رضا امیری پور

۹۸۱۴۳۷۵۳

تمرین سری سوم آنالوگ ۱

#1

$$\Rightarrow \widehat{1f} \begin{cases} D_1 : ON \longrightarrow I_{D_1} > 0 \longrightarrow \multimap\!\!\bullet\!\!\bullet \quad (SC) \\ D_2 : off \longrightarrow V_{D_2} < 0 \longrightarrow \multimap\!\!\bullet\ \bullet\!\!\multimap \quad (OC) \end{cases}$$

KVL @ I_{D_1} : $-V_{in} + 20^k \times I_{D_1} + 10 = 0 \Rightarrow 20 I_{D_1} = V_{in} - 10$

$$\Rightarrow I_{D_1} = \frac{V_{in}}{20} - 0.5 > 0 \Rightarrow V_{in} > 10$$

$$\Rightarrow \boxed{\text{if } D_1 : ON \longrightarrow V_{in} > 10} \quad (I)$$

KVL @ I_{D_1}, I_{D_2} : $-V_{in} + V_{D_2} + 30^k \times I_{D_2} + 60 = 0 \Rightarrow V_{D_2} = V_{in} - 60 < 0 \Rightarrow V_{in} < 60$

$$\Rightarrow \boxed{\text{if } D_2 : off \longrightarrow V_{in} < 60} \quad (II) \quad \xrightarrow{(I) \cap (II)} \quad \text{if} \begin{cases} D_1 : ON \\ D_2 : off \end{cases} \longrightarrow 10 < V_{in} < 60$$
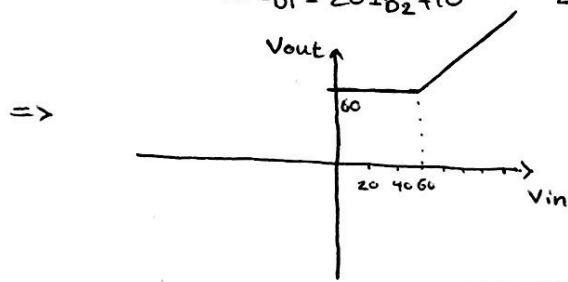
$$\Rightarrow V_{out} = 60 + 30 \times I_{D_2} = 60^u \Rightarrow \boxed{10 < V_{in} < 60 \longrightarrow \begin{cases} D_1 : ON \\ D_2 : off \end{cases} \longrightarrow V_{out} = 60^u}$$

$$\Rightarrow \frac{V_{out}}{V_{in}} = \frac{60}{V_{D_2} + 60}$$

$$\widehat{1f} \begin{cases} D_1 : off \\ D_2 : off \end{cases} \longrightarrow V_{D_1}, V_{D_2} < 0 \Rightarrow$$

KVL @ I_{D_1} : $-V_{in} + V_{D_1} + 20 I_3 + 10 = 0$

$$\Rightarrow V_{D_1} = V_{in} - 10 < 0$$

$$\Rightarrow V_{in} < 10$$

$$\Rightarrow \boxed{\text{if } D_1 : off \Rightarrow V_{in} < 10}$$

KVL @ I_{D_2} : $+V_{D_2} + 30 I_{D_2} + 60 - 10 + 20(-I_3) = 0 \Rightarrow V_{D_2} = -50$

$$\Rightarrow V_{out} = 60 + 30 I_{D_2} = 60^u \quad , \quad \boxed{V_{in} < 10 \longrightarrow D_1, D_2 : off \longrightarrow V_{out} = 60^u}$$

$$\Rightarrow \frac{V_{out}}{V_{in}} = \frac{60}{V_{D_1} + 10}$$

$$\widehat{1f} \begin{cases} D_1 : ON \\ D_2 : ON \end{cases} \longrightarrow I_{D_1}, I_{D_2} > 0 \Rightarrow$$

KVL @ I_{D_1}, I_{D_2} : $-V_{in} + 30 I_{D_2} + 60 = 0$

$$30 I_{D_2} = V_{in} - 60 \Rightarrow I_{D_2} = \frac{V_{in}}{30} - 2 > 0$$

$$\Rightarrow V_{in} > 60 \Rightarrow \boxed{\text{if } D_2 : ON \rightarrow V_{in} > 60} \quad (I)$$

