S.No. : 01 **LS1_EC_A_280819**

Analog Electronics

MADE EASY

India's Best Institute for IES, GATE & PSUs

Delhi | Noida | Bhopal | Hyderabad | Jaipur | Lucknow | Indore | Pune | Bhubaneswar | Kolkata | Patna

Web: www.madeeasy.in | **E-mail:** info@madeeasy.in | **Ph:** 011-45124612

CLASS TEST 2019-2020

ELECTRONICS ENGINEERING

Date of Test : 28/08/2019

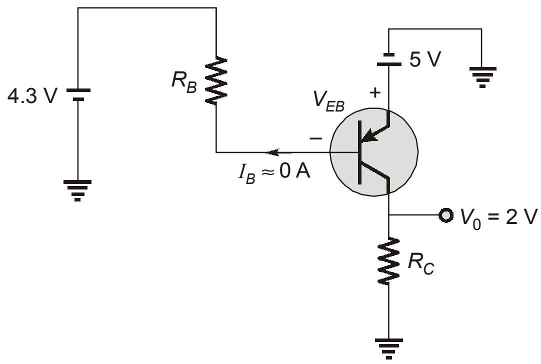
ANSWER KEY ➤ Analog Electronics

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

DETAILED EXPLANATIONS

1. (d)
   (i) For $V_{in} > 0$ V, diode D_1 and D_2 will conduct and $V_{out} = V_{in}$.
   (ii) For $V_{in} < 0$ V, diode D_1 will be in OFF state. Hence no signal will pass further and $V_0 = 0$ V.

2. (a)
   Since β is very large, base current I_B can be neglected.
   Thus



Applying KVL in base loop, we get,

$$V_{EB} + 4.3 = 5 \text{ V}$$

∴ $$V_{EB} = 0.7 \text{ V}$$

Thus $$V_B = 0.7$$

Now $$V_C = 2 \text{ V}$$

Hence $$V_{CB} = 2 - 0.7 = 1.3 \text{ V}$$

Hence, emitter base junction ⇒ forward biased and collector base junction ⇒ reverse biased.
Thus the transistor is working in forward active region or active region.

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

5. (d)
   Option (a) and (c) are wrong and option (b) does not include the resistance r_0.

6. (c)
   Since the diode will only allow the positive half cycle of the input signal to flow, the output current will be the D.C. value of the half wave rectified output.

Thus, $$I_0 = \frac{I_{max}}{\pi}$$

$$I_{max} = \frac{10}{10 \times 10^3} \text{ A} = 1 \text{ mA}$$

∴ $$I_0 = \frac{1}{\pi} \text{ mA}$$

$$I_0 = 0.318 \text{ mA}$$

7. (d)
   In a BJT, $$I_C + I_B = I_E$$

∴ $$I_C = I_E - I_B$$
$$= 10.1 - 0.1 = 10 \text{ mA}$$

Given that, $V_C = 0\text{ V}$

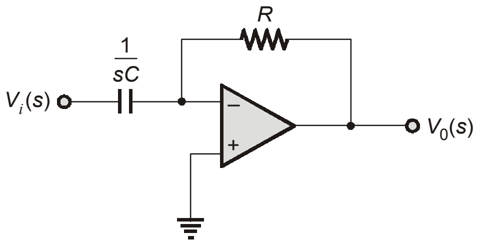
By applying KVL, we get,

$$-V_C + I_C \times 1 \times 10^3 + V_{EE} = 0$$

$$\therefore \quad V_{EE} = -10 \times 10^{-3} \times 1 \times 10^3 = -10\text{ V}$$

8. (a)

The transfer function can be obtained by taking the circuit in it's Laplace transform domain as follows:



Thus, $$\frac{V_0(s)}{V_i(s)} = -\frac{R}{1/sC} = -sCR$$

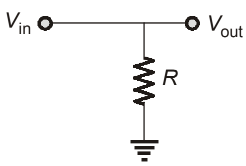
Now, $RC = 10$

$$C = \frac{10}{1\times10^6} = 10\times10^{-6}\text{ F} = 10\ \mu\text{F}$$

9. (d)

