رضا ادیب پور
۹۸۱۴۳۰۴
سری دوم تمرینات الکترونیک ۱

#1 a) $\begin{cases} N_D = 2\times10^{14}\ cm^{-3} \\ T = 300\,K \\ n_i = 1.66\times10^{15}\times T^{\frac{3}{2}}\times e^{\frac{-E_g}{2KT}}\ cm^{-3} \end{cases}$

$\Rightarrow n_i = 1.66\times10^{15}\times 300^{\frac{3}{2}}\times e^{\frac{0.66\times1.6\times10^{-19}}{2(1.38\times10^{-23})\times300}} = 2.5\times10^{13}\ cm^{-3}$

$\Rightarrow n = n_i + N_D = 0.25\times10^{14} + 2\times10^{14} = 2.25\times10^{14}$

$n_p = n_i^2 \Rightarrow p = \frac{n_i^2}{n} = \frac{(2.5\times10^{13})^2}{2.25\times10^{14}} = 2.7\times10^{12}\ cm^{-3}$

b) $\sigma_I = q n_i(\mu_n+\mu_p)$, $\sigma_N = q\left(n\mu_n + (\frac{n_i^2}{n})\mu_D\right)$

$\Rightarrow \frac{\sigma_N}{\sigma_I} = \frac{n\mu_n + (\frac{n_i^2}{n})\mu_D}{n_i(\mu_n+\mu_D)} = \frac{2.25\times10^{14}\times3800 + 2.7\times10^{12}\times1800}{2.5\times10^{13}(1800+3800)} = \underline{6.12}$

#2 $\begin{cases} I_S = ? \\ \eta = 2 \\ I_D = 5 \end{cases}$ $\Rightarrow I_D = I_S\left(e^{\frac{V_D}{\eta V_T}} - 1\right) \Rightarrow 5 = I_S\left(e^{\frac{100}{2\times26}} - 1\right)$

$\Rightarrow I_S = 0.86\ mA$

#3 a) $n_i = (1.66\times10^{15})\times400^{\frac{3}{2}}\times e^{\frac{1.1\times1.6\times10^{-19}}{2(1.38\times10^{-23})\times400}} = 3\times10^{13}\ cm^{-3}$

$n = N_D = 10^{17}$, $n_p = n_i^2 \Rightarrow p = \frac{n_i^2}{N_D} = \frac{(3\times10^{13})^2}{10^{17}} = 9\times10^{9}\ cm^{-3}$

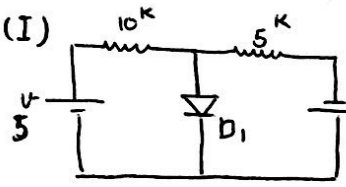
b) $\rho = \frac{1}{q(\mu_n n + \mu_p p)} = \frac{1}{1.66\times10^{-19}(1300\times10^{17} + 500\times9\times10^{9})} \simeq 0.5$

c) $R_2 = \frac{L}{h\omega q(n\mu_n + p\mu_p)} = \frac{0.1}{10^{-3}\times10^{-2}\times1.66\times10^{-19}(1300\times10^{17}+500\times9\times10^{9})} \simeq 5\times10^{3}\ \Omega$

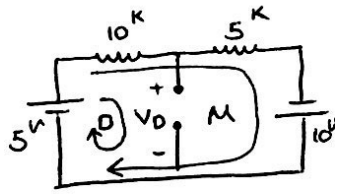
$R_T = R_1 + R_2 = 6\ k\Omega$, $V_D = 10^{V} \Rightarrow I = \frac{V_D}{R_T} = \frac{10}{6\times10^{3}} = 1.6\times10^{-3}\ A$

#4 a) ideal diodes :

(I)



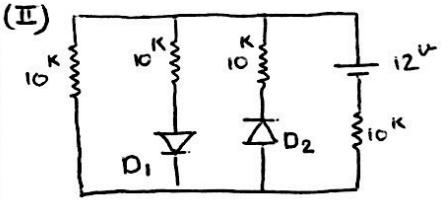
$\Rightarrow$ if D_1 : off $\rightarrow V_D < 0 \rightarrow$ ——— (oc)



