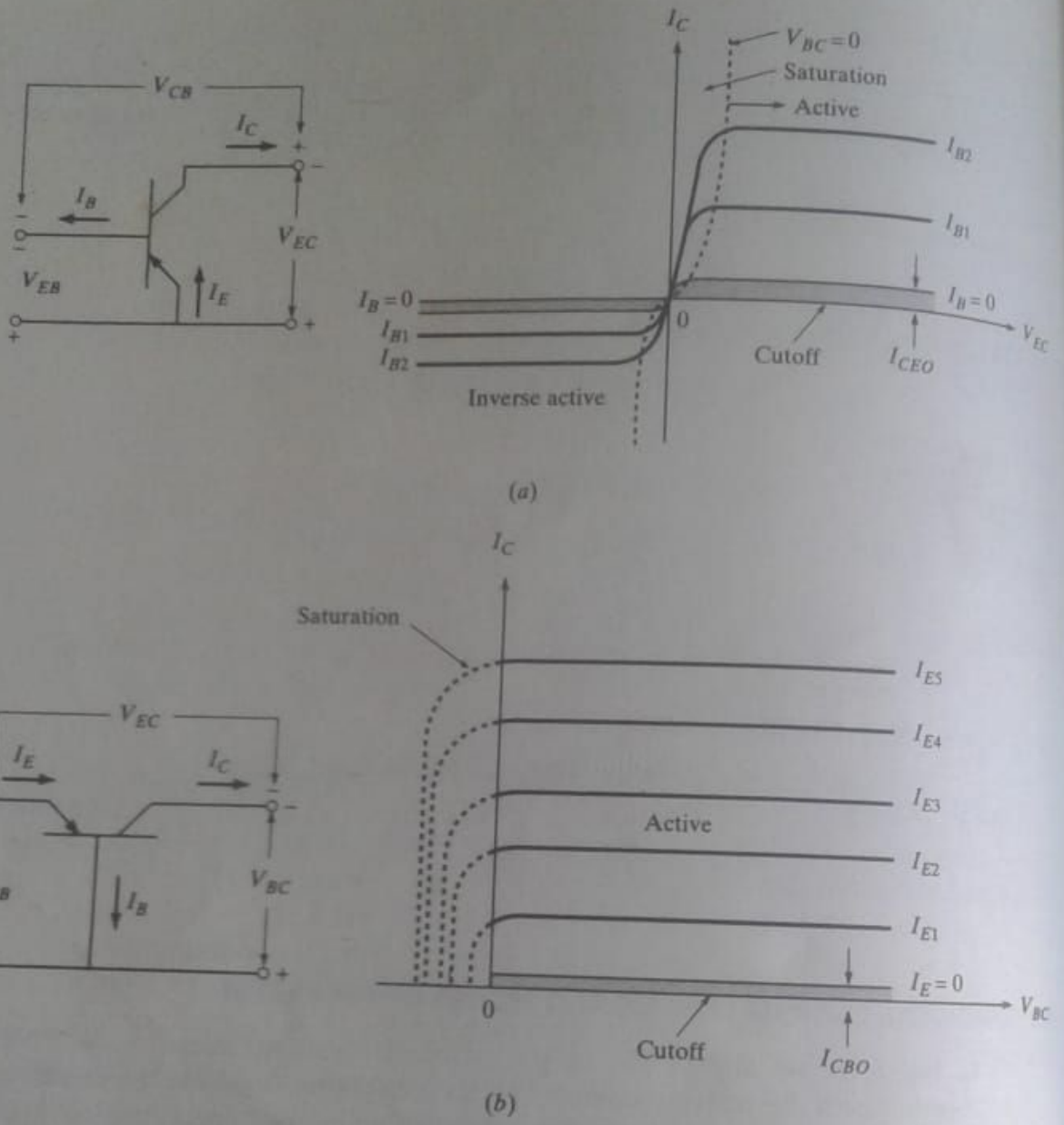

Figure 8.12 (a) Common-emitter circuit and output characteristics of the PNP transistor (b) Common-base circuit and output characteristics of the PNP transistor.

and which variables are the dependent and independent quantities, the I-V characteristics of the transistor are uniquely determined. Analogously, either connection of the BJT represents the I-V characteristics completely.

Modes of Operation

Both the CE and CB characteristics exhibit the three major modes of operation, namely: active, saturation, and cutoff. In certain switching circuits, the BJT in the CE connection is in the inverse active mode shown in the third quadrant of those characteristics of Fig. 8.12(a).

