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Delhi | Bhopal | Hyderabad | Jaipur | Pune
Web: www.madeeasy.in | E-mail: info@madeeasy.in | Ph: 011-45124612

# ANALOG ELECTRONICS

## ELECTRONICS ENGINEERING

**Date of Test : 30/06/2026**

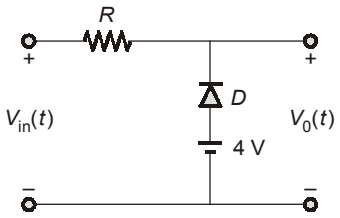
## ANSWER KEY ➤

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1. | (b) | 7. | (a) | 13. | (a) | 19. | (b) | 25. | (c) |
| 2. | (b) | 8. | (d) | 14. | (b) | 20. | (d) | 26. | (b) |
| 3. | (b) | 9. | (b) | 15. | (c) | 21. | (b) | 27. | (b) |
| 4. | (d) | 10. | (b) | 16. | (d) | 22. | (b) | 28. | (c) |
| 5. | (a) | 11. | (c) | 17. | (a) | 23. | (a) | 29. | (b) |
| 6. | (a) | 12. | (b) | 18. | (a) | 24. | (d) | 30. | (a) |

## DETAILED EXPLANATIONS

**1. (b)**

The circuit can be redrawn as




**Case (I):** when $V_{in}(t) > 4$ V

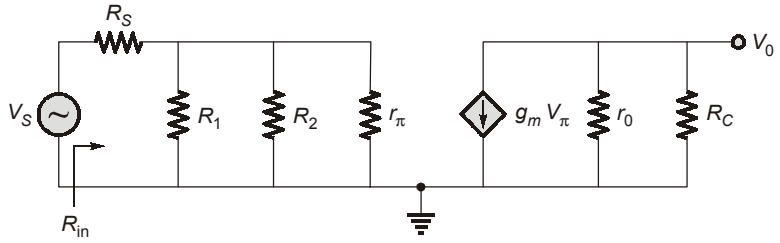
The diode $D$ will be in OFF state and $V_{in}(t) = V_0(t)$.

**Case (II):** when $V_{in}(t) < 4$ V

The diode $D$ will be in ON state and $V_{out}(t) = 4$ V.

**2. (b)**

By drawing the small signal equivalent model of the transistor by deactivating all the supply voltages, we get,




Now, the resistance seen by the source is equal to,

$$R_{in} = R_s + (R_1 \| R_2 \| r_\pi)$$

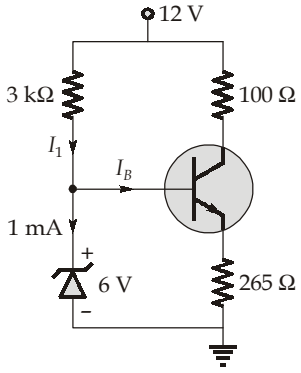
$$r_\pi = 2.74\ \text{k}\Omega \quad \text{(given)}$$

Thus,
$$R_{in} = 0.5\times10^3 + (2.74\text{k} \| 93.7\text{k} \| 6.3\text{k})$$
$$= (0.5 + 1.87) \times 10^3\ \Omega = 2.37\ \text{k}\Omega$$

**3. (b)**

The current through base resistor,

$$I_B = I_1 - 1\ \text{mA}$$
$$= \frac{6}{3\text{k}} - 1\,\text{mA} = 1\ \text{mA}$$




Apply KVL in base circuit,

$$-6 + 0.7 + 265\,(1 + \beta)I_B = 0$$
$$265\,(1 + \beta)I_B = 5.3$$
$$(1 + \beta) = \frac{5.3}{265\times10^{-3}}$$
$$1 + \beta = \frac{5.3}{0.265}$$
$$\beta = 20 - 1 = 19$$

