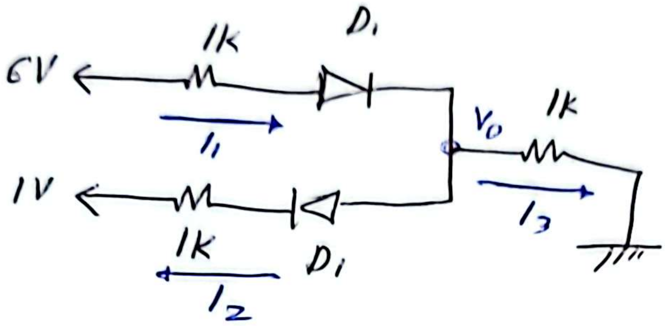
Method of Assumed States

Diodes

①

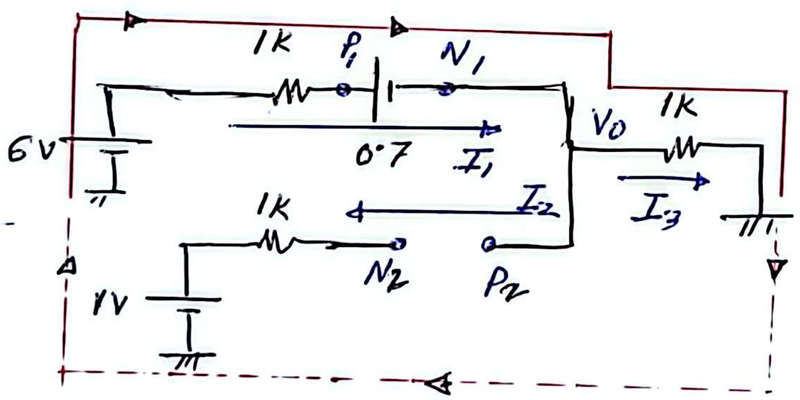


Find I_1 I_2 & I_3 also V_o to check if diodes are on/off

use CVD model. [$V_D = 0.7V$]

Ans.

Assume D_1 ON & D_2 off



I_1 is same as diode current I_{D_1}.

I_2 is zero as open ckT [d_2 off, $I_{D_2} = 0$]

$I_2 = 0$

at V_o, KCL,

$$I_1 = \underbrace{I_2}_{0} + I_3$$

$$I_1 = I_3$$

loop along D_1 [Red line] gives,

$$-6 + I_1 \times 1k + 0.7 + 1k \times I_3 = 0$$

$$\Rightarrow I_1 + I_3 = 5.3$$

$$\Rightarrow 2I_1 = 5.3$$

$$\Rightarrow I_2 = 2.65mA$$

$$I_1 = I_3 = 2.65mA.$$

I_1 is positive, current flows from $P \rightarrow N$, $\underline{D_1 \text{ ON}}$.

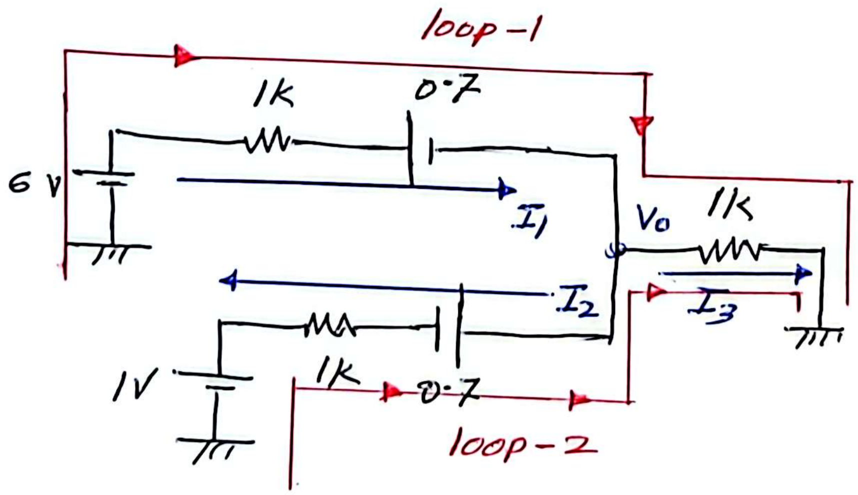
now, $V_o = V_{P_2}$ & $V_{N_2} = 1V$

$$V_o = I_3 \times 1k = 2.65mA \times 1k = 2.65V.$$

$V_{P_2} - V_{N_2} = 2.65 - 1 = 1.65 > 0.7$, $\underline{D_2 \text{ is not off}}$

Assumption wrong.

