EEE210B: Electronic Devices and Circuits   Wednesday, 10 February 2016

Second Quiz

REMARKS: 1. Hand held non-communicating calculator is allowed,

2. Closed book quiz,

3. Formula sheets are attached,

4. Marks distribution:
   Question #1:   6 points
   Question #2:   4 points

5. Justify all your answers.

# 1	
# 2	

1. The diode in the circuit of figure 1 is assumed ideal. The initial condition is $V_C(0) = 12$ V.

   (a) Show that the diode is initially reverse biased (behaves like an open-circuit at $t = 0$).

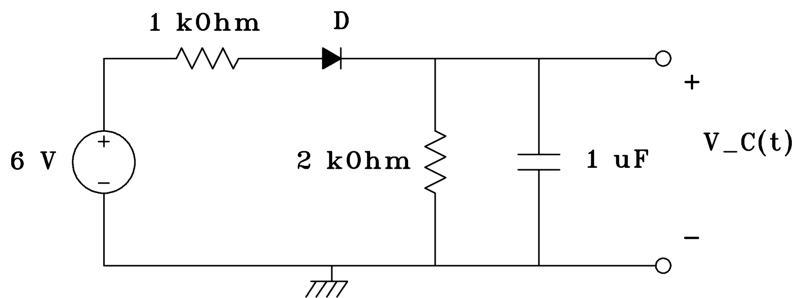   (b) Calculate the instant $t = t_p > 0$ at which the diode first becomes forward biased (short circuit).

Figure 1:

2. Consider the circuit of figure 2 in which D is a Zener diode with Zener voltage $V_{ZK} = 6.8$ V. Calculate the output voltage V_o for each of following conditions.

   (a) $V_i = 15$ V and $R_L = 50$ Ω,

   (b) $V_i = 20$ V and $R_L = 50$ Ω,

   (c) $V_i = 15$ V and $R_L = 100$ Ω,

   (d) $V_i = 20$ V and $R_L = 100$ Ω,

   (e) $V_i = 15$ V and $R_L = 25$ Ω.
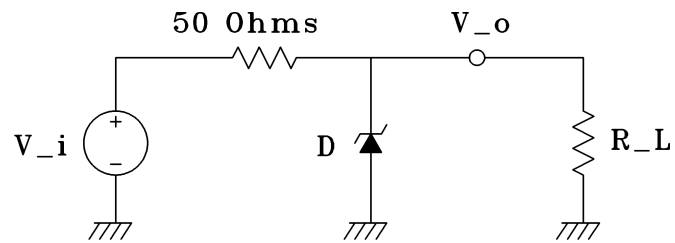
Figure 2:

END

Formula Sheets

$$\cos\theta = \sin(\theta + 90°)$$

$$2\cos u\cos v = \cos(u-v) + \cos(u+v)$$

$$2\sin u\sin v = \cos(u-v) - \cos(u+v)$$

$$2\sin u\cos v = \sin(u-v) + \sin(u+v)$$

$$2\sin\theta\cos\theta = \sin(2\theta)$$

$$2\cos^2\theta = 1 + \cos(2\theta)$$

$$2\sin^2\theta = 1 - \cos(2\theta)$$

$$\cos\theta = \frac{e^{j\theta} + e^{-j\theta}}{2}$$

$$\sin\theta = \frac{e^{j\theta} - e^{-j\theta}}{2j}$$

$$\frac{\omega}{2\pi}\int_{2\pi/\omega}\left(A\cos(\omega t + \phi)\right)^2 dt = \frac{A^2}{2}$$

$$T = \frac{1}{f} = \frac{2\pi}{\omega}$$

$$P = \frac{V^2}{R} = RI^2$$

$$v = Ri$$

$$i = C\frac{dv}{dt} \leftrightarrow v = \frac{1}{C}\int i\,dt$$

$$v = L\frac{di}{dt} \leftrightarrow i = \frac{1}{L}\int v\,dt$$

$$\mathbf{Z}_R = R$$

$$\mathbf{Z}_C = \frac{-j}{\omega C}$$

$$\mathbf{Z}_L = j\omega L$$

$$x_1 \| x_2 \| \ldots \| x_n = \left(\sum_{i=1}^{n}\frac{1}{x_i}\right)^{-1}$$

$$R_{eq} = (R_1 \| R_2) \Rightarrow R_1 = \left(R_{eq}\|(-R_2)\right)$$

$$v_{R_1}(t) = v(t)\frac{R_1}{R_1 + R_2}$$

$$i_{R_1}(t) = i(t)\frac{R_2}{R_1 + R_2}$$

$$q = Cv$$

$$v(\infty) + \left(v(0^+) - v(\infty)\right)e^{-t/\tau}$$

$$\tau = \begin{cases} R_{eq}C_{eq} \\ \\ L_{eq}/R_{eq} \end{cases}$$

$$I = I_s\left(e^{V/nV_T} - 1\right)$$

$$V_T = \frac{kT}{q}$$

$$k = 1.38 \times 10^{-23} \text{ joules/Kelvin}$$

$$q = 1.602 \times 10^{-19} \text{ Coulomb}$$

$$V_T \approx 25.2 \text{ mV at } 20\,°\text{C}$$

$$n \approx \begin{cases} 1 & \text{for Germanium} \\ 2 & \text{for Silicium} \end{cases}$$

$$R_{dynamic} = \frac{nV_T}{I_D + I_S} \approx \frac{nV_T}{I_D}$$

$$\begin{array}{c} V_{GS} > V_t \\ V_{DS} > V_{GS} - V_t \end{array}$$

$$\begin{array}{c} V_{GS} > V_t \\ 0 < V_{DS} < V_{GS} - V_t \end{array}$$

$$I_D = K\left(2(V_{GS} - V_t)V_{DS} - V_{DS}^2\right)$$

$$I_D = K\left(V_{GS} - V_t\right)^2$$

$$g_m = 2K(V_{GS} - V_t) \qquad\qquad\qquad V_{BE} < 0.7 \text{ V}$$

$$\begin{array}{ll} I_B > 0 & I_B > 0 \\ V_{CE} > 0.2 \text{ V} & 0 < I_C < \beta\,I_B \end{array}$$

$$I_C = \beta\,I_B \qquad\qquad\qquad h_{ie} \approx \frac{nV_T}{I_B} \ (n = 1 \text{ usually})$$

$$h_{fe} \approx \beta \qquad\qquad\qquad I_B = I_s\big(e^{V_{BE}/nV_T} - 1\big)$$

$$A_I = \frac{A_V\,Z_{in}}{R_L} \qquad\qquad\qquad A_P = A_V A_I$$

$$V_A - V_{CE} \approx (V_B - 0.7 \text{ V})\left(1 + \frac{R_C}{R_E}\right) \text{ if } R_B \ll \beta R_E \text{ and } \beta \gg 1$$

For the CMOS inverter:
$$NM_H = V_{oH} - V_{iH} \qquad\qquad NM_L = V_{iL} - V_{oL}$$
where
$$\left.\frac{\mathrm{d}V_o}{\mathrm{d}V_i}\right|_{V_i=V_{iL}} = -1 \text{ et } V_{iL} \equiv \text{logic } 0$$

$$\left.\frac{\mathrm{d}V_o}{\mathrm{d}V_i}\right|_{V_i=V_{iH}} = -1 \text{ et } V_{iH} \equiv \text{logic } 1$$