CLASS TEST

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ANALOG CIRCUIT

ELECTRONICS ENGINEERING

Date of Test : 08/11/2025

ANSWER KEY

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

Detailed Explanations

1. (c)

% Regulation for a half wave rectifier can be given as

$$\% \text{ regulation} = \frac{R_f}{R_L} \times 100 = \frac{12}{750} \times 100$$

$$= \frac{8}{5} = 1.6\%$$

2. (c)

$$I_B = \frac{I_C}{\beta} = \frac{4 \times 10^{-3}}{50} = 0.08 \text{ mA}$$

$$V_C = R_B I_B + 0.7 \text{ V} \qquad [\because V_{CE} = V_C - V_E = V_C]$$

$$R_B = \frac{V_C - 0.7}{I_B} = \frac{2.5 - 0.7}{0.08} \times 10^3$$

$$= \frac{1.80}{0.08} \times 10^3 = \frac{180}{8} \times 10^3 = 22.5 \text{ k}\Omega$$

$$I_0 = I_E = (1 + \beta) I_B = I_C + I_B = 4 + 0.08 = 4.08 \text{ mA}$$

$$R_B \propto \frac{1}{I_B} \propto \frac{1}{I_0}$$

3. (b)

Given that, $A_{OL} = 400$

$A_{CL} = 200$

We know that, $$A_{CL} = \frac{A_{OL}}{1 + \beta A_{OL}} = 200$$

$\Rightarrow$ $$\frac{400}{1 + \beta \times 400} = 200$$

$$1 + 400\beta = 2$$

$$\beta = \frac{1}{400} = 0.0025$$

4. (c)

Feedback topology	Input impedance	Output impedance
Voltage series	increases	decreases
Voltage shunt	decreases	decreases
Current series	increases	increases
Current shunt	decreases	increases

5. (a)

A 25-V peak signal across a 16-Ω load provides a peak load current of

$$I_L(P) = \frac{V_L(P)}{R_L} = \frac{25}{16} = 1.5625 \text{ A}$$

The dc value of the current drawn from the power supply is then

$$I_{dc} = \frac{2}{\pi}(I_L(P)) = \frac{2}{\pi} \times 1.5625$$
$$= 0.9947 \text{ A}$$

The input power delivered by the supply voltage is

$$P_i(\text{dc}) = V_{CC} I_{dc} = 40 \times 0.9947$$
$$= 39.788 \text{ W}$$

The output power delivered to the load is

$$P_0(\text{ac}) = \frac{V_L^2(P)}{2R_L} = \frac{25 \times 25}{2 \times 16} = 19.53125 \text{ W}$$

Efficiency of amplifier,

$$\%\eta = \frac{P_0(ac)}{P_i(dc)} \times 100 = \frac{19.53125}{39.788} \times 100$$
$$= 49.0883\%$$
$$\cong 49.09\%$$

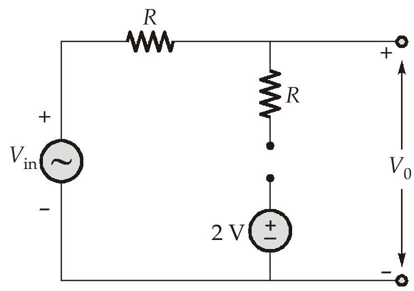
6. **(a)**

By observation, we can say when

$V_{in} \geq 2$ V; Diode is OFF.

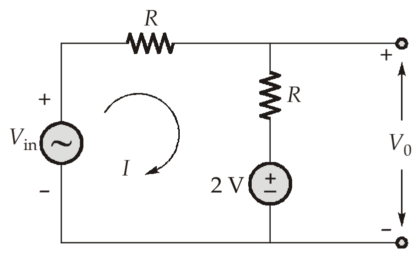
$V_{in} < 2$ V; Diode is ON.

Circuit when Diode is OFF:



$$V_0 = V_{in};\ V_{in} \geq 2 \text{ V}$$

Circuit when Diode is ON;



$$I = \frac{V_{in} - 2}{2R}$$

Now, $$V_0 = 2 + I \cdot R$$

$$= 2 + \left(\frac{V_{in} - 2}{2R}\right) \cdot R = 2 + \frac{V_{in} - 2}{2}$$

$$V_0 = \frac{V_{in}}{2} + 1;\ V_{in} < 2 \text{ V}$$

7. (d)

We have; $\alpha = 0.98$

α = current gain in CB mode.

