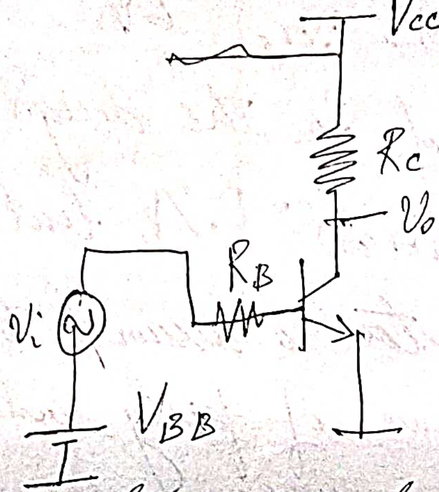
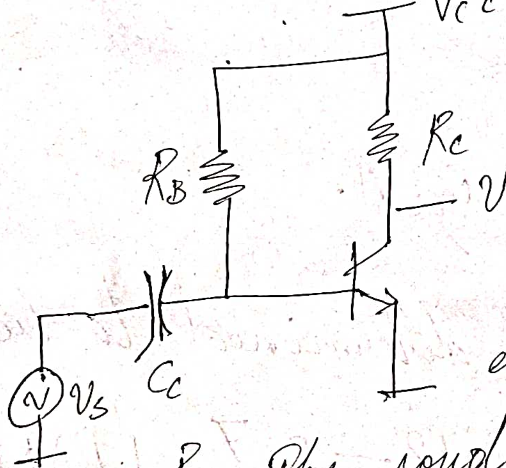
Bipolar Transistor Biasing:-

In order to keep the transistor in forward active mode to create a linear amplifier, we must establish a Q-point near the center of the load lines and couple the time varying input signal to the base

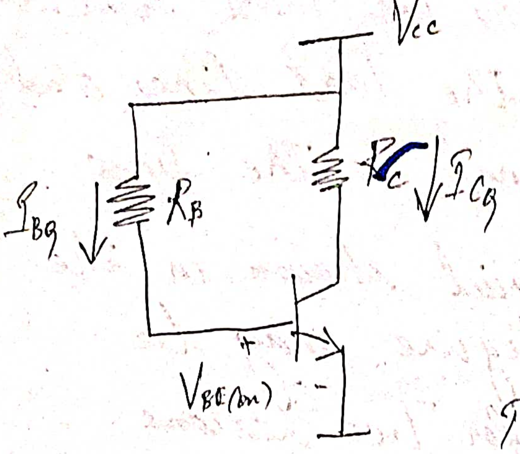


The circuit shown in the adjacent figure may be impractical for two reasons (1) the signal source is not connected to the ground and (2) there ~~are~~ may be situations where we do not want ~~to~~ a dc current flowing through the signal source. So we have to go for alternative

<u>Single Base Resistor Biasing</u> The circuit shown in Fig is one of the simplest transistor circuits. There is a single dc power supply and the quiescent base current is established through the resistor



R_B. The coupling capacitor C_C acts as an open circuit to dc, isolating the signal from the dc base current. If the frequency of the input signal is large enough and C_C also is large enough, the signal can be coupled through C_C to the base with little attenuation.



Design a circuit with a single base resistor to meet a set of specifications.

$V_{CC} = 12V$

$I_{CQ} = 1mA$, $V_{CEQ} = 6V$

The transistor used in the design has nominal values of $\beta = 100$ and $V_{BE(on)} = 0.7V$, but the current gain of this type of transistor is assumed to be in the range $50 \leq \beta \leq 150$ because of fairly wide tolerances. ~~In this example~~, We'll assume, in this example that the designed resistors values are available.

