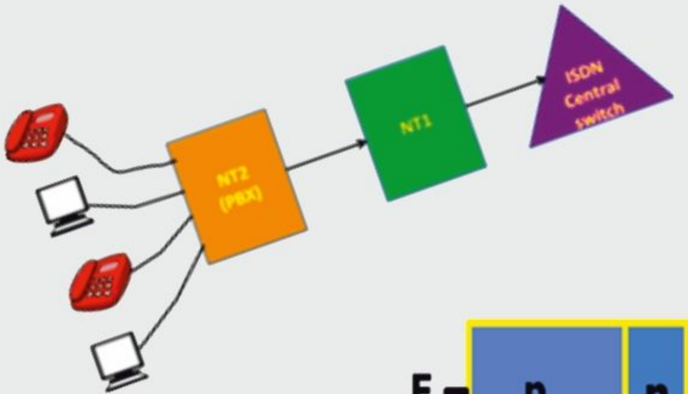
Ramani Kumar
P. Meena Priya Dharshini

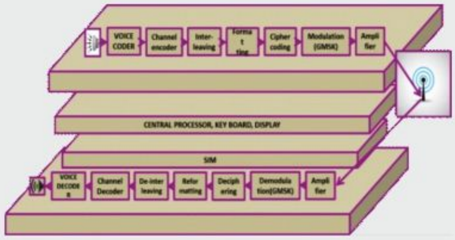
Basic Electronics

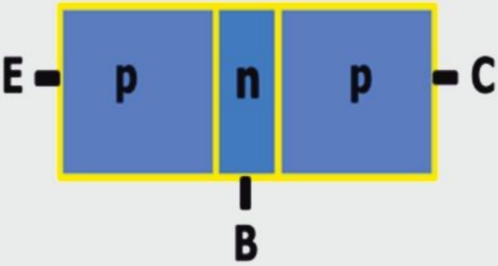
FIRST AND SECOND SEM

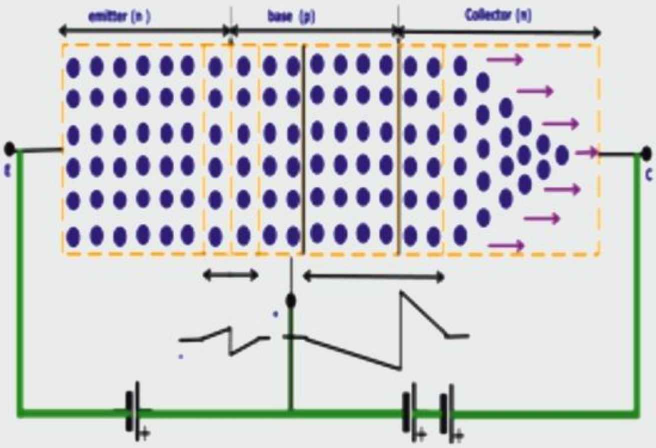
Visvesvaraya Technological University syllabus

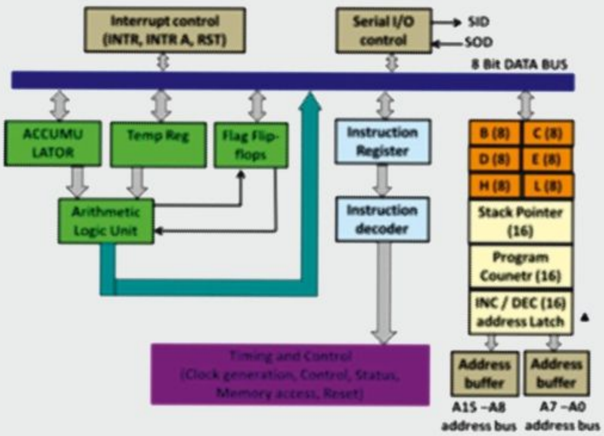
(Effective from the Academic Year 2015-2016)











BASIC ELECTRONICS

Ramani Kumar | P. Meena Priya Dharshini

BASIC ELECTRONICS

As per VTU Syllabus - Effective from the academic year 2015 -2016
[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – I and II Subject Code 15ELN15 / 15ELN25

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About the book and the author………………..

