ROHINI
COLLEGE OF ENGINEERING & TECHNOLOGY
Approved by AICTE and Affiliated to Anna University, (An ISO Certified Institution)
Near Anjugramam Junction, Kanyakumari Main Road, Palkulam, Variyoor P.O - 629 401

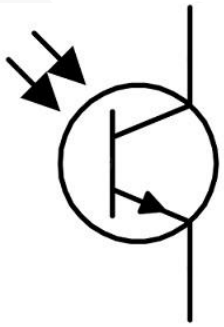
DEPARTMENT OF BIOMEDICAL ENGINEERING

III Semester- BM3301 SENSORS AND MEASUREMENTS

UNIT - 3

3.7 Photo Transistor

A phototransistor is a type of semiconductor device that belongs to the family of transistors. It is designed to detect light and is commonly used in various electronic circuits for light sensing applications. The phototransistor operates on the principle of the photovoltaic effect, where incident light generates electron-hole pairs in the semiconductor material, leading to a change in the transistor's conductivity.



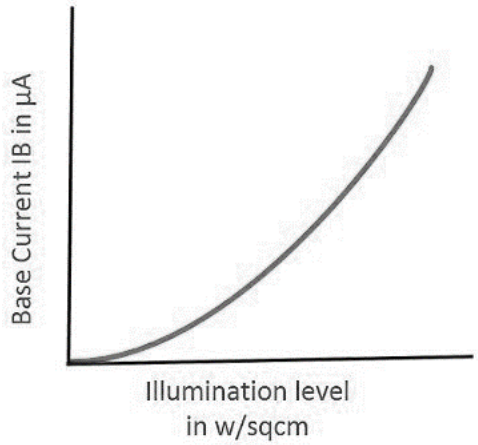
Phototransistor Symbol

Working Principle :

The working principle of a phototransistor is similar to a photodiode including an amplifying transistor. The light falls on the base terminal of a phototransistor then it will induce a little current then the current amplified through the action of a normal transistor, which results in an extensively large. Generally, as compared with a related photodiode, a phototransistor generates 50 – 100 times of a photodiode current.

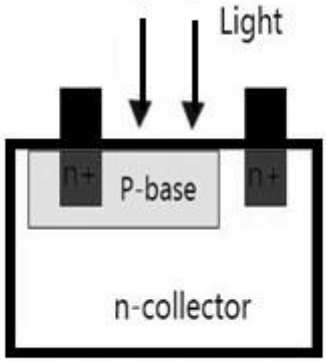
The phototransistor is fabricated with a semiconductor material. Once the light falls on the material then the charge carriers like holes or electrons of the semiconductor material can cause the current to supply within the base area. The base region of this can be used for transistor biasing.

When no light falls on the surface of the transistor, the small reverse saturation current induces on the transistor. The reverse saturation current induces because of the few minority charge carriers. The light energy falls on the collector-base junction and generates the more majority charge carrier which adds the current to the reverse saturation current. The graph below shows the magnitude of current increases along with the intensity of light.



Source: https://circuitglobe.com/phototransistor.html

Phototransistor Construction:



Construction of Phototransistor

Base Material:

The base material of a phototransistor is typically made of semiconductor materials such as silicon or germanium. Silicon is commonly used due to its widespread availability and cost-effectiveness

Emitter and Collector Regions:

Similar to a regular bipolar junction transistor (BJT), a phototransistor has three layers: the emitter, base, and collector. In the case of a phototransistor, the emitter and collector are the two outer layers. The light-sensitive region is usually the collector.

Base Region:

The middle layer is the base region. However, unlike a regular BJT, the base of a phototransistor is not externally biased. Instead, light photons are used to generate electron-hole pairs in the base-collector junction.

Construction of the Collector:

The collector region is designed to be larger in area compared to the emitter. This design maximizes the chances of light striking the collector region, generating more electron-hole pairs.

Transparent Window:

The collector region often has a transparent window, allowing light to reach the base-collector junction. This window is made of materials that are transparent to the specific wavelength of light that the phototransistor is designed to detect.

