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Active mode w/ BE junction forward-biased but BC junction reverse-biased

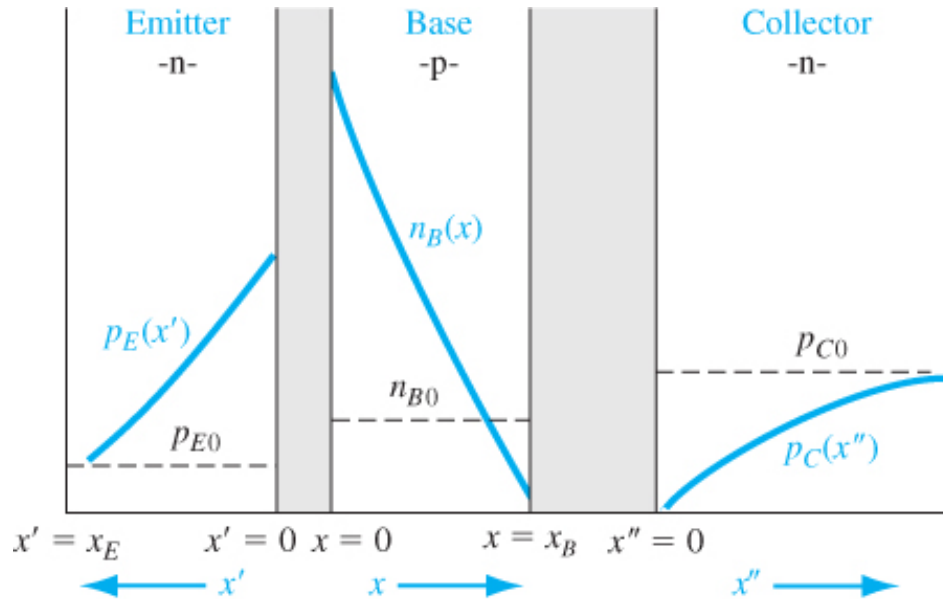


Figure 12.14 | Minority carrier distribution in an npn bipolar transistor operating in the forward-active mode.

Emitter-
$$\delta p_E(x') = \frac{p_{E0} \left[e^{V_{BE}/V_t} - 1 \right] \sinh\left(\frac{x_E - x'}{L_E}\right)}{\sinh(x_E/L_E)} \quad 0 \leq x' \leq x_E$$

where $p_E(x') = \delta p_E(x') + p_{E0} \quad 0 \leq x' \leq x_E$

Base-
$$\delta n_B(x) = \frac{n_{B0} \left[e^{V_{BE}/V_t} - 1 \right] \sinh\left(\frac{x_B - x}{L_B}\right)}{\sinh(x_B/L_B)}$$

$$\approx \frac{n_{B0}}{x_B} \left[\left(e^{V_{BE}/V_t} - 1 \right) (x_B - x) - x \right] \quad 0 \leq x \leq x_B$$

where $n_B(x) = \delta n_B(x) + n_{B0} \quad 0 \leq x \leq x_B$

Collector-
$$\delta p_C(x'') = -p_{C0} e^{-x''/L_C} \quad 0 \leq x'' \leq x_C$$

where $p_C(x'') = \delta p_C(x'') + p_{C0} \quad 0 \leq x'' \leq x_C$

Cutoff mode w/ both BE junction and BC junction reverse-biased

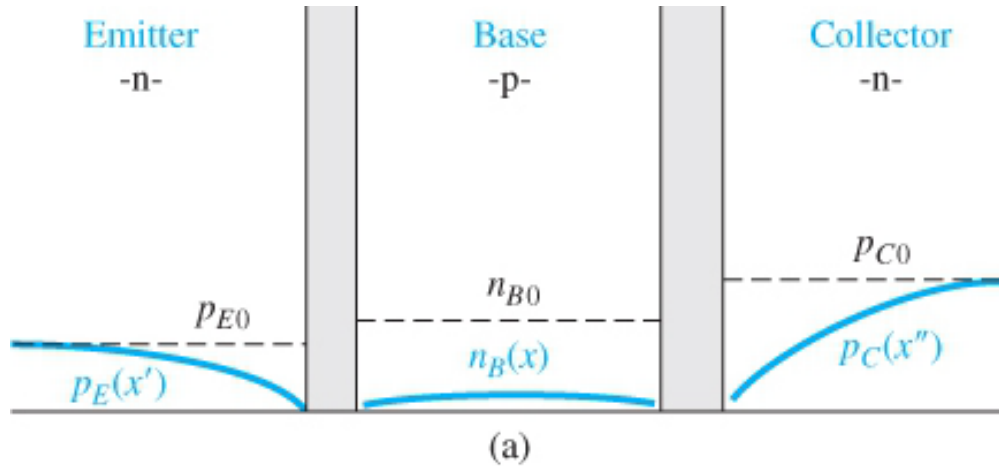


Figure 12.16 | Minority carrier distribution in an npn bipolar transistor operating in (a) cutoff

➤ Almost no minority carriers in the middle.

Saturation mode w/ both BE junction and BC junction forward-biased

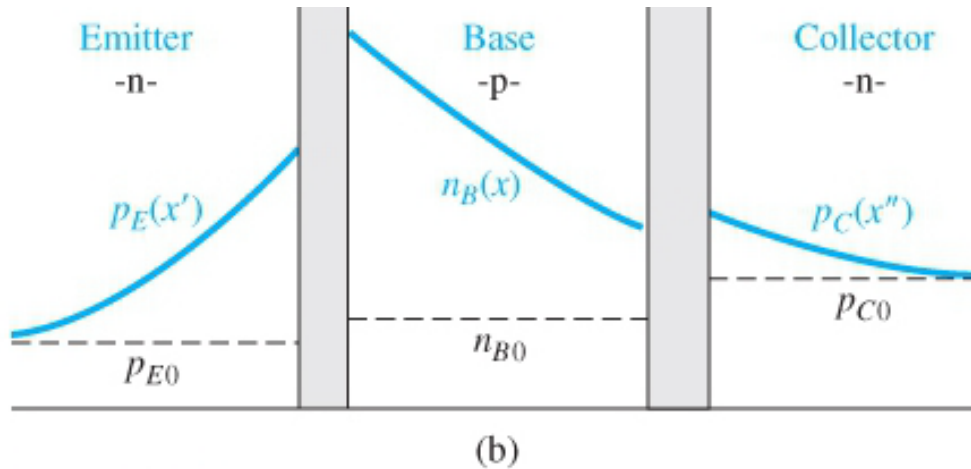


Figure 12.16 | Minority carrier distribution in an npn bipolar transistor operating in (b) saturation.

➤ Note that $p_C(x'')$ starts above p_{C0} and $n_B(x)$ does not decrease as quickly.