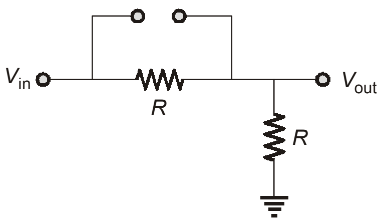
Case I: when $V_{in}(t) > 0$

The diode will conduct, thus the equivalent circuit can be given as,



$$\therefore \quad V_{out} = V_{in}$$

Case II: when the input voltage $V_{in} < 0$, The diode will not conduct, thus the equivalent circuit can be given as,



$$\therefore \quad V_{out} = V_{in}\frac{R}{R+R} = \frac{V_{in}}{2} = 0.5V_{in}$$

10. (d)

Since the configuration represents an invertor MOSFET with an active load, the output will be high for low values of input signal and low for high values of input signal.

Now, since the load transistor T_1 has shorted drain and gate,

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

$$0 > -V_T$$

Which is always true hence the transistor T_1 will always work in saturation region.

When $V_{in} = 0$ V, $I_D = 0$.

Hence,
$$I_D = K_n(V_{GS1} - V_T)$$
$$0 = (V_{GS1} - V_T)$$
$$V_{G1} - V_{S1} - V_T = 0$$

For transistor T_1, $V_{S1} = V_0$ and $V_{GS1} = V_{DD} = 5$ V

Thus,
$$V_{G1} - V_0 - V_T = 0$$
$$5 - V_0 - 1 = 0$$
$$-V_0 = -4 \text{ V}$$
$$V_0 = 4 \text{ V}$$

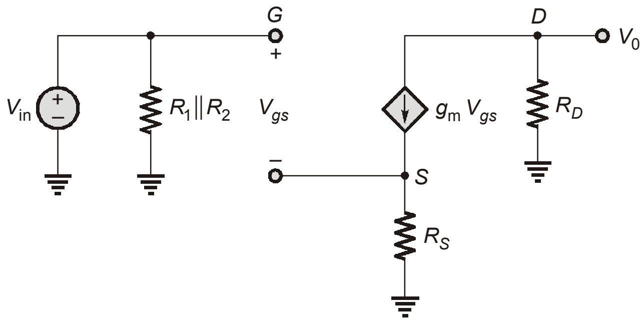
Hence maximum value of output = 4 V.

11. (b)

$$g_m = 2\left[\frac{\mu_n C_{ox} W}{2L}\right](V_{GS} - V_{TN})$$

or
$$g_m = 2\sqrt{\frac{\mu_n C_{ox} W}{2L} \times I_{DQ}}$$
$$= 2\sqrt{1\times10^{-3} \times 0.5\times10^{-3}} = 1.414 \text{ mA/V}$$

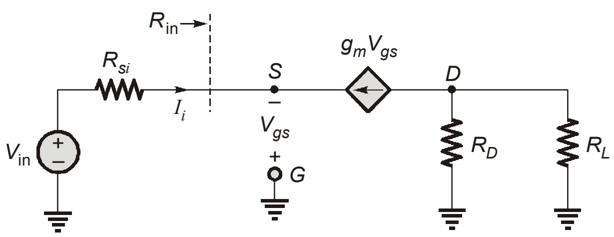
Thus, considering small signal model, we get,



Thus,
$$V_0 = -g_m V_{gs} R_D$$
$$V_{in} = V_{gs} + (g_m V_{gs}) R_S$$
$$V_{in} = V_{gs}(1 + g_m R_S)$$
$$A_v = \frac{V_0}{V_{in}} = \frac{-g_m R_D}{1 + g_m R_S}$$
$$A_v = \frac{-(1.414)(7)}{1 + (1.414)(0.5)} = -5.80$$

12. (b)

By drawing the small signal equivalent circuit by deactivating all the D.C. supplies, we get,



Now, from the figure,

$$R_{in} = \frac{-V_{gs}}{I_i}$$

and $$I_i = -g_m V_{gs}$$

$\therefore$ $$R_{in} = \frac{-V_{gs}}{-g_m V_{gs}} = \frac{1}{g_m}$$

13. (c)

The minimum value of load resistance can be calculated when maximum current flows through the load.

