This book has been prepared exclusively for

VEIS COMPUTER EDUCATION

BASIC ELECTRONICS

CHAPTER I

BASIC ELECTRICITY

1.1 Electricity: Electricity is the branch of engineering which deals with conductors.

1.2 Atomic Structure: Matter is composed of very small particles called atoms. An atom is consists of a central body called the nucleus which is surrounded by small particles, called electrons. The nucleus contains protons and neutrons. The charges of these particles are as follows:

Protons are positively charged.

Neutrons are electrically neutral.

Electrons are negatively charged.

Electrons revolve in different paths or orbits. Each electron is held in orbit by force of attraction between it and the nucleus.

The charge of an electron is equal to that of a proton. The number of electrons is equal to the number of protons in an atom. Therefore an atom is electrically neutral as a whole. The number of electrons or protons in an atom is called atomic number.

Atomic number = number of protons or electrons in an atom.

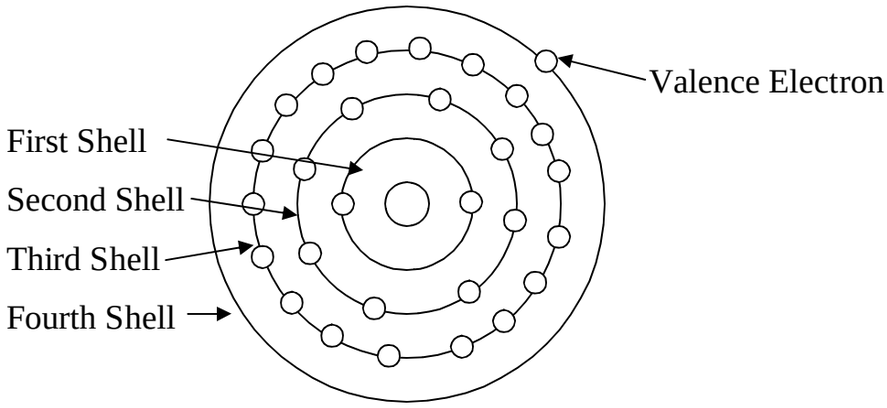
The electrons are arranged in different orbits around a nucleus. The number of electrons in any shell is given by $2n^2$ where n is the number of orbit or shell. Therefore

First orbit can contain $2 \times 1^2 = 2$ electrons

Second orbit can contain $2 \times 2^2 = 8$ electrons

And so on.

The outer shell is called the valence shell and the electrons in this shell are called valence electrons. Valence shell never has more than 08 electrons.



An atom of argon contains 18 electrons – 2 in the first shell, 8 in the second shell, and 8 in the third shell. Some heavier element would have 9 electrons in third shell. This would violate the valence rule stated above. In this case the extra electrons are placed in a fourth shell.

Thus the 19 electrons are distributed in this manner –

2 in the first shell

8 in the second shell

8 in the third shell

1 in the fourth shell

In this case outer or valence shell is fourth shell.

The valence electrons can be easily separated from the atom because the distance of valence electrons is more from the nucleus

1.3 Insulators: Substances with more than 4 valence electrons are called insulators. Insulators provide high resistance thus does not allow electricity to flow through them.

Example – Rubber, Mica etc.

1.4 Conductors: Substances with less than 4 valence electrons are called conductors. Conductors provide less resistance thus allows electricity to flow through them.

Example – Copper, Aluminum etc.

1.5 Semiconductor: Substance with 4 valence electrons are called semiconductors. Their conductivity lies between conductor and insulator.

Example – Germanium, Silicon.

1.6 Current: The flow of electrons in any conductor is called current. The symbol of current is I and it is measured in amperes or amps. The symbol for amp is A. Electrons are the negatively charged particles of a material, which are responsible for the flow of current.

1.7 E.M.F.(Electro Motive Force): It is the force, which causes to flow the electrons in any closed circuits. The unit of e.m.f. is volt and is abbreviated as V.

1.8 Potential Difference: The potential difference is the difference of potential between two points in an electrical circuit. Its unit is also volt.

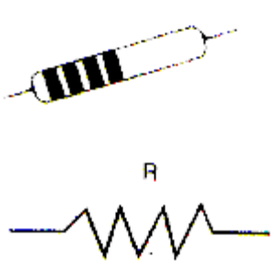
1.9 Battery: A battery is a group of cells that generates electric energy from their internal chemical reactions.

There are two basic types of batteries. These are Primary and Secondary.

1.9.1 Primary Cell: Primary Cell cannot be recharged. These are dry cell, alkaline cell, lithium cell etc.

1.9.2 Secondary Cell: Secondary Cell can be recharged. The secondary cells are lead acid wet cell, nickel cadmium cell.

1.10 Resistance: Resistance is the property of a substance (matter), which opposes the flow of electricity through it. The unit of resistance is ohm (Ω) and represented by the letter R. The substance, which has resistance is called resistor.



Resistor& symbol

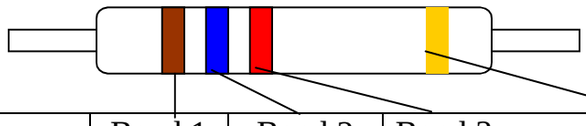
1.10.1 Resistor Ratings: Resistors have following three ratings

(i) Resistance in Ohms

(ii) Tolerance in percent

(iii) Wattage in Watt

1.10.2 Colour coding on resistors to find out resistance



Colour	Band 1 First	Band 2 Second	Band 3 Multiplier	Band 4 Tolerance
Black	0	0	1	
Brown	1	1	10	
Red	2	2	10^2	
Orange	3	3	10^3	
Yellow	4	4	10^4	
Green	5	5	10^5	
Blue	6	6	10^6	
Violet	7	7	10^7	
Grey	8	8	10^8	
White	9	9	10^9	
Gold	-	-	0.1	± 5%
Silver	-	-	0.01	± 10%
No Band	-	-		± 20%

Note: BB Roy Great Britain Very Good Wife

1.10.3 Types of Resistors

1. Fixed – In this the value of resistance is fixed.
2. Variable – Value of resistance varies with the help of potentiometer (knob).

