# GATE

MADE EASY
# Workbook 2025

## Detailed Explanations of Try Yourself *Questions*

## Instrumentation Engineering

### Analog Electronics

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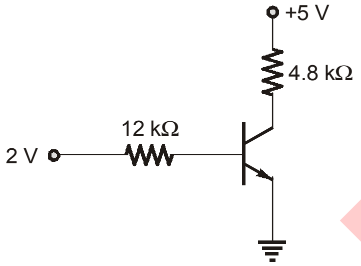
PUBLICATIONS

# 2 Testing of BJT in Different Operating Regions

## Detailed Explanation of Try Yourself Questions

**T1.** **(0.902)**



$$I_B = \frac{2-0.7}{12} = 0.10833\text{ mA}$$

$$I_{C(\text{sat})} = \frac{5-0.2}{4.8} = 1\text{mA}$$

$$I_B \geq I_{B(\text{min})}$$

$$= \frac{I_{C(\text{sat})}}{\beta}$$

$$I_B \geq \frac{1\text{mA}}{\beta}$$

$$\beta \geq \frac{1}{0.10833} \text{ and } \beta_{\min} = 9.23$$

$$\alpha_{\min} = \frac{\beta_{\min}}{1+\beta_{\min}} = 0.902$$

**T2.** **(c)**

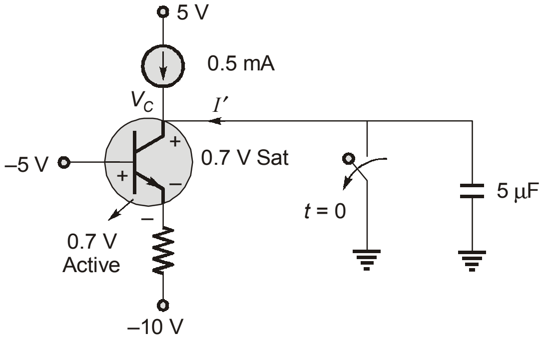
In active region

$-5 - 0.7 - 4.3\, I_E = -10$

$$I_E = \frac{10-5.7}{4.3} = \frac{4.3}{4.3} = 1\text{ mA}$$

$$I_C = I_E = I' + 0.5\text{ mA} = 1\text{ mA}$$

$$\Rightarrow \quad I' = 0.5\text{ mA}$$



In saturation region ⇒

$V_C - 0.7 - 4.3 \times 1 = -10$

$$V_C = -5\text{ V}$$

$$q = CV_C = -5 \times 10^{-6} \times 5\text{ V}$$

$$= -25 \times 10^{-6}$$

and $q = it$

$$I'(0-t) = -25 \times 10^{-6}$$

$$t = \frac{25 \times 10^{-6}}{0.5 \times 10^{-3}} = 50\text{ m sec}$$

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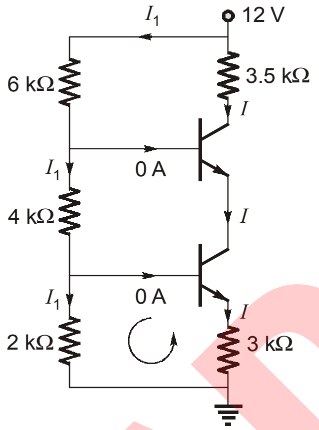
# 3 BJT Biasing

## Detailed Explanation of Try Yourself Questions

**T1. Sol.**



$$I_1 = \frac{12}{6+4+2}\text{ mA}$$

$$I_1 = 1\text{ mA}$$

Applying KVL in loop $L$

$$I_1 \times 2\text{ k}\Omega - I \times 3\text{ k}\Omega = V_{BE}$$

$$2 - I \times 3k = 0.5$$

$$-I \times 3\text{ k} = -1.5$$

$$I = \frac{-1.5}{-3} \times 10^{-3} = 0.5\text{ mA}$$

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# 4 BJT Current Mirrors

## Detailed Explanation of Try Yourself Questions

**T1.** **(a)**

$$I_{ref} = \frac{9-0.7}{30\times10^3} = 0.277 \text{ mA}$$

at node '*a*' $I_{ref} = I_C + 3I_B$

($I_{B3}$ is assumed negligible)

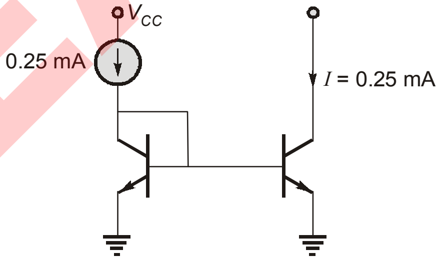
$$= I_C\left(1+\frac{3}{\beta}\right)$$

$$I_C = I_{ref}\left(\frac{\beta}{3+\beta}\right)$$

$$= 0.277\times10^{-3}\left(\frac{125}{128}\right)$$

$$I_{C_1} = 0.27 \text{ mA}$$

**T2.** **(c)**



Using current mirror concept,

For large 'β',

$$I = I_{ref}$$

so,

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

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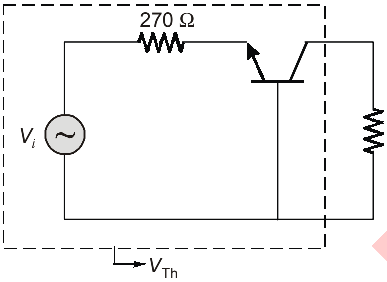
# 5

