Student Worksheet

Lesson 5: Transistors as Switches & Amplifiers

Objective: The objective of this lab is to become familiar with transistors and their use as switches and amplifiers. You will learn that transistors are the building blocks of integrated circuits and that transistors are manufactured on the micro and nanoscales. When this lesson was written in 2008 the transistor size averaged between 55 and 65nm. At the time this lesson was re-edited in 2019, the size was down to 8nm. At the 10nm size and integrated circuit can have 5,300,000,000 transistors accounting for the enhanced capabilities and speed of electronic devices. Read about this progression at https://en.wikipedia.org/wiki/Transistor_count.

Materials: (per lab group)

- 1 kΩ resistor (2)
- 680 Ω resistor (or something close)
- 2N3904 Transistor
- LED
- 9 V battery
- Battery connector
- Jumper wires
- Breadboard

Introduction:

In this lab an NPN transistor will be used to show its characteristics as a switch and amplifier. NPN transistors are also used for its amplification properties. Figure 1 illustrates and example of the type of transistor you will be using. Take the transistor in front of you and look at the bottom. Face the leads toward you. With the curved part facing upward the legs are labeled emitter, base, and collector from left to right, as shown in Figure 1. It is very important to know the identity of each leg. If they are connected incorrectly the circuit will not work and the transistor may break. The circuit schematic symbol is shown in Figure 2. The arrow indicates the direction of the current. Current enters the collector and base leads. If no current flows through the base lead, no current may enter the collector. If no current flows through the base or collector, no current leaves through the emitter.

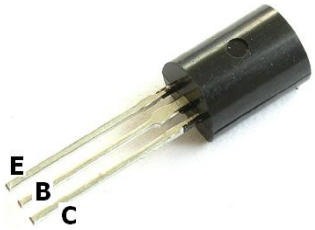

Figure 1. An NPN transistor with leads labeled as emitter, base, and collector . (www.reuk.co.uk/What-is-a-Transistor.htm)

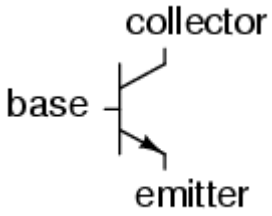

Figure 2. Transistor circuit schematic symbol. *(www.allaboutcircuits.com/vol_3/chpt_4/1.html)*

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Experimental Setup:

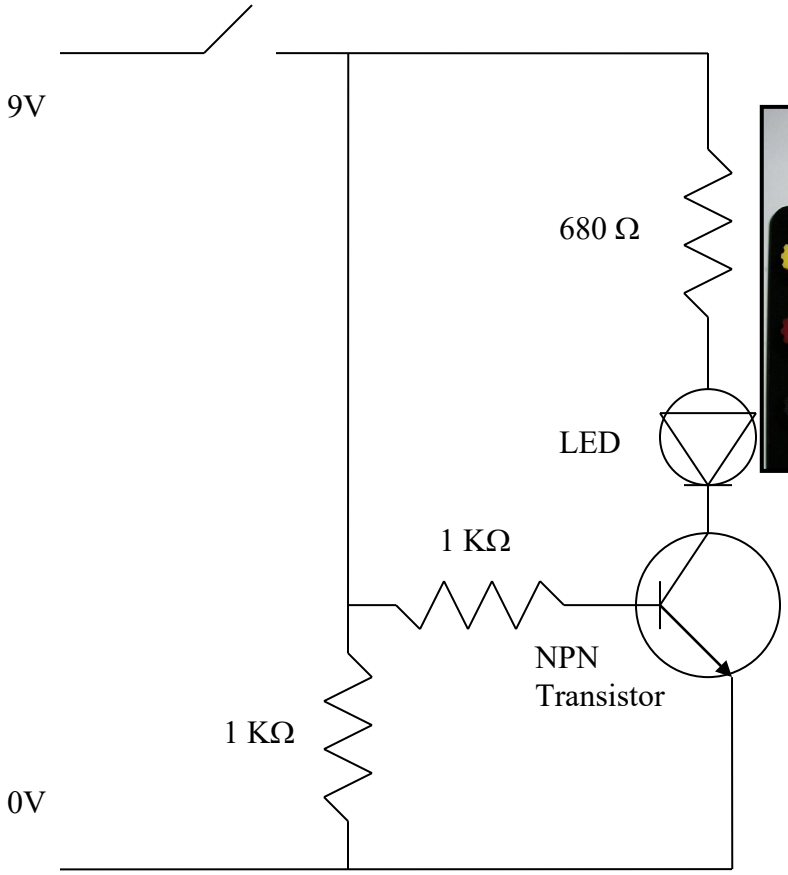

Figure 3. Circuit schematic.