Why we wrote (write?) this book?
There are so many books on Basic electronics. Why one more?

I thought quite a lot about it.
I am from the Industry. I had worked in Telecom R&D for nearly 35 years (electronics, embedded and wireless).
I have been part of huge R&D teams of some of the best Telecom institutions of India

- DRDO Bangalore, Gujarat communications Baroda, Escorts Telecom Delhi, Solidaire Chennai, Telecom Technology Ltd Chennai (and Hong Kong), Tata Telecom Chennai, Bharti Telecom, Delhi and Premier Evolvics, Coimbatore

So what?

I had the fortune of working with hundreds of engineers everywhere …..fresh engineers straight out of the college. I had trained them in circuit designs, embedded designs and telcom/wireless system designs. I know the gap between the industry expectations and the academic objectives, better than many professionals or academicians.

I thought I am qualified enough to address this gap. I taught in Engineering colleges too and tried to bring an Industry perspective into every lecture of mine. The students as well as the faculty seemed to like this approach.
This encouraged(s) me to write a book on basic electronics
The approach is simple, bringing out the design issues at every opportunity, with an objective to make the student master the concepts. At the same time I have not lost sight of the precious objective – Marks in the examination……
Simple structured presentation of the syllabus, with plenty of illustrations, should help demystification of electronics.

I acknowledge the great support from Mrs P. Meena Priya Dharshini who brought in an academic perspective to this book. Her contribution has been immense and very vital.

I dedicate this book to

> My wife **Karpagam** for her unstinted support in this journey.
> Shri **N Sitaram** [(Director DRDO (Retired)]…… from whom, I learnt designs, designs and designs……

This text book follows ***the latest VTU syllabus verbatim effective from the academic year 2015 -2016 (As per Choice Based Credit System (CBCS) scheme)*** and is brought out in just 180 pages. I am sure, the student world will welcome this.

Browse my website eazyece.com frequently, for updates on this book and other topics……….

Good luck,

Ramani Kumar

Why I wrote this book?

I am Mrs P. Meena Priya Dharshini, an Associate professor, working in CMR Institute of Technology, Bangalore. I obtained my BE degree in EIE from Tamilnadu college of Engineering, Coimbatore and my ME degree in Applied Electronics from Bannari Amman Institute of Technology, Sathyamangalam. I have 10 years of teaching experience. My area of interest is Wireless Communication and Embedded System Design. I have published several papers in various national and international journals.

Basic Electronics is one of the important core subjects, in the field of Electronics, Telecommunication, Electrical, Computer Science, Information Science and Mechanical Engineering. There has been an increase in the demand for a suitable textbook on this subject. The content of the book are presented in a simple, precise and systematic manner. Numerous solved examples, self-explanatory sketches and a large number of problems with answers have been presented in each chapter to aid conceptual understanding of the subject. The language used in explaining the various concepts is extremely simple. All the topics have been profusely illustrated with diagrams for easy understanding.

Having been myself a teacher in the field of Electronics and Communication Engineering, I am sure that this book will enrich the students' knowledge in the subject and would be welcomed by the teachers and students of all engineering institutions.

I am highly indebted to Mr.Ramani Kumar, who encouraged me from time to time with his valuable suggestions and guidance in the preparation of the manuscript.

