GOVERNMENT OF TAMIL NADU

HIGHER SECONDARY SECOND YEAR

VOCATIONAL EDUCATION

BASIC ELECTRONICS ENGINEERING

Theory & Practical

A Publication Under Free Textbook Programme of Government of Tamil Nadu

Department of School Education

Untouchability is Inhuman and a Crime

Government of Tamil Nadu

First Edition - 2019

Revised Edition - 2020, 2022, 2023

Reprint - 2021, 2024

(Published under New Syllabus)

NOT FOR SALE

Content Creation

State Council of Educational Research and Training

© SCERT 2019

Printing & Publishing

TamilNaduTextbook and Educational Services Corporation

www.textbooksonline.tn.nic.in

1_XII EE_English version FM.indd 2 24/12/2023 10:04:33

PREFACE

This book is the abridged and updated version of the curriculum to strengthen the higher secondary education on par with the Global Standards and meet the requirements of Industrial Standard 4.0 by providing skill-based learning opportunities to promote holistic approach in technical education. The objectives of this book on Basic Electronic Engineering are to shape the skill of understanding and applying electronic concepts and ideas for designing, assembling, testing, maintaining and troubleshooting basic and complex electronic gadgets. Additionally, it covers the "Earn While Learn" concept for the students to pursue their higher education with self-reliance and without financial hindrance.

This book covers the state-of-the-art techniques in the area of Electronics and related fields to encourage the multidisciplinary approach of Electronics with different subject areas. Each Chapter has been designed and written in such a way to inculcate the basic and advanced knowledge of the Electronics to the students and also to give opportunity to the stakeholders to provide a platform for exhibiting their creativity. The success of this endeavor depends on the participation of the students, subject teachers and school headmasters to kindle the students towards self-learning in order to promote imaginative activities and inquisitiveness.

Each Chapter starts with specific learning objectives, learning outcomes and detailed description of the concepts with the related figures, equations for the easy and deep understanding of the subject matter. Further, several solved problems and self-evaluation exercises are given in each Chapter to motivate the students for self-learning and to develop self-confidence in the subject matter.

With best wishes,

Prof. Dr. Damodaran Nedumaran

Chairperson

CONTENTS

Title	Page No.	Month
Chapter 1 Digital Circuit Applications	**1-21**	**June**
Chapter 2 Transmitters and Receivers	**22-41**	**June - July**
Chapter 3 Communication Devices and their Technologies	**42-60**	**July**
Chapter 4 Communication Systems	**61-77**	**August**
Chapter 5 Digital Image Processing	**78-95**	**September**
Chapter 6 Sound Engineering	**96-116**	**October**
Chapter 7 Power Electronics	**117-133**	**October**
Chapter 8 Introduction to Biomedical Instruments	**134-147**	**November**
Chapter 9 Computer Maintenance and Troubleshooting with Safety Practices	**148-167**	**November**
Chapter 10 Network Maintenance-Troubleshooting and IT Securities	**168-189**	**December**
Model Question Paper	**190-192**	
Practical	**193-250**	

JR3IH

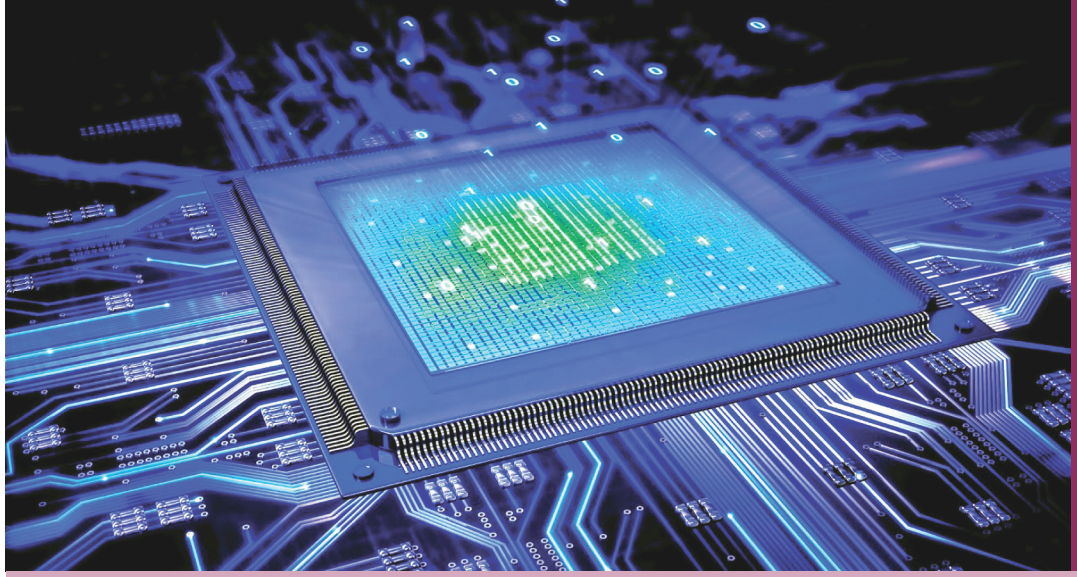
E-book

6BHS7

Assessment

BASIC ELECTRONICS ENGINEERING

Theory



CHAPTER 01

Digital Circuit Applications

LEARNING OBJECTIVE

The students can understand the following in this chapter

1. Construction and working of Basic Gates & Combinational Gates and their applications.
2. Classification of Logic circuits
3. Encoder and Decoder
4. Multiplexer
5. Flip-flops
6. Counters and Registers

Introduction

Though you are little familiar with digital electronics, its very important to learn about digital circuits, i.e., particularly the basic gates (AND, OR, NOT), the utility of these circuits in constructing many discrete circuits for instrumentation application are discussed in detail in this chapter. Further, we are going to discuss about the combinational gates.

1. Logic Gates

Logic gates are termed as digital circuits. Digital circuits operate in binary modes, each input and output signal is either '1' or '0'. The '1' and '0' designation represents predefined voltage ranges (+5V and 0V). These electronic switching circuits are called as logic gates. Each logic gate can have one or more inputs and only one output.

All logic gates can be analysed by constructing a truth table. A truth table represents all possible input and the corresponding output combinations.

The term "logic" is usually used to refer to a decision making process. A logic gate makes logical decisions regarding the existence of output depending upon the nature of the input. Hence, such circuits are called logic circuits.

1.1 Basic Logic Gates

The three basic logic gates that makeup all digital circuits are

i) OR gate, ii) AND gate and iii) NOT gate.

The following points may be noted about logic gates.

1. A binary '0' represents 0V and binary '1' represents +5V. It is common to refer to binary '0' as LOW input or output and binary '1' as HIGH input or output.
2. A logic gate has only one output and the output will depend upon the input signals and the type of gates.
3. The operation of a logic gate may be described either by truth table or Boolean algebra.

1.1.1 OR Gate

An OR gate has two or more input signals and only one output signal. An OR gate performs logical addition.

In OR gate, the inputs A, B, C, etc., produce the output as A+B+C+etc. The symbol of two input OR gate is shown in the Figure 1.1 and the Table 1.1 shows the truth table output.

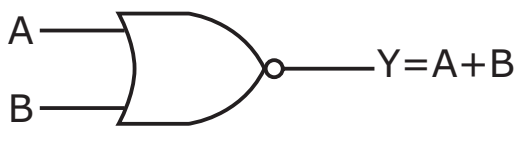


FIGURE 1.1 Symbol and Truth Table of OR Gate

TABLE 1.1 OR Gate

A	B	Y= A+B
0	0	0
0	1	1
1	0	1
1	1	1

A two input OR gate contains two input signals and only one output signal. The two input signal makes 4(2^2) combination of outputs.

In OR gates, the output is high when any one of the input is in high level. Conversely, the output is low when all the inputs are in low level.

1.1.2 AND Gate

An AND gate has two or more inputs and one output. An AND gate performs logical multiplication. In an AND gates, the inputs A,B,C, etc., produce the output as A.B.C. etc. The symbol and the truth table of two input AND gate are shown in Figure 1.2.

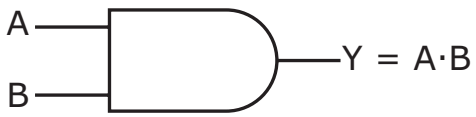


FIGURE 1.2 Symbol and Truth Table of AND Gate

TABLE 1.2 AND Gate

A	B	Y= A·B
0	0	0
0	1	0
1	0	0
1	1	1

It contains two input signals and only one output signal. In AND gates, the output is only high when all inputs are in high level. Conversely, the output is low only when any one of the input is in low level.

1.1.3 NOT Gate

A NOT gate has only one input and one output. For the NOT gate, when the input is '0'(LOW), the output is '1' (HIGH) and when the input is '1' (HIGH), the output is '0' (LOW). That is, the output is complement or inverse of the input.

Figure 1.3 shows the symbol and truth table for the NOT gate. The input is marked as A and the output is marked as Y=$\bar{A}$. The output $\bar{A}$ can be read as

complement of A or inverse of A or simply A bar.

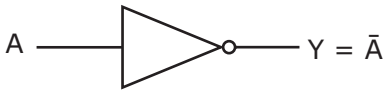


FIGURE 1.3 Symbol Table 1,3 exhibits the input-output relation of a NOT gate

TABLE 1.3 NOT Gate	
A	Y=Ā
0	1
1	0

1.1.4 Application of Basic Gates

NOT – Gate Application - Example of 1's Complement circuit using inverters.

AND – Gate Application - A simple Car-seat belt alarm circuit using AND Gate

OR – Gate Application - Simple intrusion detection alarm system

1.2 Combinational Gates

Now, let us see some of the other gates constructed by using these basic gates, which are called as combinational gates. The following are some of the important gates.

1. NAND Gate
2. NOR Gate
3. EX-OR Gate
4. EX-NOR Gate

1.2.1 NAND gate

The term NAND is derived from NOT-AND gates. It is nothing but complemented output of AND gate. The standard logic symbol for 2-input NAND gate is shown Figure 1.4.

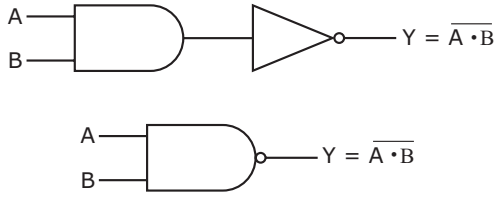


FIGURE 1.4 Symbol and Equivalent circuit of 2-input NAND gate

Operation of a NAND – gate

A NAND gate produces low output when all the inputs are high. When any of the input is low, the output will be HIGH. Figure 1.4 shows a 2-input NAND gate with the inputs labelled as A and B and the output is labelled as Y. The operation can be stated as follows.

For a 2-input NAND gates, the output Y is low only when, inputs A and B are HIGH. Output 'Y' is HIGH when either A or B is low, or when both inputs A and B are low.

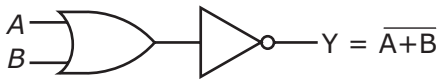
The operation of a NAND gate is opposite to that of a AND gate. In a NAND gate, low-level (0) is the active output level, as indicated by the bubble on the output. Table 1.4 shows the logical operation of the 2 input NAND gate. The logic expression for two input NAND gate is $Y = \overline{A \cdot B}$.

TABLE 1.4 Truth table of NAND gate		
A	B	$Y = \overline{A \cdot B}$
0	0	1
0	1	1
1	0	1
1	1	0

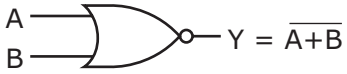
Application: NAND gate with its two inputs connected to the tank level sensor

1.2.2 NOR - gate

The NOR–gate is derived from the combination of NOT-OR gate. It is nothing but complemented output of OR gate. The standard logic symbols for 2-input NOR gate is shown in Figure 1.5.



2–input NOR gate



Equivalent circuit of NOR gate

FIGURE 1.5 Symbol and Equivalent Circuit of NOR gate

Operation of a NOR-gate

A NOR-gate produces a LOW output when any of its input is HIGH. The output will be HIGH when all the inputs are LOW. Figure 1.5 shows the NOR gate labelled A and B are inputs and Y as the output. The operations can be stated as follows.

For a 2-input NOR gate, output Y is LOW, when either input A or input B is HIGH or the output Y is HIGH only when both inputs are LOW.

The operation of NOR gate is opposite to that of OR gate. In a NOR gate, the low output is the active output level as indicated by the bubble on the output. Table 1.5 shows the logical operation of the 2-input NOR gate. The logic expression for two input NOR gate is $Y = \overline{A + B}$.

TABLE 1.5 Truth Table of NOR gate

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

Universal gate

NAND and NOR gates are termed as universal gates. Because by using these gates (either NAND or NOR), we can derive the operations of any other gates function.

1.2.3 Exclusive-OR gate

Exclusive-OR gate is formed by a combination of the earlier gates that we discussed so far. These gates are used in many fundamental applications and treated as basic logic elements. Standard symbol for Exclusive OR (XOR as short) gate is shown in Figure 1.6.

The XOR gate has only two inputs. The output of XOR gate is HIGH, only when the inputs of the gates are in opposite logic levels. The output of the gate is low when the inputs are identical i.e., both are LOW or HIGH.

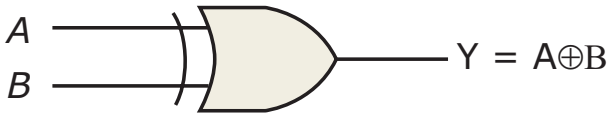


FIGURE 1.6 Symbol of Ex-OR gate

For an XOR gate the output Y is HIGH only when inputs A is low and B is HIGH and vice versa. It will be LOW on other conditions. The unique characteristic of XOR gate is that it produces HIGH output only when an odd number of HIGH inputs are present.

TABLE 1.6 Truth table of XOR gate

A	B	$Y = (\overline{A} \cdot B) + (A \cdot \overline{B})$
0	0	0
0	1	1
1	0	1
1	1	0

The logical expression for XOR-gate $Y = (\overline{A} \cdot B) + (A \cdot \overline{B})$. This can be often shortened and given as $Y = A \oplus B$. It is also called as "Inequality Comparator".

1.2.4 Exclusive -NOR GATE

The standard symbol for Exclusive–NOR (X-NOR) gate is shown in Figure 1.7. The bubble on the output of the X-NOR symbol indicates that its output is opposite to that of the XOR gate, i.e., the output is complemented XOR gate.

For an exclusive-NOR gate (X-NOR), output Y is low when input A is LOW and input B is HIGH, or when A is HIGH and B is LOW. Y is HIGH only when both A and B are HIGH or both LOW

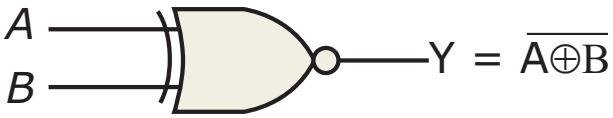


FIGURE 1.7 Symbol of X-NOR

Table 1.7 shows the logical operation of a two-input X-NOR gate. The logical expression for X-NOR gate is $Y = \left(\overline{A} \cdot B\right) + \left(A \cdot \overline{B}\right)$. This can be often standard and given as $Y = \overline{A \oplus B}$.

TABLE 1.7 Truth table of Ex-NOR gate

A	B	$Y = \overline{A \oplus B}$
0	0	1
0	1	0
1	0	0
1	1	1

Though NAND and NOR gates are called as universal gates, among them NAND gate is more versatile. So far, we have learned seven types of gate circuits consisting AND, OR, NOT, NAND, NOR, XOR and X-NOR. We can buy IC's that perform any of these seven basic functions. But, in the market NAND gate is the more widely available IC.

Activity

Write the Boolean expression for a three input NAND gate.

1.3 Boolean algebra

Though you have studied three important basic Boolean operations Addition (OR), multiplication (AND), complementation or inversion (NOT). Other than these, there are three important basic laws as like in mathematical algebra. They are,

1. Commutative law
2. Associative law
3. Distributive law

The Boolean is used to simplify the gate (digital) circuits



Boolean algebra was derived by George Boole in 1854

1.3.1 Commutative law

The law by addition and multiplication say that the order in which variable are OR-ed (or) AND-ed makes no different as the sum assured is arrived at either way. These laws of addition and multiplication for two variables are written algebraically as follows.

Commutative law of addition of two variables

$$A + B = B + A$$

Commutative law of multiplication for two variables

$$A \cdot B = B \cdot A$$

Figure 1.8 and Figure 1.9 illustrate the commutative law applied to the OR gate and the AND gate.



FIGURE 1.8 Commutative law using OR gate

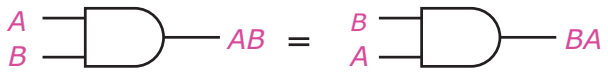


FIGURE 1.9 Commutative law using AND gate

1.3.2. Associative law

The law of addition and multiplication say that the ORing or ANDing of several variables (more than two) or grouping of the variables is immaterial and the addition results obtained are the same. These laws of addition and multiplication for three variables are written algebraically as follows. Figure 1.10 and Figure 1.11 illustrate the associative law as applied to OR and AND gates.

Associative law of addition of three variables A + (B + C) = (A + B) + C

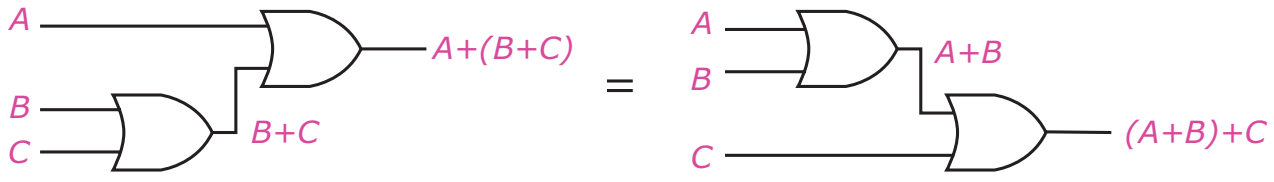


FIGURE 1.10 Associate law of three variables using OR gates

Associative law of multiplication of three variables A . (B . C) = (A . B) . C



FIGURE 1.11 Associate law of three variables using AND gates

1.3.3. Distributive law

This law states that ORing several variables and ANDing the result with the single variable is equivalent to ANDing the single variable with each of several variables and the ORing the products. The law is algebraically written as follows.

$$A \cdot (B + C) = A \,.\, B + A \cdot C$$

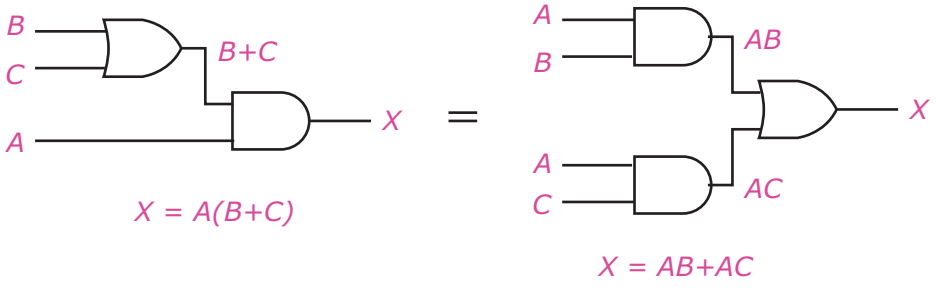


FIGURE 1.12 Distributive law using AND and OR gates

1.3.4 Boolean Algebra Rules

The table 1.8. shows the Boolean Algebra Rules.

TABLE 1.8 Boolean Algebra Rules

1. $A + 0 = A$	7. $A \cdot A = A$
2. $A + 1 = 1$	8. $A \cdot \overline{A} = 0$
3. $A \cdot 0 = 0$	9. $\overline{\overline{A}} = A$
4. $A \cdot 1 = A$	10. $A + B = B + A$
5. $A + A = A$	11. $A \cdot B = B \cdot A$
6. $A + \overline{A} = 1$	12. $A \cdot (B + C) = A \cdot B + A \cdot C$

1.4 Classification of Logic circuit

Logic circuit may be classified into two broad categories:

1. Combinational logic circuits
2. Sequential logic circuits

1.4.1 Combinational Logic circuits

A combinational logic circuit contains logic gates only but does not contain storage elements. Sequential logic circuit contains storage elements in addition to logic gates. When logic gates are connected together to provide a specified output for certain specified combination of input variables without any storage, the resulting network is known as combinational logic circuit. The block diagram of logic combinational circuit is shown in Figure 1.13.



FIGURE 1.13 Combinational Logic Circuit

1.4.2 Sequential Logic Circuit

It accepts input binary variables and generates output variables depending on the logical combination of logic gates. The combinational logic circuits with memory element is called as sequential logic circuit, which is shown in Figure 1.14.

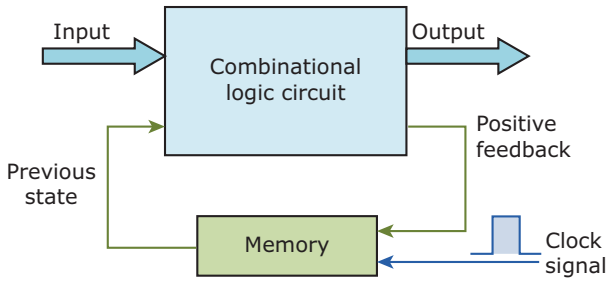


FIGURE 1.14 Block Diagram of Sequential Logic Circuit

A combinational circuit connected with feedback path termed as memory elements. The memory elements are device, capable of storing binary information within them.

1.5 Arithmetic Circuits

One of the essential functions of most computers and calculators is the performance of manipulating the arithmetic operations. The logic gates discussed so for can be used to perform arithmetic operations such as addition, subtraction, multiplication and division, which is used in electronic calculators and digital instruments. Since these circuits are electronic, they are very fast. Performing an addition takes less than 1 μs.

Now we will discuss some of the arithmetic operating circuits such as Half–adder, full-adder, parallel binary adder, half-subtractor and full-subtractor. The logic functions that are commonly used are OR, AND, and EX-OR gates.

1.5.1 Half-Adder

A logic circuits used for the addition of two single bit numbers is referred as a Half-

Adder. When we add two binary numbers, we start with the least significant column. This means that we have to add two bits with the possibility of a carry. The circuit of a half-adder is shown Figure 1.16(a). Note in the Figure that the output sum is denoted by the mathematical symbol Σ.

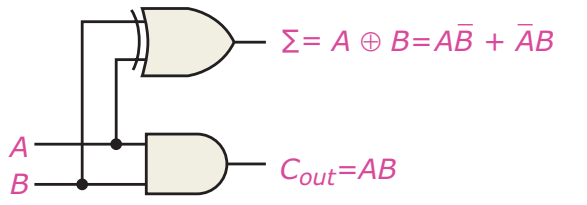


FIGURE 1.15(A) Half-Adder

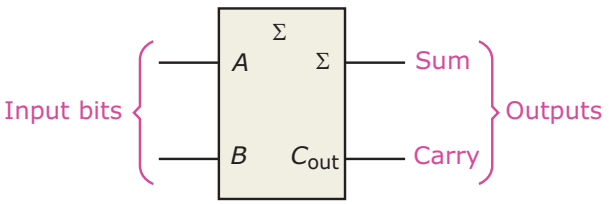


FIGURE 1.15(B) Logic symbol for a half-adder

It consists of an EX-OR gate and an AND gate. The output of an EX-OR gate is called SUM, while the output of the AND gate is called as CARRY. As the AND gate generates a high output only, when both inputs are high i.e., the carry as 1. When both inputs of EX-OR gate is high or low the output i.e., the sum is low (0). When either of the input is high the output is high. Thus its the binary addition. The logic symbol of Half-adder is shown in Figure 1.15 (b). Truth table for a half adder is given in the Table 1.9.

TABLE 1.9 Truth-Table of Half-Adder

A	B	Σ	C_{out}
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

Σ = sum
C_{out} = output carry
A and B = input variables (operands)

From the truth table a half-adder, the logical equations for CARRY and SUM can be written as,

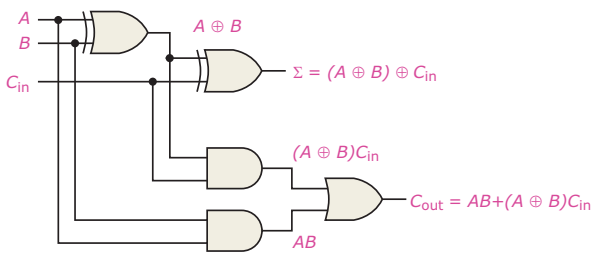
$$\text{CARRY} \quad C = A \cdot B$$

$$\text{SUM} \quad S = \overline{A} \cdot B + A \cdot \overline{B} = A \oplus B$$

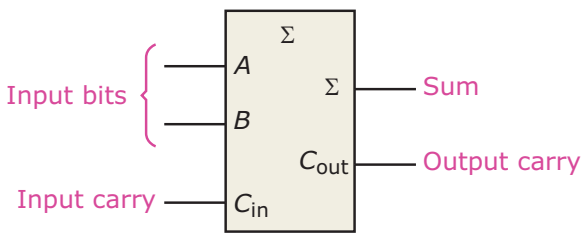
This Circuit is called as half-adder, because it cannot accept a CARRY-IN from previous additions. This is the reason that half-adder circuits can be used for binary additions of lower cost bit only. For higher order columns, we use 3-input adder called full-adder.

1.5.2 Full Adder

Full adder circuit is nothing but two half–adder circuits connected to an OR gate. As we seen in half -adder circuit, it has only two inputs and there is no provision to add CARRY coming from the lower-bit order when multi-bit addition is performed. For this purpose, we use a logic circuit, which can add three bits.



(a) Complete logic circuit for a full-adder



(b) Logic symbol of full-adder

(each half-adder is enclosed by a shaded area)

FIGURE 1.16 A simple circuit of full adder (each half-adder is enclosed by a shaded area)

The third-bit is the CARRY from a lower column. This shows that we used a logic circuit with 3-inputs and 2-outputs. Such a circuit is called full-adder. Hence, full adder may be defined as logic circuits that add 3-bits, i.e., two bits to be added and CARRY-bit from lower-bit order, which results in SUM and CARRY. Figures 1.16(a) and (b) show the logic circuit and logic symbol of full-adder circuit, respectively. It has two inputs called A and B plus a third input (C_{IN}), called the CARRY IN and two outputs SUM and CARRY OUT(C_{OUT}).

Truth table of full-adder for all possible inputs/outputs is given in Table 1.10 and can be easily checked for its validity. From the Figure 1.16(a), we can observe that the output CARRY is high when two or more number of inputs are high. Yet another output SUM will get high output, when an odd number of inputs are high. This can be verified from Table 1.10. The full adder can do more than a million additions per second.

TABLE 1.10 Truth Table of Full-Adder

A	B	C_{in}	Σ	C_{out}
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	0	1
1	0	0	1	0
1	0	1	0	1
1	1	0	0	1
1	1	1	1	1

C_{in} = input carry, sometimes designated as *CI*
C_{out} = output carry, sometimes designated as *Co*
Σ = sum
A and *B* = input variables (operands)

Parallel Binary Adder

The parallel binary adder is a combinational circuit of various full-adders in parallel structure. When more than one 1-bit numbers are to be added, there can be full-adder circuit for every column to perform the addition. The number of full-adder in a parallel binary adder depends on the number of bits present in the number for the addition. If 4-bit numbers are to be added, then there will be 4-full adder in the parallel binary adder. The parallel binary adder can be designed with the help of basic logic gates. The sub-module in the logic circuit will resemble the logic gate of half-adder and full-adder to understand it clearly. Let us put light on designing and working of the 2-bit parallel binary adder.

Logic Circuit of 2-Bit parallel Binary Adder

The 2-Bit parallel binary adder can be designed with the help of Ex-OR gate and AND gate. If you carefully observe the logic circuit of 2-bit parallel binary adder, you can notice that 2-full adder circuits are connected in a parallel manner. Now, we easily guess and understand the working of this.

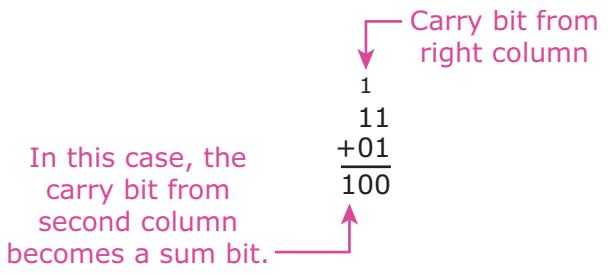


FIGURE 1.17(a) Addition of 2 parallel bits

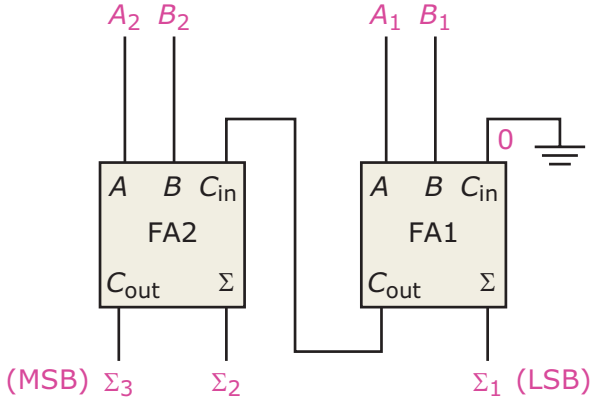


FIGURE 1.17(b) Block Diagram of 2-bit Parallel Adder

Figure 1.17(a) shows the method of 2-bit parallel addition and Figure 1.17(b) shows the schematic block diagram of the same. As we know, from the difference between the half-adder and full-adder, that the half-adder is a logic circuit which adds two 1-bit circuits but, does not add carry from previous addition. Therefore, full-adders came into action. A full-adder can add two 1-bit numbers along with the carry from previous addition.

Coming back to the parallel binary adder, it also has two full-adders. When we start add two numbers, the first step we follow is the addition of LSB (Least Significant Bit) of two numbers. After this, if we have any carry, we forward it to higher order columns. Now, the adder performs the similar task. It adds the LSBs of both the numbers and if any carry bit is there, it passes it to the carry-in terminal of another.

We may use half-adder for the addition of LSBs of both numbers as for the addition of LSBs there is no previous carry from previous addition. But, for the addition of bits present in higher order column, we must use full-adder because there may be or may not be a carry from previous addition.

Significance of Parallel Binary Adder

With the help of full-adder, we cannot add numbers of more than 1-Bit. As the number of bits increases in a number, the column of addition also increases. A full-adder can add only one column, thus for each column we used a full-adder. This combined design of all full adder results in a combinational circuit, which is called parallel binary adder.

1.5.3 Half-Subtractor

Half Subtractor is a digital circuit which process the subtraction of two 1-bit (0, 1) numbers. In this, the two numbers involved are called as Minuend and Subtrahend nothing but the inputs, named as X and Y. X is the Minuend and Y is the Subtrahend. There are two outputs named as D (differences) and B (Borrow). The word 'HALF' before the subtractor signifies that it deals with only two 1-bit numbers, it has nothing to do with the borrow from the previous stage. Figure 1.18 clearly elaborates the subtraction rule of binary numbers. The logic circuit of the Half-Adder is shown in Figure 1.19(a) and the symbol is shown in Figure 1.19(b). The operation of this logic circuit is based on the rules of binary subtraction given in truth table (Table 1.11) reproduce on the basis of subtraction process.

Procedure for Subtraction

	1			
0	0		1	1
-0	-1	Borrow 1	-0	-1
0	1		1	0

FIGURE 1.18 Binary Subtraction Rules

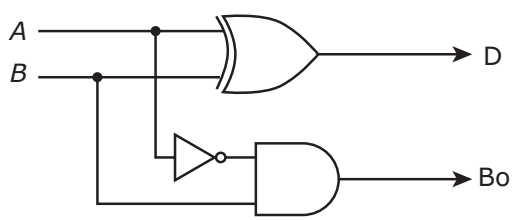


FIGURE 1.19 (A) Half Subtractor Circuit

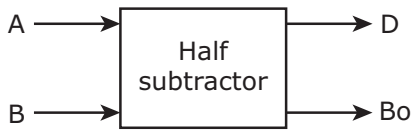


FIGURE 1.19 (B) Symbol of Half Subtractor

Circuit of Half-Subtractor

The logic circuit of Half-Subtractor involves usage of logic circuits. In order to design logic circuit, we should understand two concepts. First, the difference operation of half-subtractor resembles operation of EX-OR gate. Thus, we can easily utilise the EX-OR gate for generating difference bit. Similarly, the borrow generated by half-subtractor can be easily obtained by using the combination of NOT gate and AND gate.

TABLE 1.11 Truth Table of Half-Subtractor

Input		Output	
A	B	Difference	Borrow
0	0	0	0
0	1	1	1
1	0	1	0
1	1	0	0

Truth Table of Half-Subtractor

In case of half subtractor there are two inputs. Thus the number of possible combinations will be 4. The resultant of all the 4 inputs will be described as outputs. The output of half-subtractor is described in two columns. One will signify the difference bit and another will signify the borrow bit. To derive the truth table, just use the EX-OR operation of two inputs for generating difference and NOT followed by AND operation for generating the borrow bit.

1.5.4 Full-Subtractor

The binary subtraction half-subtractor can handle only 2-bits at a time and can be used for the least significant column of a subtraction problem. Just like a full-adder, a full-subtractor circuit is required to perform a multi-bit subtraction, where a borrow from the previous bit position may also be there.

It has 3-inputs viz., X (minuend), B (subtrahend) and B_{in} (borrow from the previous stage). It has two outputs such as D (difference) and B_{out} (borrow) as shown in the symbol given in Figure 1.21(a)

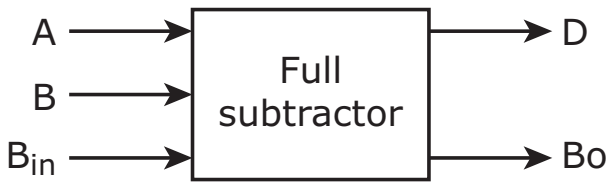


FIGURE 1.20 (A) Symbol of Full-Subtractor

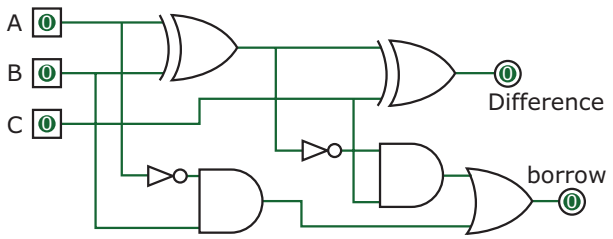


FIGURE 1.20 (B) Circuit diagram of Full Subtractor

Full-Subtractor is formed by using two half-subtractors and one OR gate. Figure 1.21(b) shows the circuit diagram of Full-Subtractor. For subtraction of n-bit numbers directly, we have to cascade n-full-subtractors. Truth table for full-subtractor is given in Table 1.12.

TABLE 1.12 Truth Table of Full-Subtractor

A	B	C	Difference	Borrow
0	0	0	0	0
0	0	1	1	1
0	1	0	1	1
0	1	1	0	1
1	0	0	1	0
1	0	1	0	0
1	1	0	0	0
1	1	1	1	1

1.6 Comparators

The basic function of comparator is to compare the magnitudes of two binary quantities to determine the relationship of those quantities.

1.6.1 Equality

The Exclusive NOR gate can be used as a basic comparator, because its output is 0, if the two input bits are not equal and 1, if the input bits are equal. Figure 1.21 shows the Exclusive-NOR gate as 2-bit comparator.

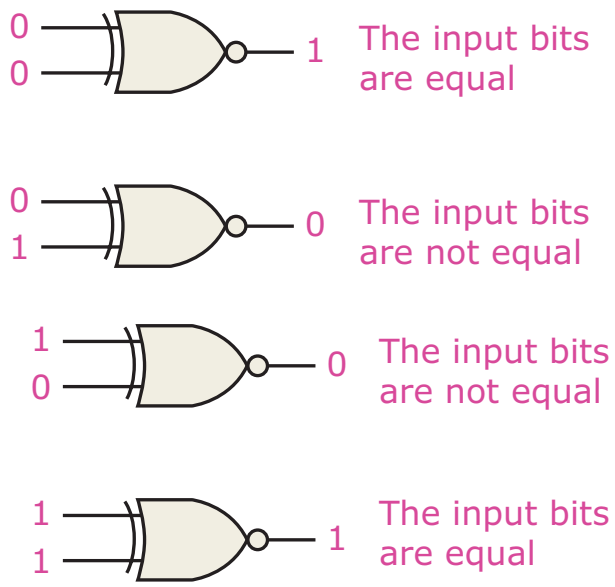


FIGURE 1.21 Basic Comparator Operation

To compare two binary-bits containing two bits each, an additional Exclusive-NOR gate is necessary. The two least significant bits (LSBs) of the two numbers are compared by gate G1, and the two most significant bits (MSBs) are compared by gate G2, as shown in Figure 1.22. If the two numbers are equal, their corresponding bits are the same and the output of each Exclusive-NOR gate is 1. If the corresponding sets of bits are not equal, a 0 occurs on that Exclusive-NOR gate output.

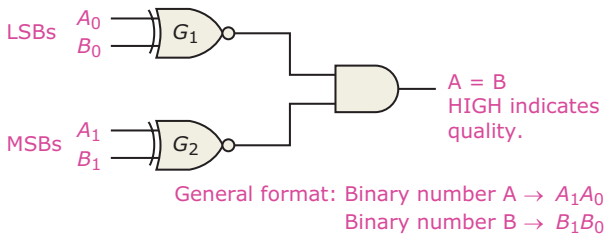


FIGURE 1.22 Logic diagram for equality comparison of two 2-bit numbers

In order to produce a single output indicating an equality or inequality of two numbers, an AND gate can be combined with XNOR gates as shown in Figure 1.22. The output of each Exclusive-NOR gate is applied to the AND gate input. When the two input bits for each Exclusive-NOR gates are equal, the corresponding bits of the numbers are equal and a 0 appears on at least one input of the AND gate to produce a 1 on its output. Thus, the output of the AND gate indicates equality (1) or inequality (0) of the two numbers. The following example clearly explains this operation for two specific cases.

Activity

Repeat the process for binary inputs of 01 and 10.

Note

The basic comparator can be expanded to any number of bits. The AND gate sets the condition that all corresponding bits of the two numbers must be equal if the two numbers themselves are equal.

