SNS COLLEGE OF TECHNOLOGY

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COIMBATORE-35
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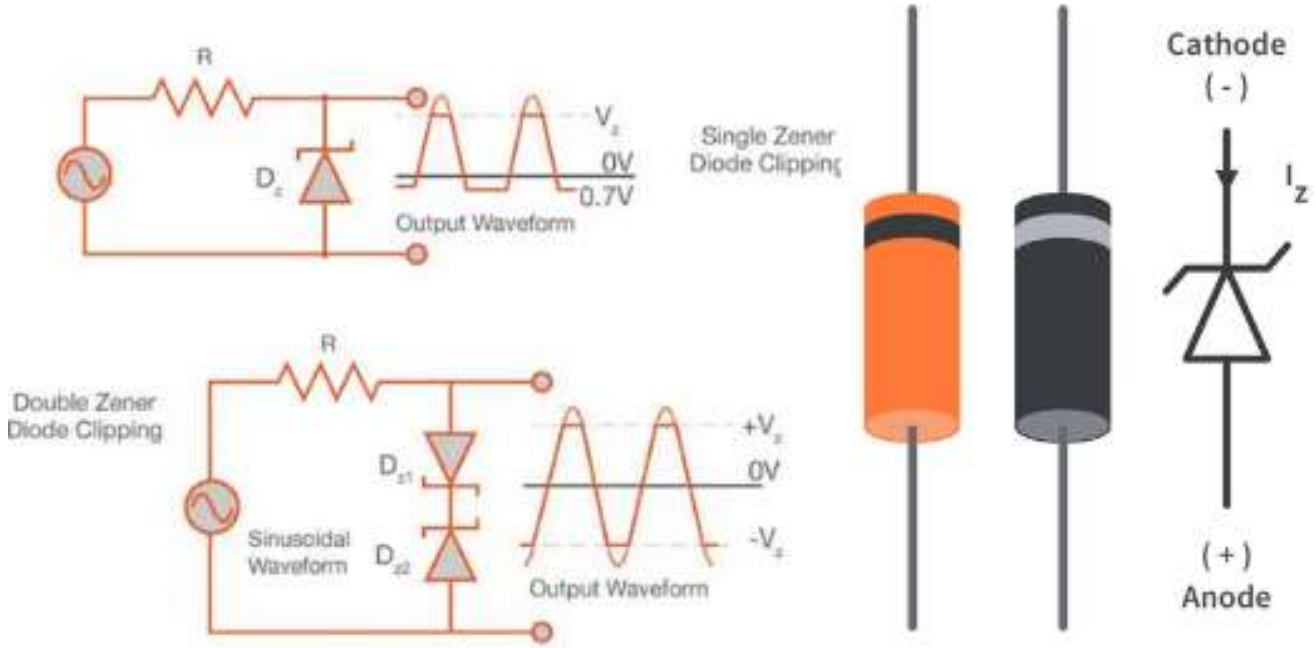
23EET104 / ANALOG ELECTRONICS CIRCUITS
I YEAR / II SEMESTER

UNIT-I: PN JUNCTION DEVICES

ZENER DIODE

TOPIC OUTLINE

- ✓ Introduction
- ✓ Breakdowns
- ✓ VI characteristics
- ✓ Applications



Introduction

A Zener diode operates just like a normal diode when it is forward-biased. However, when connected in reverse biased mode, a small leakage current flows through the diode. As the reverse voltage increases to the predetermined breakdown voltage (Vz), current starts flowing through the diode. The current increases to a maximum, which is determined by the series resistor, after which it stabilizes and remains constant over a wide range of applied voltage.

