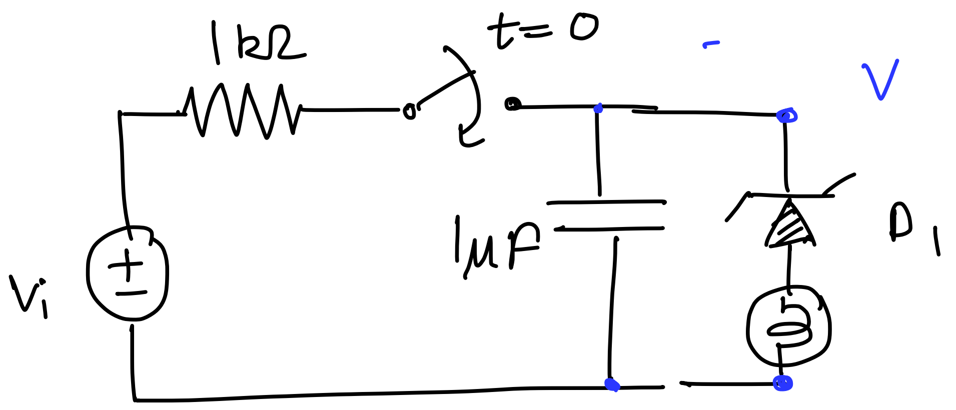
Endsem 2019



a) $V_i = -8\,V$

$V_{c,ss} = -0.7\,V$

Initially bulb is off and remains off until voltage on capacitor reaches $-0.7\,V$.

$$0.7 = 8\left(1-e^{-t/RC}\right)$$

$$t = RC \ln\left(1-\frac{0.7}{8}\right)$$

$$= 0.09\text{ ms}$$

Bulb glows for $t \geq 2.77\text{ ms}$

b) $V_i = 4\,V$

since $V_b = 6$, $V < V_b$

$\Rightarrow$ Bulb never glow.

$V_{c,ss} = 4\,V$

c) $V_i = 8V$ $\quad V_{c,ss} = 6V$

Bulb glows when voltage on capacitor builds upto 6V.

