CLASS TEST

Sl. 01 SK_EE_ABCD_02052023

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# ANALOG ELECTRONICS

## ELECTRICAL ENGINEERING

**Date of Test : 02/05/2023**

## ANSWER KEY

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

# DETAILED EXPLANATIONS

**1. (d)**

Applying KVL we get,

$$V_{CC} - I_C R_C - V_{CE} = 0$$

$$I_C = \frac{V_{CC} - V_{CE}}{R_C} = \frac{3 - 0.2}{1\text{k}} = 2.8 \text{ mA}$$

$$I_B = \frac{I_C}{\beta} = \frac{2.8\text{mA}}{50} = 56 \ \mu\text{A}$$

**2. (b)**

$$V_{EC\,(\text{sat})} = 0.2 \text{ V}$$

$$V_{EB} = 0.7 \text{ V}$$

Assume that BJT is in saturation region

KVL in outer most loop:

$$-10 + 1k\,(I_E) + V_{EC(\text{sat})} + 1k\,I_C = 0$$

$$1k\,(I_B + I_C) + 1k\,I_C = 10 - 0.2 = 9.8$$

$$1k\,I_B + 2k\,I_C = 9.8 \quad \text{...(i)}$$

KVL in emitter base loop:

$$-10 + 1k\,(I_E) + 0.7 + 270k\,(I_B) = 0$$

$$(271k)I_B + 1k\,I_C = 9.3 \quad \text{...(ii)}$$

From (i) and (ii),

$$I_B = 0.0162 \text{ mA};$$

$$I_C = 4.892 \text{ mA}$$

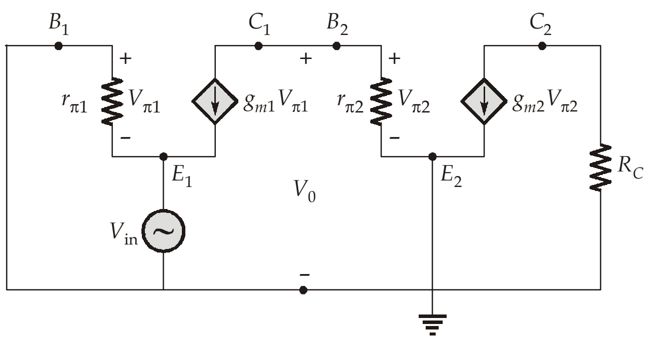
$$I_{B\text{ min}} = \frac{I_{C(\text{sat})}}{\beta} = 0.04892 \text{ mA}$$

$$I_B < I_{B\text{ min}}$$

$\therefore$ transistor is in linear or active region.

**3. (c)**

The small signal equivalent of the above circuit can be given as




$$-V_{in} - V_{\pi1} = 0$$

$$V_{in} = -V_{\pi1} \quad \text{...(i)}$$

$$V_0 = -g_{m1}\,V_{\pi1}\,r_{\pi2} \quad \text{...(ii)}$$

$$A_V = \frac{g_{m1}V_{\pi1}r_{\pi2}}{V_{\pi1}}$$

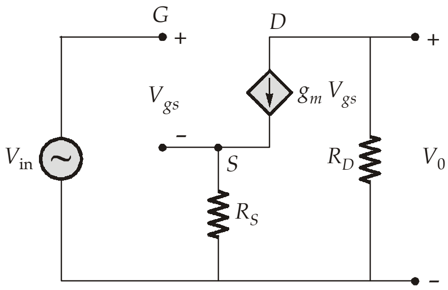
$$A_V = g_{m1}\, r_{\pi 2}$$

As we know,
$$r_\pi = \frac{\beta}{g_m}$$

$$A_V = \beta_2 \left(\frac{g_{m1}}{g_{m2}}\right)$$

**4. (c)**

For common source amplifier the ac small signal circuit is,




$$V_0 = -g_m\, V_{gs}\, R_D$$

KVL in gate source loop,

$$-V_i + V_{gs} + g_m\, V_{gs}\, R_s = 0$$

$$V_i = V_{gs}\,(1 + g_m R_s)$$

$$A_V = \frac{-g_m R_D}{1 + g_m R_s}$$

$$|A_V| = 1 = \frac{g_m R_D}{1 + g_m R_s}$$

If $g_m R_s >> 1$

$$1 = \frac{g_m R_D}{g_m R_s}$$

$$R_D = R_s$$

**5. (c)**

Dynamic resistance of diode,

$r_d$ $= \dfrac{\eta V_T}{I_0\, e^{v/\eta V_T}}$ Þ $\dfrac{r_{d_2}}{r_{d_1}} = \dfrac{e^{v_1/\eta V_T}}{e^{v_2/\eta V_T}}$