# Small Signal Analysis of BJT Amplifiers

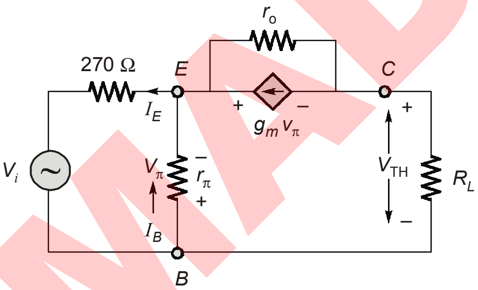
## Detailed Explanation of Try Yourself Questions

**T1.** (d)



$g_m = 2$ mS ; $r_o = 250$ kΩ

$$r_\pi = \beta r_e = \frac{\beta}{g_m} = \frac{100}{2\text{ mS}} = 50\text{ k}\Omega$$



$$V_\pi = -v_i \times \frac{r_\pi}{r_\pi + 270}$$

$$= \frac{-50\text{ k}}{50\text{ k} + 270} v_i = -0.994\, v_i$$

$$V_{Th} + r_o g_m v_\pi - v_\pi = 0$$

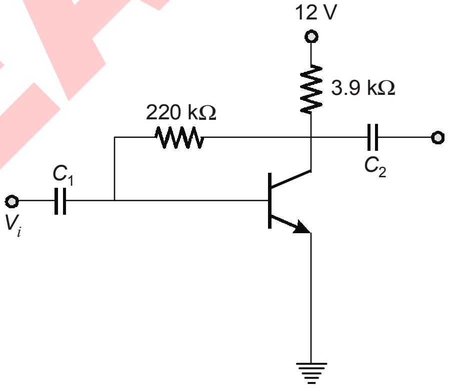
$$V_{Th} = -r_o g_m v_\pi - v_\pi$$

$$= -(1 + g_m r_o)(-0.994 v_i)$$

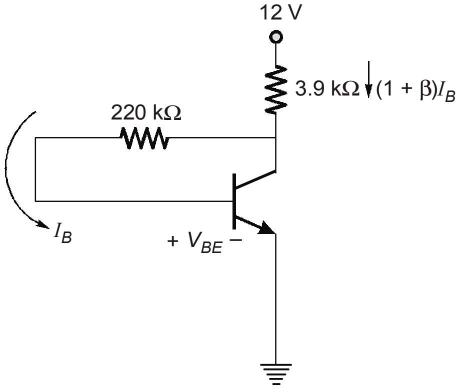
$$= -(1 + 2\text{mS} \times 250\text{ k}\Omega) \times 0.994 v_i$$

$$V_{Th} = 497.9\, v_i$$

**T2.** (d)



DC circuit

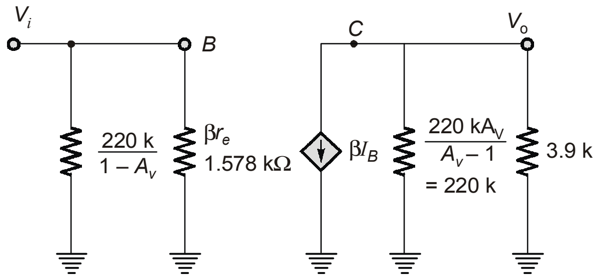


$$I_B = \frac{12 - 0.7}{(1+\beta)3.9\text{ k} + 220\text{ k}}$$

$$= 0.0163\text{ mA}$$

$$I_E = (1 + \beta)I_B = 1.97\text{ mA}$$

$$r_e = \frac{V_T}{I_E} = \frac{26\text{ mV}}{1.97\text{ mA}} = 13.15\ \Omega$$



$$V_o = -(220\text{ k} \,||\, 3.9\text{ k})\,\beta I_B$$

$$A_v = \frac{-R_C \,\|\, R_L}{r_e} = \frac{-3.83\text{ k}}{13.15}$$

$$= -291.41$$

$$Z_i = \frac{V_i}{I_i} = \frac{220\text{ k}}{1-A_v} \,\|\, \beta re$$

$$= 0.752\text{ k} \,||\, 1.578\text{ k}$$

$$= 0.509\text{ k}\Omega = 509.4\ \Omega$$

**T3. (b)**

$$A_I = \frac{-h_{fe}}{1+h_{oe}R_L} = \frac{-50}{1+\frac{1}{40}\times 10}$$

$$\Rightarrow \quad A_I = \frac{-50}{1.25}$$

$$A_v = \frac{A_I \cdot Z_L}{Z_{in}} = \frac{A_I R_L}{h_{ie}}$$

$$A_v = \frac{-50}{1.25} \times \frac{10}{1}$$

$$\Rightarrow \quad A_v = -400$$

**T4. (c)**

$$R_E = 0.5\text{ k}\Omega \quad ; \quad \beta = 100$$

$$R_C = 5\text{ k}\Omega$$

The voltage gain

$$= A_v = \frac{g_m R_C}{1+g_m R_E} \quad \left(\because R_E >> \frac{1}{g_m}\right)$$

$$\text{Thus,} \quad |A_v| \simeq \frac{R_C}{R_E} \simeq \frac{5}{0.5} \simeq 10$$

