ANSWER KEY ➤ Analog Electronics

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

DETAILED EXPLANATIONS

1. (d)

The given circuit is a differentiator,

$$V_0(s) = -R_F C_1 \, s V_i(s)$$

$$|A| = \left|\frac{V_0(s)}{V_i(s)}\right| = |-R_F C_1 j\omega|$$

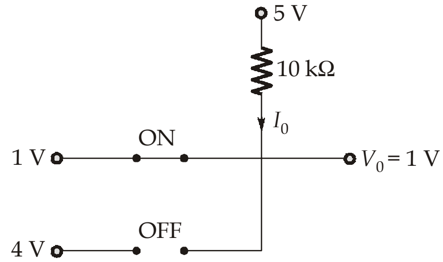
$$|A| = R_F C_1 \omega = 2\pi f R_F C_1$$

Given, $$|A| = \frac{f}{f_a}$$

$\therefore$ $$f_a = \frac{1}{2\pi R_F C_1}$$

2. (c)

From the circuit, we can conclude that diode D_1 will conduct and diode D_2 will be switched off.



$$I_0 = \frac{5\text{V} - V_0}{10\text{ k}\Omega} = \frac{5\text{V} - 1\text{V}}{10\text{ k}\Omega} = 0.4\text{ mA}$$

Thus, $V_0 = 1$ V and $I_0 = 0.4$ mA.

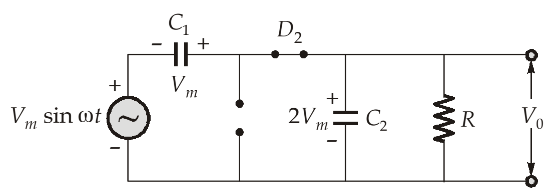
3. (b)

To increase the switching speed of a p^+n diode, the n-region width should be made smaller.

4. (d)

The above given circuit is positive voltage doubler.

During negative half cycle D_1 conducts and capacitor C_1 charges to $+V_m$ as polarity shown. During positive half cycle, D_2 is on and C_2 charges to $+2V_m$ with polarity shown.



5. (c)

$$\text{Common base dc current gain} = \alpha = 0.99$$

$$\text{Base current} = I_B = 20\ \mu\text{A}$$

$$\text{Collector current} = I_C = \beta I_B = \frac{\alpha}{1-\alpha} \cdot I_B$$

$$I_C = \frac{0.99}{1-0.99} \times 20 \times 10^{-6}$$

$$I_C = 1.98 \times 10^{-3}\text{ A} = 1.98\text{ mA}$$

$$\text{Emitter current, } I_E = I_B + I_C$$

$$= 0.02\text{ mA} + 1.98\text{ mA}$$

$$= 2\text{ mA}$$

6. (b)

The drop across zener diode must be 12 V

$$\therefore \quad V_S \times \frac{R_L}{R_L + R_S} = 12$$

$$V_S = 12 \times \left(\frac{R_L + R_S}{R_L}\right) = 12 \times \left(\frac{80k + 100k}{80k}\right) = 27\text{ V}$$

7. (c)

By KVL in the circuit:

$$-20 + I_B R_B + 0.7 + (I_C + I_B)R_E = 0$$

$$I_B = \frac{19.3 - I_C R_E}{(R_B + R_E)}$$

$$\frac{\partial I_B}{\partial I_C} = \frac{-R_E}{(R_B + R_E)}$$

$$\text{Stability factor, } S = \frac{1+\beta}{1-\beta\frac{\partial I_B}{\partial I_C}} = \frac{1+100}{1+100\times\left[\frac{R_E}{R_B+R_E}\right]}$$

$$= \frac{101}{1+100\times\left(\frac{1}{500}\right)}$$

$$S = \frac{505}{6} = 84.17$$

8. (b)

- The input impedance is high because the input is always reverse biased.
- FET is thermally stable.

9. (d)

High value of $\left(\frac{d\phi}{d\omega}\right)$ indicates high frequency stability.

10. (b)

The given circuit is a fullwave voltage doubler.

