ELEC 225, Fall 2009
Prof. Rich Kozick

Laboratory 4:
Thevenin Equivalents and Dependent Sources

Objectives: We will design a circuit using a transistor to build a light-controlled fan. Then we will find the Thevenin equivalent of this circuit analytically and with PSPICE using dependent sources.

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. Obtain a 2N3904 transistor and identify the collector, base and emitter for your device.

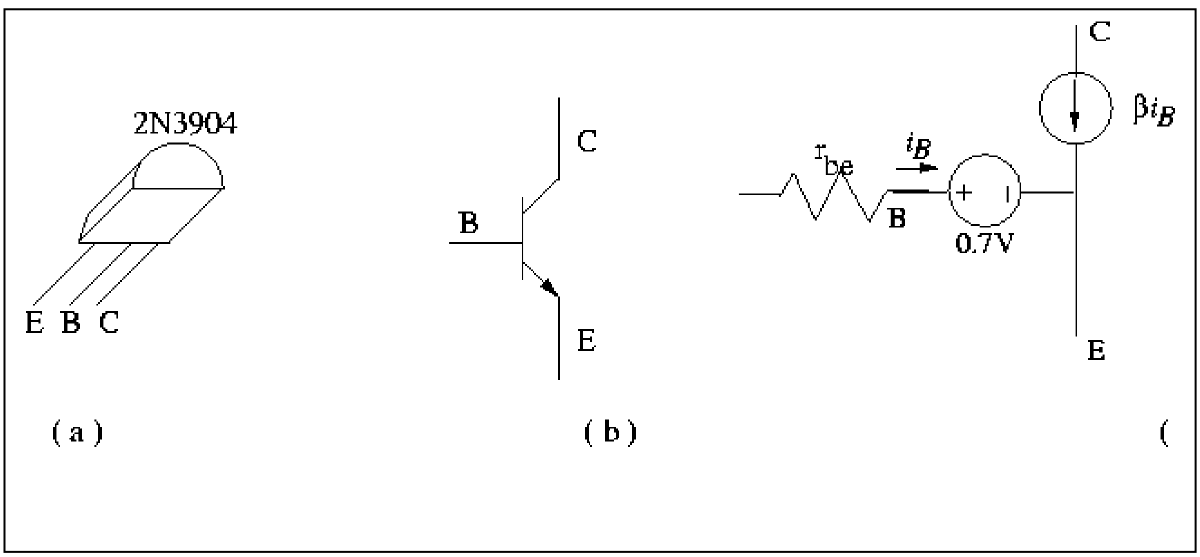


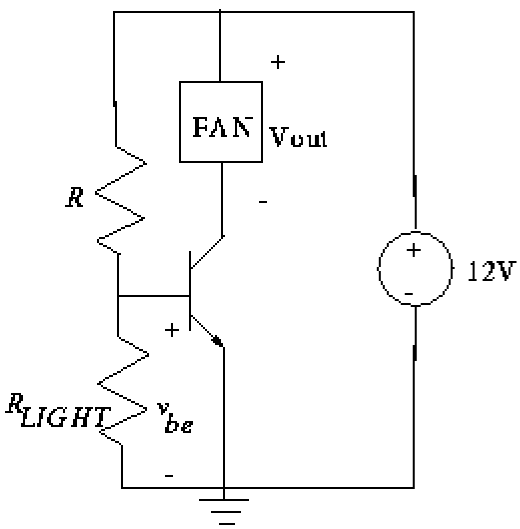
Figure 1

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 will draw when you apply 12V to it. We want to design a light sensitive fan circuit using a photoresistor and a 2N3904transistor. The maximum current rating on the transistor is 200 ma. If the fan draws more than 200 ma with 12V, reduce the voltage until the current is less than 200 ma through the fan. Then make a note of the operating conditions (fan voltage and current) for the design.

Light-Sensitive Fan Drive Circuit

Our goal is to design a circuit in which the amount of voltage across the fan can be controlled by a relatively small voltage change across the photoresistor. The circuit shown below accomplishes this by amplifying the voltage across the base-emitter junction, v_{be}.

We want to design a circuit in which the fan turns on when the light is blocked from the circuit and turns off when light hits it. The form of the circuit is shown in the following figure.



You must decide on an appropriate value for R, knowing the range of your photo resistor and the operating conditions of your fan. One of the properties that makes transistors somewhat tricky is that their operating parameters depend on the operating conditions (or DC bias point)! Thus the current gain, β, depends on the collector current, I_C. Assume that if

I_C =50 mA then β=60

I_C =100 mA then β=30

I_C =200 mA then β=25.

The input resistance, r_{be}, also depends on the collector current, but for now assume it is 50 Ω.

Using the circuit shown above and the model for the transistor, estimate a value for R such that blocking light from the photoresistor turns the fan on and allowing light to hit the photo resistor turns the fan turns off. Use PSPice to verify your results and refine your design. Note that PSPice has a model for the 2N3904 in the parts list under Q2N3904.

Build, test, and demonstrate your circuit, then answer the following questions.

a) Can you vary the speed of the fan by changing the amount of light to the circuit?
b) Measure β for your circuit.
c) Can you determine a procedure to measure r_{be} for this circuit?

Thevenin Equivalent Circuit

Next we will find the Thevenin equivalent for your fan controller circuit with respect to the terminals attached to the fan. The fan will be modeled as a resistive load.

1. Use PSPICE to find the Thevenin equivalent for your fan controller circuit.
2. Use the dependent source model for the transistor in Figure 1 and analytically solve for the Thevenin equivalent for the fan controller circuit. How does this compare to your results from PSPICE?

Lab Report

Each pair of students should demonstrate their circuit and PSPICE results. Submit a diagram of your design showing the component values and outlining the key steps in your design process. In addition, show your Thevenin equivalent circuit.