KVL @ I_{D_2} : $30 I_{D_2} + 60 - 10 + 20(I_{D_2} - I_{D_1}) = 0 \Rightarrow 50\left(\frac{V_{in}}{30} - 2\right) - 20 I_{D_1} = -50$
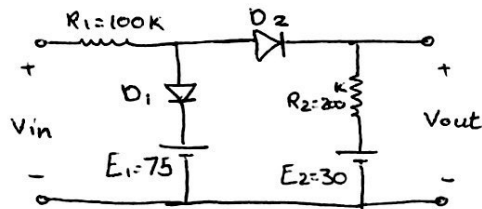
$$\Rightarrow 20 I_{D_1} = \frac{5}{3} V_{in} - 50 \Rightarrow I_{D_1} = \frac{1}{12} V_{in} - 2.5 > 0 \Rightarrow V_{in} > 30 \Rightarrow \boxed{\text{if } D_2 : ON \rightarrow V_{in} > 30} \quad (II)$$

$$\xrightarrow{(I) \cap (II)} V_{in} > 60 \quad , \quad \boxed{V_{in} > 60 \longrightarrow D_1, D_2 : ON \longrightarrow V_{out} = 60 + 30 I_{D_2}}$$
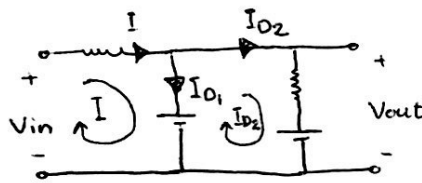
$$\Rightarrow \frac{V_{out}}{V_{in}} = \frac{60 + 30\,I_{D2}}{20\,I_{D1} - 20\,I_{D2} + 10} = \frac{6 + 3\,I_{D1}}{2\,I_{D1} - 2\,I_{D2} + 1}$$

$\Rightarrow$

(graph: Vout vs Vin, horizontal line at 60, rising line after, markings 20 40 60)

#2

(circuit: $R_1 = 100K$, D_2, D_1, $R_2 = 200K$, V_{in}, $E_1 = 75$, $E_2 = 30$, Vout)

$\Rightarrow$ ⓕ $\begin{cases} D_1 : ON \rightarrow I_{D1} > 0 \rightarrow \text{—•—} \ (SC) \\ D_2 : ON \rightarrow I_{D2} > 0 \rightarrow \text{—•—} \ (SC) \end{cases}$

(circuit: I, I_{D2}, I_{D1}, I_{D2}, Vin, Vout)

KVL @ I_{D2} : $200\,I_{D2} + 30 - 75 = 0 \Rightarrow \underline{I_{D2} = 0.225}$

KVL @ I : $-V_{in} + 100\,I + 75 = 0 \xrightarrow{I = I_{D1} + I_{D2}} -V_{in} + 100(I_{D1} + I_{D2})$

$+ 75 = 0 \Rightarrow 100\,I_{D1} = V_{in} - 97.5 \Rightarrow I_{D1} = \frac{V_{in}}{100} - \frac{97.5}{100} > 0$

$V_{out} = 30 + 200 \times 0.225 = \boxed{75}$ $\Rightarrow V_{in} > 97.5$; $\boxed{V_{in} > 97.5 \rightarrow D_1, D_2 : ON \rightarrow V_{out} = 75}$

ⓕ $\begin{cases} D_1 : off \rightarrow V_{D1} < 0 \rightarrow \text{—○—} \ (OC) \\ D_2 : ON \rightarrow I_{D2} > 0 \rightarrow \text{—•—} \ (SC) \end{cases}$ $\Rightarrow$ (circuit: I_{D2}, I_{D2}, Vin, I_{D1}, V_{D1}, I_{D2})
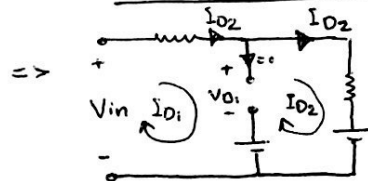
KVL @ I_{D2} : $-V_{in} + 100\,I_{D2} + 200\,I_{D2} + 30 = 0 \Rightarrow I_{D2} = \frac{V_{in}}{300} - \frac{30}{300} > 0 \Rightarrow \underline{V_{in} > 30} \ (I)$

