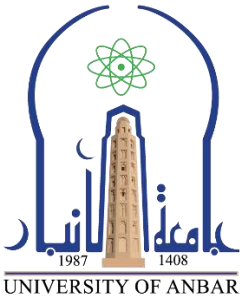

كلية : التربية للعلوم الصرفة

القسم او الفرع : الفيزياء

المرحلة: الثالثة

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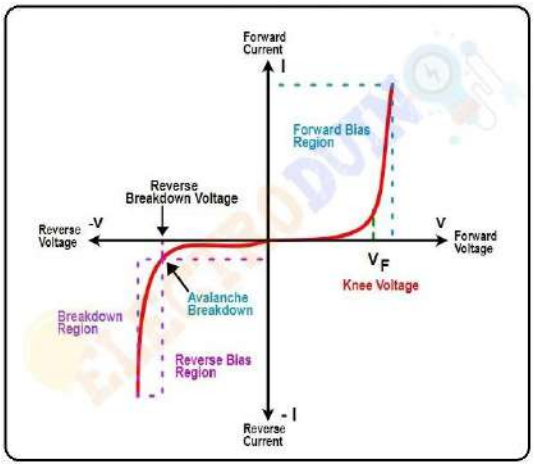
اسم المحاضرة باللغة العربية: الانحياز العكسي

اسم المحاضرة باللغة الإنكليزية : Reverse bias

Reverse Bias

Reverse Bias is a special condition in semiconductor devices. A semiconductor diode is a P-N junction diode. One part of it is made of P-type semiconductor material and the other half is made of N-type semiconductor material. A diode is made by diffusing both P and N semiconductors through a special process. The semiconductor diode is used in two ways in the circuit,

- In Forward Bias
- In Reverse Bias



What is a Diode?

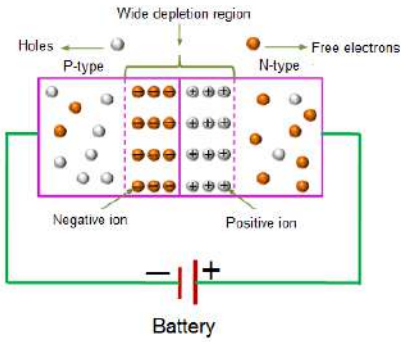
The complete name of the diode is Semi-Conductor Diode Valve. A diode is a one-way device with two ends - one known as the anode and the other known as the cathode. It functions in transforming alternating current to direct current. It can be also stated that the current flows in only one direction in this, and not in the opposite direction. Due to the fact that direct current only flows in one direction.

Reverse Bias Meaning

When a battery is connected to a P-N Junction Diode with the positive terminal to the N-region and the negative terminal to the P-region, it is known as Reverse Bias. As illustrated in the diagram of the circuit below. When the P-N Junction Diode is under reverse bias. Next, the P-region loses holes to the negative terminal of the battery, while the N-region loses electrons to the positive terminal.

As electrons and holes separate from the junction, the depletion layer width expands. The barrier potential increases proportionally with the increase in the width of the depletion layer.

The movement of holes and electrons towards the battery terminals happens rapidly. The barrier potential's polarity at the junction matches the reverse voltage applied externally.
Because the Barrier Potential is too high, some atoms in the P and N region break their bonds, leading to the generation of electrons and holes, which are referred to as Minority Charge Carriers since they are in low numbers.
Because of these carriers of charge, a small electric current begins to flow in the diode known as Reverse Current. The current in the opposite direction is minimal. It is extremely uncommon for us to disregard it.
The amount of minority charge carriers produced in reverse bias is determined by the temperature of the junction within a specific range of applied external reverse voltage, rather than the externally applied voltage.
When the temperature at the junction is maintained at a constant level, the reverse current also remains constant over a specific range of applied external reverse voltage, which is known as Reverse Saturation Current



Reverse bias

Functioning Of Reverse Bias

When the diode is reverse biased, holes are collected at the negative battery end due to it being connected to the P type material, while electrons collect at the positive end connected to the N type material. This causes both holes and electrons to move further from the junction, resulting in an increase in the thickness of the junction barrier. Therefore, there is no flow of electric current across the junction.

Current Flow in Reverse Bias

It is seen that in a reverse-biased diode, some current flows through the depletion region. This current is called leakage current. Leakage current is dependent on minority current carriers, the minority carriers are electrons in the P type material and holes in the N type material. The following figure shows how current carriers react when a diode is reverse biased.

