**Define Avalanche diodes**

An avalanche diode is a special type of semiconductor device designed to operate in reverse breakdown region. Avalanche diodes are used as relief valves (a type of valve used to control the pressure in a system) to protect electrical systems from excess voltages.

**Describe working principles of Avalanche diodes**

A normal [p-n junction diode](https://www.physics-and-radio-electronics.com/electronic-devices-and-circuits/semiconductor-diodes/pnjunctionsemiconductordiode.html) allows electric current only in forward direction whereas an avalanche diode allows electric current in both forward and reverse directions. However, avalanche diode is specifically designed to operate in reverse biased condition.

Avalanche diode allows electric current in reverse direction when reverse bias voltage exceeds the breakdown voltage. The point or voltage at which electric current increases suddenly is called breakdown voltage.

When the reverse bias voltage applied to the avalanche diode exceeds the breakdown voltage, a [junction breakdown](https://www.physics-and-radio-electronics.com/electronic-devices-and-circuits/semiconductor-diodes/depletionregionbreakdown.html) occurs. This junction breakdown is called avalanche breakdown.

When forward bias voltage is applied to the avalanche diode, it works like a normal p-n junction diode by allowing electric current through it.

When reverse bias voltage is applied to the avalanche diode, the [free electrons](https://www.physics-and-radio-electronics.com/electronic-devices-and-circuits/introduction/free-electrons.html) (majority carriers) in the [n-type semiconductor](https://www.physics-and-radio-electronics.com/electronic-devices-and-circuits/semiconductor/extrinsic-semiconductor/n-type-semiconductor.html) and the [holes](https://www.physics-and-radio-electronics.com/electronic-devices-and-circuits/semiconductor/hole.html)(majority carriers) in the [p-type semiconductor](https://www.physics-and-radio-electronics.com/electronic-devices-and-circuits/semiconductor/extrinsic-semiconductor/p-type-semiconductor.html)are moved away from the junction. As a result, the width of depletion region increases. Therefore, the majority carriers will not carry electric current. However, the minority carriers (free electrons in p-type and holes in n-type) experience a repulsive force from external voltage.

As a result, the minority carriers flow from p-type to n-type and n-type to p-type by carrying the electric current. However, electric current carried by minority carriers is very small. This small electric current carried by minority carriers is called reverse leakage current.

If the reverse bias voltage applied to the avalanche diode is further increased, the minority carriers (free electrons or holes) will gain large amount of [energy](https://www.physics-and-radio-electronics.com/physics/energy/what-is-energy.html)and accelerated to greater velocities.

The free electrons moving at high speed will collide with the [atoms](https://www.physics-and-radio-electronics.com/electronic-devices-and-circuits/introduction/atom.html)and transfer their energy to the [valence electrons](https://www.physics-and-radio-electronics.com/electronic-devices-and-circuits/introduction/valence-electrons.html)

The valance electrons which gains enough energy from the high-speed electrons will be detached from the parent atom and become free electrons. These free electrons are again accelerated. When these free electrons again collide with other atoms, they knock off more electrons.

Because of this continuous collision with the atoms, a large number of minority carriers (free electrons or holes) are generated. These large numbers of free electrons carry excess current in the diode.

When the reverse voltage applied to the avalanche diode continuously increases, at some point the junction breakdown or avalanche breakdown occurs. At this point, a small increase in voltage will suddenly increases the electric current. This sudden increase of electric current may permanently destroys the normal p-n junction diode. However, avalanche diodes may not be destroyed because they are carefully designed to operate in avalanche breakdown region.

The breakdown voltage of the avalanche diode depends on the doping density. Increasing the doping density will decreases the breakdown voltage of the avalanche diode.

**Applications of Avalanche diodes**

* Avalanche diodes can be used as white noise generators.
* Avalanche diodes are used in protecting circuits.

**Comparison Of Avalanche Diode to PIN diodes**

**PIN diode :**

* PIN photodiode does not have a high-intensity electric field region.
* Sensitivity is very low in PIN photodiode.
* The responsibility of a PIN diode is limited.
* Cost is low.
* S/N ratio is very poor.
* Conversion efficiency is 0.5 to 1.0 amps/watt.
* The response time of PIN is half that of APD.
* The detector circuit is very simple.

**APD :**

* APD is a high-intensity electric field region.
* Sensitivity is very high in APD.
* The responsibility of APD can have much larger values,
* Cost is high.
* S/N ratio is better.
* Conversion efficiency is 0.5 to 100 Amps/watt.
* The response time of APD is almost doubl