There are two types of breakdowns for a Zener Diode:

Avalanche Breakdown

Zener Breakdown

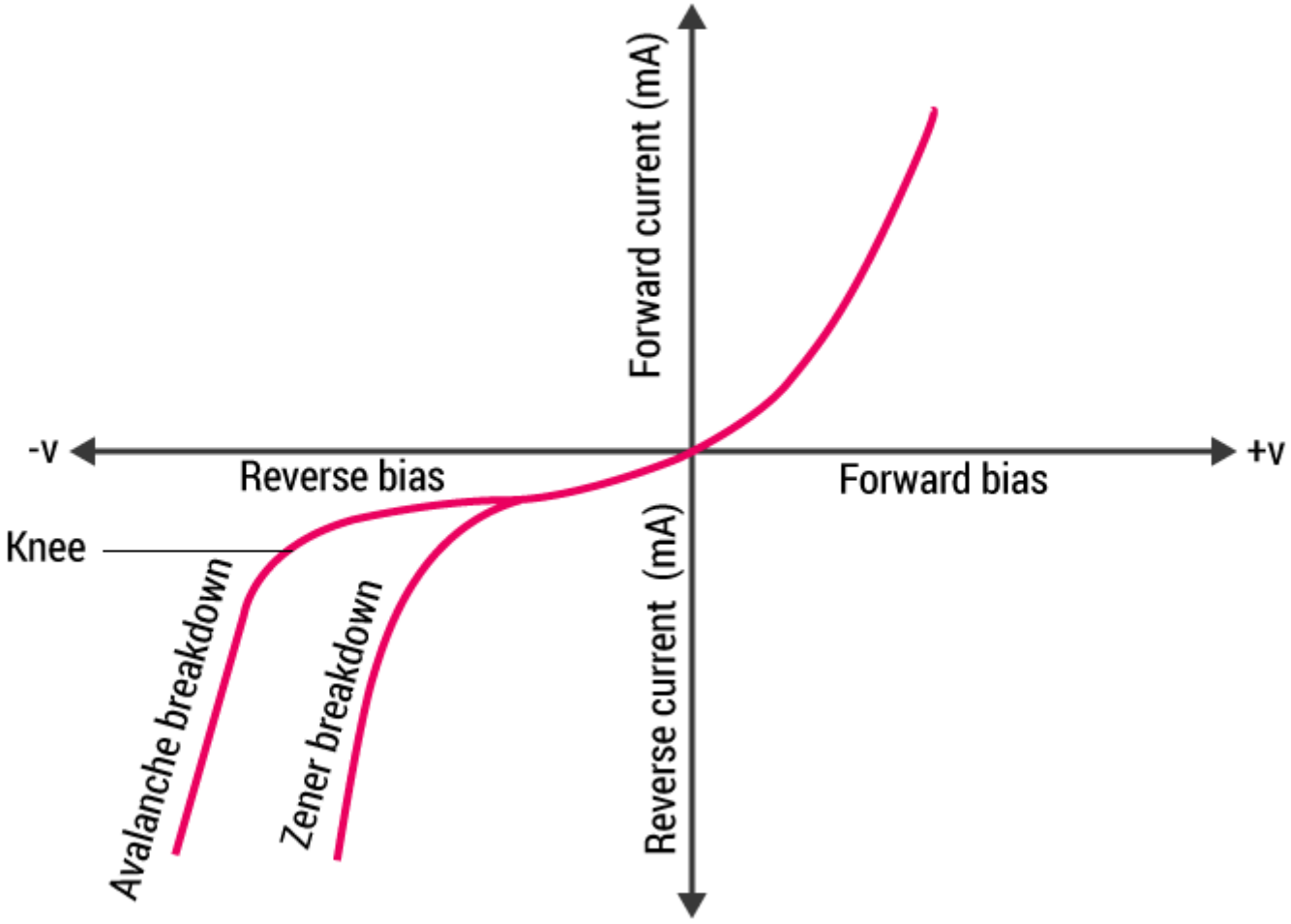
Avalanche Breakdown in Zener Diode

Avalanche breakdown occurs both in normal diode and Zener Diode at high reverse voltage. When a high value of reverse voltage is applied to the PN junction, the free electrons gain sufficient energy and accelerate at high velocities. These free electrons moving at high velocity collides other atoms and knocks off more electrons. Due to this continuous collision, a large number of free electrons are generated as a result of electric current in the diode rapidly increases. This sudden increase in electric current may permanently destroy the normal diode, however, a Zener diode is designed to operate under avalanche breakdown and can sustain the sudden spike of current. Avalanche breakdown occurs in Zener diodes with Zener voltage (Vz) greater than 6V.