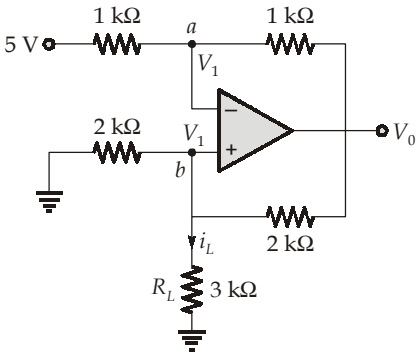
**4. (d)**

$$I_{D1} = I_{D2} = K_n\left(V_{GS} - V_t\right)^2$$

$$I_D = \frac{\mu_n C_{ox}}{2} \cdot \frac{W}{L}\left(V_{GS} - V_t\right)^2$$

$$= 0.1\ (5 - 2)^2 = 0.9\ \text{mA}$$

**5. (a)**




Apply KCL at node '*a*'

$$\frac{5 - V_1}{1} = \frac{V_1 - V_0}{1}$$

$$5 - V_1 = V_1 - V_0$$

$$-V_0 = 5 - 2V_1$$

$$V_0 = 2V_1 - 5 \qquad \ldots(i)$$

Apply KCL at node '*b*'

$$\frac{V_1}{2} + \frac{V_1}{3} + \frac{V_1 - V_0}{2} = 0$$

$$V_1\left[\frac{1}{2} + \frac{1}{3} + \frac{1}{2}\right] = \frac{V_0}{2}$$

$$V_1\left[\frac{4}{3}\right] = \frac{V_0}{2}$$

$$V_1 = \frac{3}{8}V_0 \qquad \ldots(ii)$$

From equation (i) and (ii), we get

$$V_1 = \frac{3}{8}(2V_1 - 5)$$

$$8V_1 = 6V_1 - 15$$

$$2V_1 = -15$$

$$V_1 = -7.5\ \text{Volt}$$

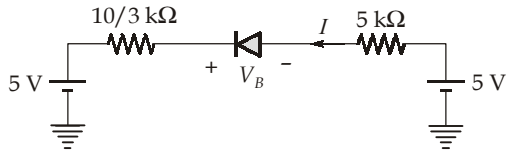
Load current, $$i_L = \frac{V_1}{3K} = \frac{-7.5}{3K} = -2.5\ \text{mA}$$

**6. (a)**

The PIV rating of full-wave rectifier with centre tap is 2 $V_m$ = 2 × 100 = 200 V

**7. (a)**

Drawing the Thevenin equivalent circuit, we get




Applying KVL we get $V_D$ = 0 V, thus no current will flow through the diode $D_1$.

Hence, $I = 0$ A

**8. (d)**

BJTs can supply more current than MOSFETs because the channel formed in the MOS is smaller than the channel in BJTs.

