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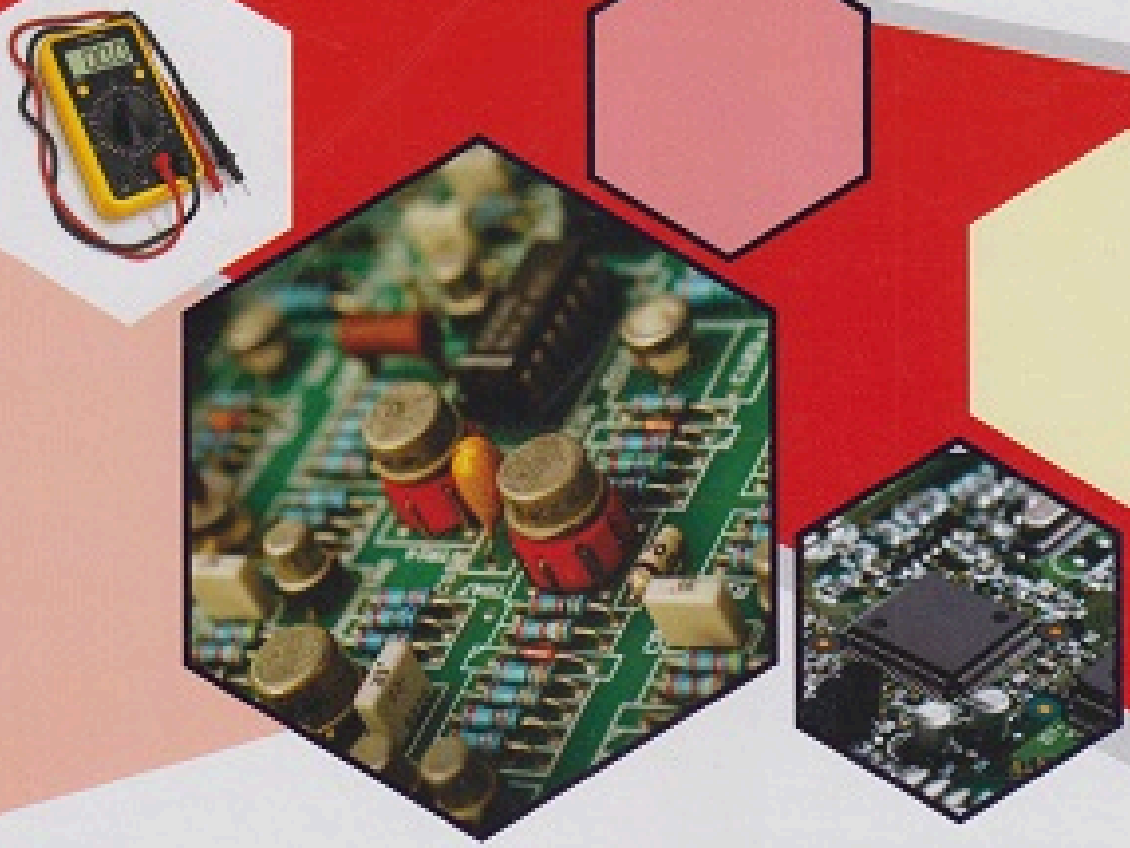
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SEMESTER-II

MSBTE's K SCHEME

AUTOMATION AND ROBOTICS / DIGITAL ELECTRONICS /
ELECTRONICS AND TELECOMMUNICATION / ELECTRONICS AND COMMUNICATION /
ELECTRONICS / INSTRUMENTATION AND CONTROL / INDUSTRIAL ELECTRONICS /
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BASIC ELECTRONICS



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NIRALI PRAKASHAN

A Text Book of

BASIC ELECTRONICS

(With Practicals)

SEMESTER - II

(Subject Code : 312314)

First Year Diploma Courses in
Automation and Robotics / Digital Electronics / Electronics and Tele-communication Engineering / Electronics and Communication Engineering / Electronics Engineering / Instrumentation and Control / Industrial Electronics / Instrumentation / Medical Electronics / Electronics and Computer Engineering Groups

(AO / DE / EJ / ET / EX / IC / IE / IS / MU / TE)

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Preface ...

We take an opportunity to present print learning material on the course **"Basic Electronics"** to the learners of second semester (Diploma in Electronics Engineering Groups). The object of this book is to present the course matter in a most concise and compact manner. This book has been written strictly according to the requirement of industry stake holder and NEP 20 based curriculum. The primary focus of this course laboratory/field work is to develop the much needed industry relevant competencies and skills.

The book has been written by constantly keeping in mind the changing technology, emerging trends in technology and new curriculum along with its assessment methods. It is also written in an easy style with full details and practical information. It is one of the foundation course learning material, which is required for students to understand working of electronic devices, circuits and systems suitable in electronics engineering applications and industry.

Each chapter includes in depth technical information. A detailed explanation is provided in each practical for uplifting psychomotor skills of students. This book is also helpful for teachers, while conducting laboratory work. In short, the book is expected to meet the need of Diploma students of Electronics Engineering Groups. This book is developed to help all stakeholders, especially the students, teachers and instructors to develop in the student the industry expected outcomes

The authors extend the grateful acknowledgement to various sources, drawn upon in the presentation of this learning material We record deepest appreciation to our family members for their valuable understanding and cooperation

It is our proud privilege to record indebtedness to the publisher Mr. Dineshbhai Furia and Mr. Jigneshbhai Furia for their keen interest in the entire work and publishing the same in a very short span of time. We also express our thanks to Mr. Rahul Thorat, Mr. Kiran Kamble and Mrs. Deepa Sawant of Nirali Prakashan team for publishing the same in a very short span of time

Although every care has been taken to check mistakes and misprints, yet it is very difficult to claim perfection as this is the first edition. Any undetected and unintentional errors, omissions, suggestions, etc. from students and colleagues for improvement brought to our notice in good spirit are most welcome.