KVL@M : $-5 + 10^K \times I + 5^K \times I - 10 = 0 \Rightarrow I = 1mA$, KVL@D : $-5 + 10 \times 1 + V_D = 0$

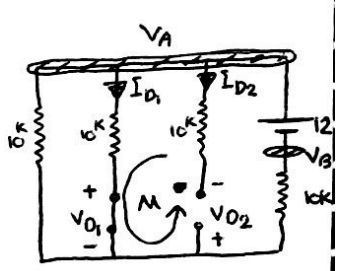
$\Rightarrow V_D = -5^V < 0$ ✓ , $\underline{I_D = 0}$

(II)



if $\begin{cases} D_1 : ON \rightarrow I_D > 0 \rightarrow$ ——— (SC) $\\ D_2 : off \rightarrow V_D < 0 \rightarrow$ ——— (oc) $\end{cases}$

$\Rightarrow$



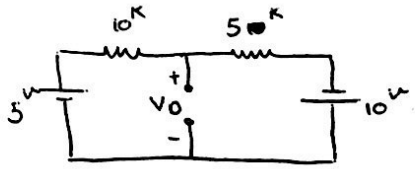
KCL@VA, VB : $\frac{V_A}{10} + \frac{V_A}{10} + \frac{V_A}{10}^{0} + \frac{V_B}{10} = 0 \Rightarrow \frac{V_A}{5} + \frac{V_B}{10} = 0$ (I)

$V_A - V_B = 12$ (II) $\xrightarrow{(II)\ in\ (I)} \frac{V_A}{5} + \frac{V_A - 12}{10} = 0 \Rightarrow \underline{V_A = \frac{12}{3} = 4^V}$, $\underline{V_B = V_A - 12 = 4 - 12 = -8}$

$\Rightarrow \underline{I_{D_1} = \frac{V_A}{10^K} = \frac{4}{10^K} = \frac{2}{5} mA > 0}$ ✓ , $\underline{I_{D_2} = 0}$, KVL@M : $I_{D_1} \times 10^K + V_{D_2} + I_{D_2} \times 10^K = 0$ ($I_{D_2} = 0$)

$\Rightarrow \underline{V_{D_2} = -4 < 0}$ ✓

b) Constant Voltage source : ($V_{D,on} = 0.7^V$)

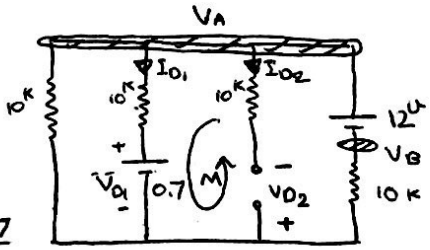


(I) if D_1 : off $\rightarrow V_D < V_{D,ON} \rightarrow$ ——— (oc)

ایده‌آل از مقدمه‌ها می‌دانیم : $V_D = -5^V < V_{D,ON}$ ✓ , $\underline{I_{D_1} = 0^A}$

II) if $\begin{cases} D_1 : ON \rightarrow I_{D_1} > 0 \rightarrow$ —|— 0.7 $\\ D_2 : off \rightarrow V_D < V_{D,ON} \rightarrow$ ——— (oc) $\end{cases}$

$\Rightarrow$



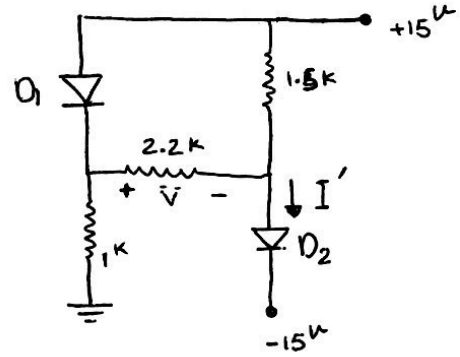
KCL@VA, VB : $\frac{V_A}{10} + \frac{V_A - 0.7}{10} + \frac{V_A}{10}^{0} + \frac{V_B}{10} = 0 \Rightarrow \frac{V_A}{5} + \frac{V_B}{10} = \frac{0.7}{10}$ (I)