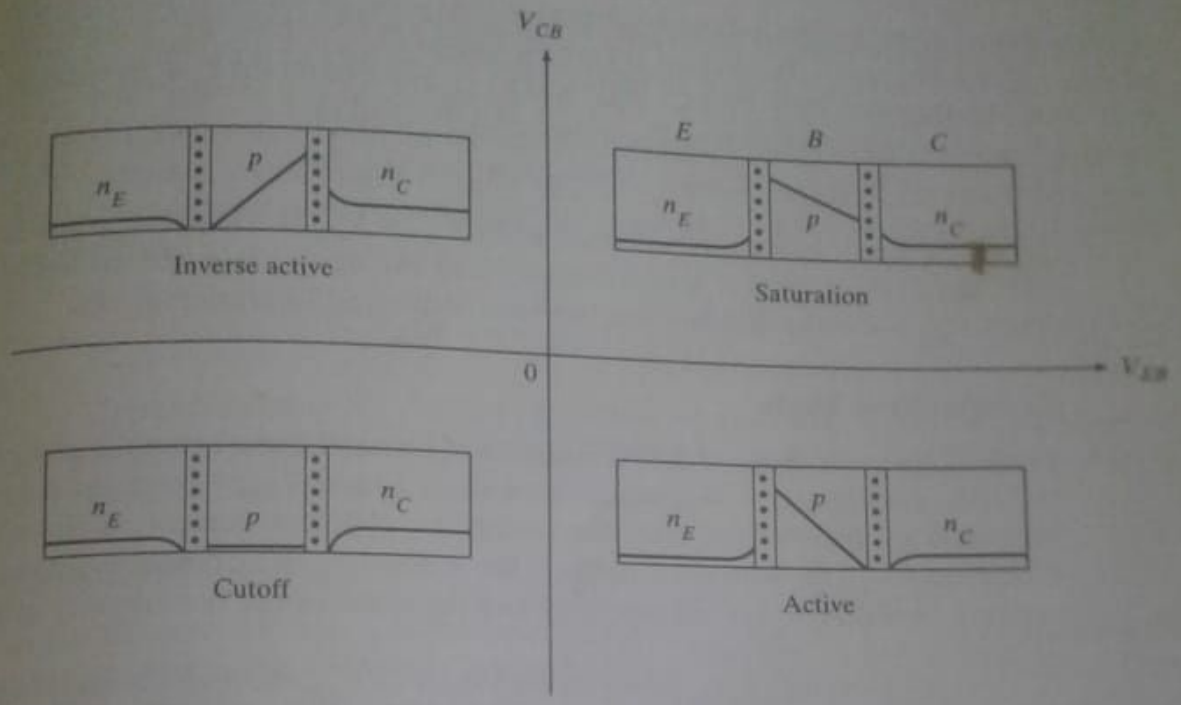

Figure 8.13 Distributions of minority carriers in the four operation modes of the PNP BJT.

In analyzing the diode currents in Chapter 6, we used the distribution of minority carriers in the P and N regions. In Fig. 8.13, we have displayed the distributions of minority carriers in each of the four operation modes of the BJT. These will be used in discussing the characteristics of the transistor. In sketching the minority carriers distributions, we have assumed that the width of the base is much smaller than the diffusion length of holes in the base and that the widths of the emitter and collector regions are much greater than the diffusion length of electrons. Just as with the diode, the values of the minority carriers densities at the junctions are given by

$$\begin{aligned} &\text{In the base at } x = 0, p(0) = p_0 \exp(qV_{EB}/kT) \quad \text{(a)} \\ &\text{In the base at } x = W_B, p(W_B) = p_0 \exp(qV_{CB}/kT) \quad \text{(b)} \end{aligned} \tag{8.19}$$

$$\begin{aligned} &\text{In the emitter at } x' = 0, n_E(0) = n_{OE} \exp(qV_{EB}/kT) \quad \text{(a)} \\ &\text{In the collector at } x'' = 0, n_C(0) = n_{OC} \exp(qV_{CB}/kT) \quad \text{(b)} \end{aligned} \tag{8.20}$$

Based on the above, we can determine expressions for the various currents by assuming that the BJT currents may be obtained from the diffusion of the minority carriers.

CE Active Mode

With I_B fixed, V_{EB} fixed, $p(0)$ fixed, and assuming that the distribution of hole density in the base is linear, as shown in Fig. 8.13, the hole current in the base is equal to the hole current in the collector (since there is no recombination in the base) and