$\therefore$ Current gain in the CC mode (γ)

$$\gamma = 1 + \beta$$

where; $$\beta = \frac{\alpha}{1-\alpha} = \frac{0.98}{0.02} = 49$$

$\therefore$ $$\gamma = 1 + 49 = 50$$

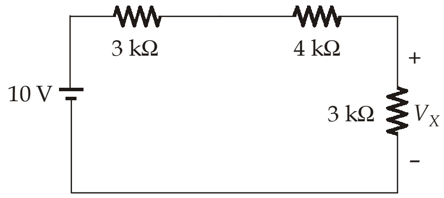
8. (c)

For MOS to conduct, $V_{GS} > V_T$

Here, $V_{GS} = 1$ V and $V_T = 2$ V

Hence, MOS is in CUT-OFF region.

Now, modified circuit will be;



$\therefore$ $$V_X = 10 \times \frac{3}{3+4+3}$$

$$= 3 \text{ Volt}$$

9. (d)

For saturation region;

$$V_{SD} \geq V_{SG} - |V_T|$$
$$5 - I(2) \geq 5 - 1$$
$$5 - 2I \geq 4$$
$$1 \geq 2I$$
$$I \leq 0.5 \text{ mA} \quad \Rightarrow \quad \text{maximum value of 'I' will be 0.5 mA}$$

10. (d)

Assume Diode is ON;

$$\text{Gate voltage } (V_G) = 2 - 0.7$$
$$= 1.3 \text{ Volt}$$

We know, current into gate terminals of MOS is not possible.

$$V_G < V_D$$

$\Rightarrow$ Flow of current into the gate terminals of MOS through the 10 Ω. resistor which is not possible.

Hence, diode will be OFF.

$\therefore$ $$V_G = V_D = 1.5 \text{ Volt} \quad \Rightarrow \quad \text{MOS is in saturation.}$$

Now, $$I_D = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}(V_{GS} - V_T)^2 = \frac{1}{2} \times 0.4 \times (1.5 - 0.3)^2$$

$$= 0.29 \text{ mA}$$

11. (a)

Transistor Q_1 is in saturation region (as $V_{DS} = V_{GS} > V_{GS} - V_T$);

$$I_D = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}(V_{GS} - V_T)^2$$

$$0.8 = \frac{1}{2} \times 0.2 \times 10 \times (V_{GS} - 0.6)^2$$
$$0.8 = (V_{GS} - 0.6)^2$$
$$0.89 = V_{GS} - 0.6$$
$$V_{GS} = 1.5 \text{ Volt}$$

Now;
$$I_D = \frac{V_{DD} - V_{GS}}{R_X}$$
$$0.8 = \frac{10 - 1.5}{R_X}$$
$$R_X = 10.62 \text{ k}\Omega$$

12. (c)

For non-interacting stages,
$$f_H' = f_H\sqrt{(2^{1/n} - 1)}$$
$$= 30 \times 10^3 \sqrt{2^{1/3} - 1}$$
$$= 30 \times 10^3 \times 0.5098 = 15.2947 \times 10^3$$
$$= 15.2947 \text{ kHz}$$
$$f_L' = \frac{f_L}{\sqrt{2^{1/n} - 1}} = \frac{25}{\sqrt{2^{1/3} - 1}}$$
$$= 25 \times 1.9614 = 49.036 \text{ Hz}$$

13. (d)

Given data,
$$V_1 = 80\ \mu\text{V};\ V_2 = -40\ \mu\text{V}$$
$$\text{CMRR} = 50$$
$$A_{dM} = 40 \times 10^3$$
$$\text{CMMR} = 50 = \frac{A_{dM}}{A_{cM}}$$
$$A_{cM} = \frac{40000}{50} = 800$$
$$V_{dM} = V_1 - V_2 = [80 - (-40)] \times 10^{-6}$$
$$= 120 \times 10^{-6} \text{ V}$$
$$V_{cM} = \frac{V_1 + V_2}{2} = \frac{80 - 40}{2} = 20\ \mu\text{V}$$
$$V_0 = VA_{dM} + A_{cM}\, V_{cM}$$
$$= 120 \times 10^{-6} \times 4 \times 10^4 + 800 \times 20 \times 10^{-6}$$
$$= 480 \times 10^{-2} + 1.6 \times 10^{-2} = 481.6 \times 10^{-2}$$
$$= 4.816 \text{ V}$$

14. (d)

The common mode gain of BJT differential amplifier is given as
$$A_{cm} = \frac{-R_C}{2R_E}$$

Since, the resistance of ideal current source is very high, hence A_{cm} decreases and the CMRR of the amplifier is increased.

