Laboratory 3:
Dependent Sources and Transistors

Objectives: We will use PSPICE to design a circuit using a transistor to build a light-controlled fan. Then we will build and test the circuit, using two different transistors. We will check the results by analysis using a model for the transistor as a current-controlled current source. Then we will investigate the Thevenin model for the function generator in the lab.

Devices:

The photoresistor
The photoresistor is a device whose resistance is dependent on light intensity. Measure the resistance of the photoresistor when it is in ambient light (uncovered) and when it is in low light (covered). Document the resistance in both cases.

The transistor
The 2N3904 transistor is a solid-state, three-pin device. The pins are named collector (C), base (B), and emitter (E). The transistor can be modeled as a current-controlled current source (CCCS), as shown in Figure 1. Get a 2N3904 transistor and identify the collector, base and emitter. Also get a 2N2222 transistor that will be used later.

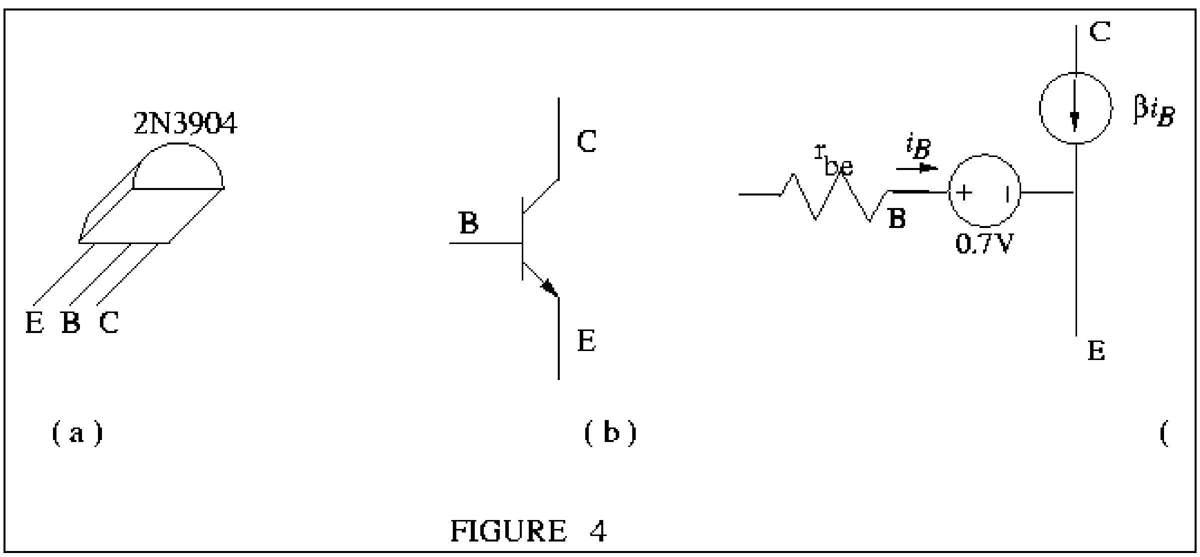


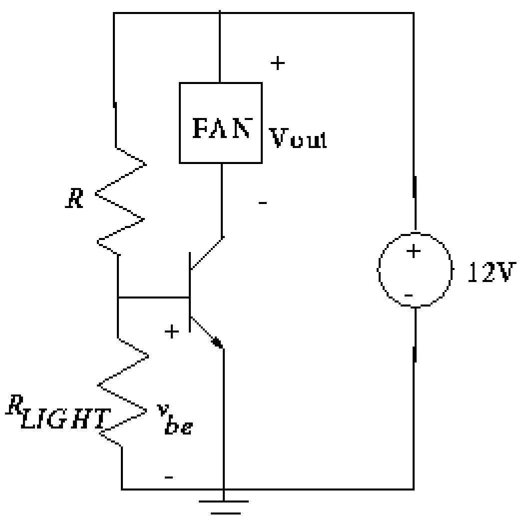
Figure 1

The fan motor
A simple model for the fan motor is an equivalent resistance. Run some tests on your fan to determine how much current it draws when you apply voltages from 0V to 12 V. Is it reasonable to model the fan as a resistor? We will design a light-sensitive fan circuit using a photoresistor and a 2N3904transistor. The maximum current rating on the transistor is 200 mA.

Light-Sensitive Fan Driver

Our goal is to design a circuit in which the amount of voltage across the fan (and therefore the current through the fan) can be controlled by a relatively small voltage change across the photoresistor. The circuit shown below accomplishes this if *R* is chosen appropriately.

We want to design a circuit in which the fan turns on when the light is blocked from the circuit and turns off (or runs slower) when light hits it.



Use PSPICE to choose an appropriate value for *R*, knowing the range of your photoresistor and modeling your fan as a resistor. Note that PSPICE has a model for the 2N3904 in the parts list under Q2N3904. You may have to add the `bipolar.olb` library. Here are some things to do by analysis and with PSPICE:

1. If the voltage at the base node B is less than 0.7 V, then the transistor base acts as an *open circuit*. Calculate how *large R* must be in order for the base voltage to drop below 0.7 V when the photoresistor is covered.
2. Build a model for the circuit in PSPICE, and perform a Bias Point analysis. Reduce the value for *R* from that calculated in step 1 until you obtain a design which will turn the fan on when the photoresistor is covered, and off when the photoresistor is uncovered.
3. From the voltages and currents in your PSPICE simulation for the case when the fan is running, estimate values for r_{BE} and β in the model for the transistor.
4. Replace the transistor by the dependent source model, and use circuit analysis to compute the current through the fan. Compare your analysis with PSPICE.
   Each lab group should submit a copy of your circuit analysis, including comparison with PSPICE, before leaving lab.

Build, test, and demonstrate your circuit, and compare with the expected results from PSPICE. Then repeat the PSPICE and testing with the 2N3904 transistor replaced by a 2N2222. **How does the value of β compare for the two transistors?**

Lab Report

Each lab group should submit their circuit analysis and comparison of β values for the two transistors.

Thevenin Equivalent Circuit

When you finish the previous activities, test the function generator by producing a square wave and attaching it to loads that are open-circuit, 5 kΩ, and 50 Ω. Compare the voltage levels on the oscilloscope with the amplitude set on the function generator. What can you conclude about the value of R_{th}? Does the amplitude set on the function generator agree with the measured amplitude on the oscilloscope for all of the loads?

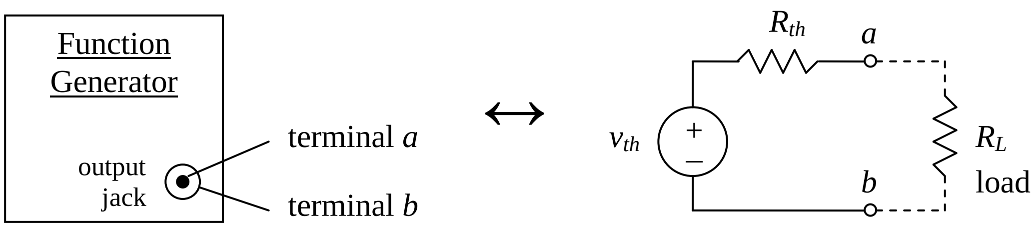


Figure 2. Configuration of the output terminals of a function generator, and the Thevenin equivalent circuit representation of the function generator.