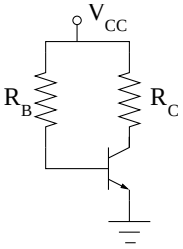
University of California, San Diego
Department of Electrical and Computer Engineering

ECE65, Winter 2012

Lab 6, BJT Biasing and Current Mirror

Note: Manufacturer spec sheet gives $\beta = 100$ for 2N3904 transistor.

Experiment 1: Poor biasing



Set $R_B = 1.5$ MΩ, $R_C = 5$ kΩ, $V_{CC} = 15$ V and a 2N3904 BJT.

Circuit Analysis:
a) Compute I_C, I_B, and V_{CE}.

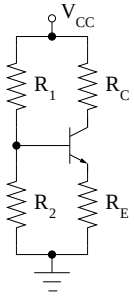
PSpice Simulation:
b) Simulate the circuit with PSpice (bias point details only) and compare values of I_C, I_B, V_{CE}, and V_{BE} from PSpice simulations with your circuit analysis.

c) Rerun your PSpice simulations for temperatures of 0 and 60°C. Make a table of I_C, I_B, V_{CE}, and V_{BE} for the above temperatures and that of part b (which is for default temperature). Explain your observations.

Lab Exercise:
d) Set up the circuit and measure I_C, I_B, V_{CE}, and V_{BE}. Note that these measurements are not straightforward. In some cases, you have to measure the quantities "indirectly." Compare your measurements of I_C, I_B, V_{CE}, and V_{BE} with your PSpice simulations.

e) Set the voltmeter to measure V_{CE}. Hold the transistor between two fingers without touching the rest of the circuit. Transistor will warm up slightly by your body temperature. What happens to V_{CE} as transistor warms up? Explain your observations.

Experiment 2: Good biasing



Set up the circuit with a 2N3904 transistor, $R_2 = 12$ kΩ, $R_1 = 39$ kΩ, $R_C = 2$ kΩ, $R_E = 1$ kΩ, and $V_{CC} = 15$ V.

Circuit Analysis:
a) Compute I_C, I_B, and V_{CE}.

PSpice Simulation:
b) Simulate the circuit with PSpice (bias point details only) and compare values of I_C, I_B, V_{CE}, and V_{BE} from PSpice simulations with your circuit analysis.

c) Rerun your PSpice simulations for temperatures of 0 and 60°C. Make a table of I_C, I_B, V_{CE}, and V_{BE} for the above temperatures and that of part b (which is for default temperature). Explain your observations. Compare your results with Experiment 1.

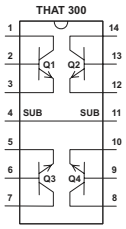
Lab Exercise:
d) Set up the circuit and measure I_C, I_B, V_{CE}, and V_{BE}. Compare your measurements with your PSpice simulations. Explain why they may be different.

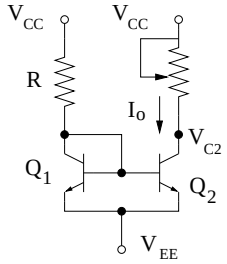
e) Set the voltmeter to measure V_{CE}. Hold the transistor between two fingers without touching the rest of the circuit. Transistor will warm up slightly by your body temperature. What happens to V_{CE} as transistor warms up? Explain your observations.

f) Compare your results from this experiment with those of Experiment 1.

Experiment 3: Current Mirror

Set up the circuit with the matched Si transistors of THAT 300 chip (Note Q1 and Q2 of the chip are matched. So are Q3 and Q4). Set $V_{CC} = 5$ V, $V_{EE} = -3$ V, and $R = 1$ kΩ. The circuit is powered with two voltage sources. Common of power supply is the ground for this circuit.



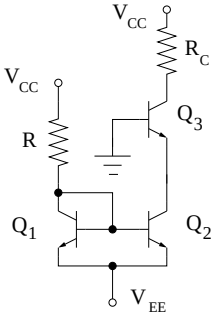


Circuit Analysis:
a) For what values of V_{C2} the circuit acts as a current mirror?
b) Compute I_o for the case that the circuit is a current mirror.

Lab Exercise:
c) With the potentiometer set to a low value, measure current I_o and voltage V_{C2}. Increase the resistance of the potentiometer while monitoring I_o and V_{C2}. Record values of I_o and V_{C2} for $V_{C2} = 5, 4, 3, ...$ V. Continue increasing the resistance of potentiometer until the circuit does not behave like a current mirror. Record the corresponding V_{C2} value and compare with part a. Tabulate the data and explain your observations.

Experiment 4: Biasing with a current mirror

We now use the current mirror of experiment 3 to bias a 2N3904 transistor (Q3) with $R_C = 500$ Ω.



Circuit Analysis:
a) Compute I_C, I_B, V_{BE}, and V_{CE} of Q3 (see also part c)

Lab Exercise:
b) Set up the circuit and measure I_C, V_{CE}, and V_{BE} of Q3. Compare your measurements with circuit analysis of part a.

c) Remove R_C from the circuit and repeat part a and b.

d) Summarize your observations of the three biasing schemes of this lab.