**T5. (b)**

$$g_m = \frac{I_c}{V_T} = \frac{100\ \mu\text{A}}{25\times 10^{-3}\text{ V}} = 4\text{ mA/V}$$

Input resistance

$$r_\pi = \frac{\beta}{g_m} = \frac{100}{4\times 10^{-3}}$$

$$\Rightarrow \quad R_i = r_\pi = 25\text{ k}\Omega$$

**T6. (c)**

$$h_{oe} \times R_L < 0.1$$

⇒ Approximate analysis can be used

$$A_I \approx -h_{fe} = -30$$

$$A_V \approx \frac{-h_{fe} R_L}{h_{ie}} = \frac{-30\times 2.5}{1} = 75$$

$$A_P = A_V \times A_I = 2250$$

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# 6

# Testing of MOSFET in Different Operating Regions

## Detailed Explanation of Try Yourself Questions

**T1. (d)**

Given : $V_{Th} = 0.4\text{ V}$

$$V_{GS} = V_G - V_S = 0.5 - 1.5$$
$$= -1\text{ V}$$

If $V_{GS} < V_{Th}$ in PMOS, $M_1$ will be ON

$$V_{DS} = V_D - V_S = 0 - 1.5 = -1.5\text{ V}$$
$$V_{GS} - V_t = -1 - 0.4$$
$$= -1.4\text{ V}$$

If $V_{DS} \le V_{GS} - V_t$, $M_1$ is in current saturation.

**T2. (b)**

Given : $V_{Th} = 0.4\text{ V}$

$$V_{GS} = V_G - V_S$$
$$= 0 - 0.9 = -0.9\text{ V}$$

If $V_{GS} < V_{Th}$ PMOS $M_2$ will be ON.

$$V_{DS} = V_D - V_S = 0.9 - 0.9 = 0$$

If $V_{DS} = 0$ V or mV, $M_2$ will be in ohmic.

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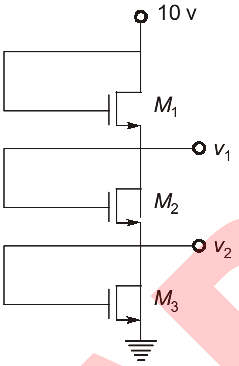
# 7

# MOSFET Biasing

## Detailed Explanation of Try Yourself Questions

**T1.** **(a)**

If $V_D = V_G$ $\therefore$ we conclude that each MOSFET is in saturation.



$$I_D = k_{n1}(V_{GS} - V_T)^2$$

MOSFET $M_1$

$$I_D = k_{n1}(V_{GS1} - V_T)^2$$

$$V_{GS1} = 10 - 5 = 5\text{ v}$$

$$0.5\text{ mA} = 36\mu \times \frac{1}{2}\cdot\left(\frac{W}{L}\right) \times (5-1)^2$$

$$\left(\frac{W}{L}\right)_1 = 1.73$$

MOSFET $M_2$

$$I_D = k_{n2}(V_{GS2} - V_T)^2$$

$$0.5\text{ mA} = 36\mu \times \frac{1}{2}\left(\frac{W}{L}\right)_2 (3-1)^2$$

$$\left(\frac{W}{L}\right)_2 = 6.94$$

MOSFET $M_3$

$$I_D = k_{n3}(V_{GS3} - V_T)^2$$

$$0.5\text{ mA} = 36\mu \times \frac{1}{2}\left(\frac{W}{L}\right)_3 (2-1)^2$$

$$\left(\frac{W}{L}\right)_3 = 27.8$$

**T2.** **(a)**

To calculate the value of $V_{DS}$, we require the voltage of both drain and source terminal.

Now, assuming the transistor to be in saturation region, the value of $V_{GS}$ can be calculated as

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

$$1 \times 10^{-3} = 0.5 \times 10^{-3} \times (V_{GS} - V_T)^2$$

$$\sqrt{2} + 1.2 = V_{GS}$$

$$V_{GS} = 1.414 + 1.2$$

$$V_{GS} = 2.614\text{ V}$$

Now, $V_{GS} = V_G - V_S$

$\because$ $V_G = 0$

Thus $V_S = -2.614$ V

And $V_D = 5$ V

Thus, $V_{DS} = V_D - V_S = 5 - (-2.614)$

$V_{DS} = 7.614$ V

$V_{DS} > V_{GS} - V_T$, so our assumption is correct.