$$6 = 8(1 - e^{-t/RC})$$

$$t = RC\ln(4)$$

Bulb glows for $t \geq 1.386$ ms

<u>Q2</u>. <u>Quiz 2</u> Q2

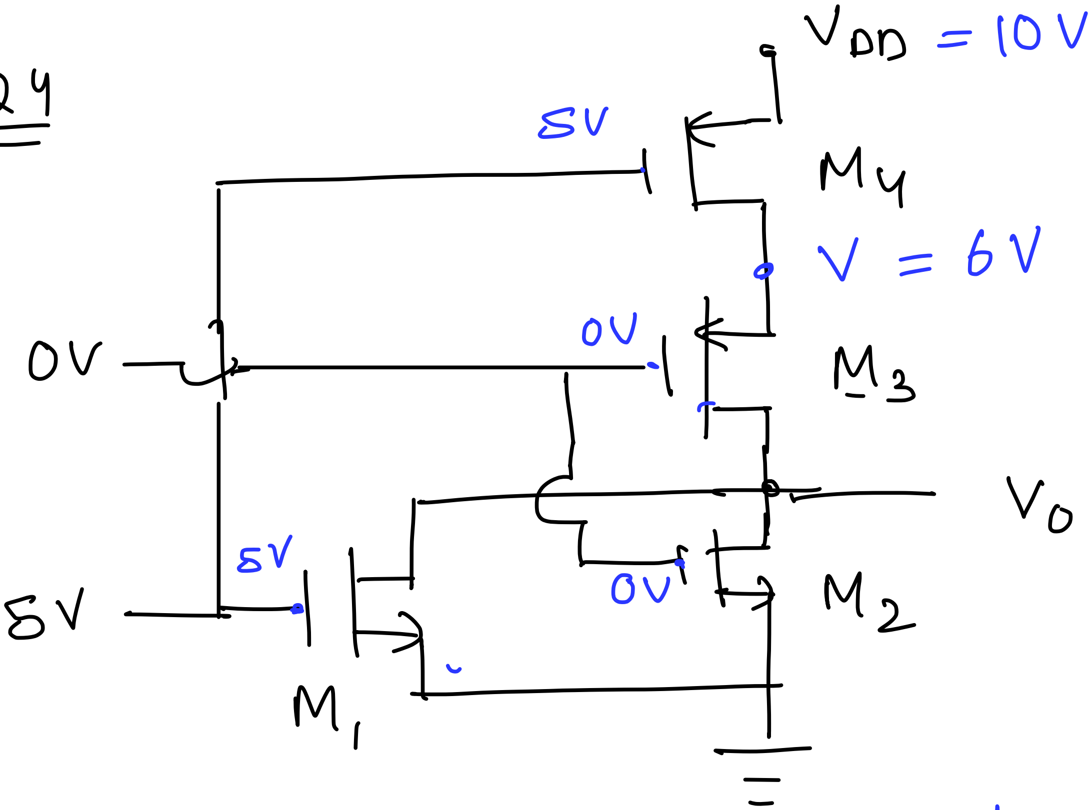
<u>Q3</u> Tutorial <u>8</u> Q5

$i' = \frac{6-0.9}{5} - \frac{(0.9+6)}{65} = 0.9138$ mA , $i = 6-0.2 = 5.8$ mA

$\beta i_B > i_N' + i_R \Rightarrow 100\times 0.124 > N \times 0.9138 + 5.8$

$N < 7.22 \Rightarrow$ fan-out $= 7$

Q4



M_1, M_3 active , M_4 ohmic

M_2 is OFF $\rightarrow (V_{GS2} = 0) \Rightarrow i_2 = 0$

$i_1 = i_3 = i_4$

$i_1 = K(5-1)^2 = K(4^2)$

$i_3 = K(-V+1)^2 \Rightarrow V = 6V$

$V_{GS4} = -5$

$i_4 = K(2(-4)(V-10) - (V-10)^2)$

$= K(16)$

$V_{DS1} > V_{GS1} - V_T$

$\Rightarrow \quad V_o > 4V$

$V_{DS3} < V_{GS3} - V_T = -5V$

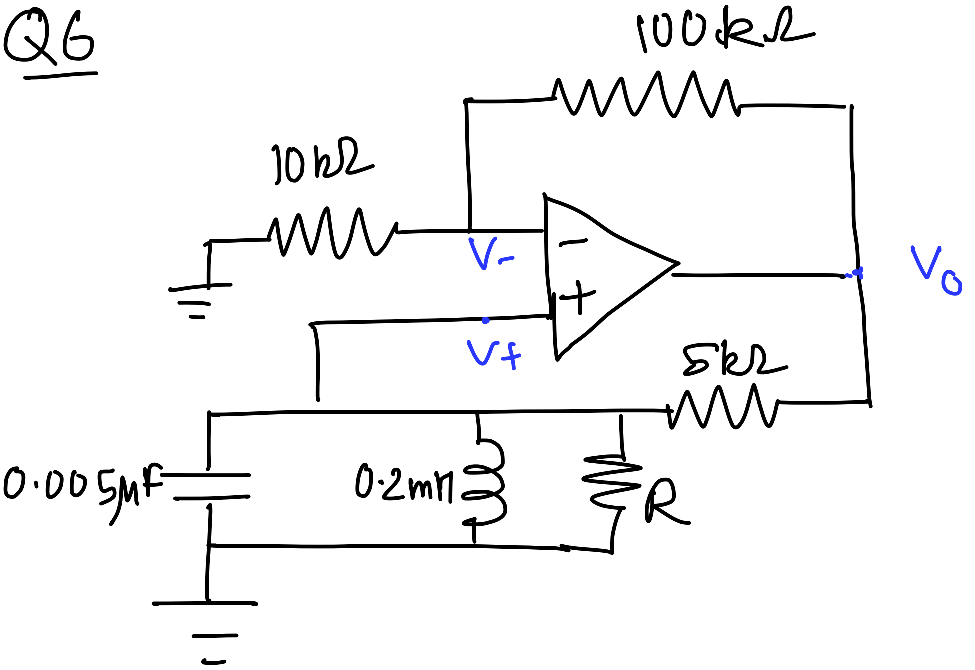
$V_o - 6V < -5V$

$V_o < 1V$

Contradiction ?!