Authors

Syllabus ...

Unit-I : Applications of Diode **(Marks 14, Hrs. 12)**

1.1 **Different types of Diodes and their materials:** Construction, symbol, working principle, applications, forward and reverse biasing, V-I characteristics of following diodes: P-N junction diode, Zener diode, LED, Photo diode, Schottky diode.

1.2 **Diode as a Rectifier:** Types of rectifiers, Half-wave, Full-wave (Bridge rectifier and Centre tapped), Circuit operation, Input-output waveforms for voltage and current, Parameters of rectifier: Average DC value, Value of current and voltage, Ripple factor, Ripple frequency, PIV of a diode, TUF, Efficiency of a rectifier.

1.3 **Types of Filters:** Shunt capacitor, Series inductor, LC and CLC filter.

1.4 **Rectifier IC:** KBU 808 IC pin diagram and application.

Unit-II : Bipolar Junction Transistors **(Marks 14, Hrs. 12)**

2.1 Current operating device.

2.2 **Different types of transistors:** PNP, NPN.

2.3 **Transistor configurations:** CB, CE, CC. Transistor characteristics (input and output) in different transistor configurations. Relation between alpha, beta and gamma. Comparison between CB, CC and CE.

2.4 **BJT Biasing:** Need of DC load line, Operating point, Stabilization, Thermal runaway, Heat sink. Types of biasing: Fixed biasing, Base bias with emitter feedback, Voltage divider.

Unit-III : BJT Amplifiers **(Marks 16, Hrs. 14)**

3.1 Classification of Amplifiers, BJT as an Amplifier.

3.2 **Single-stage amplifier:** Working, Various currents (I_b, I_c, I_e), Voltage gain of CE amplifier (no derivations required), Frequency response of CE amplifier. Simple numericals.

3.3 **Multistage Amplifiers:** General Multistage BJT based amplifiers.

3.4 **Types of BJT amplifier coupling:** Circuit diagram, operation, frequency response and applications of Direct coupled, RC coupled and Transformer coupled.

3.5 BJT as a Switch.

Unit-IV : Field Effect Transistor **(Marks 14, Hrs. 12)**

4.1 Voltage operating device, Construction of JFET (N-channel and P-channel) - Symbol, working principle and characteristics (Drain and Transfer characteristics), Different parameters of FET. FET applications.

4.2 **FET Biasing:** Source self-bias, Drain to source bias.

4.3 Common source FET amplifier.

4.4 **MOSFET:** Construction, working principle and characteristics of Enhancement and Depletion MOSFET, MOSFET handling.

Unit-V : Regulators and Power Supply **(Marks 12, Hrs. 10)**

5.1 Need of Regulated power supply. Basic block diagram of DC regulated power supply and function of each block.

5.2 Load and Line regulation.

5.3 Zener diode voltage regulator.

5.4 **Fixed voltage IC Regulator:** Three terminal pin diagram, working and applications of 78XX and 79XX series.

5.5 **Variable voltage IC Regulator:** IC 723 pin diagram, block diagram, working. Low voltage regulator, High voltage regulator.

5.6 **Switch Mode Power Supply:** Need of SMPS, block diagram and functions of blocks.



Practicals ...

Sr. No.	Practicals
1.	* Test the performance of PN Junction diode.
2.	* Test the performance of Zener diode.
3.	* Check the performance of photo diode by varying the light intensity as well as the distance of the light source.
4.	* Construct and Test the half wave rectifier.
5.	* Build and Test the half wave rectifier with LC filter/ π filter.
6.	* Prepare and Test the full wave rectifier using two diodes.
7.	* Build and Test the full wave Bridge rectifier on bread board using two diodes.
8.	* Use LC/ π filter with full wave rectifier to measure ripple factor.
9.	* Construct and Test the full wave rectifier on bread board using IC KBU 808 with filter.
10.	Build and Test the performance parameters of 7 Segment LED display FND 507/508.
11.	* Identify and select transistors using datasheets.
12.	Build and Test the performance of BJT working in CB mode.
13.	* Prepare and Test the performance of BJT working in CE mode.
14.	* Build and Test the BJT voltage divider bias circuit for given input.
15.	* Construct and Test the performance parameters of BJT as a Switch.
16.	* Build and Test the performance of single-stage low power common emitter amplifier.
17.	Simulate and Test output waveform and frequency response of single-stage common emitter (CE) amplifier using simulation software (like SPICE / Multisim).
18.	* Build and Test the performance of RC coupled two-stage amplifier.
19.	* Test the performance of FET drain characteristics.
20.	* Check the performance of FET transfer characteristics and calculate transconductance.
21.	* Build and Test the performance of common source FET amplifier.
22.	Test the various blocks of regulated D.C. power supply.
23.	* Find out faults at different stages of regulated D.C. power supply.
24.	* Trouble shoot given D.C. regulated power supply.
25.	Construct and test the performance of Zener voltage regulator for given voltage.
26.	* Build and Test the performance of Positive voltage regulator using 78XX, three terminal IC for given voltage.
27.	Build and Test the performance of Negative voltage regulator using 79XX, three terminal IC for given voltage.
28.	* Construct and Test the performance of Dual voltage regulator using 78XX and 79XX, three terminal IC for given voltage.
29.	* Build and Test the performance of Low voltage regulator using IC LM723 for given voltage. (2V-7V).
30.	Build and Test the performance of High voltage regulator using IC LM723 for given voltage. (7V-30V).

