Shariatpur polytechnic Institute

INDUSTRIAL ELECTRONICS

SUB. CODE: 26833

PRESENTED BY

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Learning Outcome (Theoretical)

After Completing the subject, students will be able to:

✓ State the Power Electronics and Power diode.

✓ Describe the features of power Transistor (MOSFET, IGBT).

✓Describe the features of UJT &GTO.

✓ escribe the features of OP-Amp.

✓Describe the features of Thyristor.

✓ Describe the features of DIAC and TRIAC.

✓ Describe the features of Single & Three phase AC to DC conversion.

✓ State the features of Chopper.

✓ State the features of Inverter.

✓ State the features of Cycloconverter.

✓ State the features of AC voltage controller.

✓ State the features of Induction and Dielectric Heating.

✓ State the Features of Power Supply.

✓ State the features of safety system.

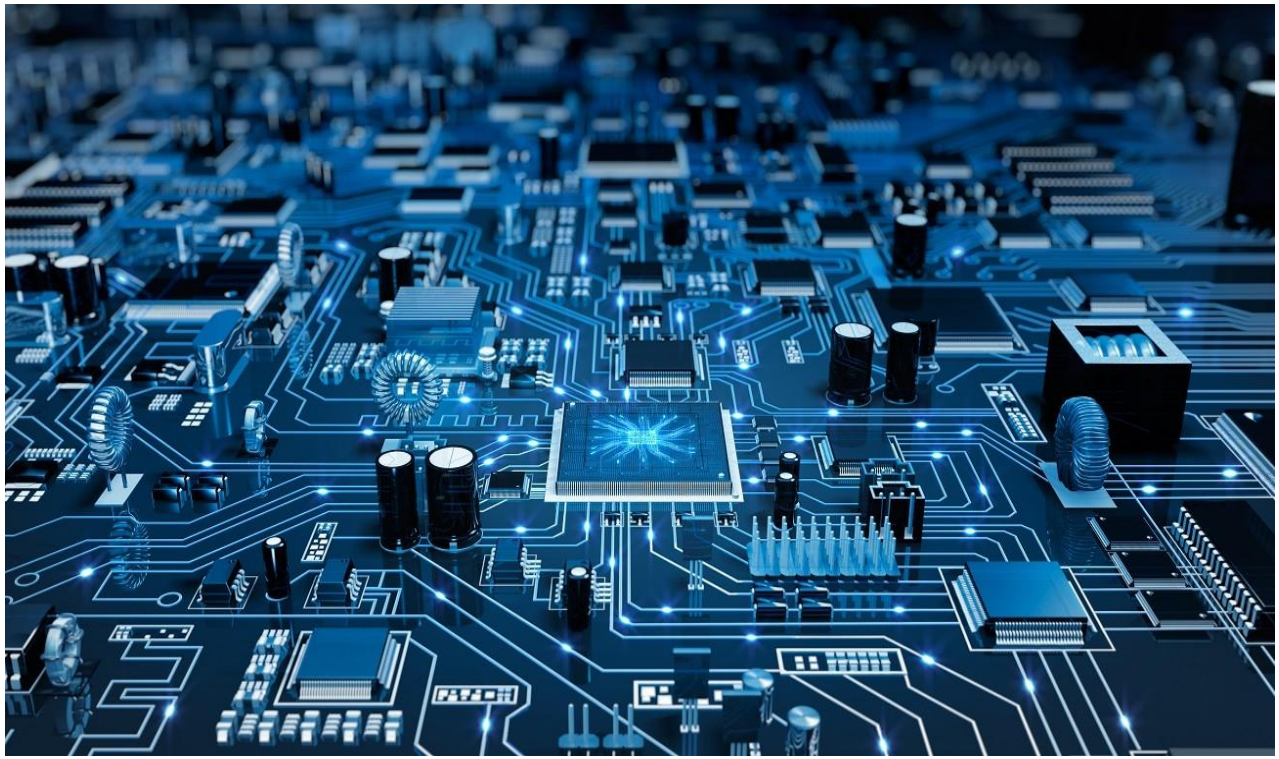
Learning Outcome (Practical)