If the no load output voltage is $10\sqrt{2}\text{ V}$, then the peak value of secondary of the transformer is

$$\frac{10\sqrt{2}}{2} = 5\sqrt{2}\text{ V}$$

$$\frac{V_2}{V_1} = \frac{N_2}{N_1}$$

$$\frac{5\sqrt{2}}{220\sqrt{2}} = \frac{1}{n}$$

$$n = 44$$

11. (b)

The given circuit is RC phase shift oscillator,

$$f_0 = \frac{1}{2\pi RC\sqrt{6}}$$

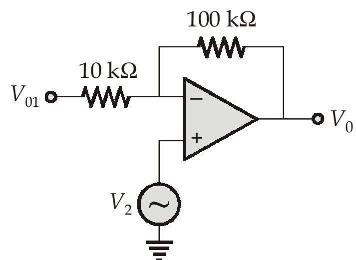
$$= \frac{1}{2\pi\times 10\times 10^{3}\times 0.001\times 10^{-6}\times\sqrt{6}}$$

$$= \left[\frac{15.915}{\sqrt{6}}\right]\text{kHz}$$

12. (d)

$$V_{01} = \left(1+\frac{R_f}{R_1}\right)V_1 = \left(1+\frac{10k}{100k}\right)V_1$$

$$V_{01} = 1.1\ V_1$$



There are two inputs V_{01} and V_2, so by applying superposition theorem.

$$V'_{02} = \frac{-R_f}{R_1}\times V_{01} \qquad \text{(by grounding } V_2\text{)}$$

$$= \frac{-100k}{10k}\times 1.1V_1 = -11\ V_1$$

While V_{01} grounded and V_2 active,

$$V''_{02} = \left(1+\frac{R_f}{R_1}\right)V_2 = \left(1+\frac{100k}{10k}\right)V_2 = 11\ V_2$$

Output of the circuit is,

$$V_0 = V'_{02} + V''_{02}$$

$$= 11\ (V_2 - V_1)$$

13. (c)

The given circuit is Wien bridge oscillator,

$$V_f = \frac{Z_1}{Z_1+Z_2}V_0$$

$$= \frac{Z_1}{Z_1+Z_2}\left(1+\frac{R_B}{R_A}\right)v_i$$

$$\text{Loop gain} = \frac{V_f}{V_i} = \left(1+\frac{R_B}{R_A}\right)\times\frac{1}{1+Z_2Y_1}$$

$$V_f = V_i \text{ Oscillator principle}$$

$$1 = \left(1+\frac{R_B}{R_A}\right)\times\frac{1}{1+\left(R_2+\frac{1}{j\omega C_2}\right)\left(\frac{1}{R_1}+j\omega C_1\right)}$$

$$1 = \left(1+\frac{R_B}{R_A}\right)\times\frac{1}{1+\frac{R_2}{R_1}+\frac{C_1}{C_2}+j\left(\omega C_1R_2-\frac{1}{\omega C_2R_1}\right)}$$

Frequency of oscillation, imaginary part is equal to zero.

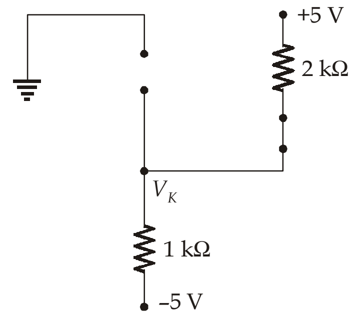
$$\omega^2 = \frac{1}{R_1 R_2 C_1 C_2}$$

for given condition,

$$\omega = \frac{1}{RC}$$

14. (d)

Assume D_1 is conducting and D_2 is off:



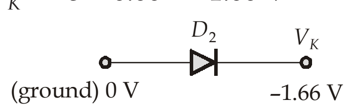
By KVL:

$$-5 + (2k \times I) + (1k \times I) - 5 = 0$$

$$I = \frac{10}{3}\text{mA} = 3.33 \text{ mA}$$

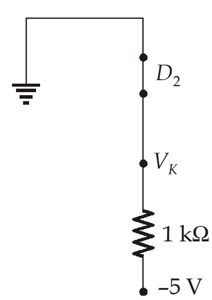
$$-5 + (3.33 \times 2) + V_K = 0$$

$$V_K = 5 - 6.66 = -1.66 \text{ V}$$



D_2 is conducting.

Assume D_2 is conducting and D_1 is off:



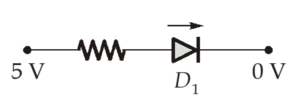
By kVL:

$$(1k \times I) - 5 = 0$$

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

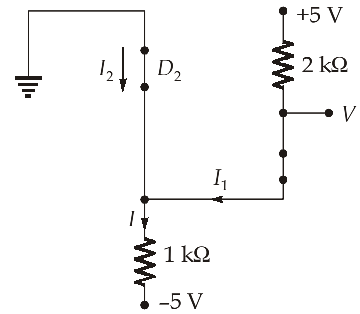
$$-V_K + (5 \text{ m} \times 1k) - 5 = 0$$

$$V_K = 0$$



i.e. D_1 is also conducting.

