Biasing of Transistors

Previously, we have learnt how does the transistor circuit can be made to work as an amplifier. It may CB, CE & CC configuration.

Now, we will learn the techniques to connect the dc power supplies to the transistor.

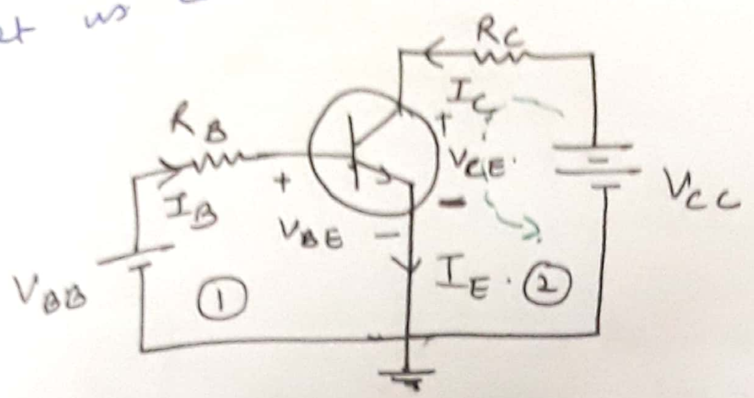
What is the meaning of dc biasing of transistor?

We know that a transistor can operate in any of the three regions of operations namely cutoff, active region and saturation.
In order to do so, we need to connect external dc power supplies with correct polarities and magnitudes. This process is called as dc biasing of a transistor.

* To understand the need of biasing, we should first know the dc load line analysis and the operating point (Q).

DC load line.

Let us consider the circuit as shown below:-



if we apply KVL in loop (2), we get.

$$V_{CC} - I_C R_C - V_{CE} = 0.$$

or $$\boxed{I_C = -\frac{1}{R_C} V_{CE} + \frac{V_{CC}}{RC}} \quad \text{---} (1)$$

If we compare it with $y = mx + c$.

Then the equation (1) is similar to a line equation whose slope $\left(m = -\frac{1}{RC}\right)$ is dependent on R_C (the load connected at o/p). Thus the eq^n (1) is known as dc load line equation.

How to plot the dc load line at the o/p characteristics of the transistor.

We have $$I_C = -\frac{1}{R_C} V_{CE} + \frac{V_{CC}}{RC}$$

Put (1) $I_C = 0$.

$$\Rightarrow V_{CE} = \frac{V_{CC}}{\cancel{R_C}}. \quad \text{(point on x-axis)}$$

(2) $V_{CE} = 0$.

$$I_C = \frac{V_{CC}}{RC} \quad \text{(point on y-axis)}.$$

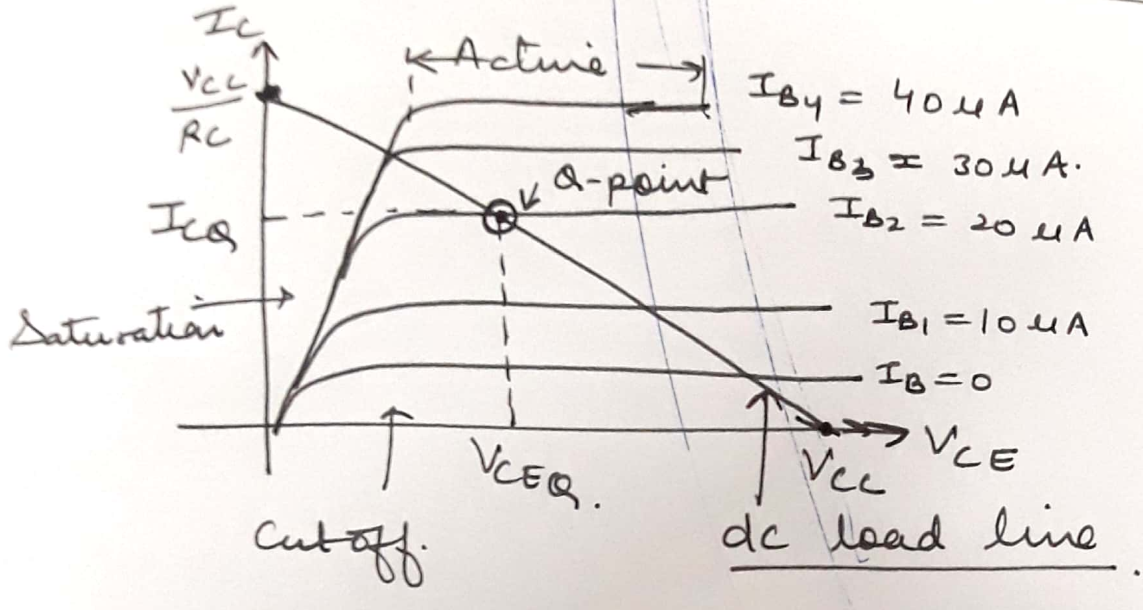


figure (1)