After undergoing the subject, students will be able to:

✓ Determine the V-I characteristics of series connected diodes.
✓ Determine the V-I characteristics of IGBT.
✓ Determine the V-I characteristics of GTO.
✓ Observe the operation of relaxation oscillator by using UJT.
✓ Perform the operation of SCR as a single phase control.
✓ Determine the V-I characteristics curve of DIAC & TRIAC.
✓Observe the step down & step-up operation of DC Choppers.
✓Perform the operation of Inverter Circuit.
✓ Observe the operation of Cycloconverter.
✓Observe the operation of SMPS/UPS.

Chapter- 1

POWER ELECTRONICS AND POWER DIODE



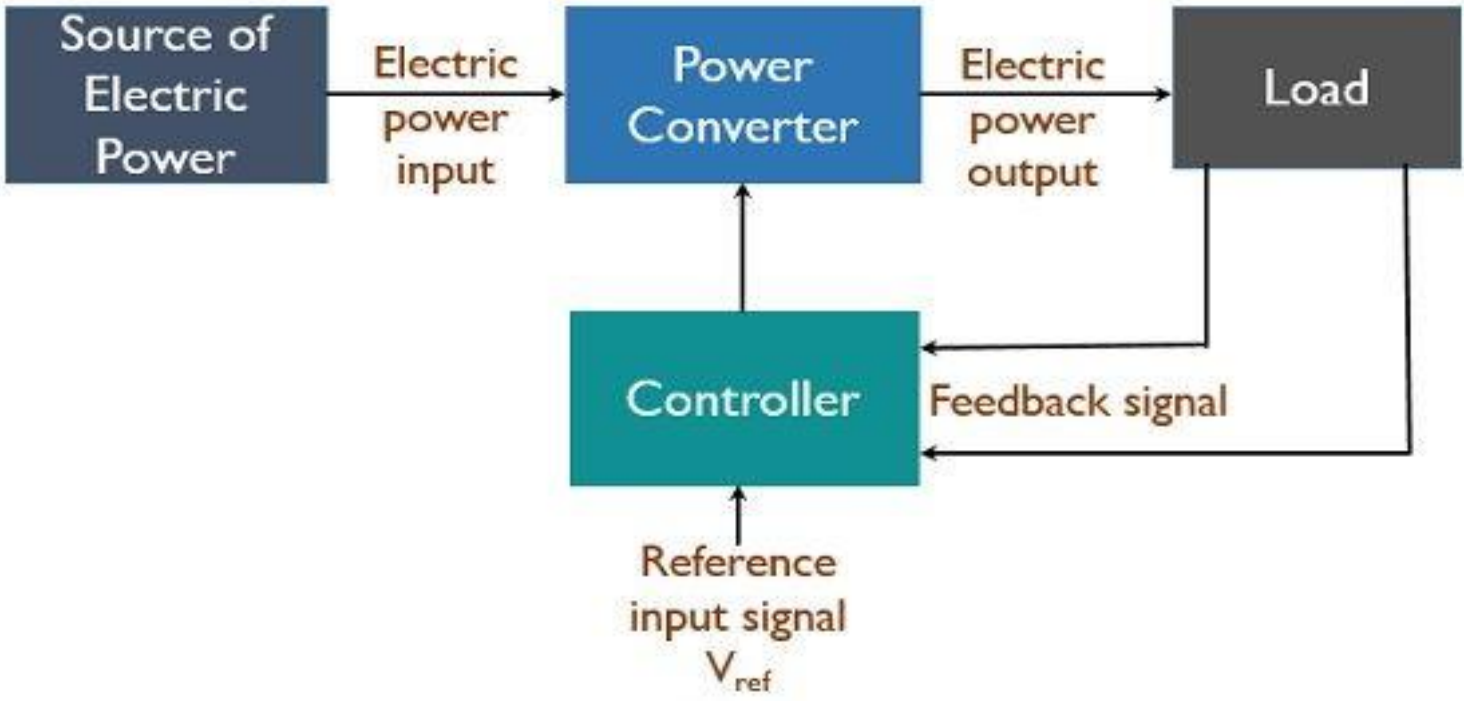
Power Electronics

A study that utilizes electronic power devices from converting one form of electric power into another form of electric power with proper control is known as **Power Electronics**. Basically, in power electronics, solid-state electronics, is used that performs the action of control and convert of the electric power.

