CLASS TEST

S.No.: 01SKEC_ABCDEFGHI_30725

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ANALOG CIRCUIT

ELECTRONICS ENGINEERING

Date of Test : 30/07/2025

ANSWER KEY

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

Detailed Explanations

1. (c)

The diode circuit is a two level clipper and the positive cycle is saturated at 8 V. Thus, diode D_1 will start conducting for $V_i > 8$ V. Thus V_1 should be –8 V. Similarly V_2 should be –6 V.

2. (d)

$$g_m = \frac{I_C}{V_{Th}} = \frac{0.5}{0.025} = 20 \text{ mA/V}$$

The value of

$$A_V = g_M R_C$$
$$= 20 \times 10^{-3} \times 7.5 \times 10^3$$
$$= 150 \text{ V/V}$$

3. (a)

For $I_{in} > 0$, D_1 will be ON and $V_{out} = I_{in}R_1$.
For $I_{in} < 0$, D_2 will be ON and all the current will flow through D_2. Since there will be no current flowing through resistance R_1, thus $V_{out} = 0$.

4. (b)

$$I_D \propto \frac{(W)}{(L)}$$

$\therefore$
$$\frac{I_{D1}}{I_{D2}} = \frac{\left(\frac{W}{L}\right)_1}{\left(\frac{W}{L}\right)_2} = 2$$

and
$$r_o \propto \frac{1}{I_D}$$

$\therefore$
$$\left(\frac{I_{D1}}{I_{D2}}\right) = \left(\frac{r_{02}}{r_{01}}\right) = 2$$

$\therefore$
$$\frac{r_{01}}{r_{02}} = 0.5$$

5. (c)

Since the op-amp is connected in the negative feedback configuration. Thus, the concept of virtual ground will be applicable.

Thus,
$$V^+ = V^- = 0 \text{ V}$$

$\therefore$
$$I_D = \frac{0-(-10)}{20 \text{ k}\Omega} = 0.5 \text{ mA}$$

$\therefore$
$$V_o = 10 - (10 \times 10^3) \times (0.5 \times 10^{-3})$$
$$= 10 - 5 = 5 \text{ V}$$

6. (a)

$$T_{ON} = 0.693(R_a + R_b)C$$

To achieve 50% duty cycle, diode is connected across resistor R_b so that during the charging of the capacitor, R_b is bypassed and hence,

$$T_{ON} = 0.693\ R_a C$$
$$T_{\text{OFF}} = 0.693\ (R_b\ C)$$

In case of 50% duty cycle frequency $= \dfrac{1}{0.693(2RC)}$

Assuming $R_a = R_b = R$. Therefore,

$$20\text{ k} = \frac{1}{0.693 \times 2 \times R \times C}$$
$$RC = 36 \times 10^{-6}$$

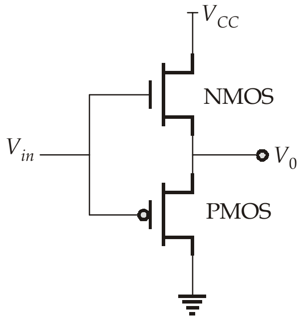
if $C = 1$ nF, $R = 36$ kΩ

RC obtained will match our requirement.

Thus, option a is correct.

7. **(c)**

If NMOS and PMOS of a CMOS inverter are interchanged, the circuit is:



If $V_{in} < V_T$, NMOS is OFF and PMOS is ON and output is low.

If $V_{\text{in}} > V_T$, NMOS is ON and PMOS is OFF and output is high.

Therefore, the circuit works as a buffer with weak levels.

8. **(c)**

We know, for CE BJT → $V_i = V_{BE}$, $V_0 = V_{CE}$

↓

In saturation, $V_{CE} \rightarrow (V_{CE})_{\text{sat}}$

$I_{CE} \rightarrow (I_{CE})_{\text{sat}} \rightarrow$ Constant

$$\Delta I_C = 0$$

$$I_E = I_B + I_C \rightarrow \text{(Universal)}$$

↓

$$I_E = I_B + (I_C)_{\text{sat}} \text{[in saturation]}$$

$$\Delta I_E = \Delta I_B$$

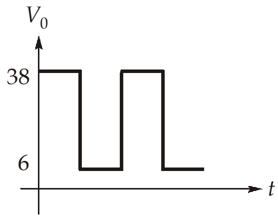
In saturation, only I_C saturates.

