Design Overview

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

For our simple photo-resistor circuit, our active component is an LED (Light Emitting Diode) and 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

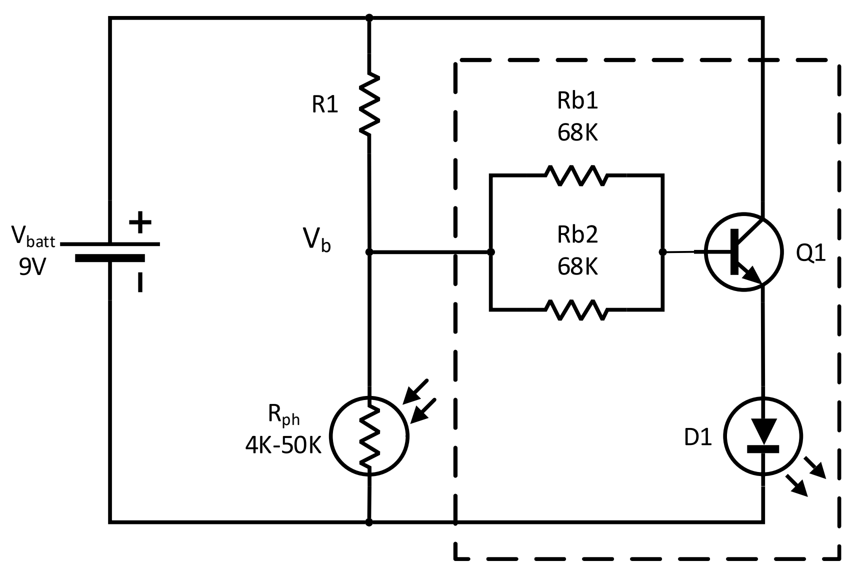

Figure 1 - Series Network Circuit and its Equivalance

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

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[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.

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 ambient light. Let's notes this value as $R_{ph} = R_{amb}$

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 is off in ambient light, we need $V_b \leq 4V$ for $R_{ph} = R_{amb}$. Substituting these in the voltage divider equation above, determine the value of R_1:

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

Rearranging this equation, we have

$$V_{Batt}\frac{R_{amb}}{R_{amb}+R_1} \leq 4V \rightarrow V_{Batt}R_{amb} \leq 4V(R_{amb}+R_1) \rightarrow V_{Batt}R_{amb} \leq 4VR_{amb} + 4VR_1 \rightarrow$$

$$V_{Batt}R_{amb} - 4VR_{amb} \leq 4VR_1 \rightarrow (V_{Batt}-4V)R_{amb} \leq 4VR_1 \rightarrow \boxed{\frac{(V_{Batt}-4V)}{4V}R_{amb} \leq R_1}$$

D. Use the equation above and the value for R_{amb} to find R_1.

$$\left.\begin{aligned} &R_1 \geq \frac{(V_{Batt}-4V)}{4V}R_{amb} \\ &V_{Batt} = 9V \\ &R_{amb} = \_\_\_\_\_\_ \end{aligned}\right\} \rightarrow R_1 \geq \frac{(9V-4V)}{4V}\_\_\_\_\_\_ \rightarrow R_1 \geq \_\_\_\_\_\_$$

E. Look through your resistors 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 D above.

F. 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. Connect the battery and test the circuit to make sure it is working correctly.

G. As an extra bonus, measure the voltage at V_b for which the LED turns on.

V_b = ________