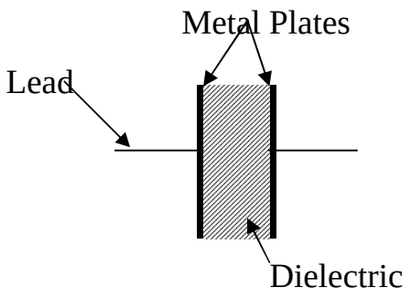
1.11 Inductor – Inductor is a device, which opposes a change in current flow.

1.12 Inductance: Ability of a device or circuit, which oppose a change in current flow, is called inductance. The substance, which has inductance property is called Inductor. The unit of inductance is hennery and represented by L.

Symbol

1.13 Capacitor: An electrical device specially designed to store electrical energy by means of electrostatic field is called capacitor. Capacitor is made up of two metal

plates, separated by non-conducting material called a dielectric. Dielectric is a media through which current does not pass or acts as an insulator example paper, glass, mica, ceramic or other type good type of insulator.



Capacitor

1.13.1 Capacitance: Capacitance is a measure of the amount of charge that a capacitor can store for an applied voltage. The unit of capacitance is Farad, abbreviated as F.

1.13.2 Types of Capacitors

Capacitors are two types. These are

(i) Variable Capacitors – We can change the value of capacitors.

(ii) Fixed Capacitors – We cannot change the value.

1.13.3 Troubles in Capacitors

Capacitors can become open or short-circuited. In either case, the capacitor is useless because it cannot store charge.

1.13.4 Checking Capacitors with an Ohmmeter

Discharge the capacitor before checking with ohmmeter.

Check the capacitor at the highest Ohm range, such as R x 1 MΩ, is preferable.

For a good capacitor, the meter pointer moves quickly towards the low-resistance side of the scale and then slowly reduces towards infinite.

When the ohmmeter initially connected, its battery charges the capacitor. This charging current is the reason the meter pointer moves away from infinite, since more current through the ohmmeter means less resistance. Maximum current flows at the first instant of charge. Then the charging current decreases as the capacitor voltage increases towards the applied voltage; therefore, the needle pointer slowly moves toward infinite resistance. Finally, the capacitor is completely charged to the ohmmeter battery voltage, the charging current is zero, and the ohmmeter reads just the small leakage current through the dielectric. This charging effect, called capacitor action, shows that the capacitor can store charge, indicating a normal capacitor. Charging causes the rise and fall of the meter readings. The capacitor discharges when the meter leads are reversed.

1.13.5 Ohmmeter Reading

1. If ohmmeter reading immediately goes practically to zero and stays there, the capacitor is short-circuited.
2. If the capacitor shows no charging action but reads very high resistance means it is open.
3. If the capacitor shows charging, but the final resistance reading is less than normal, means the capacitor is leaky.

1.14 Self-Induction – Whenever current passes through a coil, the flux linkage is changing and opposing emf is induced in the coil. This phenomenon is called self-induction and opposing emf is called self-induced emf.

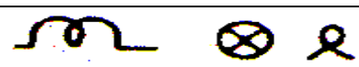
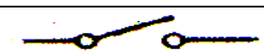
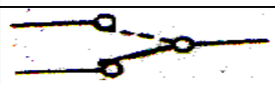
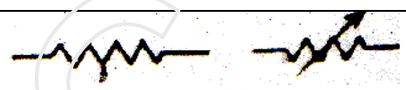
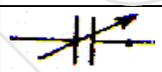
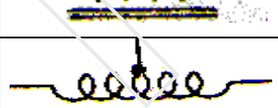
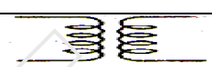
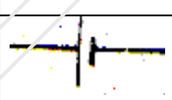
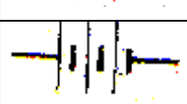
1.15 Mutual Induction: When an alternating current flows through a conductor, the magnetic field induced. If another conductor is placed close together so that conductor cut the magnetic flux lines of another, the magnetic field will induce a voltage into the second conductor.

1.16 Alternating Current: Alternating voltage sources periodically (from time to time) reverse in polarity. The Alternating Current therefore periodically reverses in direction. AC flows first in one direction and then in the opposite direction.

1.17 Direct Current: The current flow in one direction is known as Direct Current. The reason for direct current is that the battery maintains the same polarity of output voltage. The DC voltage sources have a steady output voltage.

1.18 Transformer: The transformer has two coils. The coil, which is connected to the source, is called primary coil and the coil, which is connected to load resistance, is called secondary coil. When alternating current flows through the primary coil, then the flow of current causes a magnetic field around the primary and secondary windings due to mutual induction.

1.19 Graphical Symbols used in Electricity

SNo.	Description	Symbols
1.	+ve polarity	+ (Red Colour)
2.	-ve polarity	- (Black Colour)
3.	Earth	Green Colour
4.	Lamp	
5.	One-way Tumbler Switch	
6.	Two-way Switch	
7.	Resistance Fixed	
8.	Resistance variable (rheostat)	
9.	Capacitor Fixed	
10.	Capacitor Variable	
11.	Choke	
12.	Auto Transformer	
13.	Transformer	
14.	Cell	
15.	Battery	
16.	Regulator	
17.	AC Source	

1.20 Terminology

1. Fuse – A wire between the circuit, which will melt easily and so break the connection when the current exceeds the predefined value. Such a conductor is known as fuse wire.

2. Potentiometer – It is a variable device by rotating this you can change rating or value of component.

3. Soldering – It is a process of joining two wires together with the help of solder through heating process by soldering Iron.

