

Lecture 20

BJT

TRANSISTOR BIASING
&
STABILIZATION

Transistor Biasing

The basic function of transistor is amplification. The process of raising the strength of weak signal without any change in its general shape is referred as faithful amplification. For faithful amplification it is essential that:-

1. Emitter-Base junction is forward biased
2. Collector- Base junction is reversed biased
3. Proper zero signal collector current

The proper flow of zero signal collector current and the maintenance of proper collector emitter voltage during the passage of signal is called transistor biasing.

WHY BIASING?

If the transistor is not biased properly, it would work inefficiently and produce distortion in output signal.

HOW A TRANSISTOR CAN BE BIASED?

A transistor is biased either with the help of battery or associating a circuit with the transistor. The later method is more efficient and is frequently used. The circuit used for transistor biasing is called the biasing circuit.

BIAS STABILITY

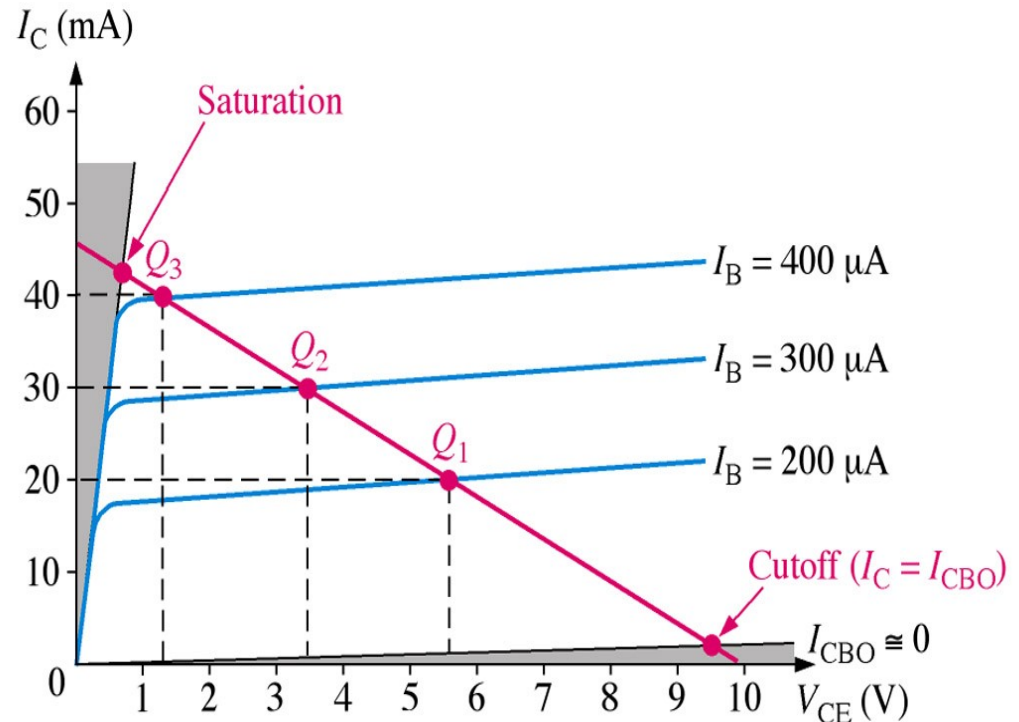
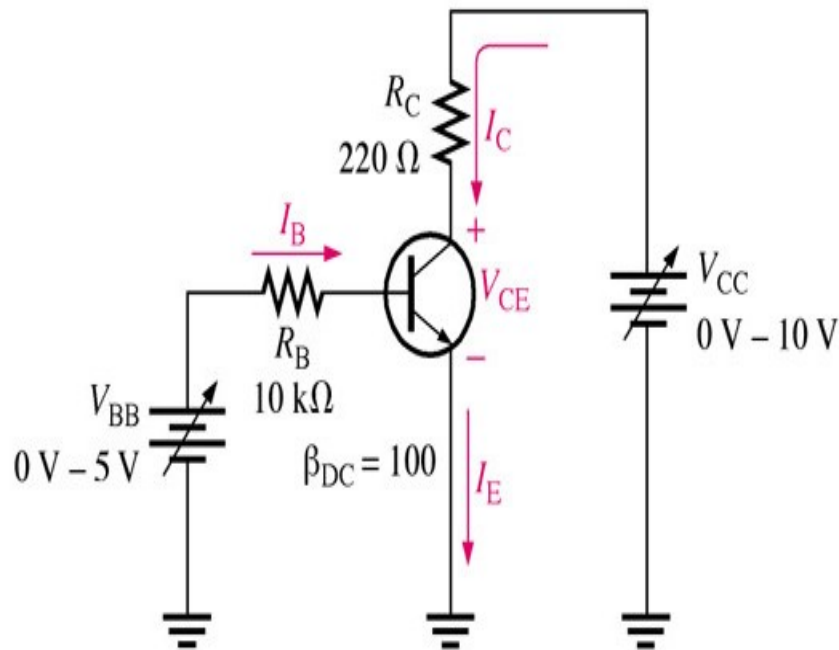
- ❖ Through proper biasing, a desired quiescent operating point of the transistor amplifier in the active region (linear region) of the characteristics is obtained. It is desired that once selected the operating point should remain stable. The maintenance of operating point stable is called Stabilisation.