# 9

# Small Signal Analysis of MOSFET Amplifiers

## Detailed Explanation of Try Yourself Questions

**T1.** **(b)**

It is common drain amplifier.

$$A_v = \frac{g_m R_s}{1+g_m R_s} = \frac{g_m\ 4\ \text{k}\Omega}{1+g_m\ 4\ \text{k}\Omega} = 0.95$$

$$g_m = 4.75\ \text{m}\mho$$

$$g_m = 2\,k_n\,(V_{GS} - V_T)$$

$$= 2\,k_n\left(\sqrt{\frac{I_D}{k_n}} + V_T - V_T\right)$$

$$g_m = 2\sqrt{I_D\,k_n}$$

$$g_m = 2\sqrt{I_D \times \frac{1}{2}\mu_n\,C_{ox}\left(\frac{W}{L}\right)}$$

$$\frac{W}{L} = 47$$

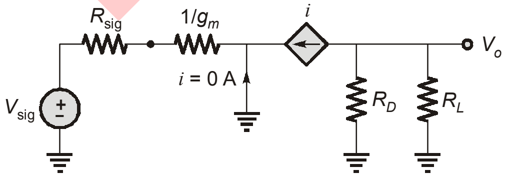
**T2.** **(c)**

$$g_m = 2\sqrt{k_n I_D}$$

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

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

now, drawing the *T* equivalent model, we have



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

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

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

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

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

**T3.** **(b)**

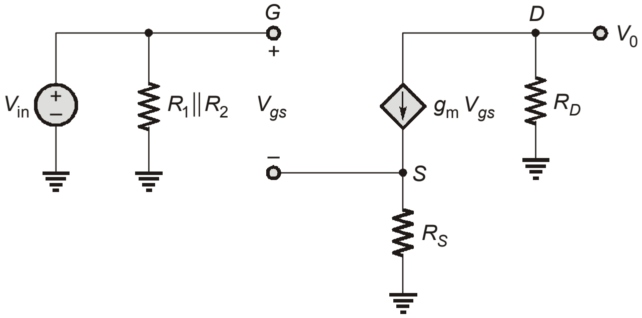
$$g_m = 2\left[\frac{\mu_n C_{ox} W}{2L}\right](V_{GS} - V_{TN})$$

or
$$g_m = 2\sqrt{\frac{\mu_n C_{ox} W}{2L}\times I_{DQ}}$$

$$= 2\sqrt{1\times10^{-3}\times0.5\times10^{-3}}$$

$$= 1.414\ \text{mA/V}$$

Thus, considering small signal model, we get,



Thus,

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

$$V_{in} = V_{gs} + (g_m V_{gs}) R_S$$

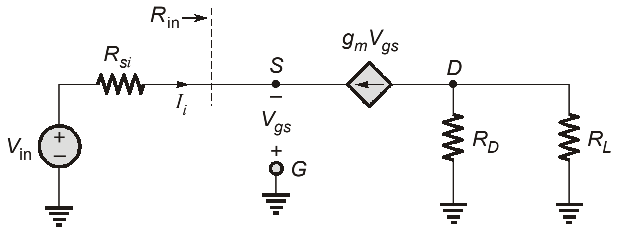
$$V_{in} = V_{gs}(1 + g_m R_S)$$

$$A_v = \frac{V_0}{V_{in}} = \frac{-g_m R_D}{1 + g_m R_S}$$

$$A_v = \frac{-(1.414)(7)}{1+(1.414)(0.5)} = -5.80$$

**T4. (b)**

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



Now, from the figure,

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

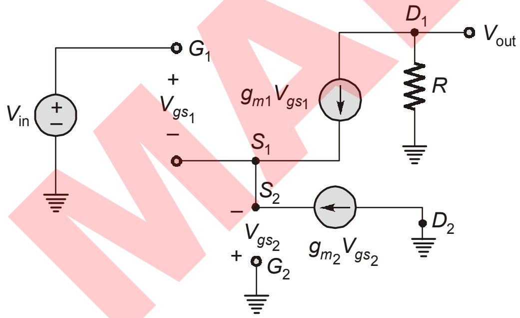
and

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

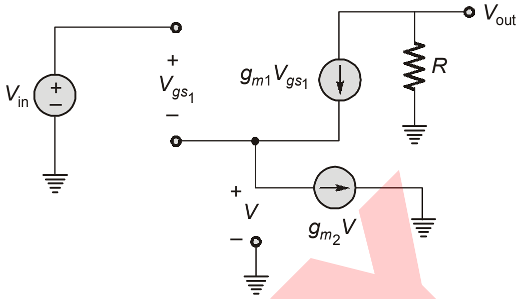
$$\therefore \quad R_{in} = \frac{-V_{gs}}{-g_m V_{gs}} = \frac{1}{g_m}$$