$V_A - V_B = 12$ (II) $\xrightarrow{(II)\ in\ (I)} \frac{V_A}{5} + \frac{V_A - 12}{10} = \frac{0.7}{10} \Rightarrow \frac{3V_A}{10} = \frac{12.7}{10} \Rightarrow V_A = \frac{12.7}{3} \simeq 4.2\overline{3}$

$V_B = 4.23 - 12 = -7.76$, $I_{D_1} = \frac{V_A - 0.7}{10} = \frac{4.23 - 0.7}{10} = 0.353 > 0$ ✓

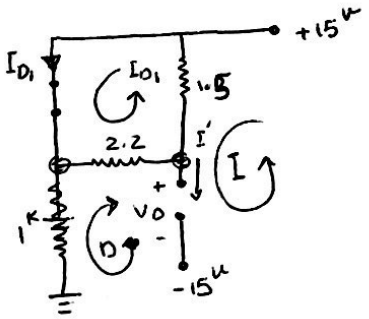
$I_{D_2} = 0 \rightarrow$ KVL@M : $10 I_{D_1} + 0.7 + V_{D_2} + 10 I_{D_2}^{0} = 0 \Rightarrow V_{D_2} = -4.23 < V_{D,on}$ ✓

#5 I)



if $\begin{cases} D_1: ON \rightarrow I_{D_1} > 0 \rightarrow \text{—•—} \ (SC) \\ D_2: off \rightarrow V_{D_2} < 0 \rightarrow \text{—• •—} \ (OC) \end{cases}$

$\Rightarrow$



KVL @ I_{D_1}: $2.2(I_{D_1} - I) + 1.5(I_{D_1} - I) = 0$

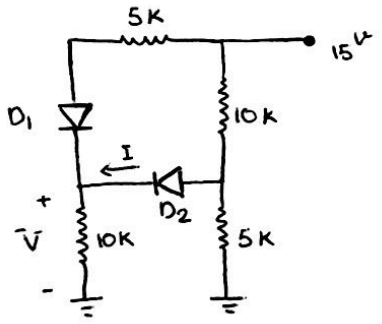
$\Rightarrow 3.7 I_{D_1} = 3.7 I \Rightarrow \underline{I_{D_1} = I}$ (I) , KVL @ I: $1.5(I - I_{D_1}) + 2.2(I - I_{D_1}) + I - 15 = 0$ (II)

$\xrightarrow[(II)]{(I) in} I_s - 15 = 0 \Rightarrow \underline{I = 15} \xrightarrow{I = I_{D_1}} \underline{I_{D_1} = 15} > 0$ ✓

KVL @ D: $2.2(I - I_{D_1}) + 1 \times 15 + V_{D_2} = 0 \Rightarrow V_{D_2} = -15 < 0$ ✓

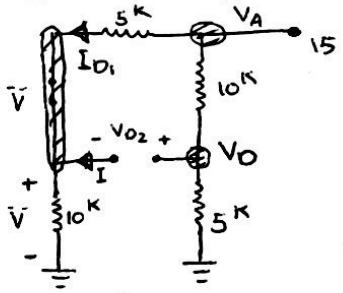
$\Rightarrow \begin{cases} I' = 0 \\ V = 15 - (-V_{D_2}) = 30^V \end{cases}$

II)



if $\begin{cases} D_1: ON \rightarrow I_{D_1} > 0 \rightarrow \text{———} \ (SC) \\ D_2: off \rightarrow V_{D_2} < 0 \rightarrow \text{—• •—} \ (OC) \end{cases}$

$\Rightarrow$



KCL @ V: $\frac{V-0}{10} + \frac{V-15}{5} = 0$

$\Rightarrow \frac{3V}{10} = 3 \Rightarrow \underline{V = 10}$

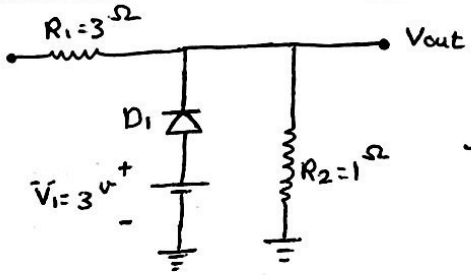
KCL @ V_D: $\frac{V_D - 0}{5} + \frac{V_D - 15}{10} = 0$