4. Solder – Material used for soldering, which is zinc, copper alloy.

5. Brazing - Soldering at high temperature using brass as solder is called brazing.

6. Flux – It is used to remove oxide (oxide means deposited dust/carbon/corrosion on the surface) from the metal for good soldering.

7. Open Circuit – It is the circuit through which current does not pass.

8. Closed Circuit – It is the circuit through which current passes.

1.21 Practical Electric Units

Elements of Electricity	Unit
Resistance	Ohm
Voltage	Volt
Current	Ampere
Quantity of Electricity	Coulomb
Capacitance	Farad
Inductance	Henry
Magnetic Flux	Weber
Energy	Joule
Power	Watt

Exercise 1

Q.1 Fill in the blanks

(i) Electricity is the branch of engineering which deals with the current flow through _____ [conductors]

(ii) The smallest particle of matter is called_____ [atom]

(iii) The central portion of an atom is called_____ [nucleus]

(iv) Nucleus is made up of _____ [protons and neutrons]

(v) The charge on a neutron is_____ [nil]

(vi) The atom as a whole is electrically_____ [neutral]

(vii) The number of electrons or protons in an atom is called_____ [Atomic Number]

(viii) The maximum number of electrons in a shell is given by the formula_____ [2n2]

(ix) The outermost shell is called_____ [valence shell]

(x) The outer shell can have a maximum of_____ electrons.[8]

(xi) Substances having more than 4 electrons are called_____ [insulators]

(xii) The flow of electrons in a conductor is called_____. [current]

(xiii) Unit of current is_____. [ampere]

(xiv) Resistance _____the flow of current. [opposes]

(xv) Unit of resistance is_____.[ohm]

(xvi) Inductor is a device which opposes _____.[the change in current]

(xvii) Inductor allows _____ and blocks _____. [DC, AC]

(xviii) The insulating material used between the two plates of a capacitor is known as _____. [dielectric]

(xix) Transformer is a device which _____. [steps up or steps down the input voltage]

(xx) Transformer is based on the principle of _____. [Mutual Induction]

Q.2 Write short Notes:

(i) Conductor

(ii) Insulator

(iii) Current

(iv) Capacitor

(v) Inductor

(vi) Transformer

(vii) Resistor

CHAPTER II

BASIC ELECTRONICS

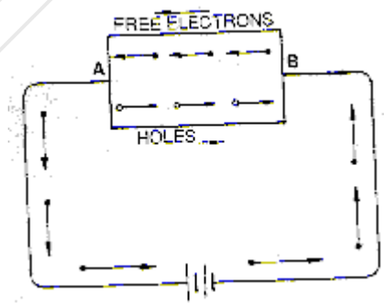
2.1 Electronics: The branch of engineering which deals with current conduction through a vacuum or gas or semiconductor is known as electronics.

2.2 Semiconductor: Semiconductors (e.g. germanium, silicon) are those substances, whose properties lies between conductor and insulator material means these material are neither conductor nor insulator.

2.3 Vacuum Tubes: Vacuum tubes are device in which current conduction is through vacuum. Vacuum tubes are working on the principle of heat. These are named as diode, triode, tetrode and pentode.

2.4 Types of Semiconductor: There are two of semiconductors. These are intrinsic Semiconductor and extrinsic semiconductor.

2.4.1 Intrinsic Semiconductor: The semiconductor is an extremely pure form is known as intrinsic semiconductor.



2.4.2 Extrinsic semiconductor**:** The intrinsic semiconductor has little current conduction capability at room temperature. To improve the conduction capability required adding impurity in the pure semiconductor. When a pure semiconductor is

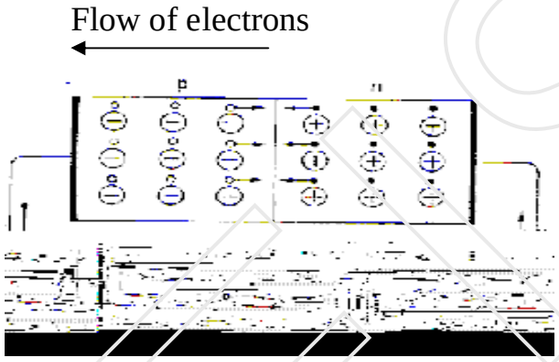
added with some impurities is called extrinsic semiconductor. The process of adding impurities to a semiconductor is called doping.

Depending on the type of impurity the extrinsic semiconductors are classified as N-type and P-type semiconductor.

2.5 P-N Junction

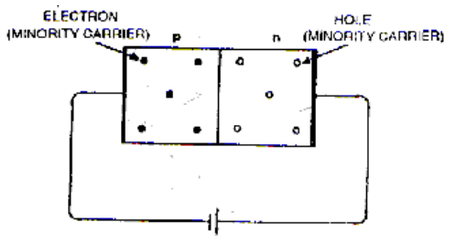
In a single piece of semiconductor material, one half is P-type semiconductor and other half is N-type semiconductor is called P-N Junction. Such a P-N junction is called semiconductor diode.

2.5.1 Forward Bias of P-N Junction:



When +ve battery terminal is connected to P-region to the semiconductor and –ve battery terminal to N-region such a configuration is called forward biased.

2.5.2 Reverse Bias of P-N Junction:



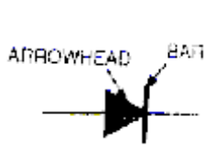
When p-type is connected to negative terminal and n-type is connected to positive terminal, such a configuration is called reverse biased.

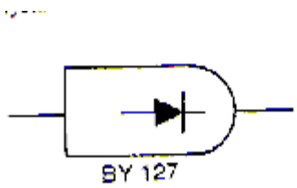
2.5.3 Identification of Diode Terminals:

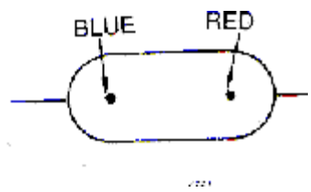
(i) Anode side has circular round or

(ii) Sometimes, red and blue marks are used on the body of the crystal diode. Red mark indicates anode and blue mark indicate cathode. Or

(iii) Connect the diode terminals with the ohmmeter lead. If the ohmmeter resistance is almost zero than diode terminal connected to the +ve terminal of ohmmeter is anode.