1.6.2 Inequality

In addition to the equality output, many IC comparators provide additional outputs that indicate which of the two binary numbers being compared is larger. That is, there is an output that indicates

when number A is greater than number B (A > B) and an output that indicates when number A is less than number B (A < B), as shown in Figure 1.23.

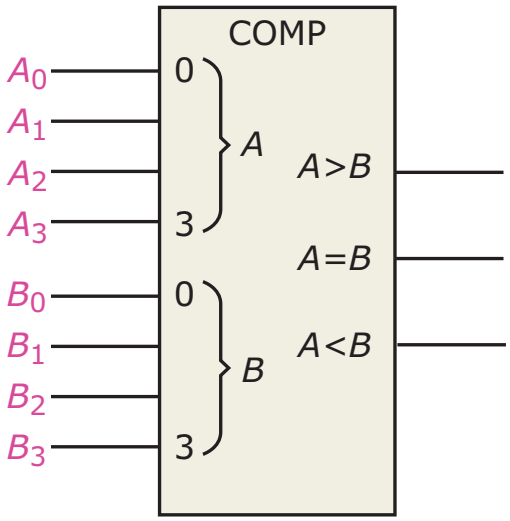


FIGURE 1.23 Logic symbol for a 4-bit comparator with inequality operation

To determine the inequality of binary numbers A and B, we first examine the highest order bit in each number. The following conditions are possible:

1. If $A_3 = 1$ and $B_3 = 0$, number A is greater than number B.
2. If $A_3 = 0$ and $B_3 = 1$, number A is less than number B.
3. IF $A_3 = B_3$, then you must examine the next lower bit position for an inequality.

These three operations are valid for each-bit position in the numbers. The general procedure used in a comparator is to check for an inequality in a bit position, starting with highest order bits (MSBs). When such an inequality is found, the relationship of the two numbers is established and any other inequalities in lower-order bit positions must be ignored because it is possible for an opposite indication to occur, the highest-order indication must take precedence. This can be explained through an example.

Activity

What are the outputs when $A_3A_2A_1A_0 = 1001$ and $B_3B_2B_1B_0 = 1010$?

1.7 Encoders

Encoder is a device, circuit, transducer, software program, algorithm or person that converts information from one format or code to another for the purpose of standardisation or compression. An encoder is a combinational logic circuit that essentially performs a "reverse" decoder function. An encoder accepts an active level on one of its inputs representing a digit, such as a decimal or octal digit and converts it to a coded output, such as BCD or binary. Encoders can also be devised to encode various symbols and alphabetic characters. The process of converting from familiar symbols or numbers to a coded format is called encoding.

1.7.1 Decimal-to-BCD Encoder

This type of encoder has ten inputs. One for each decimal digit and four outputs corresponding to the BCD code as shown in the Figure1.24. This is a basic 10-line-to-4-line encoder.

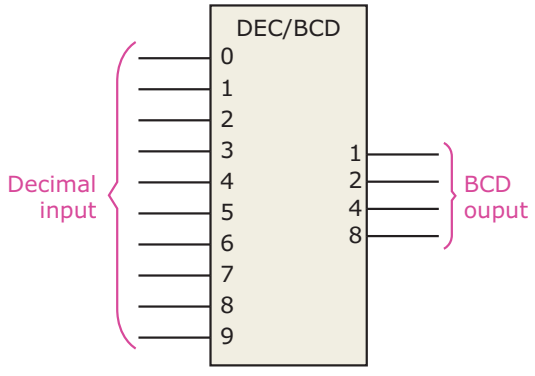


FIGURE1.24 Logic symbol for a Decimal-to-BCD encoder

The BCD (8421) code is listed in Table1.13. From this table, you can determine the relationship between each BCD bit and the decimal digits in order to analyse the logic. For instance, the most significant bit of the BCD code, A_3, is always 1 for decimal digit 8 or 9. An OR expression for bit A_3 in terms of the decimal digits can therefore be written as $A_3 = 8 + 9$.

TABLE 1.13 Decimal to BCD Encoder

	BCD Code			
DECIMAL DIGIT	A_3	A_2	A_1	A_0
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1

Bit A_2 is always 1 for decimal digit 4, 5, 6 or 7 and can be expressed as an OR function as follows:

$$A_2 = 4 + 5 + 6 + 7$$

Bit A_1 is always 1 for decimal digit 2, 3, 6 or 7 and can be expressed as

$$A_1 = 2 + 3 + 6 + 7$$

Finally, A_0 is always for decimal digit 1, 3, 5, 7 or 9

$$A_0 = 1 + 3 + 5 + 7 + 9$$

Now, let us implement the logic circuitry required for encoding each decimal digit to a BCD code by using the logic expressions just developed. It is simply a matter of ORing the appropriate decimal input lines to form each BCD output. The basic encoder logic resulting from these expressions is shown in Figure 1.25.

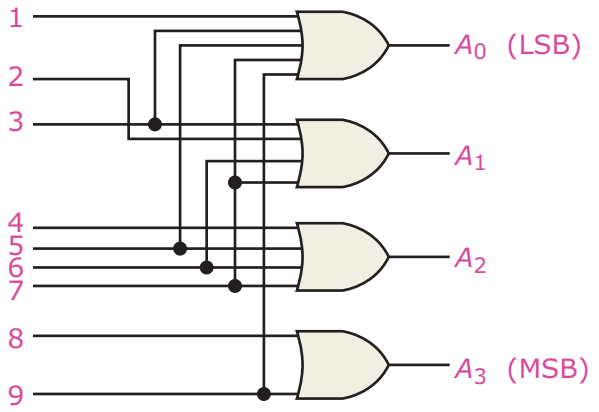


FIGURE 1.25 Basic logic diagram of Decimal-to-BCD encoder.

Note

A 0-digit input is not needed because the BCD outputs are all low, when there are no HIGH inputs.

The basic operation of the circuit shown in Figure 1.25 is briefly described as follows: When a HIGH appears on one of the decimal input lines, the appropriate levels occur on the four BCD output lines. For instance, if input line 9 is HIGH (assuming all other input lines are LOW), this condition will produce a HIGH on outputs A_0 and A_3 and LOWs on outputs A_1 and A_2, which is the BCD code (1001) for decimal 9.

1.8 Decoders

An electronic device that converts signals from one form to another i.e., code into set of signals. Decoding is the process of converting code into plain text or any format that is useful for subsequent processes. It does the reverse of encoding. It converts encoded data communicated during transmission (like TV signals from satellite and Computer e-mails) and files to their original states.

In digital electronics, a binary decoder is a combinational logic circuit that converts binary information from the 'n' coded inputs to a maximum of 2^n

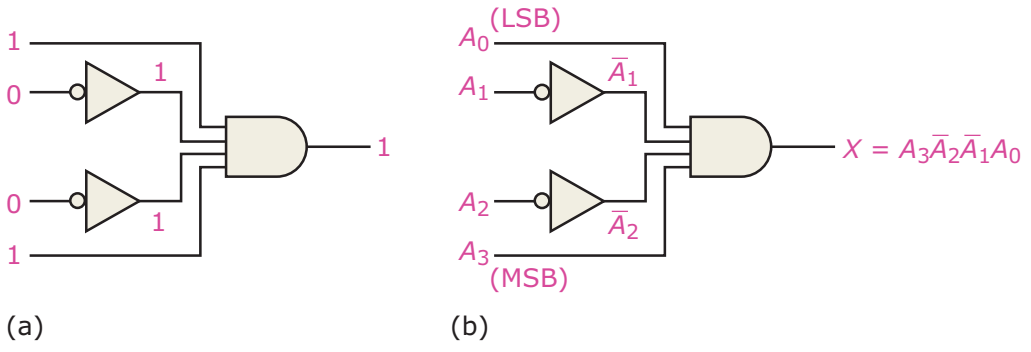


FIGURE 1.26 Decoding logic for the binary code 1001 with an active-HIGH output

unique outputs. They are used in wide variety of applications, including data demultiplexing, seven segment displays and memory address decoding.

1.8.1 Basic Binary Decoder

We need to determine when a binary 1001 occurs on the inputs of a digital circuit. An AND can be used as the basic decoding element because it produces a HIGH output only when all of its inputs are HIGH. Therefore, we must make sure that all of the inputs to the AND gate are HIGH when the binary number 1001 occurs. This can be done by inverting the two middle inputs (the 0s), as shown in Figure 1.26.

EXAMPLE 1.1

Determine the logic required to decode the binary number 1011 by producing a HIGH level on the output.

Solution

The decoding function can be formed by complementing only the variables that appear as 0 in the desired binary number as follows:

$$X = A_3 A_2 A_1 A_0 \quad (1011)$$

This function can be implemented by connecting the true (un-complemented) variables A_0, A_1 and A_3 directly to the inputs of an AND gate and inverting the variables A_2 before applying it to the AND gate input. The decoding logic is shown in Figure 1.27.

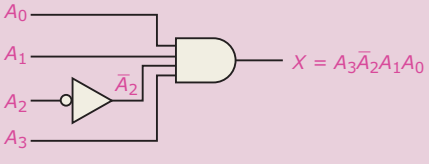


FIGURE 1.27 Decoding logic for producing a HIGH output when 1011 is on the inputs.

1.9 Multiplexer

A multiplexer (MUX) is a device allowing one or more low speed analog or digital signal to be selected, combined and transmitted at a higher speed on a single shared medium or within a single shared device. A MUX function is a multiple-input, single-output switch.

Multiple signals share one device or transmission conductor such as copper or fibre optic cable. In telecommunication, the analog or digital signals transmitted on several communication channels by a multiplex method. These signals are single-output higher-speed signals. A 4-to-1 multiplexer contains four input signals and 2-to-1 multiplexer has two input signals and one output signal.

A logic symbol for a 4-input multiplexer (MUX) is shown in Figure 1.28. Notice that there are two data-select lines because with two select bits, any one of the four data-input lines can be selected.

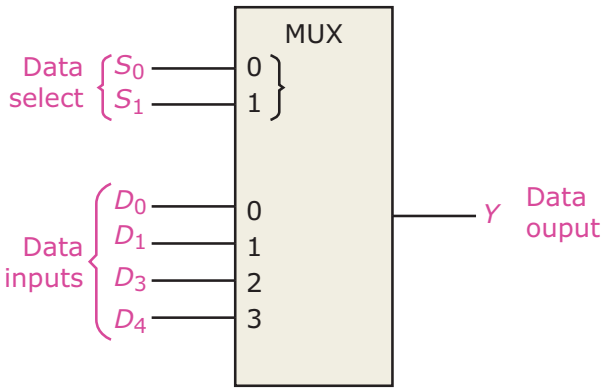


FIGURE 1.28 Logic symbol for a 1-of-4 data selector/multiplexer

Multiplexing

The technique of transmitting multiple signals over a single medium is defined as Multiplexing. This technique is widely used in the Open System Interconnection (OSI) model. The different types of multiplexing technologies are:

- Wavelength Division Multiplexing (WDM)
- Frequency Division Multiplexing (FDM)
- Dense Wavelength Division Multiplexing (DWDM)
- Conventional Wavelength Division Multiplexing (CWDM)
- Reconfigurable Optical Add-Drop Multiplexer (ROADM)
- Orthogonal Frequency Division Multiplexing (OFDM)
- Add/Drop Multiplexing (ADM)
- Inverse Multiplexing (IMUX)

1.10 Flip-Flops

The output of the digital circuits studied in previous chapters are dependent entirely on the input, i.e., if the input changes, the output also changes. However, there are requirements for a digital device or circuit whose output will remain unchanged, once set, even if there is a change in input. Such a device can be used to store a binary number. A flip-flop is one such circuit.

Multivibrators

Though we studied about Multivibrators in eleventh standard, it is essential to recollect the working of Bi-stable Multivibrators before entering into the Flip-flop.

Bi-stable or flip-flop multivibrator

The bistable multivibrator has both the states (HIGH, LOW) at stable condition. It requires an external triggering pulse to change the operation from either one state to the other. Thus, one pulse is used to generate half-cycle of square wave and another pulse to generate the next half-cycle of square wave. It is also known as a flip-flop multivibrator because of its assured two possible states. So that, it can store one bit of information and is widely used in digital logic and computer memory. Hence, a flip-flop is nothing but storage (memory) device, which can store one-bit at a time.

Definition

A flip-flop is a bi-stable circuit made up of logic gates. A bi-stable circuit can exist in either of the two stable states indefinitely and can be made to change its state by means of some external signal. The most important use of this property is that a flip-flop can "store" binary information. We have seen that a logic gate can make a logical decision based on the immediate conditions at the input terminals. However, the gates normally do not have a

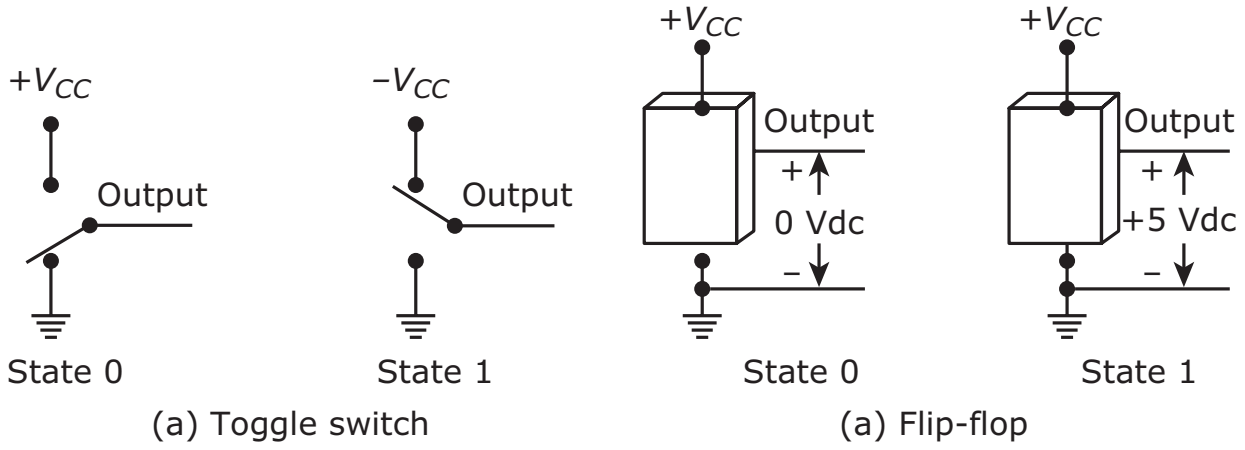


FIGURE 1.29 Flip-Flop Operations

memory characteristic to retain the input data. On the other hand, flip-flops have the valuable feature of remembering. The reason is that a flip-flop circuit is bi-stable.

Because the flip-flop's output remains at 0 or 1 depending on the last input signal, the flip-flop can be said to be in "remember" condition. Another name for the flip-flop is bi-stable multivibrator.

Flip-Flop or Latch

Any device or circuit that has two stable states is said to be bi-stable. For instance, a toggle switch has two stable states. It is either up or down, depending on the position of the switch as shown in Figure 1.29(a). The switch is also said to have memory since it will remain as set until someone changes its position. A flip-flop is a bi-stable electronic circuit that has two stable states i.e., its output is either 0 or +5 V DC as shown in Figure 1.29(b).

The flip-flop also has memory, since its output will remain as set until something is done to change it. As such, the flip-flop (or the switch) can be regarded as a memory device. In fact, any bistable device can be used to store one binary digit (bit). For instance, when the flip-flop has its output set at 0 V DC, it can be regarded as storing a logic 0 and when its output is set at + 5 V DC, as storing a logic 1. The flip-flop is often called a latch, since it will hold, or latch, in either stable state.

Basic Idea

One of the easiest ways to construct a flip-flop is to connect two inverters in series as shown in Figure 1.30(a). The line connecting the output of inverter B (*INV B*) back to the input of inverter A (*INV A*) is referred to as the feedback line.

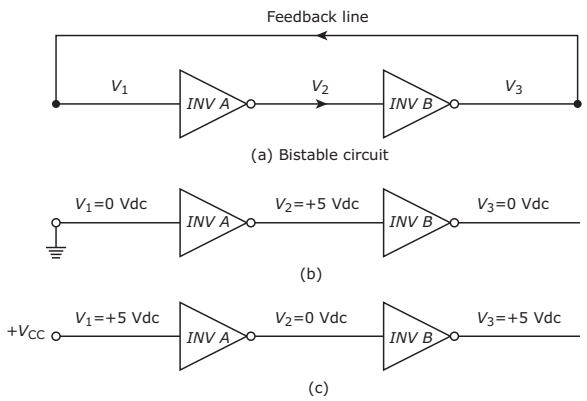


FIGURE 1.30 Flip-Flop using inverters

For the moment, remove the feedback line and consider V_1 as the input and V_3 as the output as shown in Figure 1.30(b). There are only two possible signals in a digital system, and in this case, we will define L = 0 = 0 V DC and H = 1 = + 5 V DC. If V_1 is

set to 0 V DC, then V_3 will also be 0 V DC. Now, if the feedback line shown in Figure 1.30(a) is reconnected, the ground can be removed from V_1 and V_3 will remain at 0 V DC. This is true since, the input of INV A is grounded, the output of INV B will go low and can then be used to hold the input of INV A low by using the feedback line. This is one stable state V_3 = 0 V DC. Conversely, if V_1 is +5 V DC, V_3 will also be +5 V DC as seen in Figure 1.30(c). The feedback line can again be used to hold V_1 at + 5 V DC since V_3 is also at + 5 V DC. This is the second stable state V_3 = + 5 V DC.

1.11 Counters

As you learned in previous Section, flip-flops can be connected together to perform counting operations. Such a group of flip-flops is a counter, which is a type of finite state machine. The number of flip-flops used and the way in which they are connected determine the number of states (called the modulus) and also the specific sequence of states that the counter goes through during each complete cycle. Counters are classified into two broad categories according to the way they are clocked: asynchronous and synchronous. In asynchronous counters, (commonly called ripple counters), the first flip-flop is clocked by the external clock pulse and then each successive flip-flop is clocked by the output of the preceding flip-flop. In synchronous counters, the clock input is connected to all of the flip-flops so that they are clocked simultaneously. Within each of these two categories, counters are classified primarily by the type of sequence, the number of states, or the number of flip-flops in the counter.

1.12 Registers (shift)

Shift registers are a type of sequential logic circuit used primarily for the storage of digital data and typically do not possess a characteristic internal sequence of states.

Shift Register Operations

Shift registers consist of arrangements of flip-flops and are important in applications involving the storage and transfer of data in a digital system. A register has no specified sequence of states, except in certain very specialized applications.

A register in general, is used solely for storing and shifting data (1s and 0s) entered into it from an external source and typically possesses no characteristic internal sequence of states.

A register is a digital circuit with two basic functions: data storage and data movement.

The storage capability of a register makes it an important type of memory device. Figure 1.31 illustrates the concept

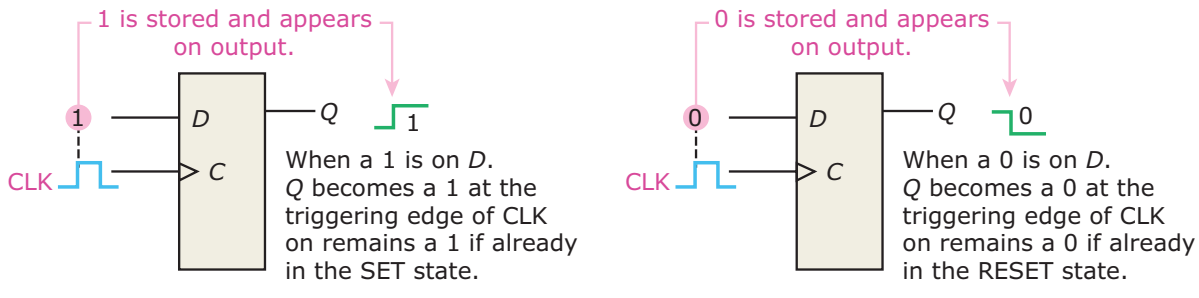


FIGURE 1.31 The flip-flop as a storage element.

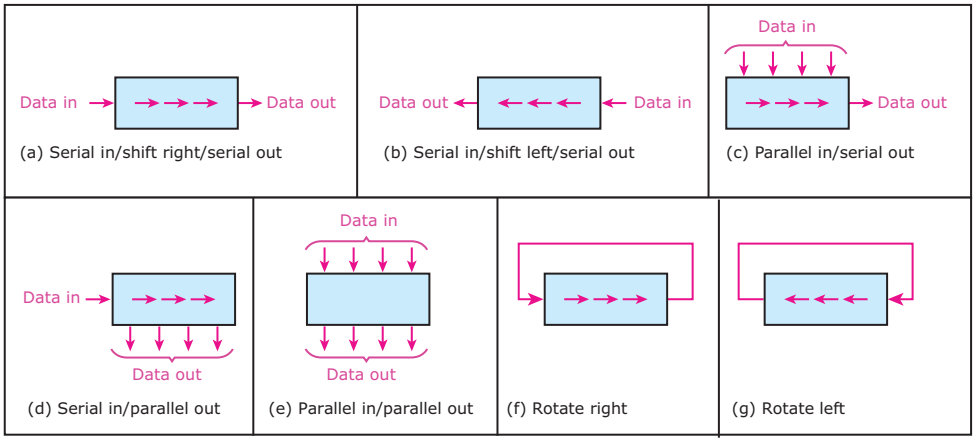


FIGURE 1.32 Basic data movement in shift registers. (Four bits are used for illustration. The bits move in the direction of the arrows.)

of storing a 1 or a 0 in a D flip-flop. A 1 is applied to the data input as shown, and a clock pulse is applied that stores the 1 by setting the flip-flop. When the 1 on the input is removed, the flip-flop remains in the SET state, thereby storing the 1. A similar procedure applies to the storage of a 0 by resetting the flip-flop, as illustrated in Figure 1.31.

The storage capacity of a register is the total number of bits (1s and 0s) of digital data it can retain. Each stage (flip-flop) in a shift register represents one bit of storage capacity; therefore, the number of stages in a register determines its storage capacity. The shift capability of a register permits the movement of data from stage to stage within the register or into or out of the register upon the application of clock pulses. Figure 1.32 illustrates the types of data movement in shift registers. The block represents any arbitrary 4-bit register, and the arrows indicate the direction of data movement.

LEARNING OUTCOME

After studying this chapter, students can understand the following

1. Construction and working of Basic Gates & Combinational Gates and their applications.
2. Classification of Logic circuits
3. Encoder and Decoder
4. Multiplexer
5. Flip-flops
6. Counters and Registers

QUESTIONS

I. Choose the best answer from the given four option.

1. Logic gates are termed as _____ circuits.
   a) Analog b) Digital
   c) Closed d) Open
2. An OR gate performs logical _____.
   a) Addition b) Subtraction
   c) Multiplication d) Division
3. A _____ Gate has only one output and one input.
   a) OR b) AND
   c) NOT d) NOR
4. When both input of the NAND gate goes High, What will be the output?
   a) 1 b) 0
   c) 10 d) 01
5. From the following Gate which one is basic Gate?
   a) NAND Gate b) NOR Gate
   c) AND Gate d) EX-OR Gate
6. According to the commutative law of addition
   a) AB = BA
   b) A+(B+C) = (A+B)+C
   c) A = A+A
   d) A+B = B+A
7. A Half Adder is characterised by
   a) two inputs and two outputs
   b) three inputs and two outputs
   c) two inputs and three outputs
   d) two inputs and one output



8. _____ Gate can be used as basic comparator.
   a) NAND b) NOR
   c) EX-NOR d) AND
9. The flip-flop belongs to a category of logic circuits known as _____
   a) Mono-stable Multi vibrator
   b) Bi-stable Multi vibrators
   c) A-stable Multi vibrators
   d) one-shots
10. Asynchronous counters are known as _____
    a) ripple counters
    b) multiple clock counters
    c) decade counter
    d) modulus counters

II. Answer in few sentence.

1. Write the name of basic logic gates.
2. Draw the construction of AND gate with truth table.
3. Write the names of Combinational gates.
4. Draw the construction of NOR gate with truth table.
5. Draw the circuit of Half-Adder.
6. Write the truth table of Half-Subtractor.
7. Define encoder.
8. Write about decoder
9. Define Multiplexer.
10. Write briefly about asynchronous counter.

III. Explain the following questions.

1. Explain in detail the construction of any two combinational gates with truth tables.
2. If any 2 bits are to be added, how it can be done through a logic gate circuit? Justify with necessary diagrams?
3. Explain in detail about the classification of logic circuit.
4. Is it possible to perform subtraction in logic gates? Prove with circuit and truth table.
5. Explain about Counters.

IV. Briefly explain the following questions

1. Explain the working of any five logic gates with true table.
2. What are the three basic Boolean laws. Define each with example.
3. Construct full adder and half subtractor circuits. Prove with truth table.
4. Explain the basic idea of flip-flop.

ANSWERS

1. (b) 2 (a) 3. (c) 4. (b) 5. (c) 6. (d) 7 (a) 8. (c) 9. (b) 10. (a)



CHAPTER 02

Transmitters and Receivers

DSTGZ

LEARNING OBJECTIVE

The students can understand the following in this chapter

1. Transmission and Reception
2. Modulation and Demodulation
3. Modem
4. Antenna
5. Radio transmitter and radio receiver
6. TV transmitter and TV receiver

2.1 Introduction

Any message or data wants to be sent from one place to another through any media is known as transmission. Earlier the transmission was successful to a short distance, later it was possible to a very long distances, because of modulation. The ultimate aim of transmission is to reach a receiver.

A device which can receive the transmitted signal is known as receiver. The transmitted signals have to be demodulated in order to get the actual message or data. So in this chapter we learn about modulation, demodulation and antenna.

2.2 Principles of Transmission and Reception

Transmission and reception are the most important techniques for the communication system.

Audio signals can travel only to a short distance without any signal loss. The Carrier Wave (CW) or Radio Frequency (RF) can travel 3 x 10^8 meter per second. The process of superimposing audio signal over the carrier wave is known as Modulation. The modulated wave is radiated and traveled through space, finally it reached the receiving antenna.

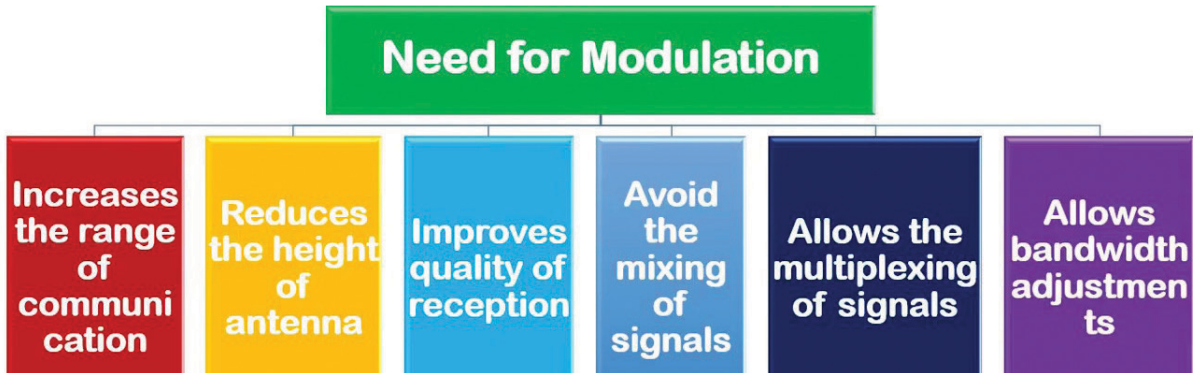
After receiving the signal by the receiving antenna, it enters the receiver. In order to get back the original audio signal, the RF should be removed by using simple detector circuit which is called as detection or demodulation.

2.3 Modulation

Modulation is the process of changing the characteristic (amplitude, frequency or phase) of the carrier signal, in accordance with the amplitude of the message signal. A device that performs modulation is called modulator.

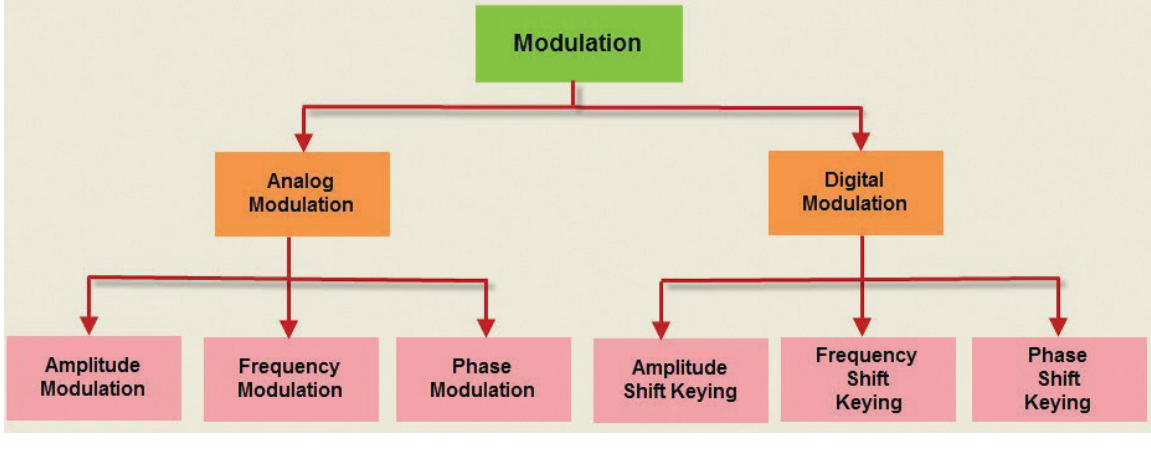
2.3.1 Need for modulation

The following flow chart shows need for modulation,



2.3.2 Types of Modulation

The following flow chart shows types of modulation.



2.3.3 Analog Modulation

In analog modulation, analog signal (Sinusoidal signal) is used as a carrier signal that modulated the message signal or data signal.

2.3.4 Amplitude Modulation (AM)

Amplitude modulation is a type of modulation where the amplitude of the carrier signal is varied (changed) in accordance with the amplitude of the message signal while the

frequency and phase of carrier signal remain constant.

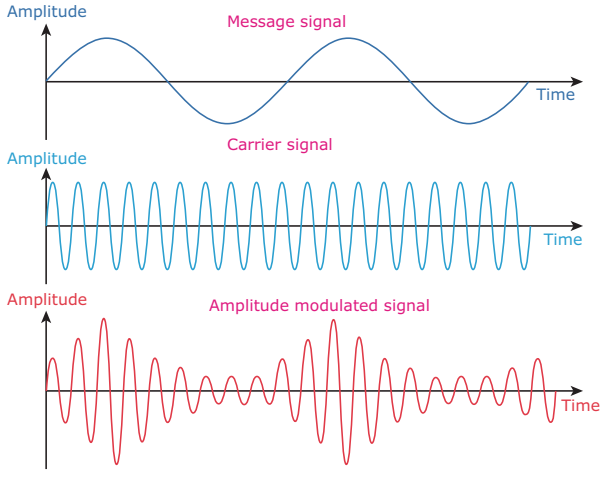


FIGURE 2.1 Amplitude modulation

The first waveform of figure 2.1 shows the modulating signal (or) message signal which contains information. The second waveform of figure 2.1 shows the high frequency carrier signal which contains no information. The third waveform of figure 2.1 shows the resultant amplitude modulated signal.

From the above three figures, it can be observed that the amplitude of the carrier signal is varied in accordance with the amplitude of the message signal while the frequency and phase of carrier signal remain constant.

2.3.5 Comparison of Analog Modulation

The comparison between Amplitude Modulation, Frequency Modulation and Phase Modulation are listed in Table 2.1

2.3.6 Digital Modulation

In digital modulation, the modulating signal is converted from analog to digital. This type of modulation is employed for efficient communication. There are many types of digital modulation techniques and also their combinations depending upon the need.

Amplitude Shift Keying (ASK) Modulation

ASK is the digital modulation technique in which the amplitude of the carrier signal is changed by varying the binary data inputs

Table 2.1 Comparison between Amplitude Modulation, Frequency Modulation and Phase Modulation

S. No.	Amplitude Modulation	Frequency Modulation	Phase Modulation
1.	Amplitude of the Carrier signal is varied	Frequency of the carrier signal is varied	Phase of the carrier signal is varied
2.	Frequency and phase of the carrier signal remain constant	Amplitude and phase remain constant	Amplitude and frequency remain constant
3.	Noise in reception	Noiseless reception	Noiseless reception
4.	Low efficiency	Less radiated power	Low power consumption
5.	This type is used in AM radio broadcasting and in computer modem.	This type is used in FM radio Broadcasting	This type is used in Wi-Fi, TV remote and satellite communication.

at a particular time. The binary signal when ASK modulated, gives a **zero** value for **Low** input while it gives the **carrier output** for **High** input.

The following figure 2.2 represents ASK modulated waveform along with its input.

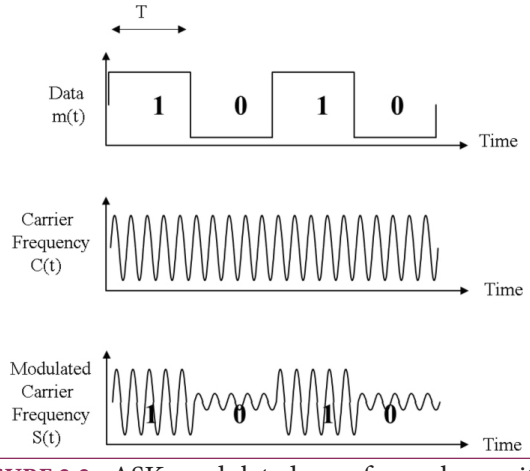


FIGURE 2.2 ASK modulated waveform along with its input

Frequency Shift Keying (FSK) Modulation

FSK is the digital modulation technique in which the frequency of the carrier signal is changed by varying the binary data inputs at a particular time. The binary **1s** and **0s** are called Mark and Space frequencies.

The following figure 2.3 represents FSK modulated waveform along with its input.

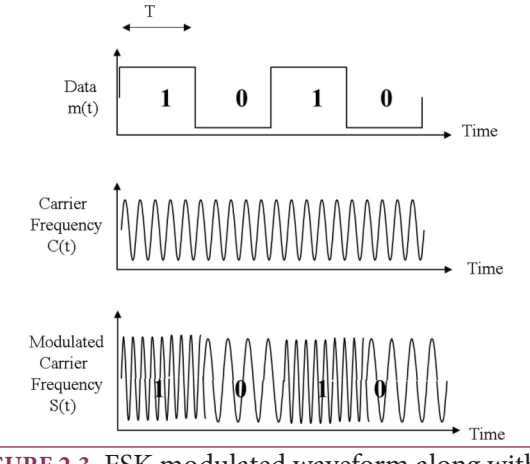


FIGURE 2.3 FSK modulated waveform along with its input

Phase Shift Keying (PSK) Modulation

PSK is the digital modulation technique in which the phase of the carrier signal is changed by varying the binary data inputs at a particular time. PSK technique is widely used for wireless LANs, bio-metric, contactless operations, along with RFID and Bluetooth communications.

The following figure 2.4 represents PSK modulated waveform along with its input.

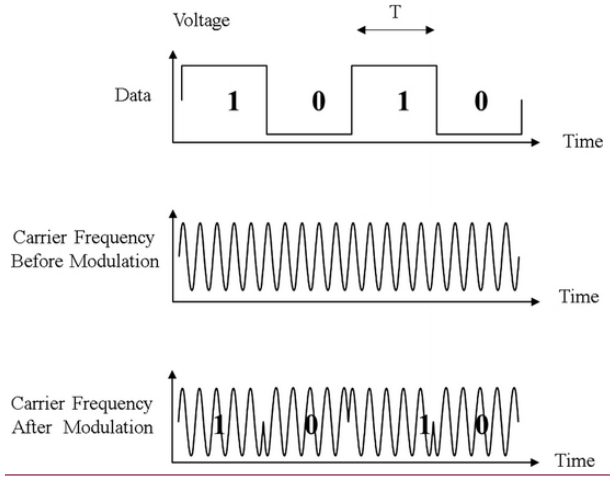


FIGURE 2.4 PSK modulated waveform along with its input

2.4 Demodulation or Detection

Demodulation or detection is a process of recovering the original modulating signal from the modulated carrier wave. (i.e.,) the demodulation is the reverse process of modulation. The device used for demodulation is called demodulator or detector.

2.4.1 Need for Demodulation

- Demodulation becomes essential to separate the audio frequency from the radio frequency carrier waves.
- The wireless signals transmitted from a transmitter consist of carrier wave and audio frequency signal wave.

- If the modulated wave is directly fed to the loud speaker, no sound will be heard from the loud speaker.
- This is because the frequency of the carrier wave is very high.
- The loud speaker diaphragm cannot respond to such high frequency due to large inertia of their vibrating disc etc.
- RF wave does not produces any effect on human ear as the frequencies are much beyond the audible range (20Hz – 20 KHz).

2.5 Modem

Modem stands for Modulator / Demodulator. A modem converts digital signals generated by the computer into analog signals which can be transmitted over a telephone or cable lines and transformed the incoming analog signals into their digital equivalents. It is a hardware device that allows a computer or other devices such as a router or a switch to access. Figure 2.5 shows the different types of Modem.



FIGURE 2.5 Types of Modem

2.5.1 Working of Modem

A Modem is typically used to send digital data over a phone line. The sending modem modulates the data (Digital) into a signal (Analog) that is compatible with the phone line and the receiving modem demodulates the signal back (Analog) into digital data. Wireless modem converts digital data into radio signals and back. Figure 2.6 shows the working principle of Modem.