$\Rightarrow \frac{3V_D}{10} = 1.5 \Rightarrow \underline{V_D = 5}$

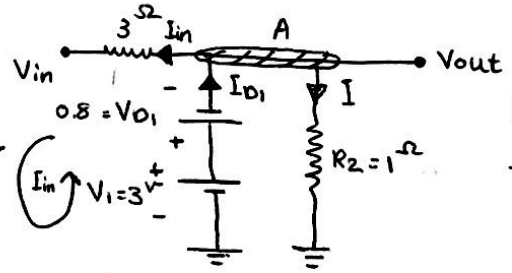
$\Rightarrow V_{D_2} = V_{(+)} - V_{(-)} = V_D - V = 5 - 10 = -5 < 0$ ✓

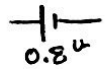
$I_{D_1} = \frac{V_A - V}{5} = \frac{15 - 10}{5} = 1 > 0$ ✓ , $\underline{I = 0}$

#6



a)



if $D_1: ON \rightarrow I_{D_1} > 0$ $\rightarrow$ 

KCL @ A: $-I_{D_1} + I_{in} + I = 0$ (*) , $I = \frac{V_A - 0}{1} = \frac{(3 - 0.8) - 0}{1} = \underline{2.2}$

KVL @ I_{in}: $+V_{in} - 3 + 0.8 + 3 \times I_{in} = 0 \xrightarrow{(*)} +V_{in} - 2.2 + 3(I_{D_1} - I_1) = 0$

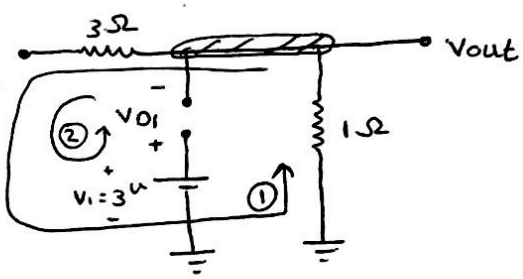
$\Rightarrow V_{in} - 2.2 + 3 I_{D_1} - 3 I_1 = 0 \xrightarrow{I_1 = 2.2} V_{in} - 2.2 + 3 I_{D_1} - 6.6 = 0 \Rightarrow I_{D_1} = \frac{1}{3}(8.8 - V_{in}) > 0$

$\Rightarrow V_{in} < 8.8$, if $V_{in} < 8.8 \rightarrow I_{D_1} > 0 \rightarrow D_1: ON$

#6 ادامه : input-output characteristic = ?

در قسمت قبل بدست آوردیم که :

$$\boxed{V_{in} < 8.8 \rightarrow I_{D_1} > 0 \rightarrow D_1 : ON \rightarrow V_{out} = 2.2}$$



if D_1 : off $\rightarrow V_{D_1} < 0 \rightarrow$ — o— (oc)

KVL @ ① : $+V_{in} + 1 \times I_{in} + 3 \times I_{in} = 0 \Rightarrow I_{in} = \frac{-1}{4} V_{in}$ (I)

KVL @ ② : $+V_{in} - 3 + V_{D_1} + 3 \times I_{in} = 0$ (II)

(I) in (II) $\rightarrow V_{in} - 3 + V_{D_1} + 3\left(\frac{-V_{in}}{4}\right) = 0 \Rightarrow V_{D_1} = 3 - \frac{1}{4} V_{in} < 0 \Rightarrow V_{in} > 12$

KCL @ Vout : $\frac{V_{out} - 0}{1} + \frac{V_{out} - V_{in}}{3} = 0 \Rightarrow 4V_{out} = V_{in} \Rightarrow V_{out} = \frac{1}{4} V_{in}$

$$\Rightarrow \boxed{V_{in} > 12 \rightarrow V_{D_1} < 0 \rightarrow D_1 : off \rightarrow V_{out} = \frac{1}{4} V_{in}}$$