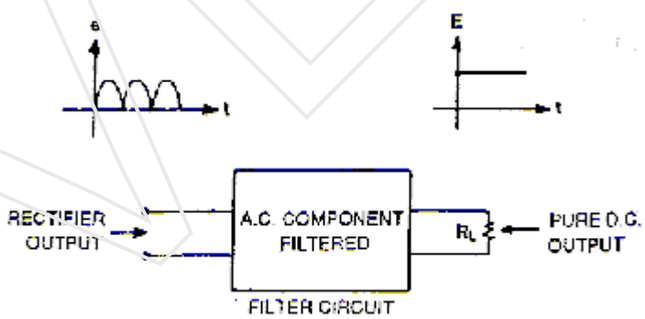


2.5.4 Operation: When P-N Junction diode is forward biased it conducts and (It is a one-way device of a lower resistance when a forward biased) when it is reversed biased it acts as insulator. Hence such diodes are mostly used as rectifier i.e. for converting AC current to DC current.

2.6 Filters: Filter is a device, which minimise ripples contained in the rectifier out put.

or

A filter circuit is a device, which removes the AC component of rectifier output but allows the DC component.



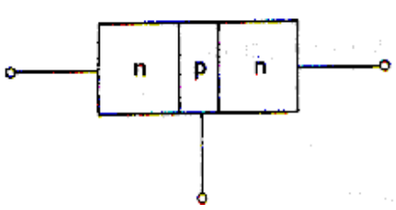
2.7 Light Emitting Diode (LED): LED is a P-N Diode, which emits light when forward biased. During the recombination of electrons holes some of the energy is

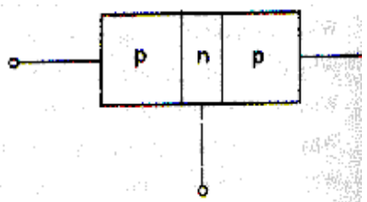
given off in the form of light. If the semiconductor material is transparent the light will emit and junction becomes the light source that is called LED.

2.8 Transistors: A transistor consists of two p-n junctions formed by sandwiching either p-type or n-type semiconductor between a pair of opposite types.

There are two types of transistor, these are:

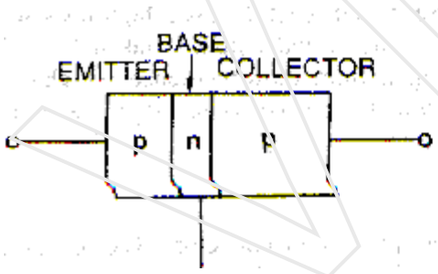
(i) n-p-n transistor (ii) p-n-p transistor

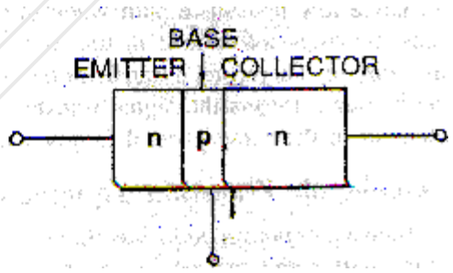




An n-p-n transistor is composed of two n-type semiconductors separated by a thin section of p-type and p-n-p transistor is formed by two p-sections separated by a thin section of n-type.

2.8.1 Transistor Terminals: A transistor (p-n-p or n-p-n) has three sections of doped semiconductors. The section on one side is the emitter and the section on the opposite side is the collector. The middle section is called the base and forms two junctions between the emitter and collector.





(i) Emitter: The section on one side that supplies charge carriers (electrons or holes) is called the emitter. The emitter is always forward biased with respect to base.

(ii) Collector: The section on the other side that collects the charge carriers is called the collector. The collector is always reverse biased.

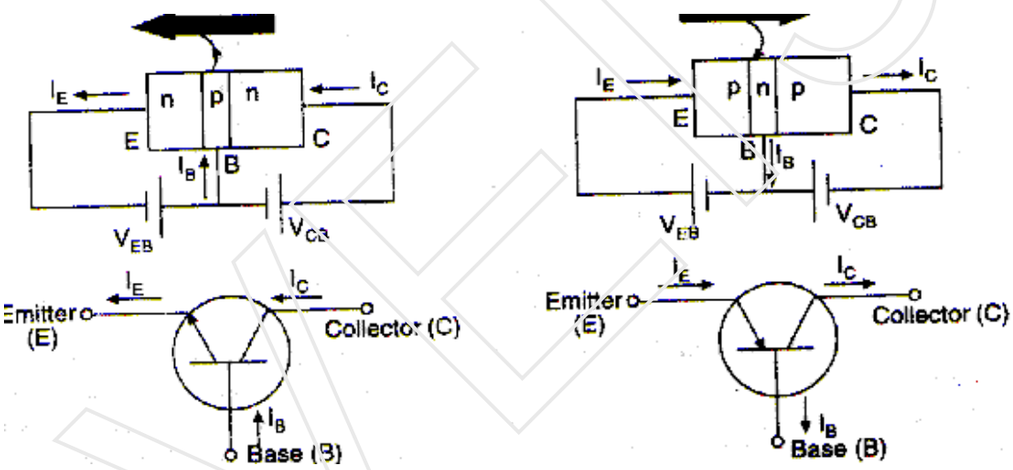
(iii) Base: The middle section, which forms two p-n junctions between the emitter and collector, is called the base. The base-emitter junction is forward biased and the base-collector junction is reverse. Biased.

Some Facts about the transistor

(i) The transistor has three regions namely; emitter, base and collector. The base is much thinner than the emitter while collector is wider than.