- ❖ The selection of a proper quiescent point generally depends on the following factors:
 - (a) The amplitude of the signal to be handled by the amplifier and distortion level in signal
 - (b) The load to which the amplifier is to work for a corresponding supply voltage

- ❖ The operating point of a transistor amplifier shifts mainly with changes in temperature, since the transistor parameters — β , I_{CO} and V_{BE} (*where the symbols carry their usual meaning*)—are functions of temperature.

The DC Operating Point

For a transistor circuit to amplify it must be properly biased with dc voltages. The dc operating point between saturation and cutoff is called the **Q-point**. The goal is to set the Q-point such that that it does not go into saturation or cutoff when an ac signal is applied.



(a) DC biased circuit

Requirements of biasing network

- Ensuring proper zero signal collector current.
- Ensuring V_{CE} not falling below 0.5V for Ge transistor and 1V for Silicon transistor at any instant.
- Ensuring Stabilization of operating point. (zero signal I_c and V_{CE})

The Thermal Stability of Operating Point ($S_{I_{CO}}$)

❖ **Stability Factor S:** - The stability factor S , as the change of collector current with respect to the reverse saturation current, keeping β and V_{BE} constant. This can be written as:

The Thermal Stability Factor : $S_{I_{CO}}$

$$S_{I_{CO}} = \left. \frac{\partial I_C}{\partial I_{CO}} \right|_{V_{BE}, \beta}$$

This equation signifies that I_C Changes $S_{I_{CO}}$ times as fast as I_{CO}

Differentiating the equation of Collector Current $I_C = (1+\beta)I_{CO} + \beta I_B$ & rearranging the terms we can write

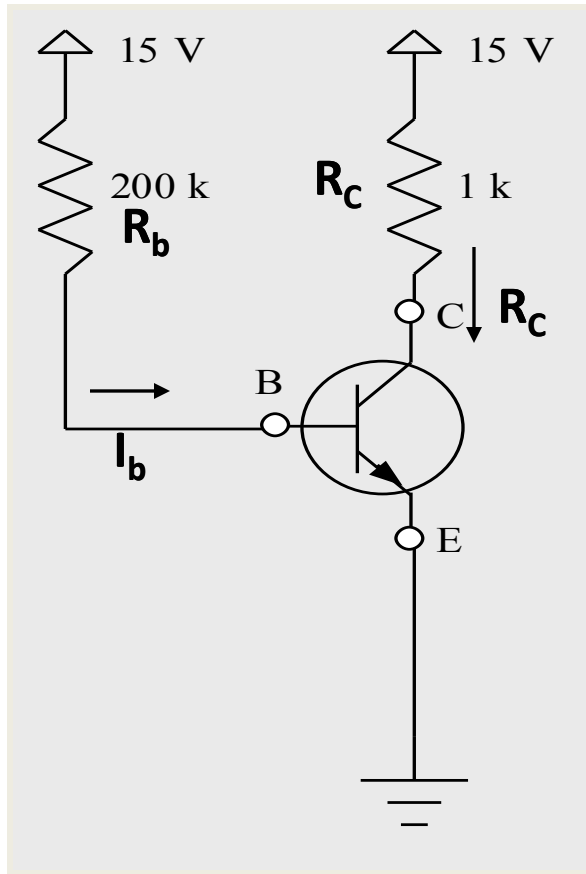
$$S_{I_{CO}} = \frac{1+\beta}{1 - \beta (\partial I_B / \partial I_C)}$$

It may be noted that Lower is the value of $S_{I_{CO}}$ better is the stability

Various Biasing Circuits

- **Fixed Bias Circuit**
- **Fixed Bias with Emitter Resistor**
- **Collector to Base Bias Circuit**
- **Potential Divider Bias Circuit**

The Fixed Bias Circuit



The Thermal Stability Factor : $S_{I_{CO}}$

$$S_{I_{CO}} = \left. \frac{\partial I_C}{\partial I_{CO}} \right|_{V_{be}, \beta}$$

General Equation of $S_{I_{CO}}$ Comes out to be

$$S_{I_{CO}} = \frac{1 + \beta}{1 - \beta (\partial I_b / \partial I_C)}$$

Applying KVL through Base Circuit we can write, $I_b R_b + V_{be} = V_{CC}$

Diff w. r. t. I_C , we get $(\partial I_b / \partial I_C) = 0$

$S_{I_{CO}} = (1 + \beta)$ is very large
Indicating high un-stability

Merits:

- It is simple to shift the operating point anywhere in the active region by merely changing the base resistor (R_B).
- A very small number of components are required.

Demerits:

- The collector current does not remain constant with variation in temperature or power supply voltage. Therefore the operating point is unstable.
- When the transistor is replaced with another one, considerable change in the value of β can be expected. Due to this change the operating point will shift.
- For small-signal transistors (e.g., not power transistors) with relatively high values of β (i.e., between 100 and 200), this configuration will be prone to thermal runaway. In particular, the stability factor, which is a measure of the change in collector current with changes in reverse saturation current, is approximately $\beta+1$. To ensure absolute stability of the amplifier, a stability factor of less than 25 is preferred, and so small-signal transistors have large stability factors.