Light, Electricity, Semiconductors

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ABSTRACT

As technology advanced these days, computers are playing a more and more important role in our daily life; especially in those areas that requires higher technology, for example, aerospace. And as computers keep developing, they tend to be smaller and lighter but much more sufficient. It is the base stone of modern information era. A CPU is the brain of a computer, and as the computers get smaller and smaller, the CPUs are getting smaller and smaller, using semiconductors. Semiconductors have many properties that is extremely useful to human, their conductivity are controlled by their environment, and therefore are adaptable and controllable

However, computers are not the only area that requires semiconductors, solar energy and even streetlights are using them to make our life easier. This project is focusing on the basic semiconductor usages and the properties of them. Since streetlights are everywhere in our life, it would make a very good example and it's easy to demonstrate. However, as the width of the semiconductor area, the experience turns out pretty complicated to explain, one explanation can leads to more.

This project will be talking about the main types of semiconductors, especially the most widely used ones, for example, silicone. A model of streetlight which is photosensitive is constructed in this project.

As mentioned previously, semiconductors are the back bone of modern information era, they play the most important role in our highest technology and will be leading us to the next level of knowledge.

This project will focus on the different types of semiconductors, including PNP and NPN, as well as their advantages and disadvantages.

MATERIALS AND PROCEDURE

Material List

- Two Flashlights with different light intensity
- One P-N-P Bipolar Junction Transistor
- One N-P-N Bipolar Junction Transistor
- Two Light Emitting Diodes
- One Light Bulb
- Several Wires
- One switches
- Tow Batteries
- One Voltmeter

First Set

Use different colour of BJTs with the same colour LED, so it's easier to compare and contrast the two sets.

Construct a current with a light bulb or LED parallel to the other

Connect one with one of the BJT and the photo resistor.

Read the Voltmeter, Record the number

Flash the dimmer flashlight on the photo resistor

Read the Voltmeter, record the number

Flash the brighter flashlight on the photo resistor

Read the Voltmeter, record the number

Second Set

Use the same current to minimize the error.

Replace one of the BJT with the other one

Read the Voltmeter, Record the number

Flash the dimmer flashlight on the photo resistor

Read the Voltmeter, record the number

Flash the brighter flashlight on the photo resistor

Read the Voltmeter, record the number

Compare and contract the two groups.

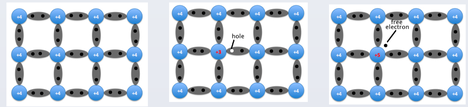
By measuring the voltage, we are able to know the voltage that is flowing in the base of the transistor.

RESEARCH

A street light could be connected and parallel to each other, then controlled by the city government and will be lightened by certain officials at certain time, however, some street light are lightened during day time, but only cloudy days. Photo resistors, also known as Light Controlled Resistors are one of the major components of those lights.

A photo resistor is a resistor controlled by light. The resistance of a photo resistor decreases with increasing incident light intensity; and increases with decreasing incident light intensity. Light make the electrons in the photo resistor more active and are able to conduct electricity, which will make the electrons flow through the current freely.

Photo resistors can be divided into two groups based on the materials used, intrinsic and extrinsic. Intrinsic semiconductors are pure, using the example of silicon or germanium, they form covalent bond using the four valance electrons on their outer shell. Therefore each ionic core consist of a nucleus and four non-covalent electrons, and the number of electrons and holes are equal at all times. Extrinsic semiconductors have impurities, they can be either natural of artificial. When another element is added to this covalent bond, for example boron, who has three valance electrons will give the compound an extra hole. The hole will the accept electrons, lattices with group three impurities are also called acceptors. Instead of replacing an atom with an atom that has five valance electrons. This will have the opposite effect on the lattice, which is, adding an electron, and impurities are called donors.



A photo resistor has the property of photo conductivity, which is the absorption of electromagnetic, in another word, light, causes the fact that a martial to becomes more electrically conductive.

Another important component is the Bipolar Junction Transistor. A Bipolar Junction Transistor, also known as the BJT is a device constructed with three layers, base, emitter and collector. There are two major types of BJT; they are P-N-P and N-P-N.

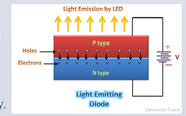
A P-N-P BJT consists of two P-type semiconductors and one N-type semiconductor. An N-type semiconductor, also known as the Negative semiconductor, is occupied with electrons, and a P-type semiconductor, also known as a Positive semiconductor, is occupied with holes.

A NPN Is turned on when there is current flowing through the base of the transistor and from C to E, and an NPN is turned on when there's no current at the base.

Another major component of this current is the LED. Although it could be replaced by a light bulb, it has some properties that a light bulb doesn't and is wildly used in areas such a solar energy.

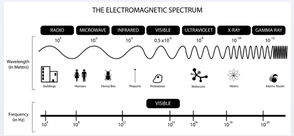
A LED is also known as a Light Emitting Diode. It is constructed with a P-type semiconductor and an N-type semiconductor. The electrons in the N-type semiconductor fill the holes in the P-type semiconductor; however, not all of them do so. Only the ones on the edge of the connection will combine with each other. This process will form a middle area.

When electricity flows through the LED, it makes the electrons more active, and then they will combine with the holes and release their energy in form of photons. Thus, LEDs can only work properly when it is constructed on the right base in terms of the battery, electricity can only go one way.



Solar energy works exactly the same but the other way around. Photons enter the middle area of this P-N junction and release its energy, it split into an electron and a hole, which produce us electricity.