Zener Breakdown in Zener Diode

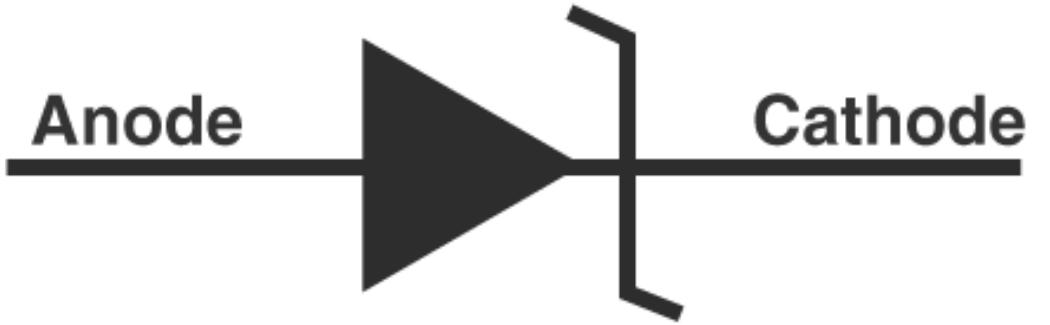
When the applied reverse bias voltage reaches closer to the Zener voltage, the electric field in the depletion region gets strong enough to pull electrons from their valence band. The valence electrons that gain sufficient energy from the strong electric field of the depletion region break free from the parent atom. At the Zener breakdown region, a small increase in the voltage results in the rapid increase of the electric current.

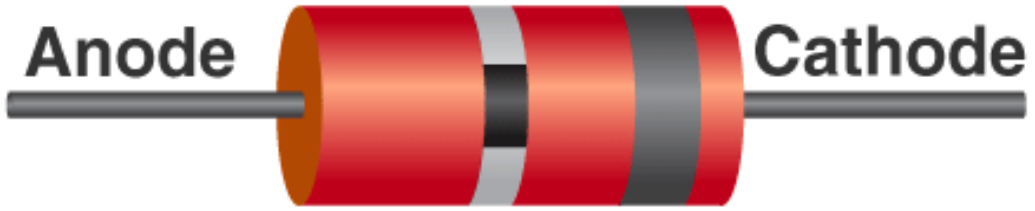
Difference Between Zener Breakdown and Avalanche Breakdown



Zener Breakdown	Avalanche Breakdown
The process in which the electrons move across the barrier from the valence band of p-type material to the conduction band of n-type material is known as Zener breakdown.	The process of applying high voltage and increasing the free electrons or electric current in semiconductors and insulating materials is called an avalanche breakdown.
This is observed in Zener diodes having a Zener breakdown voltage V_z of 5 to 8 volts.	This is observed in Zener diode having a Zener breakdown voltage V_z greater than 8 volts.
The valence electrons are pulled into conduction due to the high electric field in the narrow depletion region.	The valence electrons are pushed to conduction due to the energy imparted by accelerated electrons, which gain their velocity due to their collision with other atoms.
The increase in temperature decreases the breakdown voltage.	The increase in temperature increases the breakdown voltage.
The VI characteristics of a Zener breakdown has a sharp curve.	The VI characteristic curve of the avalanche breakdown is not as sharp as the Zener breakdown.
It occurs in diodes that are highly doped.	It occurs in diodes that are lightly doped.