- ✓ The first high-power electronic devices were made using mercury-arc valves.
- ✓ In modern systems, the conversion is performed with semiconductor switching devices such as diodes, thyristors and power transistors such as the power MOSFET and IGBT.

Block Diagram of Power Electronics

The figure below represents the block diagram of a power electronics-based system:

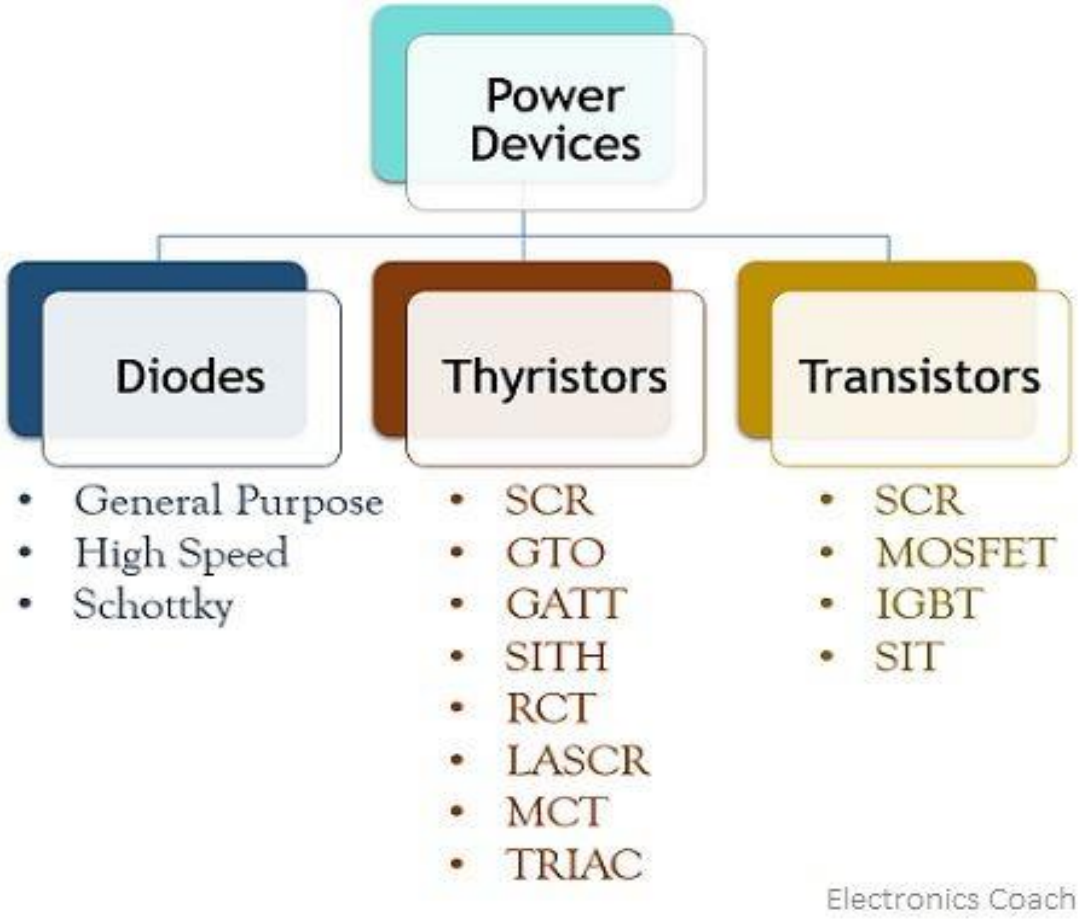


Block Diagram of Power Electronics based system

Electronics Coach

Power Semiconductor Devices

The pictorial representation given below shows the classification of power semiconductors devices in power control circuits:



Applications of Power Electronics

Power electronics shows numerous uses in various technological fields like industrial automation, energy generation and conversion, environmental pollution control, etc. Its major uses are as follows

Industries: In chemical processing equipment, welding, lighting, electroplating, pumps, and compressors, induction heating, boiler, conveyors, cranes, electromagnets, electric vehicles and furnaces, etc.

Home Appliances: Refrigerators, vacuum cleaners, washing machines, sewing machines, dryers, mixers and grinders, air conditioning, etc.

Commercial: Computers, electric fans, vending machines, audio amplifiers, battery charges, photocopiers, etc.

Medical: Medical instruments and machines, fitness and test machines, etc.

Automotive and Security systems: Electric vehicles, regulators, Radar/Sonar, Alarms, etc.

Aerospace: Satellite systems, aircraft and space vehicles, spaceship power systems, etc.

Transportation: Motor drives, trains, trollies and subways, locomotives, streetcars, elevators, magnetic levitation, etc.

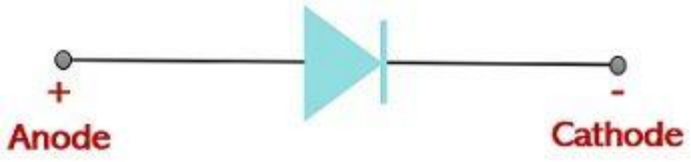
Telecommunication: DC power supply, UPS, wireless communication, transmitters, and receivers, etc.

Power systems: Static circuit breakers, thyristor controlled reactors, energy storage systems, harmonics suppression, etc.

Power Diodes

A power diode or high-power diode is one of the power semiconductor devices that have two terminals (cathode and anode) similar to the normal PN junction diode but exhibit higher power handling capability. These are designed to handle several kiloamps of current in forward biased condition with negligible power loss and must block several kilovolts under reverse-biased state.

Symbolically a power diode is represented as:



Symbol of Power Diode

Types of power semiconductor diode.

The power diodes depending on the reverse recovery time as well as the process of manufacturing are classified into three types such as

General Purpose Diodes
Fast Recovery Diodes
Schottky Diodes

General Purpose Diodes

These diodes have huge reverse recovery time around 25μs; therefore they are applicable in low frequency (up to 1 kHz) & low-speed operations (up to 1- kHz).

Fast Recovery Diodes

These diodes have quick recovery act due to their very small reverse recovery time less than 5μs, used in high-speed switching applications

Schottky Diodes

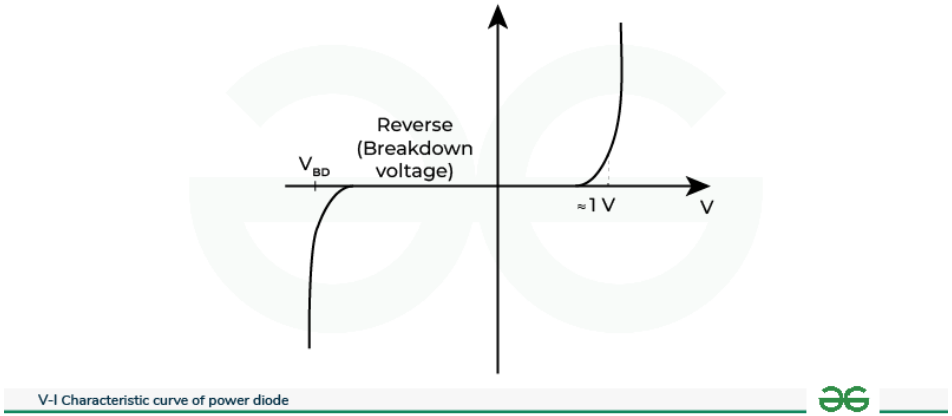
A Schottky diode is one type of electronic component, which is also known as a barrier diode. It is widely used in different applications like a mixer, in radio frequency applications, and as a rectifier in power applications.