KVL @ I_{D1} : $-V_{in} + 100\,I_{D2} + V_{D1} + 75 = 0 \Rightarrow -V_{in} + 100\left(\frac{V_{in}}{300} - \frac{30}{300}\right) + V_{D1} + 75 = 0$

$\Rightarrow V_{D1} = \frac{2}{3}V_{in} - 65 < 0 \Rightarrow \boxed{V_{in} < 97.5} \ (II) \xrightarrow{(I) \cap (II)} \boxed{30 < V_{in} < 97.5}$

$\Rightarrow V_{out} = 30 + 200\,I_{D2}$, $\boxed{30 < V_{in} < 97.5 \rightarrow \begin{cases} D_1 : off \\ D_2 : ON \end{cases} \rightarrow V_{out} = 30 + 200\,I_{D2}}$

ⓕ $\begin{cases} D_1 : off \rightarrow V_{D1}, V_{D2} < 0 \\ D_2 : off \end{cases}$ $\Rightarrow$ (circuit: $+V_{02}-$, V_{01}, Vin, I_{D1}, I_{D2})
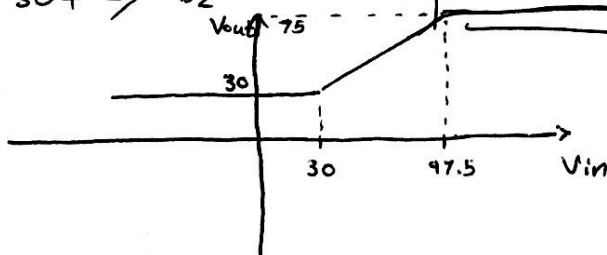
KVL @ I_{D2} : $+V_{02} + 30 - 75 - V_{01} = 0$

$\Rightarrow \boxed{V_{D2} - V_{D1} = 45}$
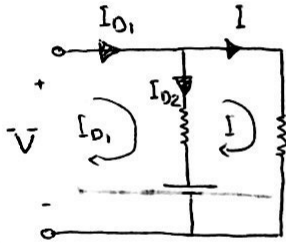
KVL @ I_{D1} : $-V_{in} + V_{01} + 75 = 0$

$\Rightarrow V_{01} = V_{in} - 75 < 0 \Rightarrow V_{in} < 75$; $\boxed{\text{ⓕ } D_1 : off \rightarrow V_{in} < 75} \ (I)$

$\Rightarrow V_{D2} - V_{in} + 75 = 45 \Rightarrow V_{D2} = V_{in} - 30 < 0 \Rightarrow \boxed{V_{in} < 30} \ (II) \xrightarrow{(I) \cap (II)} \boxed{V_{in} < 30}$

$V_{out} = 30 + 200\,I_{D2} = 30$; $\boxed{V_{in} < 30 \rightarrow \begin{cases} D_1 \\ D_2 \end{cases} : off \rightarrow V_{out} = 30}$

(graph: Vout vs Vin, horizontal at 30, rising, level 75; markings 30, 97.5)

#3

$\textcircled{1}$ $\begin{cases} D_1 : ON \\ D_2 : ON \end{cases} \longrightarrow I_{D_1}, I_{D_2} > 0 \longrightarrow \multimap \text{(sc)}$

$\overbrace{\qquad}^{*}$

KVL @ I_{D_1} : $-\bar{V} + 3 I_{D_2} + 5 = 0 \Rightarrow I_{D_2} = \frac{\bar{V}}{3} - \frac{5}{3} > 0 \Rightarrow \underline{\bar{V} > 5}$ (I)