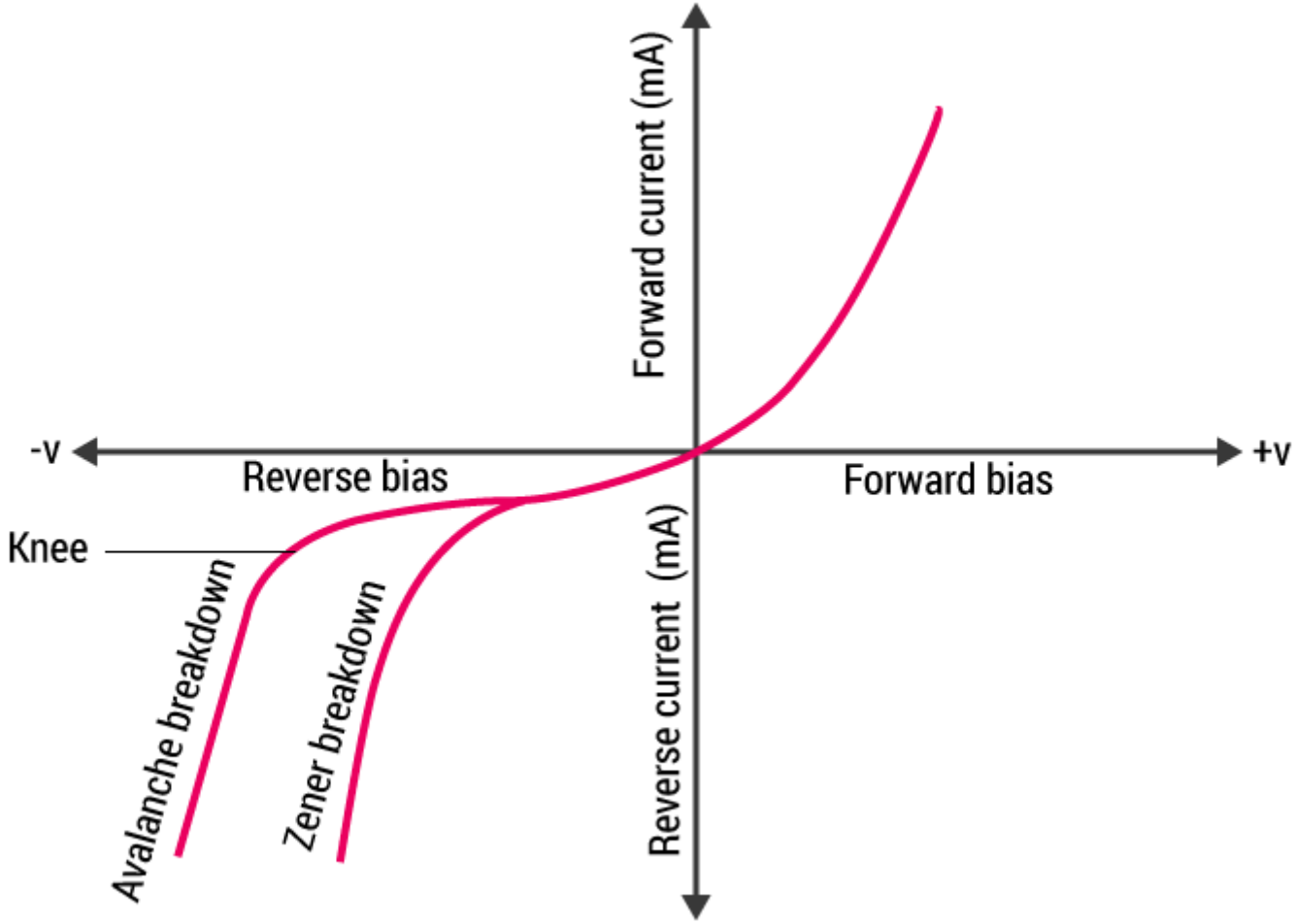
Circuit Symbol of Zener Diode





(Zener diode)

V-I Characteristics of Zener Diode



Forward Characteristics of Zener Diode

- The first quadrant in the graph represents the forward characteristics of a Zener diode. From the graph, we understand that it is almost identical to the forward characteristics of any other P-N junction diode.