figure ① represents the plotting of DC load line equation at the output curve.
The point at which the DC load line intersect the o/p curve corresponding to value of I_B (obtained by applying KVL at loop ① of the circuit) is called the operating point or Q point.

* The Q point is known as quiescent or inactive point which remains constant known as operating point.
* We can say, the operating point are the values of the o/p of a transistor when only dc signals are applied to the ckt (ac signals are zero)

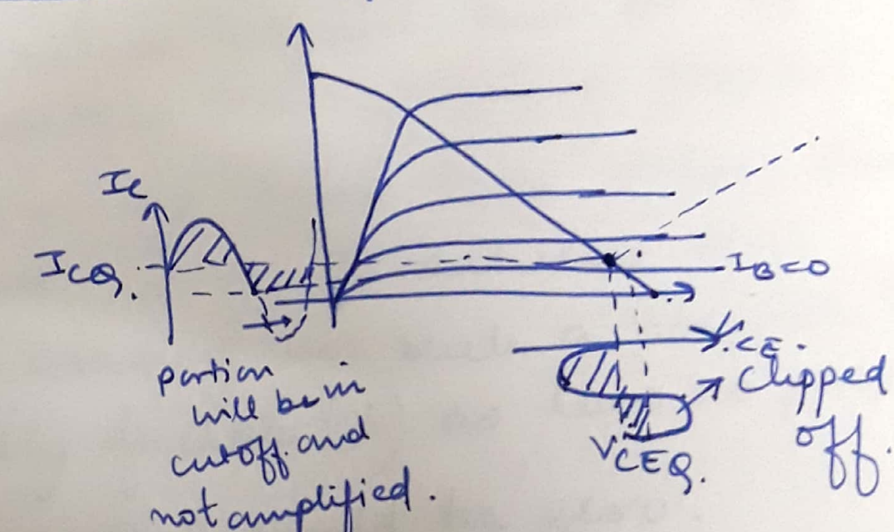
Need of Transistor Biasing.

① Since the transistor has different application therefore, it should be bias in order to perform the required task. i.e it should be in active region, then for acting as an amplifier, in saturation region to work as 'ON' switch and in cut-off region to work as 'OFF' switch.

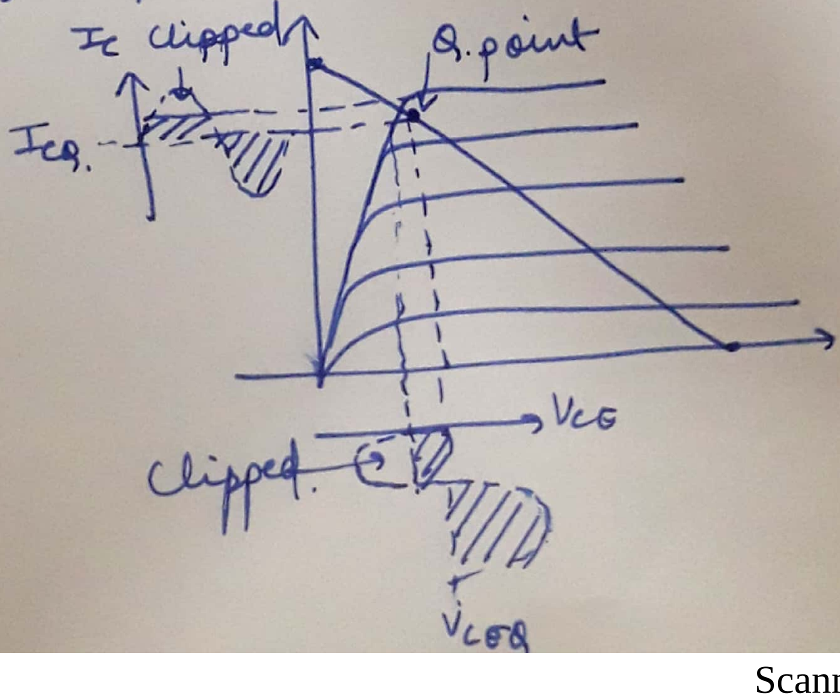
② To work as an amplifier, the operating point (Q) should be adjusted approximately at the center of the load line.