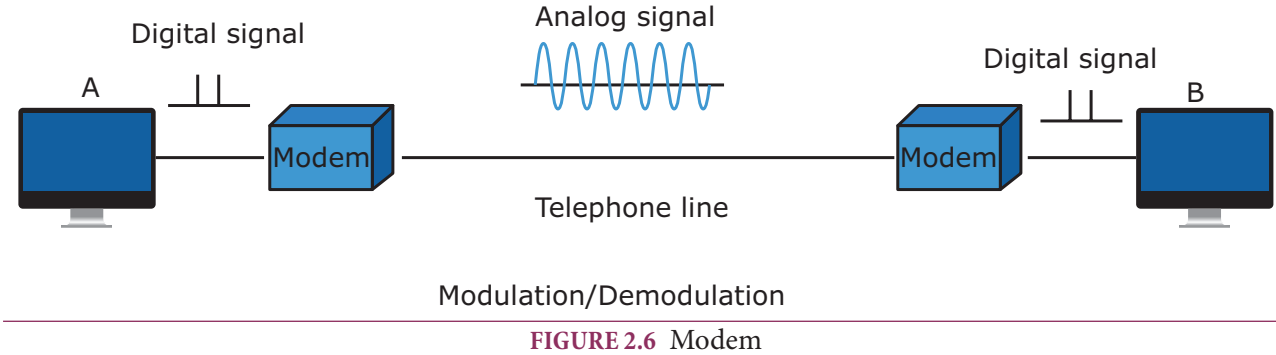


FIGURE 2.6 Modem

2.5.2 Applications of Modem

Modems were originally used for connecting users to the internet or for sending faxes. Now a days, the applications include data transfers, remote management, broadband backup, point of sale, machine to machine etc are some of these examples are as follows.

1. Point of Sale (POS)

   POS is the mostly used applications by the consumer. Anytime you pay via credit card or debit card there is a modem (dial-up or broadband) behind it transferring that data and returning an approval or denial quickly and in the case of dial-up solutions with less costs associated.

Examples

i) Credit card payment terminal in restaurants, movie theatres or retail stores.

ii) Ticketing machine in railway stations, bus stations and airports.

iii) ATM cash machines.

2. Remote management, maintenance and logistics

   Modem can be installed in remote locations at off-site locations, tight enclosures or inside sensitive locations. Certain applications can be controlled remotely via modem without having to make a visit to the actual locations. This can save time and money.

Examples

1. Stoplight timing control – ability to alter signal timing from headquarters to regulate traffic flows.
2. Roadside digital signal – ability to change messages from headquarters.
3. Safety – ability to check temperature etc., to verify interior safety is secure.

2.6 Antenna

- An antenna is a transducer, which converts electrical power into electro magnetic waves and vice versa.
- An antenna can be used either as a transmitting antenna or a receiving antenna.
- A transmitting antenna is one which converts electrical signals into electro magnetic waves and radiates them.
- A receiving antenna is one which converts electromagnetic waves from the beam into electrical signals.
- In two way communication, the same antenna can be used for both transmission and reception. Antenna can also be termed as an aerial.

There are many types of antennas depending upon their wide variety of applications. Figure 2.7 shows the types of antenna.

2.7 Radio Transmitter

A Transmitter is an electronic device used in telecommunication to produce radio waves in order to transmit or send data with the aid of an antenna. Various types of radio transmitters are in use, we shall discuss here only about AM and FM transmitter.

2.7.1 AM Radio Transmitter

It is an equipment which transmits the amplitude modulated waves. AM Radio transmitter uses double sideband transmission. Its bandwidth is 10 kHz. AM transmission broadcast range lies from 540 kHz to 1600 kHz. Figure 2.8 shows the block diagram of an AM Radio Transmitter



FIGURE 2.7 Types of Antenna

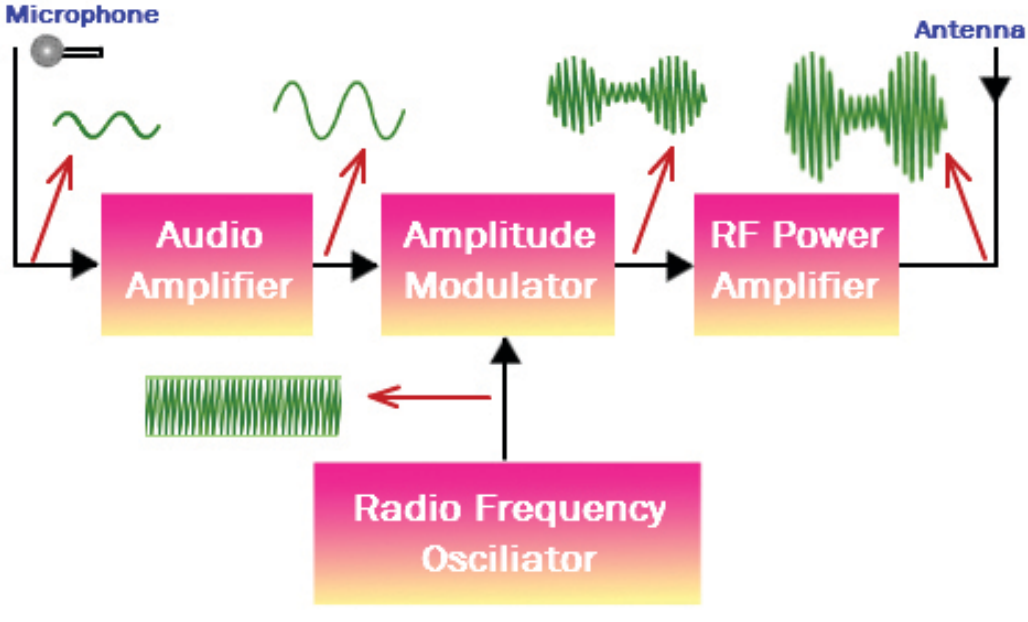


FIGURE 2.8 shows the block diagram of AM Radio transmitter.

Microphone

It converts AF signal into electrical signal and feeds to audio amplifier.

Audio amplifier

It amplifies the voltage and power level of audio signal and send to amplitude modulator.

RF Oscillator

It produces high frequency noiseless carrier waves (RF) using crystal Oscillator and send to amplitude modulator.

Amplitude modulator

Here AF signal and RF signal are amplitude modulated and send to the RF power amplifier.

RF Power amplifier

Here, the power amplifier used to increase the power level of modulated RF signal and sends to the transmitting antenna.

Transmitting antenna

It converts the modulated waves into electromagnetic waves and transmits into space.

2.7.2 FM Radio Transmitter

It is an equipment which transmits the frequency modulated waves. FM Radio transmitter uses double sideband transmission. Its bandwidth is 200 kHz. FM transmission broadcast range lies from 88 MHz to 108 MHz. Figure 2.9 shows the block diagram of FM Radio transmitter.

Microphone

It converts AF signal into electrical signal and feeds to audio pre amplifier.

Audio pre-amplifier

It amplifies the incoming AF signal and feeds to frequency modulator. Pre emphasis: Here AF signals amplitude is artifically boosted to improve signal ratio and sent to the frequency modulator stage

Crystal Oscillator

It produces noiseless high frequency waves and sends to the frequency modulator stage. It uses crystal Oscillator.

Frequency modulator

In this stage, AF signal and RF signal are frequency modulated and sent to RF power amplifier.

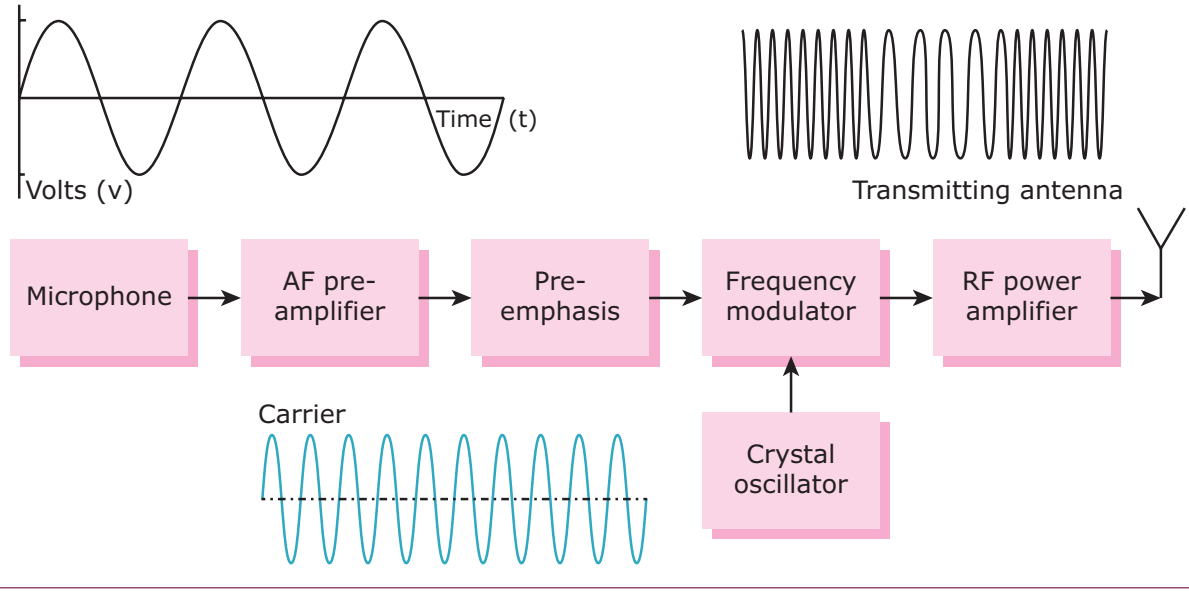


FIGURE 2.9 Block diagram of FM Radio transmitter

RF power amplifier

Here, RF waves are amplified and sent to the transmitting antenna.

Transmitting antenna

It converts the modulated waves into electromagnetic waves and transmits into space.

2.8 Radio Receiver

A receiver is an electronics device that receives radio waves and converts the information carried by them to a usable form.

2.8.1 Basic Principle of Radio receivers

The principle of the radio receivers is more or less similar in all type of radio receivers and is summarized below.

Reception

An aerial is necessary for the reception of radio waves. It receives the radio waves into the receiver.

Selection

It is the ability to select a desired radio station from various radio station. This work is performed by a LC resonant network.

Detection

In this process, radio frequency signals are converted into audio frequency signals. It is performed by a crystal diode.

Reproduction

The conversion of audio signal into sound is called reproduction. It is performed by a speaker.

2.8.2 Abilities of Receivers

The quality and specialty of a radio receiver is determined on the basis of the following abilities.

Sensitivity

It is the ability to produce sufficient audio output even for weak input radio frequency signal. It depends on the R.F. and I.F amplification capabilities.

Selectivity

It is the ability to select only the desired signal or radio station from the signals, which are received by the aerial. It depends on accurate alignment of the tuned circuits. Hence, converter and R.F amplifier are designed in such a way to improve the selectivity.

Fidelity

It is the ability to amplify the complete range of audio frequency without loss. It depends upon the design of AF amplifiers.

Stability

It is the ability to produce stable output without variation. AVC circuit is used to produce stability in the sound.

Signal to Noise ratio

It is the ratio between the signal and noise. A noise limiter stage is used to improve this quality.

Types of Radio Receivers

Generally, the radio receivers are classified into the following two types.

1. TRF radio receiver
2. Superhetrodyne radio receiver

2.8.3 TRF Radio Receiver

Figure 2.10 Shows the block diagram of a tuned radio frequency receiver. The function of each block is discussed below.

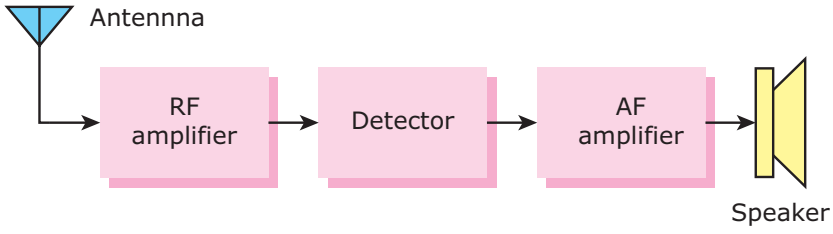


FIGURE 2.10 TRF Radio Receiver

Antenna: It receives the incoming modulated carrier signal and send it into RF amplifier.

RF Amplifier : RF Amplifier Selects the wanted signal and rejects the unwanted signal. It also amplifies the desired signal and send it into detector.

Detector: In Detector, radio frequency signals are converted into audio frequency signals and feed into AF amplifier.

AF Amplifier: It amplifies the voltage and power level of audio signal and send it into loud speaker.

Loud Speaker: It Converts audio signal into sound signal.

2.8.4 Superhetrodyne Radio Receiver

This receiver works under the principle of heterodyning. Modern radio receivers are mostly of super heterodyne types. It has converter stage which changes the incoming single into intermediate frequency (IF) signals.

Principle of Super heterodyne Receiver

The process of beating (mixing) two different signals to produce a new signal is called as Heterodyning. Fig 2.11 shows the block diagram of super heterodyning principle. If two different signals are mixed through a transistor, four types of signals are obtained in the output of the transistor. They are

1. First signal (F_o)
2. Second signal (F_s)
3. Addition of the two signals is represented as ($F_o + F_s$)
4. Difference between the two signals is represented as ($F_o - F_s$)

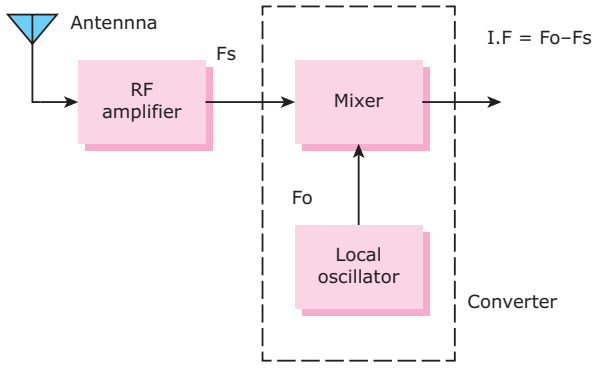


FIGURE 2.11 Super heterodyning principle

Apart from these, an unwanted signal called harmonics is produced due to the mixing of the two signals. Out of them, the difference between the two is taken as intermediate frequency (IF) and the remaining signals are filtered. This is the principle of superheterodyning. The receivers which follow this principle are named as superhet receivers. This principle is used in AM, FM, Communication, Radar and Television receivers.

Merits

1. Good sensitivity and selectivity.
2. Good fidelity.
3. Good stability.

Demerits

1. It needs alignment and tracking.
2. Complicated circuits are used.

2.8.5 AM Radio Receiver

A receiver which receives amplitude modulated radio signals is called amplitude modulated (AM) radio receiver. Fig 2.12 Shows the block diagram of AM radio receiver

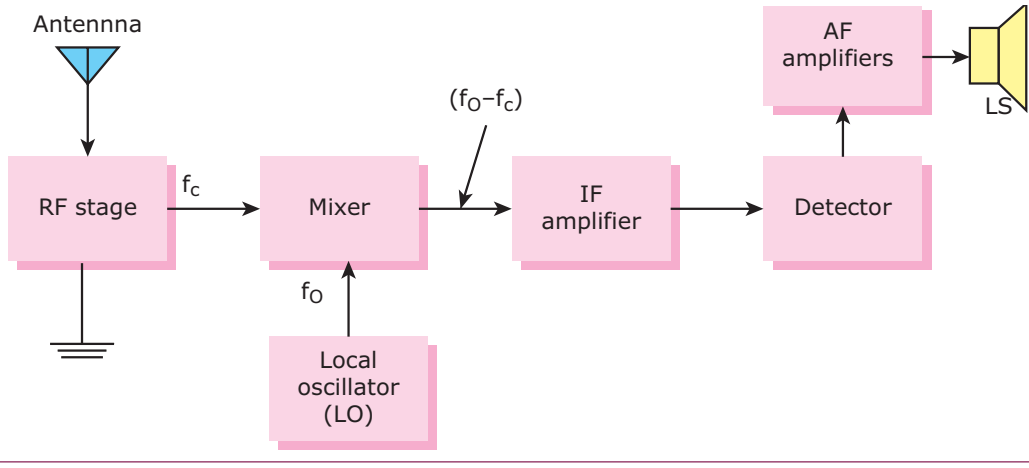


FIGURE 2.12 shows the block diagram of AM radio receiver.

Antenna	Antenna receives electromagnetic waves and converts it into electrical signal and fed into the RF amplifier.
RF Amplifier	It selects the desired RF signals (Fs) then amplifies it and fed into the mixer. It also improves selectivity.
Local Oscillator	It produces an un-modulated RF signals (F0 = FS + 455 kHz) and fed into the mixer.
Mixer	Mixer mixes the two input signal (F_s & F_o) and gives IF signal as output (455 KHz)
IF Amplifier	It Amplifies the IF Signal (455 KHz) and fed into the Demodulator. It also improves the sensitivity
Demodulator /Detector	It Separates the audio signal form Amplitude modulated IF signal, and fed it into the audio amplifier.
Audio Amplifier	This stage amplifies the voltage level and power level of audio signal and fed into the speaker. It also improves the fidelity.
Speaker	It converts audio signal into sound signal.

2.8.6 FM Radio Receiver

A receiver which receives frequency modulated radio signals is called frequency modulation (FM) radio receiver. It is also called as superhet receiver. Fig 2.13 shows the block diagram of FM receiver.

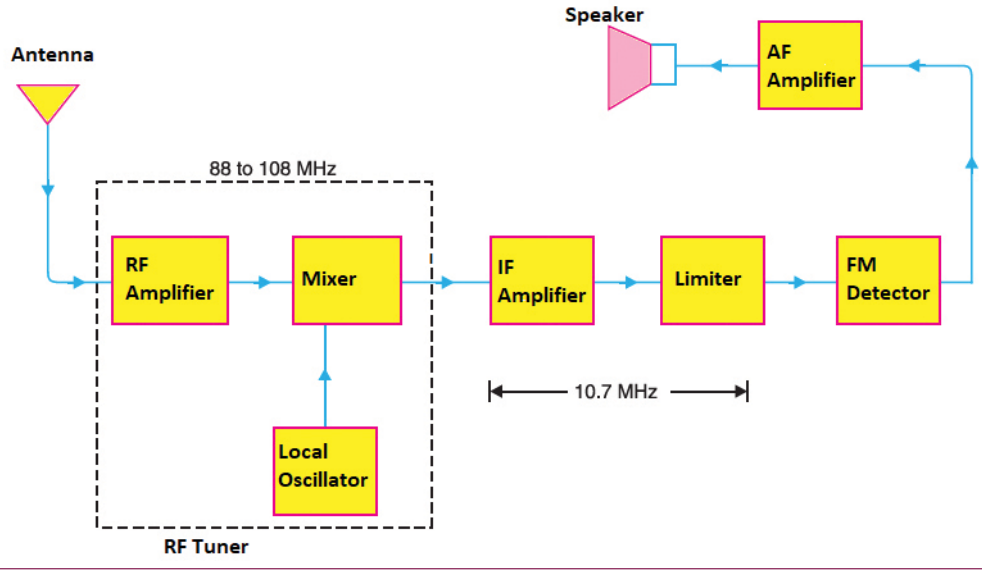


FIGURE 2.13 Block diagram of FM Radio Receiver

Antenna	Antenna receives electromagnetic waves and converts it into electrical signal and fed into the RF amplifier.
RF Amplifier	It selects the desired RF signals (fs) then amplifies it and fed into the mixer. It also improves the selectivity.
Local oscillator	It produces un-modulated RF signals (fo = fs + IF) and fed into the mixer.
Mixer	Mixer mixes the two input signals (RF) (fs and fo) and gives IF signal as output (10.7 MHz).
IF Amplifier	IF amplifier amplifies the IF signal (10.7 MHz) and fed into the limiter. It also improves the sensitivity.
Limiter	It controls the noise pulse which are mixed with signals. It works as a clipper.
Discriminator	It is a demodulator. It separates audio signal from FM modulated IF signal and fed it into the audio amplifier.
Audio amplifier	This stages amplifies the voltage level and power level of audio signal and fed into the speaker.
Speaker	It converts audio signal into sound signal.

2.8.7 Comparison between AM and FM Receiver

The comparison between AM and FM receiver are listed in Table 2.2.

Table 2.2 Comparison between AM and FM Receiver		
S.No.	AM Receiver	FM Receiver
1.	Receives and Processes the AM Signals	Receives and Processes the FM Signals
2.	Operating frequency range is from 540 kHz to 1600 kHz	Operating frequency range is from 88 MHz to 108 MHz
3.	Intermediate Frequency (IF) value is 455 kHz	Intermediate Frequency (IF) value is 10.7 MHz
4.	Bandwidth is 10 kHz	Bandwidth is 200 kHz
5.	Employs detector	Employs discriminator
6.	Does not employ limiter	Employs limiter
7.	Interference and distortion are more	Interference and distortion are less.

2.9 Servicing of FM Radio receivers

Trouble shooting techniques

It includes both the fault finding and its rectification. It is a sensitive job. It requires circuit diagram, proper tools, test equipment and identical components.

Precautions to be taken before servicing receivers

1. First, note the name, model, number of bands and stages in the receiver. Then, list the number of transistors and integrated circuits used in the circuit.
2. To prevent shock, the receiver should not be opened until the mains-cord is unplugged.
3. After opening the receiver, the missed and burnt components (parts) should be observed.
4. After giving the supply to the receiver, observe for any spark, smoke or burning smell.

Types of faults

The defects in a receiver can commonly be classified into two types.

1. Live fault
2. Dead fault

Live fault

If some sound is heard from a faulty radio in 'ON' condition, but receiver not working properly, it is termed as '**Live fault**'.

Dead fault

If no sound is heard even after a radio receiver is in 'ON' condition, it is said to be '**Dead Fault**'.

2.9.1 Rectification

Dead fault

1. Check power cord.
2. Check on-off switch & AC fuse.
3. Check for defective Power transformer.
4. Check for Defective Bridge diodes.
5. Check the main filter capacitor.
6. Check the second B+ filter capacitor.

7. Check for dry soldering and copper track cut.
8. Check B+ to Audio IC like TBA 810/ CA 810 for testing the condition of the IC.
9. Check B+ to CXA 1619 IC for ensuring its reliability.

Live faults

Distorted audio

1. Check speaker.
2. Check the volume control.
3. Check for defective filter capacitor.
4. Check for faulty series capacitor connected with speaker
5. Check for faulty Audio IC TBA 810 or defective CXA 1619 IC.

Low volume

1. Check speaker.
2. Check the volume control.
3. Check for low B+.
4. Check for faulty series capacitor connected with speaker.
5. Check for dry soldering or copper track cut.
6. Check for faulty Audio IC TBA 810.
7. Check for defective CXA 1619.

Noise only: No signal (Radio stations not received)

1. Ganged capacitor may be faulty
2. Faulty trimmer.
3. Faulty CXA 1619 IC

Hum with distorted audio

This fault occurs due to pulsating DC supplied to the receiver.

1. Defective power transformer.
2. Defective diodes.
3. Defective main filter capacitor.
4. Defective 2nd B+ filter capacitor.

2.10 TV Transmission And Reception

Television means "To see from a distance". Video and audio signals are transmitted from TV transmitter and is viewed in various places using TV receivers.

Television comprises of the following three activities:

1. Capturing Pictures—Camera
2. Recording and Transmission
3. Reception or Reproduction

2.11 TV Transmitter

TV transmitter radiates radio waves, which carry a video signal along with a audio signal. This is received by the television receiver. It transmits frequency channels in the VHF and UHF bands.

Since radio waves of these frequencies travel by line of straight, they are limited by the horizon to reception distances of 40 – 60 miles depending on the height of transmitter station.

TV transmitters use one of two different technologies, analog, in which the picture and sound are transmitted by analog signals and digital in which the picture and sound are transmitted by digital signals. But nowadays digital Television (DTV) systems are used in many countries. These transmit picture in a new format called HDTV (High Definition Television), which has higher resolution and a wider screen aspect ratio than analog. Fig 2.14 shows a simple colour TV transmitter block diagram

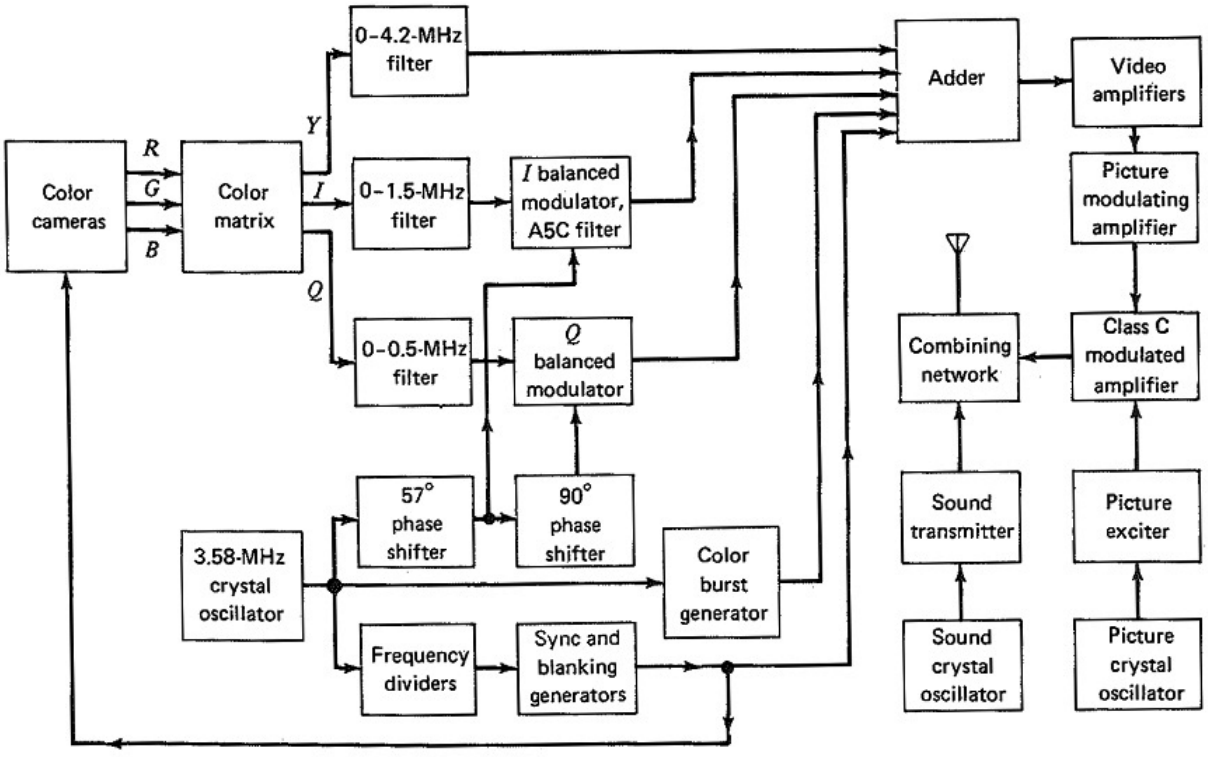


FIGURE 2.14 Simple colour television Transmitter – Block – Diagram.

2.12 TV Receiver

This 21st Century witnessed major change in television technology. The prime and important device which is essential to convert the video signal into visual picture is the CRT tube that has tremendous developments such as LCD, LED, QLED, OLED, etc. Fig 2.15 shows LED TV receiver block diagram.

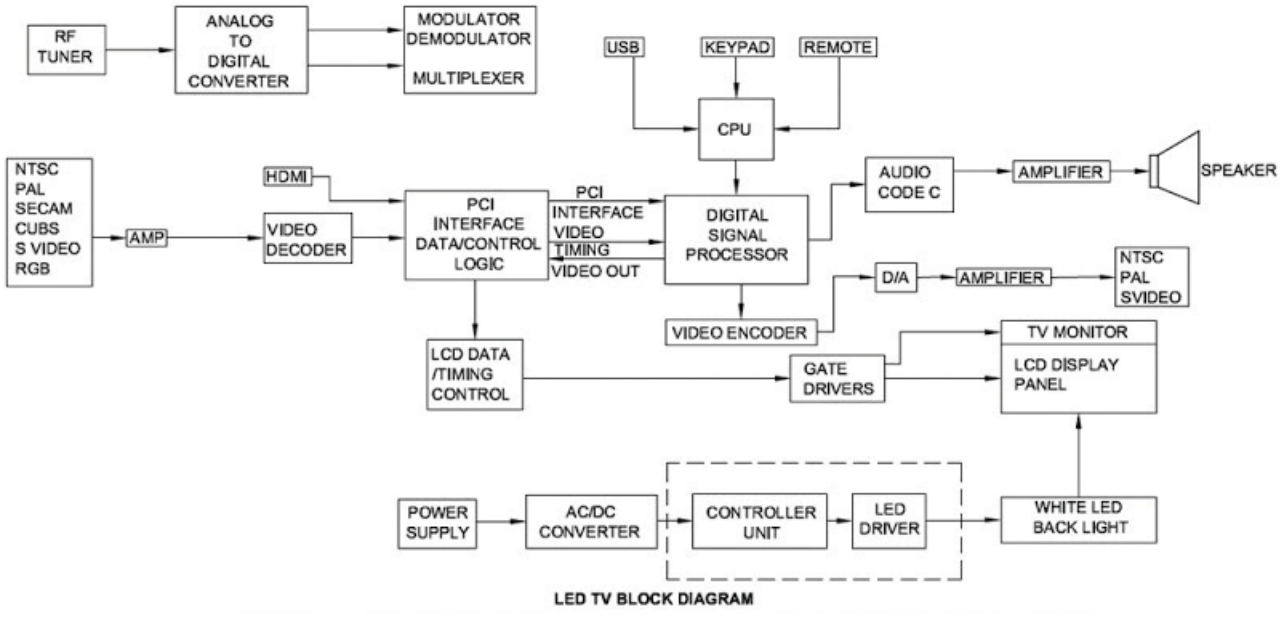


FIGURE 2.15 LED TV Receiver Block Diagram

Digital TV receivers use a set of box that convert digital signals into an analog signals allowing an analog television to receive television broadcasts. Digital converter boxes can be purchased at most home electronics retailers and relatively easy to install and use. An antenna is connected to the converter box and the box is connected to the television.

2.12.1 Liquid Crystal Display (LCD)

LCD stands for Liquid Crystal Display. It is a particular flat panel that either allows or blocks the passage of light. In this technology, liquid crystal technology is used. This technology combines liquid crystals and polarizer to create images on the screen.

Generally, LCD TVs have three polarized glass panels known as substrates. It contains liquid crystals in between them. These panels are in red, blue, and green colours. Whenever electric current passes through these substances, the crystals rotate and align to let the light pass through the other substrate. In this way, we can see colours and images. Fig 2.16 shows a back light source of LCD and LED panel

Principle of Liquid Cristal Display

A liquid crystal display (LCD) has liquid crystal material sandwiched between two sheets of glass. Without any voltage applied between transparent electrodes, liquid crystal molecules are aligned in parallel with the glass surface. When voltage is applied, they change their direction and they turn vertical to the glass surface. They vary in optical characteristics, depending on their orientation. Therefore, the quantity of light transmission can be controlled by combining the motion of liquid crystal molecules and the direction of polarization of two polarizing plates attached to both the outer sides of the glass sheets. LCDs utilize these characteristics to display images. Fig 2.17 shows working principle of LCD

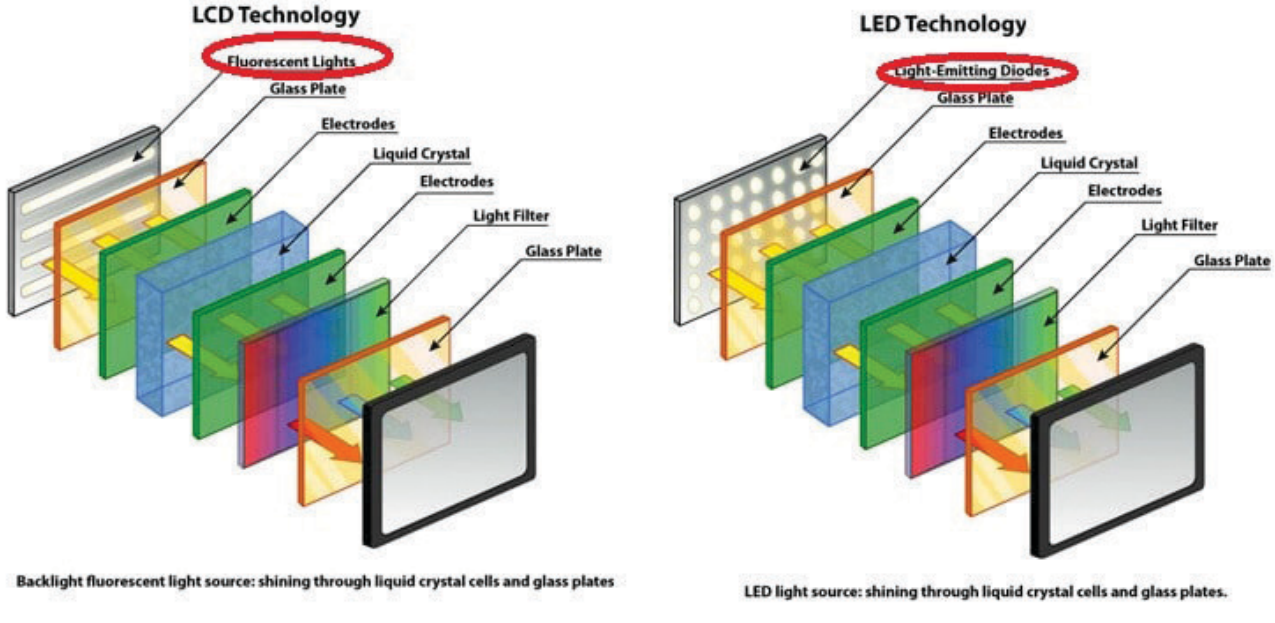


FIGURE 2.16 Back light source of LCD and LED Panel

Working Principles of LCD

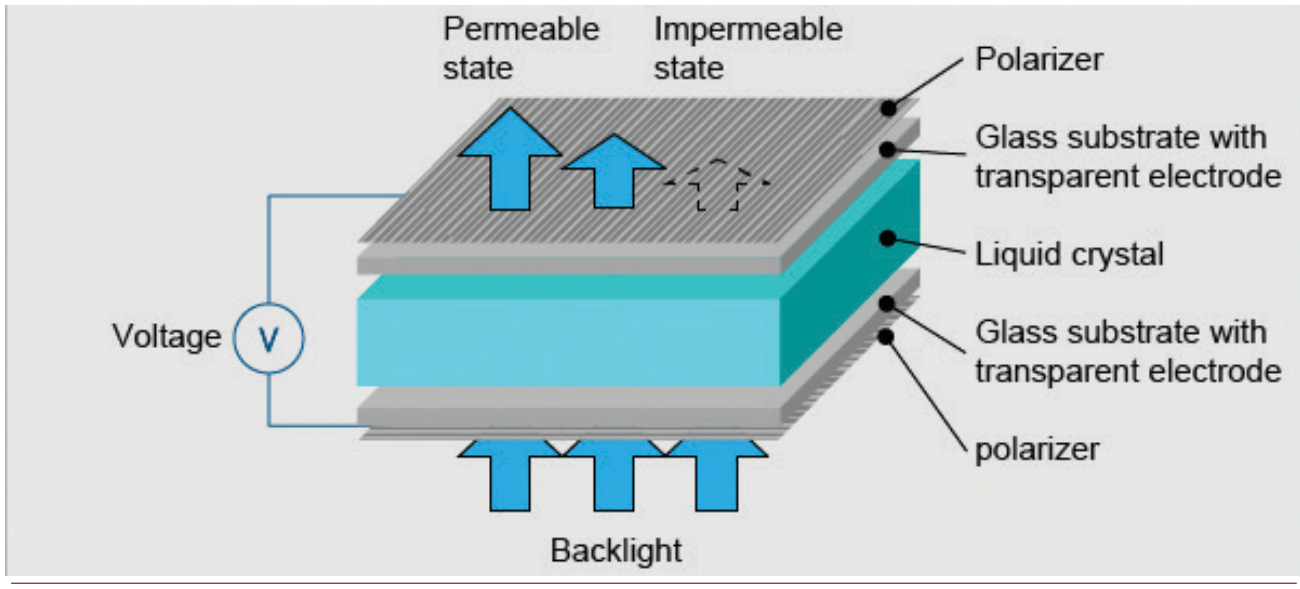


FIGURE 2.17 Working principle of LCD

TFT LCD (Thin Film Transistor LCD)

An LCD consists of many pixels. A pixel consists of three sub-pixels (Red/Green/Blue, RGB). In the case of Full HD resolution, which is widely used for smart phones, there are more than six million (1,080 x 1,920 x 3 = 6,220,800) sub-pixels. To activate these millions of sub-pixels a TFT is required in each sub-pixel. TFT is an abbreviation for " Thin Film Transistor". A TFT is a kind of semiconductor device. It serves as a control valve to provide an appropriate voltage onto liquid crystals for energizing individual sub-pixels. A TFT LCD has a liquid crystal layer between a glass substrate formed with TFTs and transparent pixel electrodes and another glass substrate with a colour filter (RGB) and transparent counter electrodes. In addition, polarizers are placed on the outer side of each glass substrate and a backlight source on the back side. A change in voltage applied to liquid crystals changes the transmittance of the panel including the two polarizing plates, and thus changes the quantity of light that passes from the backlight to the front surface of the display. This principle allows the TFT LCD to produce full-colour images. Fig 2.18 shows the structure of TFT LCD

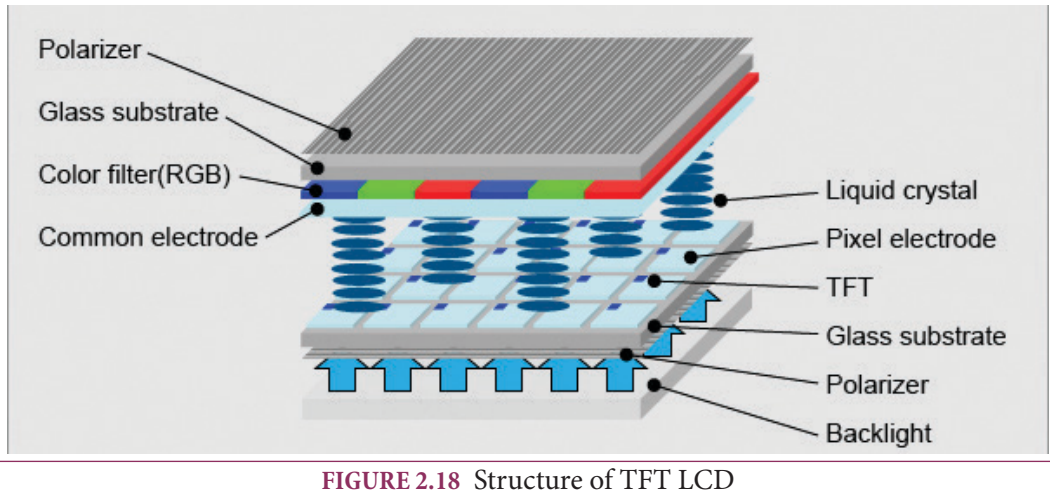


FIGURE 2.18 Structure of TFT LCD

2.12.2 LED

If Light emitting diodes are used to backlit an LCD screen, then this type of TV receiver is called as LED TV. This type of backlight is a series of LEDs placed behind the screen as shown in Fig 2.16. LEDs are more energy efficient and a lot smaller than a Cold Cathode Fluorescent lamps, enabling a thinner television screen.

