Prelab 3: Bipolar Junction Transistor Characterization

1. For the NPN device shown below in Figure 1, fill in $I_C$, $I_B$, and $I_E$ next to the current arrows.

![Figure 1: A simple NPN device for warming up](image)

2. What is $\beta$ in terms of $I_C$ and $I_B$? What is $\alpha$ in terms of $I_C$ and $I_E$? Express $\alpha$ in terms of $\beta$.

$$\beta(I_C, I_B) =$$

$$\alpha(I_C, I_E) =$$

$$\alpha(\beta) =$$

3. SPICE

![Figure 2: Circuit to simulate in SPICE](image)

- Write a SPICE netlist for the BJT test circuit shown in Figure 2. Refer to the HSPICE Tutorial if you have trouble with SPICE.
- Use the 2N4401 SPICE model provided on the course website.
• Using the .dc command, sweep $V_{CC}$ from 0 V to 5 V in 0.01 V increments and step $V_{BB}$ from 0.6 V to 0.7 V in 0.025 V increments.

• Run the simulation and check the output file for any errors.

• If there are no errors, plot $I_{CC}$ versus $V_{CC}$ and print out a copy of the plot. Note: If you notice that $I_{CC}$ is negative, use Awaves to plot the absolute value of $I_{CC}$. $I_{CC}$ appears to be negative because SPICE defines $I_{CC}$ to be going out of the BJT.

4. The configuration shown below in Figure 3 is known as the Darlington pair. Assume $Q_1$ has a DC current gain of $\beta_1$ and $Q_2$ has a DC current gain of $\beta_2$. Derive the overall current gain, $\beta_{tot} = I_{C2}/I_{B1}$, as a function of $\beta_1$ and $\beta_2$. Do not neglect any currents.

$\beta_{tot} =$

![Figure 3: Darlington configuration](image-url)