D_1 ON & D_2 ON



KVL along Loop-1

$$-6 + I_1 \times 1k + 0.7 + I_3 \times 1k = 0 \quad \text{——— (I)}$$

KVL along loop-2

$$-1 - \underbrace{I_2 \times 1k}_{\text{negative cause opposite direction}} - 0.7 + I_3 \times 1k = 0 \quad \text{——— (II)}$$

KCL at node V_o,

$$I_1 = I_2 + I_3 \quad \text{——— (III)}$$

Solving (I), (II) & (III)

$$I_1 = 2.96 mA$$

$$I_2 = 0.63 mA$$

$$I_3 = 2.33 mA$$

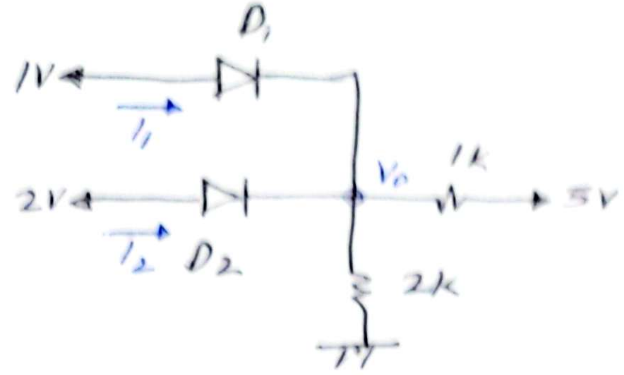
I_1 is same as I_{D_1} so current flows from $p \rightarrow n$.

I_2 is same as I_{D_2} so current flows from $p \rightarrow n$.

D_1 & D_2 ON. Assumption correct.

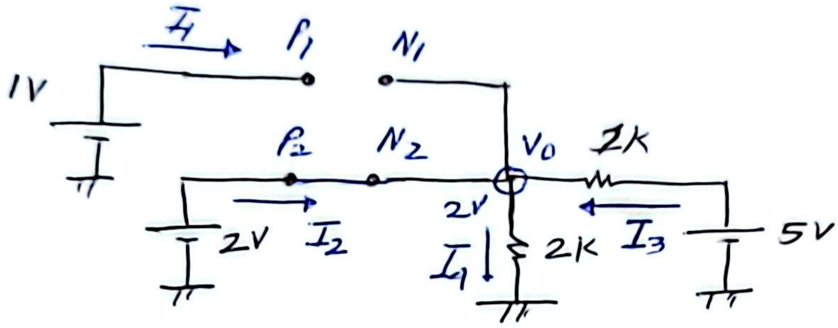
CamScanner

(2)



Find I_1, I_2 & V_o assuming diode are ideal

Ans. Assume D_2 ON & D_1 off



Since D_2 ON, P_2 & N_2 shorted [ideal]

$$V_o = 2V.$$

D_1 off $\quad V_{P_1} = 1V$ & $V_{N_1} = 2V$ $[V_{N_1} = V_o]$

$$V_{P_1} < V_{N_1}, \; D_1 \text{ off}$$

I_2 is asame as diode current I_{D2}.

