

ANALOG INTEGRATED CIRCUIT DESIGN



DAVID A. JOHNS
KEN MARTIN

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David Johns

Ken Martin

University of Toronto



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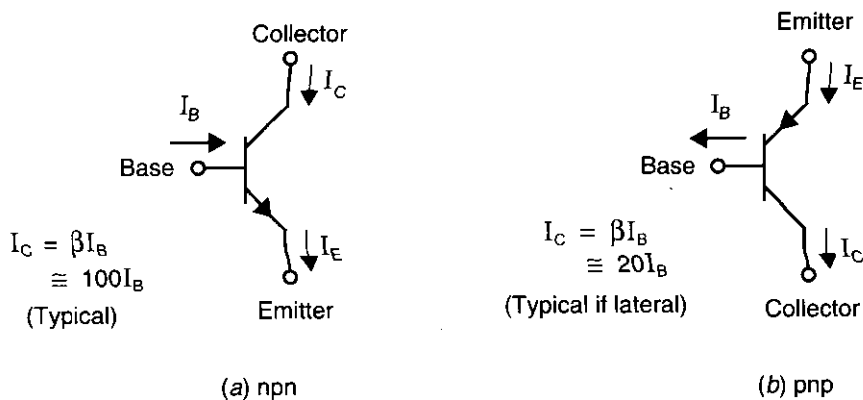


Fig. 1.27 The symbols representing (a) an npn bipolar-junction transistor and (b) a pnp bipolar-junction transistor.

region, W , is small (typically, less than $1\ \mu\text{m}$). Also, as we will see, the base must be more lightly doped than the emitter.

The circuit symbols used to represent npn and pnp transistors are shown in Fig. 1.27.

Basic Operation

To understand the operation of bipolar transistors, we consider here an npn transistor with the emitter connected to ground, as shown in Fig. 1.28. If the base voltage, V_B , is less than about 0.5 V , the transistor will be cut off, and no current will flow. We will see that when the base-emitter pn junction becomes forward biased, current will start to flow from the base to the emitter, but, partly because the base width is small, a much larger proportional current will flow from the collector to the emitter. Thus, the npn transistor can be considered a current amplifier at low frequencies. In other

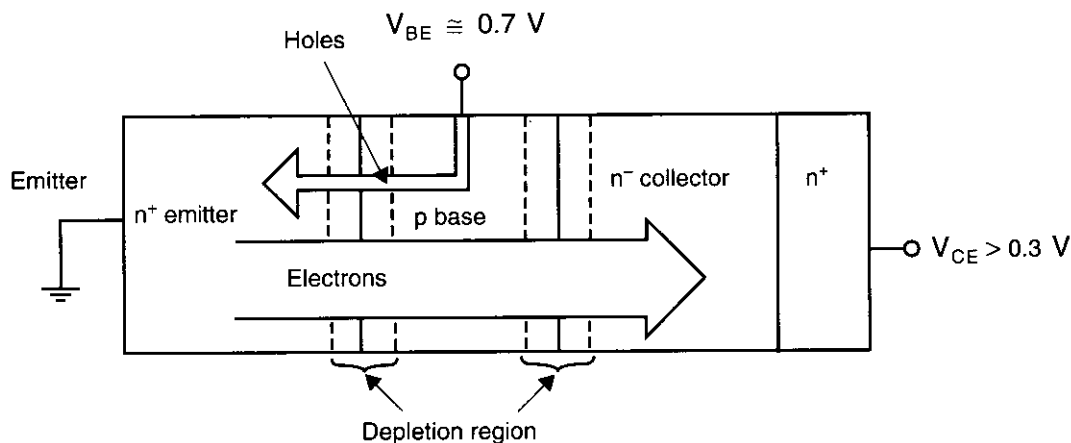


Fig. 1.28 Various components of the currents of an npn transistor.