Lab 3: BJT LED Driver

GOAL

To implement an LED Driver circuit using a bipolar junction transistor (BJT).

OBJECTIVES

To build, test, simulate, and understand BJT amplifiers based on the following circuits:

GENERAL GUIDELINES

1) Each student must build and test all circuits.
2) During the lab session, students must share test stations.
3) Students are allowed (even encouraged) to help each other. Of course, Professor Hedrick will be around to provide assistance as well. Use neat wiring for your circuits! A messy circuit will cost you 10 points from your lab grade.
4) Ask questions! The more questions you ask, the more you learn (assuming Professor Hedrick can provide adequate answers ☺).
5) Please keep your lab kit and work area organized.

NOTE: There will NOT be a formal lab report for this lab. Fill in all tables and answer all questions and attach all printouts requested in the lab handout and hand all of these at the end of the lab period.

PARTS AND MATERIALS

- Lab kit, scope, two scope probes, coaxial cable
- Function generator, coaxial cable with alligator clips, benchtop power supply
- Transistors: 2N3904   (2)
- Resistors: 150 Ω   (brown/green/brown)   (1)
                        4.7 kΩ   (yellow/violet/red)   (2)
- Red LED

Step 1 Calculate theoretical values for the LED driver circuit.

Calculate the theoretical values for the driver circuit in Figure 1.

a. Use VBE = 0.7 V, $V_{\gamma,LED}$ = 2V, I_{LED} = 20 mA and KVL in the base an collector circuits to calculate the following: I_B, I_C, A_I, V_{BE}, V_{CB}, and V_{CE}. Put all calculations in the space below.
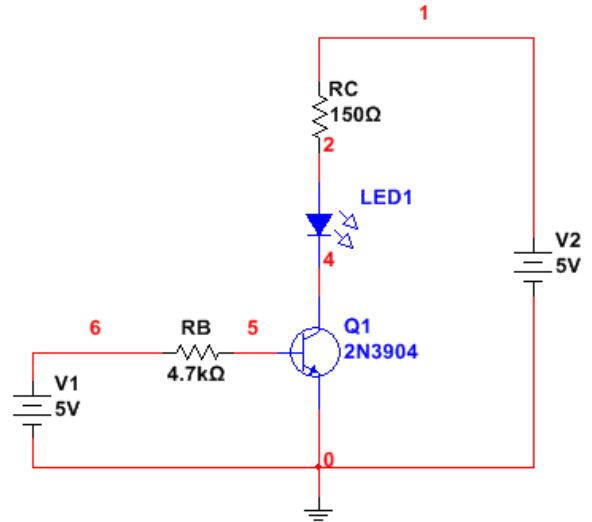

Figure 1: LED Driver circuit

b. Using your values for V_{BE}, V_{CB}, and V_{CE}. Determine the mode of operation of the transistor. Explain your answer in the space below.

c. Put your calculated values in Table 2.

Step 2 Simulate the LED driver circuit

a. Enter the circuit in Figure 1 in Multisim.

b. Turn on the node numbers by selecting: Edit | Properties | (under Net names) click on Show all. Run a simulation. Select: Simulate | Analysis and simulation | DC operating point. In the output tab select I(Q1[IB]), I(Q1[IB]), V(4), V(5), and select Add expression and enter V(4) − V(5) (this is V_{CB}). You should get something similar to table 1.

	Variable	Operating point value
1	V(4)-V(5)	-641.46113 m
2	I(Q1[IB])	902.49712 u
3	I(Q1[IC])	18.39845 m

Table 1 DC Analysis of LED Driver

c. Calculate A_I using I_B and I_B in the table. Using your values for V_{BE}, V_{CB}, and V_{CE} determine the mode of operation of the transistor. Explain your answer in the space below.

d. Print the circuit from your simulation and the DC Operating Point Analysis Table and include them with the lab handout at the end of the lab period.

e. Put the simulated values in table 2 with the calculated values.

