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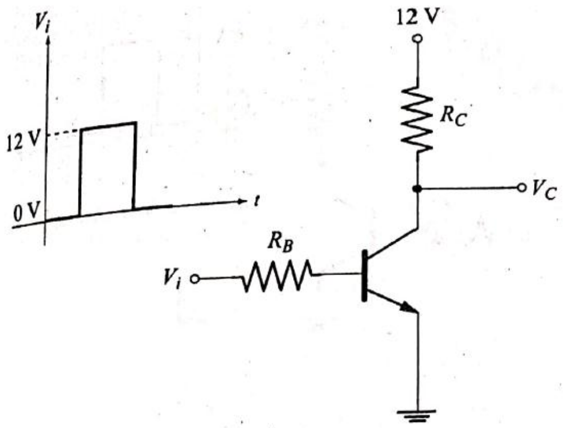
Internal Assesment Test - I

Sub:	**ANALOG ELECTRONIC CIRCUITS**							Code:	18EE34
Date:	17/12/2021	Duration:	90 mins	Max Marks:	50	Sem:	3rd	Branch:	EEE

Answer **Any FIVE FULL** Questions

		Marks	OBE CO	OBE RBT
1	For Emitter Stabilized Bias circuit V_{CC} = 10V, R_C = 1kΩ, R_E = 500Ω, R_B = 100kΩ, β = 100. Calculate I_B, I_C, V_{CE}, V_E and V_C.	10	CO1	L3
2	Design a Voltage Divider Bias circuit for the given conditions. I_c = 1mA, S_{ICO} = 20, β = 100, V_E = 1V, V_{CE} = 6V and V_{CC} = 12V.	10	CO1	L3
3	Derive the expression for stability factor $S(I_{CO})$ and $S(V_{BE})$ for Emitter Bias configuration	10	CO1	L3
4	Determine the stability factor $S(V_{BE})$ and the change in I_C from 25^0C to 100^0C for the transistor with $V_{BE}(25^0C) = 0.65V$ and $V_{BE}(100^0C) = 0.48V$ for the following bias arrangements a) Fixed Bias with $R_B = 270k\Omega$ and $\beta = 120$ b) Voltage Divider Bias with $R_1 = 39k\Omega$, $R_2 = 10k\Omega$, $R_E = 1k\Omega$ and $\beta = 120$	10	CO1	L3
5	Derive the expression for stability factor $S(I_{CO})$, $S(V_{BE})$ and $S(\beta)$ for Fixed Bias configuration	10	CO1	L3
6	For the transistor inverter shown, determine the values of R_B and R_C. Take $I_{C(sat)} = 12mA$, $\beta = 200$ and $V_{CE(sat)} = 0V$. Also draw the output voltage waveform.  	10	CO1	L3
7	What is Clamping circuits? Draw the circuit and output waveforms for Negative Clamper and Positive Clamper.	10	CO1	L1

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IAT 1 Solution

1.

$$I_B = \frac{V_{CC} - V_{BE}}{R_B + (1+\beta)R_E} = \frac{10V - 0.7V}{100K\Omega + (101)500\Omega} = \frac{9.3}{150.5} = \underline{\underline{0.062mA}}$$

$$I_C = \beta I_B = 100 \times 0.062 = \underline{\underline{6.2mA}}$$

$$V_{CE} = V_{CC} - I_C(R_C + R_E)$$

$$= 10 - 6.2(1 + 500\Omega) = \underline{\underline{0.7V}}.$$

$$V_E = I_E R_E = 6.2 \times 500\Omega = \underline{\underline{3.1V}}$$

$$V_C = V_{CC} - I_C R_C = 10 - 6.2 \times (1) = \underline{\underline{3.8V}}.$$

2.