Both the diodes D_1 and D_2 are conducting:



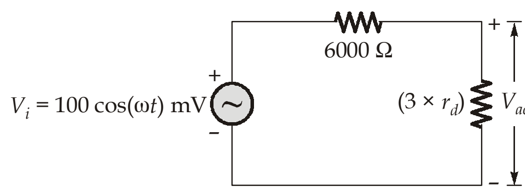
By KVL:

$$-5 + (I_1 \times 2k) = 0$$
$$I_1 = 2.5 \text{ mA}$$
$$-5 + (2k \times 2.5 \text{ m}) + V = 0$$
$$V = 0 \text{ V}$$
$$(1k \times I) - 5 = 0$$
$$I = 5 \text{ mA} = I_1 + I_2$$
$$I_2 + 2.5 \text{ mA} = 5 \text{ mA}$$
$$\therefore \quad I_2 = 2.5 \text{ mA and } V = 0$$

15. (b)

For D.C. biasing ac is short circuited

$$I_{DC} = \frac{8.1-(3\times 0.7)}{6000} = 1 \text{ mA}$$



$$r_d = \frac{V_T}{I_D} = \frac{25 \text{ mV}}{1 \text{ mA}} = 25\ \Omega$$

$$V_{ac} = \left[100\times 10^{-3}\cos(\omega t)\right]\times\frac{75}{6075}$$

$$= \frac{1}{810}\cos(\omega t) \text{ V}$$

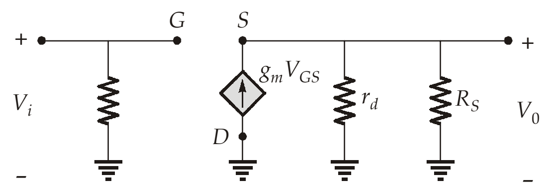
16. (c)

$$\text{Transconductance factor, } g_m = g_{m0}\left(1-\frac{V_{GSQ}}{V_P}\right)$$

$$g_{m0} = \frac{2I_{DSS}}{|V_P|} = \frac{2\times 16\times 10^{-3}}{4} = 8 \text{ mS}$$

$$g_m = 8\times10^{-3}\left(1-\frac{-2.86}{-4}\right)$$
$$= 2.28 \text{ mS}$$

According to small signal analysis:



$$V_0 = g_m\, V_{GS}\,(r_d \,||\, R_s)$$

[∵ given r_d is very large so it is neglected]

∴
$$V_0 = g_m V_{GS} \times R_S$$
$$V_i = V_{GS} + V_0 = V_{GS} + g_m V_{GS}\, R_S$$
$$\frac{V_0}{V_i} = \frac{g_m V_{GS} R_S}{V_{GS}(1+g_m R_S)} = \frac{g_m R_S}{1+g_m R_S}$$
$$A_V = \frac{V_0}{V_i} = \frac{2.28\times2}{1+(2.28\times2)} = 0.82$$

17. (d)

Given,
$$I_D = I_{D\,(ON)} = 4 \text{ mA}$$
$$V_{DS} = \frac{1}{2}V_{DD} = V_{GS}$$
$$V_{DD} = 2\times V_{GS} = 2\times6 = 12 \text{ V}$$
$$R_D = \frac{V_{DD}-V_{DS}}{I_{D(ON)}} = \frac{12-6}{4 \text{ mA}} = 1.5 \text{ k}\Omega$$

18. (d)

Given that,
$$V_{GS1} = 2 \text{ V}$$
and
$$V_{GS2} = 1.5 \text{ V}$$

Since drain current is same in both devices and both are in saturation so

$$\frac{1}{2}\mu_n C_{OX}\left(\frac{W}{L}\right)_1 (V_{GS1}-V_t)^2 = \frac{1}{2}\mu_n C_{OX}\left(\frac{W}{L}\right)_2 (V_{GS2}-V_t)^2$$

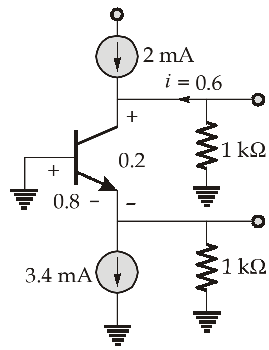
⇒
$$\frac{(W/L)_2}{(W/L)_1} = \frac{(V_{GS1}-V_t)^2}{(V_{GS2}-V_t)^2}$$
$$= \frac{(2-1)^2}{(1.5-1)^2} = \frac{1}{(0.5)^2} = 4$$