$\therefore$ $1000 = e^{|v_1 - v_2|/\eta V_T}$

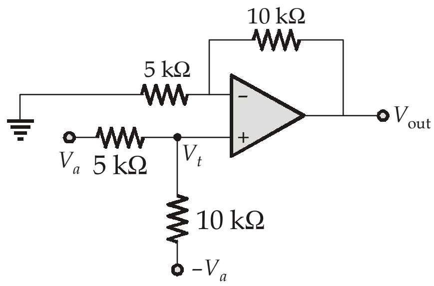
$\therefore$ $\ln 10^3 = |v_1 - v_2| / \eta V_T$

$\Rightarrow$ for $\eta = 1$, $|v_1 - v_2| = V_T\,(\ln 10^3)$

**6. (a)**

$\because$ The feedback is voltage-series feedback, so the amplifier will be a voltage amplifier.

**7. (b)**




Since, the amplifier is an non-inverting amplifier thus,

$$V_{out} = \left(1+\frac{R_2}{R_1}\right)V_t$$

Now,
$$V_t = V_a \times \frac{10\text{ k}}{15\text{ k}} - \frac{V_a \times 5\text{ k}}{15\text{ k}}$$

$$V_t = \frac{V_a}{3}$$

$$V_{out} = \left(1+\frac{10\text{ k}}{5\text{ k}}\right)\cdot V_t = 3\times\frac{V_a}{3} = V_a$$

**8. (d)**

For amplifier to have a valid

$$V_{out} = A(V_1 - V_2)$$

$$V_1 - V_2 = \frac{V_{out}}{A}$$

now, for virtual ground $A \to \infty$.

But if $A \neq \infty$, then

$$V_t = \frac{\pm V_{out}}{A} = \frac{\pm 10}{1000} = \pm 10\text{ mV}$$

**9. (d)**

The value of input capacitance is equal to

$$C_{in} = C(1 - A_v) \qquad \text{(Miller's theorem)}$$

∵ The op-amp is ideal and inverting.

$$C_{in} \approx \infty$$

**10. (d)**

The equation of output voltage for steady state can be given as

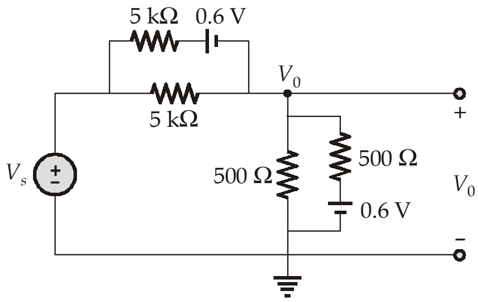
$$V_0 = V_i - 7.5$$

∴ For $V_i = 10$, $V_0 = 2.5$ V

and for $V_i = -10$ V, $V_0 = -17.5$ V

**11. (a)**

Assume both the diode to be ON.




Applying the KCL at node $V_0$, we get,

$$\frac{V_0+0.6-V_s}{5\text{ k}}+\frac{V_0-V_s}{5\text{ k}}+\frac{V_0}{500}+\frac{V_0-0.6}{500} = 0$$

$$\therefore \qquad V_0 = \frac{2}{22}V_s+\frac{5.4}{22}$$

$$V_0 = \frac{1}{11}V_s+\frac{54}{220}$$

For diode $D_1$ to be ON.

$$V_s - V_0 > 0.6$$

$$V_s-\frac{2V_s+5.4}{22} > 0.6$$

$$V_s > 0.93\text{ V}$$

For diode $D_2$ to be ON.