Note : Out of above suggestive LLOs -

- Minimum 80% of above list of lab experiments are to be performed.
- '*' Marked Practicals (LLOs) are mandatory.
- Judicial mix of LLOs are to be performed to achieve desired outcomes.

☆☆☆

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4.	Construct and test the half wave rectifier.	P.8
5.	Build and test the half wave rectifier with LC filter/π filter.	P.10
6.	Prepare and test the full wave rectifier using two diodes.	P.12
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10.	Build and test the performance parameters of 7 Segment LED Display FND 507 / 508.	P.19
11.	Identify and select transistors for given application using datasheets.	P.22
12.	Build and test the performance of BJT working in CB mode.	P.26
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Unit I

Chapter 1...

Applications of Diode

Weightage of Marks = 14, Teaching Hours = 12

Syllabus

1.1 **Different types of Diodes and their materials:** Construction, symbol, working principle, applications, forward and reverse biasing, V-I characteristics of following diodes: P-N junction diode, Zener diode, LED, Photo diode, Schottky diode.

1.2 **Diode as a Rectifier:** Types of rectifiers, Half-wave, Full-wave (Bridge rectifier and Centre tapped), Circuit operation, Input-output waveforms for voltage and current, Parameters of rectifier: Average DC value, Value of current and voltage, Ripple factor, Ripple frequency, PIV of a diode, TUF, Efficiency of a rectifier.

1.3 **Types of Filters:** Shunt capacitor, Series inductor, LC and CLC filter.

1.4 **Rectifier IC:** KBU 808 IC pin diagram and application.

Specific Objectives

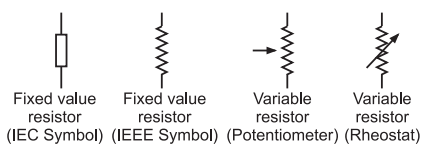
At the end of this chapter, students will be able to:

- Describe the working principle, characteristics, and application of the given type of diode.
- Describe the working of the given type of rectifier.
- Calculate ripple factor, PIV and efficiency of the given type of filter.
- Describe the need and working of rectifier filter circuit.

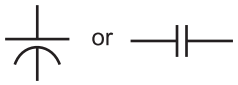
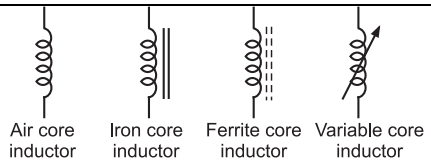
INTRODUCTION

- Electronic components play a vital role in computer engineering and its related engineering field such as AI (Artificial Intelligence), Computer hardware maintenance, Data science, Information technology. All these computer engineering fields are based on hardware and software. Without suitable hardware, software does not work efficiently. Hardware of computing systems includes various electronic components. Two main types of electronic components are (A) Passive components, (B) Active components.
- Examples of passive components are resistors, capacitors, inductors, electromechanical switches, relays, transformer etc.

Table 1.1 : Shows symbols, basic specifications and applications

Sr. No.	Passive Component	Symbol	Basic Specifications	Applications
1.	**Resistor** Fixed resistor Variable Resistor		1 Ohm Rating 1 Wattage rating 2 Fixed or Variable	1. Potential dividers 2. Current control. 3 D.C. power supplies. 4. Amplifier circuits. 5. Heating element

Contd ...

				6. Fusible resistors for protection 7. For current range extension as shunt resistor ammeter. 8. Photo resistors find application in flame detectors, burglar alarm, in photographic devices, etc
2.	**Capacitor** Electrolytic or Non-Electrolytic		1 Capacitance 2 Voltage Rating 3 Type of dielectric material	1. Storage of energy. 2. In the filter circuits to minimize the ripple voltage. 3. In the tuning circuits for selection of frequency. 4. In the snubber circuit to suppress the radio frequency interference. 5. Used for starting the motor, for running the motor 6. In equipment like SMPS, Modem. 7. On Computer mother board
3.	**Inductor** Fixed Variable		1 Inductance rating 2 Type of core 3 Variable or fixed type	1. To minimize the ripples alternating current in a circuit. 2. Used for allowing the flow of direct current. 3. Used in filter circuits to minimize the ripple voltage or ripple factor. 4. Used in tuning circuits of radio transmitters and receivers to select the frequency. 5. It is used in radio transmitters and receivers. 6. It is used in devices like Relays, Electric motors, Transformers, Sensors
4.	**Transformer**		1 Primary voltage 2 Secondary voltage 3 Current rating	1. In D.C. power supply to step down input A.C. supply. 2. For isolation purpose. 3. To step up or step down A.C. supply

- Automation, Digitization and Smart system require use of active components. Active components play a vital role in all engineering disciplines and engineering applications ranging from domestic to industrial, space, defense, agriculture, medical, transportation, education and entertainment. All electronic products are based on functioning of active components. The components whose operation changes as per external energy are termed as active components. Active components performance relies on external energy. Active components are suitable for rectifying, amplifying and switching applications.
- Two main types of active components are: (1) Tube devices, (2) Semiconductor devices.
- Now a days tube devices are not commonly used as they exhibit many drawbacks such as low speed of operation, larger size, difficult for mounting and expensive than semiconductor components. Semiconductor active components are also called as solid state components.