**9. (b)**

**10. (b)**

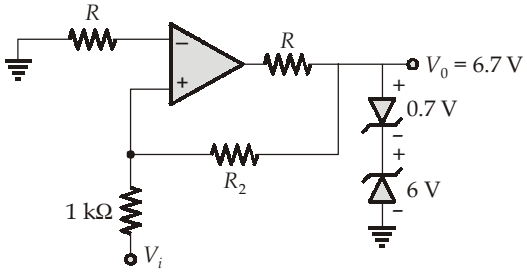
**11. (c)**

Voltage gain, $$\frac{V_0}{V_{in}} \approx \frac{-h_{fe} \cdot R_C}{h_{ie}}$$

$$A_V \approx \frac{-150 \times 3\,k\Omega}{3\,k\Omega} \approx -150$$

**12. (b)**

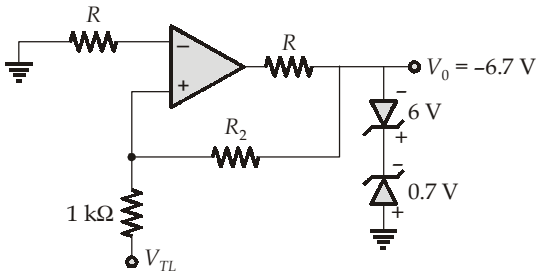
At upper Threshold point,




$$\therefore \quad \frac{R_2 V_{TH} + 6.7(1)}{R_2 + 1} = 0$$

$$V_{TH} = \frac{-6.7}{R_2}$$

At lower Threshold point,



$$\frac{R_2 V_{TL} - 6.7(1)}{R_2 + 1} = 0$$

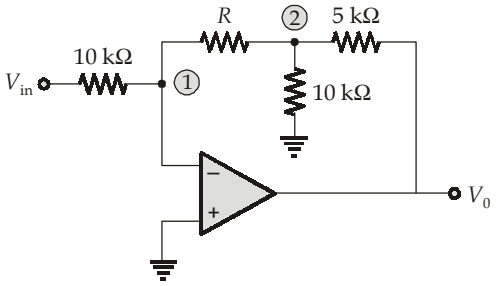
$$V_{TL} = \frac{6.7}{R_2}$$

Given that, $|V_{TH} - V_{TL}| = 2$

$$\frac{13.4}{R_2} = 2$$

$$R_2 = 6.7\ \text{k}\Omega$$

**13. (a)**




$$V_1 = 0$$

Apply KCL at node-1

$$\frac{V_{in} - 0}{10} = \frac{0 - V_2}{R}$$

$$-\left[\frac{V_{in}}{10} \times R\right] = V_2 \qquad \ldots(i)$$

Apply KCL at node-2

$$\frac{V_2}{R} + \frac{V_2}{10} + \frac{V_2 - V_0}{5} = 0$$

$$V_2\left[\frac{1}{R} + \frac{1}{10} + \frac{1}{5}\right] = \frac{V_0}{5} \qquad \ldots(ii)$$

From equation (i) and (ii), we get

$$\frac{-V_{in} \cdot R}{10}\left[\frac{1}{R} + \frac{3}{10}\right] = \frac{V_0}{5}$$

$$\frac{R}{10}\left[\frac{10 + 3R}{10R}\right] = \frac{-V_0}{V_{in}} \times \frac{1}{5}$$

$$\frac{10 + 3R}{20} = \left(\frac{-V_0}{V_{in}}\right)$$

Given that, $\frac{V_0}{V_{in}} = -6$

$$\frac{10 + 3R}{20} = 6$$

$$10 + 3R = 120$$

$$R = \frac{110}{3}\text{k}\Omega$$

$$R = 36.66\ \text{k}\Omega$$

**14. (b)**

**Case I :** When $V_{in} < 0$ V

When $V_{input} < 0$ V, then the diode $D_1$, will be in forward biased and diode $D_2$ will be OFF, hence the output is equal to 0 V, which is shown in figure-1.

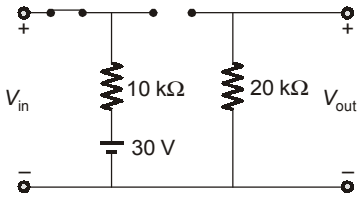



Figure (1)

**Case II :** $0 < V_{in} < 20$ V

$D_1$ is ON and $D_2$ is ON.

The equivalent circuit is shown in figure (2).

From the figure it is clear that the output

$$V_{out} = V_{in}$$

Thus it will be a straight line when plotted in the transfer curve [part (2)].

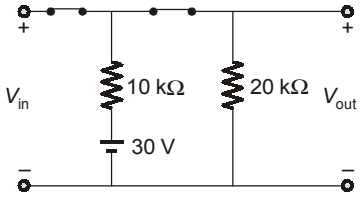



Figure (2)

**Case III :** For $V_{input} > 20$ V

$D_1$ = OFF and $D_2$ = ON

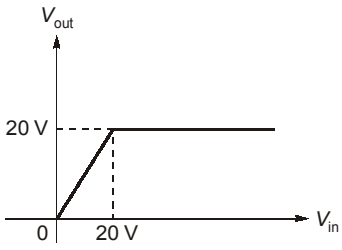
Thus, the output will be a constant voltage $V_{out}$.

$$V_{out} = \frac{20}{20+10} \times 30\ \text{V}$$

($\because$ voltage division)

Thus, $V_{out} = 20$ V

Hence, the output response can be drawn as




**15. (c)**

Now, $I_{in} = I_{D_1} + I_{D_2}$

and $V_{D_1} = V_{D_2}$

(∵ diodes are in parallel)

thus, $$V_T \ln\left(\frac{I_{D_1}}{I_{s_1}}\right) = V_T \ln\left(\frac{I_{D_2}}{I_{s_2}}\right)$$