KCL at V_o,

$$I_2 + I_3 = I_4$$

now, $I_4 = \frac{V_o}{2k} = \frac{2V}{2k} = 1mA$

$$I_3 = \frac{5 - V_o}{1k} = \frac{5-3}{1k} = 3mA$$

now, $I_2 = -I_3 + I_4$

$= -3 + 1$

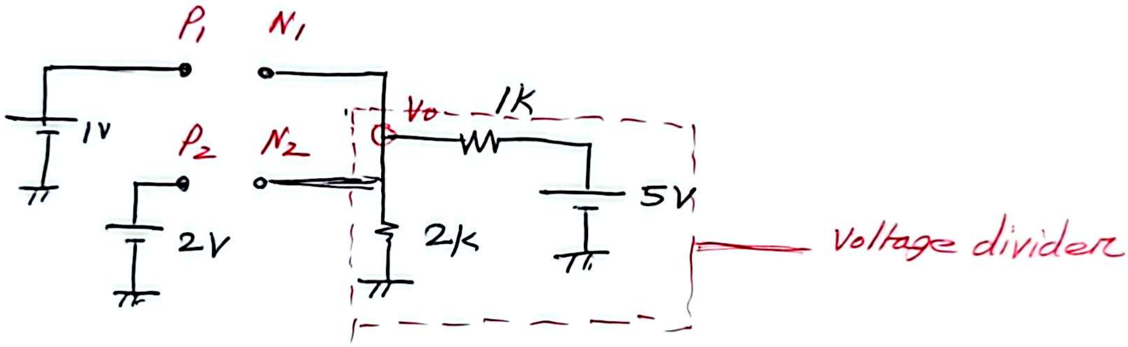
$= -2$

$I_2 = -2mA$ means current is flowing in opposite direction

I_2 negative means diode current also flowing in opposite direction i.e. it flows from $\underline{n \to p}$ not possible

D_2 ON Assumption wrong.

Now, D_1 off & D_2 off.



$V_{P_1} = 1V \quad V_{P_2} = 2V$

$V_{N_1} = V_{N_2} = V_o$

$V_o = \frac{2}{1+2} \times 5$

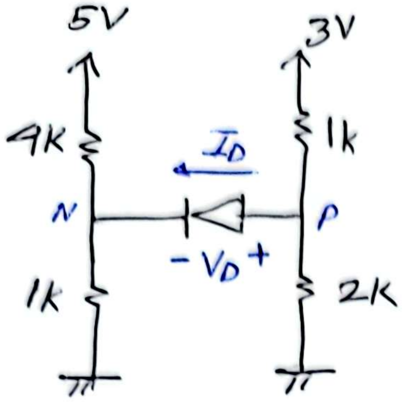
$= 3.333V$

$V_{D_1} = V_{P_1} - V_{N_1} = 1 - 3.333 = -2.33$ neg V_{D_1}

$V_{D_2} = V_{P_2} - V_{N_2} = 2 - 3.333 = -1.33$ neg V_{D_2}

Diode D_1 & D_2 both off. Assumption correct.

③

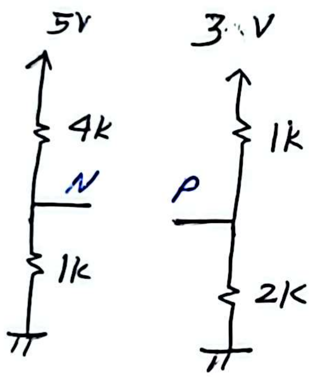


Find power consumed by diode assuming $V_D = 0.7$

[CVD]

Ans.

diode off.