These are made up of semiconductor materials. Active semiconductor components have many advantages such as : high speed of operation, compactness, easy for mounting and cheaper than tube devices. Commonly used active components are diode, BJTs (Bipolar Junction Transistors), FET (Field Effect Transistor), MOSFET (Metal Oxide Semiconductor FET), SCR (Silicon controlled Rectifier), DIAC, UJT (Uni Junction Transistor), TRIAC, IGBT, PUT, Integrated circuits.

- Semiconductor material has electrical conductivity less than conductor and more than insulator. Its conductivity changes as per application of external energy. Pure semiconductor materials are called as intrinsic semiconductor. Commonly used pure semiconductor materials are Silicon (Si) and Germanium (Ge). To improve conductivity i.e. free charge carriers, impurity is added to intrinsic semiconductor. The process of addition of impurity to intrinsic semiconductor is called as doping. Due to doping process, intrinsic semiconductor is converted into impure semiconductor. This impure semiconductor material is called as extrinsic semiconductor. Depending on type of impurity material added to intrinsic semiconductor, two types of extrinsic semiconductors are obtained such as P-type and N-type material. By using these two extrinsic semiconductors, active components are constructed. To obtain P-type extrinsic semiconductor trivalent material and to obtain N-type extrinsic semiconductor pentavalent impurity material is added. In P-type material positive charge carrier Holes are majority charge carrier while in N-type material electrons are majority charge carriers.

Table 1.2 : Comparison of conductors, insulators and semiconductors

Sr. No.	Conductor	Insulator	Semiconductor
1.	It has very large concentration of electrons.	It has very low concentration of electrons.	It has moderate concentration of electrons.
2.	It has very low resistivity.	It has very high resistivity.	It has moderate resistivity.
3.	It has very high conductivity.	It has very low conductivity.	It has moderate conductivity.
4.	It has no forbidden energy gap.	It has high forbidden energy gap of about 10 eV.	It has low forbidden energy gap of about 1 eV.
5.	It has a positive temperature coefficient of resistance.	It has a negative temperature coefficient of resistance.	It has a negative temperature coefficient of resistance.
6.	Its resistance increases with rise in temperature.	Its resistance decreases with rise in temperature.	Its resistance decreases with rise in temperature.
7.	At room temperature, it acts as a good conductor of electricity.	At room temperature, it acts as a bad conductor of electricity.	At room temperature, it acts as a bad conductor of electricity.

Table 1.3 : Comparison of intrinsic and extrinsic semiconductors

Sr. No.	Intrinsic Semiconductor	Extrinsic Semiconductor
1.	It is an extremely pure form of semiconductor.	It is a doped semiconductor.
2.	The number of free electrons and holes generated due to thermal energy are equal.	The number of free electrons and holes generated due to thermal energy are not equal.
3.	The current conduction is due to electrons and holes.	The major part of current conduction is due to either holes or free electrons.
4.	The Fermi level is at the centre of forbidden energy gap and is unchanged with change in temperature.	The Fermi level shifts upward or downward with change in temperature and type of doping material.
5.	The electrical conductivity is very poor at room temperature.	The electrical conductivity is comparatively high at room temperature.
6.	Less or almost no direct application.	All semiconductor devices are made up of extrinsic semiconductors.

- The solid materials, in which the conduction band and the valence band are separated by a wide forbidden energy gap of above 10 eV are called insulators, the energy band diagram of insulating materials is as shown in Fig. 1.1.

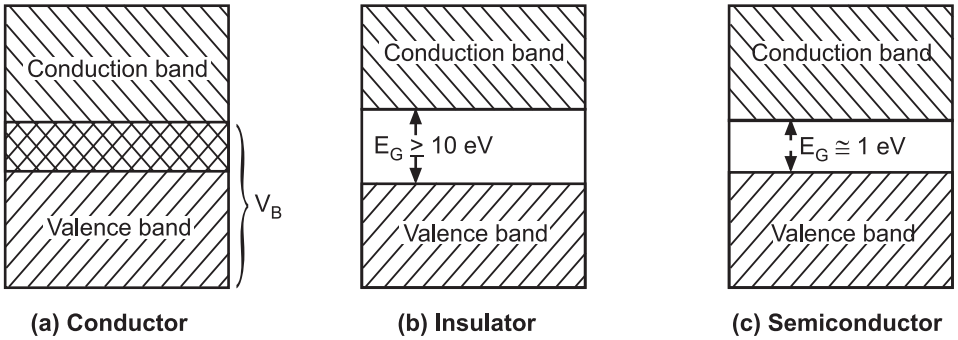


Fig. 1.1 : Energy bands in solid materials

1.1 DIFFERENT TYPES OF DIODES

- There are different types of semiconductor diodes. They are
  (1) P-N junction (2) Zener diode (3) Tunnel diode (4) LED
  (5) Varactor (6) Schottky diode (7) Photodiode (8) Gunn diode
  (9) PIN diode (10) Power diode

1.1.1 P-N Junction Diode

- When a P-type semiconductor is suitably joined to an N-type semiconductor under suitable condition by using a special technique to form a P-N junction, the device so constructed is called a P-N junction diode or a semiconductor diode. The P-N junction itself forms the most basic semiconductor device called semiconductor diode. It is also known as a rectifier diode. The meaning of the term diode is that the device having two electrodes.
- It is a unidirectional device.