$$\Rightarrow \quad \frac{I_{D_1}}{I_{s_1}} = \frac{I_{D_2}}{I_{s_2}}$$

$$I_{D_1} = \left(\frac{I_{D_2}}{I_{s_2}}\right) \cdot I_{s_1}$$

Now, $$I_{\text{in}} = I_{D_2} + I_{D_2}\left(\frac{I_{s_1}}{I_{s_2}}\right)$$

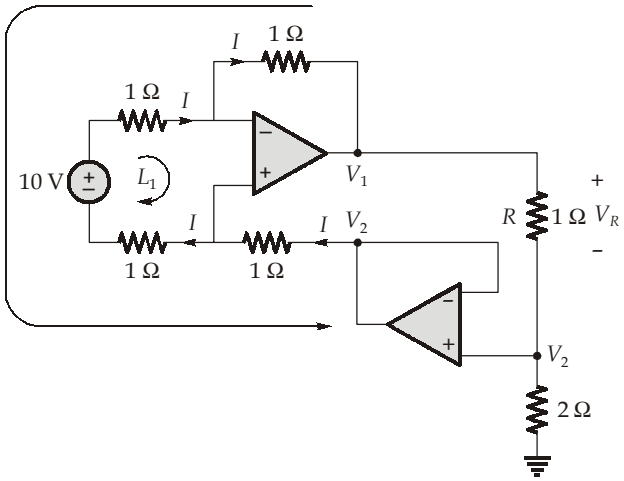
$$I_{\text{in}} = \left(1 + \frac{I_{s_1}}{I_{s_2}}\right) I_{D_2}$$

$$\Rightarrow \quad I_{D_2} = \frac{I_{in}}{1 + \frac{I_{s_1}}{I_{s_2}}}$$

Now, $I_{s_1}$ and $I_{s_2}$ are reverse saturation currents of the diodes and $I_s \propto A$.
Thus the above equation can be written as,

$$I_{D_2} = \frac{I_{\text{in}}}{1 + \frac{I_{s_1}}{I_{s_2}}} = \left(\frac{I_{\text{in}}}{1 + \frac{A_1}{A_2}}\right)$$

**16. (d)**




Apply KVL in loop-1,

$$-10 + I + I = 0$$

$$2I = 10$$

$$I = 5 \text{ A}$$

Applying KVL in the loop shown,

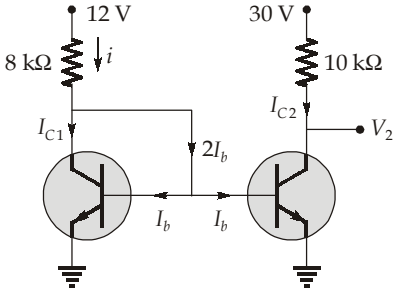
we get, $$V_1 = -5 - 5 + 10 - 5 - 5 + V_2$$

$$V_1 - V_2 = -10 \text{ V}$$

∴ voltage across resistor,

$$R = V_R = V_1 - V_2 = -10 \text{ V}$$

**17. (a)**




$$12 - i \times 8 \times 10^3 - 0.7 = 0$$

Now, $$i = \frac{12 - 0.7}{8 \times 10^3} = 1.4125 \text{ mA}$$

$$i = I_{c1} + 2I_b = (\beta + 2)I_b$$

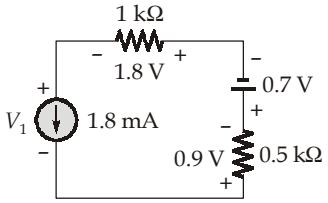
$$I_b = \frac{i}{\beta + 2} = \frac{1.4125}{202} = 6.99 \ \mu\text{A} \approx 7 \ \mu\text{A}$$

$$I_{c2} = 200I_b = 200 \times 7 \ \mu$$
$$= 1.4 \text{ mA}$$

$\therefore$ $$V_2 = 30 - I_{c2} \times 10k$$
$$V_2 = 30 - 1.4 \times 10$$
$$= 16 \text{ V}$$

**18. (a)**

From the circuit given, after observation, we can conclude that $D_2$ will be ON and $D_1$ will be OFF.

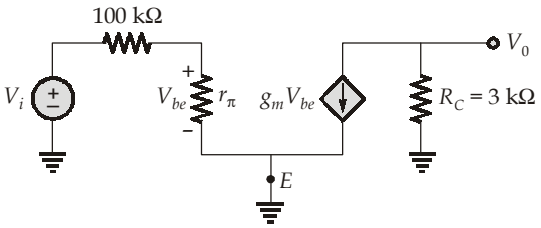



$\therefore$ $$V_1 = -0.9 - 0.7 - 1.8 = -3.4 \text{ V}$$

**19. (b)**

The first step in the analysis consists of determining the quiescent operating point. For this purpose we assume that $V_i = 0$.

