CMR INSTITUTE OF TECHNOLOGY

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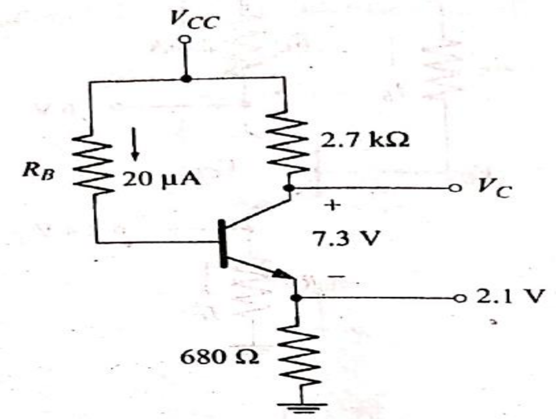
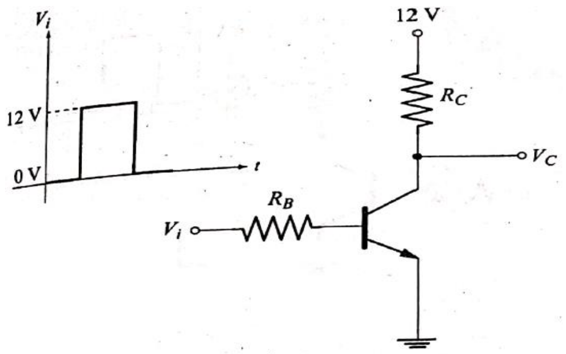
Internal Assesment Test - I

Sub:	**ANALOG ELECTRONIC CIRCUITS**							Code:	18EE34
Date:	09/09/2019	Duration:	90 mins	Max Marks:	50	Sem:	3rd	Branch:	EEE

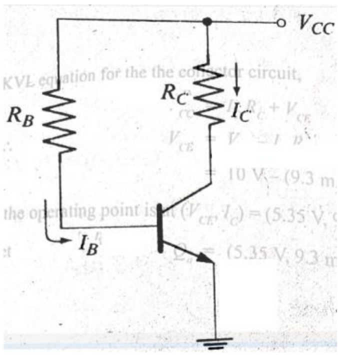
Answer **Any FIVE FULL** Questions

		Marks	OBE	
			CO	RBT
1	For the fixed-bias circuit, R_B=50KΩ, Rc=500Ω, $V_{CC} = 10V$. a) Draw the neat circuit diagram. b) Find the coordinates of the operating point. c) Draw the dc load line and locate the operating point on the dc load line. Assume silicon transistor with $\beta = 50$ and $V_{BE} = 0.7V$.	10	CO1	L3
2	The circuit shown below uses silicon transistor. Calculate a) β (b) V_{CC} (c) R_B (d) V_C (e) $I_{C(sat)}$  	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 $S(I_{CO})$ and $S(V_{BE})$ 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

Analog Electronic Circuits – IAT 1 solution

1.

a) Circuit diagram:



b)

$$I_B = \frac{V_{CC} - V_{BE}}{R_B} = \frac{10\text{ V} - 0.7\text{ V}}{50\text{ k}\Omega} = 0.186\text{ mA}$$

$$I_C = \beta I_B = 50 \times 0.186\text{ mA} = 9.3\text{ mA}$$

Writing KVL equation for the the collector circuit,

$$V_{CC} = I_C R_C + V_{CE}$$

$$\therefore \quad V_{CE} = V_{CC} - I_C R_C$$

$$= 10\text{ V} - (9.3\text{ mA} \times 0.5\text{ k}\Omega) = 5.35\text{ V}$$

Therefore the operating point is at $(V_{CE}, I_C) = (5.35\text{ V}, 9.3\text{ mA})$

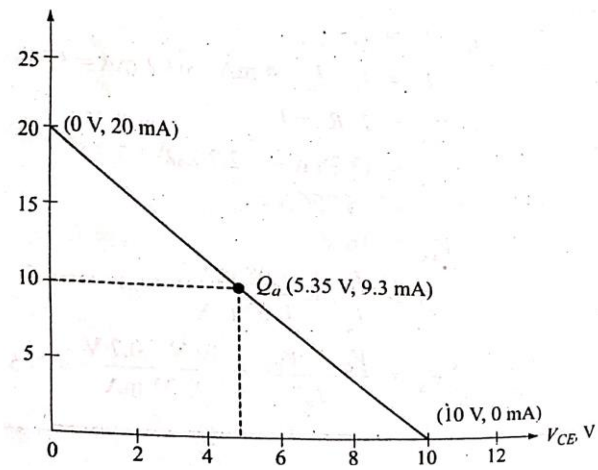
Let $\quad Q_a = (5.35\text{ V}, 9.3\text{ mA})$

The current axis intercept of the load line is

$$\frac{V_{CC}}{R_C} = \frac{10\text{ V}}{0.5\text{ k}\Omega} = 20\text{ mA}$$

and the voltage axis intercept is $V_{CC} = 10$ V. The load line is plotted by joining ((
and (10 V, 0 mA) as shown below:

c)



2.