KVL @ I : $6I - 5 + 3(I - I_{D_1}) = 0 \quad \dfrac{I = I_{D_1} - I_{D_2}}{I_{D_2} = \frac{\bar{V}}{3} - \frac{5}{3}} \rightarrow$

$= 6(I_{D_1} - I_{D_2}) - 5 + 3(I_{D_1} - I_{D_2} - I_{D_1}) = 0 \Rightarrow 6 I_{D_1} - 9 I_{D_2} - 5 = 0$

$\Rightarrow 6 I_{D_1} - 9\left(\frac{\bar{V}}{3} - \frac{5}{3}\right) - 5 = 0 \Rightarrow 6 I_{D_1} = 3\bar{V} - 10 \Rightarrow I_{D_1} = \frac{1}{2}\bar{V} - \frac{5}{3} >$

$\Rightarrow \underline{\bar{V} > \frac{10}{3}}$ (II) $\xrightarrow{\text{(I)} \cap \text{(II)}} \underline{\bar{V} > 5}$

$\Rightarrow$ KVL @ I, I_{D_1} : $-\bar{V} + 6I = 0 \Rightarrow \underline{I = \frac{\bar{V}}{6}} \xrightarrow{*} -\bar{V} + 3\left(I_{D_1} - \frac{\bar{V}}{6}\right) + 5 = 0$

$\Rightarrow 3 I_{D_1} = \frac{3}{2}\bar{V} - 5 \Rightarrow \underline{I_{D_1} = i = \frac{1}{2}\bar{V} - \frac{5}{3}} \quad ; \quad \overline{\bar{V} > 5 \rightarrow \begin{cases} D_1 : ON \\ D_2 : ON \end{cases} \rightarrow i = \frac{1}{2}\bar{V} - \frac{5}{3}}$
$\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad *$

$\textcircled{2}$ $\begin{cases} D_1 : \text{off} \\ D_2 : \text{off} \end{cases} \longrightarrow V_{D_1}, V_{D_2} < 0 \longrightarrow$

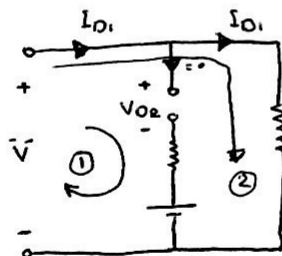KVL @ I : $-\bar{V} + I + 6I = 0 \Rightarrow \bar{V} = 7I \Rightarrow I = \frac{\bar{V}}{7} *$

KVL @ I_{D_1} : $-\bar{V} + V_{D_1} + 6 \times I_{D_1} = 0 \Rightarrow V_{D_1} = \bar{V} - 6I \xrightarrow{*} V_{D_1} = \bar{V} - \frac{6}{7}\bar{V} = \frac{1}{7}\bar{V} < 0$

$\Rightarrow \underline{\bar{V} < 0}$ (I) $\quad ; \quad$ KVL @ I_{D_2} : $-\bar{V} + I + V_{D_2} + 5 = 0 \xrightarrow{*} V_{D_2} = \frac{6}{7}\bar{V} - 5 < 0$

$\Rightarrow \underline{\bar{V} < \frac{35}{6} \approx 5.8}$ (II) $\xrightarrow{\text{(I)} \cap \text{(II)}} \underline{\bar{V} < 0} \Rightarrow I = \frac{\bar{V}}{7}$

$\Rightarrow \overline{\bar{V} < 0 \longrightarrow \begin{cases} D_1 \\ D_2 \end{cases} : \text{off} \rightarrow I = i = \frac{\bar{V}}{7}} **$