2.12.3 Quantum dot LED

QLED stands for quantum dot LED TV. QLED Television are a new type of LED backlit LCD TV with directly enhanced colour. It is a display device that uses quantum dots (QD) semiconductor nano crystals, which can produce pure monochromatic red, green and blue light. These nano crystals glow a particular colour after being illuminated light. The colour they glow depends on the size of nano crystals. When the quantum dots are illuminated by UV light some of the electrons receive enough energy to break free from the atoms. Fig 2.19 shows Q LED display

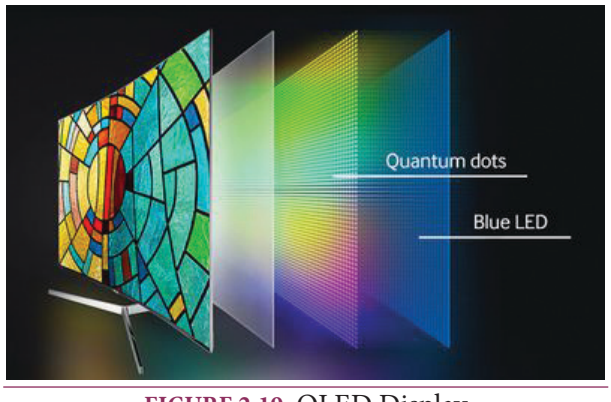


FIGURE 2.19 QLED Display

Advantages of QLED

1. Higher Brightness
2. Thinner and lighter panels
3. Improved contrast ratio
4. Longer life span
5. Less power consumption

Disadvantages of QLED

1. Suffer from light bleed effect
2. Viewing angle is dead cantex this effect is visible in screen
3. Less saturable blue.

2.12.4 OLED TV

OLED TV is a television display technology based on the characteristics of organic light emitting diodes (OLED) . OLED is a different technology than LEDTV. The OLED display is based an organic substance used as the semiconductor material in light emitting diodes (LED). Fig 2.20 shows an OLED display

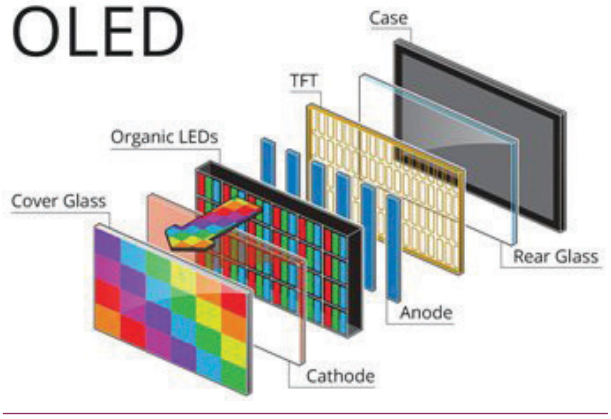


FIGURE 2.20 OLED Display

Advantages of OLED

1. The OLEDS are flexible and hence it is very easy to manufacture
2. Smaller in size
3. less weight

Disadvantages of OLED

1. Short life time
2. More expensive
3. It can be easily damaged by watts.

LEARNING OUTCOME

After studying this chapter, the student can understand the following

1. Transmission and Reception
2. Modulation and Demodulation
3. Modem
4. Antenna
5. Radio transmitter and radio receiver
6. TV transmitter and TV receiver

QUESTIONS

I Choose the best answer from the given four options.

1. Radio frequency wave can travel _____ per second
   a) 5 X 10^8 meter
   b) 20 X 10^8 meter
   c) 3 X 10^8 meter
   d) 15 X 10^8 meter



2. In amplitude modulation _____ of the carrier signal is varied in accordance with the amplitude of the message signal.
   a) Phase
   b) Frequency
   c) Amplitude
   d) None of the above
3. The type of modulation used in satellite is _____.
   a) Amplitude Modulation
   b) Frequency Modulation
   c) Phase Modulation
   d) Angle Modulation
4. A transducer which converts electrical power into electromagnetic waves and vice versa is called _____.
   a) Antenna b) Loud speaker
   c) Microphone d) Modem
5. The bandwidth of AM radio transmitter is _____.
   a) 100 kHz b) 10 kHz
   c) 200 kHz d) 540 kHz
6. The bandwidth of FM radio transmitter is _____.
   a) 100 kHz b) 10 kHz
   c) 200 kHz d) 540 kHz
7. Intermediate frequency of AM radio receiver is _____.
   a) 100 kHz b) 10.7 MHz
   c) 88 MHz d) 455 kHz
8. Intermediate frequency of FM radio receiver is _____.
   a) 100 kHz b) 10.7 MHz
   c) 88 MHz d) 455 kHz
9. In LCD TV receiver, a pixel consists of _____ sub pixels
   a) 3
   b) 5
   c) 7
   d) 8
10. Which one is odd one out?
    a) LED
    b) CRT
    c) LCD
    d) QLED

II Answer in few sentence.

1. What is Modulation?
2. What are the needs for modulation?
3. Define amplitude modulation.
4. What is demodulation?
5. What is modem?
6. What is an antenna?
7. What are the basic principles of radio receiver?
8. What are the abilities of a radio receiver?
9. Give three reasons for hum in receiver.
10. What are the advantages of OLED?

III. Explain the following questions.

1. Draw and explain the block diagram of TRF receiver.
2. Draw the block diagram of AM Radio receiver.
3. Write the difference between AM receiver and FM receiver.
4. What are the need for demodulation?
5. Explain Quantum Dot LED

IV. Briefly explain the following questions.

1. Explain the block diagram of an AM radio transmitter.
2. Explain the block diagram of FM radio receiver.
3. What are the reasons for dead faults in radio receiver?
4. Explain about LCD display.

Answers

1(c)	2(c)	3(c)	4(a)	5(b)
6(c)	7(d)	8(b)	9(a)	10(b)



CHAPTER 03

Communication Devices and their Technologies

LEARNING OBJECTIVE

The students can understand the following in this chapter

1. Transmission Modes
2. Mobile Phones
3. Radio Waves
4. Multiple Access Techniques
5. Other Special Technologies
6. Applications of Mobile phones

Introduction

Any device used to transfer information is called a communication device. We, the Human beings are enjoying the benefit of communication devices for the past 100 years. The first communication tool developed by human is the telegraph at the end of 19th century.

DO YOU KNOW?

Scientist Samuel F.B. Morse was the first person, who developed the first communication machine called Telegraph

The technology used in Telegraph to transfer information from one end to other is called Morse-Code. Then, Alexander Graham Bell developed the first phone to transfer the sound. Subsequently, the world witnessed the arrival of Radio invented by Marconi. First Television broadcast happened in the year 1928 in New York, America. The later part of the 20th Century (1980 – 90) witnessed the arrival of Mobile phone. During this 21st century, the mobile phone is taking over the World.

Mobile phones are powerful, portable and modern personal communication devices with numerous useful features. The characteristics of the modern devices are smaller, lighter and having more functionality. Smart phone is one type of mobile phone with extra computing functionality and connectivity capabilities. It enhances communication and allows the user to access internet (browsing websites, download and install application etc.,)

3.1 Transmission Modes

Transmission is the backbone of all communication devices. There are three modes of transmission and is categorized in the block diagram shown in Figure 3.1

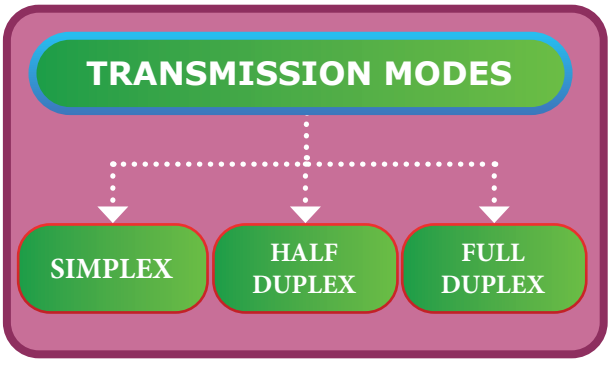


FIGURE 3.1 Different Mode of Transmission

Transmission modes describe the direction of flow of signal between two connected devices.

3.1.1 Simplex

In a Simplex transmission mode, the communication between the sender and receiver occurs only in one direction. That means, the sender can only transmit the data and receive the data. The receiver cannot reply in reverse to the sender. Simplex is like a one-way road in which the traffic moves only in one direction, no vehicle from opposite direction is allowed to enter. The entire channel capacity is utilized by the sender. The best example for Simplex transmission is Pager. (Fig 3.2)



FIGURE 3.2 Front view of a Pager.

3.1.2 Half Duplex

In a Half-Duplex transmission mode, (Shown in Fig 3.3) the communication between sender and receiver occurs and both can transmit and receive the information. But, only one is allowed to transmit at a time. Half-Duplex is still a one-way road, in which a vehicle travelling in opposite direction has to wait till the road is empty. The entire channel capacity is utilized by the transmitter, transmitting at the particular time.



Walkie-Talkies work up to 27.2 Kilometres range. Obviously, this distance is dramatically reduced by obstacles such as buildings and mountains.

Walkie-Talkie was invented in 1937, by Canadian Donald Hings (1907-2004) and around the same time by American inventor Alfred Gross (1918-2000). Both men saw their invention developed for military use during World war-II.

Half-Duplex can be understood with an example of Walkie-Talkies. As the speaker at both the end of Walkie-talkies can speak, but they have to speak one after another. Both cannot speak simultaneously.

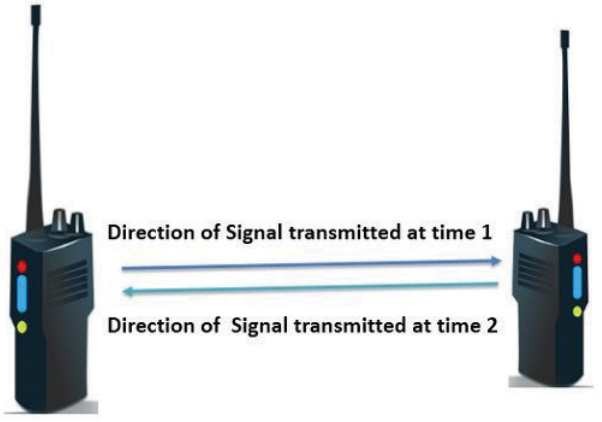


FIGURE 3.3 Half Duplex Transmission mode

Figure 3.4 shows the parts of the Walkie-Talkie hand-set and their functions are summarized below:

3.1.2.1 Parts of a Walkie-Talkie

S.No	Parts	Functions
1	**Antenna**	Sends and receives radio waves
2	**LCD Display**	Shows channel number, battery life etc
3	**Monitor**	Switch the Walkie-talkie to monitoring mode so that it can be used as a listening device or baby monitor
4	**Menu Select Buttons**	Marked with plus (+) and minus (-) symbols
5	**Menu Button**	Used for changing functions and settings. There is a provision to lock the keypad to prevent the channel or other settings from changing accidentally while the radio is in the user's pocket.
6	**Loud Speaker**	For making the audible sound.
7	**Push-To-Talk Button (PTT)**	Users press and hold the button to talk, then let go to listen.
8	**ON/OFF Switch and Volume Control.**	Users can press the Switch to Power ON and OFF the walkie-talkie and press the volume control switch to control the volume
9	**LED Indicator**	Light shows when channels are busy
10	**Microphone**	Unlike some models, Walkie-talkie has separate Loudspeaker and Microphone
11	**Transmit Call Tone**	This sends a tone signal to other radios on the same channel alerting them that the user wants to talk.



FIGURE 3.4 Parts of Walkie-Talkie

Applications

1. Military and Police organizations use the handheld radios for variety of purposes.
2. Now a days it is widely used in shopping malls, factories and even in apartments.

Advantages

1. These are robust, easy-to-use and simple.
2. Lots of people can listen and only one needs to talk at once.

Disadvantages

1. The Analog units are much expensive.
2. They are not designed for communication over longer ranges.

3. Users are hearing additional noises on the two-way radios or other conversations (interference with radios)

3.1.3 Full Duplex

In a Full-duplex transmission mode shown in figure 3.5, the communication between the sender and the receiver occurs, simultaneously. The duplex transmission mode is like a two-way road in which traffic can flow in both the direction at the same time. Here, the entire capacity of the channel is shared by both the transmitted signals, travelling in opposite directions by sharing the channel capacity in two different ways. In this mode of communication, the user physically separates the link in two parts, viz. one for sending and other for receiving. Then, the user lets the capacity of a channel to be shared by the two signals travelling in opposite directions. Full Duplex can be understood with an example of a Mobile phone. When two people communicate over a mobile phone, both are free to speak and listen at the same time.

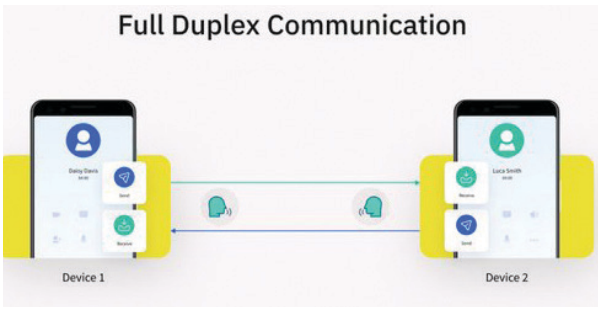


FIGURE 3.5 Full Duplex Transmission Mode

3.2 Mobile Phone

A mobile phone is a portable device that access to Cellular radio system. It has many names like, Cell phone, smart phone or telephone. This device is classified into two categories.

1. Simple device
2. Smart device

In simple devices, the user can access to make and receive the calls and send/ receive the messages. While smart devices have the facility to access the internet along with the above said two facilities.

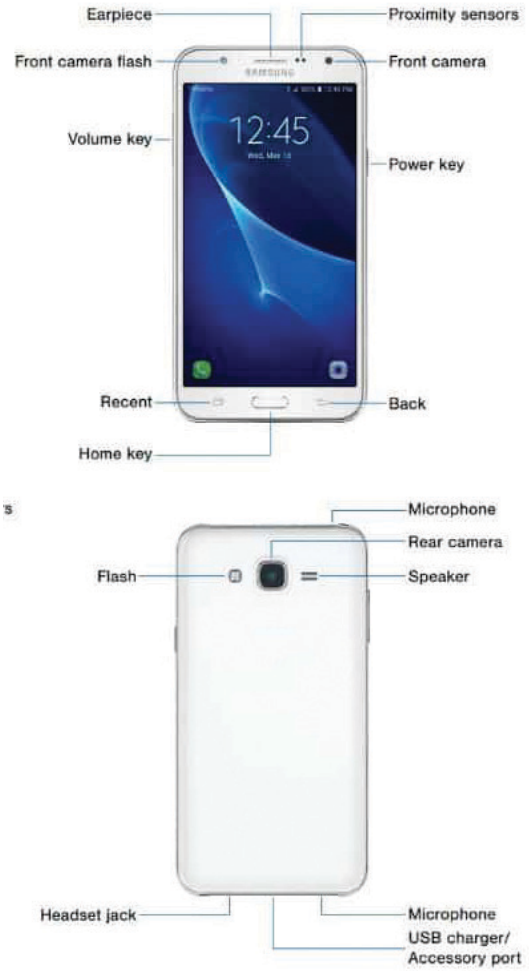


FIGURE 3.6 Parts of a Mobile phone

3.2.1 Basic Principle of Mobile Phones

A mobile phone is a two-way radio, consisting of a radio transmitter and a receiver as shown in Figure 3.6. The mobile phone converts the received voice into an electrical signal, which is then transmitted as radio waves to the nearest mobile tower. Then, the network of mobile towers relays the radio wave to the dialled mobile phone, which converts back the radio wave to an electrical signal and then

to sound waves. In the basic form, a mobile phone works just like a Walkie-talkie.

In additional to the basic function of the voice calls, most modern mobile phones come with additional features such as web surfing, camera, games, messaging and music. Smart phones can perform similar functions of a portable computer.

What is Cellular Network?

A cellular Network, also known as a mobile network is a network of mobile base stations that provide coverage for the user to establish phone calls, text messages and data services (Mobile internets).

3.2.2 Radio Waves

Mobile phones use radio waves for communication purposes as shown in Figure 3.7. Radio waves transmit digitized voice or data in the form of oscillating electric and magnetic fields, called the Electro-Magnetic Field (EMF). The rate of oscillation is called frequency of radio waves, which carry the information and travel in air at the speed of light. Mobile phones transmit radio waves in all directions. The waves can be absorbed and reflected by surrounding objects before they reach the nearest mobile tower. For example, when the mobile phone is placed near to users head during a call, a portion of the emitted energy is observed into users head (ear) and body. In this event, much of the mobile phones EMF energy is wasted and no longer available for communication. In the following sections, let we see the various components of the mobile phone communication.



FIGURE 3.7 Radio waves (EMF)

3.2.3 Antenna

An antenna converts an electrical signal in to the transmitting radio wave and vice versa. Mobile phones use single antenna as transmitter and the receiver, others have multiple transmitting or receiving antennas. Figure 3.8 shows a Mobile phone antenna switch.

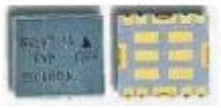


FIGURE 3.8 Mobile Phone Antenna Switch

An antenna is a metallic element (such as copper) having particular size and shape for transmitting and receiving specific frequencies of the radio waves. Older generation mobile phones have external or extractable antennas, while modern mobile phones contain more compact antenna, which is built inside the device. It is important to understand that any metallic component in the device (such as the circuit board and the metal frame) can interact with the transmission antenna(s) and contribute to the pattern of the transmitted signal. Many modern smart phones also contain more than one type of antenna. In addition to the Cellular antenna, they may also have Wi-Fi, Bluetooth and/or GPS antennas.

What is SAR?

Specific Absorption Rate (SAR) is the guidelines created for measuring the rate at which the body tissue absorbs radiation during cell phone operation. It is set at a maximum of 1.6 watts/kilogram of radiation energy absorbed by the body. Over exposure of cell phone radiation might cause cancer.

How To Limit The SAR?

The SAR limit is based upon a cell phone call that averages 30 minutes when the cell phone is held at the ear. Holding a phone away from the body or using a wired earpiece lowers the amount of radiation absorbed. Text messaging rather than talking, further reduces the radiation dosage.

3.2.4 Connectivity

The magnitude of the received signal from the mobile tower is called the "signal strength" which is commonly indicated by "bars" on the mobile phone as shown in Figure 3.9. The connectivity between a mobile phone and its cellular network depends on both signals and is affected by many factors, such as the distance between the phone and the nearest mobile tower, the number of obstacles/hindrance between them and the type of wireless technology (e.g. GSM or CDMA).

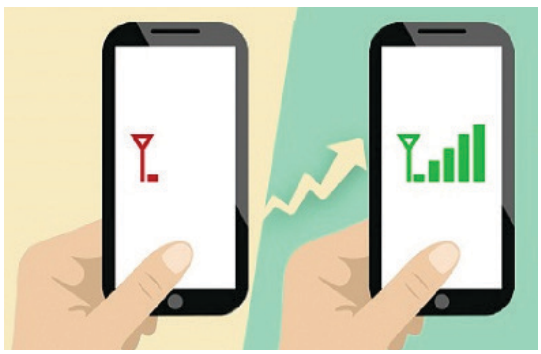


FIGURE 3.9 Mobile phone Signal Strength Image

A poor reception (fewer bars) normally indicates a long distance and/or much signal interruption between the mobile phone and the mobile tower.

3.3 Hardware parts of a GSM Mobile Phone

The block diagram 3.10 shows the Hardware parts of a GSM mobile phone. The components which include display (LCD, Touch screen), keypad, microphone, speaker, SIM card, battery, USB port, antenna, memory unit (RAM, ROM), camera, CODEC, RF part, DAC/ADC, baseband part (L1/Layer 1/physical layer) running on DSP, Application/protocol layers on CPU, ON/OFF switch and Bluetooth/GPS features

1. Mobile Phone RF Transceiver

Generally all the mobile phone will have RF part which consists of RF frequency up converter and RF frequency down converter. For GSM system, up converter converts modulated baseband signal (I and Q) either at zero IF (Intermediate frequency) or some IF to RF frequency (890 to 915 MHz). RF down converter converts RF signal (935 to 960 MHz) to baseband signal (I and Q). For GSM, GMSK (Gaussian Minimum Shift Keying) modulation is used.

2. Mobile phone Antenna

Antenna is the metallic object which converts electro-magnetic signal to electric signal and vice versa. Commonly used antennas in the mobile phone are helix type, planar inverted F type, whip or patch type. Microstrip based patch type of antennas are popular among mobile phones due to its size, easy integration on the PCB and multi frequency band of operation.

3. Tx/Rx Switch

As there is only one antenna used for both transmission and reception at different times, Tx/Rx switch is used to connect both Tx path and Rx path with antenna. Tx/Rx switch is controlled automatically by DSP based on GSM frame structure with respect to the physical slot allocated for that particular GSM mobile phone in both downlink and uplink. For FDD systems diplexer is used in place of switch which acts as filter to separate various frequency bands.

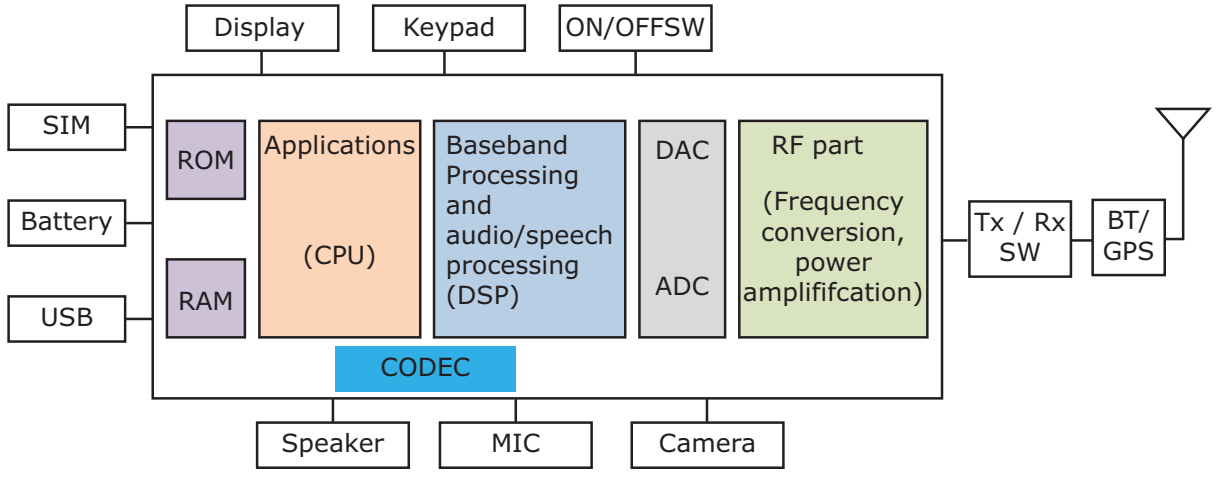


FIGURE 3.10 Hardware parts of a GSM mobile Phone

4. Mobile phone Baseband part

This part basically converts voice/data to be carried over GSM air interface to I/Q baseband signal. This is the core part which changes modem to modem for various air interface standards viz. CDMA, Wimax, LTE, HSPA and more. It is often named as physical layer or Layer 1 or L1. It is ported usually on DSP (Digital Signal Processor) to meet latency and power requirements of mobile phone. For speech/audio, codec is used to compress and decompress the signal to match the data rate to the frame it has to fit in. CODEC converts speech at 8 kHz sampling rate to 13 kbps rate for full rate speech traffic channel. To do this RELP (Residually Excited Linear Predictive Coder) speech coder is used which packs 260 bits in 20 ms duration to achieve 13 kbps rate.

The baseband or physical layer will add redundant bits to enable error detection as well as error correction. Error detection is obtained with CRC and error correction with forward error correction techniques such as convolution encoder (used at transmit part) and decoder (used at receive part).

5. ADC and DAC

ADC (Analog to Digital Converter) and DAC (Digital to Analog Converter) are used to convert analog speech signal to digital signal and vice versa in the mobile handset. At Transmit path, ADC converted digital signal is given to speech coder. There are various ADCs available, among them popular one is sigma delta type. AGC (Automatic Gain Control) and AFC (Automatic Frequency Control) are used in the receiver path to control gain and frequency. AGC helps to maintain working of DAC satisfactorily, as it keeps signal within the dynamic range of DAC. AFC keeps frequency error within limit to achieve better receiver performance.

6. Mobile phone OS (Operating System)

Various OS supported in mobile phone are Symbian, Java, Android, RT-Linux, Palm, etc. It runs on CPU of different manufacturers. For time critical applications RTOS (Real-Time Operating System) is used.

7. Battery

It is the only major source of power to make / to keep mobile phone functional. There are various types of batteries made of Nickel Cadmium (NiCd), Nickel Metal Hydride(NiMH), based on lithium, Li-ion and so on. The major factors for designers is to reduce battery size, last for more talk time and increased battery life. Battery

comes usually from 3.7 to 4.2 voltages and from 600 mAh to 7000 mAh ratings. Battery charger is usually provided with mobile phone to charge the battery. It is an AC to DC converter.

8. Microphone:

Microphone or Mic converts air pressure variations (result of our speech) to electrical signal to couple on the PCB for further processing. Usually, in mobile phone has mic of types condenser, dynamic, carbon or ribbon are used.

9. Speaker

It converts electrical signal to audible signal (pressure vibrations) for human being to hear. This is often coupled with audio amplifier to get required amplification of audio signal. It also tied with volume control circuit to change (increase or decrease) the amplitude of the audio signal.

10. Camera

Now-a-days almost all the mobile phones are having the camera feature for one to click pictures at various occasions. It is the major specification in increasing the cost of mobile phone. Latest mobile phones are fitted with various mega pixel cameras such as 12 mega pixels, 14 mega pixels, even 108 and 200 mega pixels. This has become evident because of advancement in sensor technology. If one wants to buy low cost mobile phone, they usually go for non camera mobile phone.

11. Display

There are various display devices used in mobile phone such as LCD (Liquid Crystal Display), TFT (Thin-film transistor) screen, OLED (Organic Light Emitting Diode), TFD (Thin Film Diode), touch screen of capacitive and resistive type etc., (Capacitive touch is familiar and sensitive).

12. Keypad

Earlier days keypad was simple matrix type keypad which contains numeric digits (0 to 9), alphabets (a to z), special characters and specific function keys. These have been designed for various applications such as accepting call, rejecting call, cursor movement (left, right, top, down) dialling number, typing name/sms/mms and so on. Now-a-days keypad has been removed from the phone and it has become part of mobile phone software. It pops on the display screen itself which can be operated by user using touch of a finger tip.

3.4 Mobile Phone Technologies

Cellular technology is one of the mobile technologies that gave mobile phones the name "mobile phone". Cellular technology basically refers to having many small interconnected transmitters. The other main concept of Cellular technology was that it has "multiple access", meaning it places multiple voice or data connection into a single radio channel.

Types of Mobile phone Technologies

Many people use mobile phones, but do not know about the technology variances. In India, many mobile phones runs based on GSM and CDMA networks only. Now-a-days 5G is extremely growing in India, which operates mainly based on VoLTE Network technology. An overview of the important and widely used mobile network technologies in India and across the world is presented in the following sections.

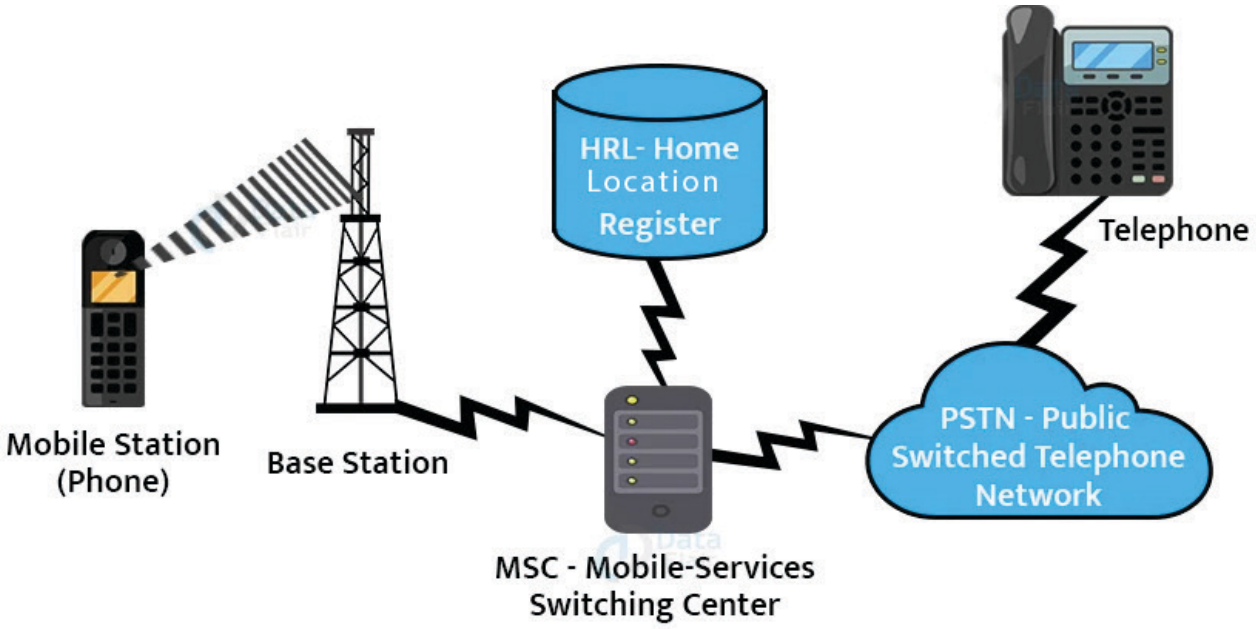


FIGURE 3.11 GSM protocol

3.4.1 GSM (Global System for Mobile Communication)

GSM is the original 2G standard launched in 1991. It was the first major mobile technology. GSM protocol shown in Figure 3.11 was initially based on time division, meaning calls take turns using the radio signal.

GSM is the global technology authenticates SIM cards and performs simultaneously voice and data transmission. 3G GSM is better for world travellers, which covered most of the countries but, weak in rural locations. GSM traditionally work on 900, 1800 and 1900 MHz and was initially designed, only for circuit switched voice service, which is a combination of FDD (Frequency Division Duplex) and TDD (Time Division Duplex).

3.4.2 GPRS (General Packet Radio Service)

GPRS is the service provided by the GSM network as shown in Figure 3.12. This is a packet data transport-based service, which provides mobile internet over a mobile device. This uses same radio interface of the mobile used to make calls.

GPRS support Nodes are devised in to two

1. SGSN: Serving GPRS Support Node in VPLMN (Visited Public Land Mobile Network) for GPRS functionality in GSM network.
2. GGSN: Gateway GPRS Support Node between Mobile and Internet.

3.4.3 Global Positioning System (GPS)

GPS is a space-based satellite Navigation system that provides location and time information in all weather conditions, anywhere on or near the earth where there is an unobstructed Line-of-Sight to four or more GPS Satellites. The system provides critical capabilities to military, civil and commercial users around the world. It is maintained by the United States of America Government and is freely accessible to

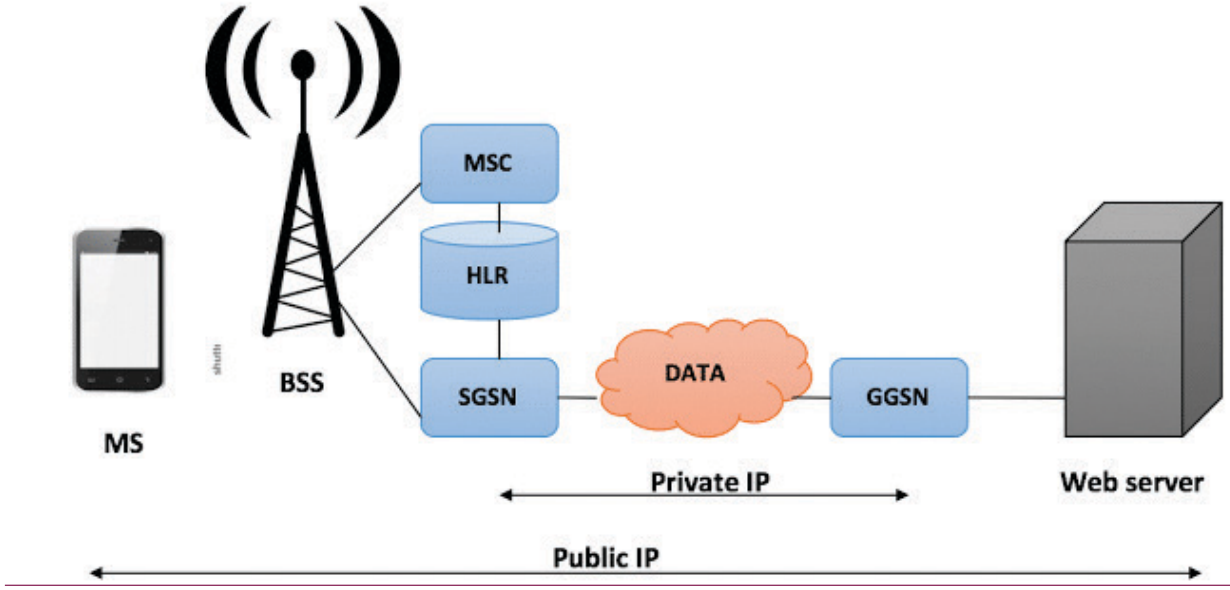


FIGURE 3.12 GPRS service provider

anyone with a GPS receiver. Figure 3.13 shows the representation of GPS.

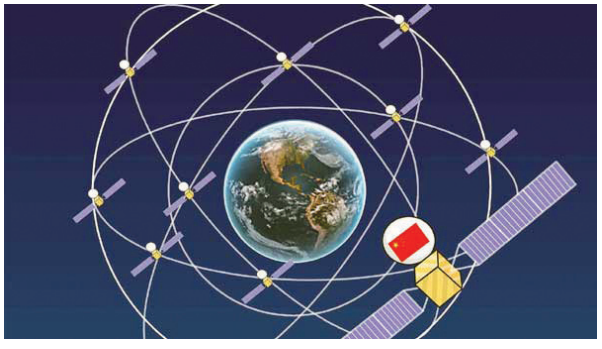


FIGURE 3.13 Space based satellite Navigation System

The GPS is made up of a network of 24 satellites placed into orbit by US Department of Defences. GPS was originally intended for military applications but, in the 1980s, the US Government made the system available for civilian use. GPS works in any weather conditional, anywhere in the world and 24 hours a day. There are no subscription fees or setup charges to use GPS.

Major Differences between GPS and GPRS

1. GPS (Global Positioning System) will give you location in terms of Latitude and Longitude.
2. GPRS will allow user to transfer data over cellular networks.

3.5 Multiple Access Techniques

Multiple access techniques are used to allow a large number of mobile users to share the allocated spectrum in the most efficient manner.

In wireless communication system, it is often desirable to allow the subscriber to send information to the base station while receiving information from the base station simultaneously.

A cellular system divides any given area into mobiles where a mobile unit in each communicates with a base station.

The main aim in the cellular system design is to be able to increase the capacity of the channel i.e. to handle as many calls as possible in a given bandwidth.

There are several different ways to allow access to the channel. Some of them are as follows

1 Frequency Division Multiple Access (FDMA)

2. Time Division Multiple Access (TDMA)
3. Code Division Multiple Access (CDMA)
4. Space Division Multiple Access (SDMA)

3.5.1 Frequency Division Multiple Access (FDMA)

FDMA is one of the most common analogue multiple access methods. The frequency band is divided into channels of equal bandwidth so that each conversation is carried on a different frequency. This was the initial multiple access technique for cellular system in which each individual user is assigned a pair of frequencies while making or receiving a call as shown in figure 3.14. One frequency is used for downlink and one pair for uplink. This is called frequency division duplexing (FDD).

The allocated frequency pair is not used in the same mobile or adjacent mobiles during the call so as to reduce the co-channel interference. Even though the user may not be talking, the spectrum cannot be reassigned as long as a call is in place. Different users can use the same frequency in the same mobile except that they must transmit at different times.

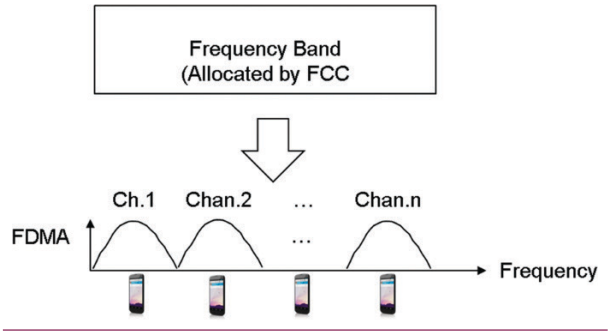


FIGURE 3.14 FDMA

3.5.2 Time Division Multiple Access (TDMA)

TDMA is a channel access method for shared-medium networks. Fig 3.15 shows TDMA. It allows several users to share the same frequency channel by dividing the signal into different time slots. In digital systems, continuous transmission is not required because users do not use the allotted bandwidth all the time. In such cases, TDMA is a complementary access technique to FDMA. Global Systems for Mobile communications (GSM) uses the TDMA technique.