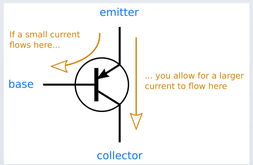
LEDs are able to produce colourful light themselves. When an electron with a high energy level combine with a hole with a low energy level, they release their energy in form of photons, and the photons travels in waves, which make the visible light that we see every day. A shorter wave requires more energy for the photon to have. Imagine you are taking the smallest step very quickly but need to go a long way.



The energy this certain photon has is the difference between the electron and the hole. However, the closer the colour the light is on the light spectrum to purple, or ultraviolet, the higher the energy level is needed. Thus, red and green are easy for LED to produce, and Professors **Isamu Akasaki**, **Hiroshi Amano** and **Shuji Nakamura** made the first blue LEDs in the early 1990s. They won the Nobel Reward in 2

RESULTS

In the PNP set, only the light bulb is lightened when the switch is turned on. Electricity flew through the current. The voltage that was been read from the voltmeter was very low, around two to three. The green LED is not lightened. Next, the dimmer flashlight was flashed on the photo resistor, the number on the voltage goes slowly from two to three to six to eight, and as the centre of the flashlight is right above the photo resistor, the voltage is at maximum.



When the brighter flashlight is shined on the photo resistor, the handle on the voltmeter went straight to maximum, as the flashlight is slowly removed, the handle came to the six slowly, and as the flashlight is completely removed, the voltage went back to the number before.

Flashlight Type	Voltage	If lightened or not
No flashlight	2.75	No
Dimmer Flashlight	6	Yes
Brighter Flashlight	Over 10	Yes

During this process, the light bulb was always lightened and has no intensity change.

The intensity of the green LED varied base on the intensity the flash light is. The brighter the flashlight is, or the more centered it is, the brighter the green LED is. And as the flashlights are removed, the LED gradually became dimmer and was off at the end.

The reasoning of this is that a PNP transistor requires a small amount of voltage to be able to conduct. When the photo resistor is not conducting, in another word, no light is shined on the photo resistor and cause the electrons inside more active. All the electricity is going through the emitter of the PNP transistor and the base of the transistor. The big amount of the voltage make the PNP unable to conduct electricity through itself and lighten the green LED.

And when the light is shined on the photo resistor, the electrons inside are more active and is conducting electricity through it, thus, a larger amount of electricity is going through the voltmeter and the photo resistor, and less electricity is going through the base of the PNP transistor. That makes the PNP transistor able to conduct electricity through itself and lighten the green LED.

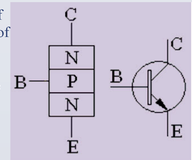
In the NPN set, the red LED was used to differentiate the two groups more visually. A 10K resistor was originally used is the experiment, but was replaced by a wire. The voltmeter itself has a huge resistance which causes the LED to be dimmer than if it's without the voltmeter.

No Flashlight	4	Yes but very dim
Dimmer Flashlight	7	No
Brighter Flashlight	Over 10	No

When the dimmer flash light shines on the photo resistor with the PNP BJT, the LED which was originally on was off. The handle was moving gradually from the left side to the right side and hit maximum when the centre of the flashlight is right above the photo resistor. However, compare to the brighter flashlight that will be brought up next, the speed of the handle was obviously slower and softer.

When the brighter flashlight was shined on the photo resistor, the handle on the voltmeter went to the right hand side with no lagging. And the red LED was turned off at once. When the flashlights were removed slowly, the red LED gains its intensity gradually and was back on again once the light source is removed.

A NPN transistor is the exact opposite of the PNP transistor. It requires a large amount of voltage at the base to be able to conduct electricity through it. When there is no light shining on the photo resistor, the electrons are not active and not able to conduct electricity through it as mentioned before. And all the electricity is going through the base and the collector of the NPN. Thus, the red LED is lightened.



When there *is* light shining on the photo resistor, the electrons inside the photo resistor are more active and are enabled to conduct electricity. And as all the electrons are going the easier way with less resistance, the red LED is not lightened.

At the end, the light bulb was always on during both of the experience and is releasing its energy in form of heat. The outer shell of the light bulb turns hot. But both the LEDs are still cool and calm like they always are.

ACKNOWLEDGEMENTS

This project will not be successful without the help of Mr. Xu. He provided most of the information used in this project, made corrections, answered questions, and helped to solve the problems encountered in this project. Thank you Mr. Xu.

CONCLUSIONS

All photo resistors controlled light cannot work without the cooperation of a BJT. And that's also the reason why semiconductors are so widely used in light related area.

The experiment was contracted by me with the assistance with my tutor Mr. Xu, he corrected many electricity problems and has contributed a lot to this project. The experiment went very smoothly and was fairly clear. The reasoning behind the project was introduced to me by either online researches, through books and Mr. Xu. The voltmeter I own isn't a professional and much accurate one, so I took several results and found the range and the average of those numbers.

After all it was absolutely a glad to have the experience to know the basic of computers and to work on this project.

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IDEAS FOR FUTURE RESEARCHES

Based on this experiment, future researches may be developed in four different ways.

Experiments could be done on the photoresistors:

- Their applies characters
- The materials used to build them
- How to improve their accuracy
- The speed it operates at, what determines it and how to change it

Experiments and researches could be done on the LEDs:

- How to produce more colour
- Electricity consummation compare to a regular light bulb
- Different material made LED and their risks
- Compare and contrast the light intensity given off by LEDs and regular light bulbs