19. (c)

∵ $V_{BE\,(sat)}$ = 0.8 V thus the voltage at V_E = –0.8 V

now, the voltage at $V_C = V_{CE} + V_E$ = 0.2 – 0.8 = –0.6 V

$\therefore \qquad i = \dfrac{0.6}{1\text{ k}} = 0.6 \text{ mA}$



20. (a)

The given circuit is that of Wein bridge

The frequency of oscillations is given by

$$f = \frac{1}{2\pi RC} = \frac{1}{(2\pi)(6\text{k}\Omega)\times(0.003\mu\text{F})} = 8.885 \text{ kHz}$$

21. (d)

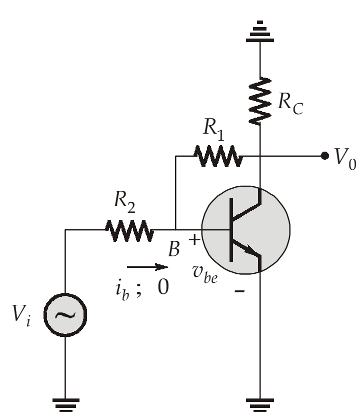
$$g_{m1} = \frac{I_C}{V_T} = \frac{1\times10^{-3}}{25\times10^{-3}} = 0.04\text{ S}$$

$$g_{m2} = \frac{2I_D}{V_{GS}-V_T} = \frac{2\times10^{-3}}{1.3-0.8} = 4\times10^{-3}\text{S}$$

$$\frac{g_{m_1}}{g_{m_2}} = \frac{0.04}{0.004} = 10$$

22. (a)

With respect to a.c.



In BJT amplifier if h_{fe} $[\beta_{ac}] \to \infty$

then $\qquad i_b = 0$

$$v_{be} = i_b r_\pi = 0$$

KCL at *B* gives: $\qquad \dfrac{v_i - 0}{R_2} = \dfrac{0 - v_0}{R_1}$

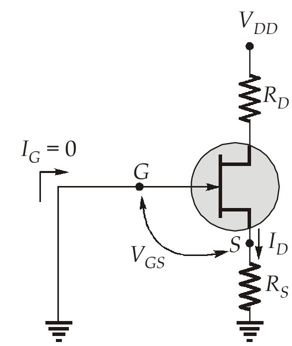
$$A_V = \frac{v_0}{v_i} = \frac{-R_1}{R_2}$$

23. (c)

$$I_D = I_{DSS}\left[1 - \frac{V_{GS\,Q}}{V_P}\right]^2$$

$$= 40\times10^{-3}\left[1-\left(\frac{-5}{-10}\right)\right]^2$$

$$I_D = 0.01 \text{ A}$$



By KVL in Gate source loop,

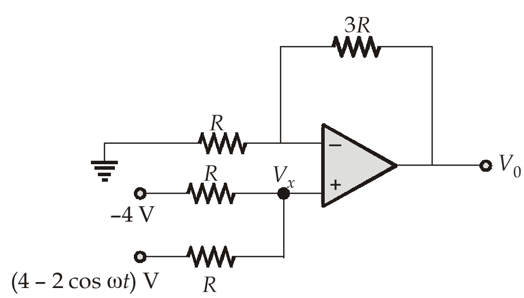
$$0 = V_{GS} + I_D R_S$$

$$I_D = \frac{-V_{GS}}{R_s}$$

$$R_S = \frac{-(-5)}{0.01}$$

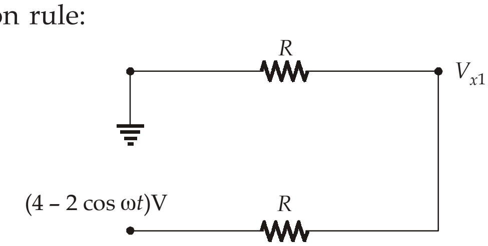
$$R_s = 500\ \Omega$$

24. (b)

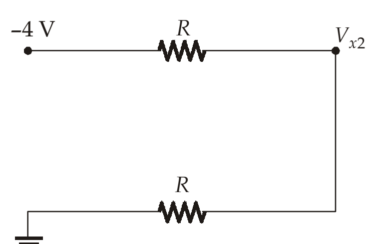


$$V_0 = \left[1+\frac{3R}{R}\right]V_x = 4V_x \qquad \text{...(i)}$$

According to voltage division rule:



$$V_{x1} = \frac{(4-2\cos\omega t)R}{2R} = (2-\cos\omega t)$$



$$V_{x2} = (-4)\times\frac{R}{2R} = -2V$$

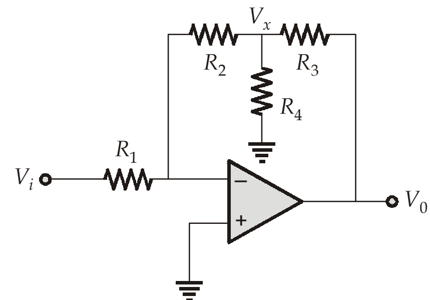
$$V_x = V_{x1} + V_{x2} = 2 - \cos\omega t - 2 = -\cos\omega t$$