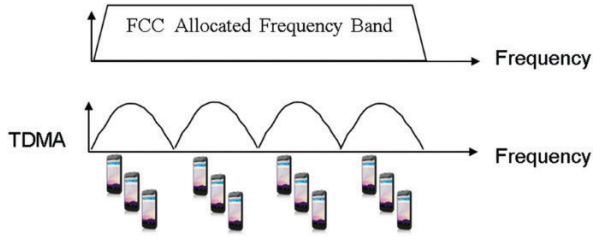


FIGURE 3.15 TDMA

3.5.3 Code Division Multiple Access (CDMA)

CDMA is a sort of multiplexing that facilitates various signals to occupy a single transmission channel. It optimizes the use of available bandwidth. This technology is commonly used in UHF cellular telephone systems, bands ranging between the 800 MHz and 1.9 GHz. In CDMA, the bandwidth is occupied by all the users, however they are all assigned separate codes, which differentiates them from each other shown in figure 3.16. CDMA utilizes a spread spectrum technique in which a spreading signal (which is uncorrelated to the signal and has a large bandwidth) is used to spread the narrow band message signal.

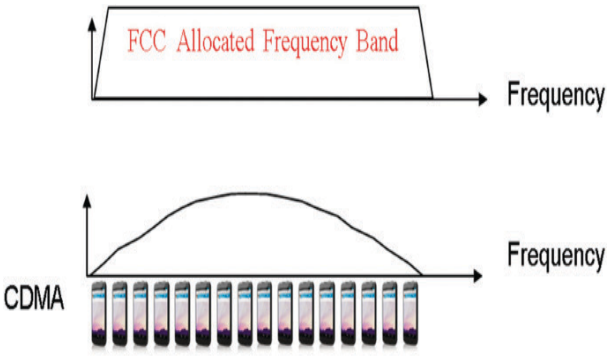


FIGURE 3.16 CDMA

Direct Sequence - Spread Spectrum (DS-SS)

This is the most commonly used technology for CDMA. In DS – SS, the message signal multiplied by a Pseudo Random Noise Code. Each user is given with codeword which is orthogonal to the codes of other users and in order to detect the user, the receiver must know the codeword used by the transmitter

3.5.4 Space Division Multiple Access (SDMA)

SDMA is used for allocating a separated space to users in wireless networks. Fig 3.17 shows SDMA. A typical application involves assigning a optimal base station to mobile phone user. The mobile phone may receive several base stations with different quality. A MAC algorithm could now decide which base station is best, taking into account which frequencies (FSM), time slots (TDM) or code (CDM) are still available. Typically,

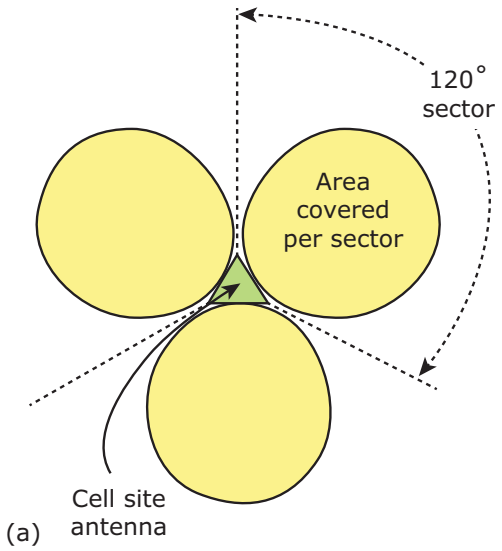


FIGURE 3.17 SDMA

Difference between FDMA, TDMA, CDMA and SDMA

Approach	SDMA	TDMA	FDMA	CDMA
Idea	Segment spaced into cells or sectors.	Segments sending time into disjoint time slots demand driven or fixed patterns.	Segment the frequency band into disjoint sub bands	Spread the spectrum using orthogonal codes.
Terminals	Only one terminal can be active in one cell or one sector.	All terminals are active for short periods of time on same frequency.	Every terminal has its own frequency uninterrupted	All terminals can be active at the same place at the same moment uninterrupted.
Signal separation	Cell structure, directed antennas	Synchronization in time domain	Filtering in the frequency domain.	Code plus special receivers.
Transmission scheme	Continuous	Discontinuous	Continuous	Continuous
Cell capacity	Depends on cell area	Limited	Limited	No absolute limit on channel capacity but it is an interference limited system

SDMA is never used in isolation but always in combination with one or more other schemes. The basis for the SDMA algorithm is formed by mobiles and sectorized antennas which constitute the infrastructure implementing space division multiplexing (SDM).

3.6 Generation of Mobile Phones

Comparison among various generations of Mobile Phone Technology.

Table 3.2 Comparison among various generations of Mobile Phone Technology

Parameter	1G	2G	3G	4G	5G
Introduced Year	1980	1993	2001	2009	2018
Technology	AMPS, NMT, TACS	IS-95, GSM	IMT2000, WCDMA	LTE, WiMAX	MIMO, mm Waves
Access System	FDMA	TDMA, CDMA	CDMA	CDMA	OFDM, BDMA
Switching Type	Circuit Switching	Circuit Switching for voice and packet switching for Data	Packet Switching except for Air Interface	Packet Switching	Packet Switching
Speed Rates	2.4Kbps to 14.4Kbps	14.4Kbps	3.1Mbps	100Mbps	20Gbps
Features	Voice Only	Multiple users on single channel	Multimedia Features, Video Call	High Speed, Real Time streaming	Higher Multi Gbps Data speeds and more uniform user experience to more users.
Support	Voice Only	Voice and Data	Voice and Data	Voice and Data	Voice and Data
Applications	Voice Calls	Voice Calls, Short messages, Browsing(Partial)	Video Conferencing, mobile TV, GPS	High speed application, mobile TV, wearable devices	High Speed Mobile Networks, Internet of Things (IoT), Smart Home, Logistics and Shipping

3.7 Other Special Technologies

In recent years, other technologies have emerged and enriched the mobile functionalities.

3.7.1 Wi-Fi

Wi-Fi is the technology used for radio wireless local area networking of devices such as personal computers, gaming console, televisions, printers and mobile phones, etc. Wi-Fi compatible devices can connect to the internet via a WLAN and wireless access point. Such an access point (or Hot Spot) has a range of about 20 meters (66 feet) indoors and a greater range outdoors. Hot Spot coverage can be as small as a single room with walls that block radio waves.

Wi-Fi most commonly uses the 2.4 GHz (12cm) UHF and 5.8 GHz (5cm) SHF radio bands. These wavelengths work best for line-of-sight Wi-Fi calling when the user calls to a phone number over the internet. It is different from VoLTE. The calls are going over the network. Also, promises the ability to swap seamlessly between Wi-Fi and wireless phone network. The symbol for Wi-Fi in mobile phones is shown in Figure 3.18.



FIGURE 3.18 Symbol of Wi-Fi

3.7.2 Bluetooth

Bluetooth is a wireless technology used to transfer data between different electronic devices. The distance of data transmission is small in comparison to other modes of wireless communication. Figure 3.19 shows the symbol of Blue Tooth.

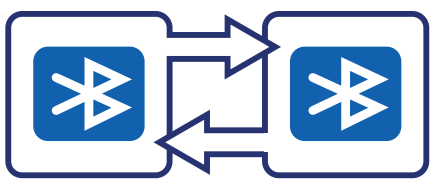


FIGURE 3.19 Symbol of Bluetooth

Key features of Bluetooth technology

1. Less complication
2. Less power consumption
3. Available at cheaper rate
4. Robustness

Versions of Bluetooth

There are five different classifications of Bluetooth, each with different capabilities. These specifications were established for an intended range of Bluetooth use.

Versions	Maximum Range	Maximum Speed
1.0	~33 feet (10m)	723.1Kbit/s
2.0	~100 feet (30m)	3Mbit/s
3.0	~Less than 200 feet	24Mbit/s
4.0	~200 feet (60.96m)	25Mbit/s
5.0	~800 feet (243.84m)	50Mbit/s

Applications

Bluetooth is one of the most popular wireless transmission technology connecting billions of devices. Bluetooth gained its wide acceptance for variety of applications.

- Wireless Keyboard, mouse and other peripherals
- Wireless speakers and high quality audio systems
- Car audio systems / hands free pairing with mobile devices
- Sports and fitness tracking devices
- Healthcare, medical and wellness devices
- Home automation and security applications

3.7.3 Hotspot

A Hotspot is a physical location where people may obtain internet access, using Wi-Fi technology, through a Wireless Local Area Network (WLAN) using a router connected to an internet service provider.

Hotspot is classified into two,

1. Public Hotspot
2. Private Hotspot

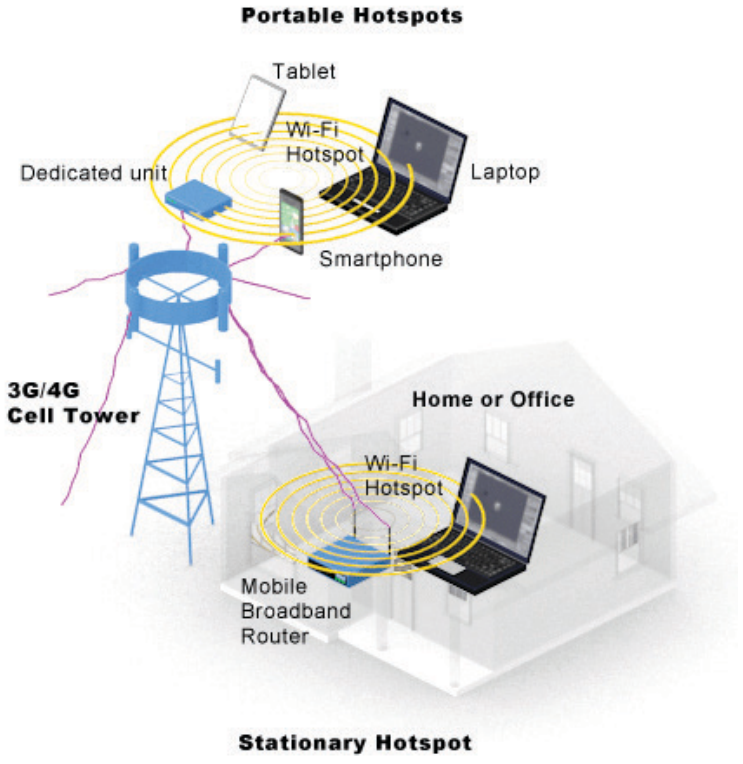


FIGURE 3.20 Hotspot Process

Public Hotspot

Public Hotspot may be created by business for use by customers such as Railway stations, Airport, etc., It is typically created from wireless access points (AP) configured to provide internet access, controlled to some degree by the venue. It connects the user's Laptop or Tablets to the Internet.

Private Hotspot

Private Hotspot may be configured on a smartphone or tablet with a Mobile network data plan to allow internet access to other devices. If both the Hotspot device and the devices accessing it are connected to the same Wi-Fi Network.

- A Wi-Fi router has a range of 30-40 meters (100-130 feet).
- A mobile hotspot (access point) generated by a Smartphone has a range of 10 meters (30 feet).

With a mobile Hotspot, user can create an Internet connection for up to five mobile phone devices on a 3G phone and up to 10 on a 4G LTE smart phones. After a few quick steps, the phone creates its own secure Wi-Fi network, which user devices can join. There is no need for a USB cable, and multiple user can share user phone's mobile data plan.

3.8 Benefits of Hexagons Used in Call Coverage of Cellular Network

While designing a network, two things are kept in mind.

1. A hexagon layout require fewer cells to cover a given area.
2. Hence, it needs fewer base stations and minimum capital investment.

Square

Won't create black spots. But distance from its centre to corner is higher than distance in any side. This will create issues in providing equal level of signals at every point.

Circle

Since distance from centre to any point in the circle would be same, so there won't be any issue in providing equal level of signals at every point. But, when we arrange circles together, many areas would be created which won't be covered by any circle. These areas are called BLACK SPOTS, where signals from nearby could be received

Hexagon

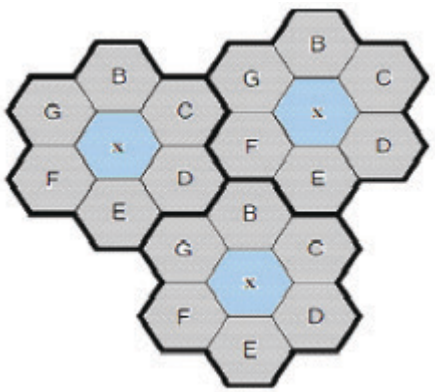


FIGURE 3.21 Hexagon

Hexagon or the beehive structure overcomes all the above said issues. Its distance from centre to any point is the same and it can be arranged in such a way that no black spots are created.

3.9 Applications of Mobile Phones

The mobile phone is the user device, already started functioning as more than just communication device. Mobile serves as watches and alarm clocks. Mobile phones also have free games, calculators, address book, contact list, calendar functions, radio, notepad, reminder services, etc.

Some of the more advanced features in mobile phone are also presented here:

1. **Digital Camera**

   Phones capture pictures and let user save them to others and to computers.

2. **Audio Recorder**

   Mobile Phones can be used to record conversations or even brief notes to one self.

3. **Video recorder**

   Phones are becoming video cameras and can record video more than an hour.

4. **Multimedia Messaging**

   Everything recorded can be shared with others by using MMS.

5. **E-mail Client**

   The phone can be used to connect to any POP or IMAP server and to allow receiving and sending email.

6. **Web Client**

   Phones can also browse website, via a WAP and/or HTML browser. Most websites may not look great on the small screen. But, it is still possible to connect to any website.

7. **Document Viewer**

   It is increasingly possible to view documents on the mobile phone in the popular MS office file format.

8. **Computer adjunct**

   For many, the mobile phone has replaced the PDA as the complement to the computer with a remote desktop application; it also becomes possible to make the mobile phone a window to one's computer.

9. **Music player**

   The big things in 2005 are reckoned to be the combining of music capabilities on the mobile phone. While phones can play MP3, it can be used to play music streamed from the internet.

10. **Television**

    In India, all operators have been promoting many TV channels on the mobile phone over next generation network like EDGE.

11. **Wallet**

    The phone can also be used to pay for purchases like a credit or debit card. There is already a billing relationship that exists between the subscriber and the operator and that can be used to make payments to merchants.

12. **Bar code and QR code readers**

    Phone also have the facility to read bar and QR (Quick Response) codes and that can have very interesting applications in all field, especially commerce.

Advantages and Disadvantages of Mobile phones

Advantages	Disadvantages
Mobile Phone as a source of information and communication.	Privacy and Security Issues.
Data Sharing and transferring easily done through mobile phones.	Vision problems.
Stay connected on the top of world events and apps for everything.	Road accident.
Learning and research using mobile phones.	Mobile Phones batteries can explodes.
Online banking and finance.	Addiction of mobile phone (video games, social media).
Mobile phone save life in an emergency.	Distraction in work.
Online shopping through mobile phones.	The radiation from the mobile phone may causes brain damage.
Control smart homes.	More usage of mobile phone will make the students very bad attention in their studies.
Track and improve your health.	Depending upon their features it may costly.

LEARNING OUTCOME

After studying this chapter, students can understand the following

1. Transmission Modes
2. Mobile Phones
3. Radio Waves
4. Multiple Access Techniques
5. Other Special Technologies
6. Applications of Mobile phones

QUESTIONS

Part – A (1 Mark)

I Multiple choice Questions

1. Who developed the first communication machine?
   a. Samuel F.B Morse
   b. Canadian Donald Hings
   c. Alfred Gross
   d. Heinrich Hertz
2. Walkie-talkie work up to
   a. 27.2 Kilo meters
   b. 58 Kilo meters
   c. 18 Kilo meters
   d. 15 Kilo meters
3. Pager is the example of _____ transmission mode.
   a. Half duplex
   b. Simplex
   c. Full duplex
   d. Half and full duplex
4. The mobile phone battery usually comes with _____ voltages.
   a. 3.0 to 3.2 b. 3.3. to 3.4
   c. 3.7 to 4.2 d. 4.8 to 4.9
5. The maximum Specific Absorption Rate (SAR) set as a guideline for mobile phone operation is_____
   a. 4.6 watts/kg
   b. 3.6 watts/kg
   c. 2.6 watts/kg
   d. 1.6 watts/kg
6. In UHF cellular system _____ technology is used.
   a. FDMA b. TDMA
   c. CDMA d. SDMA
7. Which of the following is a universally adopted shape of cell?
   a. Hexagon
   b. Square
   c. Circle
   d. Triangle
8. Which of the following is true for first generation wireless system?
   a. Digital Technology
   b. High Data Rate
   c. Efficient
   d. Low speed rate
9. Wi-Fi most commonly uses _____ band.
   a. UHF b. VHF
   c. SHF d. UHF and SHF
10. Which multiple access system allocating a separated space to users in wireless network?
    a. FDMA
    b. TDMA
    c. SDMA
    d. CDMA

Part – B (3 Marks)

II Answer in one or two sentences

1. What are the types of transmission mode?
2. Write the applications of walkie-talkie.
3. What is the major difference between GPS and GPRS?
4. What is cellular network?
5. Write short notes on mobile phone operating system.
6. What are the types of multiple access techniques?

7. What is Direct Sequence Spread Spectrum?
8. Define Bluetooth?
9. Why is public hotspot created? Where is it used?
10. What are the benefits of hexagon in cellular network?

Part – C (5 Marks)

III Answer in a paragraph

1. Draw the front and back panel of a mobile phone and mention its parts.
2. Write short notes on Wi-Fi.
3. Write the advantages and disadvantages of mobile phone.
4. Write any five applications of mobile phone.

Part – D (10 Marks)

IV Answer in One Page (Essay type Question)

1. Explain the parts of walkie talkie.
2. Draw the hardware parts of a GSM mobile.
3. Compare various generation of mobile phone technology in detail.

Answers :

1.(a)	2.(a)	3.(b)	4.(c)	5.(d)
6.(c)	7.(a)	8.(d)	9.(d)	10.(c)



CHAPTER 04

Communication Systems

MNBR8

LEARNING OBJECTIVE

The students can understand the following in this chapter

1. The principle of an OFC.
2. Advantages and disadvantages of an OFC.
3. The difference between OFC and cable communication.
4. The different types of satellite and their applications.
5. The basic function of RADAR and SONAR.

4.1 Introduction

In this present scenario, we use to say "the world becomes so fast", comparatively before 50 to 100 years. It means whether the rotation of earth becomes faster. The same 24 hours is observed on those days and today. Then which makes us to feel like that?

On those days if a message has to be conveyed or intimated to a person who is at a distance, say near town, or nearby country or near to a continent, it took few hours, few days and few months, respectively. So that the reaction times, is also long. This makes us to realize that the world gives much time to us.

But now, in this 21st century, any incident happening in any tiny corner of this world, can be seen or heard by the other people all over the world in no time or even to say on live.

How it becomes real? This all because of the communication system. Hence, let us study and understand the basic concepts of few communication systems in this chapter.

4.2 OFC Technology

Optic Fiber communication is a method of transmitting information from one place to another by sending pulse of infrared light through an optical fiber. The light is a form of carrier wave that is modulated to carry information.

The signal transmitted in optical fiber is converted from the electrical signal into light signal and at the receiving end, it is converted back into the electrical signal from the light signal.

Fiber optics also called optical fibers are microscopic strands of very pure glass with about the same diameter of a human hair. Thousands of these optical fibers are arranged in bundles in an optical cable in Fig 4.1 and are used to transmit light signals over long distances.



FIGURE 4.1 Optical Fiber Cable



Who invented fiber optic technology?

Indian Dr. Narinder Singh Kapany invented the fiber optical cable based on John.Tyndall experiments. He is also called father of fiber optics.



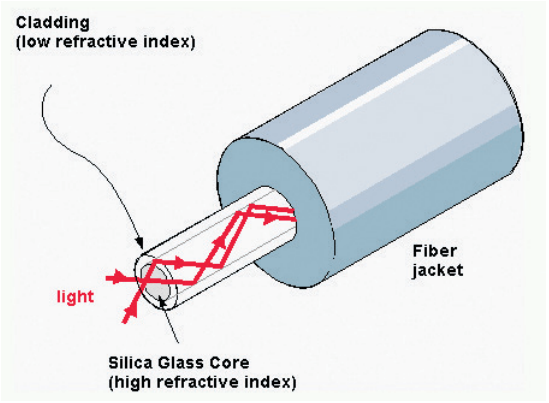


FIGURE 4.2 Total internal reflection of OFC

4.3 Construction of an Optical Fiber

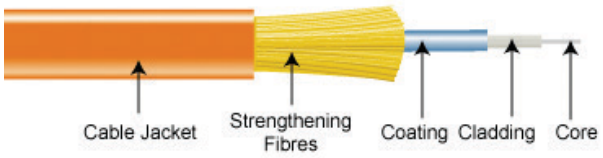


FIGURE 4.3 Construction of an optical fiber.

4.3.1 Elements of an OFC

Three basic elements of an optical fiber are the core, the cladding and the outer coating. Figure 4.3 shows the construction of an optical fiber

- The core is usually made of glass or plastic depending on the transmission spectrum desired. The core is the light transmitting portion of the fiber. The core is cylinderical rod shape, made up of dielectric material. Dielectric material conducts no electrical signal. Light propogates mainly along the core of the fibre. It is described as having a radius of an index of refraction.
- The cladding is usually made of the same material as the core but with a slightly lower refracting index.
- The coating usually comprises of one or more coats of a plastic material to protect the fiber from the physical environment.

4.3.2 Working principle of OFC

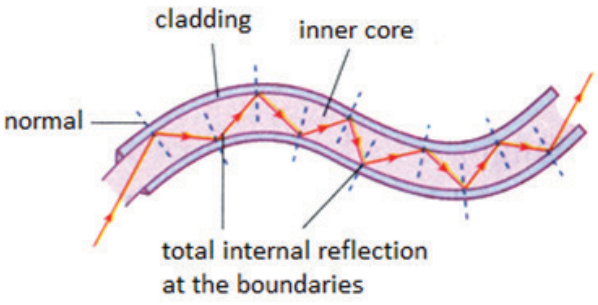


FIGURE 4.4 Working principle of OFC

Optical fibres works on the principle of total internal reflection. When light ray strikes at the internal surface of optical fibre cable such that incidence angle is greater than critical angle, then incident light ray reflects in the same medium and this phenomenon repeats. In this way light signal travels from one end of the cable to another end .The fig 4.4 shows the working principle of an OFC. The fig 4.5 shows structure of an optical fiber.

DO YOU KNOW?

Whether the audio and video signal can be transmitted through OFC as in original form?

No.., Any signal audio or video or any other should be converted into light signal and be transmitted through OFC.

4.3.3 Co–axial Cable communication

In coaxial cable communication, the medium of transmission is a pair of conductors called the transmission line. This means, in wire communication the transmitter and receiver are connected through a wire or line.

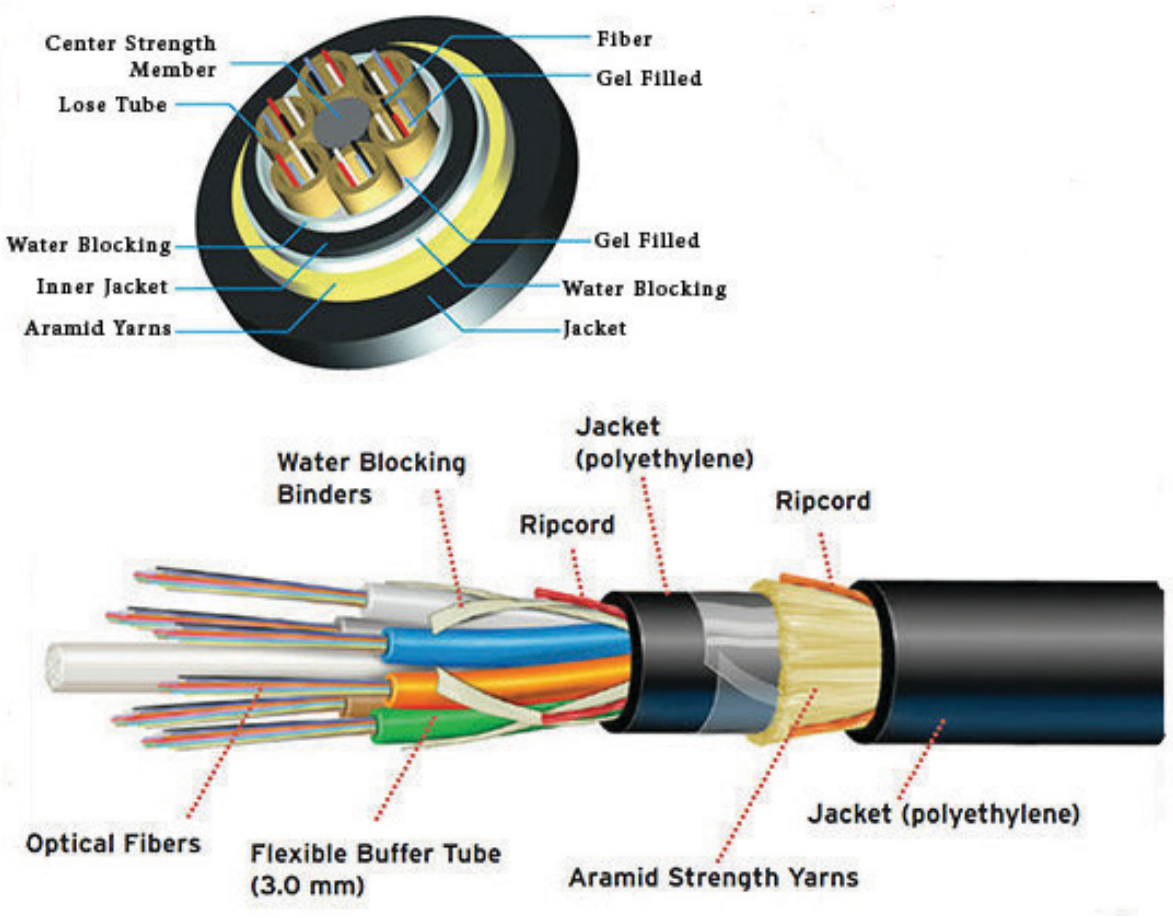


FIGURE 4.5 Structure of Optical Fiber.

4.4 Difference between Optical Fiber and Co-axial cable (Copper wire)

Table 4.1 The Difference between Optical Fiber and Co-axial cable

	Optical fiber	Co-axial cable
Basis of comparison	Transmission of the signal is in optical form(light form)	Transmission of the signal is in electrical form
Comparison of cable	Using Glass and plastic	Using Plastic and copper wire
Efficiency	High	Low
Cost	Expensive	Less expensive
Bending effect	Can affect the signal transmission	Bending of wire does not affect the signal transmission
Data transmission rate	2 Gbps	44.736 Mbps
Installation of cable	Difficult	Easy
Bandwidth	Very high	Moderately high
External magnetic field	Does not affect the cable	Affects the cable
Noise immunity	High	Intermediate
Diameter of the cable	Small	Large
Weight	Lighter weight	Heavier weight

4.5 Advantages and disadvantages of an OFC

4.5.1 Advantages of an OFC

- Greater bandwidth than metal cables.
- Low power loss.
- Faster speed with less attenuation.
- Smaller size and less weights.
- Greater information carrying capacity.
- Higher security.
- Electrical insulator.

4.5.2 Disadvantages of an OFC

- Difficult in splice.
- Highly susceptible.
- Expensive to install

4.6 Application of an OFC

Medical Industry

It is used in various instruments to view internal body parts by inserting into hollow spaces in the body.

Communication

Voice, data and video transmission are the most common uses of fiber optics and these include,

- Telecommunication.
- Local Area Network.
- Industrial control systems.
- Avionic systems.
- Military common control and Communication systems.
- Hydrophones are used for seismic and SONAR application.

Broadcasting :

These cables are used to transmit high definition television signals which have greater bandwidth and speed.

Defence

These are used in wirings in aircraft, hydrophones for SONARS and seismic applications.

Industries : They are used for research and testing purposes in industries.

Lighting and Decorations :

It is widely used in decorations and Christmas trees.

Mechanical Inspections

On-side inspections engineers use optical fibres to detect damages and faults which are at hard to reach places.

Sensors

- Sensors are used to measure various physical qualities like strain, pressure, temperature and other physical parameters.

4.7 Satellite Communication

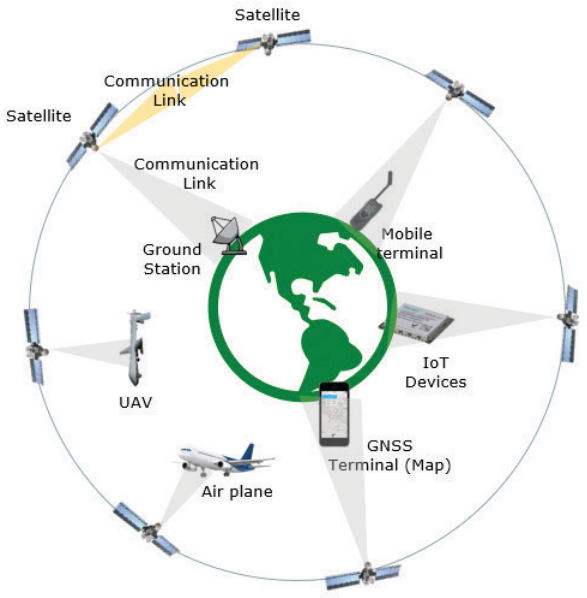


FIGURE 4.6 Satellite Communication

4.7.1 Satellite

Normally in the solar system the planets are termed as satellites to Sun. Because the planets are revolving around the Sun in a particular orbit. Likewise each planet is having one or more small planets called sub-planets which revolving that particular planet in a defined orbit. These sub-planets are called as Natural satellites.

How do satellites get power?

The sun is the main energy source for satellites. That is why all satellites have solar panel mounted on them. Each panel contains array of thousands of small solar cells which are made of silicon.

4.7.2 Types of Satellites

Satellites are classified into two types

1. Natural Satellites
2. Artificial Satellites (Man-Made)

4.7.3 Natural Satellites

Any planet in the solar system which goes around a particular planet is called Natural Satellites. In the solar system there are six planetary satellite systems containing 185 known natural satellites.

Which is the natural satellite to the earth… its nothing but "Moon"..

4.7.4 Artificial Satellites

Artificial Satellite are man-made objects (satellites) orbiting the Earth and other planets in the Solar system. Artificial Satellites are used to study the Earth, other planets to help us to communicate and even to observe the distance universe. Example Aryabhata, Baskara, Rohini, INSAT 1A, IRS…

What do artificial satellites do?

Satellites are launched into space through rockets. A satellite orbits the earth while

its speed is balanced by the pull of Earth's gravity.

Artificial satellites are further classified into two type

1. Active Satellites
2. Passive Satellites

Active Satellites

An active satellite carries an antenna system, a transmitter, a receiver and a power supply. It works as microwave repeater or transponder in the sky. Figure 4.7 shows the active satellites system.

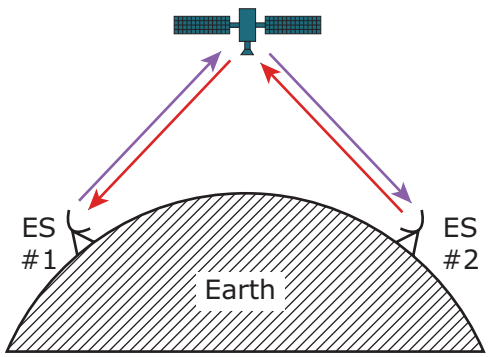


FIGURE 4.7 Active Satellite

Passive Satellites

A passive satellite is a metal coated plastic balloon or metallic sphere that works as a passive reflection. It reflects the microwave signal from one region of the earth to another region. Figure 4.8 shows the passive satellites system.

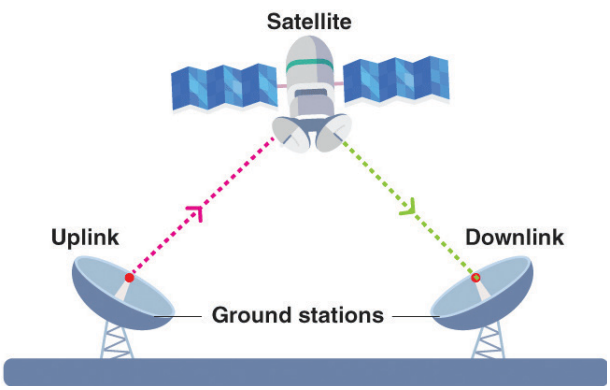


FIGURE 4.8 Passive satellites system.

4.7.5 Satellite Communication

In satellite communication, electromagnetic waves are used as carrier signals. These signals carry the information such as audio, video or any other signal between ground and space and vice-versa. Since satellite communication happens through space, it is also known as Space Communication.

4.7.6 Need of Satellite Communication

Two kinds of propagation are used in earlier communication.

1. Ground wave propagation
2. Sky wave propagation

Ground wave propagation

Ground wave propagation is suitable for frequencies upto 30 MHz. This method of communication makes use of the troposphere conditions of the earth.

Sky wave propagation

Suitable bandwidth for this type is broadly between 30 MHz to 40 MHz and it makes use of the ionosphere properties of the earth.

The station distance is limited to few thousands kilo meters in both Ground Wave propagation and Sky Wave propagation. Satellite communication over comes this limitation.

4.7.7 Satellites Classification

Satellites can be classified by their function since they are launched into space to do a specific job. The satellite must be designed specifically to fulfil its role.

The most important satellites are

1. Communication Satellites
2. Astronomical Satellites
3. Navigation Satellites
4. Bio Satellites
5. Weather Satellites
6. Remote Sensing Satellites
7. Nano Satellites
8. Earth Observation Satellites

4.7.8 Communication Satellites

Communication satellites are artificial satellites that relay received signals from an earth station and then retransmit the signal to other earth stations. They commonly move in a geostationary orbit. Communication satellites are placed in three earth orbits.

1. Geostationary Earth Orbit
2. Medium Earth Orbit
3. Low Earth Orbit

Satellites in Geostationary Earth Orbit (GEO) enable to get fax, video conferencing, Internet, long distance fixed phone service, television broadcasting and broadband multimedia service, which are provided all over the globe.

Satellites in Medium Earth Orbit (MEO) are used for mobile cell phone communication, fixed phones and other personal communications.

Satellites in Low Earth Orbit (LEO) are used paging fax, ship tracking, fixed ordinary phones, broad band multimedia, and monitoring of remote industrial spots.

Besides, Communication Satellites are helping in long way during natural calamities. In the aftermath of the earthquake, the satellites pictured and helped the search and rescue teams to keep in touch with one another and were also able to maintain international communications.

4.7.9 Working of Communication Satellite

A satellite is a body that moves around another body in a particular path(orbit). A communication satellite is nothing but a microwave repeater station in space. It is helpful in telecommunications.

A repeater is a circuit which increases the strength of received signal and then transmits it. But, this repeater works as a transponder. (it changes the frequency band of transmitted signal from the received one).

The frequency with which the signal is sent into the space is called as Up-link frequency. Similarly, frequency with which the signal is sent by the transponder to earth station is called as Down-link frequency. The fig 4.9 shows Working of communication Satellite.

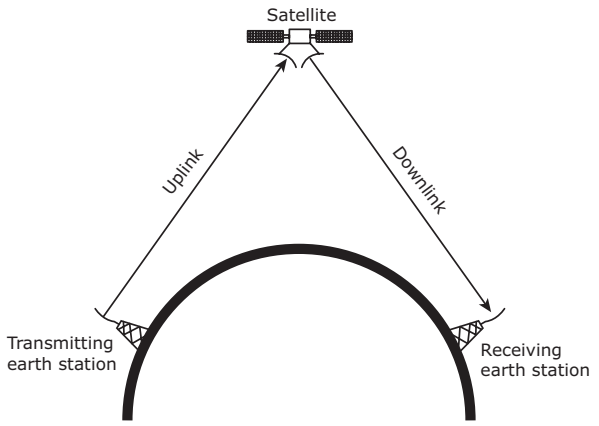


FIGURE 4.9 Working of communication Satellite

The transmission of signal from first earth station to satellite through a channel is called as Up-link. Similarly the transmission of signal from satellite to second earth station through a channel is called Down-link. This action can be done in vice-versa.

Earth stations send the information to satellites in the form of high powered, high frequency (GHz) range signals. The satellite receives and re-transmits the signals back to earth where they are received by other earth stations in the coverage area of the satellite.

Astronomical Satellites

Astronomical Satellites are used for observation of distance planets, galaxies and other outer space objects. These are used to monitor and image space.

Navigation Satellites

A satellites navigation or SATNAV system is a system that uses satellites to provide autonomous geo – spatial positioning. The system can be used for providing position, navigation or for tracking the position of something fitted with a receiver (satellite tracking). A satellite navigation system with global coverage may be termed a Global Navigation Satellite System (GNSS).

Bio Satellites

Bio satellites are satellites designed to carry living organisms generally for scientific experimentation.

Weather Satellites

Weather satellites are type of satellites that is primarily used to monitor the weather and climate of the earth. These Satellites are polar orbiting satellites, covering the entire earth asynchronously or geo stationarily, hovering over the same spot on the equator.

Remote Sensing Satellites

Remote sensors collect data by detecting the energy that is reflected from Earth. These sensors can be on satellites. Remote sensor scan be either passive or active. Passive sensors respond to external stimuli. They record natural energy that is reflected or emitted from the earth's surface. Remote sensing satellites are usually put into space to monitor resources important, for humans. It might track animal migration watch agricultural crops for weather damages or see forests fire and deforestation.

Nano Satellites

Nano Satellite are very small satellites which weigh less than 10 kg. It uses MEMS (Micro – Electro – Mechanical system) technology. It is widely used in laser communication.

Earth Observation Satellites

Earth Observation Satellite is intended for monitoring of earth surface in visible, NIR and MIR electromagnetic waves with the resolution of 8 meters for the purpose of agricultural, search of minerals and energy resources, land tenure, forestry, water resources control, monitoring of situation in emergency areas.

4.7.10 Application of Satellite Communication

1. Military Communication
2. Tele Communication
3. Satellite phone
4. VSAT (Very small aperture terminal)
5. Cable TV
6. DBS (Direct Broadcast satellite - DTH)
7. GPS (Global Positioning System)
8. Satellite Internet
9. Weather forecasting
10. Photography
11. Navigation etc…..