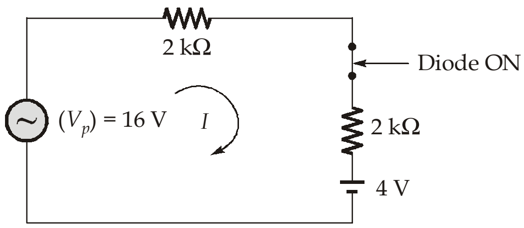
15. (a)

We have, $V_{in} = 16 \sin \omega t$ V

$(V_{in})_{peak} = 16$ V

When input voltage is at peak value, diode D will be ON and peak current will flow through the diode.

Now, simplified circuit with peak input voltage is drawn below:



$$\therefore \quad I = \frac{16-4}{2+2} = \frac{12}{4} = 3 \text{ mA}$$

$\because$ R_1 and R_2 have equal resistance value.

$$\therefore \quad \text{Current through } R_1 = \frac{I}{2} = \frac{3}{2} = 1.5 \text{ mA}$$

16. (d)

$\because$ β is very large, base current can be assume to be zero.

Voltage at base of BJT is $V_B = V_Z + V_{BE}$

$$V_B = 7.3 + 0.7 = 8 \text{ volt}$$

Now;
$$V_B = V_0 \times \frac{2}{2+3}$$

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

$$V_0 = 20 \text{ volt}$$

$$\therefore \quad I_{peak} = \frac{(V_{in})_{peak} - V_0}{2} \text{mA}$$

$$= \frac{30-20}{2} = \frac{10}{2} = 5 \text{mA}$$

17. (a)

For maximum symmetrical swing, operating point should be at middle of load line.

i.e.,
$$V_{CE} = \frac{V_{CC}}{2} = \frac{10}{2} = 5 \text{ V}$$

$$I_C = \frac{V_{CC} - V_{CE}}{R_C} = \frac{10-5}{0.5} = 10 \text{ mA}$$

$$I_B = \frac{I_C}{\beta} = \frac{10}{100} = 0.1 \text{ mA}$$

Now;
$$R_B = \frac{V_{CC} - V_{BE}}{I_B} = \frac{10-0.7}{0.1 \text{ mA}} = 93 \text{ k}\Omega$$

18. (c)

We know;
$$I_C = \alpha \cdot I_E + I_{co}$$

$$= 0.98 \times 1 + 10 \times 10^{-3}$$

$$= 0.99 \text{ mA}$$

But; $$I_E = I_C + I_B$$

$$1 = 0.99 + I_B$$

$\therefore$ $$I_B = 0.01 \text{ mA} = 10\ \mu\text{A}$$

19. (a)

From given circuit:

$$V_G = V_D = 5 \text{ V}$$

Now; $$I_D = \frac{V_{DD} - V_D}{10} = \frac{15-5}{10}$$

$$= 1 \text{ mA}$$

Now; $$V_S = I_D \cdot (1) - 2$$

$$= -1 \text{ V}$$

$\because$ $$V_{DS} = 6 \text{ V and } V_{GS} = 6 \text{ V}$$

Hence, MOS is in saturation region.

We know;

$$I_D = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}(V_{GS} - V_T)^2$$

$$I_D = \frac{1}{2}K_n(V_{GS} - V_T)^2$$

$$\text{Transconductance } (g_m) = \frac{\partial I_D}{\partial V_{GS}} = \frac{2I_D}{V_{GS} - V_T}$$

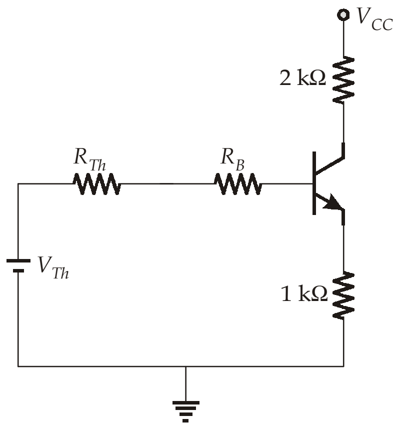
$$= \frac{2 \times 1}{6-1} = \frac{2}{5} \text{ m}\mho$$

$$g_m = 0.4 \text{ m}\mho = 0.4 \text{ mS}$$

20. (a)

With DC source; capacitor act as open circuit.

