Building a Modular, Switch-Controlled LED Circuit

Circuits Fundamentals Lab, (ENGR-UH 2019-LAB)

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***Abstract*—In this experiment a switch controlled LED circuit was built using a 330Ω resistor, as a visual indicator for the on/off status for a radio receiver to be implemented later. Calculations were carried out to confirm that the resistor value used was appropriate. A simulation was also run for further confirmation. Finally, the circuit was assembled by soldering components onto a prototype board and testing by applying a 9V source.**

I. Introduction

The purpose of this exercise was to create a switch-controlled circuit capable of powering an LED and a arbitrary system that will be implemented in the future (see Figure 1). Light-emitting diodes (LEDs) are a semiconductor device that carry current in a certain direction, and as a result produce visible light [1]. Often, LEDs are rated to operate in a amperage range. Hence, a protective resistor is often placed before the LED to regulate the current passing through the LED. A slide switch, used for this circuit, is a device with two terminals connected by a slide-able conductive piece in the middle. As a binary device, the middle piece only connects to one of the two terminals at a given time.

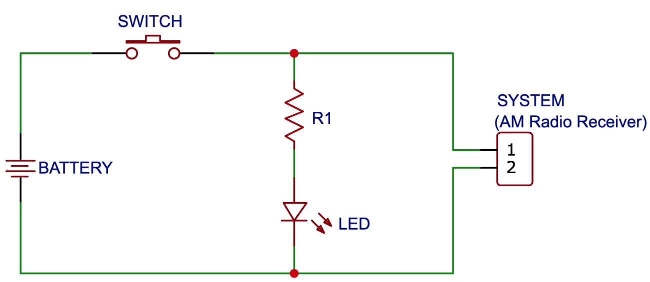

Fig. 1: A schematic for a modular, switch-controlled led circuit

As shown in the schematic above (Figure 1), the resistor and LED were connected in parallel with the system to avoid a voltage drop as the LED was lit up. The switch was also deliberately placed in series with the battery before the LED and system to control the flow of electricity to both devices. Thus, the LED was used as a power on/off indicator for the main system. Finally, all devices were connected to the common ground.

Ohm's law (Equation 1) can be manipulated to calculate the current passing through the devices in the circuit (see Equation 2).

$$V = IR \tag{1}$$

$$I = \frac{V}{R} \tag{2}$$

II. Circuit Assembly

Following the schematic, components were placed onto a breadboard for initial testing (Figure 2). Later the working circuit was transferred onto a prototyping board and components were soldered. Two screw terminals were placed at either end of the board to allow for battery cables and radio receiver cables to be fed in and out and be replaced if needed. The slide switch was soldered in the middle of the board; the power cable from the battery terminal was soldered to the common pin, while the power cable leading to the radio receiver was soldered to the terminal 2 pin. Thus, the circuit could be opened by sliding the common pin to connect with the terminal 1 pin.

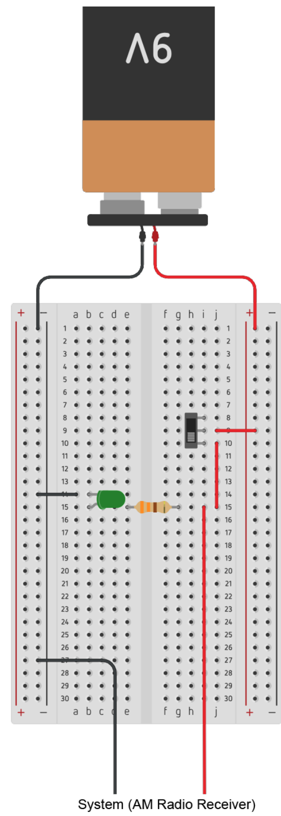

Fig. 2: CAD layout recreating the switch-controlled circuit.

A cable was directly connected between the negative terminals on both screw terminals. The anode of the LED was soldered to the negative terminal on the battery terminal for grounding. One leg of the protective resistor was soldered to the terminal 2 pin of the switch, while the other leg of the resistor was soldered to the cathode of the LED, thus completing the circuit (see Figure 3).

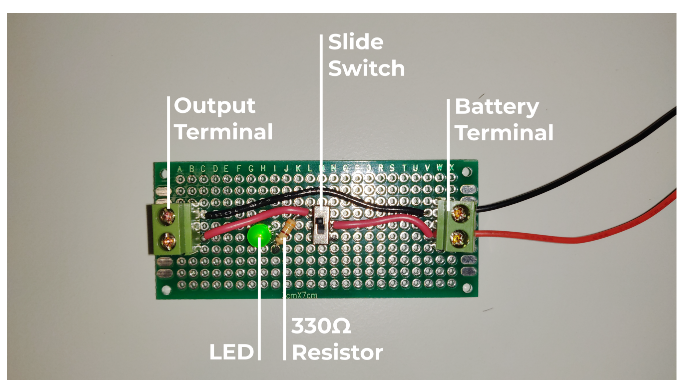

Fig. 3: Switch-controlled circuit to control LED and any attached system.