9. **(c)**

The reverse saturation doubles for every 10° rise in temperature, thus disturbing the Q-point.

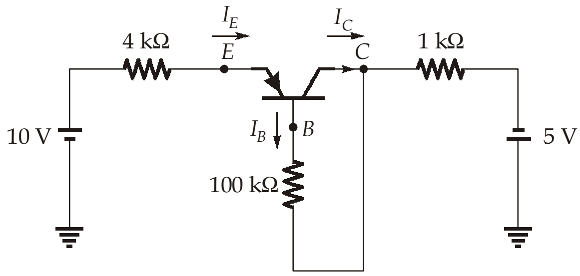
10. **(d)**

The circuit given in the question is a clamper circuit. The total signal will be clamped above the +6 V. So, the output waveform will be



Therefore, the maximum value of V_0 is 38 V.

11. (c)



$$I_E = \frac{10 - V_E}{4\text{ k}\Omega} = \frac{10-4}{4\text{ k}\Omega} = 1.5\text{ mA}$$

$$V_C = -5 + 1.5 = -3.5\text{ V}$$

$$V_{EB} = V_E - V_B = 0.7\text{ V}$$

$$\Rightarrow \quad V_B = 4 - 0.7 = 3.3\text{ V}$$

$$\therefore \quad V_{BC} = V_B - V_C = 3.3 - (-3.5) = 6.8\text{ V}$$

$$I_B = \frac{V_{BC}}{100\text{ k}\Omega} = 0.068\text{ mA}$$

$$\frac{I_E}{I_B} = \beta + 1$$

$$\frac{1.5}{0.068} = \beta + 1$$

$$\beta = 21$$

12. (b)

Since the gate current is zero, then

$$I_{D1} = I_{D2} \text{ (Assuming both the transistor be in saturation region)}$$

$$\frac{1}{2}(200\times10^{-6})\left(\frac{500}{9}\right)(V_B - 0.4)^2(1+0.1\times0.9) = \frac{1}{2}(100\times10^{-6})(1.8 - V_B - 0.4)^2(1+0.1\times0.9)\left(\frac{500}{3}\right)$$

$$2(V_B - 0.4)^2 = 3(1.4 - V_B)^2$$

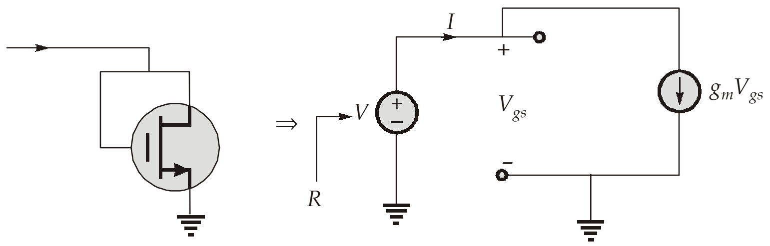
$$\sqrt{\frac{2}{3}}(V_B - 0.4) = (1.4 - V_B)$$

$$1.816V_B = 1.7264$$

$$V_B = 0.95\text{ V}$$

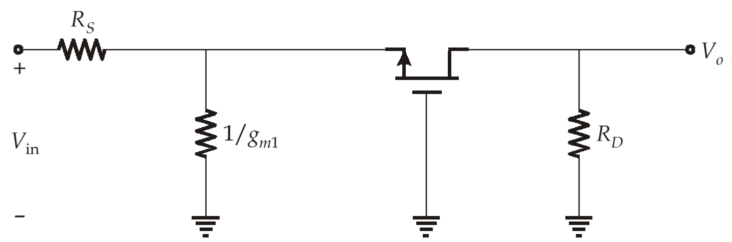
13. (c)