Thus, $$I_{L(max)} = I_{in} - I_{Z(min)}$$

Now, $$I_{Z(min)} = 0 \quad \because \text{ knee current nearly equal to zero}$$

$\therefore$ $$I_{L(max)} = I_{in}$$

$$I_{in} = \frac{50-10}{1\,\text{k}\Omega} = 40 \text{ mA}$$

$\therefore$ $$R_{L(min)} = \frac{10}{40} \times 10^3 = \frac{1}{4} \times 10^3 = 250\ \Omega$$

Now, for maximum value of load resistance, there should be minimum value of current through the load

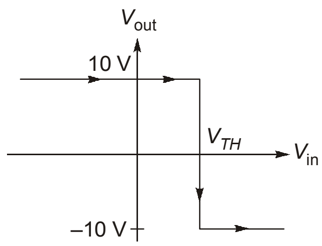
$\therefore$ $$I_{L(min)} = I_{in} - I_{Z(max)}$$

$$I_{L(min)} = (40 - 20) \times 10^{-3} = 20 \text{ mA}$$

$\therefore$ $$R_{L(max)} = \frac{10}{20} \times 10^3 = 500\ \Omega$$

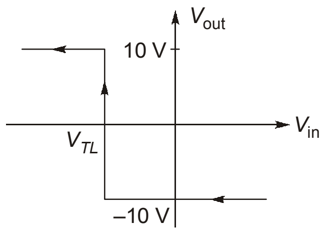
14. (a)

For the positive values of V_{in}, the transfer characteristic curve can be given as,



Where, $$V_{TH} = \frac{V_{sat}}{2} = \frac{10}{2} = 5\text{ V}$$

For negative values of input, the transfer characteristic curve can be given as,

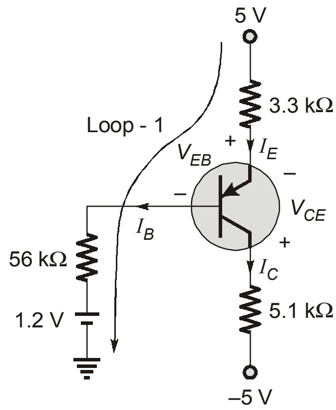


Where, $$V_{TL} = \frac{-V_{sat}}{2} = \frac{-10}{2} = -5\text{ V}$$

15. (b)

By applying KVL in loop (1), we get,

$5 - 3.3 \times 10^3 \times I_E - 0.7 - I_B \times 56 \times 10^3 - 1.2 = 0$ ...(1)



Now, $I_E = (\beta + 1) I_B$

Thus substituting it in equation (1), we get,

$$I_B = \frac{5 - 0.7 - 1.2}{56 + (101)3.3} \text{ mA}$$

$$I_B = 7.963 \, \mu A$$

$$I_C = \beta I_B = 100 \times 7.963 \, \mu A = 0.796 \text{ mA}$$

and $I_E = I_B + I_C = 0.804$ mA

Now, $V_C = -5 + I_C R_C$

$= -5 + 5.1 \times 10^3 \times 0.796 \times 10^{-3}$

$= -0.940$ V

and $V_E = 5 - R_E I_E$

$= 5 - 3.3 \times 10^3 \times 0.804 \times 10^{-3}$

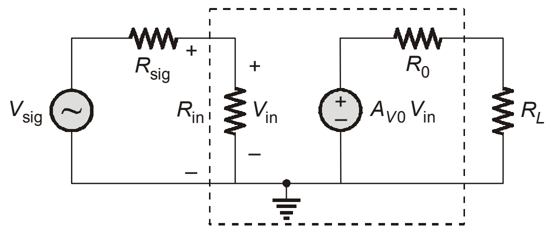
$V_E = 2.347$ V

Thus $V_{CE} = V_C - V_E$

$= -0.940 - 2.347 = -3.287$

16. (c)

The amplifier can be modeled as shown in the figure:



Now, $$V_{out} = A_{V0} V_{in} \times \frac{R_L}{R_L + R_0}$$

Where, A_{V0} = voltage gain when R_L was not connected

Thus, $$A_{V0} = \frac{90}{9} = 10 \text{ V/V}$$

$$\frac{V_{out}}{V_{in}} = A_{V0} \times \frac{R_L}{R_L + R_0}$$

$$\frac{70}{8} = 10 \times \frac{10 \times 10^3}{10 \times 10^3 + R_0}$$

$\Rightarrow$ $R_0 = 1.43$ kΩ

17. (a)