PN Junction Diode.

Connection of p-type and n type semiconductors using a special technique results in the development of PN Junction at that point where the two types of semiconductors connect with each other. However, the nature of a device developed after junction is similar to that of diode valve. Therefore, this is termed as P-N Junction Diode.

When the two types of impure semiconductors are blended, charge carriers (free electrons and holes) begin to travel through diffusion at the junction. Holes emerge from the P-Type semiconductor and travel into the N- Type one, electrons come out from the latter diffusing to enter the former. After diffusion, the charge carriers reverse their charges. In this manner a thin neutral layer is created on either side of the junction. In this neutral layer, there are no charge carriers of any type. This middle layer has no net charge and is called the Depletion Layer. Width of this layer is about 10-6m.

Diffusion of charge carriers causes an increase in positively charged holes for the n-region and negatively charged electrons with the p-region near to junction. This leads to the formation of a potential difference across the junction, which is known as Barrier Potential. Consequently, an internal electric field arises at the junction whose direction points from n-region to p-region. Sometime later, this domain gets so powerful that charge carrier diffusion halts.

Reverse Bias p-n Junction

In reverse bias condition p-n junction diode, the positive terminal attracts the electron away from the junction in N side and the negative terminal attracts the holes away from the junction in P side.

Advantages and Disadvantages of Reverse Bias

Various advantages and disadvantages of reverse bias condition in any diode are added below,

Advantages of Reverse Bias

Advantages of reverse bias in any diode are,

- **Reduction in Current Flow:** The main benefit of the reverse bias is that it greatly decreases current flow through a semiconductor device. It can be effective in managing and controlling functionality of electronic devices.
- **Barrier Broadening:** In reverse-biased diode the depletion zone increases in width. It also increases the barrier potential, limiting charge carriers to move across. This characteristic is an important feature of diodes and transistors.
- **Breakdown Voltage:** The method of reverse bias is used to investigate and determine the breakdown voltage in a semiconductor device. The breakdown voltage is the highest reverse bias that can occur without causing a rapid increase in current, leading to device failure.
- **Zener Diode Operation:** A zener diode requires reverse bias for its proper functioning. Zener diodes are operated in the reverse breakdown, which allows almost unchanging voltage over a diode regardless of variations of the current.

Disadvantages of Reverse Bias

Disadvantages of the reverse bias in any diode are,

- **Leakage Current:** Under the reverse bias, even though a very small amount of current which is called leakage current may sometimes pass through the semiconductor device. This could lead to power dissipation and its effect on the device's performance.
- **Avalanche Breakdown:** In certain instances, reverse bias voltage can result in avalanche breakdown if it is too high. This is a transient peak in current owing to the generation of pairs from collisions at this depletion region resulting into destruction of device.

- **Time-Dependent Effects:** Moreover, long-term exposure to reverse bias conditions in high temperatures can result in time-dependent effects that lower the device's semiconductor reliability over a period.
- **Recovery Time:** Some of the semiconductor devices that have been subjected to reverse bias may take some time for recovery before they are able revert back into their normal operating state. While recovering, the device might not work as planned.

Applications of Reverse Bias

Some applications of reverse bias are,

1. **Zener Diode:** Zener diodes are specifically designed to operate in reverse bias. These are employed as voltage regulators in electronic circuits, maintaining a nearly constant voltage across the diode over a wide range of currents.
2. **Photodiode:** Reverse bias is applied to the photodiode to create a depletion region that increases sensitivity to light. When photons strike the photodiode, they generate electron-hole pairs, creating a photocurrent that can be measured.
3. **Avalanche Photodiodes:** Similar to regular photodiodes, avalanche photodiodes use reverse bias to induce avalanche breakdown, resulting in high sensitivity to low levels of light. These are often used in applications where high speed and low light detection are important, such as fiber optic communications.
4. **Varactor Diodes:** Varactor diodes, also known as voltage-variable capacitors, are reverse-biased to take advantage of the change in capacitance with applied voltage. They find applications in voltage-controlled oscillators, phase-locked loops, and frequency modulators in communication systems.
5. **Avalanche Transistor:** Some transistors, such as avalanche transistors, are designed to operate in reverse avalanche breakdown. This feature is used in some high-frequency applications, such as RF (radio frequency) amplifiers.
6. **Breakdown Voltage Testing:** Reverse bias is often used in testing semiconductor devices to determine their breakdown voltage, an

important parameter in understanding device reliability and performance limits.