$\therefore$ $$I_B = \frac{V_{BB} - 0.7}{100k} = \frac{3 - 0.7}{100k} = 23 \ \mu\text{A}$$




$$I_C = \beta I_B = 100 \times 23 \ \mu = 2.3 \text{ mA}$$

$\therefore$ $$V_C = 10 - I_C \cdot R_C$$

$$= 10 - 2.3 \times 3 = 3.1 \text{ V}$$

$$r_e = \frac{V_T}{I_E} = \frac{25 \text{ mV}}{(2.3 / 0.99) \text{ mA}} = 10.8 \ \Omega$$

$$g_m = \frac{I_C}{V_T} = \frac{2.3 \text{ mA}}{25 \text{ mV}} = 92 \text{ mA/V}$$

$$r_\pi = \frac{\beta}{g_m} = \frac{100}{92} = 1.09 \text{ k}\Omega$$

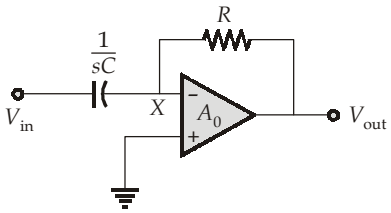
$$\therefore \quad V_{be} = V_i \times \frac{r_\pi}{r_\pi + R_{BB}}$$

$$V_{be} = V_i \times \frac{1.09}{101.09} = 0.011 \ V_i$$

$$\therefore \quad V_0 = -g_m \ V_{be} \ R_C$$
$$= -92 \times 0.011 \ V_i \times 3$$
$$= -3.04 \ V_i$$

$$\therefore \quad A_V = \frac{V_0}{V_i} = -3.04 \approx -3$$

**20. (d)**




Applying KCL at node '$X$', we get,

$$\frac{V_{\text{in}} - V_x}{1/sC} = \frac{V_x - V_{\text{out}}}{R_1}$$

now, $$\frac{-V_{\text{out}}}{A_0} = V_x$$

$$\therefore \quad \frac{-V_{\text{out}}}{V_{\text{in}}} = \frac{-RCs}{1 + \frac{1}{A_0} + \frac{sRC}{A_0}}$$

$$\frac{s_p RC}{A_0} + \frac{1}{A_0} + 1 = 0$$

$$\frac{s_p RC}{A_0} = -1 - \frac{1}{A_0}$$

$$\text{Pole, } s_p = \frac{-(1 + A_0)}{RC}$$

Hence option (d) is correct.

**21. (b)**

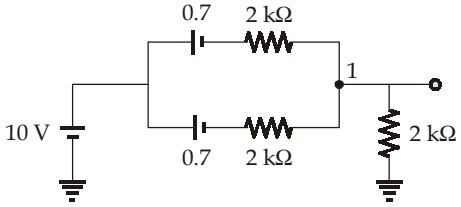
$$A_{CL} = \frac{A_{OL}}{1+A_{OL}\beta} = \frac{\frac{A_0}{(1+j\omega/\omega_0)}}{1+\frac{A_0}{\left(1+\frac{j\omega}{\omega_0}\right)}\cdot\beta} = \frac{A_0}{1+j\frac{\omega}{\omega_0}+A_0\beta}$$

$$= \frac{\frac{A_0}{1+A_0\beta}}{1+j\frac{\omega}{\omega_0(1+A_0\beta)}} = \frac{A'_{CL}}{1+j\frac{\omega}{\omega'_0}}$$

$\therefore \quad \omega'_0 = \omega_0(1+A_0\beta)$

**22. (b)**

The above circuit can be represented as,




Applying KCL at node 1,

$$\frac{V_0}{2k}+\frac{V_0-10+0.7}{2k}+\frac{V_0-10+0.7}{2k}=0$$

$$V_0\left[\frac{3}{2k}\right] = \frac{9.3}{1k}$$

$$V_{out} = \frac{9.3}{3}\times 2 = 6.2\text{ V}$$

**23. (a)**

The output voltage of differential amplifier is given as,

$$V_0 = A_dV_d + A_cV_c$$

Where,

$A_d$ = Differential gain

$A_c$ = Common mode gain

$V_d$ = Differential input voltage = $V_1 - V_2$

$V_c$ = Common mode input voltage = $\frac{V_1+V_2}{2}$

$$V_0 = A_dV_d\left[1+\frac{A_cV_c}{A_dV_d}\right] = A_dV_d\left[1+\frac{1}{\rho}\cdot\frac{V_c}{V_d}\right]$$