$$I_C \simeq I_E = \underline{\underline{1mA}}.$$

$$V_E = I_E R_E \Rightarrow R_E = \frac{V_E}{I_E} = \underline{\underline{1K\Omega}}.$$

$$I_B = \frac{I_C}{\beta} = 0.01mA.$$

$$V_{CC} - V_{CE} - I_C(R_C + R_E) = 0.$$

$$\therefore R_C = \frac{V_{CC} - V_{CE}}{I_C} - R_E = \underline{\underline{5K\Omega}}$$

$$S(I_{CO}) = (1+\beta)\left[\frac{R_E + R_{Th}}{(1+\beta)R_E + R_{Th}}\right]$$

$$[(1+\beta)R_E + R_{Th}]20 = (1+\beta)(R_E + R_{Th})$$

$$2020R_E + 20R_{Th} = 101R_E + 101R_{Th}.$$

$$81R_{Th} = 1919R_E$$

$$R_{Th} = 23.691K\Omega$$

$$V_{Th} = R_{Th} I_B + I_E R_E + V_{BE}$$

$$= (23.691 \times 0.01) + (1 \times 1) + 0.7$$

$$= 1.937\,V$$

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

$$V_{Th} = \frac{V_{CC}}{R_1} \frac{R_1 R_2}{(R_1 + R_2)} = \frac{V_{CC}}{R_1} R_{Th}$$

$$R_1 = \frac{V_{CC}}{V_{Th}} R_{Th} = \frac{12}{1.937} \times 23.691 = 146.769\,K\Omega$$

$$\simeq \underline{147\,K\Omega}$$

$$R_{Th} = R_1 // R_2 \Rightarrow \frac{1}{R_{Th}} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$\frac{1}{R_2} = \frac{1}{R_{Th}} - \frac{1}{R_1} = \frac{R_1 - R_{Th}}{R_1 R_{Th}}$$

$$\therefore R_2 = \frac{R_1 R_{Th}}{R_1 - R_{Th}} = \frac{147 \times 23.691}{147 - 23.691}$$

$$= 28.243\,K\Omega$$

$$\simeq \underline{28\,K\Omega}$$

3.

Stability Factor $S(I_{CO})$,

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

$$V_{CC} = I_B R_B + V_{BE} + I_E R_E$$

But $I_E = I_B + I_C$

$$\therefore \quad V_{CC} = I_B R_B + V_{BE} + I_B R_E + I_C R_E$$

Differentiating with respect to I_C keeping V_{BE} constant, we get

$$0 = \frac{\partial I_B}{\partial I_C} R_B + \frac{\partial I_B}{\partial I_C} R_E + R_E = \frac{\partial I_B}{\partial I_C}(R_B + R_E) + R_E$$

$$\therefore \quad \frac{\partial I_B}{\partial I_C} = -\frac{R_E}{R_B + R_E}$$

$$S(I_{co}) = \frac{1+\beta}{1-\beta\left(\frac{-R_E}{R_B+R_E}\right)} = \frac{1+\beta}{1+\beta\left(\frac{R_E}{R_B+R_E}\right)}$$

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

$$\boxed{S(I_{co}) = \frac{(\beta+1)\left(1+\frac{R_B}{R_E}\right)}{(\beta+1)+\frac{R_B}{R_E}}}$$

Stability Factor S(V_{BE})

$$S(V_{BE}) = \frac{\partial I_C}{\partial V_{BE}}$$

$$V_{CC} = I_B R_B + V_{BE} + I_B R_E + I_C R_E$$

Substuiting $I_B = \frac{I_C}{\beta}$

$$V_{CC} = \frac{I_C}{\beta} R_B + V_{BE} + \frac{I_C}{\beta} R_E + I_C R_E$$

$$= \left[\frac{R_B}{\beta} + \frac{R_E}{\beta} + R_E\right] I_C + V_{BE}$$

$$= \left[\frac{R_B + R_E + \beta R_E}{\beta}\right] I_C + V_{BE}$$

$$V_{CC} = \left[\frac{R_B + (1+\beta) R_E}{\beta}\right] I_C + V_{BE}$$

Differentiating with respect to I_C, keeping β constant, we get

$$0 = \frac{R_B + (1+\beta) R_E}{\beta} + \frac{\partial V_{BE}}{\partial I_C}$$

$$\therefore \boxed{S(V_{BE}) = \frac{\partial I_C}{\partial V_{BE}} = \frac{-\beta}{R_B + (1+\beta) R_E}}$$

4.