$V_P = \frac{2}{1+2} \times 3$

$= 2V$

$V_N = \frac{1}{4+1} \times 5$

$= 1V$

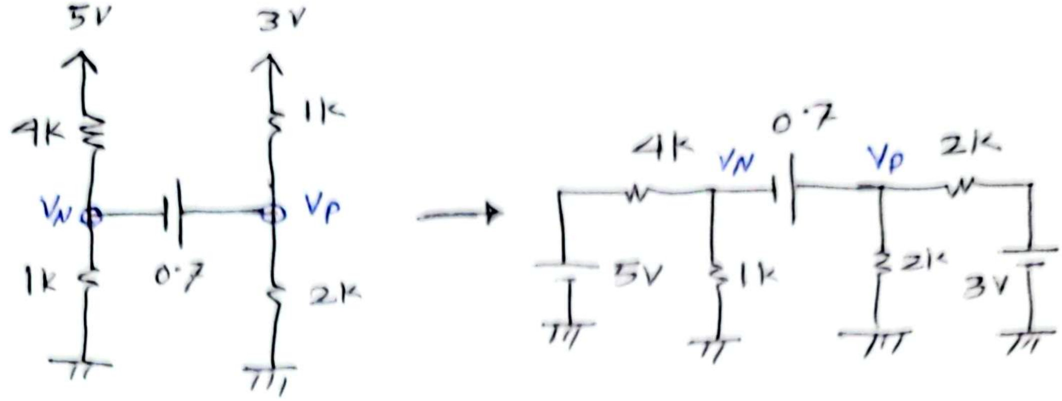
Voltage divider

$V_P - V_N = 2 - 1 = 1 > 0.7$

now, since $V_P - V_N > 0.7$ diode can not be off.

Assumption wrong.

Diode ON.



supernode is formed.

$$V_P - V_N = 0.7 \quad \text{——} \quad (1)$$

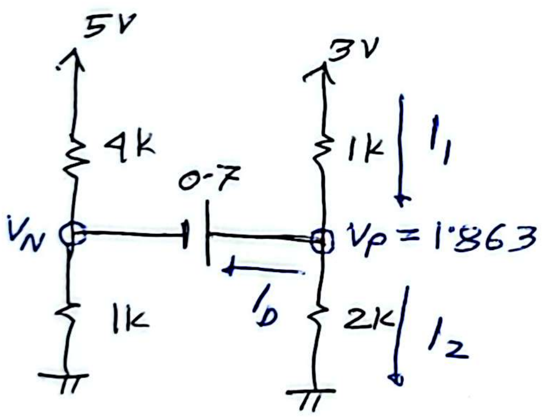
$$\frac{V_N - 5}{4} + \frac{V_N}{1} + \frac{V_P}{1} + \frac{V_P - 3}{2} = 0 \quad \text{——} \quad (11)$$

solving (1) & (11)

$$V_P = 1.863\text{ V}$$

$$V_N = 1.163\text{ V}$$

now, we need to check diode current.



KCL at V_P,

$$I_1 = I_D + I_2$$

$$I_1 = \frac{3 - V_P}{1k} = \frac{3 - 1.863}{1}$$

$$= 1.137\text{mA}$$

$$I_D = I_1 - I_2 = 0.205\text{mA} \qquad I_2 = \frac{V_P}{2k} = \frac{1.863}{2} = 0.932\text{mA}$$

It flows from $P \rightarrow N$ correct. Power $= V_D I_D$

$$= 0.7V \times 0.205\text{mA}$$

KCL at V_o,

$$I_1 + I_2 = 5mA$$

$$I_1 = 5 - I_2 = 5 - 0.02 = 4.98mA$$

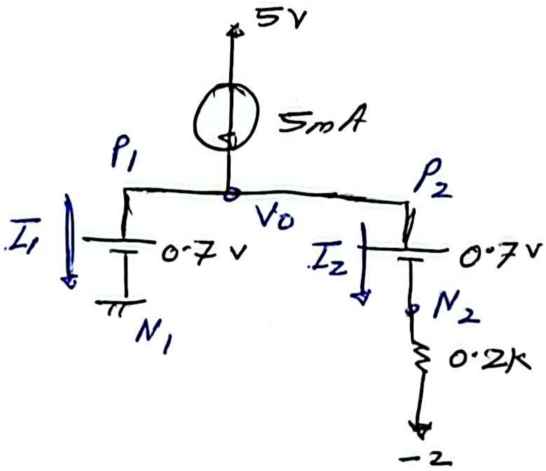
Both I_1 & I_2 are same as I_{D_1} & I_{D_2} respectively.

For both diodes current is flowing from $P \rightarrow N$.

Assumption Correct.

Case (ii) $R = 0.2k$

D_1 & D_2 ON Assume.