1.1.1.1 Construction Details

- A P-N junction diode consists of a P-N junction formed either in Germanium or Silicon crystal as shown in Fig. 1.2 (a). A P-N junction diode is constructed by joining a P-type semiconductor to an N-type semiconductor under suitable condition by using a special technique. It has two terminals called anode A and cathode K. The P-region of a diode is called anode (A) and the N-region is called cathode (K).
- The P-N junction (or semiconductor diode) is represented by its schematic symbol as shown in Fig. 1.2 (b).
- The symbol looks like an arrow pointing from the P-region to the N-region. The arrow head, shown in the circuit symbol, points the direction of conventional current flow, when it is forward biased. It may be noted that it is in the same direction in which the movement of holes takes place.

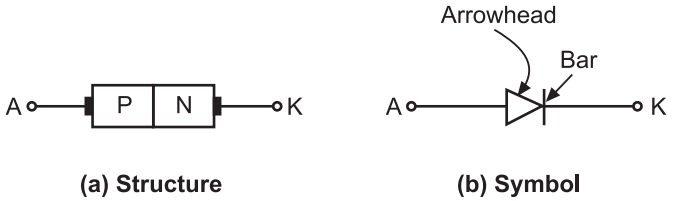


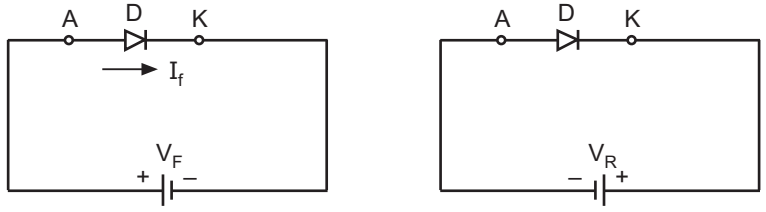
Fig. 1.2 : P-N junction diode

1.1.1.2 Working Principle

1. Forward bias :

- Consider a P-N junction diode as shown in Fig. 1.3 (a). When the battery is not connected, there is a barrier potential (i.e. fictitious battery) of 0.3 V for Germanium and 0.7 V for Silicon across the P-N junction of a diode.

- The external applied voltage of forward bias is opposed by the barrier voltage and the diode does not conduct the current due to the majority charge carriers.



(a) Forward bias (b) Reverse bias

Fig. 1.3 : P-N junction diode

- As the applied voltage is increased above the barrier potential, it overcomes the opposition of barrier potential and the diode conducts the current due to majority carriers. This current is called forward current (I_f) and flows from anode to cathode through the diode. It is of the order of 20 to 50 mA at about 1 V.

2. Reverse bias :

- Consider a P-N junction diode as shown in Fig. 1.3 (b). The barrier potential of fictitious battery across the P-N junction add with the external applied voltage. But, diode does not conduct the current due to majority charge carriers.
- As the applied reverse voltage is increased, very small amount of current (negligible as compared to forward current) flows through the diode due to minority charge carriers. This current is called reverse saturation current (I_o). It is of the order of nanoamperes (1 nA = 10^{-9} A) for Silicon and microamperes (1 μA = 10^{-6} A) for Germanium diode.

1.1.1.3 Specifications

- The important specifications of a P-N junction diode are listed below :
  1. Maximum reverse voltage (V)
  2. Repetitive peak voltage (V)
  3. Maximum forward current (mA)
  4. Power dissipation.
  5. Repetitive peak forward current
  6. Average forward current (A)
  7. Surge current (A)
  8. Operating ambient temperature (°C)
  9. Maximum junction temperature (°C)
  10. Forward voltage (V)
  11. Reverse saturation current (μA)
  12. Cut-in voltage (knee voltage) V_z

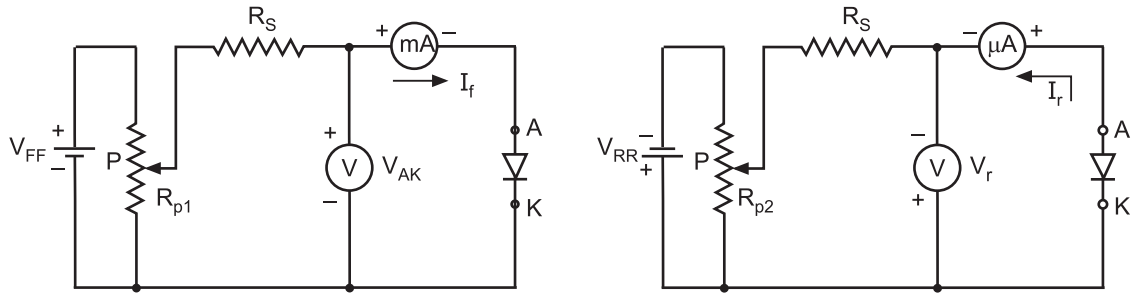
1.1.1.4 V-I Static Characteristics of P-N Junction Diode

- The V-I characteristic is a graph between the voltage applied across the terminals of an semiconductor device and the resulting current that flows through it.