(ii) The emitter is heavily doped so that it can inject a large number of charge carriers (electrons or holes) into the base. The base is lightly doped and very thin; it passes most of the emitter injected charge carriers to the collector. The collector is moderately doped.

2.8.2 Transistor Symbols: The symbols used for NPN and PNP transistors are shown



Emitter is shown by an arrow, which indicates the direction of conventional current flow when forward biased. For NPN connection, it is clear that conventional current flows out of the emitter as indicated by the outgoing arrow. Similarly for PNP connection, the conventional current flows into the emitter as indicated by inward arrow.

2.8.3 Purpose of Transistors: Transistors are mainly used as amplifiers and oscillators. Amplifier is a device, which increases the strength of a weak signal. Oscillator is a device, which generates continuous oscillations when supplied with positive feedback.

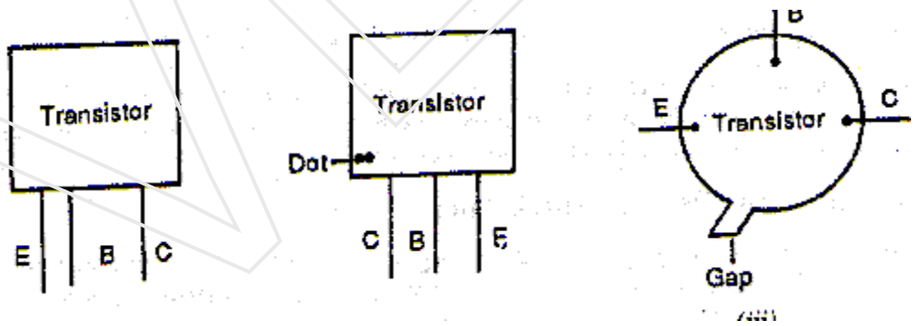
2.8.4 Transistor Lead Identification: There are three leads in a transistor viz. collector, emitter and base.

(i) When the leads of a transistor are in the same plane and randomly spaced, they are identified by the position and spacing of leads. The central lead is the base lead. The collector lead is that which is far from the base lead the remaining lead is the emitter.

(ii) When the leads of a transistor are in the same plane but equally spaced, the central lead is the base, the lead identified by dot is the collector and the remaining lead is the emitter.

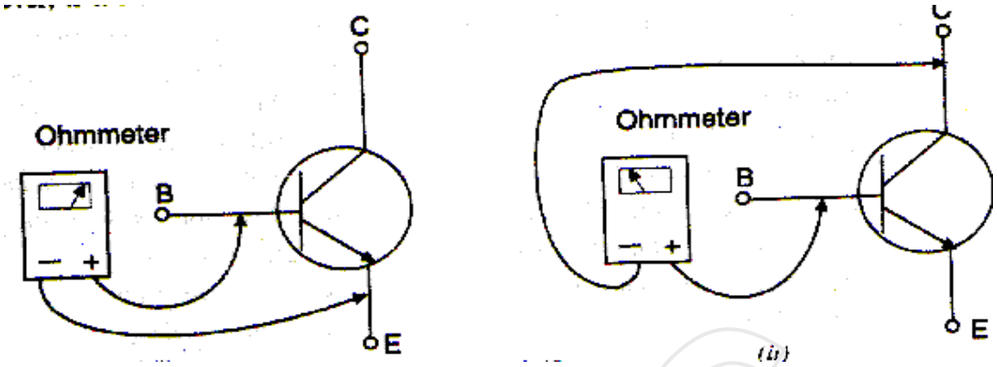
(iii) When the leads of a transistor are spaced around the circumference of a circle, the three leads are generally in E-B-C order clockwise from a gap.

(iv) When only two leads are given then body will always act as collector. Connect one lead of ohmmeter with one of the transistor lead and other lead with the body and look for continuity. If continuity is there it means the transistor lead is the base and other lead is emitter.



2.8.5 Identification of PNP or NPN transistor: Connect +ve terminal of a battery with base and –ve terminal with emitter and collector one by one, if continuity is there, it means transistor is NPN otherwise PNP.

Transistor Testing: An ohmmeter can be used to check the state of a transistor i.e., whether the transistor is good or not. We know that base-emitter junction of a transistor is forward biased while collector-base junction is reverse biased. Therefore, forward biased base-emitter junction should have low resistance and reverse biased collector-base junction should have much higher resistance.



(i) The forward biased base-emitter junction (biased by internal supply) should read a low resistance. If that is so, the transistor may be good. If this check fails, the transistor is faulty.

(ii) The reverse-biased collector-base junction (biased by internal supply) should read a high resistance (approx infinity). If that is so, the transistor is good. If this check fails, the transistor is faulty.

Note: When testing a *pnp* transistor, the ohmmeter leads must be reversed. The results of the tests, however, will be the same.

2.9 Integrated circuits: An integrated circuit is one in which circuit components such as transistors, diodes, resistors, capacitors etc. are automatically part of a small semiconductor chip and perform a complete electronic function.

2.9.1 Scale of Integration:

Scale of Integration	Abbreviation	No. of components
Small	SSI	1 to 20
Medium	MSI	21 to 100
Large	LSI	101 to 1000
Very Large	VLSI	1001 to 10000
Super Large	SLSI	10001 to 1 Lac

2.10 Multivibrators: An electronic circuit that generates square waves (or other non-sinusoidal waveforms such as rectangular, sawtooth waves etc.) is known as multivibrator.

Exercise 2

Q.1 Fill in the blanks

(i) N-type semiconductor is formed due to addition of a _____ impurity. (pentavalent)

(ii) P-type semiconductor is formed by addition of a _____ impurity. (trivalent)

(iii) Diode is a _____ terminal device. (two)

(iv) Circular ring on a diode indicates _____. (anode).