Now, given circuit can be modified as:



$$V_{\text{Th}} = V_{CC} \cdot \frac{R_2}{R_1 + R_2}$$

$$R_{\text{Th}} = \frac{R_1 \cdot R_2}{R_1 + R_2} = 5 \text{ k}\Omega$$

Stability factor because of I_{CO} is defined as:

$$S = \frac{\partial I_C}{\partial I_{CO}} = \frac{1+\beta}{1-\beta\left(\frac{\partial I_B}{\partial I_C}\right)}$$

Applying KVL in the base-emitter loop,

$$V_{Th} - I_B (R_{Th} + R_B) - (I_B + I_C) = 0$$

$$V_{Th} - I_B (R_{Th} + R_B + 1) - I_C = 0$$

Differentiating w.r.t I_C, we get

$$\frac{\partial I_B}{\partial I_C} = \frac{-1}{R_{Th} - R_B + 1}$$

The stability factor, is thus given as

$$S = \frac{1+\beta}{1+\beta\left(\frac{1}{R_{Th}+R_B+1}\right)}$$

$$20 = \frac{51}{1+50\left(\frac{1}{5+R_B+1}\right)}$$

$$1+\frac{50}{6+R_B} = \frac{51}{20}$$

$$\frac{50}{6+R_B} = \frac{31}{20}$$

$$1000 = 186 + 31R_B$$

$$R_B = 26.25 \text{ k}\Omega$$

21. (b)

$$\frac{1}{f_H} = 1.1\sqrt{\frac{1}{f_1^2}+\frac{1}{f_2^2}+\ldots\frac{1}{f_n^2}}$$

$$t_r = 1.1\sqrt{t_{r1}^2 + t_{r2}^2}$$

$$t_r = 1.1\sqrt{(0.35)^2 + (0.43)^2}$$

$$t_r = 0.61 \text{ msec}$$

22. (b)

Applying superposition theorem to determine the output, we have

$$V_o = -\frac{R_2}{R_1}\cdot V_1 + \left(\frac{R_4}{R_3+R_4}\right)\cdot\left(1+\frac{R_2}{R_1}\right)\cdot V_2$$

$$= -10V_1 + 10.0833\,V_2$$

Now, the differential input voltage is given as

$$V_d = V_2 - V_1$$

and common mode input voltage,

$$V_c = \frac{V_1+V_2}{2}$$

Thus, $$V_1 = V_c - \frac{V_d}{2}$$

$$V_2 = V_c + \frac{V_d}{2}$$

$\therefore$ $$V_o = (10.0833)\left[V_c + \frac{V_d}{2}\right] - 10\left[V_c - \frac{V_d}{2}\right]$$

$$V_o = 10.042\ V_d + 0.0833\,V_c$$

Comparing the equation from the standard result,

i.e. $$V_o = A_d V_d + A_c V_c$$

We get, $$A_d = 10.042$$

$$A_c = 0.0833$$

$\therefore$ $$(\text{CMRR})_{\text{dB}} = 20\log_{10}\left[\frac{10.042}{0.0833}\right] = 41.63 \text{ dB}$$

23. (c)

For FET Colpitt's oscillator, the frequency of oscillation is given by,

$$f_0 = \frac{1}{2\pi}\sqrt{\frac{1}{L}\left[\frac{1}{C_1} + \frac{1}{C_2}\right]}$$

$$f_0 = \frac{1}{2\pi}\sqrt{\frac{1}{9.2\times10^{-6}}\left[\frac{1}{10\times10^{-6}} + \frac{1}{1.32\times10^{-6}}\right]}$$

$$f_0 = 48.59 \text{ kHz}$$

24. (c)

The output of op-amp is connected to RC circuit which acts as differentiator. The output of differentiator is connected to diode. So, the circuit generates positive pulses and acts as a zero crossing detector.

25. (c)

The given circuit is a Wien Bridge oscillator.