For a MOS Circuit

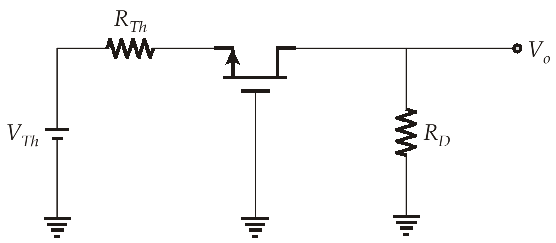


$$I = g_m V_{gs}$$
$$I = g_m V$$
$$R = \frac{V}{I} = \frac{1}{g_m}$$

Thus, the circuit can be viewed as



Let the circuit be drawn as



where $$R_{Th} = \frac{1}{g_{m1}} \parallel R_s$$

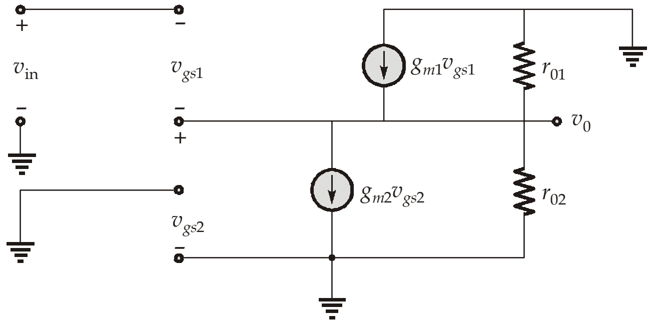
and $$V_{Th} = \frac{\frac{1}{g_{m1}}}{\frac{1}{g_{m1}} + R_s} \cdot V_{in}$$

Thus, the gain of this circuit is given as

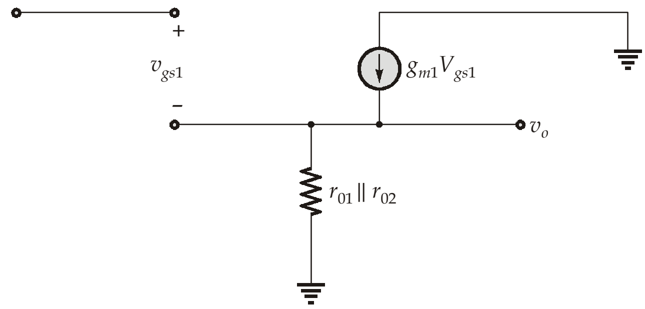
$$V_o = \frac{g_{m2} R_D}{1 + g_{m2} R_s} V_{Th}$$
$$= \frac{g_{m2} R_D}{1 + g_{m2} R_s} \times \frac{1}{1 + g_{m1} R_s} V_{in}$$
$$= \frac{g_{m2} R_D}{1 + (g_{m1} + g_{m2}) R_s + g_{m1} g_{m2} R_s^2}$$
$$V_o \approx \frac{g_{m2} R_D}{1 + (g_{m1} + g_{m2}) R_s}$$

14. (a)

Drawing the small signal equivalent model, we get



Thus, the circuit reduces to



$\therefore$ $$v_o = (g_{m1}v_{gs1})(r_{o1} \| r_{o2})$$

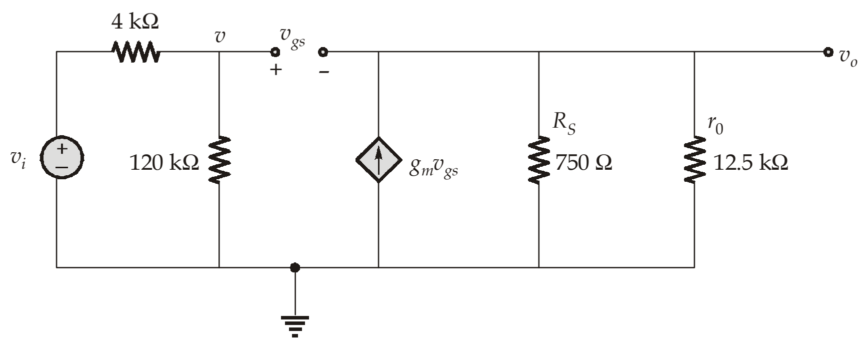
and $$v_{gs1} = v_{in} - v_o$$

$$v_o = g_{m1}(r_{o1} \| r_{o2})(v_{in} - v_o)$$

$$\frac{v_o}{v_{in}} = \frac{g_{m1}(r_{o1} \| r_{o2})}{1 + g_{m1}(r_{o1} \| r_{o2})}$$

15. (c)