(v) When diode is in forward biased, then ohmmeter reads almost _____ resistance. (zero)

(vi) Diode is mainly used as a _____. (rectifier)

(vii) A transistor has _____ junctions. (two)

(viii) Three sections of a transistor are _____. (emitter, base and collector)

(ix) Transistor is mainly used as an _____. (amplifier)

(x) In a two lead transistor body acts as _____. (collector)

Q.2 Write short notes

(i) Diode

(ii) Transistor

(iii) Biasing of diode

(iv) Biasing of a transistor

(v) Ics

CHAPTER III

DIGITAL TECHNIQUES

3.1 Analog and Digital signals

(i) Analog signal: A continuously varying signal *(voltage or current)* is called an analog signal. For example, an Alternating Current varying sinusoidally is an analog signal. If such an analog signal is applied to the input of a transistor amplifier, the output voltage will also vary sinusoidally. This is the analog operation i.e. the output voltage can have an infinite number of values. Due to many valued output, the analog operation is less reliable.

(ii) Digital signal: A signal *(voltage or current)* that can have only two discrete (separate) values is called a digital signal. For example, a square wave. It is because this signal has only two values viz, +5V and 0V and no other value. These values are labeled as high and low. The high voltage is + 5V and the low voltage is 0V. If proper digital signal is applied to the input of a transistor, the transistor can be driven between cut off and saturation. In other words, and transistor will have two state operation i.e. output is either low or high. Since digital operation has only two states (i.e. ON or OFF), it is far more reliable than many value analog operation. It is because with two state operations, all the signals are easily recognised as either low or high.

3.2 Digital Circuit:

An electronic circuit that handles only a digital signal is called a digital circuit.

The output voltage of a digital circuit is either low or high and no other value. In other words, digital operation is a two state operation. These are (high or low) or (ON or OFF) or (1 or 0). The digital uses only two digits 1 and 0 is called the binary number system.

3.3 Number System

3.3.1 Binary, Octal, Hexadecimal

Binary, Octal and Hexadecimal are mathematics of computer. In decimal system the digits are 0 to 9 therefore base of decimal system is 10, whereas binary uses 1 and 0 therefore base of binary is 2. Octal number uses values from 0 to 7 and has base 8 and Hexadecimal uses values 0 to 9 and alphabets from A to F therefore base is 16.

Comparison of Decimal, Binary, Octal and Hexadecimal

Decimal	Binary	Octal	Hexadecimal
0	0000	0	0
1	0001	1	1
2	0010	2	2
3	0011	3	3
4	0100	4	4
5	0101	5	5
6	0110	6	6
7	0111	7	7
8	1000	10	8
9	1001	11	9
10	1010	12	A
11	1011	13	B
12	1100	14	C
13	1101	15	D
14	1110	16	E
15	1111	17	F

3.3.2 Decimal to Binary Conversion

Divide the integer by 2 and note down the remainder and multiply the fraction by 2 and note down the carry.

Example Convert $(14)_{10}$ into binary.

2	**14**	**R**
2	7	0
2	3	1
2	1	1
2	0	1

The binary equivalent will be 1110, so $(14)_{10} = (1110)_{2.}$ If we were converting to base 8 or base 16, the value of 2 would replace 8 and 16 respectively.

3.3.3 Binary to Decimal Conversion

Example: Convert $(1110)_2$ to Decimal

1110_2	=	$1x2^3$	$+ 1x2^2$	$+ 1x2^1$	$+ 0x2^0$
	=	1x8	+ 1x4	+ 1x2	+ 0x1
	=	8	+ 4	+ 2	+ 0
	=	14			

$(1110)_2 = (14)_{10}$

3.4 Binary: Binary arithmetic has two distinct symbols 0 and 1. These are called levels or states of logic. For example, a binary 1 represents a High level and a binary 0 represents a low level.

Arithmetic operations in a computer are done using binary numbers and not decimal numbers.

3.4.1 Binary Addition

0 + 0 = 0

0 + 1 = 1

1 + 0 = 1

1 + 1 = 0 plus a carry of 1 to next higher column

Example 1: Add the binary number 10011 and 1001.

Carry			**1**	**1**	
	MSB				LSB
	1	**0**	**0**	**1**	**1**
	+	**1**	**0**	**0**	**1**

	1	**1**	**1**	**0**	**0**

3.4.2 Binary Subtraction

Subtraction is done by direct method and complement method. Computer does the subtraction by the complement method.

Direct Method

0 - 0 = 0

0 - 1 = 1 with a borrow from the next column

1 - 0 = 1

1 - 1 = 0

Example: Subtract the binary number 1110 from 10101.

```
      1   0   1   0   1
-     0   1   1   1   0
      ---------------------------------
      0   0   1   1   1
```

In the first column, o is subtracted from 1. No borrow is required in this case and the result is 1. In the second column, we have to subtract 1 from 0, borrow is necessary to perform this subtraction. So a 1 is borrowed from the third column, which becomes 2 in the second column because the base is 2. Now in the second column, we subtract 1 from 2 giving a result of 1. The borrow performed in the second column reduces the 1 in the third column to 0. So in the third column, once again we have to subtract 1 from 0 for which borrow is required. The fourth column contains a 0 and thus has nothing to borrow. Therefore we have to borrow from the fifth column. Borrowing 1 from the fifth column gives 2 in the fourth column. Now fourth column has something to borrow. When 1 of the 2 in the fourth column is borrowed, it becomes 2 in the third column. Now in the third column, we subtract 1 from 2 giving a result of 1. The borrow performed in the third column reduces the 1 in the fifth column to 0 and the 2 in the fourth column to 1. Hence, subtraction of the fourth column is now 1 from 1 giving 0. Thus the final result of subtraction is 001112.

Example 1: Subtract the binary number 01110000 from 101110.

```
      1   0   1   1   1   0   0
-     0   1   1   1   0   0   0
      -----------------------------------------------
      0   1   0   0   1   0   0
      -----------------------------------------------
```

3.4.3 Complements

Complements are used in digital computers for simplifying the subtraction operation and for logic manipulations.