Substituting the value of V_x in equation (i), we get

$$V_0 = -4 \cos \omega t \text{ V}$$

25. (c)

Since the two port network is symmetric thus converting into T-network we get the circuit as



Where,

$$R_1 = 1 \text{ k}\Omega$$
$$R_2 = 10 \text{ k}\Omega$$
$$R_3 = 10 \text{ k}\Omega$$
$$R_4 = 1 \text{ k}\Omega$$

$[\because Z_{11'} = R_2 + R_4 = 11 \text{ k}\Omega = Z_{22'}, \quad Z_{12} = Z_{21} = R_4 = 1 \text{ k}\Omega]$

By KCL at node V_x :

$$\frac{V_x}{R_2} + \frac{V_x}{R_4} + \frac{V_x - V_0}{R_3} = 0$$

$$V_x\left[\frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4}\right] = \frac{V_0}{R_3}$$

$$V_0 = V_x\left[1 + \frac{R_3}{R_2} + \frac{R_3}{R_4}\right]$$

$$\frac{V_0}{V_i} = \frac{-R_2}{R_1}\left[1 + \frac{R_3}{R_2} + \frac{R_3}{R_4}\right] \qquad \left(\therefore V_x = \frac{-R_2}{R_1} V_i\right)$$

By substituting all values,

$$\frac{V_0}{V_i} = -\frac{10k}{1k}\left[1 + \frac{10k}{10k} + \frac{10k}{1k}\right]$$

$$\frac{V_0}{V_i} = -120$$

26. (d)

$$\text{Lower threshold voltage, } V_{LT} = \frac{V_{ref} . R_1}{R_1 + R_2} - \frac{V_{sat} R_2}{R_1 + R_2}$$

$$0 = \frac{1.5 R_1}{R_1 + R_2} - \frac{(6.3 + 0.7) R_2}{R_1 + R_2}$$

$$7 R_2 = 1.5 R_1$$

$$\frac{R_1}{R_2} = \frac{7}{1.5} = 4.67$$

27. (c)

The nodal equation at inverting terminal is,

$$\frac{V_i(s)}{R_1} + \frac{V_0(s)}{R_2} + V_0(s) s C_2 = 0$$

$$\frac{V_0(s)}{V_i(s)} = \frac{-\frac{1}{R_1}}{\left[\frac{1}{R_2} + sC_2\right]}$$

$$|A| = \frac{\frac{R_2}{R_1}}{\sqrt{1+(\omega_0 R_2 C_2)^2}}$$

At low frequency, $$|A|_{max} = \frac{R_2}{R_1}$$

$$\frac{\frac{R_2}{R_1}}{\sqrt{1+(\omega_0 R_2 C_2)^2}} = \frac{1}{\sqrt{2}} \times \frac{R_2}{R_1}$$

$$\sqrt{1+(\omega_0 R_2 C_2)^2} = \sqrt{2}$$

$$\omega_0 = \frac{1}{R_2 C_2}$$

28. (d)

Voltage gain without feedback,

$$A_v = \frac{2\text{ V}}{5\text{ mV}} = 400$$

$$V_f = \frac{V_0 \times 1K}{20K} = \frac{V_0}{20}$$

$$\frac{V_f}{V_0} = \beta = \frac{1}{20}$$

$$A_{vf} = \frac{A_v}{1+\beta A_v} = \frac{400}{1+\frac{400}{20}} = \frac{400}{21}$$

29. (a)

The given circuit is a triangular wave generator (function generator).

Frequency of oscillations,

$$f_0 = \frac{R_2}{4R_1R_3C} = \frac{1\times 10^3}{4\times 2\times 10^3 \times 1\times 10^3 \times 0.1\times 10^{-6}} = 1.250\text{ kHz}$$

30. (d)

$$I_D = \frac{0-(-10)}{20} = 0.5\text{ A}$$

Now, $$V_0 = 10 - 10 \times I_D = 10 - 5$$

$$V_0 = 5\text{ V}$$

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