The IC-555 is connected as a pulse-strecher/mono-stable configuration. Thus for a mono stable configuration, the pulse width T_w can be given as,

$T_w = 1.1$ RC

Given that, $T_w = 0.825 \times 10^{-3}$ sec

and $R = 7.5$ kΩ

Thus, $$C = \frac{0.825 \times 10^{-3}}{1.1 \times 7.5 \times 10^3}$$

$= 0.10 \, \mu$F

18. (b)

Given $k_n = 20$ mA/V², $R_D = 5$ kΩ

$V_{DS} = 1.1 - I_D R_D$

$$I_D = k_n(V_{gs} - V_T)^2$$
$$= k_n(V_{gs} - 1)^2$$

For saturation region of operation,

$$V_{DS} \geq V_{gs} - V_T$$
$$V_{DS} \geq (V_{gs} - 1\text{ V})$$
$$(1.1 - I_D R_D) \geq (V_{gs} - 1)$$
$$1.1 - R_D k_n (V_{gs} - 1)^2 \geq (V_{gs} - 1)$$
$$1.1 - (5 \times 10^3)(20 \times 10^{-6})(V_{gs} - 1)^2 \geq (V_{gs} - 1)$$
$$1.1 - (0.1)(V_{gs} - 1)^2 \geq (V_{gs} - 1)$$
$$1.1 - (0.1)(V_{gs}^2 - 2V_{gs} + 1) \geq (V_{gs} - 1)$$
$$1.1 - \frac{V_{gs}^2}{10} + \frac{2V_{gs}}{10} - 0.1 \geq (V_{gs} - 1)$$
$$-\frac{V_{gs}^2}{10} + \frac{2V_{gs}}{10} - V_{gs} + 2 \geq 0$$
$$-V_{gs}^2 - 8V_{gs} + 20 \geq 0$$

at the edge of saturation, $V_{gs} = V_{gs\,max}$

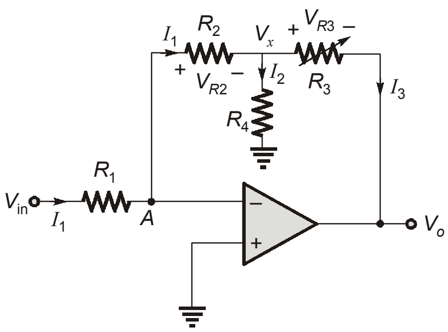
so, $-V_{gs\,max}^2 - 8V_{gs\,max} + 20 = 0$

$$V_{gs\,max}^2 + 8V_{gs\,max} - 20 = 0$$
$$V_{gs\,max} = \frac{-8 \pm \sqrt{64 + 80}}{2}\text{ V}$$
$$= \frac{-8 \pm 12}{2}\text{ V} = -10\text{ V}, 2\text{ V}$$

valid $V_{gs\,max} = 2\text{ V}$

$V_{g\,max} = 2\text{ V}$ $\quad \because V_s = 0$

19. (c)



Now, from the circuit,

$$I_1 = \frac{V_{in}}{R_1}$$

thus, $V_{R2} = I_1 R_2 = \dfrac{V_{in} R_2}{R_1}$

now, $V_x = -\dfrac{V_{in} R_2}{R_1} = -V_{R2}$ $\quad$ ($\because$ node A is virtually grounded)

now, $I_2 = \dfrac{V_x - 0}{R_4} = -\dfrac{V_{in} R_2}{R_1 R_4}$

$$I_3 = \frac{V_{in}}{R_1} + \frac{V_{in}R_2}{R_1R_4}$$

$$V_{R3} = I_3R_3 = \left(\frac{V_{in}}{R_1} + \frac{V_{in}R_2}{R_1R_4}\right)R_3$$

$$\therefore \quad V_o = -(V_{R2} + V_{R3})$$

$$V_o = -\left[\frac{V_{in}R_2}{R_1} + \frac{V_{in}R_3}{R_1} + \frac{V_{in}R_2R_3}{R_1R_4}\right]$$

$$\frac{V_o}{V_{in}} = -\frac{R_2}{R_1}\left[1 + \frac{R_3}{R_2} + \frac{R_3}{R_4}\right]$$

