Lab 4: Bipolar Junction Transistors (BJTs)

4.0 Objectives

By completing the research, design, and experimental requirements of this lab, the student should be able to:

a. Determine the iv-characteristics of a BJT
b. Extract BJT model parameters from iv measurements
c. Compare the behavior of base bias and voltage divider bias circuits for BJTs.

4.1 Prelab

0. No prelab required

4.2 Components

Analog Discovery 2 module
Resistors: different values as needed.
Transistors: 2N3904, 2N3906

4.3 Task 1: Output characteristics

1. Use a similar procedure to the one used in Lab 3 to obtain the output characteristics of the 2N3904. You will need to choose your voltage step levels to ensure that the graph with i_B = 0 is included in your plot.
2. From this plot, estimate $V_{CE(\text{sat})}$ for the BJT.
3. Replace the 2N3904 (NPN) with the 2N3906 (PNP) while maintaining pin connectivity. I.e. connect the emitter of the PNP to the same node where you had the emitter of the NPN, and similarly for the base and collector. Reverse the sign of the dc offsets on all sources and displays. The resulting characteristics should look identical in shape to what you observed for the NPN. This demonstrates that the only difference between an NPN and a PNP is the polarity of the voltages and currents.

Recall that the output characteristics is the plot of i_C vs. v_{CE} for different values of i_B.

4.4 Task 2: Transfer characteristics

4. Use a similar process to what you used in Lab 3 to generate the transfer characteristics of the 2N3904 (NPN), for v_{CE} = 5V.
5. From the graph, estimate the value of $V_{BE(\text{ON})}$.
6. Export the data you obtained.
7. Using Excel, or any other data analysis software, plot ln(I_C) and ln(I_B) on the same graph, with v_{BE} on the x-axis. To calculate I_B, use your estimate of $V_{BE(\text{ON})}$. From the graph, estimate the value of β.

Recall that the transfer characteristics is the plot of i_C vs. v_{BE} for different values of v_{CE}.

4.5 Task 3: Base bias circuit

8. Build the circuit in Figure 4.1. Select values for R_1 & R_2 so that if β = 200 you get I_C = 1.5 mA and V_{CE} = 2V. Use the V+ from the AD2 to set V_{DD} = 5V. Use the V- to set $-V_{SS}$ = −1.5V. You may not have the exact resistor values needed. Use the closest values.
9. Run the supplies and use the voltmeter to measure V_B and V_C. Calculate I_B and I_C.
10. From your calculations estimate β.

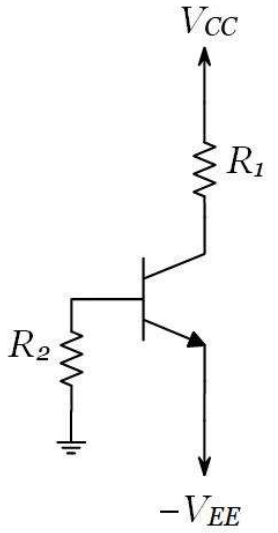

Figure 4.1. Base bias.

11. Switch the BJT to another NPN from your component kit. Repeat steps 8 – 10.

4.6 Task 4: Voltage divider bias

12. Construct the circuit in Figure 4.2. Use the V+ from the AD2 to set V_{DD} = 5V. Use the V- to set $-V_{SS}$ = −5V. Use R_1 = R_2 = 10kΩ and R_3 = R_4 = 1kΩ. Repeat steps 9 – 11.

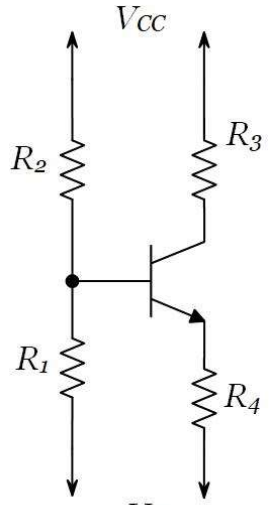

Figure 4.2. Voltage divider bias.