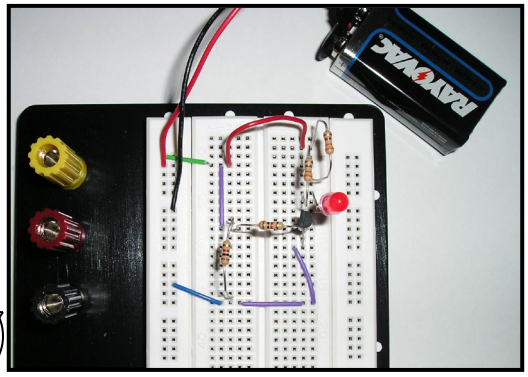

Figure 4. Breadboard circuit

Procedure:

1. Connect the circuit as shown above in the experimental setup section. Leave the switch open or battery unattached so that you don't electrocute yourself.
2. Double check to see that the transistor leads are properly placed.
3. Make sure that the red lead of the battery is attached to switch. If the polarity is switched the LED will not light up.
4. Turn the switch to the ON position or attach the battery.
5. What happens to the LED?
6. Measure the current entering the collector lead of the transistor.
7. Record the data in Table 1.
8. Measure the current entering the base lead of the transistor.
9. Record the data in Table 1.
10. Measure the current leaving the emitter lead of the transistor.
11. Remove the battery or turn off the switch.
12. Detach the 1 k resistor connected to the base lead of the transistor as shown in Figure 5.

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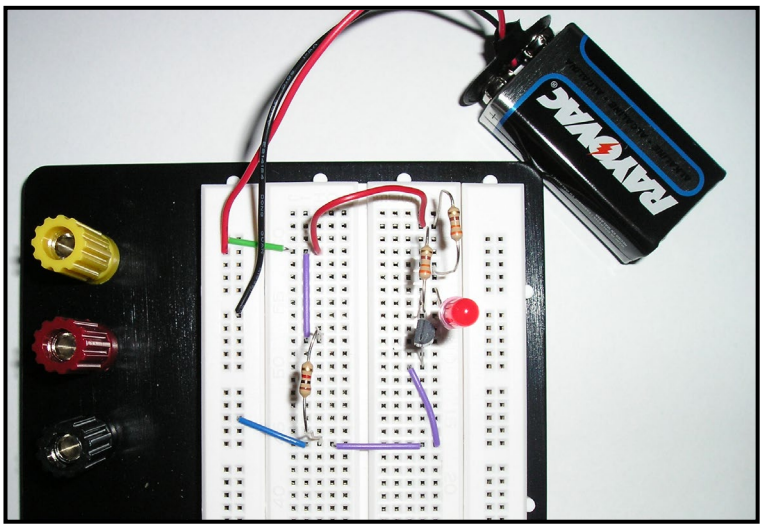

Figure 5. Circuit with the base resistor removed.

13. Reattach the battery.
14. Repeat steps 4 through 12.

Record Data:

Table 1. Current data for the transistor.

Circuit	Collector Current (A)	Base Current (A)	Emitter Current (A)
1			
2			

Analysis and Conclusion:

1. Why doesn't the second circuit's LED light up?

2. What is the base's role in a transistor?

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3. What was the current gain for the first circuit?

4. What is the current gain for the second circuit?

Optional Extension Activity (your instructor may assign)

Explore Moore's Law and the impact nanotechnology has had and is having on electronics. Based on your research and your imagination, propose you solution for electronics in a post-Moore's Law world. Be imaginative and explore means that may not be possible today.

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