(a) β

Given the voltage across the emitter resistance, we can obtain the emitter current as

$$I_E = \frac{V_E}{R_E} = \frac{2.1\text{ V}}{680\ \Omega} = 3.09\text{ mA}$$

The emitter current is approximately equal to collector current.

$$\therefore \quad I_C = 3.09\text{ mA}$$

Now

$$\beta = \frac{I_C}{I_B} = \frac{3.09\text{ mA}}{20\ \mu\text{A}} = 154.5$$

(b) V_{CC}

From the KVL equation for the collector emitter circuit, we have

$$V_{CC} = I_C R_C + V_{CE} + V_E$$
$$= (3.09\text{ mA} \times 2.7\text{ k}\Omega) + 7.3\text{ V} + 2.1\text{ V} = 17.74\text{ V}$$

(c) R_B

Writing the KVL equation for the base-emitter circuit

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

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

$$= \frac{17.74\text{ V} - 0.7\text{ V} - 2.1\text{ V}}{20\ \mu\text{A}} = 747\text{ k}\Omega$$

d)

$$V_C = V_{CE} + V_E = 7.3\text{ V} + 2.1\text{ V} = 9.4\text{ V}$$

e)

$$I_{C\,(sat)} = \frac{V_{CC}}{R_C + R_E} = \frac{17.74\text{ V}}{2.7\text{ k}\Omega + 680\ \Omega} = 5.248\text{ mA}$$

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

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

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

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

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

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

Stability factor $S(V_{BE})$

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

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

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

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

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

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

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

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

4.

$$\Delta V_{BE} = V_{BE}(100° \text{ C}) - V_{BE}(25° \text{ C})$$
$$= 0.48 \text{ V} - 0.65 \text{ V} = -0.17 \text{ V}$$

a)

Fixed Bias

$R_1 = 270\text{ k}\Omega \quad \beta = 120$

$$S(V_{BE}) = \frac{-\beta}{R_B} = -\frac{120}{270\text{ k}\Omega} = -0.44 \times 10^{-3}$$

$$\Delta I_C = S(V_{BE})\,\Delta V_{BE}$$

$$= (-0.44 \times 10^{-3})(-0.17) = 74.8\ \mu\text{A}$$

b)

Voltage Divider Bias

$R_1 = 39\text{ k}\Omega \quad R_2 = 10\text{ k}\Omega \quad R_E = 1\text{k}\Omega \quad \beta = 120$

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

$$R_{th} = R_1 \,\|\, R_2 = 39\text{ k}\Omega \,\|\, 10\text{ k}\Omega = 7.95\text{ k}\Omega$$

$$S(V_{BE}) = \frac{-120}{7.95\text{ k}\Omega + (121)(1\text{ k}\Omega)} = -0.93 \times 10^{-3}$$

$$\Delta I_C = S(V_{BE})\,\Delta V_{BE} = (-0.93 \times 10^{-3})(-0.17) = 158.1\ \mu$$

5. Stability factor $S(I_{CO})$

$$S(I_{CO}) \equiv \frac{\partial I_C}{\partial I_{CO}}$$

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

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

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

Differentiating with respect to I_C**,**

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

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

Stability factor $S(V_{BE})$

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

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

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

$$I_B \simeq \frac{I_C}{\beta}$$

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

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

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

6.

Calculation of R_C

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

From the output waveform, $V_{CE(sat)} = 0$ V

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

Calculation of R_B

$$I_{B(max)} = \frac{I_{C(sat)}}{\beta_{dc}} = \frac{12\text{ mA}}{200} = 60\ \mu\text{A}$$

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

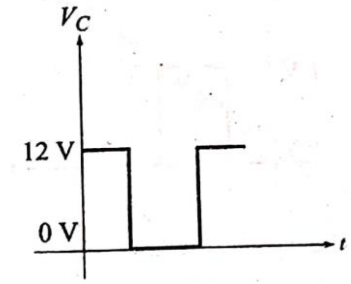
$$= (1.5)(60\ \mu\text{A}) = 90\ \mu\text{A}$$

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

$$= \frac{12\text{ V} - 0.7\text{ V}}{90\ \mu\text{A}}$$

$$= 125.55\text{ k}\Omega$$

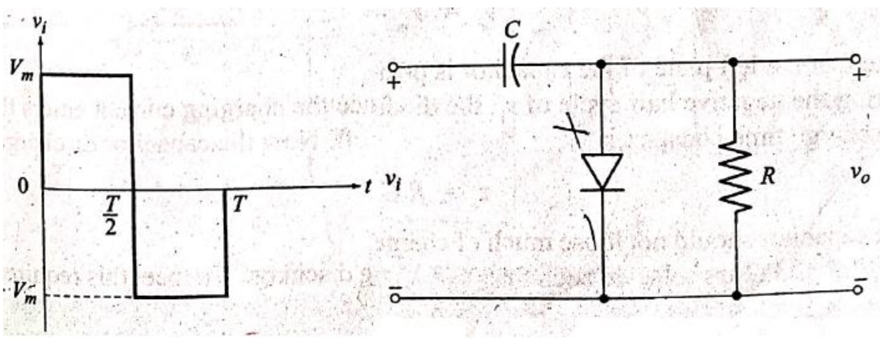
Output voltage waveform

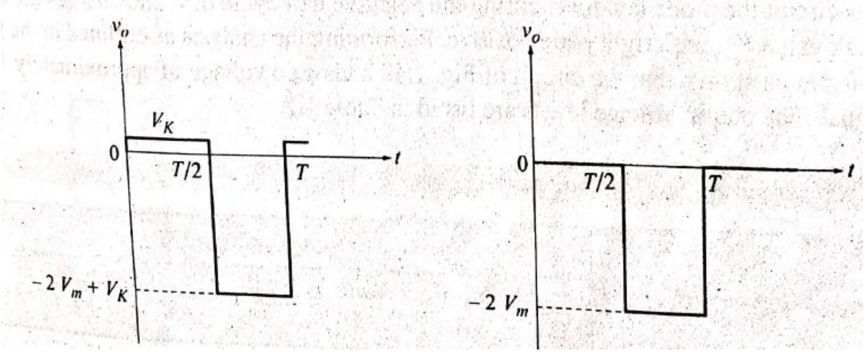


7.

Clamping circuits are used toad dc level to the input signal. They are also called dc restorers or dc inserters. It uses diode, resistors and capacitors.

Negative clamper





Positive clamper