Frequency of sinusoidal oscillation $f = \dfrac{1}{2\pi\sqrt{R_s C_s R_p C_p}}$

$$= \frac{1}{2\pi\sqrt{11\times22\times0.01\times0.047\times10^{-6}}}$$

$$= 471.9 \text{ Hz}$$

Gain of non inverting amplifier

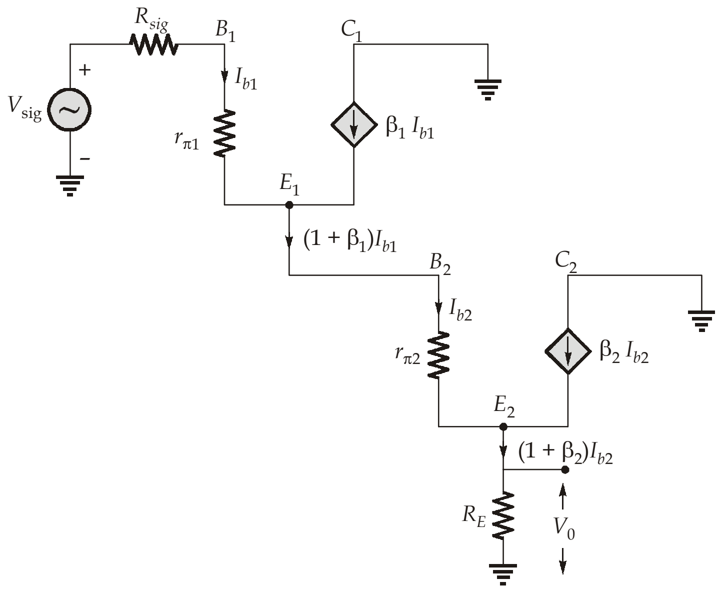
$$|A| \geq 1 + \frac{R_s}{R_p} + \frac{C_p}{C_s}$$

$$|A| \geq 1 + \frac{11}{22} + \frac{0.01}{0.047}$$

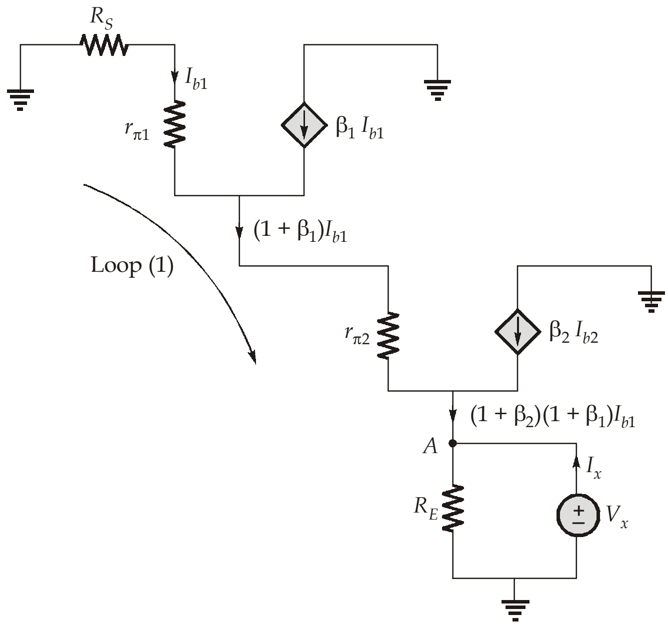
$$|A| \geq 1.713$$

26. (c)

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



For R_{out}, disable the input source and apply test signal. Therefore, the modified circuit is given as;



Applying KVL in loop (1), we get,

$$(R_s + r_{\pi 1})I_{b1} + r_{\pi 2}(1 + \beta_1)I_{b1} + V_x = 0$$

$$\therefore \quad I_{b1} = \frac{-V_x}{R_s + r_{\pi 1} + r_{\pi 2}(1+\beta_1)} \quad \text{...(1)}$$

