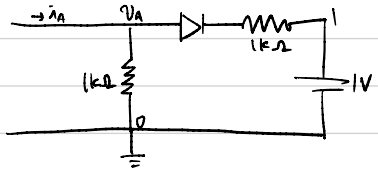
EEC HW2 : 2021-16988 Jaewan Park.

Exercise 4.4

(a)

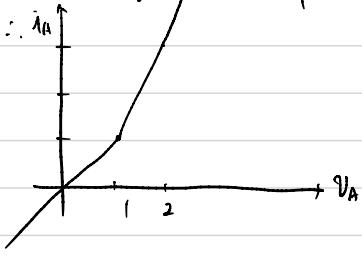


i) Diode off : $v_A < 1$

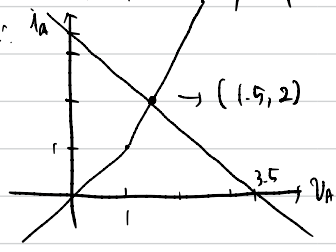
$$i_A = \frac{v_A}{1k\Omega} = v_A$$

ii) Diode on : $v_A \geq 1$

Node analysis : $i_A = \frac{v_A - 0}{1} + \frac{v_A - 1}{1} = 2v_A - 1$



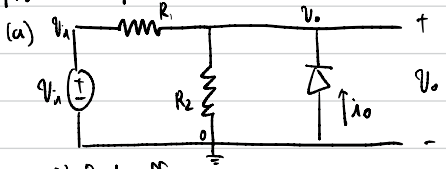
(b) $3.5 = 1k\,i_T + v_T$, $i_T = -v_T + 3.5$



$\therefore i_T = 2mA$

Problem 4.4

(a)



i) Diode off : $i_D = 0$, $v_o > 0$

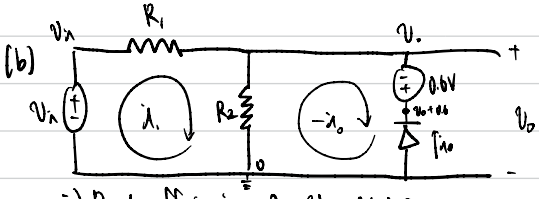
$$v_o = v_i \times \frac{R_2}{R_1 + R_2} = \frac{1}{2} v_i > 0. \quad \therefore v_i > 0$$

ii) Diode on : $v_o = 0$, $i_D \geq 0$

$$i_D = -\frac{v_i}{R_1} \geq 0, \quad \therefore v_i \leq 0$$

$$\therefore v_o = \begin{cases} \frac{1}{2} v_i & (v_i > 0) \\ 0 & (v_i \leq 0) \end{cases}$$

(b)



i) Diode off : $i_D = 0$, $v_o + 0.6 > 0$

$$v_o = \frac{1}{2} v_i > -0.6. \quad \therefore v_i > -1.2V$$

ii) Diode on : $v_o + 0.6 = 0$. $i_D \geq 0$

Loop analysis : $v_i = R_1 i_1 + R_2 (i_1 + i_o)$

$$0.6 = R_2 (-i_o - i_1)$$

$$i_1 = \frac{v_i + 0.6}{R_1}, \quad i_o = -\frac{v_i + 1.2}{R_1} \geq 0$$

$$\therefore v_i \leq -1.2V$$

$$\therefore v_o = \begin{cases} \frac{1}{2} v_i & (v_i > -1.2V) \\ 0.6V & (v_i \leq -1.2V) \end{cases}$$

Problem 4.13

$v_i = 10^{-3}\sin(\omega t)$, $V_N = 10$, $i_N = 10^{-4} V_N^2 = 10^{-2}$

$i_N = I_N + i_n = 10^{-4} v_N^2 = 10^{-4} V_N^2 + 2\cdot 10^{-4} V_N \cdot v_n$

$i_n = 2\cdot 10^{-4} V_N \cdot v_n$

$r_N = \dfrac{1}{2\cdot 10^{-4} V_N} = 500$

$v_{out} = v_i \times \dfrac{R}{r_N + R} = \dfrac{R}{R+500} 10^{-3}\sin(\omega t)$

Exercise 5.8

(a) output: $0.9V < v < 4.3V$, input: $1.5V < v < 3.5V$

will be treated inverted

(b) $NM_H = 4.3V - 3.5V = 0.8V$

$NM_L = 1.5V - 0.9V = 0.6V$

Problem 5.10

$0 < V_{IN} < V_{IL} \Rightarrow V_{OH} < V_{OUT} < 5$

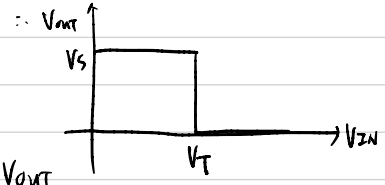
$V_{IH} < V_{IN} < 5 \Rightarrow 0 < V_{OUT} < V_{OL}$

$\therefore C.$

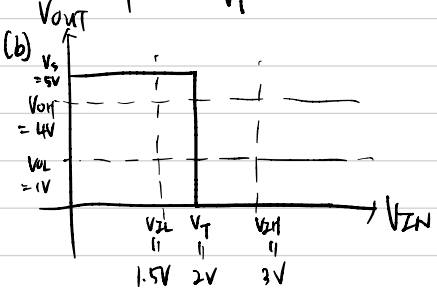
Problem 6.3

(a) $V_{IN} < V_T \Rightarrow V_{out} > V_S$

$V_{IN} > V_T \Rightarrow V_{out} = 0$



(b)