$$V_0 > 0.6\text{ V}$$

$$\frac{2V_s+5.4}{22} > 0.6$$

$$V_s > 3.9\text{ V}$$

**12. (d)**

To find maximum power dissipated across the resistance, we have to find the maximum current flowing in the load resistance $R_L$

$$i_{\text{Load (max)}} = i_{\text{in}} - i_{z(\text{min})}$$

$$= \frac{6.3-4.8}{12}-5\times10^{-3} = (125-5)\times10^{-3} = 120\text{ mA}$$

$$\therefore \qquad P_{(\text{max})} = (120\times10^{-3})\times4.8$$

$$= 0.576\text{ W}$$

For maximum value of resistance $R_L$, we have to find $i_{L(\text{min})}$

$$i_{\text{Load (min)}} = i_{\text{in}} - i_{z(\text{max})}$$

$$= 125\times10^{-3}-\frac{0.48}{4.8} = 125\times10^{-3}-100\times10^{-3} = 25\text{ mA}$$

$$\therefore \qquad R_{L(\text{max})} = \frac{4.8}{25}\times10^{3} = 192\ \Omega$$

**13. (c)**

$$S_v = \left.\frac{\partial I_C}{\partial V_{BE}}\right|_{\beta,\, I_{CO} \text{ are constant}}$$

$$= \frac{-\beta}{R_B + R_E(1+\beta)} = \frac{-\dfrac{\beta}{R_E}}{1+\beta+\dfrac{R_B}{R_E}}$$

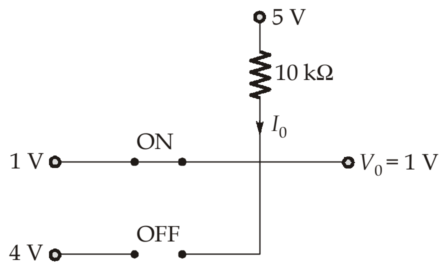
$$S_v \approx -\frac{1}{R_E} \qquad \because \frac{R_B}{R_E} << 1+\beta \text{ and } 1+\beta \cong \beta$$

**14. (d)**

If the bypass capacitor is removed, then the mid band voltage gain will decrease and the input resistance will increase. This happens because of the negative feedback introduced by $R_E$.

**15. (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.

**16. (c)**

For astable multivibrator

$$f = \frac{1.44}{(R_A + 2R_B)C}\text{ Hz}$$

therefore,
$$2 \times 10^3 = \frac{1.44}{(R_A + 2R_B)C}$$

$$(R_A + 2R_B)C = 7.2 \times 10^{-4}$$

$$R_A + 2R_B = 7.2 \times 10^3 \qquad (\because C = 0.1\ \mu\text{F}) \qquad \ldots\text{(i)}$$

now, Duty cycle $D$

$$D = 0.75 = \frac{R_A + R_B}{R_A + 2R_B}$$

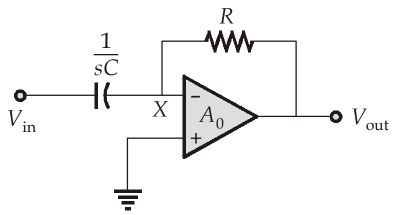
$$R_B = 0.5R_A \qquad \ldots\text{(ii)}$$

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

$$R_B = 1.8\ \text{k}\Omega$$

$$R_A = 3.6\ \text{k}\Omega$$

**17. (d)**




Applying KCL at node 'X', we get,

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

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

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

$$\frac{s_pRC}{A_0}+\frac{1}{A_0}+1 = 0$$

$$\frac{s_pRC}{A_0} = -1-\frac{1}{A_0}$$

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

Hence option (d) is correct.

**18. (b)**

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

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

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

**19. (d)**

Applying KVL we get,

$$V_{CC} - I_CR_C - V_{CE} = 0$$

$$I_C = \frac{V_{CC}-V_{CE}}{R_C} = \frac{3-0.2}{1\text{k}} = 2.8 \text{ mA}$$

$$I_B = \frac{I_C}{\beta} = \frac{2.8\text{mA}}{50} = 56\ \mu\text{A}$$

**20. (d)**

If transistor is in normal active region, base current can be calculated as

At input loop,

$$10 - I_E(1 \times 10^3) - 0.7 - 270 \times 10^3 I_B = 0$$

$$9.3 = 10^3(1+\beta)I_B + 270 \times 10^3 I_B$$

$$I_B = \frac{9.3\text{ mA}}{270+101} = 25\ \mu\text{A}$$

In saturation, base current is

$$10 - I_C(1\text{ k}) - V_{CE\text{ sat}} - I_E(1\text{ k}) = 0$$

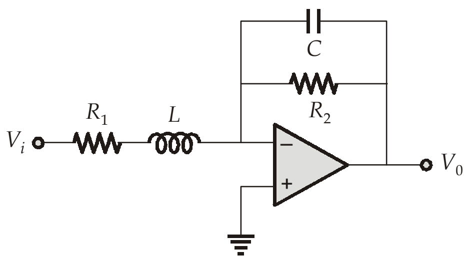
$$I_{C\text{ sat}} = \frac{10}{2\text{k}} = 5\text{ mA} \qquad (\because I_E \approx I_C)$$

$$I_{B\text{ sat}} = \frac{I_{C\text{sat}}}{\beta} = \frac{5\text{ mA}}{100} = 50\ \mu\text{A}$$

$$I_B < (I_B)_{\text{sat}}$$

So transistor is in forward active region.