Experimental Set-up :

1. For Forward characteristics :

- Fig. 1.4 (a) shows the experimental set-up for obtaining the forward characteristic of P-N junction diode.



(a) Forward characteristics (b) Reverse characteristics

Fig. 1.4 : Experimental set-up for a P-N junction diode

2. For Reverse characteristics :

- Fig. 1.5 shows the experimental set-up for obtaining the reverse characteristics of a P-N junction diode.

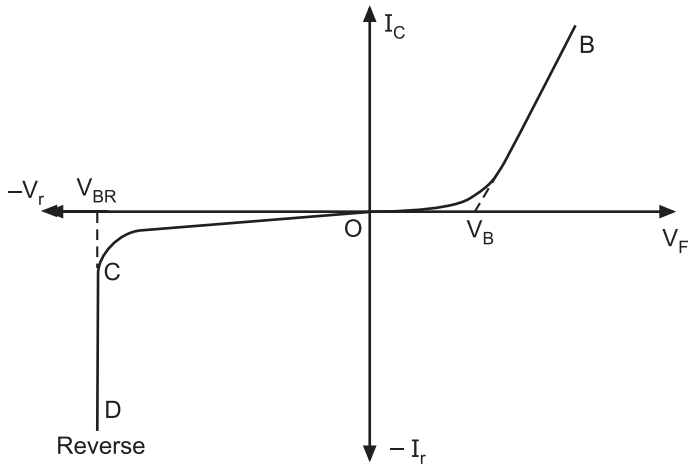


Fig. 1.5 : V-I characteristics of a P-N junction diode

Forward characteristics :

- Consider the experimental set-up as shown in Fig. 1.6 (a). A graph between the forward voltage across the terminals of a P-N junction diode and the current flowing through it is known as a forward characteristic.
- A forward characteristic of a P-N junction diode is as shown in Fig. 1.6 (a). The P-N junction conducts the forward current only after the cut-in (i.e. knee) voltage. Cut-in voltage depends on semiconductor material

Reverse characteristics :

- Consider the experimental set-up as shown in Fig. 1.6 (b). A graph plotted between the reverse voltage across the terminals of a P-N junction diode and the current flowing through it is known as a reverse characteristic. A reverse characteristic of a P-N junction diode is as shown in Fig. 1.6 (b). It is observed that the flow of reverse current is very small till the breakdown voltage V_{BR} is reached. The voltage at which the abrupt increase in reverse current through the P-N junction occurs, is known as breakdown voltage.

Static and Dynamic Forward Resistance :

1. Static Forward Resistance :

- It is calculated from forward characteristics of a P-N junction diode. It is defined as the ratio of a D.C. (constant) voltage across the P-N junction to the resulting small change in D.C. current. It denoted as R.

$$R = \frac{V_{ak}}{I_a}$$

2. Dynamic Forward Resistance :

- It is also calculated from forward characteristics of a P-N junction diode.
- It is defined as the ratio of change in voltage to the resulting change in D.C. current.

$$r = \frac{V_2 - V_1}{I_2 - I_1} = \frac{\Delta V_{ak}}{\Delta V I_a}$$

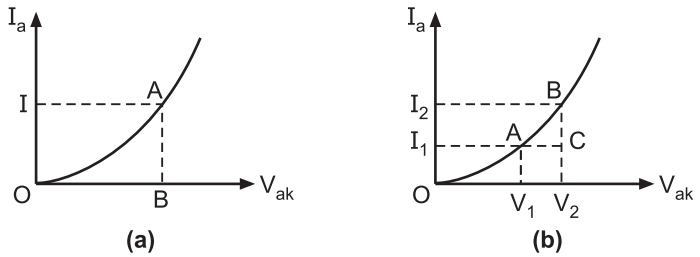


Fig. 1.6

Effect of Temperature on V-I Characteristics :

- The current flowing through P-N junction diode depends on applied voltage and operating temperature.

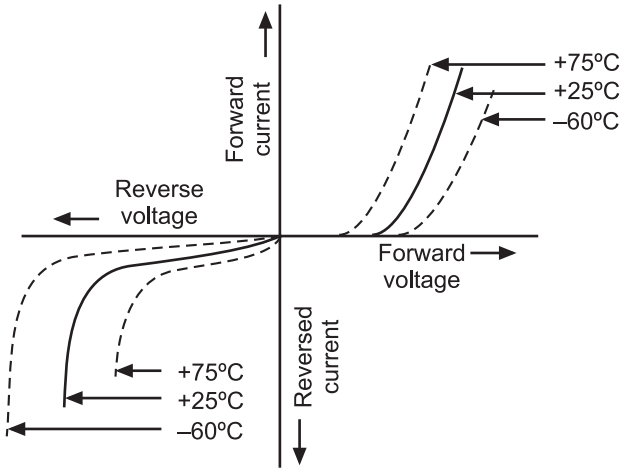


Fig. 1.7 : Effect of temperature on diode characteristics

- The increased temperature of a diode will result in a large number of broken covalent bonds thereby increasing the large number of majority and minority carriers. As a result, this amounts to large current flowing through the diode. The above phenomenon applies both to forward current and reverse current. The effect of temperature on the V-I characteristic curve of a PN junction diode is as shown in Fig. 1.7. It may be noted that the forward characteristic shifts upwards with the increase in temperature (from 25°C to 75°C).On the other hand, the reverse characteristic shifts downwards with the increase in temperature.

