Name: Instructor Table number: Solution

ECE 327: *Electronic Devices and Circuits Laboratory I*

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

Description. *This quiz tests your comprehension of what you've read on bipolar junction transistors (BJTs). Complete this quiz with* ***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).

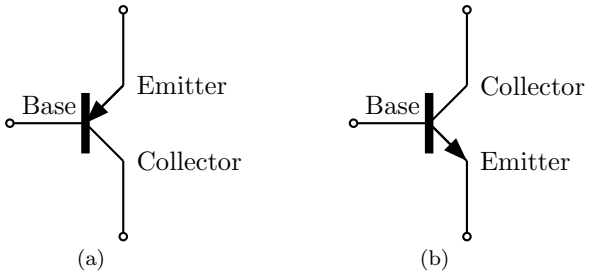

Figure Q1-1: BJT Transistors

Problem Q1-1: Transistor Types

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

An *npn* transistor is depicted in __(b)__. (emitter arrow is **n**ot **p**ointing i**n**)
A *pnp* transistor is depicted in __(a)__. (emitter arrow **p**oints i**n** **p**roudly)

Problem Q1-2: Transistor Labeling

2.1. Label the **base**, **collector**, and **emitter** terminals of Figure Q1-1(a). **(3 points)**

2.2. Label the **base**, **collector**, and **emitter** terminals of Figure Q1-1(b). **(3 points)**

2.3. The transistor symbol's arrow points in the direction of __current flow__. **(1 point)**

Solution

The correct labels are shown in Figure Q1-1.

- The **base** is usually considered to be the *input* or *control* of the transistor. It is depicted as the solid dark line perpendicular to its terminal.
- The **emitter** is labeled with an *arrow* that points in the direction of active-mode positive current flow. A *pnp* transistor emits *positive* charge carriers, or "holes," into its base. So the arrow on a *pnp* transistor points *into* the base. A *npn* transistor emits *negative* charge carriers, or "electrons," into the base. Positive current flow is opposite the direction of electron flow, and so the arrow on an *npn* transistor points *out of* the base.
- The *collector* collects any charge carriers that don't make it into the base, and so it is opposite the emitter.

Problem Q1-3: Transistor Gain

Assume the transistors above are in *active* mode with current gain β. Express collector current i_C in terms of β and base current i_B. **(2 points)**

Solution

By the Ebers–Moll model of a transistor,

$$\boxed{i_C = \beta i_B}$$

in active mode. The collector current i_C joins with the base current i_B to form the emitter current i_E, and so $i_C = i_C + i_B = (\beta + 1) i_B$ (in active mode).

Problem Q1-4: Limiting Ratio of Currents (BONUS)

Assume the transistors above are in *active* mode with current gain β. Call the collector current i_C and the emitter current i_E. The following questions refer to Equation (Q1-4.1).

$$\lim_{\beta \to \infty} \frac{i_C}{i_E} \tag{Q1-4.1}$$

4.1. What is the value of Equation (Q1-4.1)? **(3 bonus points possible)**

Solution

Using the values from Problem Q1-3,

$$\lim_{\beta \to \infty} \frac{i_C}{i_E} = \lim_{\beta \to \infty} \frac{i_B \beta}{i_B (\beta + 1)} = \lim_{\beta \to \infty} \frac{\beta}{\beta + 1} = \boxed{1.}$$

4.2. What does the answer to 4.1 mean about i_C and i_E in active mode when β is very large (i.e., $\beta \gg 1$)? **(3 bonus points possible)**

Solution

For $\beta \gg 1$, $i_C \approx i_E$. In other words, in active mode we often assume that the collector and emitter currents are the same (i.e., the base current i_B is negligibly small relative to i_C and i_E).

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