Soln:- The collector resistor is found from

$$R_C = \frac{V_{CC} - V_{CEQ}}{I_{CQ}} = \frac{12-6}{1mA} = 6k\Omega.$$

The base current is

$$I_{BQ} = \frac{I_{CQ}}{\beta} = \frac{1mA}{100} = 10\mu A.$$

and the base resistor is determined to be

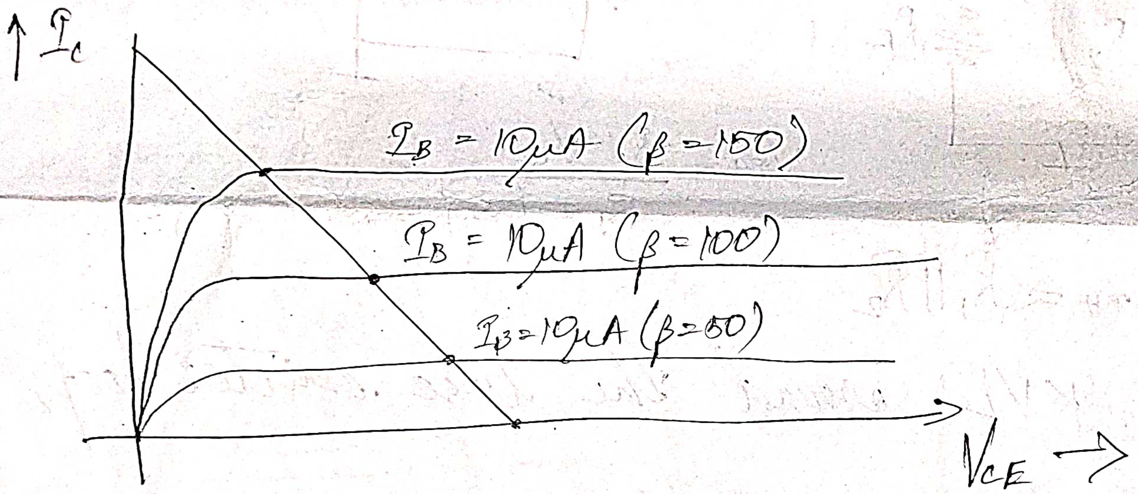
$$R_B = \frac{V_{CC} - V_{BE(on)}}{I_{BQ}} = \frac{12-0.7}{10\mu A} = 1.13M\Omega$$

Trade-offs: In this example, we will assume that the resistor values are fixed and will investigate the effects of the variation in transistor current gain β.

The base current is given by.

$$I_{BQ} = \frac{V_{CC} - V_{BE(on)}}{R_B} = 10\mu A.$$

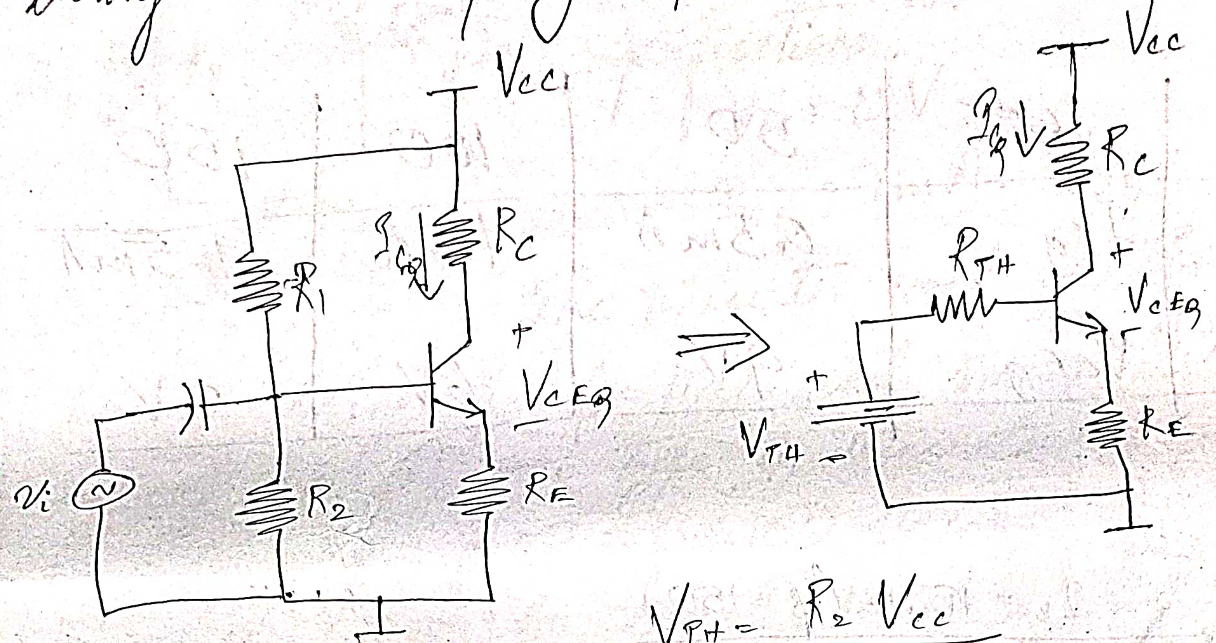
β	~~50~~	50	100	150
Q-point values	I_{CQ}	0.5mA	1mA	1.5mA
	V_{CEQ}	9V	6V	3V