D_1 ON,

$$V_{P_1} - V_{N_1} = 0.7$$

$$\Rightarrow V_{P_1} - 0 = 0.7$$

$$V_{P_1} = 0.7$$

$$V_{P_1} = V_{P_2} = V_o$$

D_2 ON,

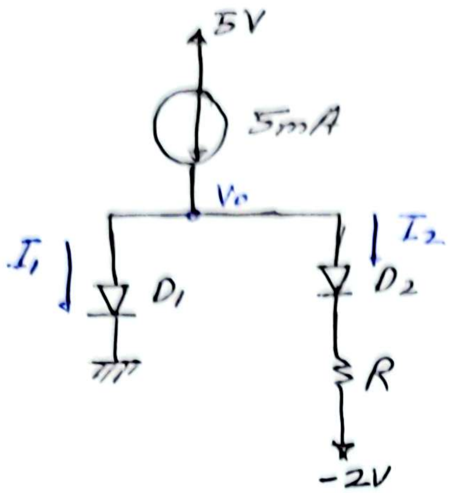
$$V_{P_2} - V_{N_2} = 0.7$$

$$\Rightarrow 0.7 - V_{N_2} = 0.7$$

$$V_{N_2} = 0$$

$$I_2 = \frac{V_{N_2} - (-2)}{0.2k} = \frac{0+2}{0.2k} = 10mA$$

(9)

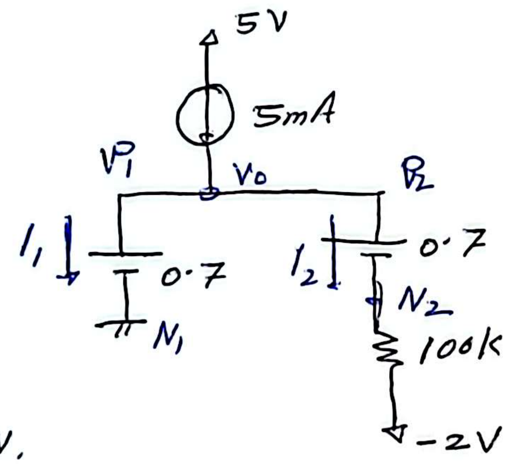


Find I_1, I_2 & V_o for case-1 $R=100k$ case-2 $R=0.2k$.

Use CVD Model, $V_D = 0.7V$

Case-(1) $R = 100k$

Assume D_1 & D_2 ON.



D_1 ON.

$V_{P_1} - V_{N_1} = 0.7$

$V_{P_1} = V_{P_2} = V_o$

D_2 ON,

$\Rightarrow V_{P_1} - 0 = 0.7$

$V_{P_2} - V_{N_2} = 0.7$

$\Rightarrow V_{P_1} = 0.7$

$\Rightarrow 0.7 - V_{N_2} = 0.7$

$\Rightarrow V_{N_2} = 0$

$$I_2 = \frac{V_{N_2} - (-2)}{100k} = \frac{0+2}{100k} = 0.02mA$$

again KCL at V_o,

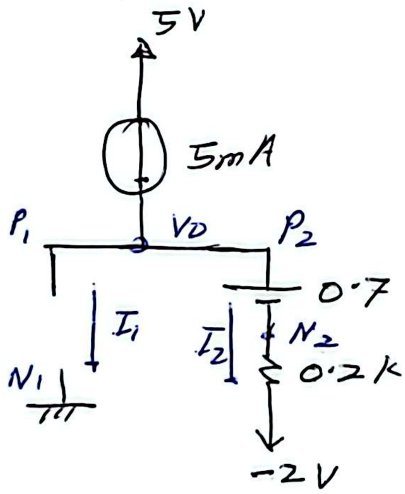
$$5 = I_1 + I_2$$

$$\Rightarrow I_1 = 5 - 10 = -5$$

I_1 negative means $I_{D_1} = -5$ which means current flows from $N \to P$. Not possible.

Assumption wrong.