Table 1.4 : Comparison between Germanium and Silicon Diodes

Sr. No.	Property	Germanium Diode	Silicon Diode
1.	Cut-in voltage	0.2 V	0.6 V
2.	Reverse saturation current	more	less
3.	Maximum operating temperature	upto 85°C	upto 175°C
4.	Rate of decrease of barrier potential with temperature	2.5 mV/°C	2.5 mV/°C
5.	Applications	In low and medium power	In high power

Table 1.5 : Comparison between Ideal and Practical Diodes

Sr. No.	Ideal diode	Practical (Real) diode
1.	It can act as perfect conductor and as a perfect insulator.	It cannot act as perfect conductor and as perfect insulator.
2.	It has zero voltage drop across it, when forward biased.	It has very low voltage drop (< 1 V) across it, when forward biased.
3.	It draws zero reverse saturation current, when reverse biased.	It draws negligibly small reverse saturation current, when reverse biased.
4.	It has zero cut-in (knee) voltage.	It has very low cut-in (knee, < 1 V) voltage.
5.	It offers zero resistance, when forward biased.	It offers very low resistance, when forward biased.
6.	It offers infinite resistance, when reverse biased.	It offers very high resistance, when reverse biased.
7.	It cannot be manufactured.	It can be manufactured.

1.1.1.5 Types of Breakdown

- There are two types of reverse breakdowns in a P-N junction as under :
  (1) Zener breakdown, (2) Avalanche breakdown.

1. Zener Breakdown :

- Zener breakdown occurs in the P-N junctions which are heavily doped. The heavily doped P-N junctions have a narrow depletion region. When the reverse voltage is increased, the electric field across the P-N junction also increases. The high value of electric field causes a covalent bond to break from the crystal structure of a P-N junction.
- As a result of this, a large number of minority charge carriers are generated and a large current flows through the P-N junction. This mechanism of breakdown is called Zener breakdown. In certain cases, especially in Silicon P-N junctions, the Zener breakdown can be represented by a straight line which corresponds to a constant reverse voltage as shown in Fig. 1.8 (a).

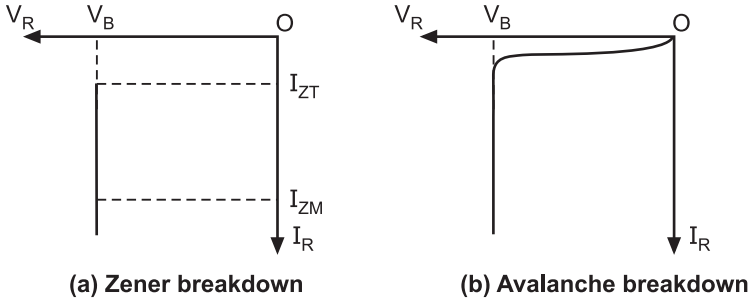


Fig. 1.8 : Reverse breakdown mechanism in P-N junction

- The Zener breakdown principle is used in the construction of a zener diode. In Zener diode charge carrier tunneling effect occurs.

Avalanche Breakdown :

- Here diffusion of charge carrier occurs across the P-N junction. When sufficient voltage is applied, the minority carriers acquire a large amount of kinetic energy (or momentum). When these minority carriers collide with semiconductor (Germanium or Silicon) atoms within the crystal structure of a P-N junction they impart sufficient energy to break covalent bond and generate additional carriers (i.e. electron-hole pairs). As a result of this, the reverse current through the P-N junction increases rapidly. The cumulative process of carrier generation (i.e. multiplication) is known as avalanche breakdown. The value of breakdown voltage depends upon the degree of doping in P-N junction. The principle of avalanche breakdown is used in power electronic devices such as SCR, Diac, Triac etc. In this breakdown, reverse bias current increases as voltage increases gradually.
- The difference between avalanche breakdown and Zener breakdown is as under :

Table 1.6 : Comparison of Avalanche and Zener Breakdowns

Sr. No.	Avalanche Breakdown	Zener Breakdown
1.	It occurs in junctions which are lightly doped and have wide depletion width.	It occurs in junctions which are heavily doped and have narrow depletion width.
2.	It occurs at higher reverse voltages when thermally generated electrons get enough kinetic energy to produce more electrons by collision.	It occurs due to rupture of covalent bonds by strong electric field set up in depletion region by the reverse voltage.
3.	At reverse voltage above 6 V, breakdown is due to Zener effect.	At reverse voltage below 6 V, breakdown is due to avalanche effect.

1.1.1.6 Applications

- The P-N junction diode has the following important applications :
  1. As a rectifier in D.C. power supply.
  2. As a free wheel diode across relay or inductive load.
  3. As a switch in logic circuits used in computers.

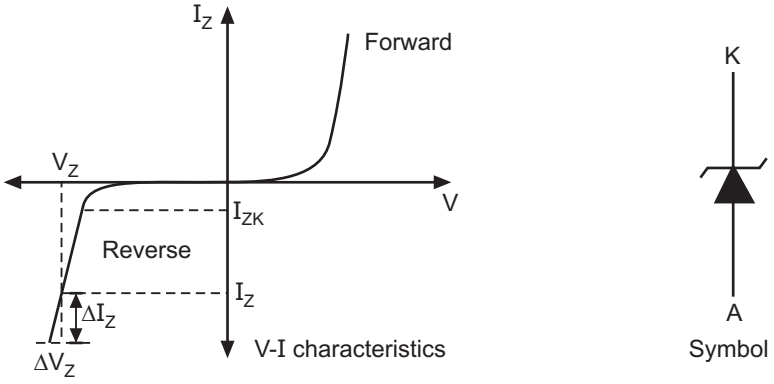
4. As a detector in demodulation circuits of communication receiver.
5. For non-linear waveshaping circuits such as in clipping and clamping circuits.
6. As a voltage doubler, tripler, quadrupler in voltage multiplier circuits.