Meena Priya Dharshini

Syllabus:

BASIC ELECTRONICS

[As per Choice Based Credit System (CBCS) scheme] (Effective from the academic year 2015 -2016)

SEMESTER - I/II **Subject Code 15ELN15 / 15ELN25**

Course objectives:
The course objective is to make students of all the branches of Engineering to understand the efficacy of Electronic principles which are pervasive in engineering applications

Module -1

Semiconductor Diodes and Applications (Text-1): p-n junction diode, Characteristics and Parameters, Diode approximations, DC load line analysis, Half-wave rectifier, Two-diode Full-wave rectifier, Bridge rectifier, Capacitor filter circuit (only qualitative approch), Zener diode voltage regulators: Regulator circuit with no load,
Loaded Regulator. Numerical examples as applicable. (6 hours)

Bipolar Junction Transistors: BJT operation, BJT Voltages and Currents, BJT amplification, Common Base, Common Emitter and Common Collector Characteristics, Numerical examples as applicable. (4 hours)

Module -2

BJT Biasing (Text-1): DC Load line and Bias Point, Base Bias, Voltage divider Bias, Numerical examples as applicable. (04 Hours)

Introduction to Operational Amplifiers (Text-2): Ideal OPAMP, Inverting and Non Inverting OPAMP circuits, OPAMP applications: voltage follower, addition, subtraction, integration, differentiation; Numerical examples as applicable.
(06 Hours)

Module – 3

Digital Electronics (Text-2): Introduction, Switching and Logic Levels, Digital Waveform (Sections 9.1to 9.3). Number Systems: Decimal Number System, Binary Number System, Converting Decimal to Binary, Hexadecimal

Number System: Converting Binary to Hexadecimal, Hexadecimal to Binary, Converting Hexadecimal to Decimal, Converting Decimal to Hexadecimal, Octal Numbers: Binary to Octal Conversion. Complement of Binary Numbers.

Boolean Algebra Theorems, De Morgan's theorem.

Digital Circuits: Logic gates, NOT Gate, AND Gate, OR Gate, XOR Gate, NAND Gate, NOR Gate, X-NOR Gate. Algebraic Simplification, NAND and NOR Implementation (Sections 11.7 and 11.8): NAND Implementation, NOR Implementation. Half adder, Full adder.
(10 Hours)

Module-4

Flip-Flops (Text-2): Introduction to Flip-Flops (Section 12.1), NAND Gate Latch/ NOR Gate Latch, RS Flip-Flop, Gated Flip-Flops: Clocked RS Flip-Flop (Sections 12.3 to 12.5).
(05 Hours)

Microcontrollers (Ref.1): Introduction to Microcontrollers, 8051 Microcontroller Architecture and an example of Microcontroller based stepper motor control system (only Block Diagram approach).
(05 Hours)

Module-5

Communication Systems (Text-2): Introduction, Elements of Communication Systems, Modulation: Amplitude Modulation, Spectrum Power, AM Detection (Demodulation), Frequency and Phase Modulation. Amplitude and Frequency Modulation: A comparison.
(06 Hours)

Transducers (Text-2): Introduction, Passive Electrical Transducers, Resistive Transducers, Resistance Thermometers, Thermistor. Linear Variable Differential Transformer (LVDT). Active Electrical Transducers, Piezoelectric Transducer, Photoelectric Transducer.
(04 Hours)

Course outcomes:
After studying this course, students will be able to: ·
Appreciate the significance of electronics in different applications,

- Understand the applications of diode in rectifiers, filter circuits and wave shaping,
- Apply the concept of diode in rectifiers, filters circuits ·
- Design simple circuits like amplifiers (inverting and non inverting), comparators, adders, integrator and differentiator using OPAMPS, ·
- Compile the different building blocks in digital electronics using logic gates and implement simple logic function using basic universal gates, and
- Understand the functioning of a communication system, and different modulation technologies, and
- Understand the basic principles of different types of Transuducers.

Question paper pattern:

- The question paper will have ten questions.
- Each full Question consisting of 16 marks
- There will be 2 full questions(with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. David A. Bell, **"Electronic Devices and Circuits**", Oxford University Press, 5th Edition, 2008.
2. D.P. Kothari, I. J. Nagrath, **"Basic Electronics"**, McGraw Hill Education (India) Private Limited, 2014.