Complements are two types. These are

(i) 1's complement

(ii) 2's complement

3.4.3.1 Subtraction by 1's complement

In the 1's complement each 1 is changed to 0 and 0 to 1.

Number	1's Complement
100	011
1010	0101
111	000

Example: Subtract 101 from 111

Take 1's complement of number to be subtracted. Add is to the given number.

```
      1   1   1
+     0   1   0     (1's complement of 101)
      -------------
1     0   0   1
      -------------
```

Fourth bit (left bit) 1 is called End Around Carry (EAC). Add this EAC to remaining three bits. When EAC is present means answer is positive.

```
      0   0   1
      +       1
```

---

0 1 0 (final answer)

Example: Subtract 1101 from 1010

1 0 1 0

\+ 0 0 1 0 (1's complement of 1101)

---

1 1 0 0

No EAC means answer will be in negative, to get the answer convert this result in the 1's complement.

\- 0 0 1 1 (answer, 1's complement of 1100).

3.5 Codes: Codes are a symbolic representation of information, which may be present in the form of number's, letters. The symbols used are the binary digits 1 or 0, which are arranged according to the rules of codes. These codes are used to communicate information to a digital computer to retrieve messages from it. A code is used to enable on operation to feed data into a computer directly in the form of decimal numbers, alphabets and special characters. The computer converts these data in to binary codes and after computation, transforms the data into its original format (decimal number alphabets & special character).

3.5.1 ASCII: The ASCII pronounced "as–kee". The ASCII code stands for American Standards Code for Information Interchange used in most microcomputer by its manufacturers. The ASCII code represents a character with seven bits with one additional zero bit.

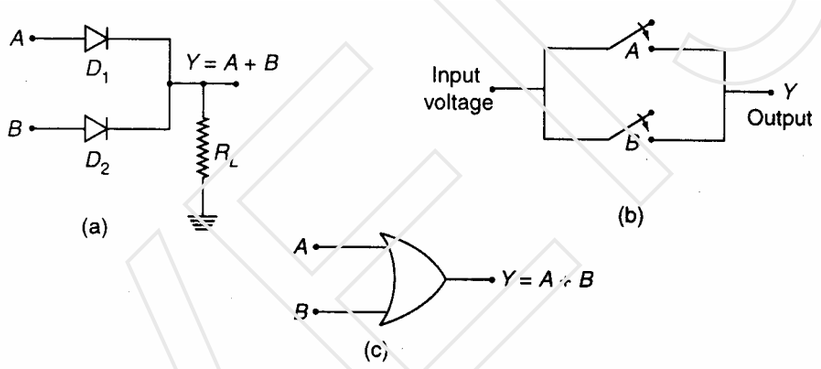
3.6 Logic Gates**:** A logic gate is an electronic circuit, which makes logical decision. The common logic gates are OR, AND, NOT, NAND & NOR gates. The NAND and NOR gates are called universal gates (because using NAND and NOR

you can design any gate). The exclusive-OR Gate is another logic gate which can be constructed using AND, OR and NOT gates.

Logic gates have two or more inputs and only one output except NOT Gate, which has only one input. The logic gates are building block of hardware, which are available in the form of various IC's. Each Gate has its own logic symbol. The relationship between input and output variables of each Gate can be represented in a tabular form called a truth table.

3.6.1 OR GATE: The OR Gate performs logical addition. The OR gate has two or more inputs and only one output. The output of OR gate will be high when any of the input is HIGH (1). The output is low when all the inputs are low (0). If A and B are the input variables of an or gate and Y in its output, then Y=A+B.

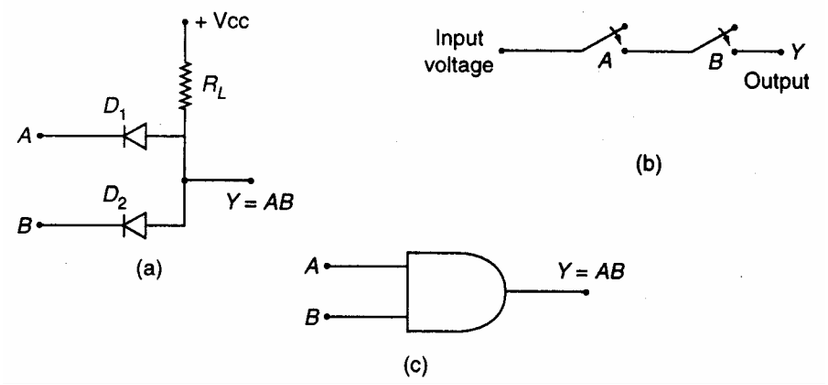
Inputs		Output
A	*B*	*Y = A + B*
0	0	0
0	1	1
1	0	1
1	1	1



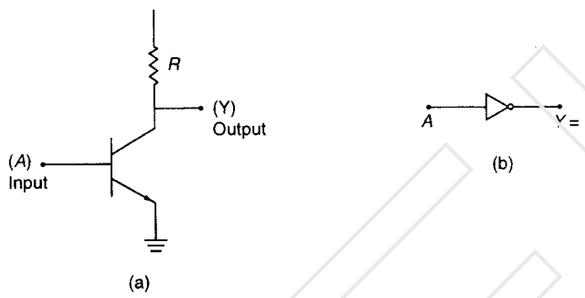
3.6.2 AND GATE: The AND gate performs logical multiplication. (Known as AND function). The AND gate has two or more inputs and a single output. The output of an AND gate in high only when all the inputs are high. Even if any one of the inputs in low, the output will be low.

If A and B are the input variables of an and gate and Y in its output, then Y=A.B.

