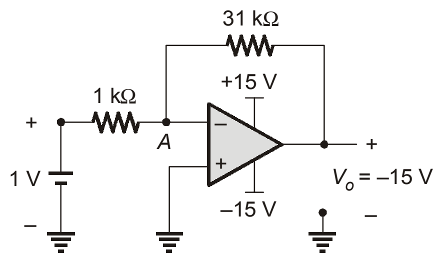
$$\therefore \quad V_o = -\frac{31\text{k}\Omega}{1\text{k}\Omega} \times 1\text{V}$$

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

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,

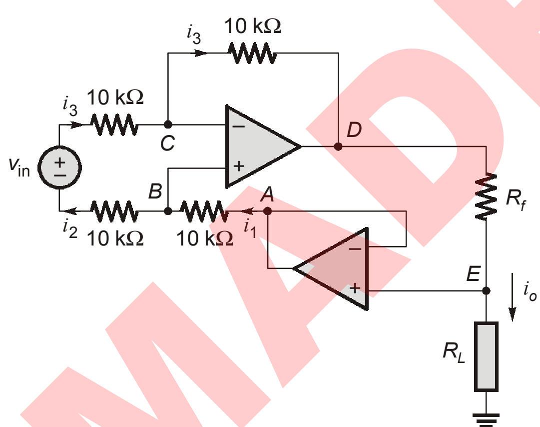
$$\frac{V_A - (-15)}{31\text{k}\Omega} + \frac{V_A - 1}{1\text{k}\Omega} = 0$$

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

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

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

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,

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

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

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

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

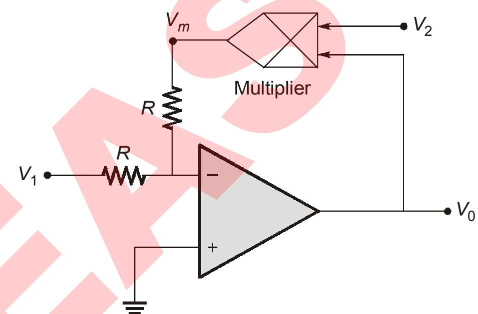
$$\therefore \quad V_B = V_C$$

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

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

T5. (b)

From the given figure



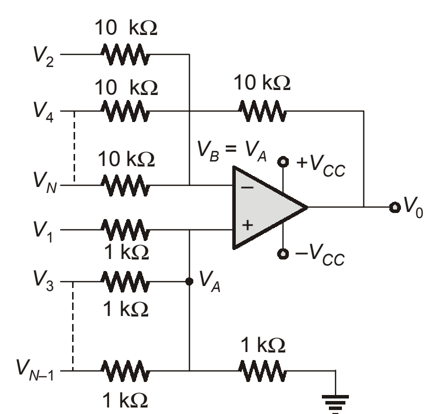
$$V_m = V_2 \times V_0$$

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

$$\text{Thus,} \quad -V_1 = V_2 \times V_0$$

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

T6. (15)



Node A:

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

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

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

Node B:

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

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

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

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

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

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

$\Rightarrow$ Output of op-amp goes to saturation

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

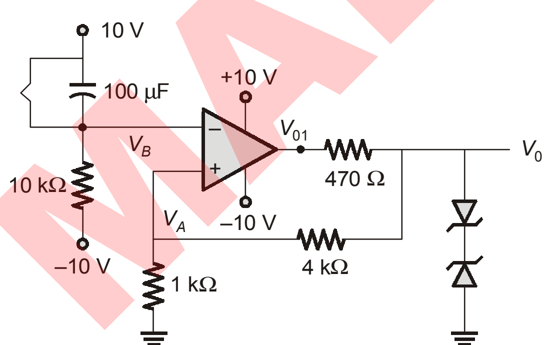
T7. (0.798)

Initially switch is closed and $V_B = 10$ V

$\Rightarrow \quad V_{01} = -10$ V

$\Rightarrow \quad V_0 = -V_2 = -5$ V

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



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

$\Rightarrow V_0$ charges from –5 V to 5 V

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

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

At $t = T_1 \quad V_B = -1$

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

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

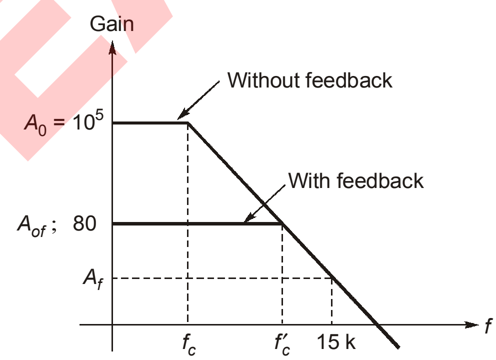
$$= 10 \times 10^3 \times 100 \times 10^{-6} \times 0.798$$

$$= 0.798\text{ sec}$$

T8. (44.4)