Reference Books: MuhammadAli Mazidi, **"The 8051 Microcontroller and Embedded. Systems. Using Assembly and C."** Second Edition, 2011, Pearson India.

MODULE 1

Chapter 1: Semiconductor Theory

1.1 ATOM –Structure

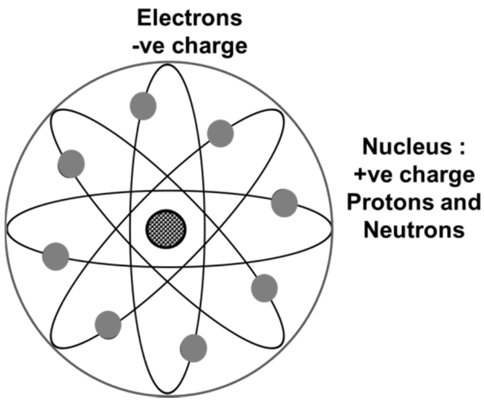


Fig 1.1 Atom - Structure

- Atom consists of a nucleus. Electrons in several orbits move around the **nucleus**..
- Contains three basic Particles –**Protons, Neutrons & electrons.**
- Nucleus contains two types of particles
  - **Protons** **:** Positively charged particles.
  - **Neutrons** **:** Particles with neutral charge.
- **Electrons:** Negatively charged particles (Charge = 1.602X 10^{-9} Coulombs).

Usually protons and electrons will be equal in number .Therefore, atoms are normally neutral, electrically.

- If an atom loses an electron, it means that it has lost some -ve charge & hence has a net + ve charge ……….. and vice versa.

1.1.1 Holes & Electrons (Silicon & Germanium)

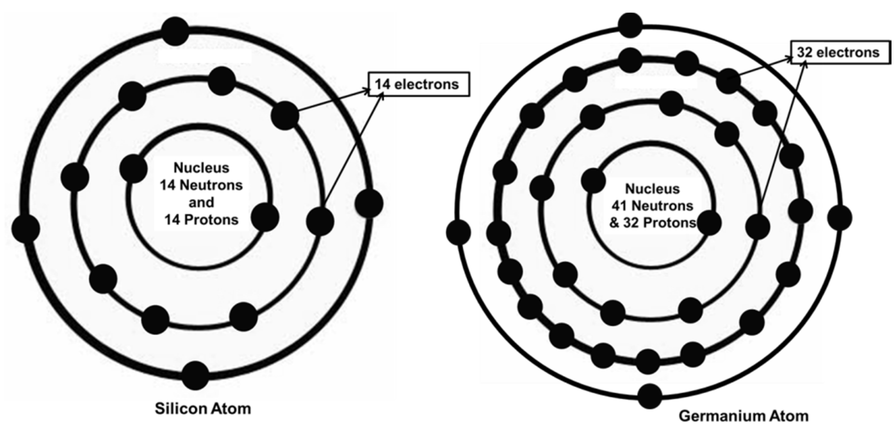


Fig 1.2

Pls recall,

1. Electrons can occupy only some fixed orbits, called **shells**.
2. Each shell can be occupied by only some **specific number of electrons**.
3. The outer most shell called **valence shell**, may be only partially filled by electrons.
4. Figure 1.2 gives a 2 D simplified orbital arrangement of silicon & germanium atom.
5. Absence of an electron in a shell, is defined as a **hole**.
6. Silicon & Germanium atoms are **electrically neutral (outer shell has 4 holes and 4 electrons each**)