Effect of Q-point close to cut-off.

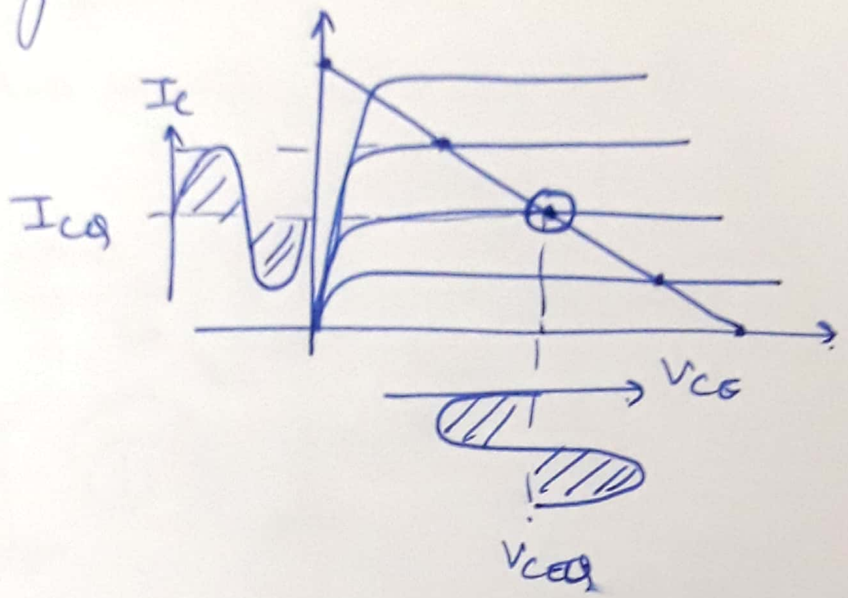
Some of the ac signal will come in cut-off region and hence cannot be amplified.



Effect of Q-point close to saturation



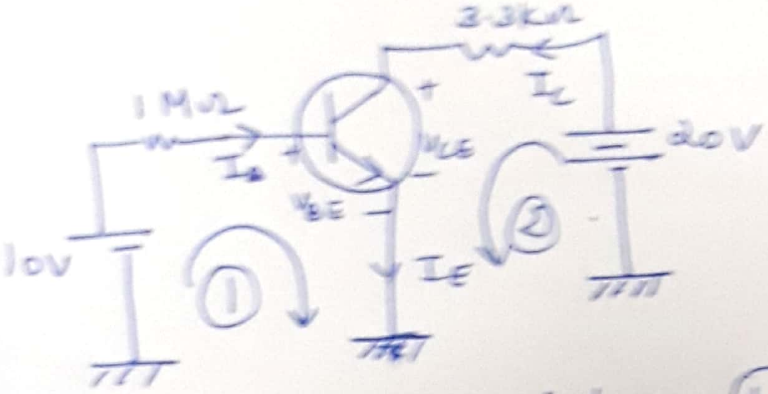
Effect of Q-point in the middle of active region



whole signal will be amplified

3) Since, we have bias the circuit in a manner to get operating point in the middle of the active region, But it is necessary to maintain the operating point at that level i.e the I_{CQ} & V_{CEQ} values should remain constant. Thus, to achieve this we make the biasing in such a manner to get the stability factor (S) as low as possible. The ideal value of S should be zero.

Numerical :- find out the Q point of the following ckt and also draw the load line and locate the Q-point. ($\beta = 100$)



applying KVL in loop ①

$$10 - 1\times10^{3}\, I_B - 0.7 = 0.$$

$$I_B = \frac{10-0.7}{10^{3}} = 9.3\ \mu A$$

applying KVL in loop ②.

$$20 - 3.3 I_C - V_{CE} = 0.$$

where $I_C = \beta I_B = 100 \times 9.3 = .93\ mA$

$\Rightarrow$ $V_{CE} = 20 - 3.3 \times .93$

$\approx 17V.$

$\Rightarrow$ $I_{CQ} = .93\ mA$

and $V_{CEQ} = 17\ V.$