

Name: _____

College Number: _____

EEE210B: Electronic Devices and Circuits

Tuesday, 20 January 2015

First Quiz

- REMARKS:
1. Hand held non-communicating calculator is allowed,
 2. Closed book quiz,
 3. Formulae sheets are attached,
 4. Marks distribution:
 - Question #1: 4 points
 - Question #2: 3 points
 - Question #3: 3 points
 5. Justify all your answers.

# 1	
# 2	
# 3	

1. The diode in the circuit of figure 1 is assumed to be ideal. Calculate and sketch on a clearly labelled graph the input-output characteristic (V_o versus V_i) of the circuit.

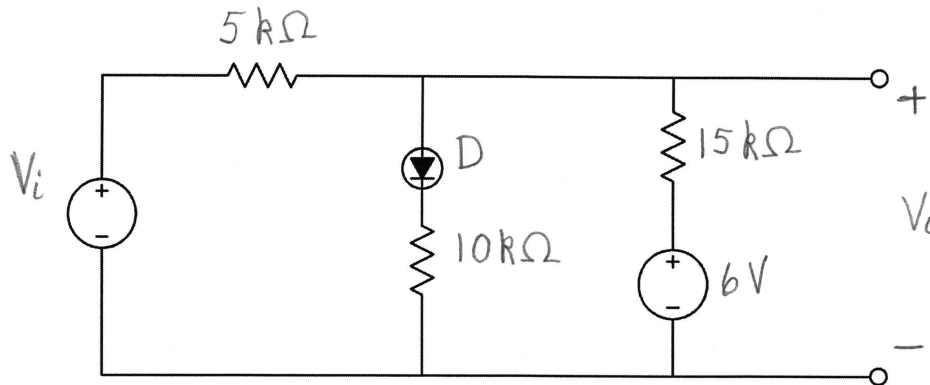


Figure 1:

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2. The current in the diode of the circuit of figure 2 is 10 mA.

(a) Calculate the voltage V_S of the source if the diode characteristic is given by:

$$I = I_S (e^{V/(nV_T)} - 1)$$

in which:

$$n = 2 \qquad V_T = 25.2 \text{ mV}$$

$$I_S = 1 \text{ nA} (= 10^{-9} \text{ A})$$

(b) Calculate the voltage V_S of the source if the diode is modelled as an ideal diode in series with a 0.7 V voltage source and a 15 Ω resistor.

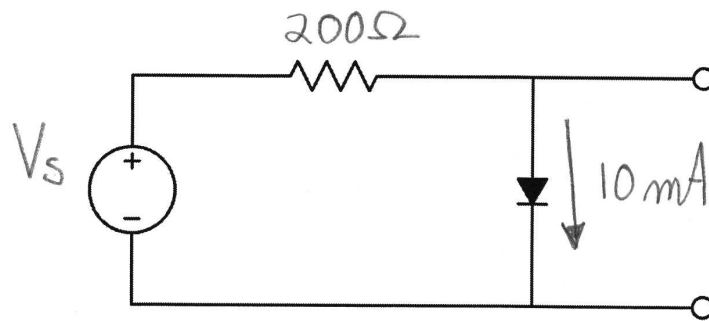


Figure 2:

3. Express $v_o(t)$ as a function of $v_i(t)$ and the components and parameters of the circuit in figure 3.

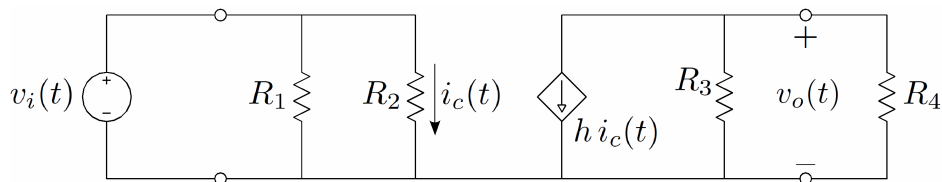


Figure 3:

END

Formula Sheets

$$\cos \theta = \sin(\theta + 90^\circ)$$

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

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

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

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

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

$$v = Ri$$

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

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

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

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

$$q = C v$$

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

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

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

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

$$0 < V_{DS} < V_{GS} - V_t$$

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

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

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

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

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

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

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

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

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

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

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

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

$$K_1 + K_2 e^{-t/\tau}$$

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

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

$$V_T \approx 25.2 \text{ mV at } 20^\circ \text{C}$$

$$\begin{aligned} V_{GS} &> V_t \\ V_{DS} &> V_{GS} - V_t \end{aligned}$$

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

$$g_m = 2K(V_{GS} - V_t)$$

Formula Sheets (continued)

$$V_{BE} < 0.7 \text{ V}$$

$$\begin{aligned} I_B &> 0 \\ V_{CE} &> 0.2 \text{ V} \end{aligned}$$

$$\begin{aligned} I_B &> 0 \\ 0 < I_C &< \beta I_B \end{aligned}$$

$$I_C = \beta I_B$$

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

$$h_{ie} \approx \frac{nV_T}{I_B} \quad (n = 1 \text{ usually})$$

$$h_{fe} \approx \beta$$

$$I_B = I_s (e^{V_{BE}/nV_T} - 1)$$

$$A_I = \frac{A_V Z_{in}}{R_L}$$

$$A_P = A_V A_I$$

For the CMOS inverter:

$$NM_H = V_{oH} - V_{iH} \quad NM_L = V_{iL} - V_{oL}$$

where

$$\left. \frac{dV_o}{dV_i} \right|_{V_i=V_{iL}} = -1 \text{ and } V_{iL} \equiv \text{logic 0}$$

$$\left. \frac{dV_o}{dV_i} \right|_{V_i=V_{iH}} = -1 \text{ and } V_{iH} \equiv \text{logic 1}$$