4.8 Microwave Communication

Sending and receiving the signal via microwaves is called Microwave Communication. It is also known as "line of sight" communication. It should be composed of voice, data, television, telephony or radio signals. Microwaves are also emitted by natural objects as well as from space.

Microwave is a part of electromagnetic spectrum, comprising the bands between 300 MHz and 300 GHz. Microwave Communication is used for point to point communication. It requires a direct line of sight path between the transmitter and receiver. Microwave communications avoid the need for a physical connection between the transmitter and receiver.



What is the meaning of microwave?

Microwave means "very Short Wave"

Microwave communication would generally require a repeater, which is placed in every few tens of miles of distance between the transmitter and the receiver. When satellites are used for microwave communication rather than for broadcasting purposes, highly directive antennas are essential to provide the required, which acts as a repeater in microwave communication.

The satellites acts as a repeater in microwave communication. Figure 4.10 shows the microwave communication.

4.8.1 Advantages of Microwave Communication

1. It has larger bandwidth and hence large amount of information can be transmitted using it.
2. It helps to manage crowded spectrum with the use of highly selective receivers.
3. The channels will not overlap or do not cause interference to nearby channels.
4. Wired communication is not possible in hilly remote areas where microwave communication is suitable choice in that place.

4.8.2 Disadvantages of Microwave Communication

1. Microwave Communication is limited to line of sight mode only, other modes of communication are not possible.
2. It is difficult to implement lumped components such as resistors, inductors and capacitors at microwave frequencies.

4.8.3 Application of Microwave Communication

Microwave communications are used in the following fields.

1. Wireless communications (space, cellular, phones, Bluetooth, satellites….)
2. Radar and Navigation (to detect aircraft, ship, space craft, weather formation, etc…..)
3. Remote sensing (land surface …)
4. RF Identification (security, product tracking, animal tracking…)
5. Broadcasting (mobile phones and WiFi….)
6. Heating (baking, food process, ovens, drying….)
7. Bio-medical applications (diagnostics)

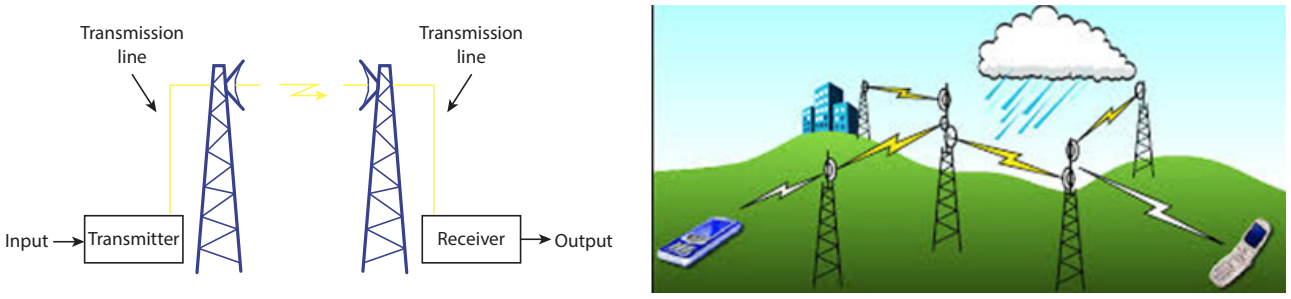


FIGURE 4.10 Microwave Communication

4.9 RADAR Technology

RADAR stands for Radio Detection And Ranging. It is a type of radio system where radio frequency signals are used to determine the position of speed of an object. Often the objective is passive, so the reflection of RF signal from the object is used to find the speed or velocity of the object. Figure 4.11 shows the block diagram of Radar.

Transmitter

The radar transmitter produces high frequency RF pulses and is transmitted into space by the antenna.

Receiver

The receiver amplifies and demodulates the received RF-signals. The receiver provides video signals on the output.

Power Supply

The power supply provides the electric power for all the components

Synchronizer

The synchronizer sync the timing for the range determination. It will send the signal along with the transmitted signal to know the return sweep and display the signal.

Duplexer

This will act like a switch between the transmitter and the receiver. This is required because high power pulses of the transmitter will destroy the receiver, if energy were allowed to enter the receiver.

Radar antenna

The antenna transfers the transmitting signals to space with the required distribution and efficiency.

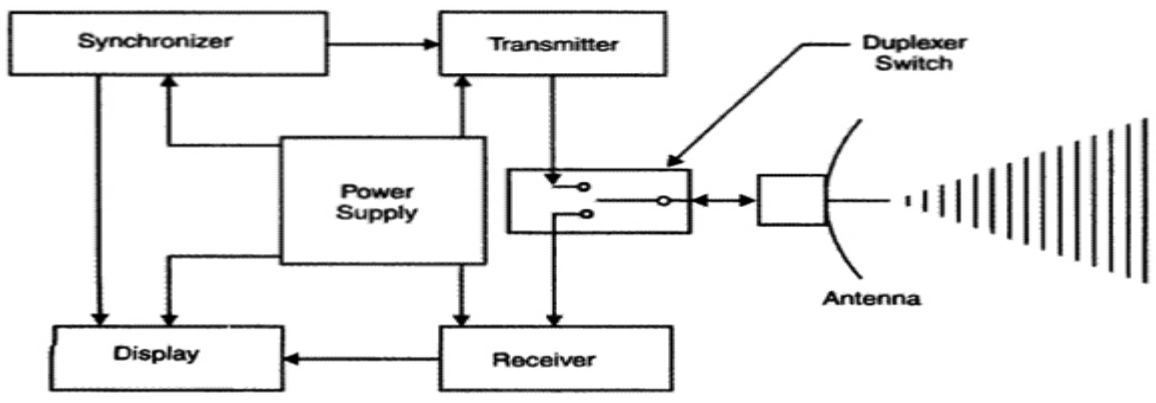


FIGURE 4.11 The block diagram of RADAR

Display

Display units used to represent the object on the the screen to analyze the object very easily.

4.9.1 Types of RADAR

The following flow charts shows the different types of Radars

4.9.2 Applications of Radar

- **Air Traffic Control (ATC)**

  Radar are used for safety controlling of the air traffic.

- **Air Craft Navigation**

  The weather avoidance radars and ground mapping radars are employed in aircrafts to navigate it properly in all the conditions.

- Ship Navigation and safety

  Radars are used for beaconing and used an aid of navigation and also used to find the depth of sea.

- Space

  Radars are used for docking and safely landing of spacecrafts.

- Remote Sensing and Environment

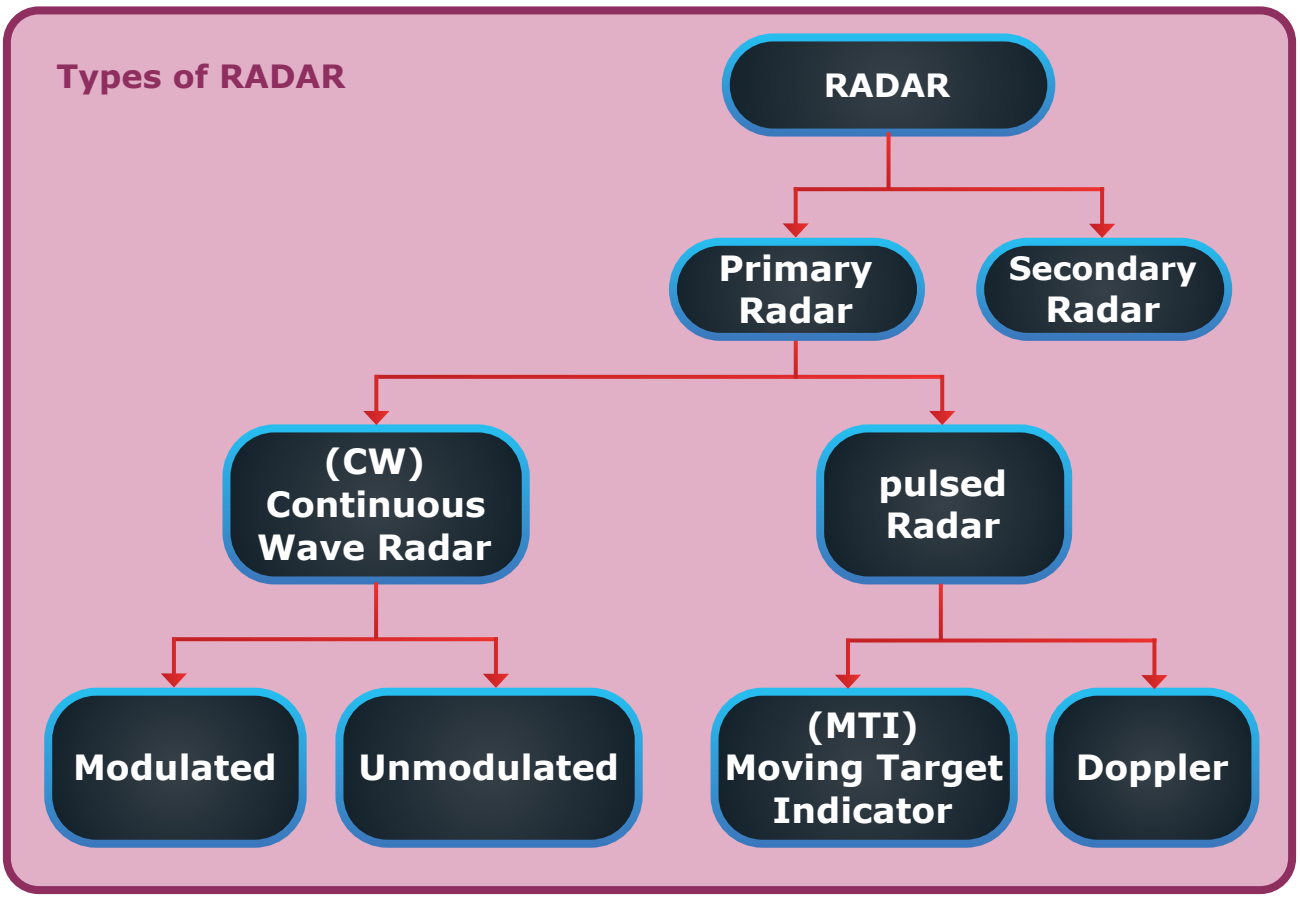
  They are employed in remote sensing for detecting weather conditions of the atmosphere and tracking of planetary conditions.

- Law Enforcement

  High way police force widely uses radars to measure the vehicle speed for safety regulation.

- Military area

  They are used in Air, Naval and Ground for defence purposes.



4.10 SONAR Technology

SONAR (Originally an acronym for Sound Navigation And Ranging) is a technique that uses sound propagation. Sonar uses the echo principle by sending out sound waves under water or through the human body to locate objects.

When man or animal or machine makes a noise, it sends sound waves into the environment around it. Those waves bounced back after hitting any nearby objects, and some of them reflect back to the object that made the noise. SONAR works using, this echo principle.

A method or device detecting or locating the objects especially in underwater by means of sound waves sent out were reflected by the objects. Also a device for detecting the presence or a vessel (such as a submarine) by the sound, it emits in water. Figure 4.12 shows the SONAR technology.

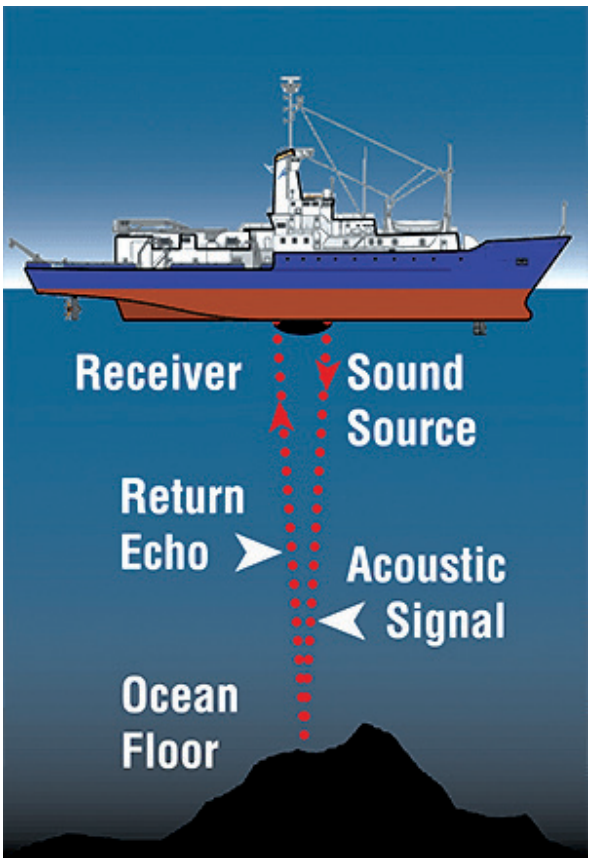


FIGURE 4.12 SONAR Technology

4.10.1 Types of SONAR

They are two types of SONAR

1. Active SONAR
2. Passive SONAR

Active SONAR

Active SONAR is emitting pulses of sound and listening echoes. It sends out sound pulses. Then receives the returning sound echo.

Passive SONAR

It is essentially listening for the sound made by vessels. It receives sound echoes without transmitting their own sound signals.

4.10.2 Uses of Active SONAR

1. Detecting and tracking submarines, ships, etc (under- water combat)
2. Mapping the ocean flour (navigation / Surveillance)
3. Detecting under water mines

4.10.3 Uses of Passive SONAR

1. Listening to the noise from enemy submarines, surface vessels etc over long range.
2. Many animals use echo – location for hunting and navigation purposes.

4.10.4 Applications of SONAR

1. To detect, track and destroy enemy ships and submarines.
2. Detecting underwater mines.
3. To determine navigational location.
4. Mapping the Ocean floor.
5. In research, it is used to find animal location and tracking.
6. In medical, it is used in zonography and auditory research.

4.11 Tsunami System

4.11.1 What is Tsunami?

A Tsunami is a series of fast moving waves in the ocean caused by powerful earthquakes or volcanic eruptions. A tsunami has a very long wavelength. It can be hundreds of kilometres long.

4.11.2 Need of Tsunami Warning System

The east and west coasts of India and the island regions are likely to be affected by tsunamis generator mainly due to earthquakes in the seduction zones. Hence, there was a need for developing tsunami warning system.

4.11.3 Tsunami Warning System

Tsunami warning system is used to detect tsunami in advance and issue warnings to prevent losses of life and property damage

It is made up of two equally important components

1. A network of sensors to detect tsunamis.
2. A communication infrastructure to issue timely alarms to permit evacuation of the costal areas.

DO YOU KNOW?

Where is the tsunami warning system located in India?

Answer: In Hyderabad

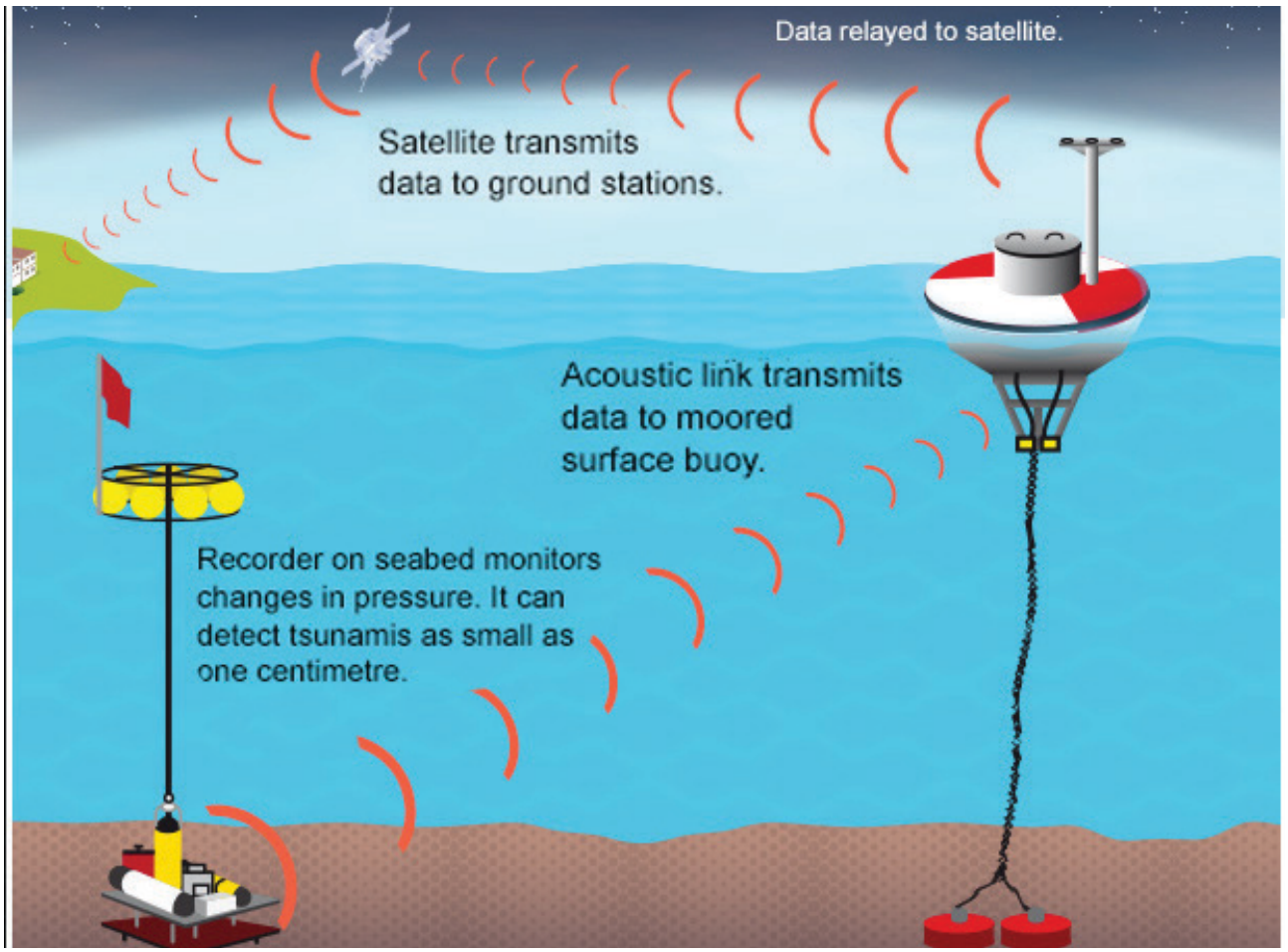


FIGURE 4.13 shows the Tsunami warning system.

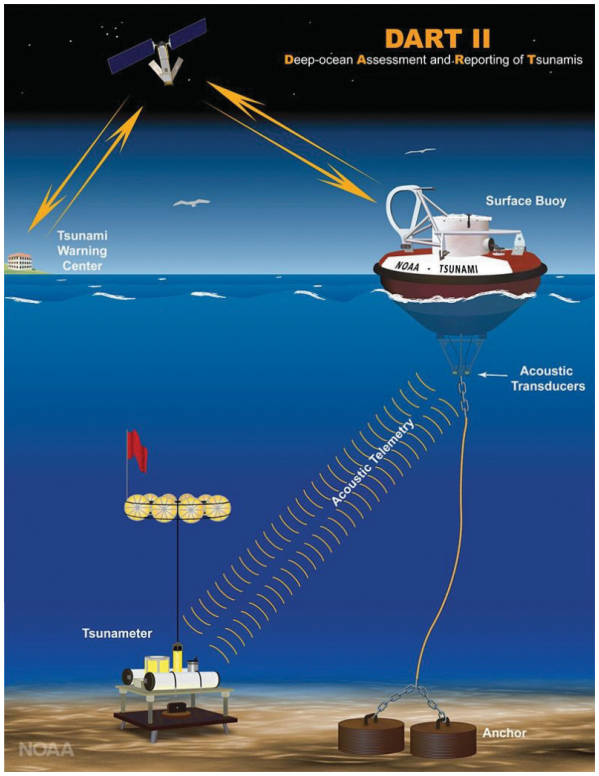


FIGURE 4.13 Tsunami warning system

4.12 Seismograph and Avionics

4.12.1 Seismograph

A Seismograph is a device for measuring the movement of the earth and consists of a ground-motion detection sensor, called a seismometer, coupled with a recording system.

A Seismograph is an instrument which is used to detect and record earthquake. Generally, it consists of a mass attached to a fixed base. During an earthquake, the base moves and the mass does not.

The motion of the base with respect to the mass is commonly transferred into an electrical voltage. Figure 4.14 shows the seismograph.

The electrical voltage is recorded on paper, magnetic tape or recording medium. This record is proportional to the motion of the seismometer mass relative to the earth but it can be mathematically converted to a record of the absolute motion of the ground.

The magnitude of an earthquake is determined by recording of the seismic waves resulting from the vibration generator by the seismic source. Sensitive seismograph, which greatly magnify these ground motions that can detect strong earthquakes from sources anywhere in the world. The time, locations and magnitude of an earthquake can be determined from the data recorded by seismograph station.

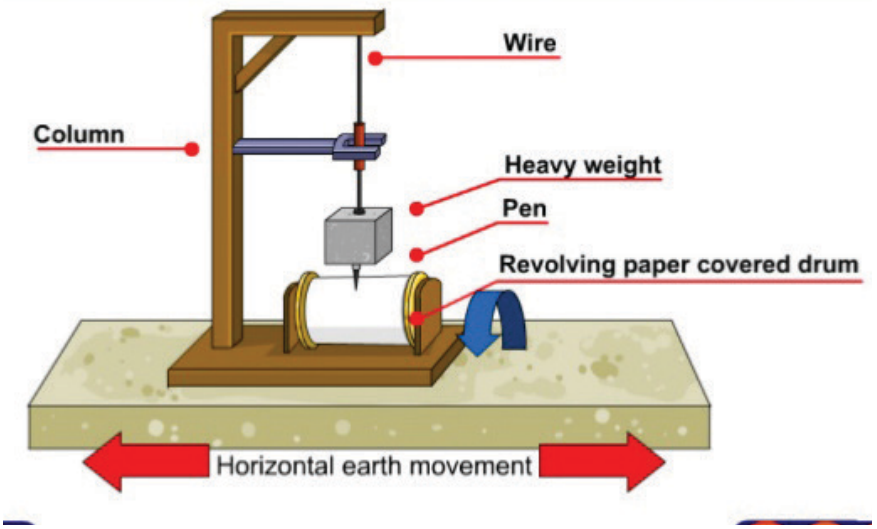


FIGURE 4.14 Seismograph



FIGURE 4.15 The cockpit of flight Airbus A380

4.12.2 Avionics system

Avionics are the electronic Systems used on aircraft, artificial satellites and space craft. Avionic system included communications, navigations, the display and magnet of multiple system and the hundreds of systems that's are fitted to aircraft to perform individual function.

4.12.3 Aircraft AVIONICS



How does the word Avionics come from?

The word avionics comes from Aviation + electronics

The cockpit of an aircraft is a typical location for avionic equipment, including control, monitoring, communication, navigation, weather, and anti-collision systems. The majority of aircraft power their avionics using 14- or 28volt DC electrical systems; however, larger, more sophisticated aircraft (such as airliners or military combat aircraft) have AC systems operating at 400 Hz, 115 volts AC. A separate international organisation called Airlines Electronic Engineering Committee (AEEC) prepare the International standards for Avionics equipment. Figure 4.15 shows the Cockpit of flight Airbus A380.

LEARNING OUTCOME

After studying this chapter, students can understand the following

1. The principle of an OFC.
2. Advantages and disadvantages of an OFC.
3. The difference between OFC and cable communication.
4. The different types of satellite and their applications.
5. The basic function of RADAR and SONAR.

QUESTIONS

I. Choose the best answer from the given four options.

1. The principle of an OFC technology was
   a) Electromagnetic induction
   b) Total internal reflection
   c) Electro motive force
   d) Mutual inductance
2. _____ is called as father of fiber optics.
   a) John Tyndall
   b) Dr. Narinder singh kapany
   c) Charles babbage
   d) Sir.C.V.Raman
3. _____is the primary source of power for satellites.
   a) Sun b) Light
   c) Heat d) None of the above
4. Satellite communication is also called _____.
   a) Space communication
   b) Microwave communication
   c) Cable communication
   d) Optical fiber communication
5. Nano Satellites weigh less than _____.
   a) 5 Kg b) 20 Kg
   c) 10 Kg d) 15 Kg
6. Microwave Communication is also called _____.
   a) Satellites Communication
   b) Optical fibre Communication
   c) Line of sight Communication
   d) Space Communication
7. Microwave frequency ranges were
   a) 1 GHz to 30 GHz
   b) 100 KHz to 30 MHz
   c) 550 KHz to 1650 KHz
   d) 300 MHz to 300 GHz
8. _____works as microwave repeater.
   a) Amplifier
   b) Satellite
   c) Antenna
   d) SONAR



9. Radar is used to determine location or speed of an _____.
   a) Ship
   b) Object
   c) Wave
   d) Metal
10. SONAR uses principles by sending out sound waves under water.
    a) Electromagnetic
    b) Electromotive
    c) Echo
    d) Mutual inductance

II. Answer in few sentence.

1. What are fiber optics?
2. What are the basic elements of fiber optics?
3. What are the disadvantages of an OFC?
4. Write short notes on an artificial satellite.
5. Write about weather satellite.
6. Define microwave communication.
7. What is RADAR?

8. Write short notes about SONAR.
9. What is Tsunami?
10. Define Seismograph.

III. Explain the following questions.

1. Write about the working principle of an OFC.
2. What are the advantages and disadvantages of Microwave communication?
3. Draw the block diagram of RADAR.
4. What are the uses of RADAR?
5. Explain about SONAR Technology.

IV. Briefly explain the following questions.

1. Explain briefly the difference between optical fiber and co-axial cable.
2. What are the applications of an OFC?
3. Explain about any five artificial satellites.

Answer

1(b)	2(b)	3(a)	4(a)	5(c)
6(c)	7(d)	8(b)	9(b)	10(c)



CHAPTER 05

Digital Image Processing

SNGX4

LEARNING OBJECTIVE

The students can understand the following in this chapter

- Analog and Digital Image Processing.
- Representation of Digital Image.
- Components of Digital Image Processing.
- Fundamental steps of Digital Image Processing.
- Applications of Digital Image Processing.

5.1 Introduction

The field of digital image processing refers to processing digital images by means of digital computer. Digital image is composed of a finite number of elements, each of which has a particular location and value. These elements are called picture elements, image elements, pels and pixels. Pixel is the term most widely used to denote the elements of digital image. An image is a two-dimensional function that represents a measure of some characteristic such as brightness or color of a viewed scene. An image is a projection of a 3- D scene into a 2D projection plane. Figure. 5.1 shows the concepts of Digital Image Processing.



FIGURE 5.1 Concepts of Digital Image Processing

An image may be defined as a two-dimensional function f(x,y), where x and y are spatial (plane) coordinates, and the amplitude to f at any pair of coordinates (x,y) is called the intensity of the image at that point. The term gray level is used often to refer to the intensity of monochrome images. Color images are formed by a combination of individual 2-D images.

5.2. Types of Images

5.2.1. Analog Image Processing

The analog image processing is applied on analog signals and it processes only two-dimensional signals. The images are manipulated by electrical signals. In analog image processing, analog signals can be periodic or non-periodic. An analog image can be represented as continous range of values representing position and intensity. Figure 5.2 shows the analog image.

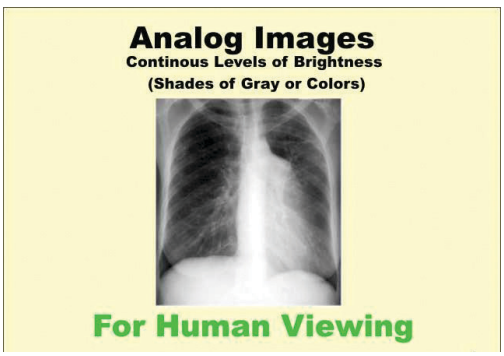


FIGURE 5.2 Analog Image

Examples: Television images, Photographs, Paintings, and Medical images etc.

5.2.2 Digital Image Processing

A digital image processing is applied to digital images (a matrix of small pixels and elements). For manipulating the images, there is a number of software and algorithms that are applied to perform changes. It is composed of picture element called pixel. Pixel value must be discrete. Figure 5.3 shows the Digital Image.

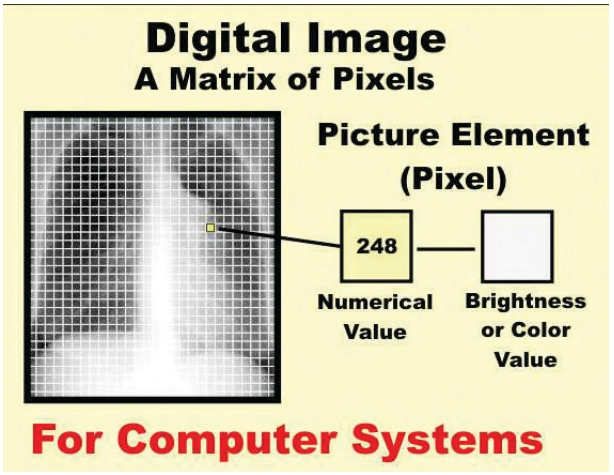


FIG.5.3 Digital Image

Examples: Color processing, Image recognition, Video processing, etc.

5.3 Pixel

Pixel is the smallest element of an image. Each pixel correspond to anyone value. In an 8-bit grey scale image, the value of the pixel ranges between 0 and 255. The value of pixel at any point corresponds to the intensity of the light photons striking at that point. Each pixel stores a value proportional to the light intensity at that particular location. Figure 5.4 shows the pixel representation of an image. Pixel is also known as PEL (Picture Element). In this picture thousands of pixels that together make up the image. If we zoom the image to the extent that we are able to see some pixels division.

Calculation of total number of pixels

We have defined an image as a two dimensional signal or matrix. From this,

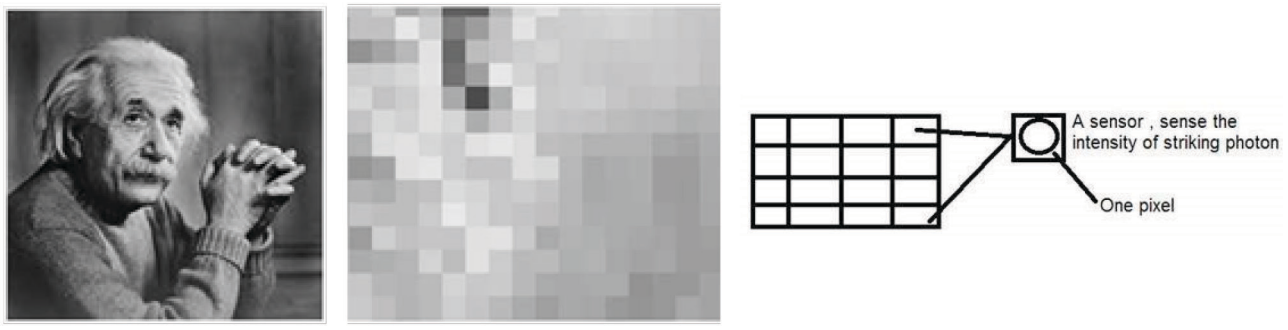


FIGURE 5.4 Pixel representation of an image

the number of pixel is equal to number of rows multiplied with number of columns.

A pixel can have only one value and this value denotes the intensity of light at that point of image. Now, we can see the unique value of 0 (zero's) and 1 (One's). The value 0 means absence of light and also denotes darkness. The valuve of 1 means the presence of light and also denotes brightness. For example, the following matrix is filled with 0s and 1s

$$\begin{bmatrix} 0 & 1 & 0 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \end{bmatrix}$$

Formula:

Total no. of pixels = total no. of rows x total no. of columns = 3 x 3 = 9

It means that an image is formed with 9 pixels, and that image is having a dimension of 3 rows and 3 columns.

5.4. Analog Image Processing vs. Digital Image Processing

Following table shows the differences between Analog Images Processing and Digital Image Processing:

Analog Image Processing	Digital Image Processing
The analog image processing is applied on analog signals and it processes only two-dimensional signals.	The digital image processing is applied to digital signals that work on analyzing and manipulating the images.
Analog signal is time-varying signals so the images formed under analog image processing get varied.	It improves the digital quality of the image and intensity distribution is perfect in it.
Analog image processing is a slower and costlier process.	Digital image processing is a cheaper and fast image storage and retrieval processes.
Analog signal is a real-world but not having good quality of images.	It uses good image compression techniques that reduces the amount of data required and produces good quality of images
It is generally continuous and not broken into tiny components.	It uses an image segmentation technique which is used to detect discontinuity which occurs due to a broken connection path.

5.5. Representing the Digital Image

A digital image f(m,n) described in a 2D discrete space is derived from an analog image f(x,y) in a 2D continuous space through a sampling process that is frequently referred to as digitization. The effect of digitization is shown in figure 5.5

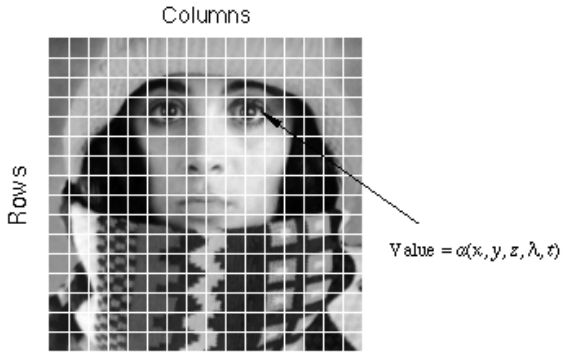


FIGURE 5.5 Effects of Digital Image

The 2D continuous image f(x,y) is divided into n rows and m columns. The intersection of a row and a column is termed a pixel. The value assigned to the integer coordinates (m,n) with m=0,1,2..n-1 and n=0,1,2...n-1 is f(m,n). In fact, in most cases, is actually a function of many variables including depth, color and time (t).

5.5.1 Sampling and Quantization

To create a digital image, we need to convert the continuous sensor signal into digital form. This involves two processes.

1. Sampling
2. Quantization

A continuous image, f(x, y), that we want to convert to digital form. An image may be continuous with respect to the x and y coordinates, and also in amplitude. To convert it to digital form, we have to sample the function in both coordinates as amplitude value.

Sampling

Digitization of spatial coordinates (x,y) is called Image Sampling. To be suitable for computer processing, an image function f(x,y) must be digitized both in spatial and magnitude domains. Figure 5.6 shows the Image Sampling.

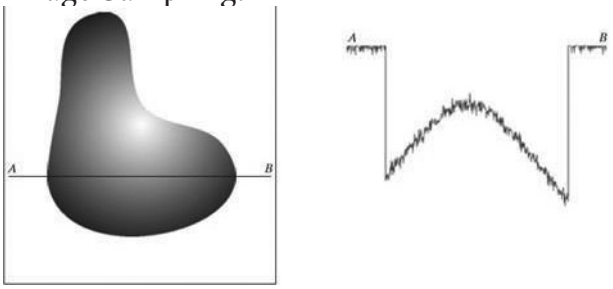


FIGURE 5.6 Sampling

Quantization

Digitizing the amplitude values is called Quantization. Quality of digital image is determined to a large degree by the number of samples and discrete gray levels used in sampling and quantization process. Figure 5.7 shows the Image quantization.

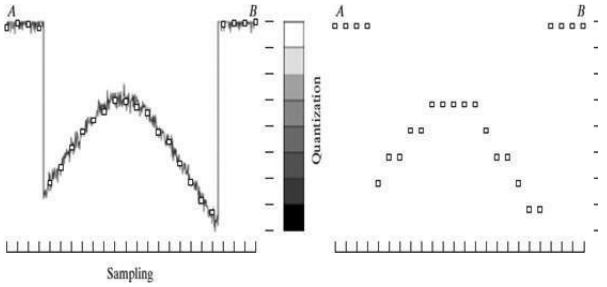


FIGURE 5.7 Quantization.

The result of sampling and quantization is matrix of real numbers. Assume that an image f(x,y) is sampled so that the resulting digital image has m rows and n columns. The values of the coordinates (x,y) now become discrete quantities thus the value of the coordinates at origin become (x,y) = (0,0). The next coordinates value along the first signify the image along the first row. It does not mean that these are the actual values of physical coordinates when the image was sampled. Thus, the right side of the matrix

represents a digital element, pixel or pel. The matrix can be represented in the following form as well.

$$f(x,y) = \begin{bmatrix} f(0,0) & f(0,1) & f(0,2) & \dots & f(0,N-1) \\ f(1,0) & f(1,1) & f(1,2) & \dots & f(1,N-1) \\ \vdots & \vdots & \vdots & & \vdots \\ f(M-1,0) & f(M-1,1) & f(M-1,2) & \dots & f(M-1,N-1) \end{bmatrix}$$

Hence f(x,y) is a digital image if gray level (that is, a real number from the set of real number R) to each distinct pair of coordinates (x,y). This functional assignment is the quantization process. Due to processing storage and hardware consideration, the number of gray levels typically are an integer power of 2.

$$L=2^k$$

Then, the number 'b' of bits required to store a digital image is

$$b=m \times n \times k$$

When M=N, the equation become

$$b=n^2 \times k$$

When an image can have 2^k gray levels, it is referred to as "k- bit". An image with 256 possible gray levels is called an "8- bit image" ($256=2^8$).

Image Processing can be classified into three main types and are summarized in the following subsections.

Low level Processing

It involves primitive operations such as image processing to reduce noise, contrast enhancement and image sharpening. These kinds of processes are characterized by the properties of both the input and output images.

Mid-level Image Processing

It involves tasks like segmentation, description of those objects to reduce them to a form suitable for computer processing and classification of individual objects. The inputs to the process are generally images but outputs are attributes extracted from images.

High level Processing

It involves "making sense" of an ensemble of recognized objects, as in image analysis, and performing the cognitive functions normally associated with vision.

5.6 Image Processing Tool Box (IPT)

It is a collection of functions such as MATLAB numeric computing environment, MATLAB language make many image-processing operations easy to write in a compact, clear manner, thus providing an ideal software prototyping environment for the solution of image processing problem.