Reverse Characteristics of Zener Diode

- When a reverse voltage is applied to a Zener voltage, initially a small reverse saturation current Io flows across the diode. This current is due to thermally generated minority carriers. As the reverse voltage is increased, at a certain value of reverse voltage, the reverse current increases drastically and sharply. This is an indication that the breakdown has occurred. We call this voltage breakdown voltage or Zener voltage and it is denoted by Vz.

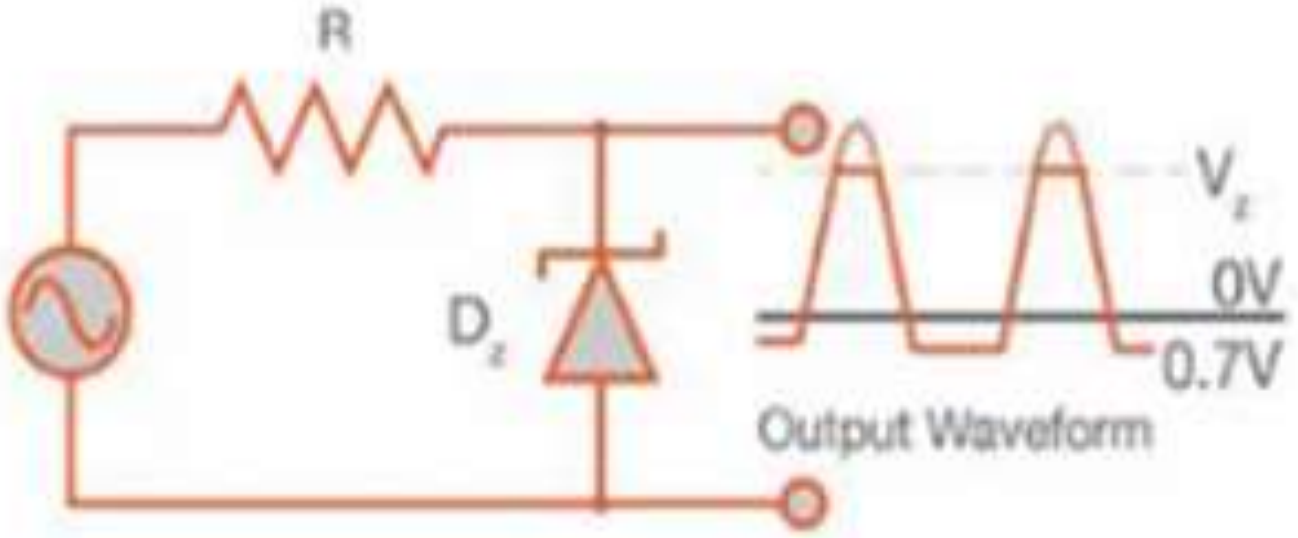
Zener Diode Specifications

- **Zener/Breakdown Voltage** – The Zener or the reverse breakdown voltage ranges from 2.4 V to 200 V, sometimes it can go up to 1 kV while the maximum for the surface-mounted device is 47 V.
- **Current Iz (max)** – It is the maximum current at the rated Zener Voltage (Vz – 200μA to 200 A)
- **Current Iz (min)** – It is the minimum value of current required for the diode to breakdown.
- **Power Rating** – It denotes the maximum power the Zener diode can dissipate. It is given by the product of the voltage of the diode and the current flowing through it.
- **Temperature Stability** – Diodes around 5 V have the best stability
- **Voltage Tolerance** – It is typically ±5%
- **Zener Resistance (Rz)** – It is the resistance to the Zener diode exhibits.