1.2 Electron &Hole Dynamics

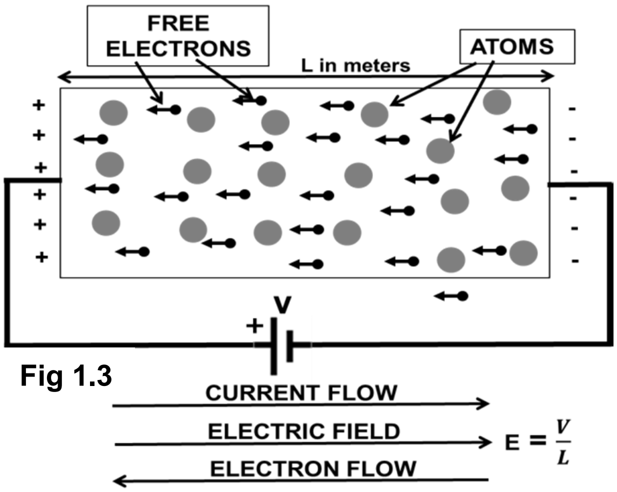


Fig 1.3

Refer fig 1.3.

- **Electrons** are –vely charged particles. Electrons are **repelled by –ve voltage**. Therefore, they will move towards a terminal **where + ve voltage is applied**.
- **Holes** are **+vely charged** particles. Holes are repelled by + ve voltage. They will move towards a terminal **where -ve Voltage is applied**.
- Please note the direction of the current flow is **always opposite** to the direction of electron flow.

1.3 N type & P type Semiconductors

1.3.1 Intrinsic semiconductor: It is very pure chemically. It has **equal numbers of** electrons (-ve) and holes (+ve). It has **poor conductivity.**

1.3.2 Extrinsic semiconductor:

- When a **small amount, of impurity is added** to a pure semiconductor, the conductivity of the semiconductor is increased manifold.
- Such materials are known as extrinsic semiconductors.
- The deliberate addition of a **desirable impurity**, is called **doping.**
- Doping yields two types of semiconductors viz p type and n type.
- The impurity atoms are called **dopants.**
- Such a material is also called a **doped semiconductor.**
- **Silicon & Germanium** are the standard semiconductor atoms, used by the industry.

Some of the popular dopants used, in doping the tetravalent Si or Ge are,

Trivalent atoms such as Boron or Aluminium, for producing p type semiconductors.

Pentavalent atoms such as Arsenic or Phosphorous, for producing n type semiconductors.

n type: Refer fig 1.4. **Pentavalent (5)** impurities like Arsenic (As), Antimony (Sb), Phosphorous (P), when added to either silicon or germanium, will produce N type semiconductors. **Electrons are the majority carriers**.

p type: Refer fig 1.5. **Trivalent (3)** impurities like Indium (In), Boron (B), Aluminium (Al) when added to either Silicon or Germanium, will produce P type semiconductors. **Holes are the majority carriers**.

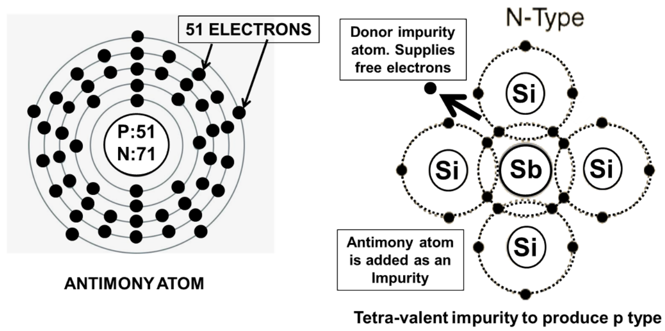


Fig 1.4 n-type pentavalent atom

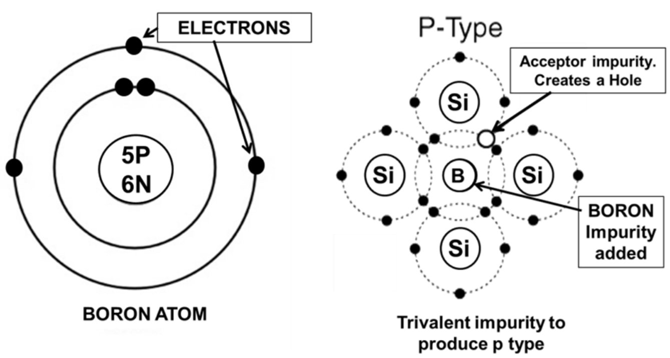


Fig 1.5 p-type trivalent atom

Majority and minority carriers

Majority carriers:

- The more abundant charge carriers
- Primarily responsible for current transport in a semiconductor.
- n-type semiconductors: Electrons
- p-type semiconductors: Holes.