Step 3 Build the circuit in figure 1 and measure the DC circuit voltage and current values.

a. Wire the benchtop power supply to your proto-board.
- The (+) output should go to your board's RED terminal.
- The (-) output should go to your board's GREEN terminal.
- Use red wires for VCC and black for common. Use the ground and VCC busses on the protoboard.

b. The pin diagram for the 2N3904 is in the data sheet on the course website.

c. The LED cathode is the FLAT side of the LED "rim" and the anode is the longer lead.

d. Use the multi-meter to measure V_{BE}, V_{CB}, and V_{CE}.

e. Measure the Voltage across R_C and divide this voltage by 150 Ω to get I_C.

f. Measure the Voltage across R_B and divide this voltage by 4.7k Ω to get I_B.

g. Calculate A_I from your measured I_B and I_C.

h. Put all your calculations in table 2.
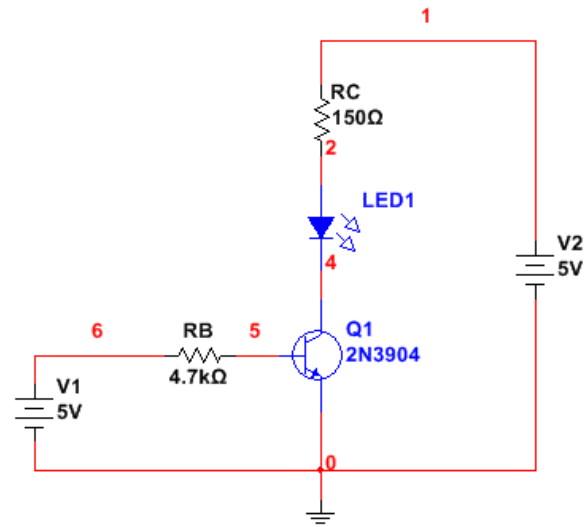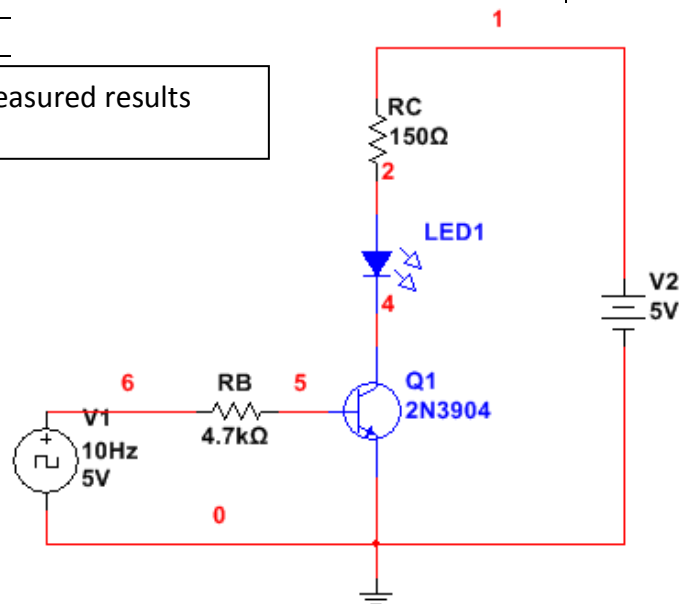
   Use the space below for your calculations.

Figure 1: LED Driver circuit

I_B	I_C	A_I	V_{BE}	V_{CB}	V_{CE}
Calculated Values					
Simulated Values					
Measured Values					

Table 2: Calculated, Simulated and measured results

DO NOT DISSASEMBLE YOUR CIRCUIT YET YOU WILL BE MODIFYING IT FOR STEP 4.

Step 4 Modify the circuit in figure 1 to use a digital signal as the input.

a. Connect the function generator to circuit as indicated in diagram in figure 2. Use the coaxial cable with alligator clips to connect the function generator to the circuit. Connect the BNC connector to the function generator "sync" output. Set the function generator to 10 Hz.

b. Connect two scope probes to the oscilloscope and connect the channel 1 probe to the base of the 2N3904 transistor and the channel 2 probe to the collector of the 2N3904 transistor.

c. Adjust the scope to get two cycles of the base and collector voltages.

d. Use Matlab to capture and plot the waveforms from both the oscilloscope channels .

```
[Vb, t1] = swave(1);
[Vc, t2] = swave(2) ;
plotyy(t1,Vc, t2, Ic) %plot with two vertical axes
grid
title('Transistro LED driver base and collector voltages')
ylabel('Voltage (V)') % change to mV if appropriate.
xlabel('time (s)')      % change to ms or us if appropriate.
```

e. Print out and hand in the labeled (voltage, time, figure number, and title) oscilloscope displays.

Hand in:

1. This handout with calculations and values. Table 2 filled in.
2. Simulated circuit diagram from step 2 Multisim simulation with a print out of the DC Operating Point Analysis Table.
3. Printout of oscilloscope graphs from step 4 of the base and collector voltages.

There is no formal lab report for this lab.

(End of Lab 3)