Bipolar Junction Transistors (BJTs) and Circuits

Common-Base (CB) Configuration:

The common-base configuration with npn and pnp transistors are indicated in Fig. 8-3. The common-base terminology is derived from the fact that the base is common to both input and output sides of the configuration. In addition, the base is usually terminal at, the ground potential.

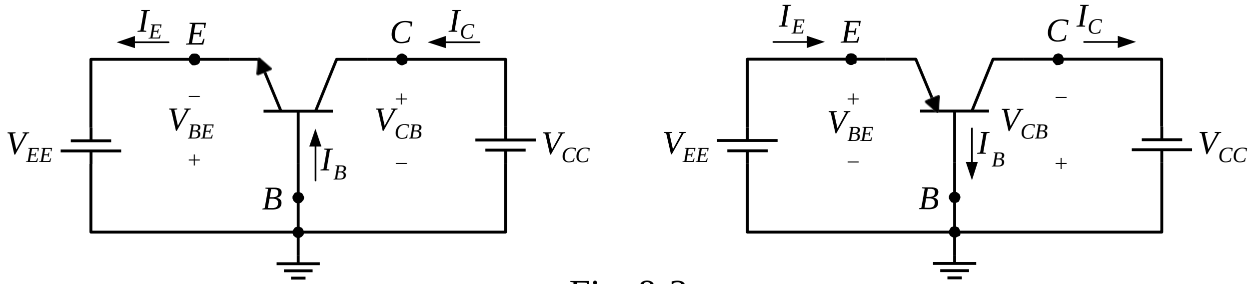

Fig. 8-3

In the dc mode the levels of I_C and I_E due to the majority carriers are related by a quantity called ***alpha*** (α_{dc}) and defined by the following equation:

$$\alpha_{dc} = \frac{I_C}{I_E} \qquad [8.3]$$

Where I_C and I_E are the levels of current at the point of operation and $\alpha_{dc} \approx 1$, or for practical devices: $0.900 \le \alpha_{dc} \le 0.998$.
Since alpha is defined for the majority carriers and from Fig. 8-4, Eq. [8.2] becomes

$$I_C = \alpha I_E + I_{CBO} \qquad [8.4]$$

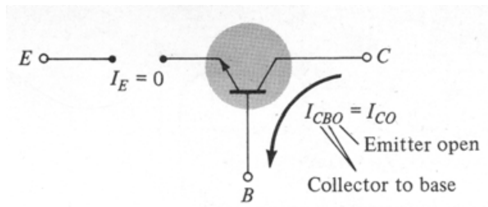

Fig. 8-4

The input (emitter) characteristics for a CB configuration are a plot of the emitter (input) current (I_E) versus the base-to-emitter (input) voltage (V_{BE}) for a rage of values of the collector- to-base (output) voltage (V_{CB}) as shown in Fig. 8-5. Since, the exact shape of this I_E-V_{BE} carve will depend on the reverse-biasing output voltage, V_{CB}. The reason for this dependency is that the grater the value of V_{CB}, the more readily minority carriers in the base are swept through the C-B junction. The increase in emitter-to-collector current resulting from an increase in V_{CB} means the emitter current will be greater for a given value of base-to-emitter voltage (V_{BE}).

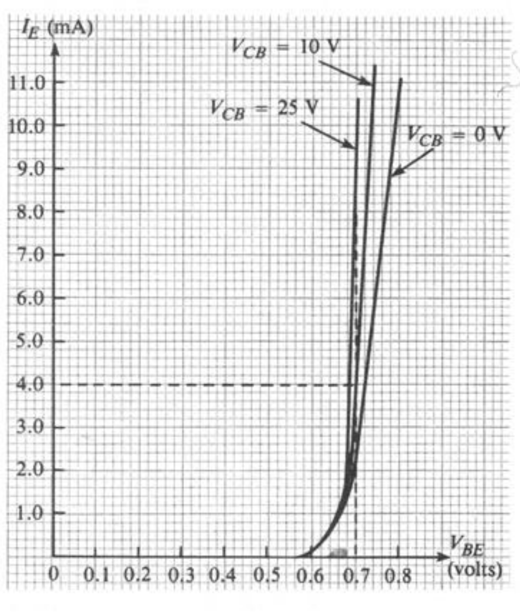

Fig. 8-5

The output (collector) characteristics for CB configuration will be a plot of the collector (output) current (I_C) versus collector-to-base (output) voltage (V_{CB}) for a range of values of emitter (input) current (I_E) as shown in Fig. 8-6. The collector characteristics have three basic region of interest, as indicated in Fig. 8-6, the active, cutoff, and saturation regions.

