Name: ____________________ College Number: ____________________

EEE210B: Electronic Devices and Circuits Friday, 14 February 2014

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: 5 points
   Question #2: 5 points
5. Justify all your answers.

# 1	
# 2	

1. The Zener voltage of the diode in the circuit of figure 1 is 2 V and the initial condition is $v_o(0) = 0$. As shown the input is

$$v_i(t) = 5u(t) \text{ V},$$

where as usual $u(t)$ denotes the unit step function. Calculate and sketch on a clearly labelled graph $v_o(t)$ for $0 \leq t \leq 50$ ms.

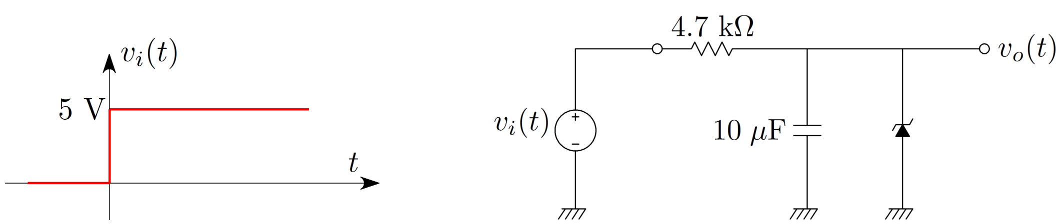

Figure 1:

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2. The parameters of the enhancement-type N-channel MOSFET in the circuit of figure 2 are $V_t = 1.4$ V and $K = 0.2$ mA/V^2. Calculate its Q-point.

   Hint: In the circuit with the component and parameter values shown, $V_{GS} > V_t \Rightarrow V_{DS} > V_{GS} - V_t$ (you need not show this).

   Suggestion: Firstly solve for I_D. You may use the equivalent model shown in figure 3 in which I_D is given by:

$$I_D = \begin{cases} 0 & ; \; V_{GS} < V_t \\ K(V_{GS} - V_t)^2 & ; \; V_{GS} > V_t \text{ and } V_{DS} > V_{GS} - V_t \\ K\big(2(V_{GS} - V_t)V_{DS} - V_{DS}^2\big) & ; \; V_{GS} > V_t \text{ and } V_{DS} < V_{GS} - V_t \end{cases}$$

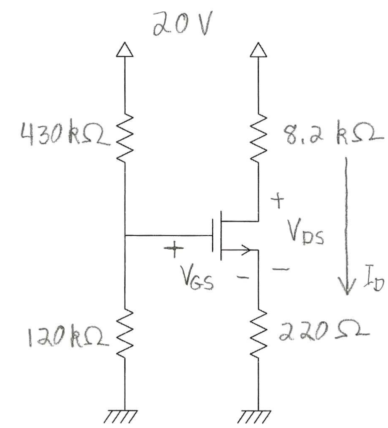

Figure 2:

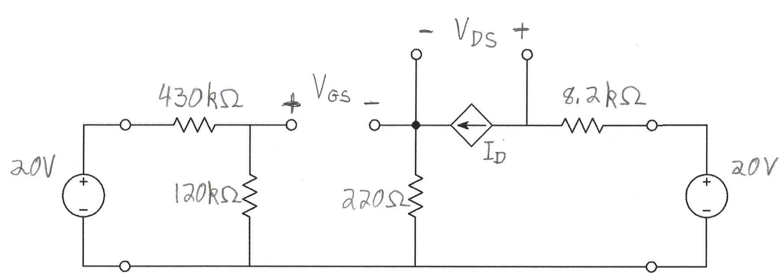

Figure 3:

END

Formula Sheets

$\cos\theta = \sin(\theta + 90°)$

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

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

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

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

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

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

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

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

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

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

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

$v = Ri$

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

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

$\mathbf{Z}_R = R$

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

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

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

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

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

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

$q = C\,v$

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

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

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

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

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

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

$V_T \approx 25.2$ mV at 20 °C

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

$V_{GS} < V_P$

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

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

$I_D = I_{DSS}\left(2\left(\frac{V_{GS}}{V_P} - 1\right)\left(\frac{V_{DS}}{V_P}\right) - \left(\frac{V_{DS}}{V_P}\right)^2\right)$

$I_D = I_{DSS}\left(1 - \frac{V_{GS}}{V_P}\right)^2$

$g_m = \frac{2I_{DSS}}{-V_P}\left(1 - \frac{V_{GS}}{V_P}\right)$

$V_{GS} < V_t$

Formulae Sheets (continued)

$$V_{GS} > V_t$$
$$V_{DS} > V_{GS} - V_t$$

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

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

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

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

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

$$I_B > 0$$
$$V_{CE} > 0.2 \text{ V}$$

$$I_B > 0$$
$$0 < I_C < \beta\, I_B$$

$$I_C = \beta\, I_B$$

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

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

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

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

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

$$A_P = A_V A_I$$