Lesson 1452, Optoelectronics

Experiment 5, Photodiode and Phototransistor Resistance Measurements
Objectives

- To show the resistance of a photodiode varies as the light intensity varies
- To show the resistance of a phototransistor varies as the light intensity varies
Introduction

- A photodiode is a special diode whose resistance varies with light.
  - It behaves much like the CdS cell you studied earlier
  - Unlike CdS cells; photodiodes show many of the characteristics of ordinary diodes.
    - Photo diodes have P-N junctions
- The main difference between the two is that no current flows through the photodiode when it is in complete darkness.

- The photodiode also responds to changes in light intensity very quickly.

- An external voltage source must be connected to the photodiode, since it is a passive device.

- Any current flowing through the device will increase as the light increases because the resistance of the photodiode decreases.
Photodiode Symbol
The two arrows pointing toward the P/N junction indicate the device responds to changes in light.

If we connect a meter in series with the diode as shown in the following slide, the diode will be reversed biased.

As a result, the meter will indicate when the resistance changes.
Equivalent Ckt for Resistance Measurements

Photodiode

Equivalent Meter Circuit

Meter Battery

I
• Note that the meter is connected so that its internal battery reverse-biases the device.

• If the meter leads were reversed, the diode would be forward-biased.

• This would cause an excessive current to flow, probably damaging the device.

• Some disadvantages of using a photodiode will be discussed on the next slide.
Disadvantages of using a Photodiode

- No amplification of the control current takes place
  - As a result, the amount of current that can be used in a given circuit is limited by the amount of current the device can handle
  - As a result, low-level control signals are of little use when using such photodiodes
Phototransistors

- A Phototransistor is actually a device that has a conventional transistor combined in the same package with a photodiode.
- Below is the schematic symbol
Phototransistor Equivalent Circuit
Functionally, the phototransistor is very similar to the light-meter circuit we built and discussed previously.

As the photodiode resistance decreases, the base current of the transistor increases, and the collector current increases accordingly.

If an Ohmmeter were connected across the emitter and collector, it would see a decrease in resistance as the current increased. Though, this is impossible to measure.
Procedure:

- Now you will measure photodiode and phototransistor resistances
  - The photodiode measurements will be made between the base and collector terminals of the phototransistor
  - The phototransistor measurements will be made between the collector and emitter terminals of the phototransistor
1. Locate the phototransistor
   a) The phototransistor is very similar to a normal transistor, except for the plastic lens on the top of the transistor

2. Mount the photo transistor on the breadboard.
   a) Use posts for measurements or carefully spread the leads of the transistor apart to allow you to connect your meter leads
FPT 100A (Bottom View)

MRD 3050

Phototransistor lead configuration
3. Note the lead configuration as seen from the bottom of the transistors.

4. Switch your meter to X 1000 Resistance range and connect the meter to the transistor as shown in the next slide.

a) Note: We have assumed the positive lead of the battery is connected to the Black meter lead. (Reverse the meter connections if your battery is connected the opposite way!)
5. Temporarily place a piece of black electrical tape over the lens of the transistor

a) Switch meter to the best range and measure the resistance

b) Record the reading in the data table; an example of the table is shown on the slide following the schematic
Photodiode Measurements Schematic
Photodiode Pictorial

Emitter
Left
Unconnected

Positive Meter Lead

Negative Meter Lead

Q₁

MRD 3050
Photodiode Pictorial

Emitter Left Unconnected

Q₁

Positive Meter Lead

Negative of Battery

Negative Meter Lead

Positive of Battery
6. Remove the tape from the lens and place the device about three feet from a 60W lamp

7. Move the lamp closer and farther from the transistor. Notice if the resistance of the photodiode increases or decreases.
8. Change the meter lead connections to agree with the following schematic.

9. Temporarily place a piece of black electrical tape over the lens of the transistor. Record the resistance.

10. Remove the tape from the lens and place the device about three feet from a 60W lamp. Record the resistance.
Phototransistor Measurements
Schematic

- Left unconnected
- Black Probe
- Red Probe
- Meter
Phototransistor Pictorial

Base Left Unconnected

Q₁

Positive Meter Lead

Negative Meter Lead
11. Vary the distance between the lamp and the phototransistor.

a) As the lamp distance decreases, do you expect the resistance of the phototransistor to increase or decrease? Why do you expect this?

You should have seen a trend of decreasing resistance with increasing light.
Final Discussion

- You measured the resistance of both the photodiode and phototransistor.
  - You should have seen the resistance decreased as the light increased with both devices.
  - You probably measured different resistance values, for the two devices, with the same light conditions.
A phototransistor consists of a photodiode connected between the base and the collector of the transistor

- You were able to make your photodiode measurements by measuring between the base and collector leads of the transistor
- You were also able to make your phototransistor measurements by measuring between the collector and emitter leads of the transistor
In most applications, phototransistors are used in this way, only using the two leads (Collector and Emitter) connected to the circuit.

<table>
<thead>
<tr>
<th>Light Conditions</th>
<th>Photodiode Resistance</th>
<th>Phototransistor Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dark (Tape on lens)</td>
<td>2 MΩ</td>
<td>150 kΩ</td>
</tr>
<tr>
<td>Room light (60 W Lamp)</td>
<td>200 kΩ</td>
<td>5 kΩ</td>
</tr>
</tbody>
</table>
Resources

The End

Developed and Produced by the Instructors in the CIE Instruction Department.

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