Where, $\rho = \frac{A_d}{A_c}$ = common mode rejection ratio

Set of signal 1,

$$V_d = 50\ \mu\text{V} - (-50\ \mu\text{V}) = 100\ \mu\text{V}$$

$$V_c = \frac{50\ \mu\text{V}-50\mu\text{V}}{2} = 0$$

$$V_{01} = 100\mu V\, A_d[1+0] = 100\, A_d\ \mu V$$

$$V_c = \frac{1050\,\mu V + 950\,\mu V}{2} = 1000\ \mu V$$

$$V_d = 1050\ \mu V - 950\ \mu V = 100\ \mu V$$

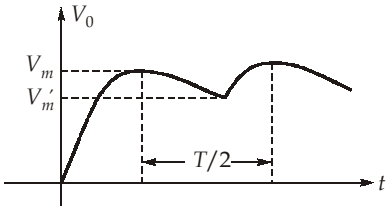
$$\therefore \quad V_{02} = A_d 100\mu V\left[1 + \frac{1}{100} \times \frac{1000\mu V}{100\mu V}\right] = 110\, A_d\ \mu V$$

$$\%\ \text{difference} = \frac{V_{02} - V_{01}}{V_{01}} \times 100 = \frac{110 - 100}{100} \times 100 = 10\%$$

**24. (d)**

$$V_{max} = \sqrt{2} \times 220 = 311.12\ V$$

Since output is a rectified wave we have,




$$V_m' = V_m\left(1 - \frac{T}{2RC}\right)$$

$$V_m - V_m' = \frac{V_m T}{2RC}$$

$$\text{ripple} = V_m - V_m' = \frac{V_m T}{2RC}$$

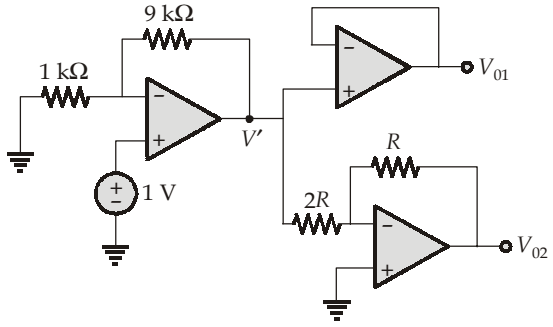
Peak to peak ripple voltage,

$$= 0.01 \times V_{max}$$
$$= 0.01 \times 311.12$$
$$\text{ripple} = 3.11$$

$$3.11 = \frac{311.12}{2 \times 50 \times 10 \times 10^3 \times C}$$

$$C = 100\ \mu F$$

**25. (c)**



$$V' = \left(1+\frac{9\,\text{k}\Omega}{1\,\text{k}\Omega}\right)\times 1\,\text{V} \qquad (\because \text{non-inverting amplifier})$$

$$V' = 10\,\text{V}$$

now, $V_{01} = V' = 10\,\text{V}$ $(\because$ it is a voltage buffer)

and $V_{02} = -\frac{R}{2R}V'$

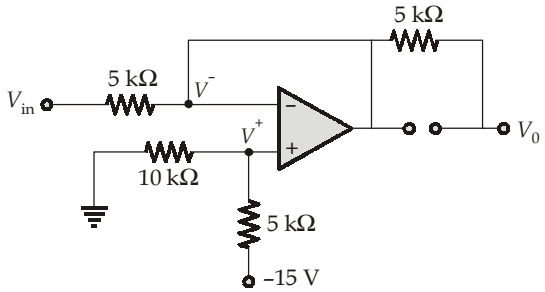
$(\because$ inverting amplifier)

$$V_{02} = -\frac{1}{2}V' = -\frac{10\,\text{V}}{2} = -5\,\text{V}$$

$\therefore$ $V_{02} - V_{01} = -5\,\text{V} - 10\,\text{V} = -15\,\text{V}$

**26. (b)**

**Case -I :** When $V_{in} > -10$ V, then the voltage across diode $D_1$ is positive so diode $D_1$ is in ON state, and therefore the equivalent circuit can be drawn as