$\textcircled{3}$ $\begin{cases} D_1 : ON \\ D_2 : \text{off} \end{cases}$

KVL @ $\underline{1}$: $-\bar{V} + V_{D_2} + 3 \times I_{D_2} + 5 = 0$
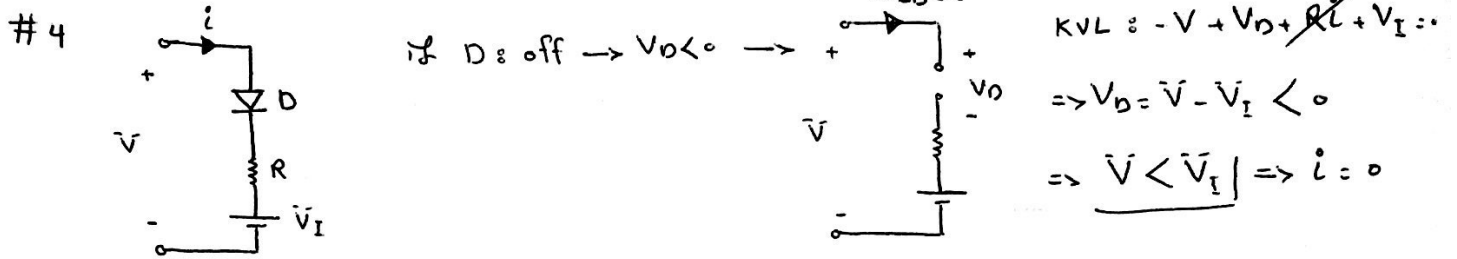
$\Rightarrow V_{D_2} = \bar{V} - 5 < 0 \Rightarrow \underline{\bar{V} < 5}$ (I)

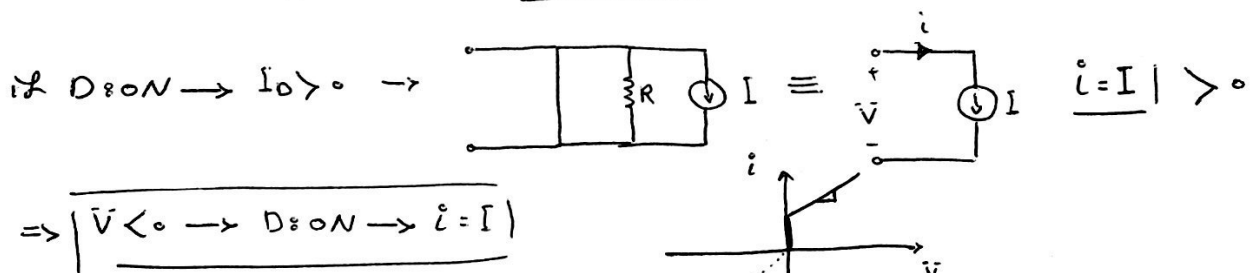KVL @ $\underline{2}$: $-\bar{V} + 6 I_{D_1} = 0 \Rightarrow I_{D_1} = \frac{\bar{V}}{6} > 0$

$\Rightarrow \underline{\bar{V} > 0}$ (II) $\xrightarrow{\text{(I)} \cap \text{(II)}} \underline{0 < \bar{V} < 5} \quad , \quad I = \frac{\bar{V}}{6}$

$\Rightarrow \overline{0 < \bar{V} < 5 \longrightarrow \begin{cases} D_1 : ON \\ D_2 : \text{off} \end{cases} \rightarrow I = i = \frac{\bar{V}}{6}} ***$

4

if D: off → $V_D < 0$ →

$i = I_D = 0$

KVL : $-V + V_D + Ri + V_I = 0$

$\Rightarrow V_D = V - V_I < 0$

$\Rightarrow \boxed{V < V_I} \Rightarrow i = 0$

$\Rightarrow \boxed{V < V_I \longrightarrow D: off \longrightarrow i = 0}$, if D: ON → $I_D > 0$

$i = I_D$

KVL : $-V + I_D R + V_I = 0 \Rightarrow I_D = \dfrac{V - V_I}{R} > 0 \Rightarrow \boxed{V > V_I}$

$\Rightarrow \boxed{V > V_I \longrightarrow D: ON \longrightarrow i = I_D = \dfrac{1}{R}(V - V_I)}$