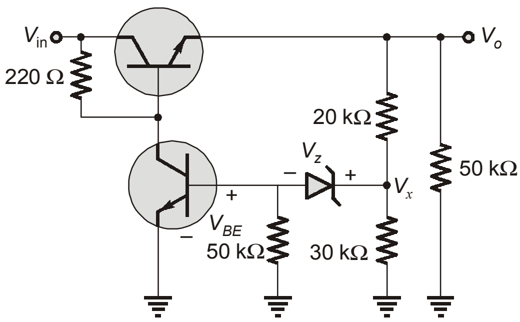
Putting all the known values, we get

$$-8 = -\frac{2\times10^3}{1\times10^3}\left[1 + \left[\frac{1}{2\times10^3} + \frac{1}{2\times10^3}\right]R_3\right]$$

$$4 = 1 + \frac{R_3}{1\times10^3}$$

$$R_3 = 3 \times 10^3 = 3\text{ k}\Omega$$

20. (b)



Now, the voltage of terminal at $V_x = V_Z + V_{BE} = 8.3 + 0.7 = 9$ V

Now, $$V_x = \frac{30\text{ k}\Omega}{20\text{ k}\Omega + 30\text{ k}\Omega}\cdot V_o$$

$$V_o = \left(1 + \frac{2}{3}\right)\cdot 9$$

$$V_o = \frac{5}{3}\times 9\text{ V}$$

$$V_o = 15\text{ V}$$

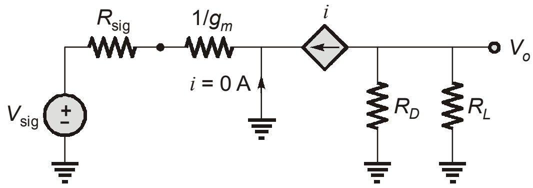
21. (c)

$$g_m = 2\sqrt{k_nI_D}$$

$$= 2\sqrt{10\times10^{-3}\times10\times10^{-3}}$$

$$g_m = 20\text{ mA/V}$$

now, drawing the T equivalent model, we have



$$i = -\frac{V_{sig}}{\frac{1}{g_m}+R_{sig}}$$

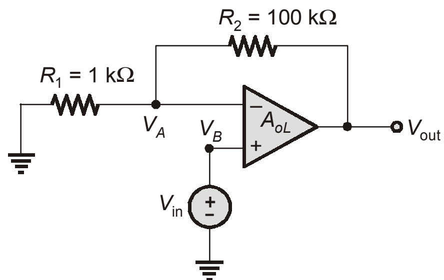
and
$$V_{out} = \frac{(R_D \| R_L)\cdot V_{sig}}{\frac{1}{g_m}+R_{sig}}$$

$$V_{out} = \frac{g_m(R_D \| R_L)}{1+g_m R_{sig}}\cdot V_{sig}$$

∴
$$V_{out} = \frac{20\times10^{-3}(2\times10^3 \| 2\times10^3)\times1\times10^{-3}}{1+20\times10^{-3}\times50}$$

$$V_{out} = 10 \text{ mV}$$

22. (c)



$$V_i = V_B - V_A$$

$$V_o = A_{OL}(V_B - V_A)$$

now,
$$V_B = V_{in}$$

$$V_A = \left(\frac{R_1}{R_1+R_2}\right)V_o$$

∴
$$V_o = A_{OL}\left[V_{in} - \frac{R_1}{R_1+R_2}V_o\right]$$

$$V_o = A_{OL}V_{in} - \frac{A_{OL}R_1}{R_1+R_2}V_o$$

$$\left(1+\frac{A_{OL}R_1}{R_1+R_2}\right)V_o = A_{OL}V_{in}$$

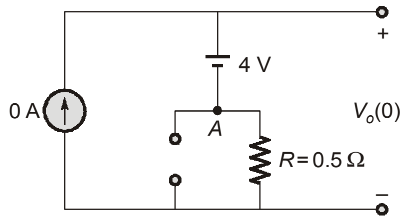
$$\frac{V_o}{V_{in}} = \frac{A_{OL}}{1+\frac{A_{OL}R_1}{R_1+R_2}} = \frac{\left(\frac{R_1+R_2}{R_1}\right)}{1+\frac{1}{A_{OL}}\left(\frac{R_1+R_2}{R_1}\right)}$$

$$\therefore \qquad A_{CL} = \frac{\left(1+\frac{R_2}{R_1}\right)}{1+\frac{1}{A_{OL}}\left(1+\frac{R_2}{R_1}\right)}$$

$$A_{CL} = \frac{(1+100)}{1+\frac{1}{1000}\times\left(1+\frac{100}{1}\right)} = 91.734$$

23. (d)

For $i(t)$ = 0 Amp, the diode D_1 will be reverse biased and $V(0)$ = 4 V as shown in the figure below.



