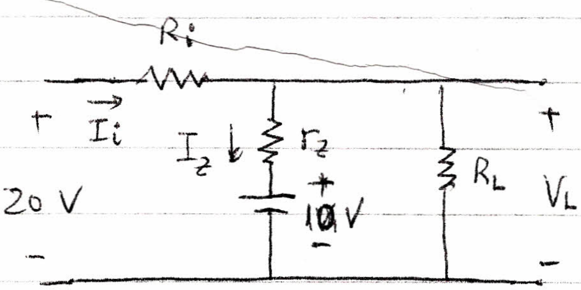
$$V_I = R_1 I_{D2} + V_{D2} + V_{D3} + V_O$$

$$I_{D2} = \frac{V_O}{R_2} + I_{D1}$$

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

$$I_{D2} = I_{D3} = I_S\left(e^{V_{D2}/V_T} - 1\right) \Rightarrow V_{D2} = V_{D3}$$

Problem 5



$$P_{z,max} = V_z \cdot I_z \le 400\text{ mW}$$

$$I_z \le \frac{400\text{ mW}}{10\text{ V}} = 40\text{ mA}$$

$$V_{r_z} = I_z r_z = 400\text{ mA} \times 10\,\Omega = 0.4\text{V}$$

$$I_{R_i} = \frac{V_i - (V_z + V_{r_z})}{R_i} = \frac{20 - (10 + 0.4)}{200} = 48\text{ mA}$$

$$I_L = I_{R_i} - I_z = 8\text{ mA}$$

$$V_{R_L} = V_z + V_{r_z} = I_L R_L$$

$$R_L \le \frac{V_z + V_{r_z}}{I_L} = \frac{10.4\text{ V}}{8\text{ mA}} = 1.3\text{ k}\Omega$$

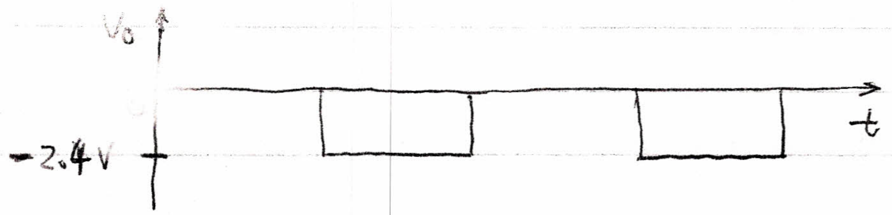
Problem 3

$V_I + 2 < -V_\gamma$ diode on $V_o = V_I + 2 + V_\gamma$

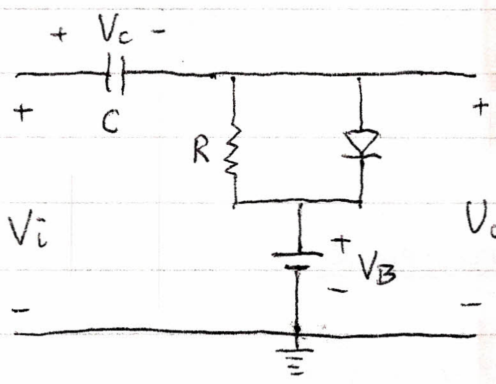
$V_I + 2 > -V_\gamma$ diode off $V_o = 0$

V_I 20V diode off $V_o = 0$

$V_I = -5V$ diode on $V_o = -5 + 2 + 0.6 = 2.4\ V$



Problem 4



When $V_i > V_B$, diode is on.

Capacitor is charging

$$V_{c,max} = V_{i,max} - V_B$$

$$= V_M - V_B$$

$V_c \simeq V_{c,max}$ due to very slow discharging

$$V_o(t) = V_i(t) - V_{c,max} = V_i(t) - V_M + V_B$$