The small signal equivalent model can be drawn as



The value of output voltage $$v_o = g_m(R_s \| r_o)v_{gs}$$

Applying KVL we get

$$v - v_{gs} - g_m v_{gs}(R_s \| r_o) = 0$$

$$v = v_{gs}(1 + g_m(R_s \| r_o))$$

Substituting the value of v_{gs}, we get

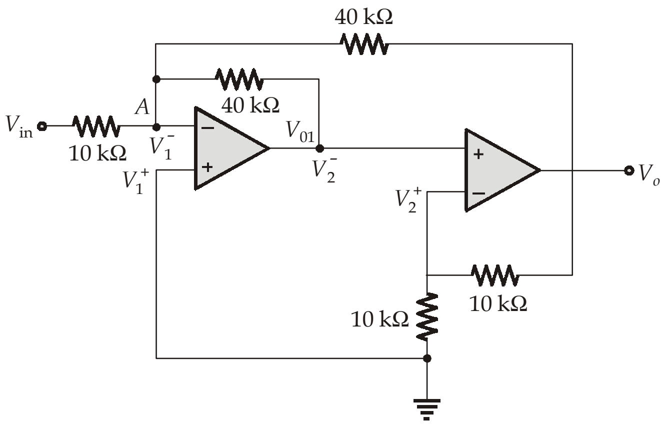
$$v_o = \frac{g_m(R_s \| r_o)v}{1 + g_m(R_s \| r_o)}$$

$$\therefore \quad v = \frac{R_i}{R_i + R_{si}} \times v_i$$

$$\therefore \quad \frac{v_o}{v_i} = \frac{120}{120+4} \times \frac{(11.3)(0.75 \| 12.5)}{1 + 11.3(0.75 \| 12.5)}$$

$$A_V = \frac{v_o}{v_i} = 0.86$$

16. (c)



Apply KCL at node 'A'.

$$\frac{V_1^- - V_{in}}{10\text{ k}\Omega} + \frac{V_1^- - V_{o1}}{40\text{ k}\Omega} + \frac{V_1^- - V_o}{40\text{ k}\Omega} = 0$$

$$V_1^-\left[\frac{1}{10\text{ k}\Omega} + \frac{1}{40\text{ k}\Omega} + \frac{1}{40\text{ k}\Omega}\right] = \frac{V_{in}}{10\text{ k}\Omega} + \frac{V_{o1}}{40\text{ k}\Omega} + \frac{V_o}{40\text{ k}\Omega}$$

Due to virtual ground, $V_1^- = V_1^+ = 0\text{ V}$

$$\therefore \quad \frac{V_{in}}{10\text{ k}\Omega} + \frac{V_{o1}}{40\text{ k}\Omega} + \frac{V_o}{40\text{ k}\Omega} = 0 \quad \ldots(1)$$

Now, $V_o = 2V_{o1}$

$$\because \quad V_2^+ = \frac{V_o}{2}$$

$$\therefore \quad V_2^- = V_2^+ = \frac{V_o}{2} = V_{o1}$$

$$\therefore \quad V_o = 2V_{o1} \quad \ldots(2)$$

From eqn. (1) and (2), we get

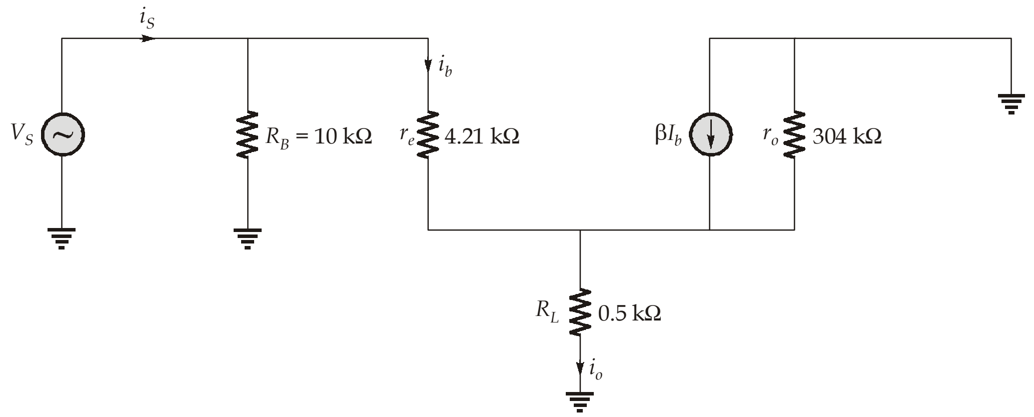
$$\frac{V_{in}}{10\text{ k}\Omega} + \frac{V_o}{80\text{ k}\Omega} + \frac{V_o}{40\text{ k}\Omega} = 0$$

$$\frac{V_{in}}{10\text{ k}\Omega} + \frac{3V_o}{80\text{ k}\Omega} = 0$$

$$\frac{V_o}{V_{in}} = \frac{-8}{3}\text{ V/V}$$

17. (a)