Now, as the current will increase, it will start flowing till the voltage at node A will be equal to 0.7 V.

Thus, $$iR = 0.7\text{ V}$$

$$t(0.5) = 0.7$$

$$t = 1.4\text{ sec}$$

Thus at 1.4 sec and the output will be

$$V_o(t) = 4 + 0.7 = 4.7\text{ V}$$

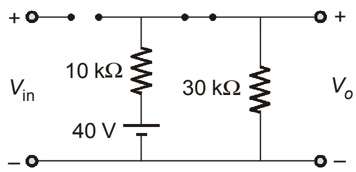
24. (b)

Case - I : When $V_i < 30$ V

Then $$D_1 = \text{OFF}$$

$$D_2 = \text{ON}$$

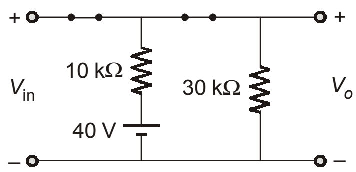
$$V_o = \frac{40\times 30}{40} = 30\text{ V}$$



Case - II : When $V_i > 30$ V

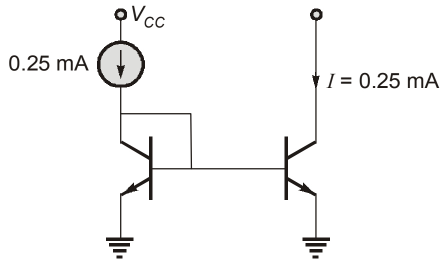
Then D_1 and D_2 will be ON.

Thus, the circuit will look like



$$V_o = V_i$$

25. (c)



Using current mirror concept,
For large 'β',

$$I = I_{ref}$$

so,

$$I_y = (0.25 + 0.25 + 0.25) \text{ mA}$$
$$I_x = (0.25 + 0.25) \text{ mA}$$
$$I_x + I_y = (0.25)\, 5 \text{ mA}$$
$$= 1.25 \text{ mA}$$

26. (a)

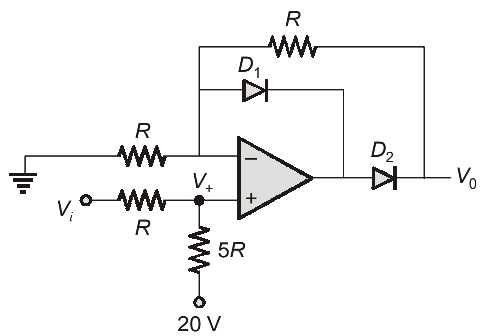
$$V^- = 5 \text{ V}$$
$$V^+ = \frac{V_i(1) + 2(1)}{2}$$
$$V^+ = \frac{V_i + 2 \text{ V}}{2}$$

LED is 'ON' for

$$V^+ - V^- > 0, \qquad V_0 = + V_{sat}$$
$$\frac{V_i + 2 \text{ V}}{2} > 5 \text{ V}$$
$$V_i + 2 \text{ V} > 10 \text{ V}$$
$$V_i > 8 \text{ V}$$

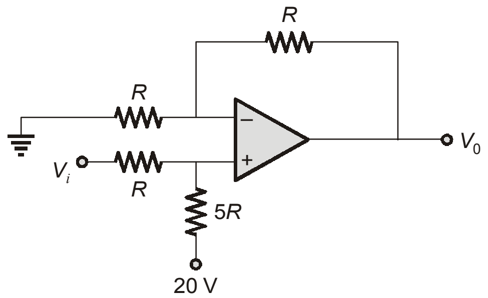
LED is 'ON' For $V_i > 8$ V.