In this circuit configuration with a single base resistor, the Q-point is not stabilized against variations in β; as β changes, the Q point varies significantly. We now notice the importance of the placement of the Q-point.

Alternative Biasing Scheme:-

The circuit shown in figure below is a classic example of discrete transistor biasing. The single bias resistor R_B in the previous circuit is replaced by a pair of resistors R_1 and R_2 and an emitter resistor R_E is added. The ac signal is still coupled through the base of the transistor through the coupling capacitor C_C.



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

$$R_{TH} = R_1 \| R_2$$

Applying KVL around the base emitter loop, we obtain

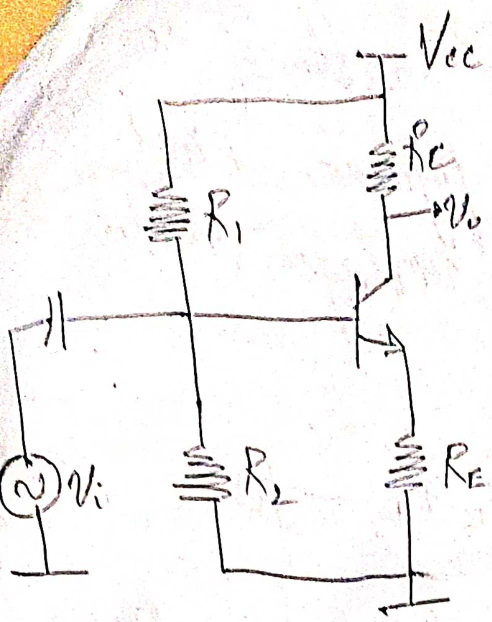
$$V_{TH} = I_{BQ} R_{TH} + V_{BE(on)} + I_{EQ} R_E$$

for the transistor in FAM.

$$I_{EQ} = (1+\beta) I_{BQ}$$

$$I_{BQ} = \frac{V_{TH} - V_{BE(on)}}{R_{TH} + (1+\beta) R_E}$$

$$I_{CQ} = \beta I_{BQ} = \frac{\beta (V_{TH} - V_{BE(on)})}{R_{TH} + (1+\beta) R_E}$$



$V_{CC} = 10V$; $V_{BE(on)} = 0.7V$

$\beta = 100$; $R_1 = 56k\Omega$;

$R_2 = 12.2k\Omega$; $R_C = 2k\Omega$; $R_E = 400\Omega$;

$R_{TH} = 10.0k\Omega$

$$V_{TH} = \frac{R_2 V_{CC}}{R_1 + R_2} = 1.79V$$

$$I_{BQ} = \frac{V_{TH} - V_{BE(on)}}{R_{TH} + (1+\beta)R_E} = \frac{1.79 - 0.7}{10 + (101)(0.4)} = 21.6\mu A$$

The collector current is

$$I_{CQ} = \beta I_{BQ} = 2.16 mA$$

$$I_{EQ} = 2.18 mA$$

$$V_{CEQ} = V_{CC} - I_{CQ} R_C - I_{EQ} R_E = 4.81 V.$$

β	50	100	150
I_{BQ}	$35.9\mu A$	$21.6\mu A$	$15.5\mu A$
I_{CQ}	1.80 mA	2.16 mA	2.32 mA
V_{CEQ}	5.67 V	4.81 V	4.4 V.

The load line and Q points are plotted. The variation in Q-points for this circuit configuration is to be compared with the values shown above.