

ECE 327: *Electronic Devices and Circuits Laboratory I*

Lab 1: The Bipolar (Junction) Transistor Quiz (10 points)

Description. This quiz tests your comprehension of what you've read on bipolar junction transistors (BJTs). This quiz is **closed-book** and **closed-notes**.

The following questions refer to Figure Q1-1, where (a) refers to Figure Q1-1(a) and (b) refers to Figure Q1-1(b).

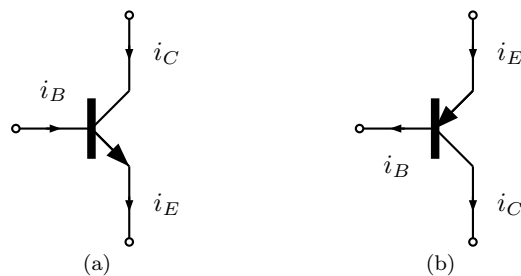


Figure Q1-1: BJT Transistors

Problem Q1-1: Transistor Terms

What do the current subscripts B , C , and E stand for? (3 points)

Solution

Base, Collector, and Emitter

Problem Q1-2: Transistor Types

Fill in the blanks with either (a) or (b). (1 point)

An *npn* transistor is depicted in (a).

A *pn*p transistor is depicted in (b).

Problem Q1-3: *npn* Charge Injection

Fill in the blanks. (1 point)

In active mode, the *emitter* in an *npn* transistor injects negative charge carriers (i.e., electrons) into the transistor, so it must be at a(n) lower potential than the other two pins of the transistor.

Problem Q1-4: *npn* Charge Injection

Fill in the blanks. (1 point)

In active mode, the *emitter* in a *npn* transistor injects positive charge carriers (i.e., “holes”) into the transistor, so it must be at a(n) higher potential than the other two pins of the transistor.

Problem Q1-5: Gain Expressions

Assume the transistors above are in *active* mode with current gain β . Express i_C and i_E in terms of β and i_B . (4 points)

Solution

By definition of a transistor’s current gain,

$$i_C = \beta i_B$$

and

$$\begin{aligned} i_E &= i_B + i_C \\ &= i_B + \beta i_B \\ &= (\beta + 1)i_B. \end{aligned}$$

Problem Q1-6: Limiting Ratio of Currents (BONUS)

Assume the transistors above are in *active* mode with current gain β . What is the value of [Equation \(Q1-6.1\)](#), and what does this mean about i_C and i_E when β is very large (i.e., $\beta \gg 1$)? (6 bonus points possible)

$$\lim_{\beta \rightarrow \infty} \frac{i_C}{i_E} \tag{Q1-6.1}$$

Solution

Using the values from [Problem Q1-5](#),

$$\begin{aligned} \lim_{\beta \rightarrow \infty} \frac{i_C}{i_E} &= \lim_{\beta \rightarrow \infty} \frac{i_B \beta}{i_B (\beta + 1)} \\ &= \lim_{\beta \rightarrow \infty} \frac{\beta}{\beta + 1} \\ &= 1. \end{aligned}$$

Therefore, $i_C \approx i_E$ when $\beta \gg 1$. In other words, we often assume that the collector and emitter currents are the same.

Problem Q1-7: Limit of a Current (BONUS)

Assume that the transistors above are in *active* mode with current gain β . Given a *fixed* current i_E , what is the value of [Equation \(Q1-7.1\)](#), and what does this mean about i_B when β is very large (i.e., $\beta \gg 1$)? (6 bonus points possible)

$$\lim_{\beta \rightarrow \infty} i_B \tag{Q1-7.1}$$

Solution

Using the values from [Problem Q1-5](#),

$$\begin{aligned}\lim_{\beta \rightarrow \infty} i_B &= \lim_{\beta \rightarrow \infty} \frac{i_E}{\beta + 1} \\ &= 0.\end{aligned}$$

Therefore, $i_B \approx 0$ when $\beta \gg 1$. In other words, we often assume that there is no current going into or out of the base of the transistor.