ECE 206 BJT Amplifiers

Challenge: BJT Amplifiers

In ECE 205, you were introduced to BJT theory. Now, you will use the BJT circuit (Figure 1) as a current amplifier to power the DC motor.

Our motivation is to study the characteristics of BJT and use BJT as a switch to turn on/off the DC motor with the help of the STEMTera.

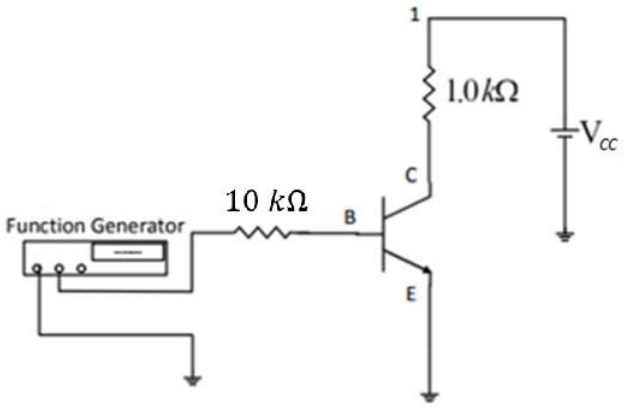

Figure 1. Circuit for obtaining I_C v/s V_{BE} Characteristics.

The lab has 2 parts:

- Collecting data (V_{BE},V_{CE}, I_B,I_C) to produce the circuit's IV characteristic for your 2N3904 transistor (see Figure 2).
- Using the BJT amplifier to boost the STEMTera output current to drive your DC motor with the circuit that is shown in Figure 3. You can set the output voltage of pin 9 as HIGH.

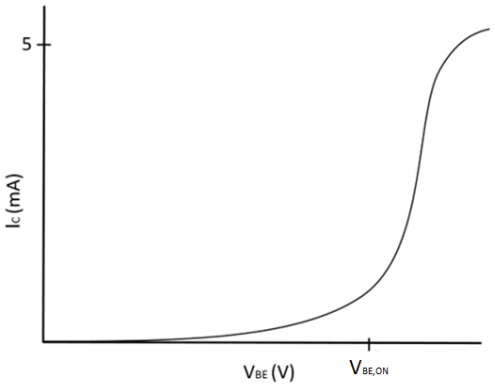

Figure 2. BJT IV Characteristic V_{BE} vs. I_C

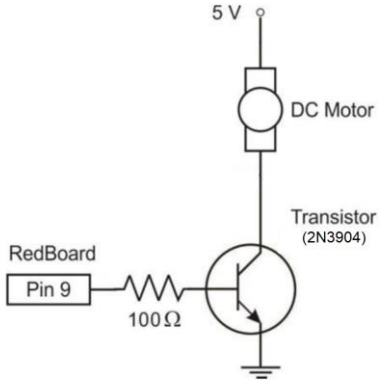

Figure3. Circuit for spinning the motor

Prelab: (in Compass, to be submitted during lab)

- Suppose you had the above curve (Figure 2) along with the known circuit test setup (Figure 1). How would you estimate from the graph BJT parameters: V_{CESat} , and β?
- For example: for V_{BEon} (which is marked and provided as an example), you can say ***that V_{BEOn} is the point on the x-axis (V_{BE}) where I_C starts to increase.***

Challenges:

You will need LTSpice software to design and simulate the BJT circuit in Figure 1. A basic LTSpice tutorial is provided in the website. For the circuit design, use a voltage source instead of a function generator with the following parameters: function = SINE, DC offset = 0.5 V, Amplitude = 1 V, and Freq = 1 Hz. You can find a BJT component by searching 'npn' from 'Select Component Symbol'. Once you create a BJT, right click →'Pick new transistor' → '2N3904'. Also set V_{cc} = 9 V and label a node B as 'V_{be}'.

After you finish the circuit design, go to 'Simulate' → 'Edit Simulation Cmd'. Next, select 'Transient' tab and make Stop time = 10, and Time to start saving data = 0. Right click on the horizontal axis and set Quantity Plotted as 'V(Vbe)'. Finally, right click on the center screen → 'Add traces' → I(R2). You should now see an IV curve like the one in Figure 2. Record $V_{BE,ON}$, the threshold at which I_c starts increasing.

Find an amplification factor (β) of the BJT by changing an AC voltage source to DC voltage source at $V_{BE,ON.}$ Now, select 'Edit Simulation Cmd' → 'DC op pnt', which displays current values for I_c and I_b. The amplification factor is then I_c/I_B.

The second part of the lab is to turn on the DC motor by supplying a small current at the base of the BJT. You will build a motor circuit as shown in Figure 3 on STEMTera. Set a pin to output a logic 1, like what you did for the LEDs. Make sure that you can control the motor from the STEMTera board.

In summary,

- Plot IV characteristic as shown in Figure 2. Determine $V_{BE,ON.}$
- Find β (I_c/I_B) when $V_{BE} = V_{BE,ON}$
- Estimate the BJT transistor's parasitic power when running the motor. You can assume the motor to be 30 Ohms, and the transistor to be in saturation.

Report Deliverables:

- Provide descriptions with accompanying diagrams of your circuits and experimental setup; include an annotated schematic of your experimental setups by using Fritzing.
- Include IV characteristic plot and describe how you can use this behavior to make BJT circuit as a switch.
- Report the motor power requirement and amplifier power dissipation.
    - What impact would the amplifier's power loss have on your motor's performance?

References:

- Chapter 16, Digital Voltmeter (DVM), Keysight InfiniiVision 3000 X-Series Oscilloscope User's Guide, 75019-97073, April 2013. http://literature.cdn.keysight.com/litweb/pdf/75019-97073.pdf
- ECE 205 Lecture notes, lessons 25-27.
- ECE 110 common emitter BJT circuit, https://courses.engr.illinois.edu/ece110/su2017/content/courseNotes/files/?commonEmitterBJTCircuit