**T5. (a)**

By drawing the small signal equivalent circuit, we get



the above circuit can be redrawn as



Substituting $V = -V_{gs_2}$

now, $V_{in} = V_{gs_1} + V$ ...(i)

and $g_{m_1} V_{gs_1} = g_{m_2} \cdot V$

(∵ from KCL at node $S_1$) ...(ii)

thus $V_{out} = -\left[g_{m_1} V_{gs_1} R\right]$ ...(iii)

$$V_{out} = -g_{m_1} R(V_{in} - V) \qquad \text{(from (i))}$$

$$= -g_{m_1} R V_{in} + g_{m_1} VR$$

now, $V = \dfrac{g_{m_1} V_{gs_1}}{g_{m_2}}$ (from equation (ii))

$$V_{out} = -g_{m_1} R V_{in} + \frac{g_{m_1} R V_{gs_1}}{g_{m_2}} \cdot g_{m_1}$$

now from (3), we get

$$V_{out} = -g_{m_1} R V_{in} - \frac{g_{m_1}}{g_{m_2}} V_{out}$$

$$\left(1 + \frac{g_{m_1}}{g_{m_2}}\right) V_{out} = -g_{m_1} R V_{in}$$

$$V_{out} = \frac{-g_{m_1} R}{1 + \dfrac{g_{m_1}}{g_{m_2}}} V_{in}$$

$$\frac{V_{out}}{V_{in}} = \frac{-R}{\dfrac{1}{g_{m_1}} + \dfrac{1}{g_{m_2}}}$$

Hence, option (a) is correct.

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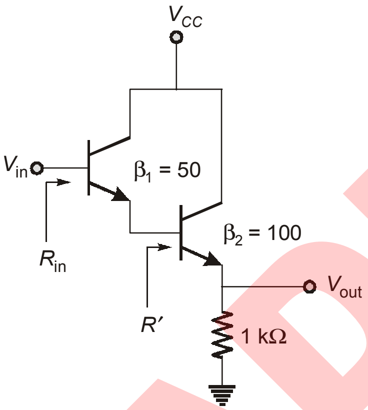
# 10 Multistage Amplifiers

## Detailed Explanation of Try Yourself Questions

**T1. (b)**

The input resistance will be



$$R' = r_\pi + (\beta_2 + 1)R_E$$
$$= 1\,\text{k} + (101)(1\,\text{k}) = 102\ \text{k}\Omega$$
$$R_{in} = r_\pi + (\beta_1 + 1)R'$$
$$= 1\,\text{k} + (51)(102\,\text{k}) = 5.203\ \text{M}\Omega$$

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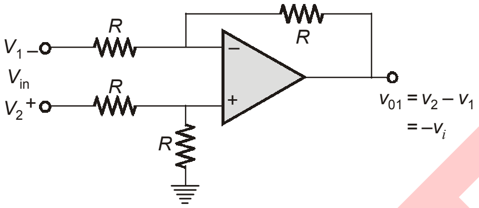
# 11 Differential Amplifiers & Operational Amplifiers

## Detailed Explanation *of* Try Yourself Questions

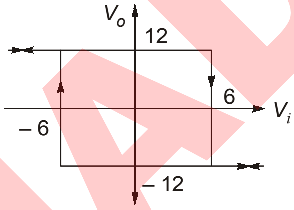
**T1. (b)**

Output of op-amp 1



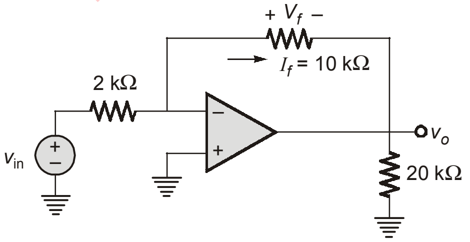
It is connected to schmitt trigger (inverting mode) → clockwise.

But inverting amplifier + inverting schmitt trigger → anticlockwise.

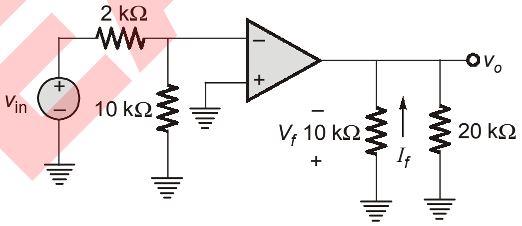


**T2. (b)**

$$R_{if} = \frac{R_i}{1+A\beta} = \frac{R_i}{A\beta} \qquad A\beta >> 1$$



voltage shunt



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

$$\beta = \frac{I_f}{V_0} = -\frac{1}{10\text{k}}$$

$$|\beta| = \frac{1}{10\text{k}}$$

$$R_{if} = \frac{R_i}{A\beta} = \frac{10\text{k}}{10^5 \times \frac{1}{10\text{k}}}$$

$$= \frac{10 \times 10 \times 10^6}{10^5}$$

$$R_{if} = 1\ \text{k}\Omega$$

**T3. (0.5)**

Applying the concept of virtual ground, we get,

$$V_o = -\frac{R_2}{R_1} \cdot V_{in}$$

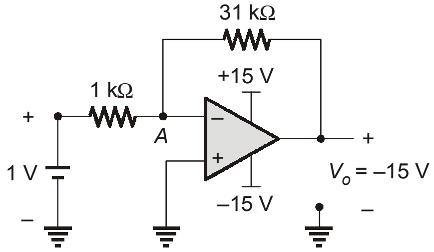
[∵ non-inverting amplifier]

$$\therefore \qquad V_o = -\frac{31\text{k}\Omega}{1\text{k}\Omega}\times 1\text{V}$$

$$V_o = -31\text{ V} < -15\text{ V}$$

which is not possible

Hence, the output voltage of the op-amp is equal to −15 V.