$$V^+ = -15\times\frac{10}{15} = -10\,\text{V}$$

Due to virtual ground, $V^+ = V^- = -10$ V

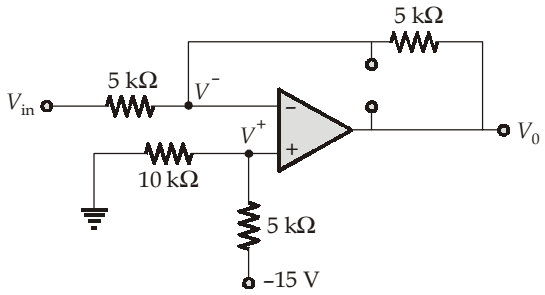
and $V_0 = V^- = -10$ V

$\therefore$ $V_0 = -10$ V

**Case -II :** When $V_{in} < -10$ V

$$V_0 = +V_{sat}$$

Thus,




$\therefore$ $V_0 = -\frac{5}{5}\times V_{in} = -V_{in}$ (for $V_{in} < -10$ V)

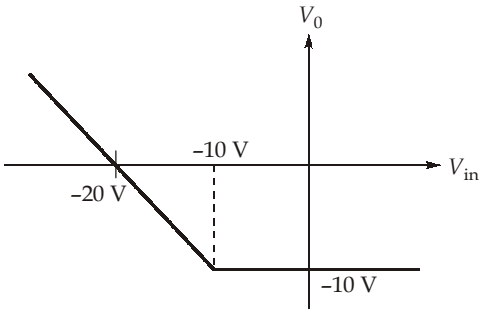
Alternately, we can write the equation of the graph by applying KCL at node $V^-$

$\because$ $V^- = V^+ = -10$ V

$$\frac{-10 - V_{in}}{5\,k\Omega} + \frac{-10 - V_0}{5\,k\Omega} = 0$$

$$-20 - V_{in} - V_0 = 0$$

$$V_0 = -V_{in} - 20$$

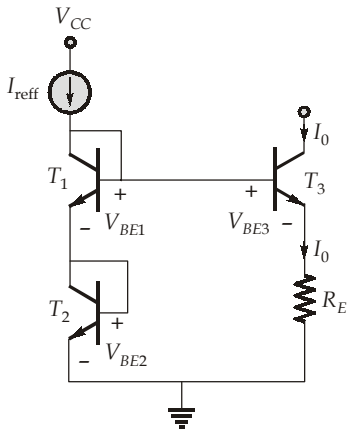



**27. (b)**

Applying KVL in the circuit shown below, we get,

$$2V_{BE1} = V_{BE3} + I_0R_E$$

($\because$ both the transistor are matched with negligible base current thus $V_{BE1} = V_{BE2}$ for same $I_{reff}$).




Now,

$$V_{BE1} = V_T \ln\left(\frac{I_{reff}}{I_s}\right)$$

$$V_{BE3} = V_T \ln\left(\frac{I_0}{I_s}\right)$$

$$2V_T \ln\left(\frac{I_{reff}}{I_s}\right) - V_T \ln\left(\frac{I_0}{I_s}\right) = I_0R_E$$

$$V_T \ln\left(\frac{I_{reff}^2}{I_0I_s}\right) = I_0R_E$$

$$R_E = \frac{V_T}{I_0}\ln\left(\frac{I_{reff}^2}{I_0I_s}\right) = 0.208\ln\left(\frac{625}{10\times120\times10^{-3}}\right) = 15.638\,k\Omega$$

**28. (c)**

Assuming all the diodes are forward biased,

$$V_B = -0.7\ V$$

$$V_A = 0\ V$$

$$\therefore \quad I_2 = \frac{10-0}{10\,k} = 1\ mA$$

and

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

$\because$

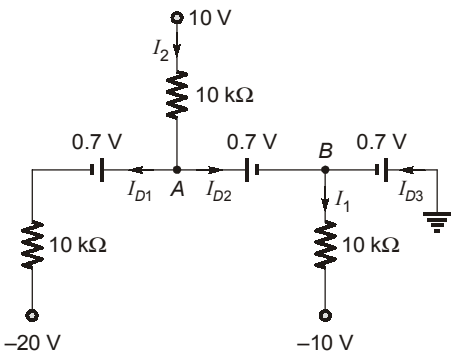
$$I_2 = I_{D_1} + I_{D_2}$$

and

$$I_1 = I_{D_2} + I_{D_3}$$

applying KVL in the outer loop, we get,

$$10\,k I_2 + 0.7 + 10\,k\,I_{D_1} - 20 = 10$$



$$10\,k(I_{D_1} + I_{D_2}) + 10\,k\,I_{D_1} = 30 - 0.7 = 29.3$$
$$20\,kI_{D_1} + 10k\,I_{D_2} = 29.3$$