Minority Carriers:

- The less abundant charge carriers
- n-type semiconductors: Holes
- p-type semiconductors: Electrons.

1.4 pn junction

Figure 1.6 shows independent p type independent n type semi-conductor.

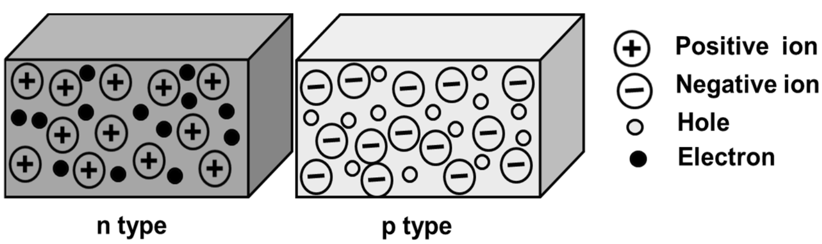


Fig 1.6 Semiconductor material n-type and p-type

Fig 1.7 shows a p type and n type conductor joined together (fabricated) to form a p-n junction

- There is no external voltage (bias) applied.
- Initially, pn junction is electrically neutral.

- **Majority carriers of n type are electrons.**
- **Majority carriers of p type are holes.**

1.4.1 Diffusion

Refer fig 1.7. Due to thermal agitation, electrons and holes start moving randomly, even if there is no bias. Look at the diffusion process below.

Few electrons close to the junction, start crossing the junction, to reach p side	Few holes close to the junction, start crossing the junction, to reach the n side

These electrons combine with some holes in the p side, to create some –ve ions.	These holes combine with electrons in the n side to create some +ve ions.
Due to these ions, a -ve voltage build up (barrier) is created, on the p side.	Due to these ions, a +ve voltage build up (barrier) is created on the n side.

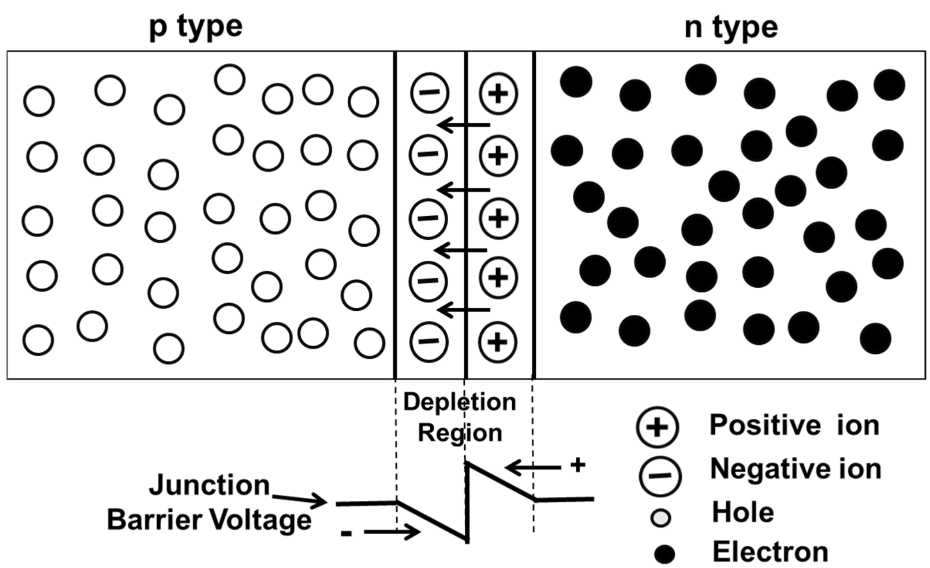


Fig 1.7 p-n junction diode – No bias voltage

This barrier voltage build up is shown in the figure 1.8.