Now applying KCL of node '*A*', we get,

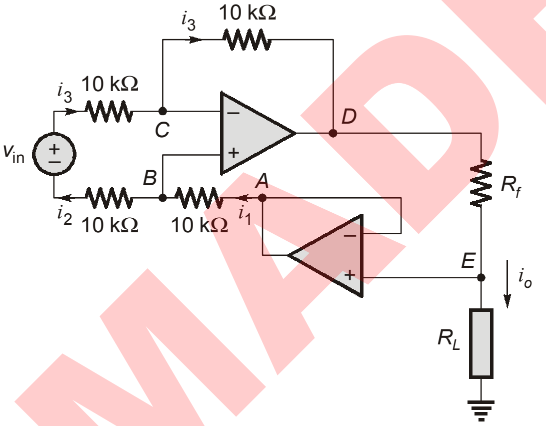
$$\frac{V_A-(-15)}{31\text{k}\Omega}+\frac{V_A-1}{1\text{k}\Omega} = 0$$

$$\frac{V_A}{31\text{k}\Omega}+\frac{V_A}{1\text{k}\Omega} = \frac{-15}{31\text{k}\Omega}+\frac{1}{1\text{k}\Omega}$$

$$V_A\left[\frac{1}{31}+\frac{1}{1}\right] = -\frac{15}{31}+1$$

$$V_A = 0.5\text{ V}$$

**T4. (b)**



From the circuit,

$$V_E = i_o R_L$$

$$V_E = V_A \text{ (Virtual short concept)}$$

$$i_1 = i_2 = i_3$$

If we apply KVL between node *B* and *C*,

$$\therefore \qquad V_B = V_C \text{ (Virtual short concept)}$$

$$i_1 = i_2 = i_3 = \frac{V_{in}}{20\text{ k}\Omega}$$

$$V_C - V_D = i_3\times 10\text{ k}\Omega = \frac{V_{in}}{2}$$

and $$V_A - V_B = i_1\times 10\text{ k}\Omega = \frac{V_{in}}{2}$$

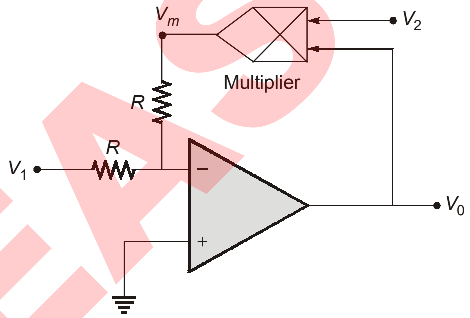
$$\therefore \qquad V_B = V_C$$

$$\Rightarrow \qquad V_D - V_E = -V_{in}$$

$$\because \qquad i_o = \frac{-V_{in}}{R_f}$$

**T5. (b)**

From the given figure



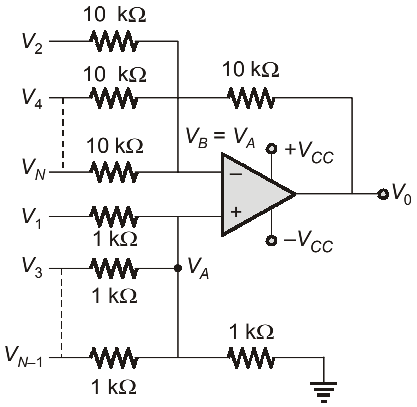
$$V_m = V_2\times V_0$$

and $$V_m = -V_1\left(\frac{R}{R}\right) = -V_1$$

Thus, $$-V_1 = V_2\times V_0$$

$$V_0 = -\frac{V_1}{V_2} = \frac{-15}{3} = -5\text{ Volts}$$

**T6. (15)**



Node A:

$$\frac{V_A-V_1}{1\text{K}}+\frac{V_A-V_3}{1\text{K}}+\ldots\ldots\frac{V_A-V_{N-1}}{1\text{K}}+\frac{V_A}{1\text{K}} = 0$$

$$V_A\left(\frac{N}{2}+1\right) = V_1 + V_3 + \ldots + V_{N-1}$$

$$V_B = V_A \qquad \because \text{ Virtual short}$$

Node B:

$$\frac{V_A - V_2}{10\text{ K}} + \frac{V_A - V_4}{10\text{ K}} + \ldots + \frac{V_A - V_N}{10\text{K}} + \frac{V_A - V_0}{10\text{K}} = 0$$