$$2I_{D_1} + I_{D_2} = 2.93 \text{ mA} \quad ...(i)$$

also, $$I_{D_1} + I_{D_2} = I_2 = 1 \text{ mA} \quad ...(ii)$$

from (i) and (ii)

$$I_{D_1} = 1.93 \text{ mA and } I_{D_2} = -0.93 \text{ mA}$$

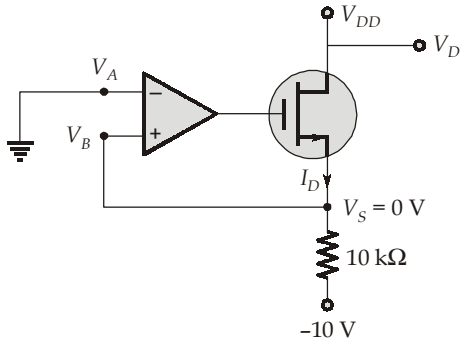
$\because$ $$I_{D_2} + I_{D_3} = 0.93 \text{ mA}$$

$\Rightarrow$ $$I_{D_3} = -I_{D_2} + 0.93 \text{ mA} = 1.86 \text{ mA}$$

Here $I_{D_2}$ is negative, Hence, our assumption is incorrect.
Therefore, $D_2$ is reverse biased
and $\because$ $I_{D_1}$ and $I_{D_3}$ are positive,
$D_1$, $D_3$ are forward biased.

**29. (b)**

For the transistor




$$V_S = V_B = V_A$$

due to virtual ground,

thus, $$V_S = 0 \text{ V}$$

Hence, $$I_D = \frac{0-(-10)}{10\times10^3} = 1 \text{ mA}$$

$$I_D = \frac{\mu_n C_{ox} W}{2L}(V_{GS} - V_T)^2$$

$\therefore$ $$V_{GS} - V_T = \sqrt{\frac{I_D}{\frac{\mu_n C_{ox} W}{2L}}}$$

$$V_{GS} - V_T = \sqrt{\frac{1\times10^{-3}}{\frac{0.5\times10^{-3}}{2}}}$$

$$V_{GS} - V_T = 2 \text{ V}$$

For the MOSFET to be in saturation region

$$V_{DS} \geq V_{GS} - V_T$$

$\therefore$ at the edge of saturation

$$V_{DS} = V_{GS} - V_T = 2\text{ V}$$

$\because$ $V_S = 0$

$\therefore$ $V_D = V_G - V_T$

$\Rightarrow$ $V_{DD} = 2\text{ V}$

**30. (a)**

For upper MOSFET,

$$V_{DS} = 8 - V_a$$

$$V_{GS} - V_T = 6 - V_a - 2 = 4 - V_a$$

Upper MOS will be in saturation because

$$V_{DS} > V_{GS} - V_T$$

For lower MOS, $V_{DS} = V_a$

$$V_{GS} - V_T = V_a - 2$$

So, $V_{DS} > V_{GS} - V_T$

Hence both MOS will be in saturation

$$I_D = \mu_n C_{ox}\left(\frac{W}{L}\right)\left(V_{GS} - V_T\right)^2$$

$$I_{D1} = \mu_n C_{ox}(9)\left(4 - V_a\right)^2$$

$$I_{D2} = \mu_n C_{ox}(4)\left(V_a - 2\right)^2$$

But $I_{D1} = I_{D2}$

$\therefore$ $\mu_n C_{ox}(9)\left(4 - V_a\right)^2 = \mu_n C_{ox}(4)\left(V_a - 2\right)^2$

$$\frac{9}{4} = \left(\frac{V_a - 2}{4 - V_a}\right)^2$$

$$\frac{3}{2} = \frac{V_a - 2}{4 - V_a}$$

$$12 - 3V_a = 2\,V_a - 4$$

$$16 = 5\,V_a$$

$$V_a = \frac{16}{5} = 3.2\text{ Volts}$$

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