- Commonly available P-N junction diodes are BY 125, BY 126, 1N 4001, … 1N4007.

1.1.2 Zener Diode

1.1.2.1 Zener Diode Construction

- Zener diode is a two terminal semiconductor solid state device. It is a specially doped P-N junction diode. Doping concentration i.e. amount of impurity is very high as compared to normal P-N junction diode.
- In forward biased condition, it shows same operation as normal P-N junction diode. In reverse biased condition, it shows Zener breakdown characteristics. When applied reverse bias voltage is more than Zener rating voltage i.e. Zener breakdown voltage then tunneling of charge carriers occurs across the junction. Now the voltage across it remains constant but current varies.
- Zener diodes are designed to operate in the breakdown region without damage. By varying the doping level it is possible to produce Zener diodes with breakdown voltages ranging from about 2 V to 200 V.
- The Zener characteristics and the symbol are shown in Figs. 1.9 (a) and (b) respectively.



(a) Zener characteristics **(b) Symbol**

Fig. 1.9 : Zener diode

- As seen from the characteristics, the voltage across Zener remains approximately same after the breakdown voltage V_Z, though the current increases sharply. So it acts like a constant voltage source or a voltage reference.

1.1.2.2 Zener Specifications

(i) Zener voltage V_Z : The manufacturers specify the value of breakdown voltage known as zener voltage V_Z at some test current I_{ZT}.

(ii) Power dissipation : It is the product of V_Z and I_Z.

(iii) Breakover current I_Z : Since the reverse characteristics is of curvature nature at low value of I_z, near the breakover knee, a value I_{ZK} is specified.

(iv) Dynamic resistance R_Z : It is usually evaluated in the linear region of the specified test current I_{ZT}.

$$R_Z = \frac{\Delta V_Z}{\Delta I_Z}$$

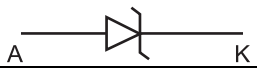
Zener Ratings :

1. The Zener voltage is 2.4 V to 200 V.
2. I_{max} : The maximum current is 10 mA to few hundred mA.

3. P_{max} : The maximum power dissipation is 150 mW to 50 W.
4. The dynamic resistance R_d or R_z in few ohms.
5. Temperature coefficient of voltage (TCV) μs.

- It is the change in stabilization voltage caused by change in temperature. It may be a few thousand to a few tenths of 1% per degree. It may be even negative.

Table 1.7 : Comparison of P-N Junction and Zener Diodes

P-N Junction Diode	Zener Diode
1. It is not properly doped to control reverse breakdown.	1. It is properly doped to control reverse breakdown.
2. It conducts only in forward bias.	2. It conducts in both forward bias and reverse bias.
3. It has no sharp reverse breakdown.	3. It has sharp reverse breakdown.
4. It is used for rectification.	4. It is used for rectification and for voltage regulation.
5. Symbol : 	5. Symbol : 

1.1.3 LED

1.1.3.1 LED Construction

- Light Emitting Diodes (L.E.Ds.) is a light-emitting two terminal solid state semiconductor device with a single P-N junction intended to convert electric energy into light energy. It is an active display device. Its function is opposite to that of the photo diode. When an electron and a hole combine, the electron may fall from a high energy state to ground state. The difference of energy in the two states is given out as light. LED operates on the Electro luminance principle.
- LEDs may be made from gallium phosphide (GaP), gallium arsenide (GaAs) and silicon carbide (SiC). SiC gives yellow light, gallium arsenide phosphide gives red light while GaAs gives infrared radiation. GaP with nitrogen gives green light.
- The construction of an LED is shown in Fig. 1.10.

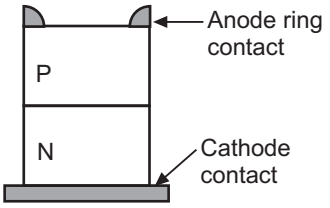


Fig. 1.10 : Construction of LED

- Table 1.8 shows LED material and colour of emitted light.

Table 1.8

Sr. No.	LED Material	Colour of Emitted Light	Wavelength
1.	Indium gallium nitride (InGaN), AIN, AlGaN, AlGaInP	Ultraviolet	Below 400
		Violet	400 to 450
		Blue	450 to 500
2.	Gallium Phosphide with Nitrogen AlGaInP	Green	500 to 570
3.	Silicon Carbide (SiC)	Yellow	570 to 590
4.	Aluminium Gallium Indium Phosphide (AlGaInP)	Orange or Amber	590 to 610
5.	Gallium Arsenide Phosphide GaAsP	Red	610 to 760
6.	Gallium Arsenide (GaAs)	Infra Red light	Above 760

1.1.3.2 Applications

- LEDs find applications in various fields, including optical communication, alarm and security systems, remote-controlled operations, robotics, etc. It finds usage in many areas because of its long-lasting capability, low power requirements, swift response time, and fast switching capabilities. Below are a few standards LED uses:
  - Used for TV back-lighting
  - Used in displays