Drawing the small signal model, we get



$$i_o = \frac{r_o}{r_o + R_L}(\beta + 1)i_b$$

$$i_b = \frac{R_B}{R_B + r_e + (R_L \parallel r_o)(1+\beta)} i_s$$

$$A_i = \frac{i_o}{i_s} = \frac{r_o}{r_o + R_L}(1+\beta) \times \frac{R_B}{R_B + r_e + (R_L \parallel r_o)(1+\beta)}$$

$$= \frac{304 \times 10^3}{304 \times 10^3 + 500} \times 81 \times \frac{10 \times 10^3}{10 \times 10^3 + 4.21 \times 10^3 + (0.5\text{ K} \parallel 304\text{ K})(81)}$$

$$= 0.998 \times 81 \times \frac{10 \times 10^3}{14.21\text{ K} + 40.5\text{ K}} = 14.8\text{ V/V}$$

18. (a)

$$\text{Line regulation} = \frac{\Delta V_{out}}{\Delta V_{in}} \times 100$$

$$I = \frac{V_{in} - V_{Z0}}{4410\ \Omega}$$

$$V_z = V_{zo} + IR_z = V_{zo} + \frac{10}{4410}(V_{in} - V_{zo})$$

$$V_{out} = \left(1 + \frac{10}{10}\right)V_z = 2V_z = \frac{880}{441}V_{zo} + \frac{2}{441}V_{in}$$

$$\frac{\Delta V_{out}}{\Delta V_{in}} = \frac{2}{441} \times 100 = 0.45\%$$

19. (a)

$\because$ $\beta = 98$

$$1\text{ mA} = 17I_B + I_C = \left(\frac{17}{\beta} + 1\right) \cdot I_C$$

$$I_C = \left(\frac{\beta}{17+\beta}\right) \times 1\text{ mA}$$

$$I_C = 0.85\text{ mA}$$

$\therefore$ $I_{C0} = I_{C1} = I_{C2} = \ldots\ldots = I_{Cn}$ ($\because$ all are having same value of V_{BE})

Now, $V_o = nI_C(R)$

$$= 16 \times 0.85 \times 10^{-3} \times 100 = 1.36$$

20. (d)

Since the value of voltage gain $A_V = \frac{v_o}{v_i}$ is equal to

$$A_V = \frac{v_o}{v_i} = \frac{-g_m R_D}{1 + g_m R_S}$$

where
$$g_m = 2\sqrt{\left(\frac{\mu_n C_{ox} W}{2L}\right) I_{DQ}}$$

$$= 2\sqrt{0.5 \times 2 \times 10^{-6}}$$

$$g_m = 2 \times 10^{-3} = 2 \text{ mA/V}$$

$\therefore$
$$A_V = \frac{-(2)(10)}{1 + 2 \times 3} = -2.85 \text{ V/V}$$

21. (c)

$$\frac{V_i}{R} = I_s e^{\frac{V_{BE}}{V_T}}$$

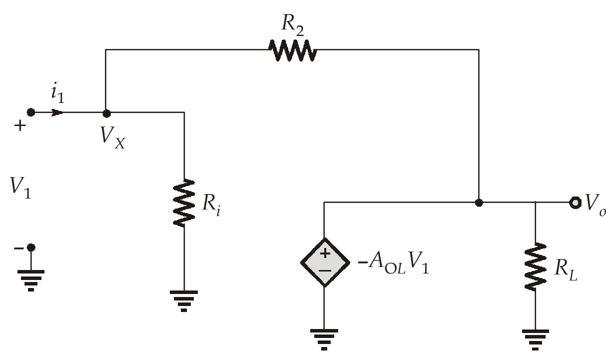
$$\frac{2}{1 \times 10^3} = 2 \times 10^{16} e^{\frac{V_{BE}}{V_T}}$$

$$V_T \ln 10^{13} = V_{BE}$$

$$V_{BE} = 0.78 \text{ V}$$

$$V_0 = -V_{BE} = -0.78 \text{ V}$$

22. (c)