The power diodes depending on the penetration of the depletion region are reversed biased condition are classified into two types such as

Punch through Diodes
Non-Punch through Diodes

V-I characteristics of Power diode.

The V-I (voltage-current) characteristics of a power diode describe its behavior in terms of voltage and current when operating in different modes.



V-I Characteristic curve of power diode

✓ With increase of the source voltage Vs from zero to cut- in voltage, the forward- diode current is veritably small.

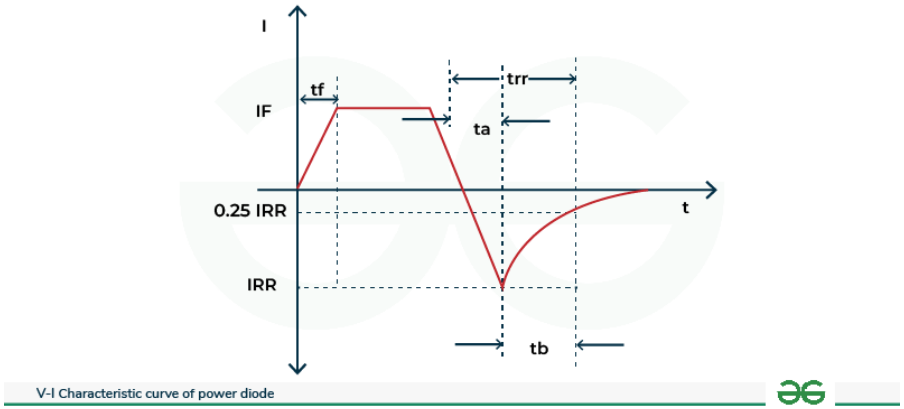
✓ Cut- in voltage is also known as threshold voltage or turn- on voltage.

✓ The current of the diode rises rapidly for the values lying beyond the cut-in voltage and the diode starts conducting.

✓ For silicon diode, the cut- in voltage is around 0.7 V. When diode conducts, there's a forward voltage drop of the order of 0.8 ~1V.
✓ For high power diodes, the forward current grows linearly with increase in voltage.
✓ For low power diodes, the forward current first increases exponentially with the voltage and then becomes linear with respect to change in voltage.
✓ In the reverse biased condition, a small reverse current called leakage current, arises.
✓ The leakage current is nearly independent of the magnitude of reverse voltage until this voltage reaches breakdown voltage. At this breakdown point, voltage remains nearly constant but reverse biased current becomes relatively high-limited only by the external circuit resistance.
✓ By operating the diode below the peak reverse repetitive voltage V_{RRM} .
✓ Peak Inverse Voltage is the largest reverse voltage to which a diode may be subordinated during its working. PIV is the same as V_{RRM}

Reverse Recovery Characteristics

Reverse Recovery Characteristics shows the behavior of power diode, when transitioning from the conduction state to the non-conducting state. Given below is the graph fo Reverse Recovery Characteristic of power diode.



➢When a diode is forward-biased, it conducts current easily. However, when the polarity reverses and the diode become reverse-biased, there's a brief period where the diode doesn't immediately stop conducting. During this time, known as the reverse recovery time (trr), carriers (electrons or holes) that were previously injected into the diode take some time to get extracted.

- This reverse recovery time (trr), is essential because during this interval, the diode is still conducting, which might cause issues in certain applications, especially in high-frequency circuits or power electronic systems.

- The reverse recovery characteristic is typically depicted on a graph showing the reverse recovery current (I_{RR}), which is the residual current flowing momentarily during the transition period, and the reverse recovery time, the time it takes for the diode to fully stop conducting after the polarity reverses.

- The diode regains its blocking capability unit reverse recovery current decays to zero.