5.7 Components of Image Processing System:

Image Processing System is the combination of the different elements involved in the digital image processing. Digital image processing is the processing of an image by means of a digital computer. It uses different computer algorithms to perform image processing on the digital images. Figure 5.8 shows the components of image processing system.

It consists of the following components:-

5.7.1 Image Sensors

With reference to sensing, two elements are required to acquire digital image. The first is a physical device that is sensitive to

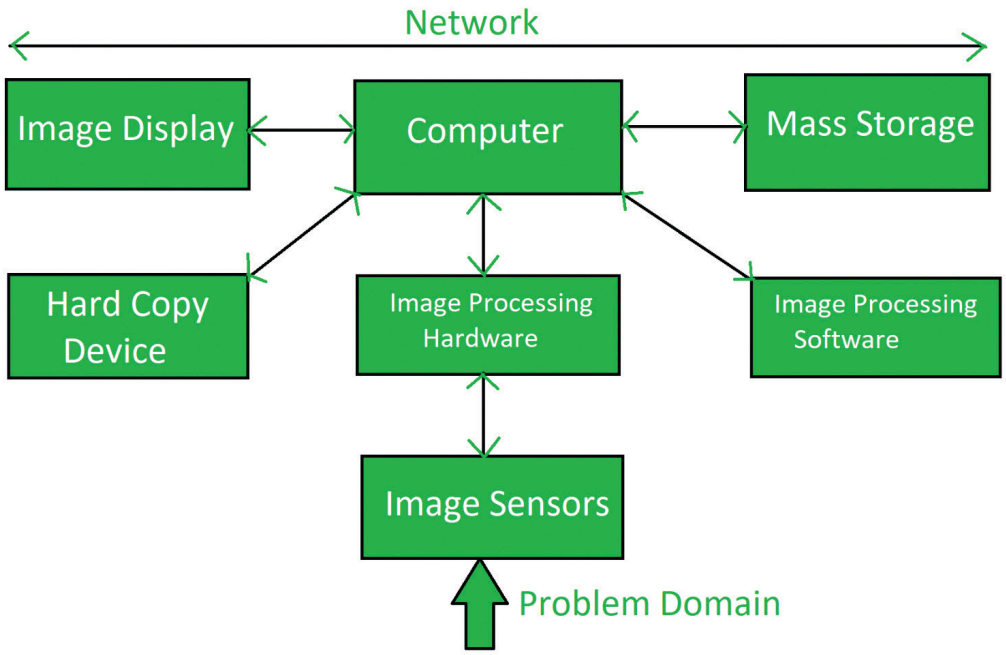


FIGURE 5.8 Components of Image processing System

the energy radiated by the object we wish to image and second is specialized image processing hardware.

5.7.2 Specialized Image Processing Hardware

It consists of the digitizer just mentioned, plus hardware that performs other primitive operations such as an arithmetic logic unit, which performs arithmetic operations such as addition and subtraction and logical operations in parallel on images.

5.7.3 Computer

It is a general-purpose computer and can range from a PC to a supercomputer depending on the application. In dedicated applications, sometimes specially designed computer is used to achieve a required level of performance

5.7.4 Software

It consists of specialized modules that perform specific tasks using a well-designed package, which includes capability for the user to write code, as a minimum, utilizes the specialized module. More sophisticated software packages allow the integration of these modules.

5.7.5 Mass Storage

This capability is a must in image processing applications. An image of size 1024 x1024 pixels, in which the intensity of each pixel is an 8-bit quantity requires one Megabytes of storage space, if the image is not compressed.

Image processing applications falls into three principal categories of storage.

- Short term storage for use during processing.
- On line storage for relatively fast retrieval.
- Archival storage such as magnetic tapes and disks.

5.7.6 Image Display

Image displays in use today are mainly color TV monitors. These monitors are driven by the outputs of the image and graphics displays cards that are an integral part of the computer system.

5.7.7 Hardcopy Devices

The devices for recording image include laser printers, film cameras, heat sensitive devices, inkjet units and digital units such as optical and CD ROM disk. Films provide the highest possible resolution, but paper is the obvious medium of choice for written applications.

5.7.8 Networking

It is almost a default function in any computer system in use today because of the large amount of data inherent in image processing applications. The key consideration in is image transmission bandwidth.

5.8. Fundamental Steps in Digital Image Processing.

There are two categories of the steps involved in the image processing –

- Methods whose outputs and input are images.
- Methods whose outputs are attributes extracted from those images.

Figure 5.9 shows the fundamental steps in Digital Image Processing.

5.8.1 Image Acquisition

In image processing, image acquisition is the action of retrieving an image from a source, usually hardware systems like cameras, sensors, etc. It is the first and the most important step in the workflow sequence because, without an image, no actual processing is possible by the system. Generally, the image acquisition stage involves processing such as sampling,scaling and coding. Figure 5.10 shows the Image Acquisition Process.

5.8.2 Image Enhancement

It is among the simplest and most appealing areas of digital image processing. It is the process of improving the quality of digitally stored image by manipulating the

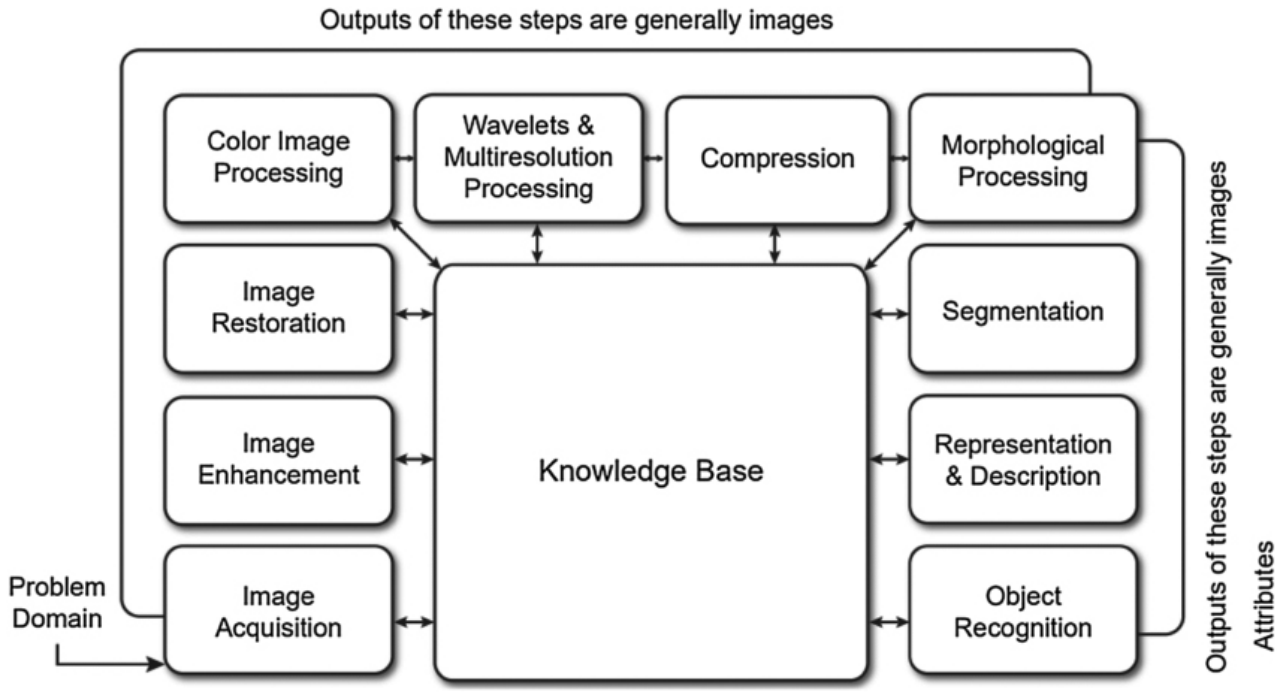


FIGURE 5.9 Fundamental Steps in Digital Image Processing

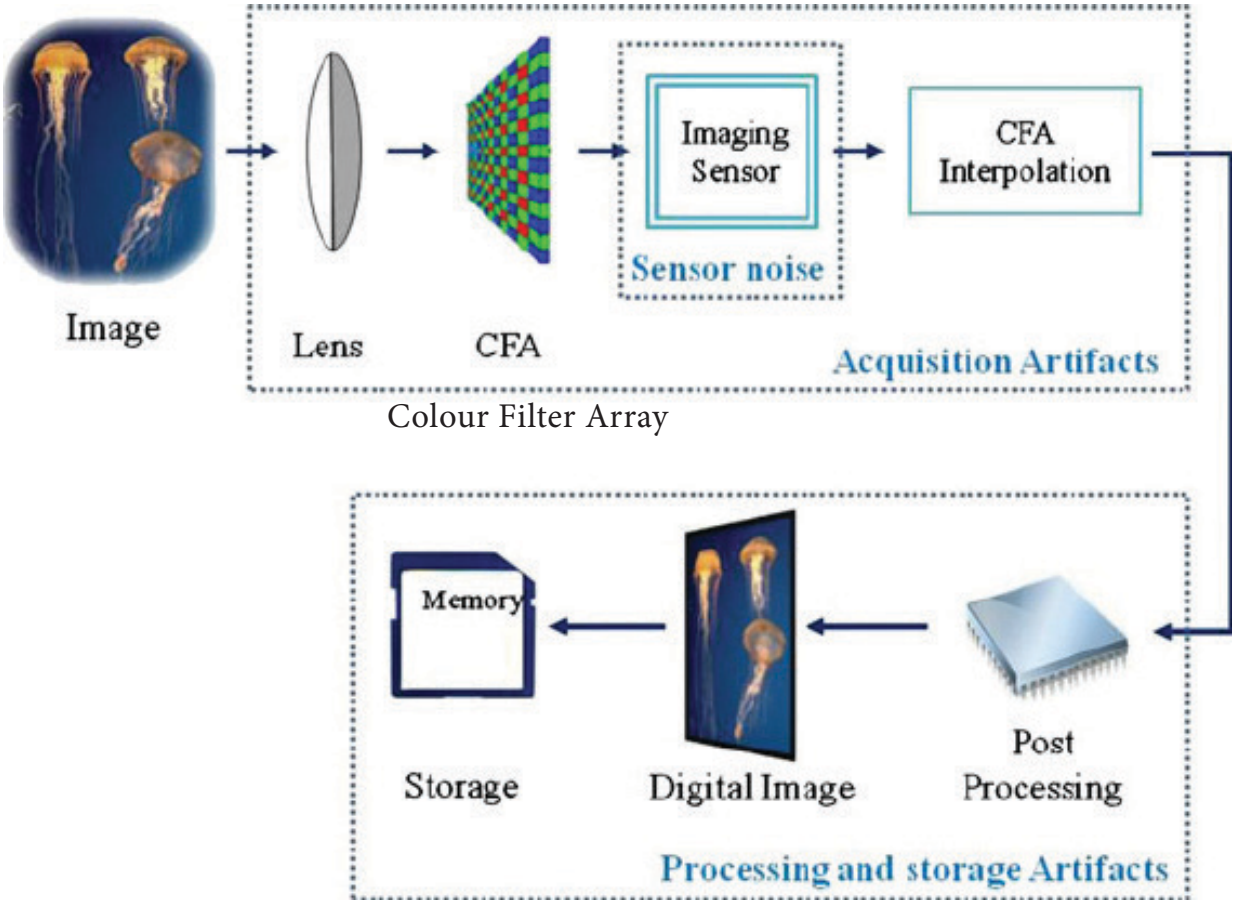


FIGURE 5.10 Image Acquisition Process

image with software. The idea is to bring out details that are obscured or simply to highlight certain features of interest in image. Image enhancement is a very subjective area of image processing. For example, removing noise, sharpening or brightening an image. Figure 5.11 shows the image enhancement on a noisy image, which exhibits improved features as well as complete removal of noise. (Salt and Pepper Noise)

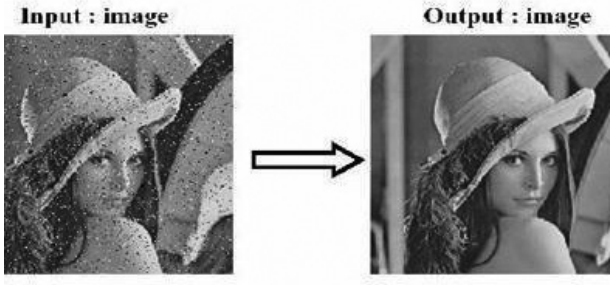


FIGURE 5.11 Enhanced Image after removing the salt and pepper noise

5.8.3 Image Restoration

It is the process of recovering an image from a degraded version. The degradation may comes in many forms like blurred, noisy image and camera out of focus problems. In order to restore the original image, we have to apply the inverse process to restore the degraded pixels.

It is an objective approach, in the sense that restoration techniques tend to be based on mathematical or probabilistic models of image processing. Enhancement, on the other hand is based on human subjective preferences regarding what constitutes a "good" enhancement result. Figure 5.12 shows the restored image from the out of focus image.

The types of noises are as follows

- Gaussian noise

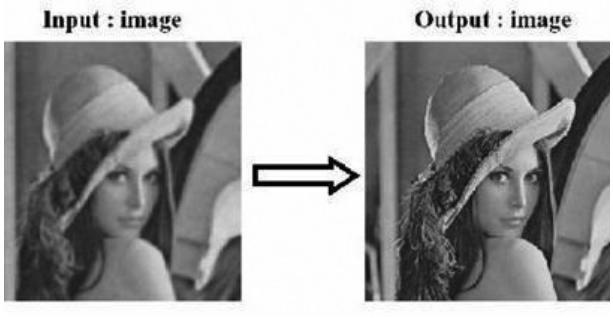


FIGURE 5.12 Image Restoration correcting an out of focus image.

- Rayleigh noise
- Gamma noise
- Exponential noise
- Uniform noise
- Impulse (Salt &Pepper) noise

5.8.4 Colour Image Processing

Color image processing deals with basically color models and their implementation in image processing applications. Colour is a powerful descriptor which simplifies object identification and extraction.

Example. Face Detection using skin colors.

It can be broadly classified into,

1. Full colour Image Processing
2. Pseudo colour image Processing

Full Colour Image Processing

- Images are acquired from full colour sensor or equipment like colour TV camera and Colour Scanner.

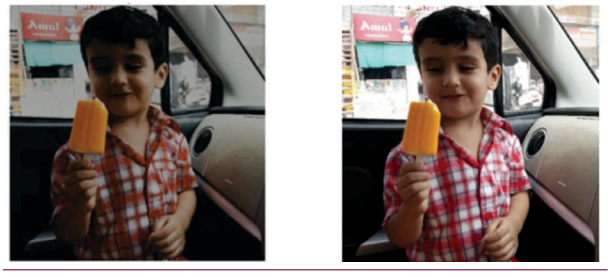


FIGURE 5.13 Full Colour Sensor Image

- It is used in publishing, visualization and the internet. Figure 5.13 shows the full colour sensor image.

Pseudo Colour Image Processing

Before few decades, colour sensor and processing hardware were not available.

Pseudo colour images are generated by assigning a shade of colour to a monochrome intensity (or range of intensities). Figure 5.14 shows the pseudo colour image.

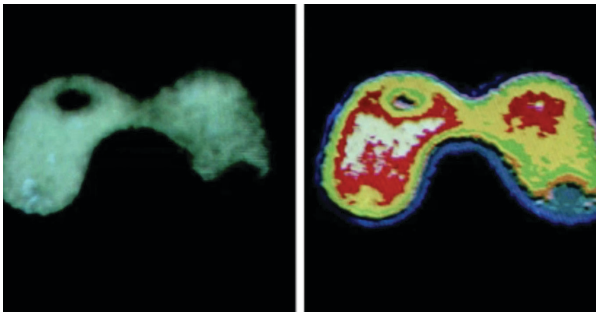


FIGURE 5.14 Pseudo Colour Image

The physical nature of colour can explained by experimental and theoretical results. The concept of electromagnetic spectrum is shown in figure 5.15.

Visible light wavelength from around 400 to 700nm.

Characteristics of Light

1. For an achromatic (Monochrome) light source, there is only one attribute to describe the quality is Intensity.
2. For a chromatic light sources there are three attributes to describe the quality:
   - Radiance : Total amount of energy flow from a light source (Watts)
   - Luminance : Amount of Energy received by an observer (Lumens)
   - Brightness : Intensity

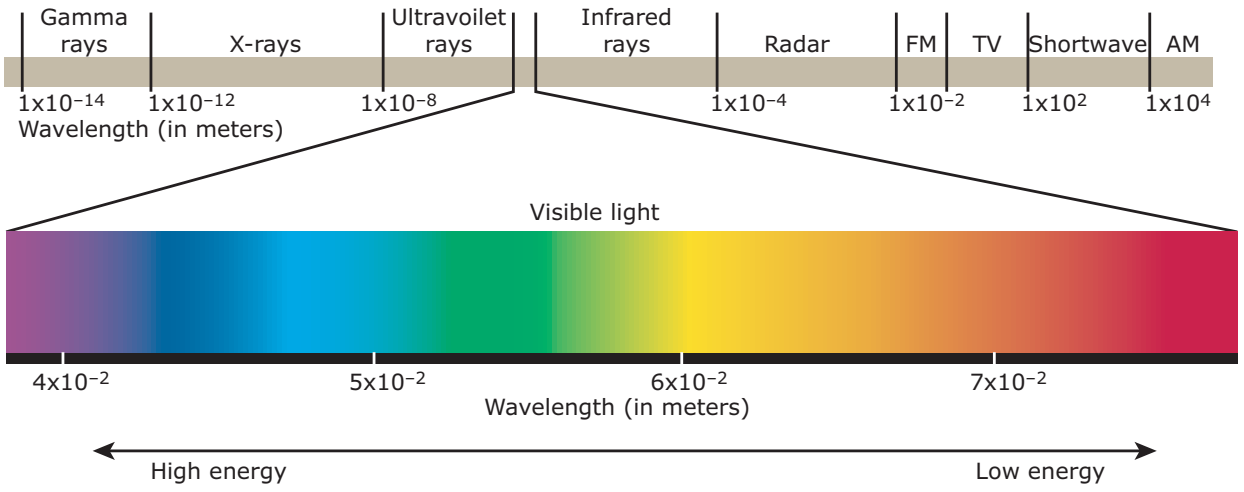


FIGURE 5.15 Electromagnetic Spectrum

There are three quantities to describe any colour:

HSI (Hue, Saturation, Intensity) Model is used for image processing applications.

1. **Hue:** The predominant spectral colour of an object.
2. **Saturation:** It means how pure the hue is or how less white light is mixed with it. How less the object is diluted by light is called its saturation.
3. **Intensity (Brightness):** It is the subjective descriptor that is practically impossible to measure.

- Red, Green and Blue (RGB model) are called Primary colours, which are used in colour monitors and video cameras
- Cyan, Magenta and Yellow (CMY model) are called the Secondary Colours used for colour printing. Secondary colours are the colours which can be obtained by the combination of primary colours. Figure 5.16 shows the primary and secondary colours.

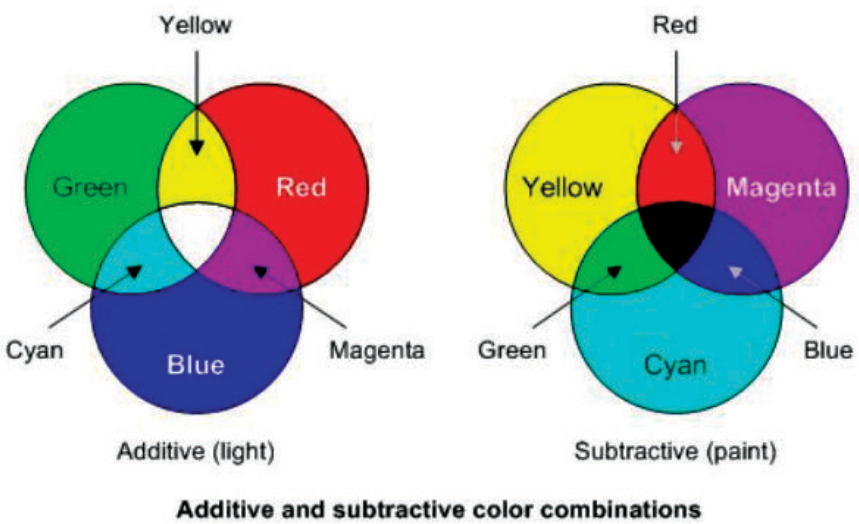


FIGURE 5.16 Primary and Secondary colours

5.8.5 Wavelets and Multiresolution Processing

Wavelet transform is used to analyze a signal (image) into different frequency components at different resolution scales (i.e. multiresolution). These are the foundation for representing image in various degrees of resolution. Figure 5.17 shows the Multiresoultion Images.

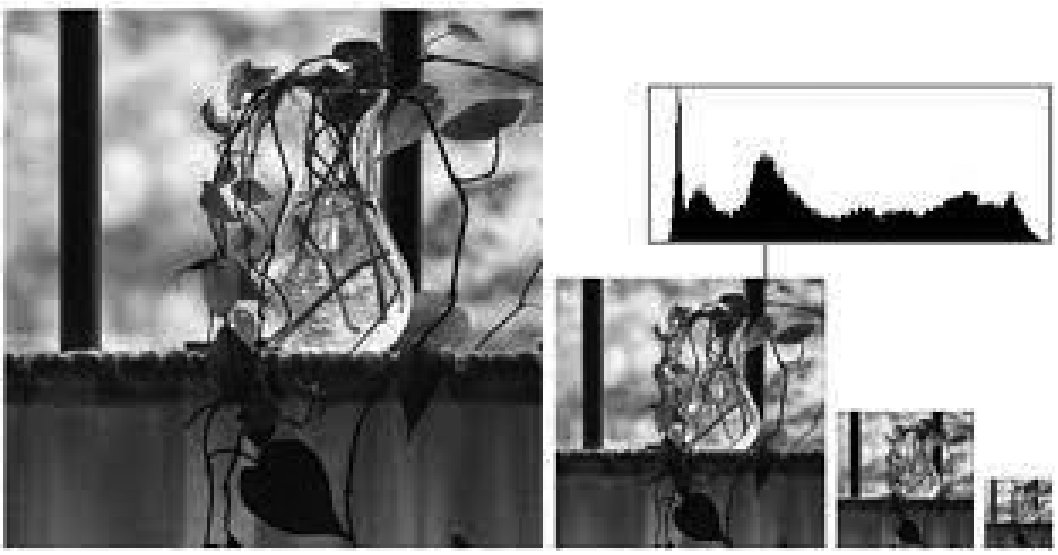


FIGURE 5.17 Multiresolution Images

Multiresolution theory incorporates Image Pyramid techniques. It is a powerful simple structure for representing images at more than one resolution. It is a collection of decreasing resolution images arranged in the shape of pyramid as shown in figure 5.18.

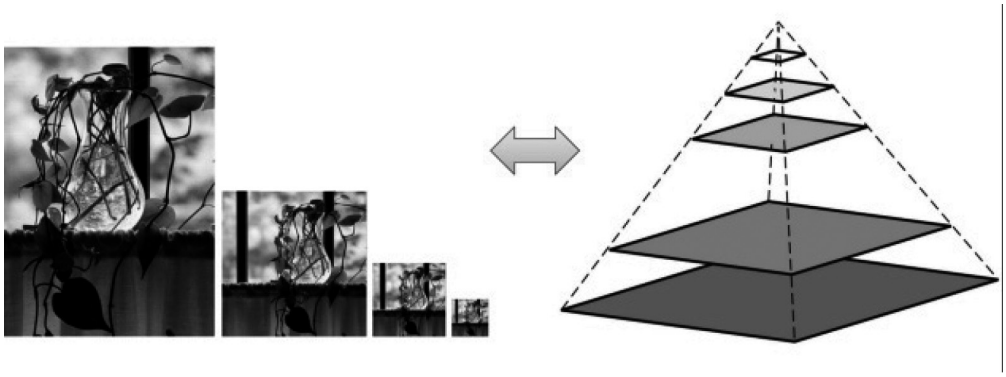


FIGURE 5.18 Multiresolution Images arranged in an Image Pyramid

5.8.6 Image Compression

It deals with techniques reducing the storage required to save an image, or the bandwidth required to transmit it over the network. It has two major approaches

1. Lossless Compression
2. Lossy Compression

Figure 5.19 shows the comparison between original and compressed image.

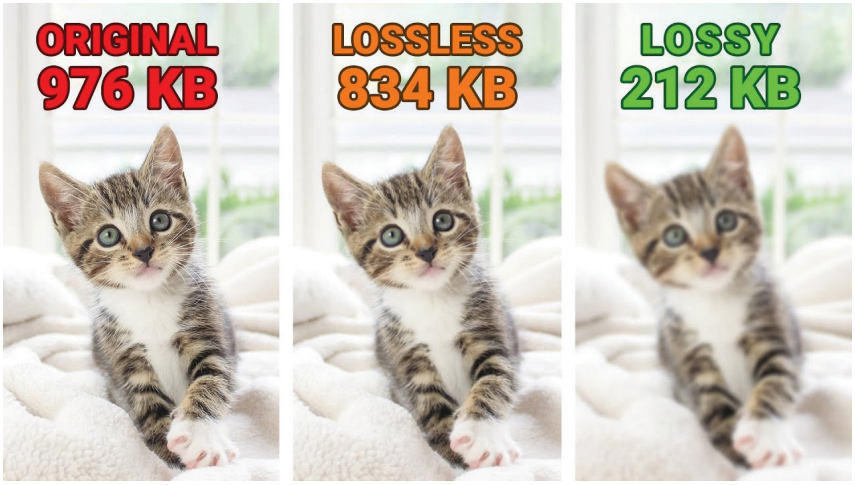


FIGURE 5.19 Comparison beween Original and Compressed Image.

Difference between Lossless and Lossy Compression		
FACTORS	**Lossless Compression**	**Lossy Compression**
Definition	Lossless compression is a class of data compression algorithms that allow the original data to be perfectly reconstructed from the compressed data.	Lossy compression is the class of data encoding method that uses inexact approximations to represent the content. These techniques are used to reduce the data size for storage, handling, and transmitting content.
Algorithm	RLW, LZW, Arithmetic encoding, Huffman coding and Shannon-Fano coding.	Transform coding, DCT,DWT, Fractal compression, Rectangle Segmentation and Sparse Matrix Storage (RSSMS).
Uses	Text or programs, images and sound.	Images, audio and video.
Images	RAW, BMP, and PNG are all Lossless formats.	JPEG and GUI are lossy image formats.
Audio	WAV, FLAC, and ALAC are all Lossless.	MP3, MP4, and OGG are lossy audio formats.
Video	Few lossless video formats are in common consumer use, they would result in video files taking up a huge amount of space.	Common formats like H-264, MKV, and WMV are all lossy. H-264 can provides smaller files with higher qualities than previous generation of video codec because it has a "smaller" algorithm that's better at choosing the data for throughput.
Advantages	It maintains quality.	It can make a multimedia file much smaller than its original size.
Disadvantages	It doesn't reduce the file size as much as lossy compression.	Conversion to another format only with loss of audio information.

5.8.7 Morphological Processing

It deals with tools for extracting image components that are useful in the representation and description of shape and boundary of objects. It is majorly used in automated inspection applications.

It is a broad set of image processing operations that process images based on shapes. It apply a structuring element to an input image, creating an output image of the same size. In a morphological operation, the value of each pixel in the output image is based on a comparison of the corresponding pixel in the input image with its neighbours. Figure 5.20 shows the morphological operation on binaray image.

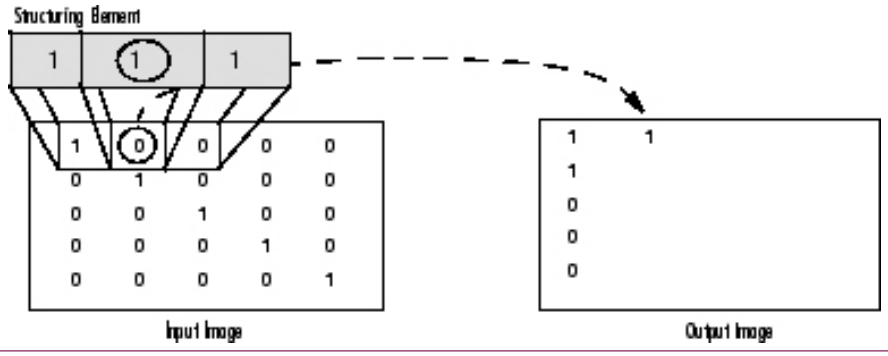


FIGURE 5.20 Morphological operations on binary image

The most basic morphological operations are as follows:-

1. Dilation
2. Erosion

Dilation

- Dilation adds pixels to the boundaries of objects in an image.
- Dilation makes objects more visible and fills-in small holes in the objects, Lines appear thicker, and filled shapes thus appear larger.

Figure 5.21 shows the original and processed images using dilation operation.

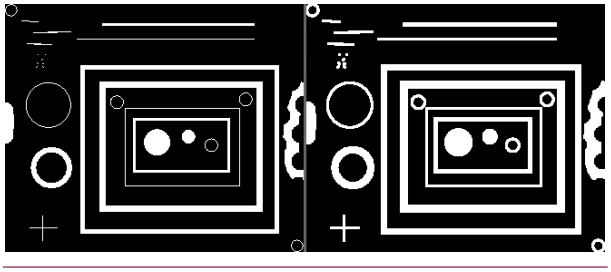


FIGURE 5.21 Original and Processed Images using Dilationi

Erosion

- Erosion removes pixels on the boundaries of the objects in an image.
- Erosion removes floating pixels and thin lines so that only substantive objects remain. Remaining lines appear thinner and shapes appear smaller.

Figure 5.22 shows the original and processed images using erosion operation.

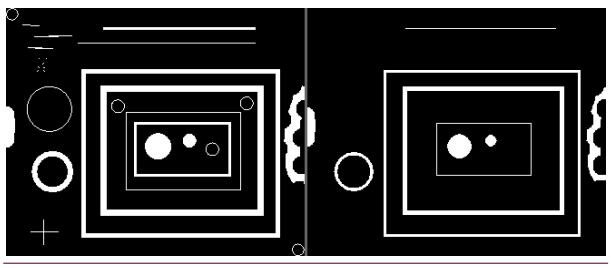


FIGURE 5.22 Original and Processed Images using Erosion

5.8.8 Image Segmentation

Image segmentation is a method in which a digital image is broken down into various subgroups called image segments,

which helps in reducing the complexity of the image to make further processing or analysis of the image simpler.

Approaches in Image Segmentation

1. **Similarity approach:**This approach is based on detecting similarity between image pixels to form a segment, based on a threshold. ML algorithms like clustering are based on this type of approach to segment an image.
2. **Discontinuity approach:** This approach relies on the discontinuity of pixel intensity values of the image. Line, Point, and Edge Detection techniques use this type of approach for obtaining intermediate segmentation results which can be later processed to obtain, the final segmented image.

Image Segmentation Techniques

1. Threshold Based Segmentation
2. Edge Based Segmentation
3. Region-Based Segmentation
4. Clustering Based Segmentation
5. Artificial Neural Network Based Segmentation

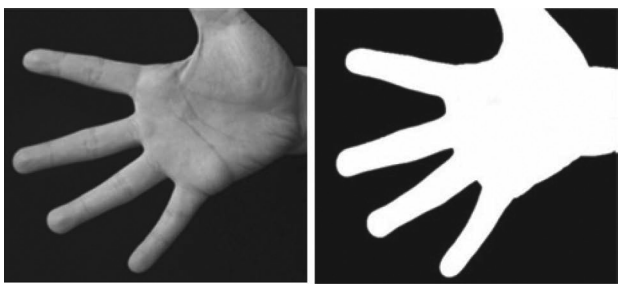


FIGURE 5.23 Segmentation of Palm Image

5.8.9 Representation and Description

1. Representation

   After an image is segmented into regions in the segmentation process, each region is represented and described in a form suitable for further computer processing. Representation makes a decision whether the data should be represented as a boundary or as a complete region.

Boundary Representation

- Focus on the external shape characteristics, such as boundaries, corners and inflections.
- Chain code method is used to represent the boundaries using a connected sequence of straight line segments.
- The below figure 5.24 shows the four and eight connectivity of chain codes method.

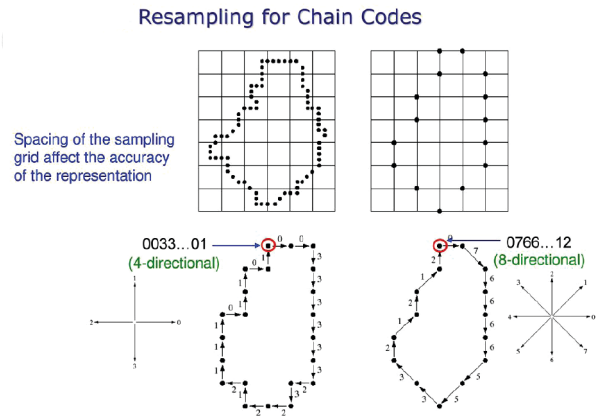


FIGURE 5.24 Chain codes (Four and Eight Connectivity)

Region Representation

- Focus on the internal properties, such as colour, texture or skeleton shape.
- These representation works based on the number of pixels present in that region.

2. Description

   Description means that we quantify the objects which we represented. Based on the representation we have two types of descriptors.

- Boundary Descriptors
- Region Descriptors

Boundary Descriptors

Some of the boundary descriptors are as follows

- Length
- Diameter
- Major axis
- Minor axis
- Eccentricity
- Curvature
- Shape number

Regional Descriptors

Some of the regional descriptors are as follows

- Area
- Perimeter
- Compactness
- Circularity ratio
- Rectangularity

These descriptors will allows us to compare the properties of two different images to make sure whether it is same or different.

5.8.10 Object Recognition

It is the process that assigns label to an object based on its descriptors. It is the last before step of image processing, which use artificial intelligence software. Object recognition is a computer vision technique for identifying objects in images or videos.

Object recognition is a key output of deep learning and machine learning algorithms. When humans look at a photograph or watch a video, we can readily spot people, objects, scenes, and visual details. Figure 5.25 shows face recognition of a person for different expressions.

Object recognition is a key technology behind driverless cars, enabling them to recognize a stop sign or to distinguish a pedestrian from a lamp post. It is also useful in a variety of applications such as disease identification in bioimaging, industrial inspection, and robotic vision.

5.8.11 Knowledge Base

Knowledge is the last stage in DIP. In this stage, important information of the image is located, which limits the searching processes. The knowledge base is very complex when the image database has a high-resolution satellite.

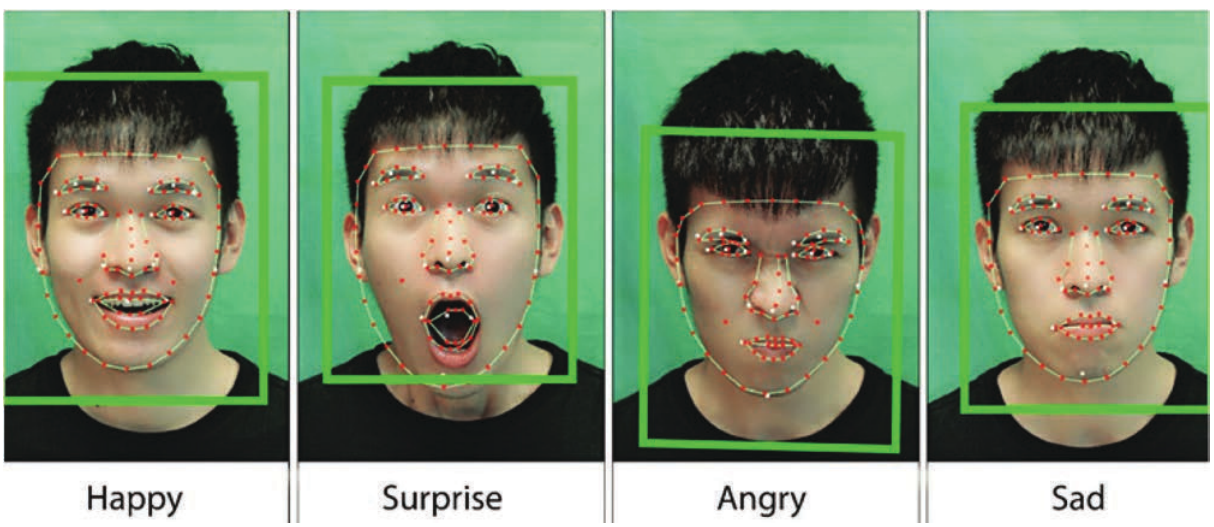


FIGURE 5.25 Face recognition of an individual based on the expression of a person

5.9 Applications of Digital Image Processing System

The field of Digital Image Processing has experienced continuous and significant development in recent years. Some of the applications which include

Medical field

For medical diagnosis, different types of imaging modalities such as which include

- X-ray,
- Ultrasound,
- Computed aided tomography (CT), Cine angiograms,
- Radiology Nuclear Magnetic Resonance (NMR) etc.,

Remote sensing satellites

In this application, sensors mounted on a remote sensing satellite use DIP for carrying out the following operations

- Employed in flood control and fire control
- Mobilization of Earth resources
- Geographical mapping
- Prediction of agricultural crops
- Urban growth and weather monitoring

Intelligent transportation system

This technique is used in

- Automatic number plate recognition and Traffic sign recognition.
- RADAR (Radio Detection and Ranging)
- Acoustic Image Processing (The study of underwater sound is known as Underwater Acoustics or Hydro Acoustics)
- SONAR (Sound Navigation and Ranging)
- Robotics and automated inspection of industrial parts.

Pattern recognition

Pattern recognition is used in

- computer aided diagnosis
- recognition of handwriting
- recognition of image.

Space image applications include

- Recognition and analysis of objects contained in images obtained from deep space-probe missions.
- Image transmission and storage applications occur in broadcast television
- Teleconferencing
- Transmission of facsimile images for Office automation.
- In military communications

LEARNING OUTCOME

After studying this chapter, students can understand the following

1. Analog and Digital Image Processing.
2. Representation of Digital Image.
3. Components of Digital Image Processing.
4. Fundamental steps of Digital Image Processing.
5. Applications of Digital Image Processing.