$$V_0 = V_A\left(\frac{N}{2}+1\right) - (V_2 + V_4 + V_6 + \ldots + V_N)$$

$$= \left(\frac{N}{2}+1\right)\cdot\frac{(V_1 + V_3 + \ldots + V_{N-1})}{\left(\frac{N}{2}+1\right)} - (V_2 + V_4 + \ldots + V_N)$$

$$= V_1 - V_2 + V_3 - V_4 + \ldots$$

$$= 1 + \frac{1}{2} + \frac{1}{3} + \frac{1}{4} \ldots$$

$$= \Sigma\frac{1}{N} = \infty$$

⇒ Output of op-amp goes to saturation

$$V_0 = V_{\text{sat}} = V_{CC} = 15\text{ V}$$

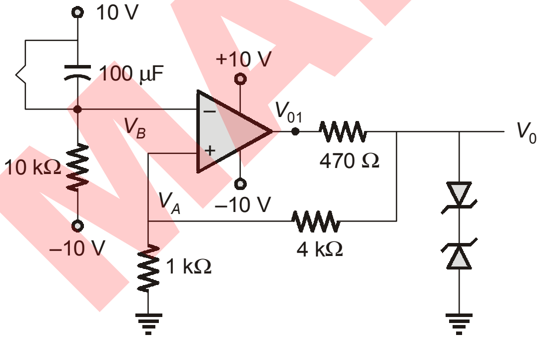
**T7.** **(0.798)**

Initially switch is closed and $V_B = 10$ V

$$\Rightarrow \qquad V_{01} = -10\text{ V}$$

$$\Rightarrow \qquad V_0 = -V_2 = -5\text{ V}$$

$$\Rightarrow \qquad V_A = \frac{V_0}{4\,\text{k} + 1\text{k}} \times 1\text{k} = -1\text{ V}$$



At $t = 0$;

The switch is opened and as $t \to \infty$, $V_B$ approaches –10 V.

Let at $t = T_1$,

$V_B$ exceeds $V_A$ (–1 V) so that $V_{01}$ changes from –10 V to 10 V

⇒ $V_0$ charges from –5 V to 5 V

$$V_B = V_f + (V_i - V_f)e^{-t/\tau}$$

$$= -10 + [10 - (-10)]\, e^{-t/RC}$$

$$\text{At } t = T_1 \qquad V_B = -1$$

$$-1\text{ V} = -10 + 20\, e^{-T1/RC}$$

$$\Rightarrow \qquad T_1 = RC\,ln\frac{20}{9}$$

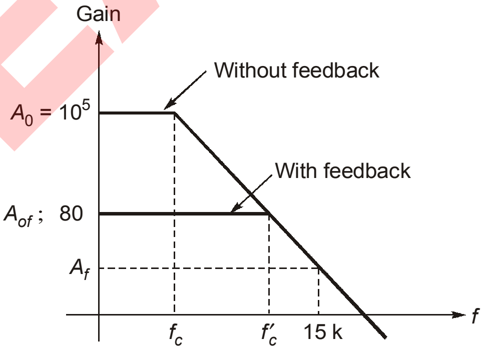
$$= 10 \times 10^3 \times 100 \times 10^{-6} \times 0.798$$

$$= 0.798\text{ sec}$$

**T8.** **(44.4)**

- In the given circuit,

  Feedback factor, $\beta = \dfrac{R_1}{R_1 + R_2} = \dfrac{1}{80}$



- $A_{of} = \dfrac{A_o}{1 + A_o\beta} \simeq 80$

- $f'_c = f_c(1 + A_o\beta) = 8\left(1 + \dfrac{10^5}{80}\right)\text{Hz} = 10{,}008\text{ Hz}$

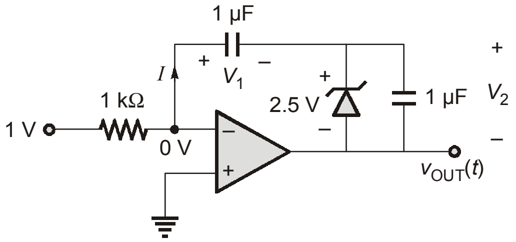
- Gain at $f = 15$ kHz $= 15000$ Hz is,

$$A_f = \frac{A_{of}}{\sqrt{1 + \left(\frac{f}{f'_c}\right)^2}}$$

$$= \frac{80}{\sqrt{\left(1 + \left(\frac{15000}{10008}\right)^2\right)}} \simeq 44.4$$

**T9. (c)**

For $t > 0$,



$$I = \frac{1\text{V}}{1\text{k}\Omega} = 1\text{mA}$$

The capacitor charges with constant current I and both $V_1$ and $V_2$ will increase till $V_2$ reaches 2.5 V. Thereafter, $V_2$ = 2.5 V and $V_1$ increases with time.