- Reverse recovery time- (trr)- The reverse recovery time is defined as the amount of time during the interval in which the forward current is zero and the reverse recovery current reaches 25% of its maximum value.

- During the time ta, the charge stored in depletion layer is removed. During tb, charge from the semiconductor layers is removed.

V-I characteristics of series connected diodes.

Series connection means a side by side connection. When two components are connected in series, they have one common junction. The variation of voltage and current in a series connection is as follows:

✓ Potential difference across every component is different.

✓The current across every component connected in series remains the same.

The same properties also hold true for diodes when they are connected in a series configuration.

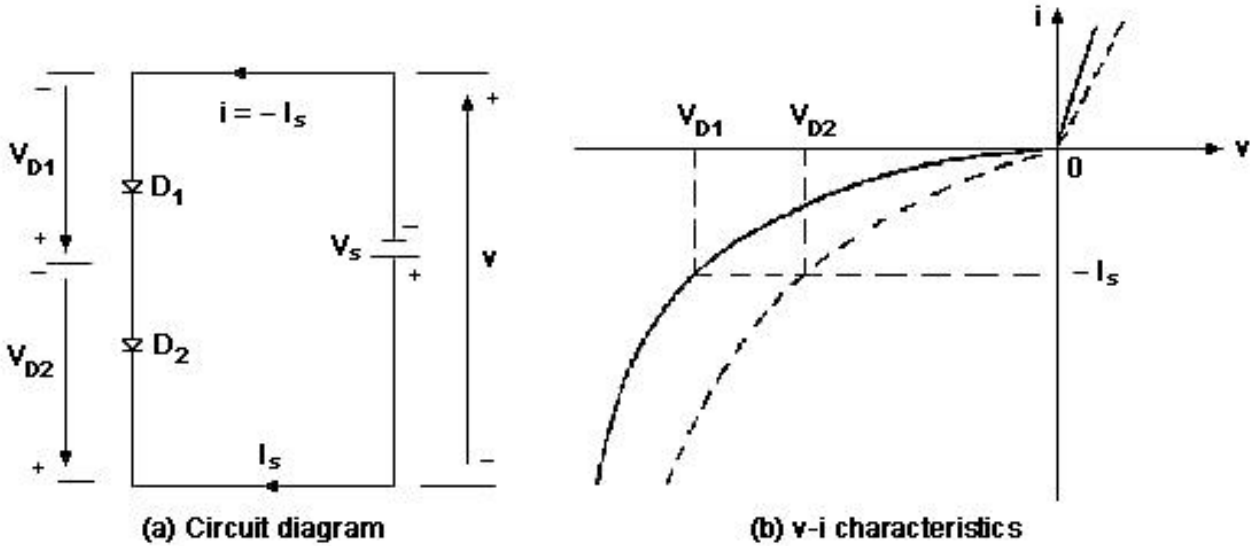
Diode Characteristics in Series Configuration

When connected in series, we observe the following properties to hold true among the diodes:

✓ Resultant diode's forward voltage increases.

✓ Reverse blocking capabilities of diodes are increased in series connection.

Consider two diodes connected in series. The thing to be kept in mind over here is that all the diodes connected in series won't have the same characteristics as shown in the graph below.



V-I characteristics show that the diodes have different blocking voltages. In forward biased state, the voltage drop and the forward current would be same on the diodes. While in the reverse biased the blocking voltage is different as the diodes have to carry the same leakage current.

Application of Power diode :

The applications of power diode include the following.

- ✓ This diode provides uncontrolled power rectification
- ✓ It is used in different applications like DC power supplies, for charging the battery, inverters and AC rectifier.
- ✓ These are used like snubber networks and free-wheeling diodes due to their characteristics like voltage & high-current.
- ✓ These diodes are used as feedback, freewheeling diodes, and high-voltage rectifier.
- ✓ In reverse breakdown condition, when the current and voltage of this diode are huge, the power dissipation can be high so the device can be destroyed.


Any
Questions


THANK YOU
FOR YOUR
ATTENTION