Application of Zener Diode

Zener diode as a voltage regulator:

Zener diode is used as a Shunt voltage regulator for regulating voltage across small loads. The breakdown voltage of Zener diodes will be constant for a wide range of current. Zener diode is connected parallel to the load to make it reverse bias and once the Zener diode exceeds knee voltage, the voltage across the load will become constant.



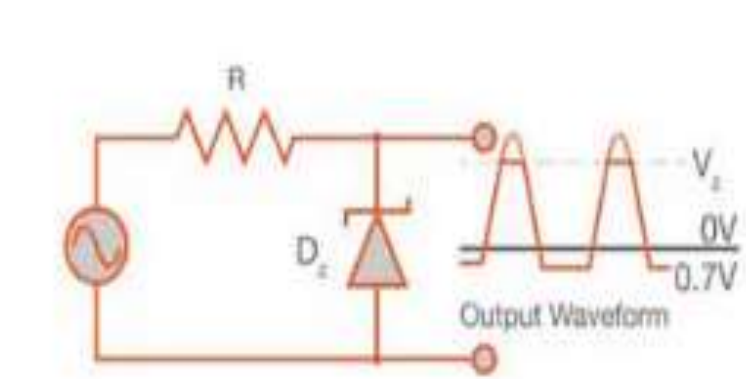
Application of Zener Diode

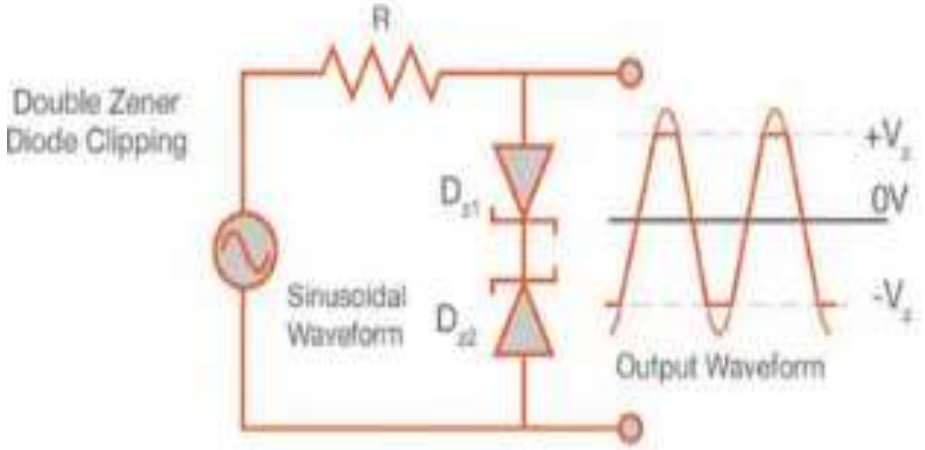
Zener diode in over-voltage protection:

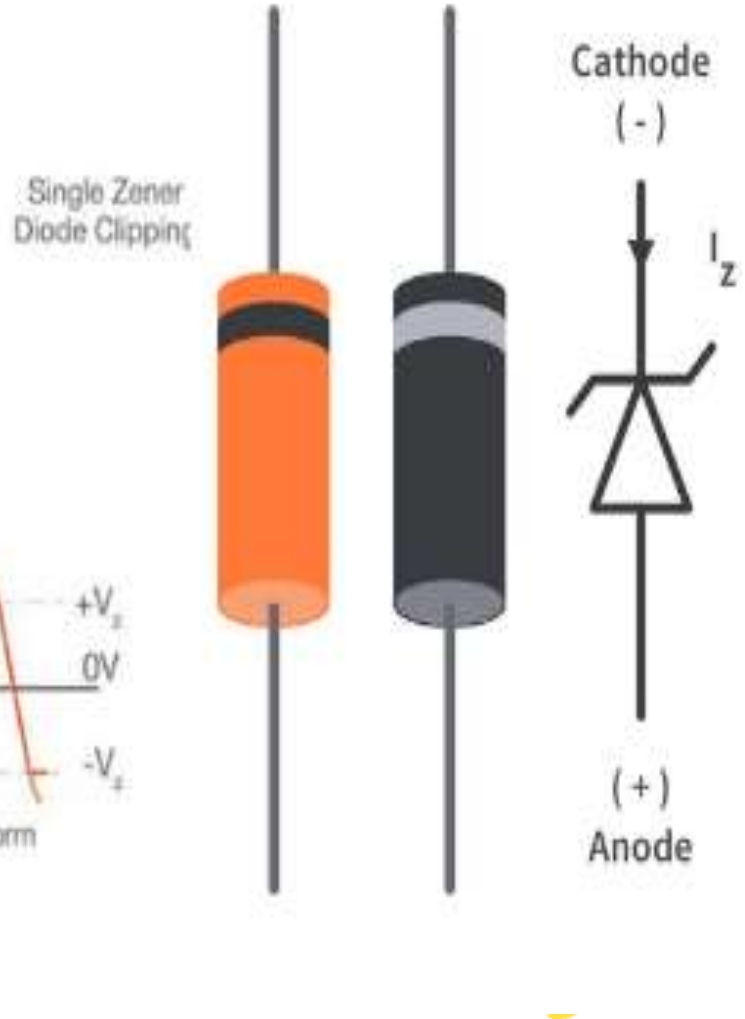
When the input voltage is higher than the Zener breakage voltage, the voltage across the resistor drops resulting in a short circuit. This can be avoided by using the Zener diode.

Zener diode in clipping circuits:

Zener diode is used for modifying AC waveform clipping circuits by limiting the parts of either one or both the half cycles of an AC waveform.







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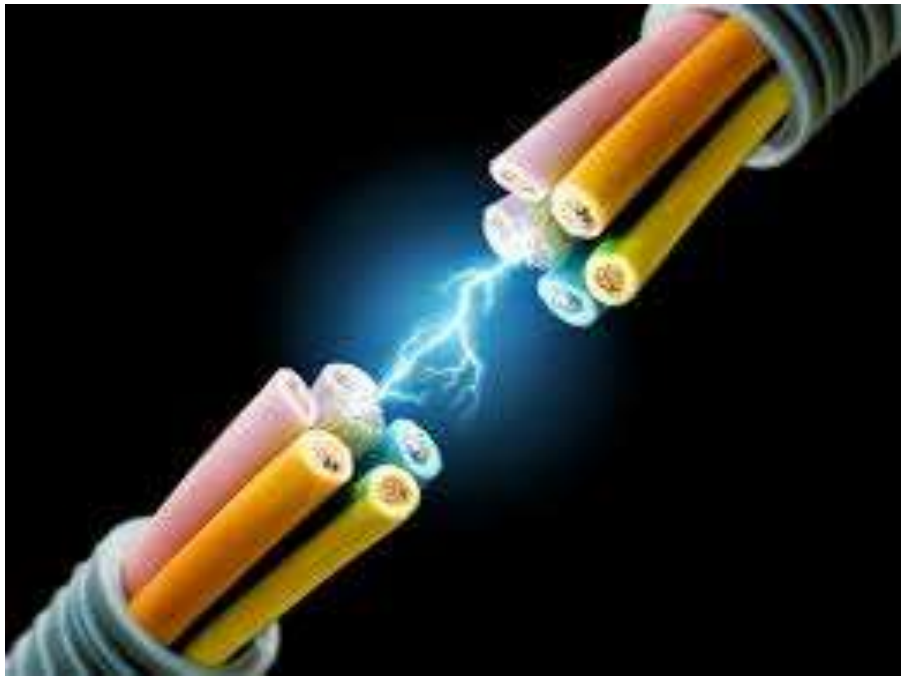

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