D_1 off. D_2 ON [Because D_2 was ok as current flew from $P \to N$. So it next assumption we just correct the D_1 diode's assumption]



at V_o, KCL

$$I_1 + I_2 = 5mA$$

$$0 + I_2 = 5mA$$

$$I_2 = 5mA$$

$I_1 = 0$ as D_1 is off.

now, D_2 is ON and I_{D_2} is I_2 flowing from $P \to N$.

$$I_2 = \frac{V_{N_2} - (-2)}{0.2K}$$

$$\Rightarrow \quad 5mA \times 0.2K = V_{N_2} + 2$$

$$\Rightarrow \quad 1V = V_{N_2} + 2$$

$$\Rightarrow V_{N_2} = 1 - 2$$

$$\therefore V_{N_2} = -1$$

$$V_{P_2} - V_{N_2} = 0.7$$

$$\Rightarrow \quad V_{P_2} = 0.7 + V_{N_2}$$

$$= 0.7 - 1$$

$$= -0.3$$

$$V_{P_2} = V_{P_1} = -0.3$$

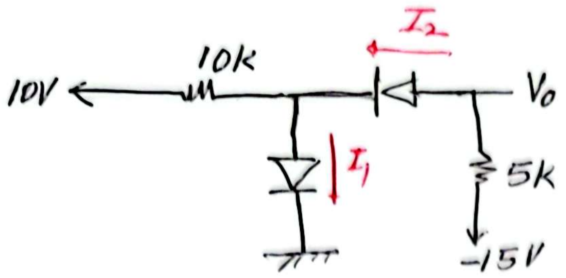
$$V_{P_1} - V_{N_1} = -0.3 - 0 = -0.3 < 0.7$$

$V_{P_1} - V_{N_1} < 0.7$ D_1 off

Assumption correct.

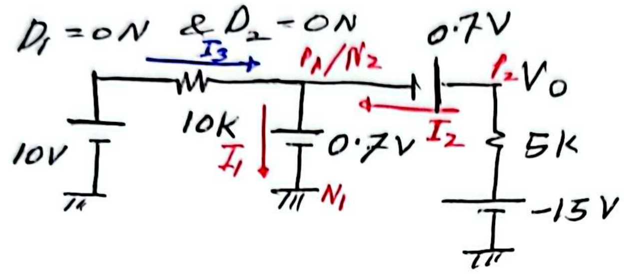
CamScanner

5



Find V_0, I_1 & I_2 use CVD model with $V_D = 0.7V$.

Ans. $D_1 = ON$ & $D_2 = ON$



$V_{P_1} - V_{N_1} = 0.7$

$V_{P_1} - 0 = 0.7$

$V_{P_1} = 0.7 \mid V_{N_2} = 0.7$

$V_{P_2} = V_0 = 1.4$

$V_{P_2} - V_{N_2} = 0.7$

$\Rightarrow V_{P_2} = 0.7 + V_{N_2}$

$\Rightarrow V_{P_2} = 0.7 + 0.7 = 1.4$

now, $I_3 = \frac{10-0.7}{10k} = \frac{9.3}{10k} = 0.93mA$

$I_2 = \frac{-15-1.4}{5k} = \frac{-16.4}{5k} = -3.28mA$

KCL @ P_1,

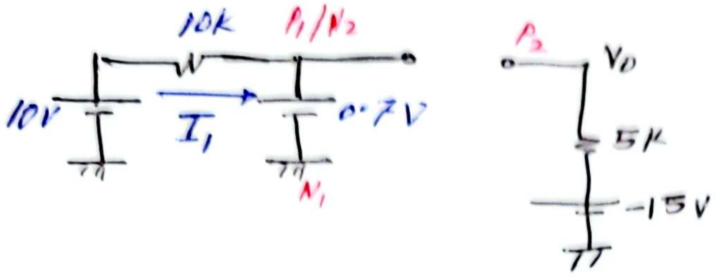
$I_3 + I_2 = I_1$

$\Rightarrow 0.93 - 3.28 = I_1$

$I_1 = -2.35mA$

Both I_1 & I_2 are negative. Means in both diodes currents flow from N-P (not possible)

$D_1 = ON$ & $D_2 = OFF$



$V_{P_1} = 0.7 / V_{N_2}$

$V_{N_1} = 0.0$

$V_{P_2} = -15V$

since, CKT D_2 is open

$$I_1 = \frac{10 - 0.7}{10k} = 0.93\,mA$$

since I_1 is positive current flows from $P \to N$

D_1 ON.

$V_{P_2} = -15V$

$V_{N_2} = 0.7V$

$V_{P_2} - V_{N_2} = -15 - 0.7 = -15.7 < 0.7$

D_2 is OFF

Assumption Correct.