Inputs		Output
A	*B*	*Y = A · B*
0	0	0
0	1	0
1	0	0
1	1	1



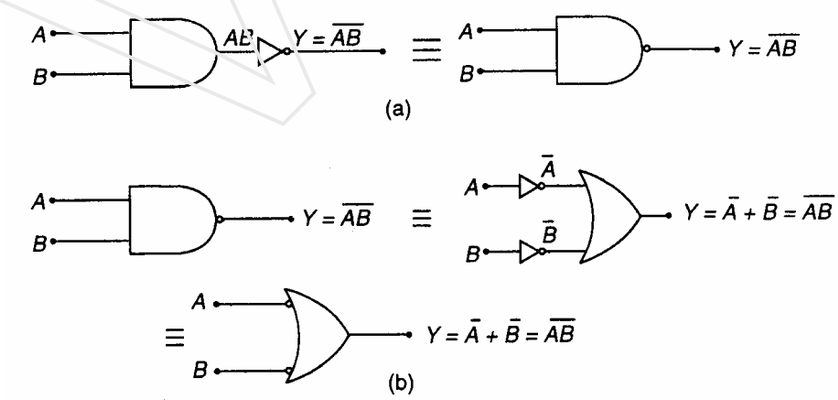
3.6.3 NOT GATE: The NOT gate performs logical function called complementation (inversion). This gate converts one logic level into the opposite logic level. It has one input and one output.



Input A	Output $Y = \overline{A}$
0	1
1	0

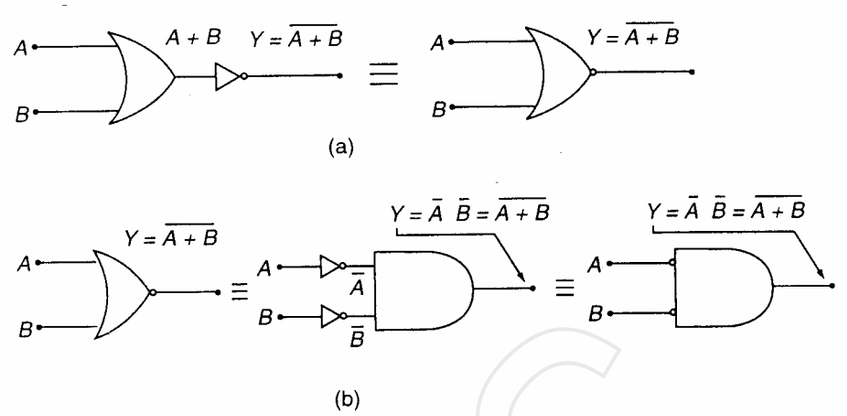
3.6.4 NAND GATE:

Inputs		Output
A	B	$Y = \overline{A\ B}$
0	0	1
0	1	1
1	0	1
1	1	0



3.6.5 NOR GATE:

Inputs		Output
A	B	$Y = \overline{A+B}$
0	0	1
0	1	0
1	0	0
1	1	0



3.7 Multiplexers: The term ‘multiplex’ means “ many into one”. Multiplexing in the process of transmitting a large number of information over single line.

3.8 Demultiplexers: The word “ demultiplex” means one into many. De-multiplexing is the process of taking information from one input and transmitting the same over one of several outputs. The circuit has one input signal, m select signals and n output signals. The select inputs determine to which output the input data will be connected.

3.9 Encoder: A encoder is a logic circuit that converts binary number into decimal numbers.

3.10 Decoders: A decoder is a logic circuit that converts decimal number into binary numbers.

3.11 Flip–Flops: The logic circuits whose outputs at any instant depend only on the input signals present at that time are known as combinational circuits. Combinational circuits do not have capacity to retain the information. The logic circuits whose output depends upon present inputs as well as previous output are called sequential circuits. In sequential circuits output signals are fed back to the input side.

Sequential circuits have memory variables.

3.12 Registers: A register is a group of flip –flop suitable for string binary information. Each flip-flop is a binary cell capable of storing one bit of information. And n-bit register has a group of n flip-flops and is capable of storing any binary information containing n bits. The register in mainly used for storing and shifting binary data entered into it from an external source.

3.13 Shift Registers: A shift register moves the stored bit left or right. This bit shifting is essential for certain arithmetic and logic operations used in microcomputers.

3.14 Integration of integrated circuits (ICs):

(i) SSI (Small Scale Integration): Includes approx 10 gates on the same chip.

(ii) MSI (Medium Scale Integration): includes 12 to 100 gates per chip.

(iii) LSI (Large Scale Integration): 100 to 500 gates per chip.

(iv) VLSI (Very Large Scale Integration): Several thousand gates on a same chip.

Exercise 3

Q.1 Fill in the blanks

(i) A continuously varying signal is called _____. (Analog signals)

(ii) A signal that has only two different valued is called _____.(Digital Signal)

(iii) The number system, which we use in our day-to-day life is _____. (Decimal number system)

(iv) The number system used by the digital computers is _____. (Binary number system).

(v) The number of symbols used by a number system is called _____. (Base)

(vi) Base of Hexadecimal number system is _____. (16)

(vii) The Hexadecimal number system uses _____ (Digits 0 to 9 and alphabets A to F)

(viii) Binary, octal and hexadecimal equivalent of decimal number 14 is _____.

(ix) 1's complement of 100 is _____. (011)

(x) 2's complement is _____. (1's complement + 1)

(xi) Basic gates are _____ (OR, AND, NOT)

(xii) Universal gates are _____ (NOR, NAND)

(xiii) _____ gate has only one input and one output.(NOT)

(xiv) Output of a OR gate is high when _____. (any of the input is high).

(xv) Output of an AND gate low when _____. (any of the input is low)

Q. 2 Convert

(i) $(1110)_2$ = (_____)$_{10}$

(ii) $(87)_{10}$ = (_____)$_2$

(iii) $(111011)_2$ = (_____)$_{10}$

Q. 2 Write short notes

(i) NOT Gate

(ii) Universal gates

(iii) NAND gate

(iv) NOR gate

(v) Multiplexer

(vi) Flip-flops

(vii) Registers