Metal Contacts:

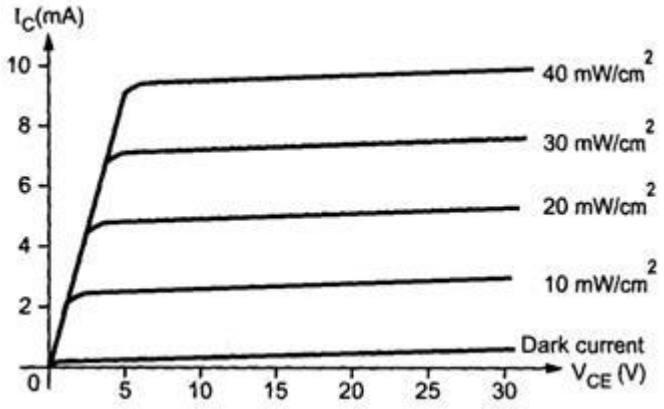
Metal contacts are placed on the emitter and collector regions to provide electrical connections to the external circuit.

Encapsulation:

The entire phototransistor is encapsulated in a protective material, such as epoxy or plastic, to shield it from environmental factors and to enhance its durability.

When light strikes the collector region, it generates electron-hole pairs in the base-collector junction. The resulting current flow between the emitter and collector is then amplified by the transistor action, producing an output current

proportional to the incident light intensity. The graph below shows the magnitude of current increases along with the intensity of light.



Characteristics of Photo transistor

Each curve on the characteristic graph is related to specific light intensity. The collector current level increases corresponding to increase in the light intensity. In most of the applications the phototransistor is used as a two-lead device. The phototransistor is not sensitive to all the light but sensitive to light within a certain range.

Difference between Photodiode and Phototransistor:

The main difference between photodiode and phototransistor includes the following.

	Photo Diode	Photo Transistor
1.	It is responsive more to incident light	It is not responsive more to incident light
2.	The linear response is high	The Linear Response is low
3.	It allows less current, so used in less power consumption applications	It allows more current, so used in high power consumption applications
4.	It is not sensitive	It is more Sensitive
5.	Dark current is low	Dark Current is High
6.	Operational Speed is high	Operational Speed is low
7.	Noise interference is less immune	Noise Interference is more immune
8.	It generates both current and voltage	It generates only current
9.	Output response is fast	Output response is slow

10.	The photodiode is used in solar power plants, in light meters, etc.	phototransistor is used for detecting light.

Advantages of Phototransistor

1. Simple, compact and less expensive.
2. Higher current, higher gain and faster response times in comparison with photodiodes.
3. Results in output voltage unlike photo resistors.
4. Sensitive to a wide range of wavelengths ranging from ultraviolet (UV) to infrared (IR) through visible radiation.
5. Sensitive to large number of sources including incandescent bulbs, fluorescent bulbs, neon bulbs, lasers, flames and sunlight.
6. Highly reliable and temporally stable.
7. Less noisy when compared to avalanche photodiodes.

Disadvantages of Phototransistor

1. Cannot handle high voltages if made of silicon.
2. Prone to electric spikes and surges.
3. Affected by electromagnetic energy.
4. Do not permit the easy flow of electrons unlike electron tubes.
5. Poor high frequency response due to a large base-collector capacitance.
6. Cannot detect low levels of light better than photodiodes.

Biomedical Applications of Phototransistors:

Phototransistors find several biomedical applications where the detection and measurement of light play a crucial role. Here are some biomedical applications of phototransistors:

- ✓ Phototransistors can be employed in PPG sensors to capture the pulsatile changes in blood volume, which are useful for ***monitoring heart rate*** and detecting various cardiovascular conditions.
- ✓ Phototransistors can be integrated into ***glucose sensors*** to measure the amount of light passing through or reflecting off a sample containing blood, providing information about glucose levels.
- ✓ Phototransistors can be used to detect the intensity of transmitted or reflected light, providing information about the ***oxygen levels in the blood***.

Other Applications of Phototransistor:

1. Object detection
2. Automatic electric control systems such as in light detectors
3. Security systems
4. Punch-card readers
5. Relays
6. Counting systems
7. Smoke detectors
8. Optical remote controls
9. CD players
10. Infrared receivers
11. Cameras as shutter controllers
12. Level comparators

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