$$R_{in} = \frac{V_1}{i_1}$$

$$i_1 = \frac{V_X}{R_i} + \frac{V_X - (-A_{OL}V_1)}{R_2} \qquad \{V_d = -V_1\}$$

$$i_1 = \frac{V_X}{R_i} + \frac{V_X + A_{OL}V_1}{R_2}$$

$$\frac{1}{R_{eq}} = \frac{i_1}{V_1} = \frac{1}{R_i} + \frac{1 + A_{OL}}{R_2} \qquad (R_i = R_{eq})$$

$$R_{eq} = \left[\frac{1}{R_i} + \frac{1+A_{OL}}{R_2}\right]^{-1}$$

$$R_{eq} = 0.1\ \Omega$$

$$R_{in} = R_{eq} + 2000\ \Omega$$

$$= 2000.1\ \Omega$$

23. (d)

Let $Z_1 = R_1$ and $Z_2 = R_2 \| \frac{1}{sC_2}$

$$\frac{V_0(s)}{V_i(s)} = -\frac{Z_2(s)}{Z_1(s)}$$

$$\frac{V_0(s)}{V_i(s)} = \frac{-R_2}{sR_1R_2C_2 + R_1} = \frac{-R_2/R_1}{sR_2C_2 + 1}$$

The dc gain k is $\frac{V_0(s)}{V_i(s)}$ at $s = 0$

$\therefore$ $$k = \frac{-R_2}{R_1}$$

24. (c)

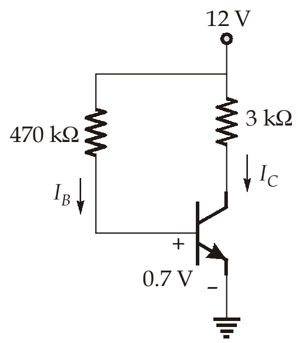
From the circuit,

$$V_0 = \begin{cases} 7\text{ V}; & 7\text{ V} < V_i < 10\text{ V} \\ V_i; & -5\text{ V} < V_i < 7\text{ V} \\ -5\text{ V}; & -10\text{ V} < V_i < -5\text{ V} \end{cases}$$

$\therefore$ Only option (c) satisfies the above condition.

25. (b)

DC Analysis:



$$I_B = \frac{12 - 0.7}{470\text{ k}} = 24.04\ \mu\text{A}$$

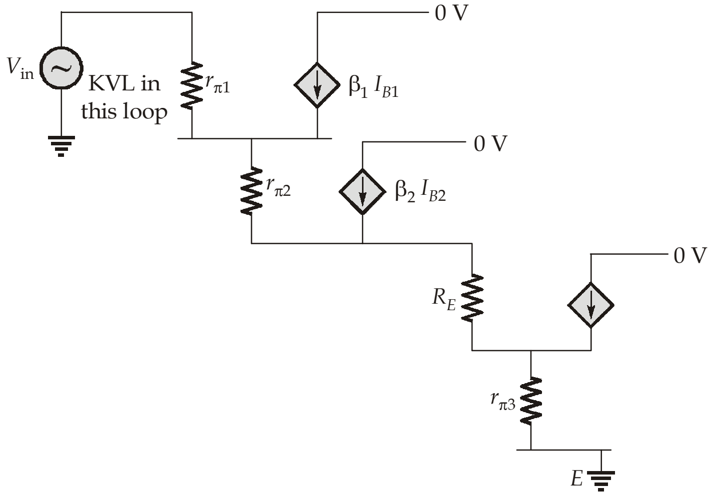
$$I_E = (1 + \beta)I_B = (101) \times 24.04\ \mu\text{A} = 2.428\text{ mA}$$

$$r_e = \frac{V_T}{I_E} = \frac{26\text{ mV}}{2.428\text{ mA}} = 10.71\ \Omega$$

$$A_V = \frac{-R_C}{r_e} = \frac{-3\text{ k}\Omega}{10.71} = -280.11$$

26. (d)

By using the π model:



$V_{in} = I_{B1} r_{\pi1} + r_{\pi2}(1 + \beta_1)I_{B1} + R_E(1 + \beta_2)I_{B2} + r_{\pi3}(1 + \beta_2) I_{B2}$

where $I_{B2} = (1 + \beta_1)I_{B1}$

thus on substitution option (d) is obtained.