5

D R I

if D: off → $V_D < 0$ ⇒

$\Rightarrow$ KVL @ I : $-V - V_D = 0$

$\Rightarrow V_D = -V < 0 \Rightarrow \boxed{V > 0}$

KCL @ V : $-i + \dfrac{V}{R} + I = 0 \Rightarrow \underline{i = \dfrac{V}{R} + I}$ $\longrightarrow \boxed{V > 0 \longrightarrow D: off \longrightarrow i = \dfrac{V}{R} + I}$

if D: ON → $I_D > 0$ →

R I $\equiv$

$i = I > 0$

$\Rightarrow \boxed{V < 0 \longrightarrow D: ON \longrightarrow i = I}$

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6 شیب خط منحنی : $\dfrac{i - V}{ } = \dfrac{1}{R}$ ⇒
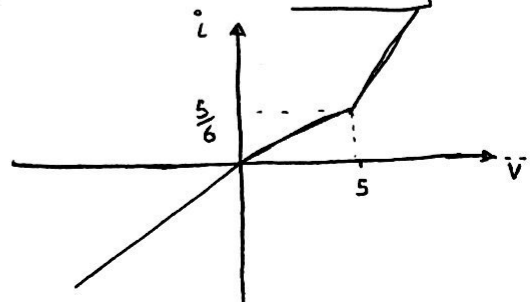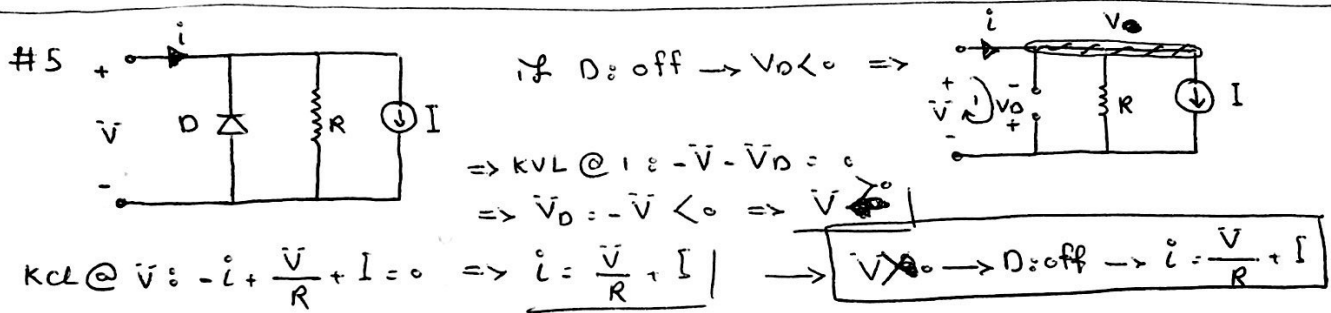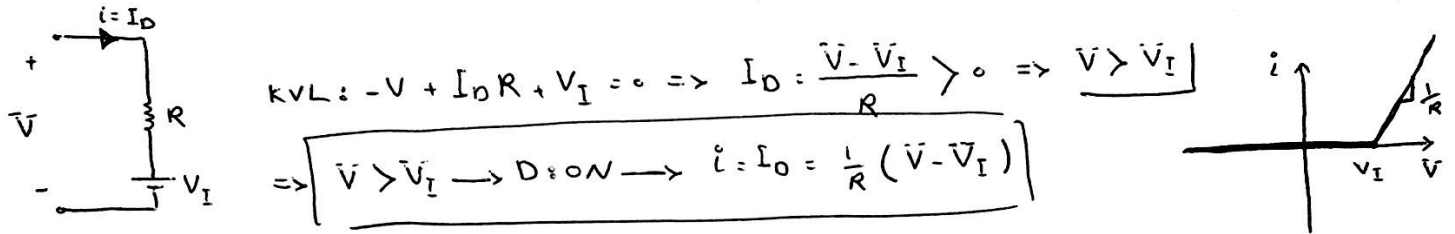
$\dfrac{1}{R} = 1.5$

I) $0 < V < 1 \longrightarrow \dfrac{1}{R} = 1 \Rightarrow \boxed{R = 1}$

II) $V > 1 \longrightarrow \dfrac{1}{R} = 1.5 \Rightarrow R = 0.6$

٩ .... intresting ! but time is limited