If M_3, M_4 are switched, some information will be missing

Q6



Assume Virtual short $V_- = V_+$

$$\frac{V_o - V_-}{100} = \frac{V_-}{10} \Rightarrow V_o = 11V_-$$

$$\frac{10V_+}{5} = \frac{V_o - V_+}{5} = \frac{V_+}{|Z_{eq}|} \Rightarrow |Z_{eq}| = \frac{1}{2} \times 10^3$$

$$\frac{1}{|Z_{eq}|^2} = 4 \times 10^{-6} = \frac{1}{R^2} + \left|\omega C - \frac{1}{\omega L}\right|^2$$

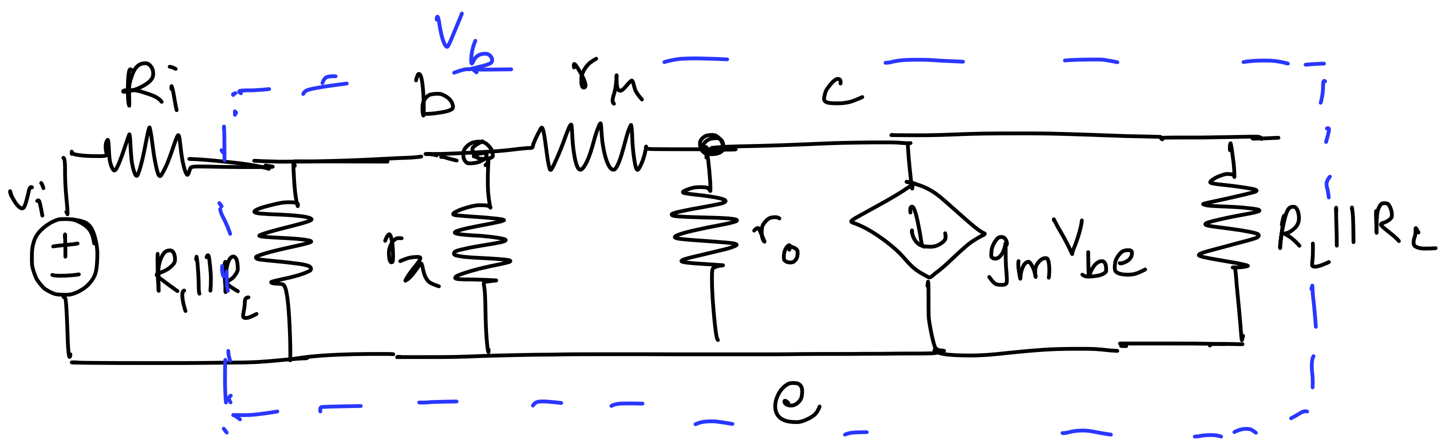
$$\Rightarrow \frac{1}{R^2} \leq 4 \times 10^{-6} \Rightarrow R \geq 500\Omega$$

At $R = 500\Omega$,

$$\omega = \frac{1}{\sqrt{LC}} = 10^6 \text{ rad/s}$$

Q7.

small signal model



$$\frac{V_b - V_c}{r_\mu} = \frac{V_c}{r_o \| R_L \| R_c} + g_m V_b$$

$$A_v = \frac{V_c}{V_b} = \left(\frac{1}{\frac{1}{r_\mu} + \frac{1}{r_o \| R_L \| R_c}} \right) \left(\frac{1}{r_\mu} - g_m \right)$$

$$= (r_\mu \| r_o \| R_L \| R_c) \left(\frac{1}{r_\mu} - g_m \right)$$

Finding R_{in} $\quad V_{oc} = 0$

connect V.

$$i = \frac{V}{R_1 \| R_2} + \frac{V}{r_\pi} + \frac{V - V_c}{r_\mu}$$

$$= \frac{V}{R_1 \| R_2} + \frac{V}{r_\pi} + \frac{V - A_v V}{r_\mu}$$

$$R_{in} = \frac{V}{I} = R_1 \| R_2 \| r_\pi \| \frac{r_\mu}{(1 - A_v)}$$

$$\frac{V_i - V_b}{R_i} = \frac{V_b}{R_1 \| R_2} + \frac{V_b}{r_\pi} + \frac{V_b - V_c}{r_\mu}$$

$$\frac{V_i}{R_i} = V_b \left(\frac{1}{R_i \| R_1 \| R_2 \| r_\pi \| \frac{r_\pi}{1 - A_v}} \right)$$

$$\frac{V_i}{R_i} = V_b \left(\frac{1}{R_i \| R_{in}} \right)$$

$$V_i = V_b \left(\frac{R_i + R_{in}}{R_{in}} \right)$$

$$A_{vs} = \frac{V_c}{V_i} = \frac{V_c}{V_b} \cdot \frac{V_b}{V_i} = A_v \frac{R_{in}}{R_i + R_{in}}$$