27. (c)

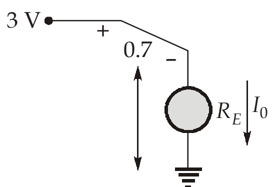
In figure (II), current mirror circuit

for $\beta = 100, \dfrac{(I_{C3})}{A_3} = \left(\dfrac{I_{C2}}{A_2}\right)$

$$I_0 = \frac{A_3}{A_2} I_{C2} = \frac{A_3}{A_2}\left[\frac{I_{in}}{\left(1+\frac{2}{\beta}\right)}\right]$$

$$I_0 = 3 \cdot \frac{2mA}{\left(1+\frac{2}{100}\right)} = 5.88 \text{ mA}$$

In figure (I),

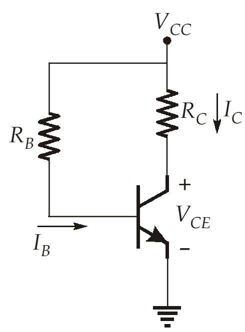


⇒ $3 \text{ V} = 0.7 + R_E I_0$

⇒ $R_E = \dfrac{2.3}{I_0} = 0.39 \text{ k}\Omega$

28. (d)

The fixed-bias circuit is shown below:



$$I_C = \frac{V_{CC} - V_{CE}}{R_C}$$

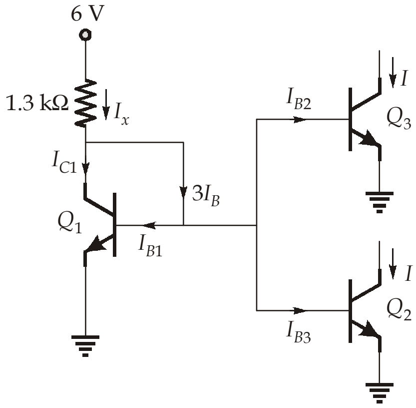
∴ $V_{CE} = V_{CC}$ at $I_C = 0$

and $I_C = \dfrac{V_{CC}}{R_C}$ at $V_{CE} = 0$

∴ $V_{CC} = 20 \text{ V}; \dfrac{V_{CC}}{R_C} = 10 \text{ mA}$

⇒ $R_C = \dfrac{20 \text{ V}}{10 \text{ mA}} = 2 \text{ k}\Omega$

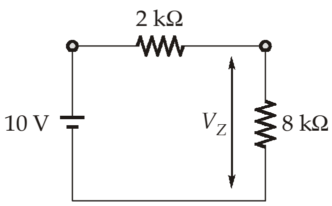
29. (b)



$\therefore$
$$I_x = I_{C1} + I_{B1} + I_{B2} + I_{B3} \qquad \{I_{B1} = I_{B2} = I_{B3} = I_B\}$$
$$I_x = I_{C1} + 3I_B$$
$$I_x = I_{C1}\left[1+\frac{3}{\beta}\right] \qquad \{\because \beta \text{ is very large}\}$$
$$I_x \cong I_{C1} \cong I$$
$$I = \frac{6-V_{BE}}{1.3\text{ k}} = \frac{6-0.7}{1.3\text{ k}} = 4.08\text{ mA}$$

30. (d)

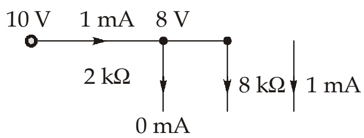
For (V_S = 10 V) → Zener in Breakdown ⇒ $(V)_{R_L} = V_z$



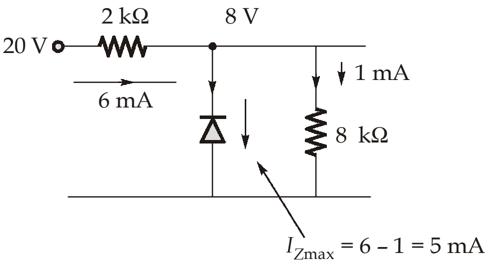
⇒ $\left[V_z = \frac{8}{(8+2)} \times (10) = 8\text{ V}\right]$

At Breakdown, $I_z = I_{z\ min}$ (V_s = 10 V)

$$I_S = I_{z\ min} + I_L$$
$$1\text{ mA} = I_{z\ min} + I\text{ mA}$$
⇒ $$I_{z\ min} = 0\text{ mA}$$



for Max Power dissp. $I_{z\ max}$ flow through Zener.



$\therefore$ $[I_{z\ max} - I_{z\ min} = 5\text{ mA} - 0\text{ mA} = 5\text{ mA}]$

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