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# A Simple Photo-sensor Circuit

## Discussion Overview

The basics of circuit design include identifying the required voltages and currents of active components used in a circuit and adjusting passive component values to achieve the desired voltages and currents.

For our simple photo-resistor circuit, our active component is an LED (Light Emitting Diode) and a transistor combination which we will treat as a "black box"[1] circuit. We will use the specs (specifications) for this black box circuit to determine the voltage required to turn on the LED when the amount of light detected by the sensor drops below a certain amount.

We will also use a photo resistor as our sensor. The specs for the photo resistor will come from our last experiment; namely the resistance of the photo resistor in low and bright lights.

## Schematics

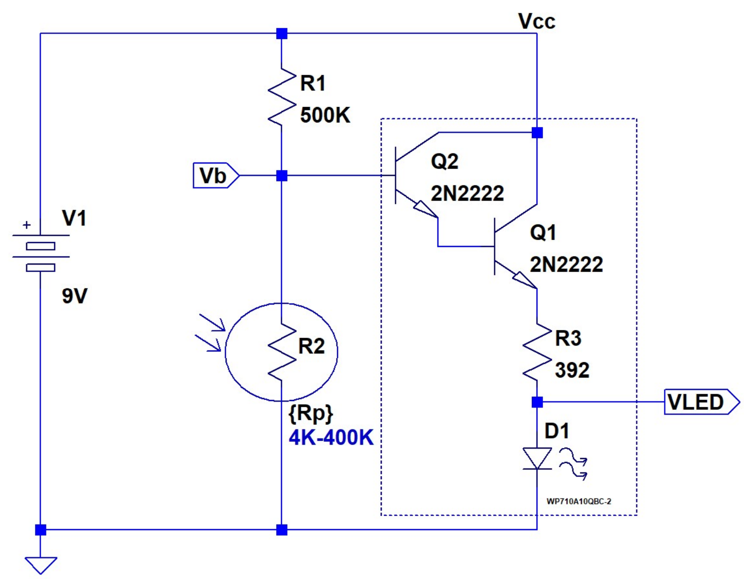


*Figure 1 – Simple Photosensor Circuit*

[1] A "black box" is usually referred to a circuit where we don't know (or need to know) the details of the circuit as long as we know the required voltages and currents for input and output ports.



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Note that the black box circuit in the schematics above is marked by the dashed rectangle. The followings are the specs for the black box:

- $V_b \geq 4V$ for the LED to turn on

# Procedure

Given the circuit shown in Figure 1, determine the value of $R_1$ for which the LED turns on when the amount of light detected by the sensor is less than "ambient" daylight.

A. Look through your data for the "Series Resistor Network" project to find the resistance value of the photo-resistor for when it's dark. Let's note this value as $R_{ph} = R_{dark}$

B. Recall that the "voltage divider" equation from your "Series Resistor Network" project. Applying the voltage divider equation to find $V_b$ we have

$$V_b = V_{Batt}\frac{R_{ph}}{R_{ph} + R_1}$$

C. In order to make sure, the LED turns on when it is dark, we need $V_b \geq 4V$ for $R_{ph} = R_{dark}$. Substituting these in the voltage divider equation above, determine the value of $R_1$:

$$\left.\begin{aligned} &V_b \geq 4V \\ &R_{ph} = R_{dark} \\ &V_b = V_{Batt}\frac{R_{ph}}{R_{ph} + R_1} \end{aligned}\right\} \rightarrow V_{Batt}\frac{R_{dark}}{R_{dark} + R_1} \geq 4V$$

Rearranging this equation, we have

$$\boxed{R_1 \leq \frac{(V_{Batt} - 4V)}{4V} \times R_{dark}}$$

D. Measure and record the resistance of the photo-resistor for when it is dark.

$R_{dark} =$ ______________ $\Omega$

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E. Use the equation above and the value for $R_{dark}$ to find $R_1$.

$$\left.\begin{array}{l} R_1 \le \dfrac{(V_{Batt} - 4V)}{4V} \times R_{dark} \\ V_{Batt} = 9V \\ R_{dark} = \_\_\_\_\_\_ \end{array}\right\} \rightarrow R_1 \le \frac{(9V - 4V)}{4V} \times \_\_\_\_\_\_ \rightarrow R_1 \le \_\_\_\_\_\_\,\Omega$$

F. Look through your resistor kit to find one (or a combination of) resistor(s) whose value comes as close as possible to the value you calculated for $R_1$ in step E above.

G. Construct the circuit given in Figure 1.
   a. Your breadboards should already have the black box circuit constructed on them.
   b. Add your photo-resistor and $R_1$ to the circuit.
   c. Set your power supplies to 9V and limit the current to 20ma.
   d. Connect the power supply to your circuit and test the circuit to make sure it is working correctly.

H. Measure $V_b$ for when it is dark and when there is light and compare the measured values to your calculations:

$V_{b\_dark} = \_\_\_\_\_\_\_\_\_\_\_\_ V$

$V_{b\_ligh} = \_\_\_\_\_\_\_\_\_\_\_\_ V$