Applying Nodal analysis at node A we get,

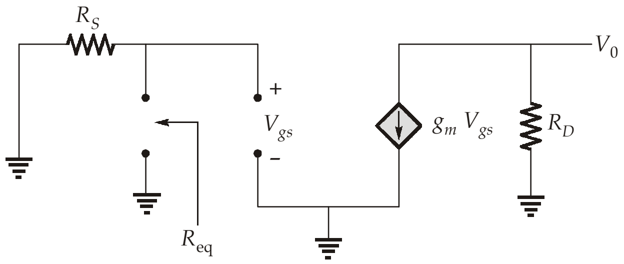
$$\frac{V_x}{R_E} = I_x + (1 + \beta_1)(1 + \beta_2)I_{b1}$$

$$V_x\left[\frac{1}{R_E} + \frac{(1+\beta_1)(1+\beta_2)}{R_s + r_{\pi 1} + r_{\pi 2}(1+\beta_1)}\right] = I_x \quad \text{[from (1)]}$$

$$\therefore \quad R_{out} = \frac{V_x}{I_x} = R_E \parallel \left[\frac{(R_S + r_{\pi 1})}{(1+\beta_1)(1+\beta_2)} + \frac{r_{\pi 2}}{(1+\beta_2)}\right]$$

27. (c)

The equivalent resistance seen from C_{in} is given as



$$\therefore \quad R_{eq} = R_S = 1.3 \text{ k}\Omega$$

$$\text{The pole frequency } f = \frac{1}{2\pi R_{eq} C_{in}}$$

$$\therefore \quad f = \frac{1}{2\pi \times 1.3 \times 10^3 \times 9 \times 10^{-9}} = 13.6 \text{ kHz}$$

28. (d)

The gain with feedback amplifier at high frequency is given as,

$$A_f = \frac{A}{1+\beta A}$$

where, $$A = \frac{A_0}{1+\frac{j\omega}{\omega_2}} \quad \text{...(given)}$$

$$\therefore \quad A_f = \frac{\frac{A_0}{1+j\frac{\omega}{\omega_2}}}{1+\beta\frac{A_0}{1+j\frac{\omega}{\omega_2}}}$$

$$\therefore \quad A_f = \frac{A_0}{1+\frac{j\omega}{\omega_2}+\beta A_0} = \frac{A_0}{(1+\beta A_0)\left[1+\frac{j\omega}{\omega_2(1+\beta A_0)}\right]}$$

$$A_f = \frac{\frac{A_0}{(1+\beta A_0)}}{1+\frac{j\omega}{\omega_2(1+\beta A_0)}} = \frac{A_{f0}}{1+\frac{j\omega}{\omega_{2f}}}$$

where $$\omega_{2f} = \omega_2(1+\beta A_0) \quad \text{...(1)}$$

Substituting $\omega_{2f} = 10^6$ rad/sec, $\omega_2 = 10^5$ rad/sec and $A_0 = 10000$ in equation (1), we get

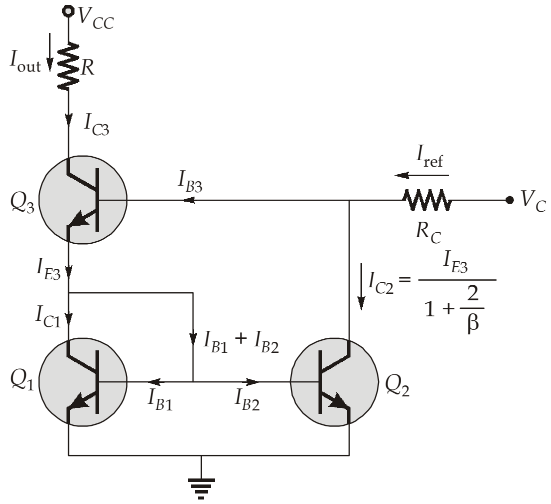
$$10^6 = 10^5[1+\beta \times 10000]$$

$$10 - 1 = \beta \times 10000$$

$$\beta = \frac{9}{10000} = 0.0009$$

29. **(d)**

The given circuit diagram is Wilson current mirror:



From the figure,

$$I_{E3} = I_{C1} + I_{B1} + I_{B2}$$

Since, Q_1 and Q_2 are perfectly matched.

$$\therefore \quad I_{C1} = I_{C2} \text{ and } I_{B1} = I_{B2}$$

$$\therefore \quad I_{E3} = \left(1+\frac{2}{\beta}\right)I_{C1} = \left(1+\frac{2}{\beta}\right)I_{C2}$$

$$\therefore \quad I_{C2} = \frac{I_{E3}}{1+\frac{2}{\beta}} \qquad ...(1)$$

$$I_{ref} = I_{B3} + I_{C2}$$

and
$$I_{ref} = I_{B3} + \frac{I_{E3}}{1+\frac{2}{\beta}} \qquad \text{[from (1)]}$$

$$\therefore \quad I_{ref} = \frac{I_{C3}}{\beta} + \left(\frac{1}{1+\frac{2}{\beta}}\right)\left(\frac{1+\beta}{\beta}\right)I_{C3}$$

$$\therefore \quad I_{ref} = I_{C3}\left[\frac{1}{\beta} + \frac{1+\beta}{2+\beta}\right] \qquad ...(2)$$