4. a) $dV_{BE} = V_{BE}(100^\circ C) - V_{BE}(25^\circ C) = -0.17V$.

$S_{VBE} = \frac{-\beta}{R_B} = -0.44 \times 10^{-3}$.

$dI_C = S_{VBE} \times \delta V_{BE} = 74.8 \mu A$

b) $\delta V_{BE} = -0.17V$.

$S(V_{BE}) = \frac{-\beta}{R_{Th} + (1+\beta) R_E}$

$R_{Th} = R_1 || R_2 = 7.95 K\Omega$.

$\therefore S(V_{BE}) = -0.93 \times 10^{-3}$.

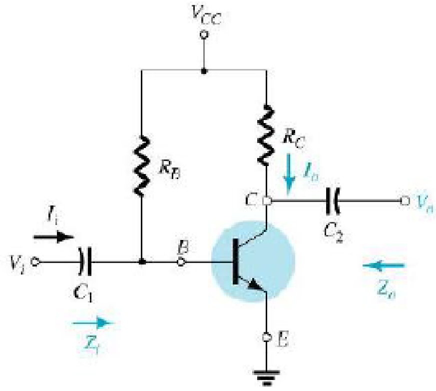
$\delta I_C = S(V_{BE}) \times \delta V_{BE} = 158.1 \mu A$.

Stability Factor $S(I_{CO})$,

$S(I_{CO})$ or $S = \frac{\partial I_C}{\partial I_{CBO}}$ at constant V_{BE} and β

From circuit diagram

$$I_B = \frac{V_{CC} - V_{BE}}{R_B}$$



$$V_{CC} \gg V_{BE}$$

$$I_B \simeq \frac{V_{CC}}{R_B}$$ which is constant

Differentiating with respect to I_C,

$$\frac{\partial I_B}{\partial I_C} = 0$$

Substitute in equation A,

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

Stability Factor $S(V_{BE})$

$$S(V_{BE}) \equiv \frac{\partial I_C}{\partial V_{BE}}$$

$$V_{CC} = I_B R_B + V_{BE}$$

$$\therefore \quad V_{BE} = V_{CC} - I_B R_B$$

$$\text{But} \quad I_B \simeq \frac{I_C}{\beta}$$

$$\therefore \quad V_{BE} = V_{CC} - \frac{I_C}{\beta} R_B$$

Differentiating with respect to V_{BE}, keeping β constant, we get

$$1 = 0 - \frac{R_B}{\beta} \frac{\partial I_C}{\partial V_{BE}}$$

$$\boxed{S(V_{BE}) = -\frac{\beta}{R_B}}$$

6.

Solution To find R_C, $I_{C(sat)} = \frac{V_{CC} - V_{CE(sat)}}{R_C}$

$\therefore R_C = \frac{V_{CC}}{I_{C(sat)}} = \frac{12V}{12mA} = \underline{1K\Omega}$

To find R_B, $I_{B(max)} = \frac{I_{C(sat)}}{\beta_{dc}} = \frac{12mA}{200} = 60\mu A$.

Let $I_B = 150\%$ of $I_{B(max)}$ [to ensure saturation]

$= 1.5(60\mu A) = 90\mu A$.

$\therefore R_B = \frac{V_i - V_{BE}}{I_B} = \frac{12V - 0.7V}{90\mu A} = \underline{125.55K\Omega}$.

7.

- A clamping circuit is a circuit that shifts an AC waveform (up or down) to a different DC level.
- Also known as a level shifter.
- The input and output waveforms have identical shapes, only the DC level is different.