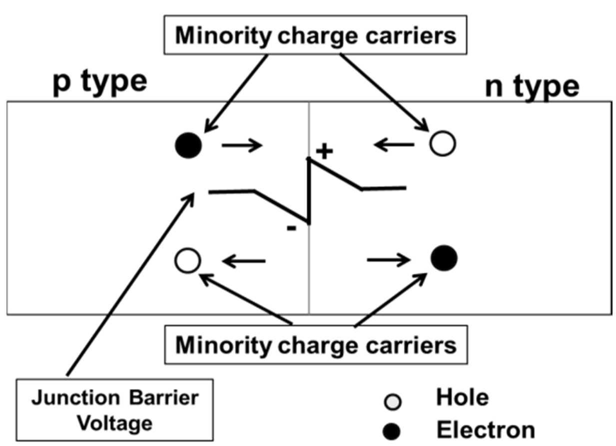


Fig 1.8 Barrier Voltage at p-n junction

- Barrier voltage is typically **0.7 V, for Silicon**.
- Barrier voltage is typically **0.3 V, for Germanium.**
- At around the barrier voltage, **electrons (from n side) are repelled by the – ve barrier voltage in the p side.**
- At around the barrier voltage**, holes (from p side) are repelled by the +ve barrier voltage in the n side.**
- Therefore further diffusion stops.

1.4.2 Depletion region

- In the diffusion process mentioned above, **when the barrier potential is reached, further diffusion stops.**
- No charge carriers (electrons or holes) will be present, closer to the junction.
- Only ionized atoms (+ve and –ve), will be present on either side of the junction.
- This region is known as **depletion region**.

1.5 pn junction biasing

1.5.1 Reverse biased p-n junction

What is reverse bias?

Refer figure 1.9.

An external dc voltage (bias) is applied to a diode such that, p side is connected to the –ve terminal and n side is connected to the +ve terminal of a battery.

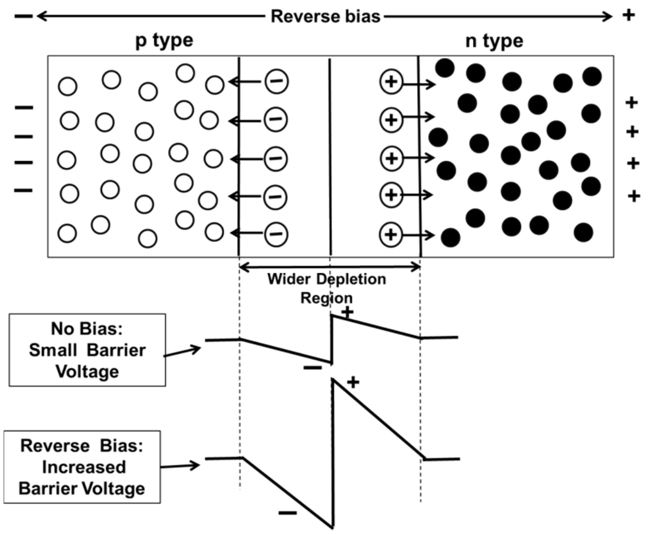


Fig 1.9 Reverse biased p-n junction

- This biasing arrangement increases the barrier voltage, as shown in the figure.
- Barrier voltage at n, becomes more +ve and the barrier voltage at p becomes more –ve.
- Electrons (majority carriers) in the n side, are repelled away from the junction and are attracted towards the +ve terminal.
- Holes (majority carriers) in the p side, are repelled away from the junction, and are attracted towards the –ve terminal.
- Consequently, depletion region further widens and barrier voltage increases as shown.

Result: Majority carriers cannot flow across junction and therefore, under reverse bias conditions, no current flow is possible. In other words, forward current does not flow.