- In the given circuit,

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



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

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

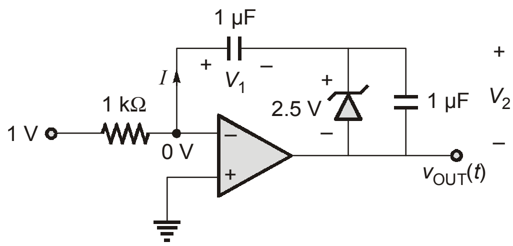
- Gain at $f = 15$ kHz = 15000 Hz is,

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

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

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, β = 0.009.

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

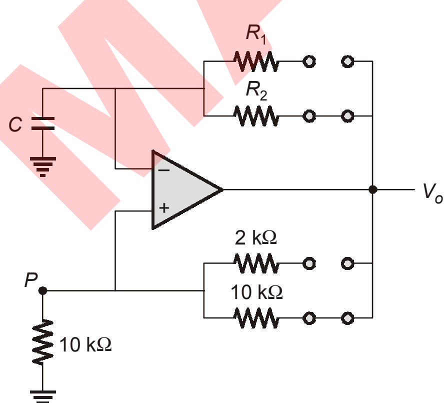
$\Rightarrow$ Close loop Voltage gain increase by 2.55%.

T2. (b)

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

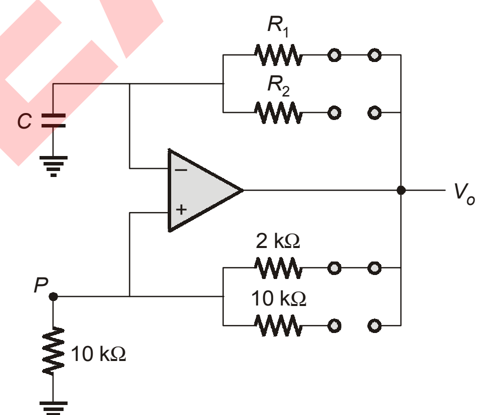
T3. (a)

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



So, V_p = 6 V

when output is –12 V then



So, V_p = –10 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.

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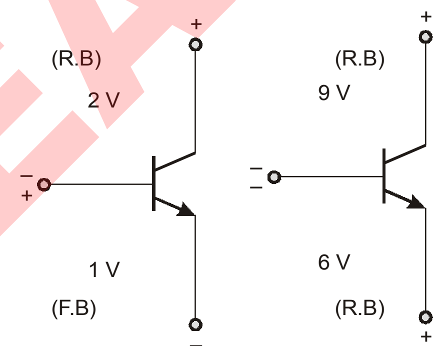
14 Bipolar Junction Transistor

Detailed Explanation *of* Try Yourself Questions

T1. (c)



(Active) (Cut off)

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

$$\therefore \quad \beta = 199$$

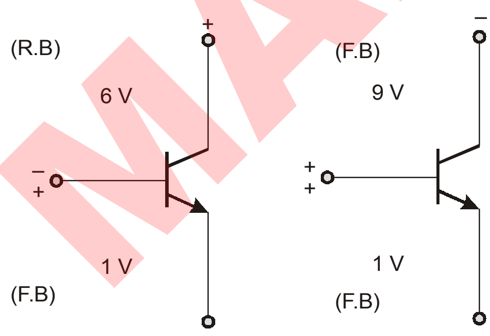
T2. (d)

$$\because \quad I_B = 0$$

then only emitter to collector current will flow

$$\therefore \quad I_{CEO} = (\beta + 1)I_{CBO}$$
$$= 101 \times 15 \times 10^{-6}$$
$$= 1515\ \mu A = 1.515\ mA$$

T3. (c)



(Active) (Saturation)

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

$$\therefore \quad \beta = 199$$

$$\therefore \quad I_C = 199(10\ \mu A) + (1 + 199) \times 3 \times 10^{-6}$$
$$= 2.59 \times 10^{-3}\ \text{Amp}$$

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