When $v_{out}(t) = -10$ V,

$$V_1 = 7.5\text{ V}$$

So,

$$\frac{1}{1\mu\text{F}}\int_0^t (1\text{mA})dt = 7.5\text{ V}$$

$$10^3 t = 7.5$$

$$t = 7.5\text{ msec}$$

■■■■

# 12 Negative Feedback Amplifiers & Oscillators

## Detailed Explanation of Try Yourself Questions

**T1.** **(a)**

The overall forward gain is 1000 and close loop gain is 100. Thus, $\beta = 0.009$.

Now, when gain of each stage increase by 10% then overall forward gain will be 1331 and using the previous value of $\beta$ the close loop will be 102.55.

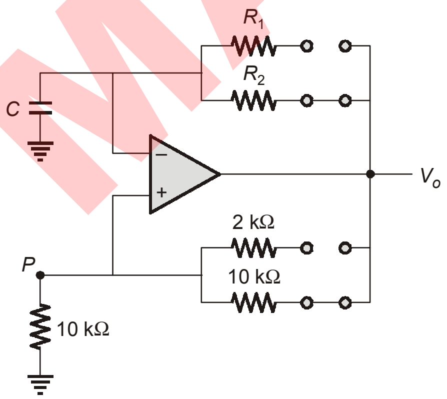
$\Rightarrow$ Close loop Voltage gain increase by 2.55%.

**T2.** **(b)**

The feedback element is $R_f$ it samples voltage and mix current so shunt-shunt feedback.

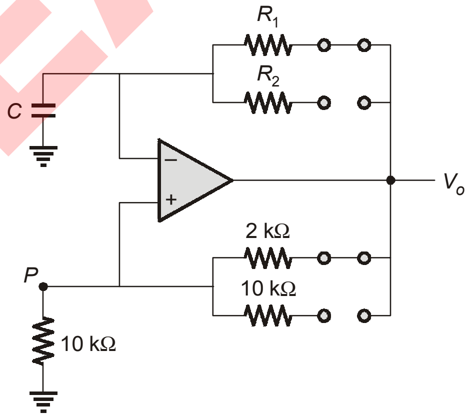
**T3.** **(a)**

The output can be ±12 V only, when output is 12 V then



So, $\quad V_p = 6\text{ V}$

when output is –12 V then



So, $\quad V_p = -10\text{ V}$

**T4.** **(d)**

Since their are 3 capacitors the maximum phase shift that can be provided will be 270° but due to the presence of the RC circuit the phase shift is equal to 60° for the individual RC circuit, making the phase shift of the feedback network equal to 180°. Thus the amplifier should be an inverting amplifier so that it can be a positive feedback circuit and because the amplifier is a practical amplifier thus $|A\beta| > 1$ for the circuit to work.

# 14 Bipolar Junction Transistor

## Detailed Explanation of Try Yourself Questions

**T1. (c)**

$$\because \qquad (\beta + 1) = \frac{I_{CEO}}{I_{CBO}} = \frac{0.6 \times 10^{-3}}{3 \times 10^{-6}} = 200$$

$$\therefore \qquad \beta = 199$$

**T2. (d)**

$$\because \qquad I_B = 0$$

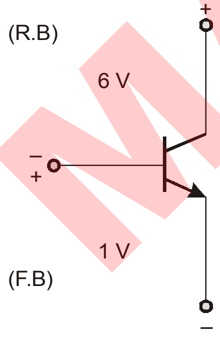
then only emitter to collector current will flow

$$\therefore \qquad I_{CEO} = (\beta + 1)I_{CBO}$$

$$= 101 \times 15 \times 10^{-6}$$

$$= 1515\ \mu A = 1.515\ mA$$

**T3. (c)**



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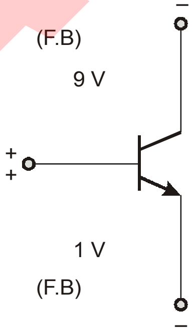
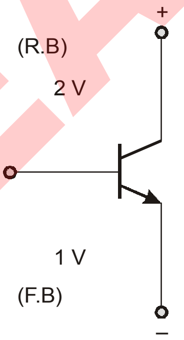
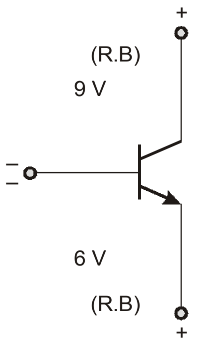


(Saturation)



(Active)



(Cut off)

**T4. (c)**

If base length > length of diffusion then the carriers will not enter the collector.

**T5. Sol.**

$$I_C = \beta I_C + (\beta + 1)I_{CO}$$

Now, $$\beta + 1 = \frac{I_{CEO}}{I_{CBO}} = \frac{0.6 \times 10^{-3}}{3 \times 10^{-6}} = 200$$

$$\therefore \qquad \beta = 199$$

$$\therefore \quad I_C = 199(10\ \mu A) + (1 + 199) \times 3 \times 10^{-6}$$

$$= 2.59 \times 10^{-3}\ \text{Amp}$$

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