1.5.2 Forward biased p-n junction

Refer figure 1.10.

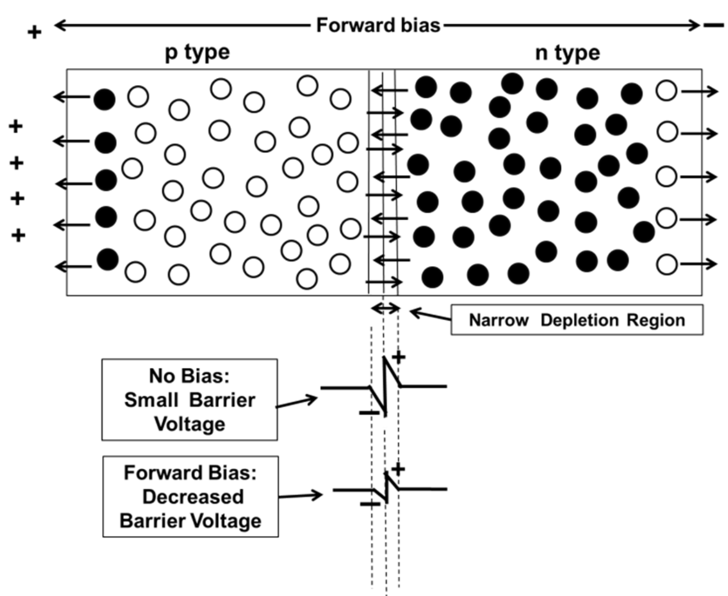
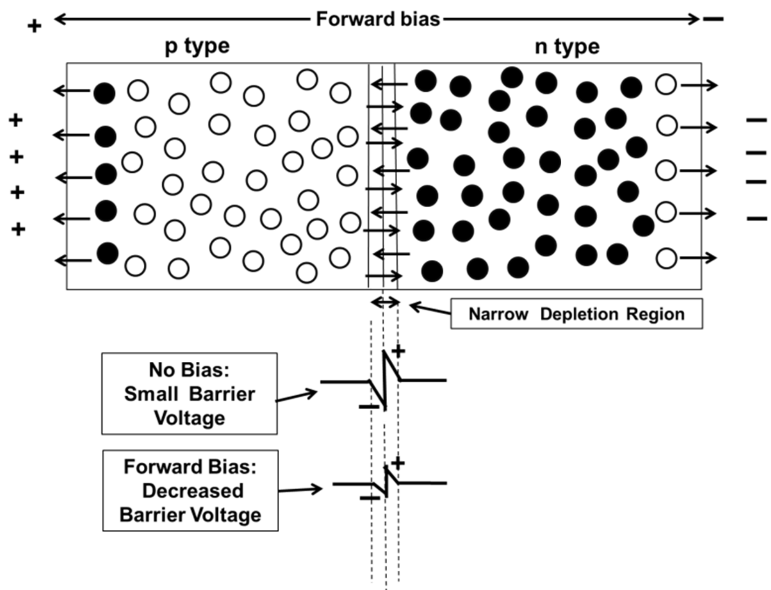


Fig 1.10 Forward biased p-n junction

What is forward bias?

An external dc voltage (bias) is applied to a diode such that **n side is connected to the – ve terminal and p side is connected to the +ve terminal of a battery.**

- This biasing arrangement decreases the barrier voltage, as shown in the figure 1.10.
- Barrier voltage at n, becomes less +ve and the barrier voltage at p becomes less –ve.
- Electrons (majority carriers) in the n side, are attracted across the junction, **towards the p side and are attracted towards the +ve terminal.**
- Holes (majority carriers) in the p side, are attracted across the junction, **towards the n side and are attracted towards the –ve terminal.**



- Consequently, depletion region decreases and the barrier voltage also reduces, as shown.

Result: Majority carriers will flow across junction and therefore, under positive bias conditions, current flow is possible. In other words, forward current flows.

Fig 1.10 Forward biased p-n junction