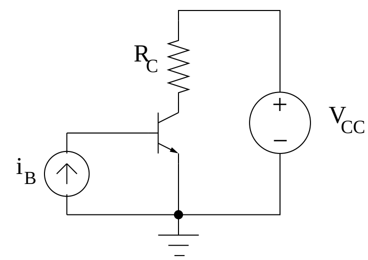
University of California, San Diego
Department of Electrical and Computer Engineering

ECE65, Winter 2012

Lab 4: BJT as a Switch

Experiment 1: PSpice simulation of BJT $i-v$ Characteristics

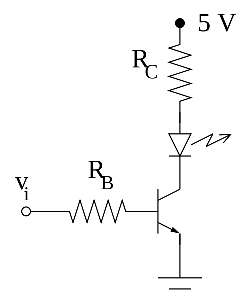
Simulation: Simulate the circuit with a 2N3904 BJT and $R_C = 400\ \Omega$. Do a "parametric sweep" of the DC voltage source V_{CC} with V_{CC} ranging from 0 to 30 V (use 0.1 V intervals). Do a "secondary parametric sweep" on the current source with values of $i_B = 0, 50, 100, 150, 200,$ and 250 μA. Plot i_C vs v_{CE} (v_{CE} being the X axis). Set the X axis to show only values from 0 to 10 V (by default it will show up to 30 V). Label each curve with its i_B value. Print out a copy for use in your Experiment. You may want to keep an electronic copy of this plot for use in later labs.



Experiment 2: BJT Switch

Consider the circuit below with a 2N3904 Si BJT transistor, a 351-3230-RC LED, $R_C = 270\ \Omega$ and $R_B = 20$ kΩ. For this diode, $V_\gamma = 1.7$ V. Asuume BJT $\beta = 200$ for calculations.

Circuit Analysis:



1) Using BJT large-signal model, compute the state of transistor, i_B, i_C, v_{CE}, and v_{BE} for $v_i = 0$. Is LED ON or OFF?

2) Repeat part 1 for $v_i = 5$ V.

3) Compute the input voltage that turns the LED on (assume that the LED will light as soon as the transistor comes out of the cut-off region).

4) Explain functions of the transistor, R_C, and R_B. Explain how values of R_C and R_B are chosen. Note the manufacturer says that the LED is brightly lit when the current in the LED is about 20 mA.

5) Print-out the *i*-*v* characteristics of 2N3904 from your PSpice simulation. Draw the load line of the circuit on the plot (Use $v_D = 1.7$ V for plotting the load line)

Lab Exercise: Assemble the circuit.

1) Measure i_B, i_C, v_{CE}, and v_{BE} for $v_i = 0$ and $v_i = 5$ V. Make the above measurements with only using a <u>volt</u> meter! Explain how you make these measurements. Compare the results with your calculations and explain any discrepancies.

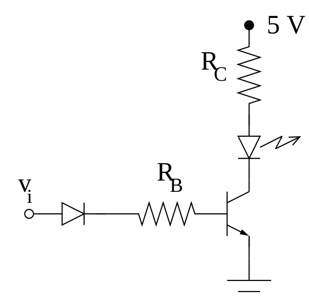
2) Set $v_i = 0$. Slowly increase the input voltage until LED turns on. Report the input voltage when the LED turns on and compare with your circuit analysis. Measure i_B, i_C, v_{CE}, and v_{BE} of this point.

3) Starting from v_i value that LED just turns ON, slowly increase v_i while monitoring the value of i_B. For $i_B = 50, 100, 150$, and 200 μA, measure values of i_C and v_{CE}. Mark the seven sets of data for i_B, i_C, and v_{CE} on the load line plot (4 set here, 2 sets from part 1 and 1 set from part 2). Explain your observations.

Experiment 3

The value of v_i that turns LED ON in experiment 2 is uncomfortably close to 0 which is the reference voltage for 0 state (LED OFF). One way to increase the value of v_i that turn the LED ON is to add a diode (1N4148) to the input as is shown in the circuit below.

Circuit Analysis: Following circuit analysis of experiment 2, compute the input voltage that turns the LED on (assume that the LED will light as soon as the transistor comes out of the cut-off region).

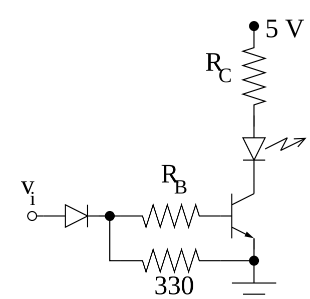


Lab Exercise: Assemble the circuit. Set $v_i = 0$. Slowly increase the input voltage until LED turns on. Report the input voltage when the LED turns on and compare with your circuit analysis. Explain why it is different than what you have calculated. Hand-waving arguments are not acceptable. You should measure various currents and voltages in the circuit in order to justify your explanation.

Experiment 4

The problem encountered above can be fixed by adding a resistor as is shown below.

Circuit Analysis: Following circuit analysis of experiment 2, compute the input voltage thata turns the LED on (assume that the LED will light as soon as the transistor comes out of the cut-off region).



Lab Exercise: Assemble the circuit. Set $v_i = 0$. Slowly increase the input voltage until LED turns on. Report the input voltage when the LED turns on and compare with your circuit analysis. Explain why the addition of the resistor as resolved the problem. Again, you should measure various currents and voltages in the circuit in order to justify your explanation.