∴ Yes

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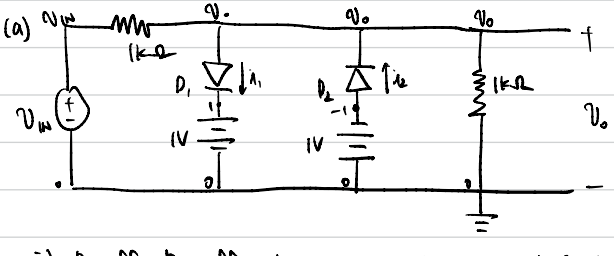
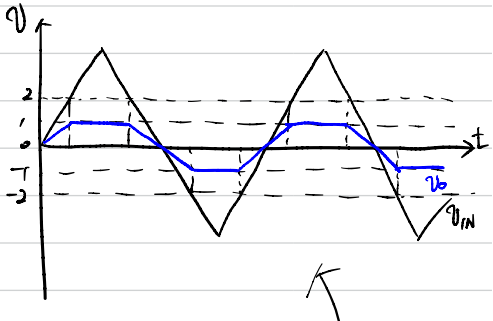
(a)





i) D_1 off, D_2 off : $i_1 = 0$, $i_2 = 0$. $v_o - 1 < 0$, $-1 - v_o < 0 \Rightarrow -1 < v_o < 1$, $i_1 = 0$, $i_2 = 0$

$v_o = v_{IN} \times \frac{1}{1+1} = \frac{1}{2} v_{IN}$, $-1 < \frac{1}{2} v_{IN} < 1$, $\therefore -2 < v_{IN} < 2$

ii) D_1 off, D_2 on : $i_1 = 0$, $v_o - 1 < 0$, $v_o = -1$, $i_2 \geq 0 \Rightarrow v_o = -1$, $i_1 = 0$, $i_2 \geq 0$

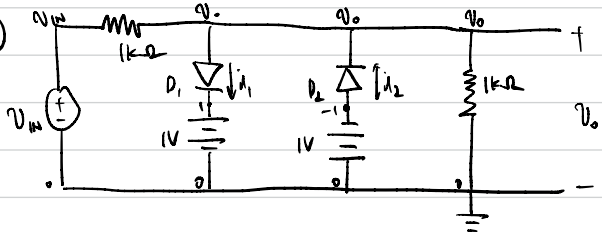
$i_2 = -\frac{v_{IN}}{1} - \frac{1}{1//1} = -v_{IN} - 2 \geq 0$, $\therefore v_{IN} \leq -2$ ($\because$ superstition)

iii) D_1 on, D_2 off : $v_o = 1$, $i_1 \geq 0$, $i_2 = 0$, $-1 - v_o < 0 \Rightarrow v_o = 1$, $i_1 \geq 0$, $i_2 = 0$

$i_1 = \frac{v_{IN}}{1} - \frac{1}{1//1} = v_{IN} - 2 \geq 0$, $\therefore v_{IN} \geq 2$. ($\because$ superstition)

$$\therefore v_o = \begin{cases} \frac{1}{2} v_{IN} & (-2 < v_{IN} < 2) \\ -1 & (v_{IN} \leq -2) \\ 1 & (v_{IN} \geq 2) \end{cases}$$

(b)



i) D_1 off, D_2 off $\Rightarrow i_1 = 0,\ V_o - 1 < 0.6,\ i_2 = 0,\ -1 - V_o < 0.6 \Rightarrow -1.6 < V_o < 1.6,\ i_1 = 0,\ i_2 = 0$

$V_o = \frac{1}{2} V_{IN},\quad -1.6 < \frac{1}{2} V_{IN} < 1.6,\quad -3.2 < V_{IN} < 3.2$

ii) D_1 off, D_2 on $\Rightarrow i_1 = 0,\ V_o - 1 < 0.6,\ -1 - V_o = 0.6,\ i_2 \geq 0 \Rightarrow V_o = -1.6,\ i_1 = 0,\ i_2 \geq 0$

$i_2 = -\frac{V_{IN}}{1} - \frac{1.6}{1//1} = -V_{IN} - 3.2 \geq 0,\quad V_{IN} \leq -3.2$ (∵ superstition)

iii) D_1 on, D_2 off $\Rightarrow V_o - 1 = 0.6,\ i_1 \geq 0,\ i_2 = 0,\ -1 - V_o < 0.6 \Rightarrow V_o = 1.6,\ i_1 \geq 0,\ i_2 = 0$

$i_1 = \frac{V_{IN}}{1} - \frac{1.6}{1//1} = V_{IN} - 3.2 \geq 0,\quad V_{IN} \geq 3.2$ (∵ superstition)

$\therefore V_o = \begin{cases} \frac{1}{2} V_{IN} & (-3.2 < V_{IN} < 3.2) \\ -1.6 & (V_{IN} \leq -3.2) \\ 1.6 & (V_{IN} \geq 3.2) \end{cases}$