**21. (b)**




$$\frac{V_i - 0}{R_1 + sL} = \frac{(0 - V_0)(1 + R_2Cs)}{R_2}$$

$$\left|\frac{V_0}{V_i}\right| = \frac{R_2}{(R_1 + sL)(1 + R_2Cs)}$$

This is a low pass filter.

**22. (a)**

$$\text{Output voltage, } V_0 = V_Z - V_{BE}$$
$$= 8.3 - 0.7 = 7.6\text{ V}$$

$$\text{Current through, } R = \frac{V_i - V_z}{R} = \frac{15 - 8.3}{1.8}\text{mA} = 3.72\text{ mA}$$

$$I_L = \frac{V_0}{R_L} = \frac{7.6}{2} = 3.8\text{ mA}$$

$$I_B = \frac{I_C}{\beta} = \frac{I_L}{\beta} = \frac{3.8}{100}\text{mA} = 0.038\text{ mA}$$

$$I_Z = I_R - I_B$$
$$= 3.72 - 0.038 = 3.684\text{ mA}$$

**23. (a)**

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

**24. (d)**

Miller effect increase input capacitance and there by decreases the higher cut-off frequency.

**25. (d)**

$$V_G = \frac{47\,\text{k}\Omega(16\,\text{V})}{47\text{k}\Omega + 91\text{k}\Omega} = 5.44\text{ V}$$

$$I_D = \frac{V_{DD} - V_D}{R_D} = \frac{16-12}{1.8\text{k}\Omega} = 2.22\text{ mA}$$

$$V_{GS} = V_G - I_D R_S$$

$$-2 = 5.44 - (2.22\text{ m})\,R_s$$

$$R_s = \frac{7.44}{2.22\,\text{m}} = 3.35\text{ k}\Omega$$

**26. (b)**

$$I = \frac{V_2 - V_{BE}}{R_E} = \frac{6.2-0.7}{1.8\text{k}\Omega}$$

$$= 3.06\text{ mA} \approx 3\text{ mA}$$

**27. (b)**

$$\text{Feedback factor, } \beta = \frac{V_f}{V_0} = \frac{-R_E}{R_C}$$

**28. (b)**

Transistor will enter to saturation region for $V_{CE\,(\text{sat})}$ = 0 V

Applying KVL in collector emitter loop,

$$-20 + (I_C \times 10\text{ k}) + V_{CE\text{ sat}} = 0$$

$$I_C = \frac{20 - V_{CE(\text{sat})}}{10\text{k}} = 2\text{ mA}$$

$$I_B = \frac{I_C}{\beta} = \frac{2\times10^{-3}}{50} = 40\ \mu\text{A}$$

Applying KVL in base emitter loop

$$-10 + I_B R_B + 0.7 = 0$$

$$R_B = \frac{10-0.7}{40\times10^{-6}} = 232.5\text{ k}\Omega$$

∴ For all values of $R_B$ > 232.5 kΩ the transistor will not operate in saturation region.

**29. (a)**

The output voltage of differential amplifier is given as,

$$V_0 = A_d V_d + A_c V_c$$

Where,

$$A_d = \text{Differential gain}$$

$$A_c = \text{Common mode gain}$$

$$V_d = \text{Differential input voltage} = V_1 - V_2$$

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

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

Where,

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

Set of signal 1,

$$V_d = 50\ \mu V - (-50\ \mu V) = 100\ \mu V$$

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

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

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

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

$\therefore$

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

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

**30. (c)**

The given circuit is voltage series feedback,

$\therefore$

$$Z_{if} = Z_i (1 + \beta A)$$

$$= 10\ k\Omega\ (1 + 10) = 110\ k\Omega$$

$$Z_{0f} = \frac{Z_0}{1 + \beta A} = \frac{20 \times 10^3}{11} = 1.82\ k\Omega$$

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