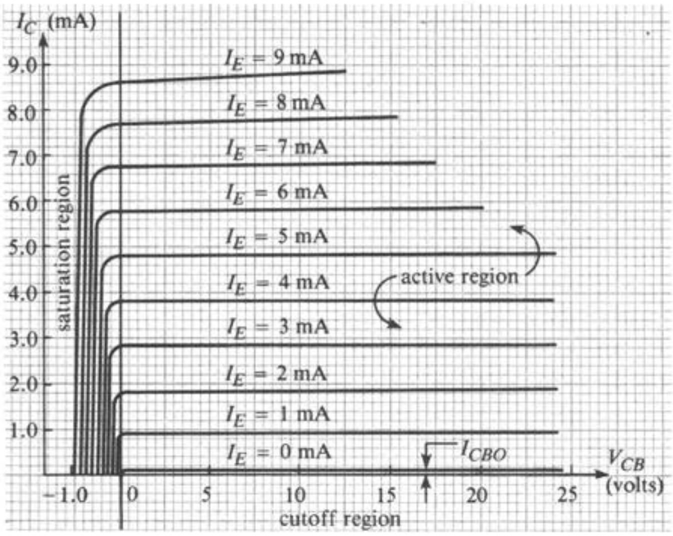

Fig. 8-6

Active region:

$V_{CB} > 0$ and $I_C = \alpha I_E$.

Cutoff region:

$I_E = 0$ and $I_C = I_{CBO}$.

Saturation region:

$V_{CB} < 0$ and $I_{C\,(sat.)} \approx I_{E\,(sat.)}$.

For ac situations where the point of operation moves on the characteristic carve, an ac alpha (α_{ac}) is defined by

$$\alpha_{ac} = \left.\frac{\Delta I_C}{\Delta I_E}\right|_{V_{CB}=const.} \qquad [8.5]$$

The ac alpha is formally called the ***common-base***, ***short-circuit***, ***amplification factor***, and for most situations the magnitudes of α_{ac} and α_{dc} are quite close, permitting the use of the magnitude of one for other.

Fig. 8-7 shows how the common-base output characteristics appear when the effects of breakdown are included. Note the sudden upward swing of each curve at a large value of V_{CB}.

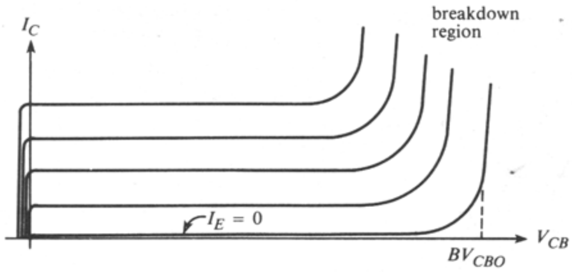

Fig. 8-7

Transistor Amplification Action:

The basic voltage-amplifying action of the CB configuration can now be described using the circuit of Fig. 8-8. The dc biasing does not appear in the figure since our interest will be limited to the ac response. For the CB configuration, the input resistance between the emitter and the base of a transistor will typically vary from 10 to 100 Ω, while the output resistance may vary from 100 kΩ to 1 MΩ. The difference in resistance is due to the forward-biased junction at the input (base to emitter) and the reverse-biased junction at the output (base to collector). Using effective values and a common value of 20 Ω for the input resistance, we find that

$$I_i = V_i / R_i = 200mV / 20\Omega = 10mA .$$

If we assume for the moment that

$\alpha_{ac} = 1$ ($I_c = I_e$),

$$I_L = I_i = 10mA$$

and $V_L = I_L R_o = (10mA)(5k\Omega) = 50V$.

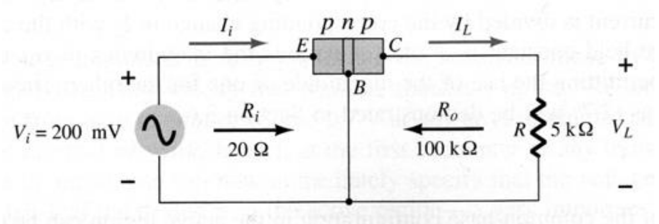

Fig. 8-8

The voltage amplification is

$$A_v = V_L / V_i = 50V / 200mV = 250 .$$

Typical values of voltage amplification for the common-base configuration vary from 50 to 300. The current amplification (I_C/I_E) is always less than 1 for the CB configuration. This latter characteristic should be obvious since $I_C = \alpha I_E$ and α is always less than 1.

The basic amplifying action was produced by ***transferring*** a current *I* from a low-to a high-***resistance*** circuit. The combination of the two terms in italics results in the label transistor; that is, ***transfer + resistor*** → ***transistor***.