We have,
$$I_{C3} = I_{out} \qquad \text{[from the figure]}$$

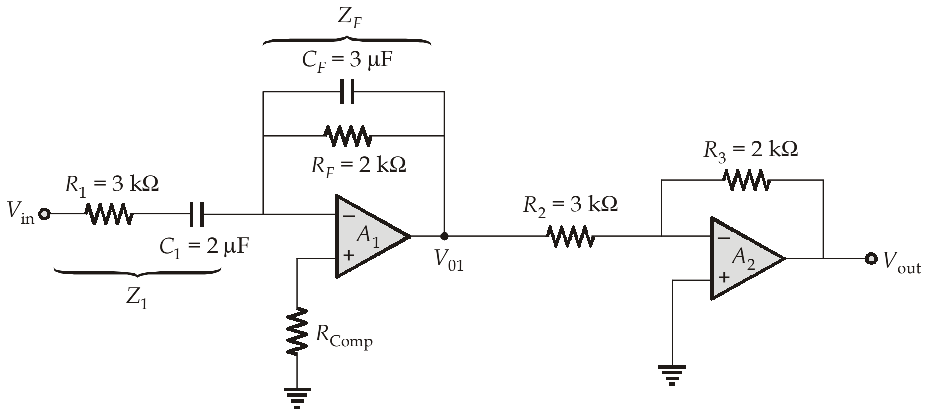
$$\therefore \quad I_{ref} = I_{out}\left[\frac{2+\beta+\beta+\beta^2}{\beta(2+\beta)}\right]$$

$$I_{out} = \frac{I_{ref}}{1+\frac{2}{\beta(2+\beta)}}$$

$$\therefore \quad \frac{I_{out}}{I_{ref}} = \frac{1}{1+\frac{2}{\beta(2+\beta)}}$$

30. (b)

The given op-amp based circuit is



A_1 is practical differentiator and A_2 is inverting amplifier

and $$R_1C_1 = R_FC_F \quad ...(1)$$

For A_1 op-amp, the transfer function is given as

$$\frac{V_{01}}{V_{in}} = \frac{-Z_F}{Z_1}$$

where, $$Z_F = \frac{R_F}{1+sR_FC_F} \text{ and } Z_1 = \frac{sR_1C_1+1}{sC_1}$$

$$\therefore \quad \frac{V_{01}}{V_{in}} = \frac{-sR_FC_1}{(1+sR_FC_F)(1+sC_1R_1)}$$

$$\therefore \quad \frac{V_{01}}{V_{in}} = \frac{-sR_FC_1}{(1+sR_1C_1)^2} \quad ...[\text{from (1)}] \quad ...(2)$$

For A_2 op-amp, the transfer function $\left(\frac{V_0}{V_{01}}\right)$ is given as

$$\frac{V_0}{V_{01}} = \frac{-R_3}{R_2} \quad ...(3)$$

The overall transfer function is given as

$$\frac{V_0}{V_{in}} = \frac{V_{01}}{V_{in}} \times \frac{V_0}{V_{01}} = -\left[\frac{sR_FC_1}{(1+sR_1C_1)^2}\right]\left[\frac{-R_3}{R_2}\right] \quad \text{from (2) and (3)}$$

$$\left|\frac{V_0}{V_{in}}\right| = \frac{R_3}{R_2}\left[\frac{\omega R_FC_1}{1+(\omega R_1C_1)^2}\right] \quad ...(4)$$

Substituting the given values in equation (4) we get,

$$\left|\frac{V_0}{V_{in}}\right| = \left(\frac{2}{3}\right)\left[\frac{100\times 2\times 10^3\times 2\times 10^{-6}}{1+(100\times 3\times 10^3\times 2\times 10^{-6})^2}\right]$$

$$\left|\frac{V_0}{V_{in}}\right| = \frac{10}{51}$$

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