27. (c)



$$V_+ = \left(\frac{5}{6}V_i + \frac{20}{6}\right)$$

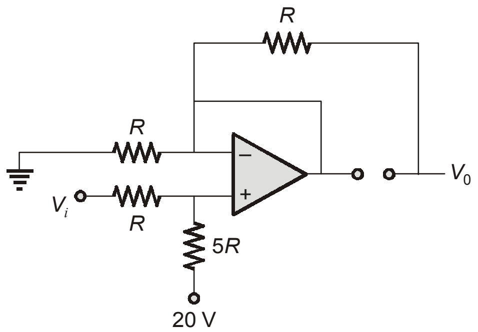
⇒ V_+ is positive when $V_i \geq -4$ V, V_+ is negative when $V_i < -4$ V.
When V_+ is positive then D_1 is off and D_2 is on
So,



$$V_0 = 2\,V_+ = \left(\frac{5}{3}V_i + \frac{20}{3}\right)$$

When V_+ is negative then D_1 is on and D_2 is off

So,



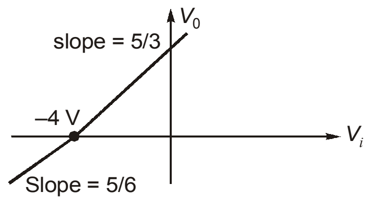
Since no current will flow in output branch and opamp is in negative feedback

So, $V_+ = V_-$

and $V_0 = V_+ = \frac{5V_i}{6} + \frac{20}{6}$

So, when V_+ is positive $V_0 = 2\,V_+$

V_+ is negative $V_0 = V_+$

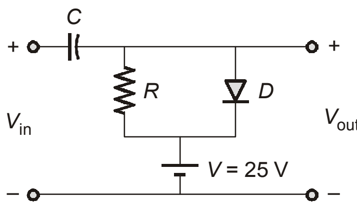


28. (c)

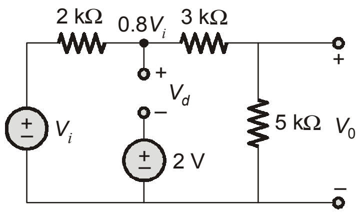
Since the output is reproduced in the negative cycle, i.e., the clamper used is to add a negative D.C. level to the circuit, hence it is a negative clamper. Thus diode must be S.C. for a positive voltage applied at the input.

Now, after deciding the polarity of the diode we have to make sure that the diode is forward biased if the input is lower than 25 V.

Thus, the circuit will look like the one shown in the figure below.



29. (c)



$$V_d = 0.8V_i - 2$$

for $V_d < 0$, diode acts open circuit

$$0.8V_i < 2$$

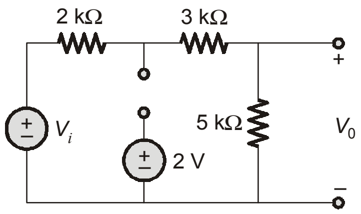
$\Rightarrow$ $V_i < \dfrac{2}{0.8} = 2.5$ Volts

for $V_i > 0$, diode acts shorts circuit

$$0.8V_i > 2$$

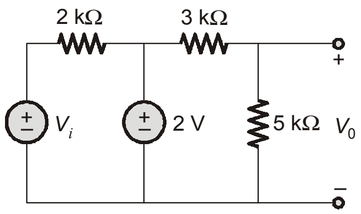
$\Rightarrow$ $V_i > 2.5$ V

Case - I (when $V_i < 2.5$ V) :



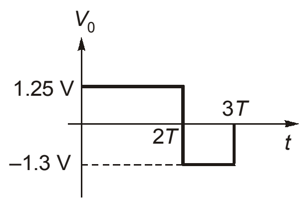
$$V_0 = \frac{V_i}{2}$$

Case - II (when $V_i > 2.5$ V) :



$$V_0 = \frac{2 \times 5}{8}$$

$$V_0 = 1.25 \text{ V}$$



30. (b)

$$V^+ = V^- = 0$$

$$V_0 = -V_D$$

$$I = I_0 e^{\alpha(-V_0)} \qquad ln(ab)$$

$$\Rightarrow \quad \frac{I}{I_0} = e^{-\alpha v_0}$$

$$\frac{1}{\alpha} ln\left(\frac{I_0}{I}\right) = V_0 = K\, ln\left(\frac{I}{I_0}\right)$$

so, $$V_0 \propto ln\left(\frac{I}{I_0}\right)$$

■■■■