III. Ohm's Law Calculations

The resistance value of the protective resistor is important as it prevents the current from exceeding the maximum specified current for the component. The green LED used was rated for a maximum $30mA$ forward current and 100 mA peak forward current [2]. Ohm's law was used to calculate the required resistor values that satisfied the ratings of the LED as shown in Equation 3.

$$R = \frac{V}{I} = \frac{9V}{30mA} = 300\Omega \quad (3)$$

While the calculations imply the use of a 300Ω resistor for the case of maximum forward current, any resistor value which supplies approximately below $30mA$ (for a reasonably luminescent LED) is appropriate. In this case, a 330Ω resistor was used as it was the closest resistor value and provided a maximum forward current of $27mA$, which is under the recommended maximum. This decision was confirmed by the simulation (see Figure 4), which shows that using a 330Ω resistor results in a forward current of $20.9mA$, far less than the recommended $30mA$. The operation of the circuit was also confirmed by soldering the components to a prototype board and supplying $9V$ through the battery terminal resulting in a functional circuit(see Figure 5).

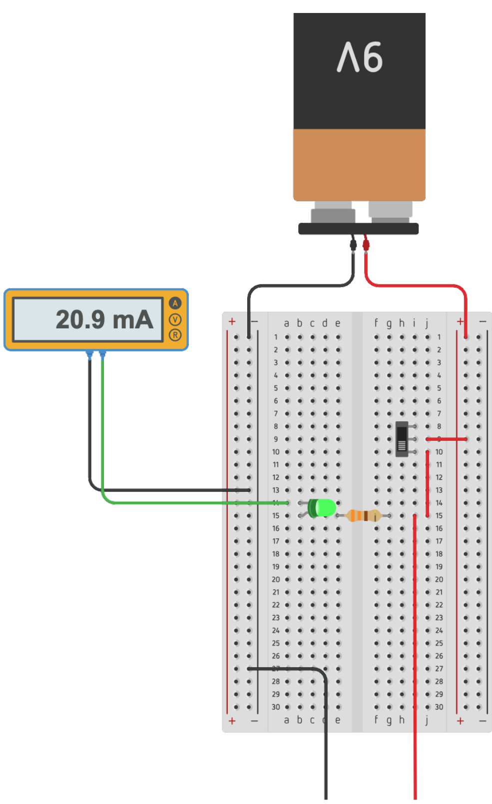

Fig. 4: Simulation for 330Ω resistor in the circuit

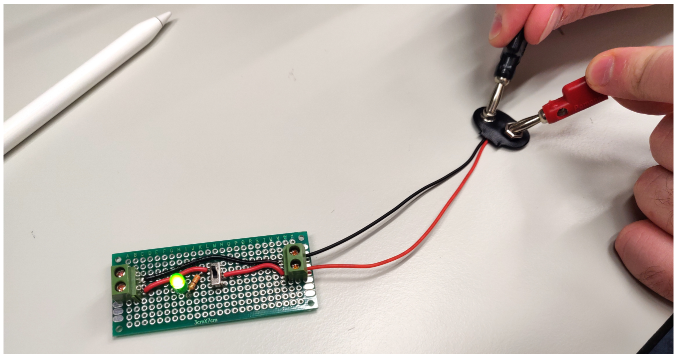

Fig. 5: Final testing of the completed circuit

IV. Discussion and Conclusion

A generic power switch for a system (AM radio receiver) was assembled. An LED with a protective resistor was also fitted into the circuit to act as a status indicator. A 300Ω resistor value was calculated using Ohm's Law assuming peak forward current. The closest resistor value of 330Ω was used for the circuit, resulting in a forward current of $20.9mA$ and a successful circuit. The lab also acted as an exercise for good soldering practices, such as setting the right temperature and ensuring solder to pad connection, which were critical to the circuit operating when finally assembled.

References

[1] W. H. Hayt, J. E. Kemmerly, and S. M. Durbin, *Engineering circuit analysis*. McGraw-Hill New York, 1986.

[2] I. Cree, *Cree 5-mm Round LED Datasheet, C503B-BCS/BCN/GCS/GCN*. 2014. [Online]. Available: https://www.cree.com/led-components/media/documents/C503B-BAS-BAN-BCS-BCN-GAS-GAN-GCS-GCN-1094.pdf.