QUESTIONS

I. Choose the best answer from the given four options.

1. _____ is the term used most widely to denote the elements of digital element.
   a) Amplitude
   b) Intensity
   c) Pixel
   d) Gray Level



2. The term gray level is used often to refer to the intensity of _____
   a) Monochrome Image
   b) Pseudocode Image
   c) Analog Image
   d) Digital Image
3. Digitizing the amplitude values is called _____
   a) Sampling
   b) quantization
   c) Gray Levels
   d) Spatial Domain
4. IPT (Image Processing Tool Box) is a function in _____
   a) Java Script
   b) MATLAB Language
   c) LAB VIEW
   d) Python
5. _____ is the action of retrieving an image from a source such as cameras and sensor.
   a) Image enhancement
   b) Image restoration
   c) Image acquisition
   d) Image compression
6. _____ is the process of improving the quality of digitally stored image by manipulating the image with software.
   a) Image restoration
   b) Image acquisition
   c) Image compression
   d) Image enhancement
7. _____ Model used for Image Processing Application.
   a) HSI (Hue,Saturation, Intensity)
   b) Radiance
   c) Luminance
   d) RGB Model
8. _____ add pixels to the boundaries of object in an Image
   a) Erosion
   b) Dilation
   c) Region
   d) Descriptors
9. _____ deals with technique reducing the storage required to save an image.
   a) Image Enhancement
   b) Image Restoration
   c) Image Compression
   d) Image Acquisition
10. _____ is a collection of decreasing resolution image arranged in the shape of pyramid.
    a) Wavelet
    b) Lossy Compression
    c) Lossless Compression
    d) Multiresolution

II. Answer in few sentence.

1. What is the Digital Image Processing?
2. How to representing the digital image?
3. Define Sampling and quantization.
4. What is meant by IPT?
5. What are the types of noise in Image restoration?.
6. What is meant by HSI Model?.
7. What is Image Enhancement?.
8. What is Image Compression? Give its types.
9. Define Image Segmentation.
10. Mention few boundary and regional descriptors?

III. Explain the following questions.

1. How to calculate the total number of pixels in an Image. Explain
2. Distinguish between analog and digital image.
3. Sketch the block diagram for fundamental steps in Digital Image Processing.
4. Describe the characteristics of Light and three quantities of colour.
5. Explain in detail about the object recognition.

IV. Briefly explain the following questions.

1. Write the difference between Lossy and Lossless Compression.
2. Explain in detail about the Morphological Process and its operation.
3. What are the applications of Digital Image Processing in various fields?

ANSWERS

1(c)	**2(a)**	**3(b)**	**4(b)**	**5(c)**
6(d)	**7(a)**	**8(b)**	**9(c)**	**10(d)**



CHAPTER 06

Sound Engineering

ME6QN

LEARNING OBJECTIVE

The students can understand the following in this chapter

1. Characteristics of sound waves
2. Microphones & Speakers
3. Audio mixer-types
4. Applications of Acoustic Engineering
5. PA system and Audio power amplifier circuits
6. Effects of noise pollution

6.1 Introduction

In this chapter, we can learn some fundamental knowledge and skills regarding the field of sound engineering.

First we have to understand, what is sound and audio? Sound is a frequency caused by vibration that can be heard by humans, animals or any device that can pick up those frequencies.

Audio means 'of sound' or 'of the reproduction of sound'. Specifically it refers to the range of frequencies detectable by the human ear-approximately 20Hz to 20 kHz. The audio work involves the production, recording, manipulation and reproduction of sound waves.

We can also study about the microphone, speaker, PA system, Power amplifier circuits, acoustical applications and DTS/DOLBY systems.

DO YOU KNOW?

Sound travels in different mediums in different speed

Speed of sound in solids : 5960 m/s

Speed of sound in liquids : 1482 m/s

Speed of sound in Air (gases) : 334 m/s

Sound cannot travel in Vacuum

6.2 Characteristics of Sound waves

The figure 6.1 shows the waveform of a sound wave. We know that *sound travels*

in the form of waves.A wave is a vibratory disturbance in a medium which carries energy from one point to another without a direct contact between the two points.

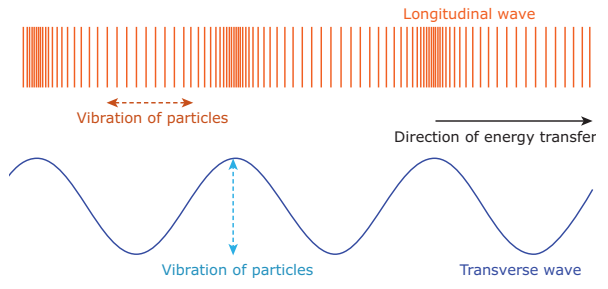


FIGURE 6.1 Longitudinal and Transverse Wave

There are two types of waves:

1. Longitudinal waves
2. Transverse waves.

Longitudinal Waves: A wave in which the particles of the medium vibrate back and forth in the 'same direction' in which the wave is moving. Medium can be solid, liquid or gases. Therefore, sound waves are longitudinal waves.

Transverse Waves: A wave in which the particles of the medium vibrate up and down 'at right angles' to the direction in which the wave is moving. These waves are produced only in a solids and liquids but not in gases.

Sound is a longitudinal wave which consists of compressions and rarefactions travelling through a medium.

Sound wave can be described by five characteristics: They are

1. Wavelength
2. Amplitude
3. Time-Period
4. Frequency
5. Speed or Velocity

Fig 6.2 shows characteristics of sound waves.

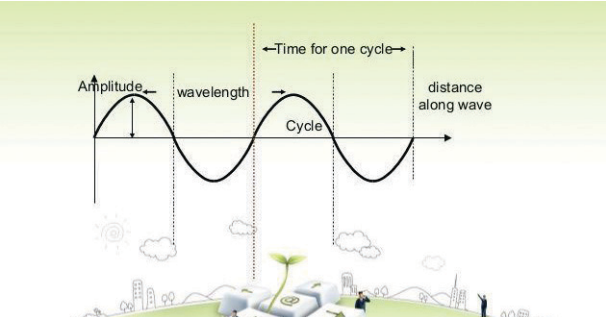


FIGURE 6.2 Characteristics of Sound waves

1. Wavelength

The minimum distance in which a sound wave repeats itself is called its wavelength. That is it is the length of one complete wave. It is denoted by a Greek letter λ (lambda). In a sound wave, the combined length of a compression and an adjacent rarefaction is called its wavelength. Also, the distance between the centers of two consecutive compressions or two consecutive rarefactions is equal to its wavelength. The SI unit for measuring wavelength is meter (m).

2. Amplitude

When a wave passes through a medium, the particles of the medium get displaced temporarily from their original undisturbed positions. The maximum displacement of the particles of the medium from their original undisturbed positions, when a wave passes through the medium is called amplitude of the wave. In fact the amplitude is used to describe the size of the wave. The SI unit of measurement of amplitude is meter(m). The amplitude of the vibrating body producing the sound determines the loudness of the sound. If the amplitude is higher, the sound produced is louder.

3 Time-Period

The time required to produce one complete wave or cycle is called time-period of the wave. Now, one complete wave is produced

by one full vibration of the vibrating body. So, we can say that the time taken to complete one vibration is known as time-period. It is denoted by letter T. The unit of measurement of time-period is second (s).

4. Frequency/pitch

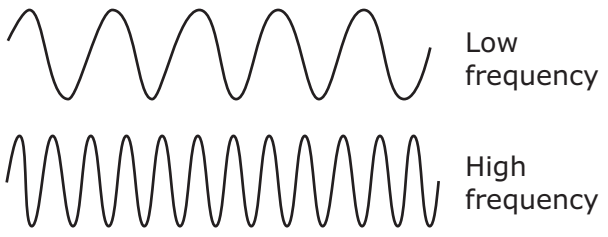


FIGURE 6.3 High and low frequency

The number of complete waves or cycles produced in one second is called frequency of the wave. Since one complete wave is produced by one full vibration of the vibrating body, so we can say that the number of vibrations per second is called frequency. The SI unit of frequency is Hertz (Hz). The pitch of a sound is the ear and brain interpreting the frequency of the sound. When there is a high frequency, the ear interprets the sound as a higher pitch, when the frequency is low the ear hears a low pitch as shown in fig 6.3. It is a measure of sound in frequency.

5. Speed or Velocity

The distance travelled by a wave in one second is called velocity of the wave or speed of the wave. It is represented by the letter v. The SI unit for measuring the velocity is meters per second (m/s or ms^{-1}).

6.3 Microphones

Though we studied about microphones in XI standard, here we see some more important role of microphones in sound engineering.

A microphone is a device that translates sound vibrations in the air into electronic signals and scribes them to a recording medium or over a loudspeaker. Microphones enable many types of audio recording devices for purposes including communications of many kinds, as well as music vocals, speech and sound recording. The following is the method of conversion of sound waves into electrical signal.

- Sound waves strike the diaphragm.
- Diaphragm vibrates in response.
- The voice coil, attached with the diaphragm, vibrates with it.
- The voice coil is surrounded by a magnetic field created by the magnet.
- The motion of the voice coil in this magnetic field generates the electrical signal.

The basic types of microphones, classified according to their principle of operation are: Carbon, Crystal, Dynamic, Ribbon and condensor.

Characteristics of microphone

Each of these has its own characteristics of microphone: (1) Output level (2) Frequency response, (3) Output impedance and (4) Directivity.

Among the above the important characteristic of a microphone is its output impedance. This is a measurement of the AC resistance looking back into the microphone. Generally, microphones can be divided into low (50–1,000 ohms), medium (5,000–15,000 ohms) and high (20,000+ ohms) impedance.

6.3.1 Specifications of Microphone

- Frequency response.
- Polar response.
- Sensitivity.
- Maximum sound pressure level.
- Self-noise.

Among the above, Frequency response and Polar response are more important for a microphone performance.

Frequency Response

If we break down the term, "frequency response" means how well a microphone responds to frequencies. Microphones are primarily designed to respond to sound frequencies (20 Hz – 20,000 Hz). Some microphones will also respond well to infrasound (sound frequencies less than 20 Hz) and ultrasound (sound frequencies greater than 20,000 Hz).

Polar Response

A microphone's polar response/pattern represents its directional sensitivity. In other words, how well the mic responds to sounds from various directions. Omni directional, Cardioid or Unidirectional and Bidirectional are common qualitative polar patterns, and each mic has its own quantitative polar pattern.

Polar Pattern Types

There are 3 general microphone polar patterns:

- Omni directional: Omni directional microphones are, at least in theory, equally sensitive to sounds coming from all directions.
- Bidirectional: bidirectional microphones are equally sensitive to sounds from the front and rear of the mic capsule/element and have a "ring of silence" which rejects sound sources from the sides of the capsule/element.
- Unidirectional: unidirectional microphones are most sensitive in one direction. These are the Cardioid-type polar patterns which vary greatly in their directionality and null points of maximum rejection.

Microphones are also classified according to their power usage, they are passive microphone and active microphone.

6.3.2 Active Microphone

Active microphones are the same as passive microphones, but, they have one major difference — they have internal electronics and a custom transformer that boost the mic's output level and maintain consistent impedance over the entire frequency spectrum.

6.3.3 Passive Microphone

A passive microphone does not need power in order to function. Dynamic mics are passive since they work on electromagnetic induction, which requires no power. Mics without internal preamps,



FIGURE 6.4 Dynamic & Cardioid microphones

6.3.4 Lavalier Microphone (color Mic)

Lavalier Microphone (Fig 6.5) are also known as lav, lapel or lap microphones. It is a very small condenser mic designed to pick up speech from a single person. This mic is widely used for TV program, public Address systems etc.



FIGURE 6.5 Lavalier Microphone

Lavalier mic is usually attached to the subject's clothing with a specialized lapel or thereabouts. This provides consistent close range sound pickup and ideal for interview situations. It also It also means that the subject does not have to worry about the mic techniques to worry about mic techniques.

Try to discretely hide the cable in the clothing. If there is nowhere to place the mic on the subject's chest, try the color. Lavalier mics can be quite susceptible to noise caused by movement of the subject position the mic, making sure it can not move around too much, and make sure the cable not to be pulled by anyway.

A small wind filter can be used to reduce wind noise.

6.3.5 Micro Electro-mechanical Microphones (MEMS)

MEMS microphones (Fig 6.6) are extremely small microphones designed to fit on a silicon chip. They are based on the same working principles as condenser microphones. They have an analog to digital converter (ADC) module installed on the same chips. It converts the analog input into digital values, which are used by the modern electronic devices of today.

MEMS find use in modern-day electronic gadgets, such as cellphones, tablets, laptops, automotive industry, etc.

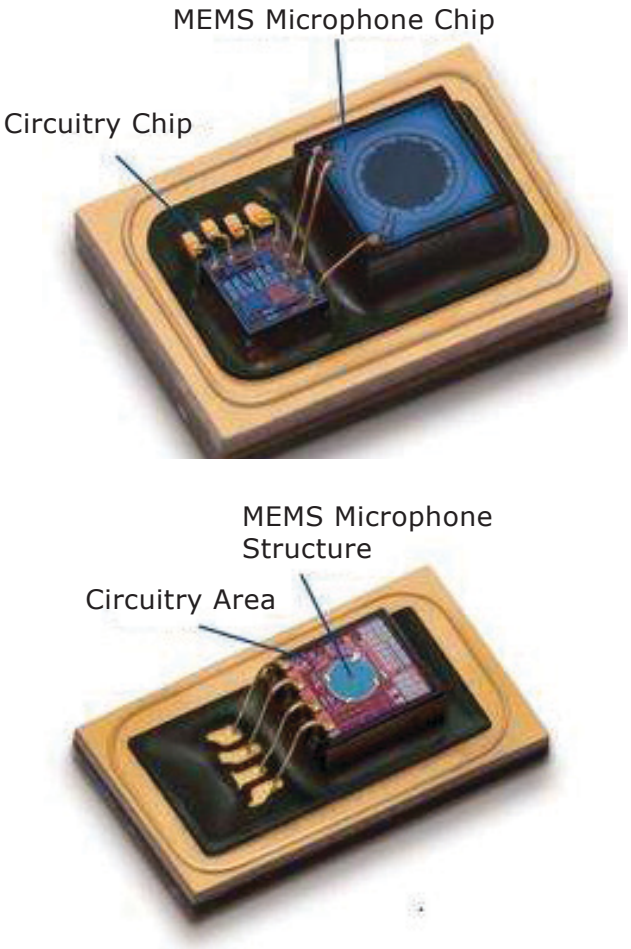


FIGURE 6.6 MicroElectroMechanical Michrophones (MEMS)

6.4 Head phones

Headphones (Fig 6.7) are a pair of small speakers, which is used for listening to sound from a music player, computer, Laptop, Smart phone or such other electronic devices. It is also called as earphones or Headset.

The modern headphones are available in much smaller format that is inserted into the ear and commonly called ear buds. Nowadays headphones can be either wireless or wired.

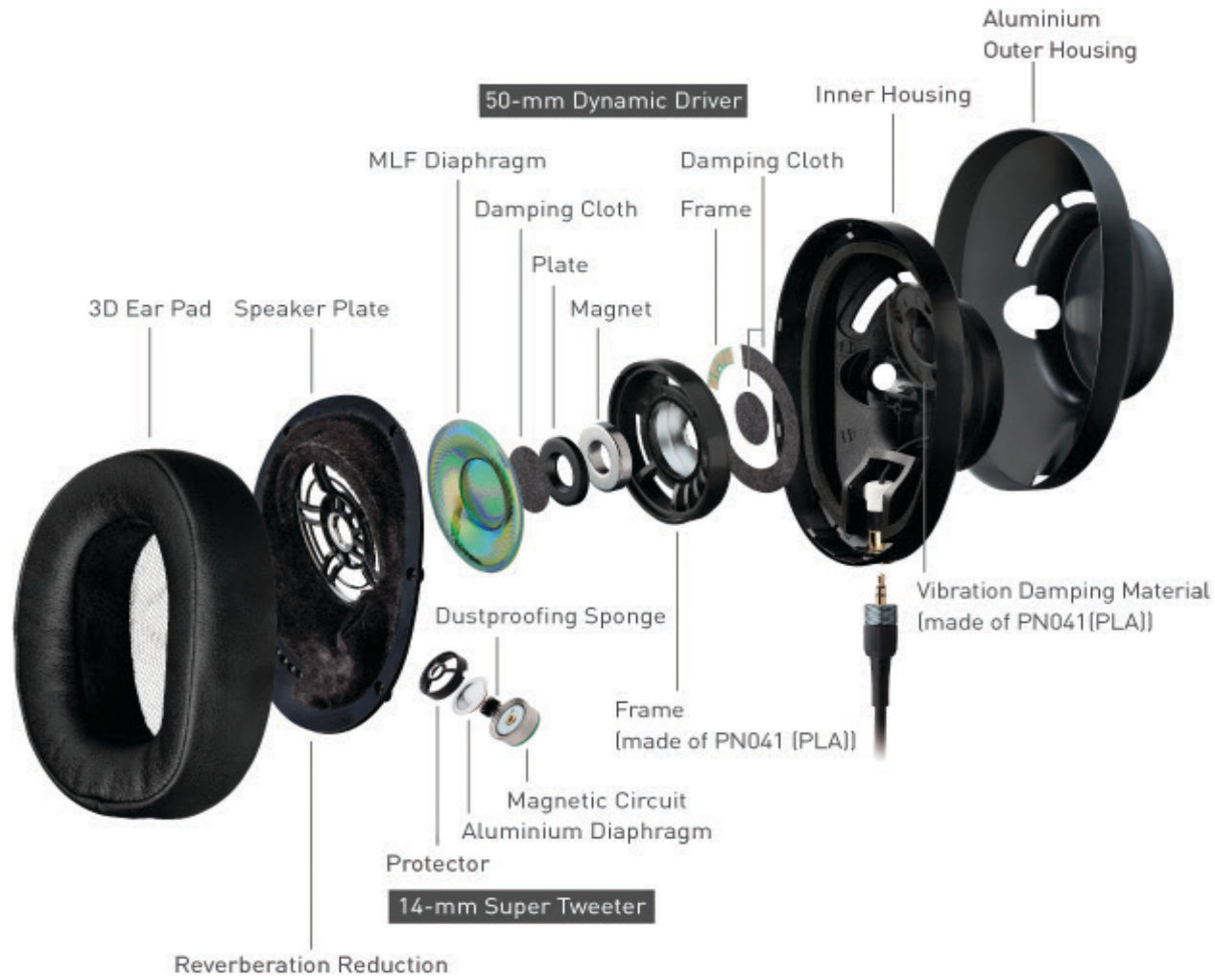


FIGURE 6.7 Headphones

DO YOU KNOW? **The first headphone was developed in 1910 by the US navy. It was simple and was used as an earpiece device without complicated electronics.**

Working functions

Headphones work like a speaker and opposite to microphones. It covert electrical energy into sound by using magnet to vibrate the air, which creates sound.

Once the electrical signals make its way through the wires into your headphones, it reaches what is called a driver unit.

There are three types of driver units. They are

1. Dynamic driver
2. Planar magnetic driver
2. Electrostatic driver

Most of the headphones uses Dynamic driver unit. They are

1. Permanent magnet
2. Electromagnetic coil
3. Diaphragm.

Basically, how headphones work largely lies in the fact that they use magnets. In each ear cup, one magnet is permanent magnet and is firmly placed and the other is an electromagnet, which moves.

When the electrical signal hits your ear cup, it is sent to the electromagnet, which rapidly switches its polarity back and forth depending on the pattern it sent or the sound being reproduced. When the electromagnet switches it is polarity, it's rapidly repelled and attracted to the permanent magnet, which makes it vibrate. Those vibrating electromagnets are attached to what is called a 'diaphragm' which is a thin membrane. When the electromagnets vibrate, the diaphragm does too, which causes the air around it to vibrate, which is what we called sound.

Different frequencies vibrate at different rates so the electromagnet vibrates faster to produce high tones, or slower to produce slow tones. When we turn the volume up or down, the vibrations are more or less intense, which causes the air to vibrate high or low and thus sound varies. Most of the headphones uses dynamic driver unit.

6.5 Speakers

Loudspeaker, also called speaker, is a sound reproduction device for converting the electrical energy into acoustic signal energy, that is radiated into a room or open air.. The term signal energy indicates that the electrical energy has a specific form, corresponding, to speech, music, or any other signal in the range of audible frequencies (roughly 20 to 20,000 Hertz).

A single loudspeaker cannot fully reproduce the entire frequency range of recorded sound, so it is customary to divide the frequency spectrum into parts that are reproduced by different kinds of speakers designed for a particular frequency range. The low-frequency speaker is called a woofer, and the high-frequency speaker is called a tweeter. In many sound reproduction systems a third, or midrange, speaker is also used, and in a few systems there are separate "subwoofers" and "super tweeters" to reproduce the extremities of the audible spectrum. The sound energy is measured by the unit called decibels (dB).

6.5.1 Basic Speaker Parts

Figure 6.8 shows various parts of a speaker (driver).

- The Driver. A loudspeaker is defined as the sound driver or driver.
- The Enclosure. Made from wood, plastic and in some cases drywall or concrete. The enclosure is the box or cavity where the driver is mounted.
- The Diaphragm.
- The Cone.
- The Voice Coil.
- The Dust Cap.
- The Spider.
- The Surround.

Every speaker has at least three parts – enclosure, driver (or drivers), and electronic components (crossovers, amplifiers).

Speaker Driver

Driver is the part of the speaker that actually transforms all the electrical signals into sound. It consists of several parts that are glued together.

At the bottom of the driver, there is a rear (bottom) plate and a pole piece (they are made of metal). A ring-shaped permanent magnet is placed onto the bottom plate and then glued to the top (front) plate. The voice coil windings are held by the voice coil former, which fits the pole piece. Two ends of the voice coil are attached to the solder terminal (which is located somewhere on the frame).

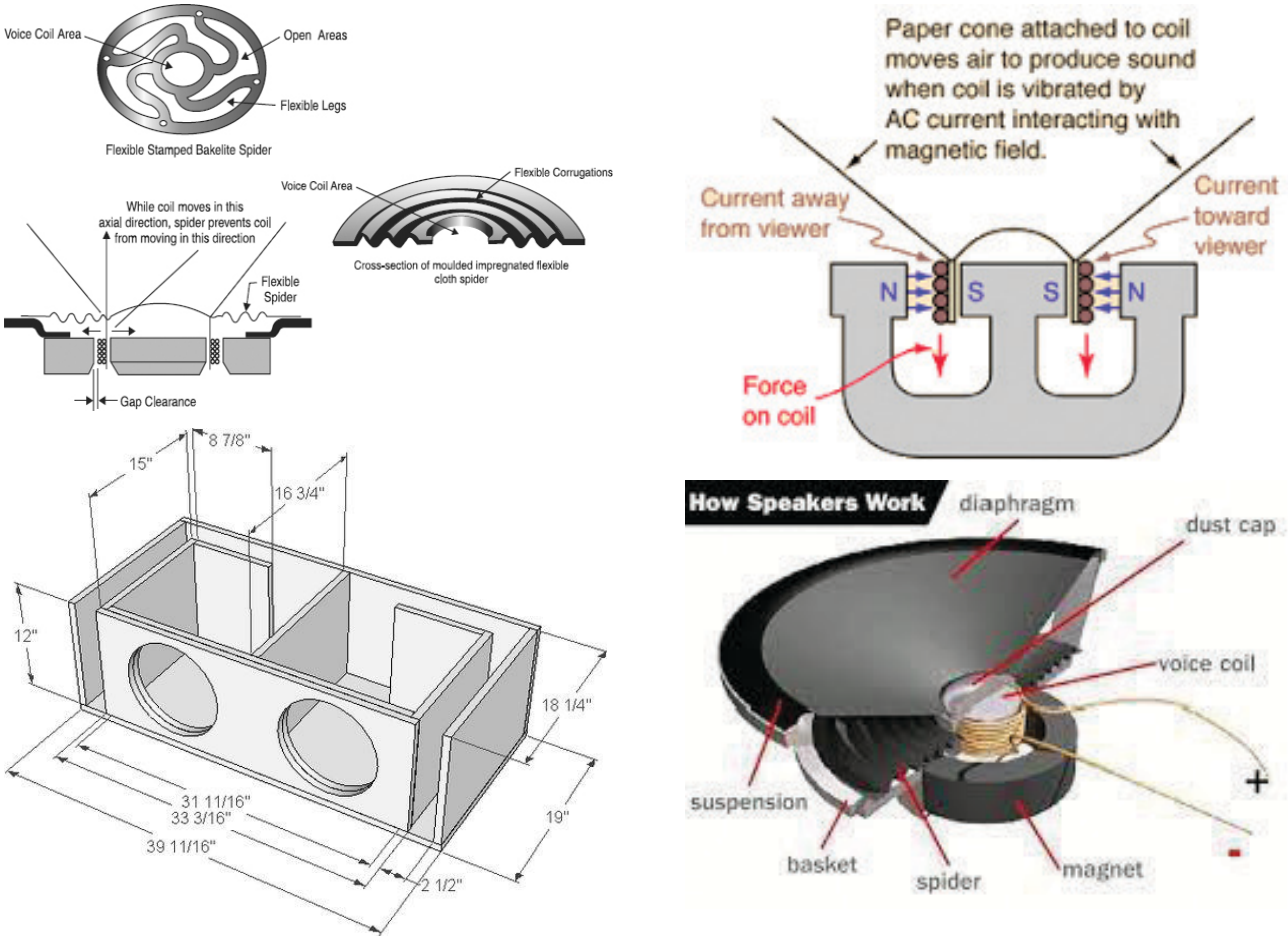


FIGURE 6.8 Various parts of speaker (driver)

The amplifier is also connected to the solder terminal. When the electrical signal from the amplifier (alternating current) is fed to the coil, the coil becomes an electromagnet and reacts with that ring-shaped permanent magnet. This basically means that the voice coil moves back and forth depending on the orientation of the poles (electromagnet changes the orientation of the poles if the current flow is reversed). The electrical signal fed to the coil constantly changes the flow of the current causing the voice coil to move. The metal frame (basket) is glued to the top plate and it holds the speaker cone (diaphragm).

Cone/Diaphragm

It is the part that creates the sound waves (converts the mechanical motion of the voice coil into sound). The diaphragm is glued to the voice coil former and to the rubber surround which is the thing that keeps the diaphragm in place (along with spider). The diaphragm is glued to the frame.

The spider

It is the part that keeps the voice coil in position and ensures that the voice coil only moves along the axis. The spider is glued to the frame and to the voice coil.

The dust cap

It covers and protects the voice coil and internal parts of the speaker.

When the electrical signal (current) is fed into the coil, the coil moves back and forth and along with the coil, the diaphragm (cone or dome) moves, since it is glued to it. The diaphragm basically gets pushed and

pulled by the voice coil. The diaphragm pushes and pulls the air in front of it and creates sound waves (sound pressure waves). These waves come to our eardrums and cause them to vibrate. The eardrum vibrations are sent to our brain as electrical signals and then interpreted as sound.

Since the electrical signal can be interpreted as a wave, the loudness and frequency of the output sound (which is also a wave) are determined by the input signal. The frequency of the electrical signal determines the speed of the voice coil movements which corresponds to the frequency of the output sound. The amplitude of the input electrical signal determines the distance the voice coil has to cover which corresponds to the loudness of the sound (sound pressure level).

Now, let's think about the last two sentences. Is it possible for one driver to produce all the audible frequencies (20 Hz to 20 kHz) equally well? Larger drivers have larger cones which mean they are heavier and harder to move/vibrate. They are not good enough when it comes to high-frequency reproduction, since they cannot move fast. On the other hand, small driver cones can vibrate at a greater rate (they can move faster) but they are not good enough for low-frequency reproduction (it is difficult to make them vibrate at slow rates). That's why many manufacturers make speakers with multiple drivers – each driver is in charge of reproducing a certain range of frequencies.

6.5.2 Types of Drivers

Based on the size, the drivers can be divided into 3 groups:

Woofers – The largest drivers (usually larger than 5 inches). They are in charge of low frequencies.

Midrange drivers (midrange woofers or mid woofers) – Smaller than woofers but larger than tweeters (usually 3-5 inches). They are in charge of midrange frequencies.

Tweeters – The smallest drivers (usually 1-inch drivers or even smaller). They are in charge of high frequencies. Figure 6.9 shows the three different types of speakers.



FIGURE 6.9 Different types of drivers in a 3-way speaker

6.5.3 Importance of Crossover

In order to connect the different drivers (woofers, midrange woofers, and tweeters) to work together, you need a device that would break the input signal into two or

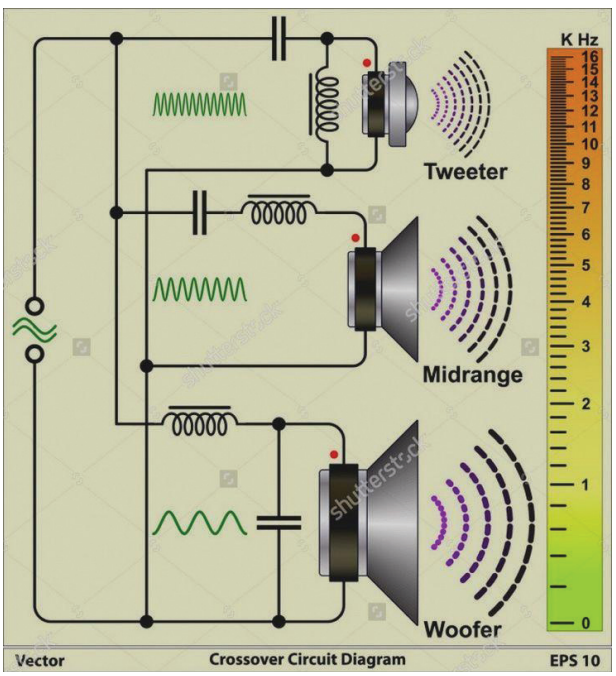


FIGURE 6.10 Cross over Connection of speakers

three smaller outputs signals (low, mid, and high-frequency signals) and send them to appropriate drivers. These devices are called crossovers. Figure 6.10 shows cross over connection of speakers.

6.5.4 Enclosure/Housing/ Cabinet

The box inside which all the drivers and other components are installed is called enclosure. Depending on the type and size of the enclosure, the sound will be different.

6.5.5 The Importance of the Enclosure

The third part of a speaker is the enclosure. This is the box (made of wood, MDF, plastic, or some other material) that holds the drivers and other electronic components. The sound would exist even without the enclosure but there are a few reasons for using it. The first reason is the most basic one – it is more convenient to install everything inside one compact box. The enclosure is also very important for sound quality. (see the Fig 6.11). It is supposed to eliminate the driver vibrations and handle the air (sound) that gets pushed behind the driver cone (diaphragm). The diaphragm vibrates due to the movement of the voice coil – it pushes the air toward our ears but it also pushes it back toward the enclosure (it moves back and forth). Different types of enclosures handle this air (or sound waves, if you want) in different ways.



FIGURE 6.11 Enclosure of speakers

6.5.6 Electronic components (crossovers and amplifiers)

Many speakers have amplifiers. Their purpose is to amplify the electrical signal and improve the accuracy of the output signal. Some speakers (those with two, three, or multiple drivers) have crossovers, which redirect signals of different frequencies to dedicated drivers (woofers, midrange woofers, tweeters).

6.5.7 Speaker efficiency

In order to calculate the efficiency, you have to divide the acoustic power output by the electrical power input. The speakers, in general, are highly inefficient when it comes to converting the electrical input into acoustic power output and even the most efficient speakers have efficiency rated at 2%.The higher the sensitivity rating, the louder your speaker is. An average speaker comes with a sensitivity of around 87 dB to 88 dB. A speaker with a sensitivity rating over 90 dB is considered excellent.

6.5.8 Wattage of speaker

Higher the power (watts), the louder and cleaner the speakers will play. Small differences in power however don't make much of an audible change. In order to perceptively hear a difference (a 3dB increase), the power would have to double.

6.5.9 Impedance of speaker

Speaker impedance is a measure of the amount of opposition to current flow in an electric circuit. The speaker impedance is usually measured in ohms, and it is essential for amplifiers, AV receivers, or speakers connected to each other because mismatched impedance will cause distortion.

6.6 Audio Mixer

Audio mixer, also called mixing console, is an electronic device for combining and modifying audio signals. Audio mixers can be analog or digital type. Digital audio mixer use digital signal processing and analog mixers are usually based on operational amplifiers (op-amps) electronic circuits. An 8 channel Audio mixer is shown in figure 6.12



FIGURE 6.12 Audio Mixer

6.6.1 Basic functions and working of audio mixer

An audio mixer is a device with the primary function to accept, combine, process and monitor audio. Mixers are primarily used in four types of environments: live (at a concert), in a recording studio, for broadcast audio, and for film/television. An audio mixer can come in either analog or digital form.

The general functionalities of an audio mixer in a typical sound system.

At the most basic level, an audio mixer combines multiple signals and routes them to a common output for recording or amplification through a sound reinforcement system. "Signals" are those sounds captured by microphones or received from electric instruments.

The function of mixer in the amplifier

A mixer is an electronic device which is often used for changing the quality and the levels of audio signals. It is also known as a mixing console, an audio mixer, or a soundboard. Using a mixer is the most convenient way to route or combine various audio signals and even change the timbre and dynamics of the sound.

The parts of audio mixer

- Input jacks.
- Microphone preamplifiers.
- Equalization.
- Dynamics processing (e.g. dynamic range compression, gating), if supported.

- Routing, including direct outs, auxiliary-sends, panning control, and subgroup assignments.
- Level-control faders (on small mixers, these may be rotary knobs to save space and cost)

Mixer setup instructions

1. Turn each channel's gain knob and level fader all the way down.
2. Connect your main speakers to the mixer's Main out jacks.
3. Power on the mixer and speakers (or power amplifier).
4. Set mixer levels to unity and adjust the speaker output level.
5. Turn up the Main mix fader level to 0 (unity).

The importance of mixing audio

Mixing helps to vary the frequency of each instrument in order to result in a cleaner and better sound quality. Example, placement and instrument volume are adjusted to different levels throughout the song to lead to the intended audio experience.

Using a mixer in the field or in post production gives more control over sound production. By addressing the soundtrack in the same way how we deal with the video, we'll find dramatic increase in the quality of the audio in our video productions.

The four types of audio signal level

In fact, there are four different types of signals in the audio world that when mismatched can cause problems.

- Microphone Level. Microphone level or mic level is the voltage signal produced by a microphone (surprise) and is the weakest of all the audio signals.
- Line Level – Examples of line level – Headphone output of phone, Aux input on car stereo.
- Instrument Level – Examples Guitar, keyboard.
- Speaker Level – Example Speaker.

Analog Mixers

Analog consoles follow a more "hands-on" approach that makes the workflow very fast and intuitive. They might seem intimidating at first because of all the knobs that they have, but these controls are actually organized in a very simple-to-understand way, since all the controls on channel one are identical to the controls on channel 2, and these are called "channel strips".

Digital Mixer

With digital consoles one could say that you also get that instant access to all the controls like faders, and other simple processing (this depends on the mixer itself), but you also have the ability to access a lot more processing power that comes built-in with the mixer. However, this has to be done on a channel-by-channel basis, meaning that you have to select the channel you want to process and then go into a menu to select the effects you want to add.

One difference with analog mixers is the routing; you can select where to route each input, and in fact you can even layer multiple inputs, meaning that you can control a large number of input channels via a handful of faders by arranging them in fader layers.



FIGURE 6.13 Digital Mixer

One feature that is worth noting about digital consoles is that they can store your different setups as presets. You may have three different bands playing at a venue and instead of manually moving the faders like you would on an analog console. You can save the settings for each band as presets and recall them with the press of one button.

6.7 Acoustic Engineering

Acoustic is a branch of physics concerned with the study of sound (mechanical waves in gases, liquids and solids), and a scientist or an engineer who works in the field of acoustics is an acoustical. Acoustics have much application in the everyday world and this technology is called acoustical engineering.

The study of acoustical can be sub divided into three parts. They are production, transmission, and reception. All these elements are necessary for sound to occur. For example, a ringing alarm clock cannot be heard if it is placed inside a vacuum container. Without air, sound produced by the clock has no medium through which it can travel.

Application of Acoustics:

Acoustics have wide range of applications in many fields. We can study some of them.

1. Noise and environmental Acoustics

Noise Specialists are mostly concerned with making our world a (quitter) peaceful place. They study man – made noise caused by machinery, transportation using roadways, Railways, aircraft and general activities. Knowledge produced by these scientists can be used to redesign noisy machinery or to recommend ways of redesign noisy machinery or to recommend ways of shielding the noise, They also help law makers and public officials to create rules for limiting exposure of noise.

2. Medical Acoustics

Medical researchers and doctors studied and used acoustics to diagnose and treat different types of ailments. The study of material acoustics includes the use of ultrasound and other acoustical techniques to learn how different types of sound interact with cells, tissues, organs and entire organisms. Bio medical acoustians may work with engineers, physician and speech therapist.

3. Musical acoustics

Musical acoustians study the science of how music is made, travels and is heard. Since musical acoustics combines elements of art and science, people with training in this field can work in the entertainment industry and much more.

4. Speech and hearing

Hearing specialist and speech scientists are interested in how our ears sense sounds, what types of sounds can damage our ears and how speech is made, is traveled and is heard. People interesting in hearing and speech come from many different

fields, including physics, speech and hearing science, experimental psychology, linguistics, electrical Engineering and others.

5. **Architectural acoustics**

Architectural acoustians study how to design buildings and other spaces that have pleasing sound quality and safe sound levels. Architectural acoustics includes the design of concert halls, classrooms and even heating systems they may work with musical acoustians and noise specialists.

6.7.1 Acoustics in Auditorium and Theater

A most important part of our auditorium design is the acoustics. We will start with a brief description of how our ear works in the context of listening.



FIGURE 6.14 Auditorium

How the ear works

The human ear has developed over the evolution of humans into an organ capable of receiving the short term fluctuations of air pressure around us and extracting vast amounts of information from them. These short term air pressure fluctuations are commonly called sound waves.

When listening in an auditorium, our brains try to make sense of the cacophony of sound waves arriving at the ears. Here, it is useful to think of the concept of the flicker fusion threshold.

When the ear is presented with reflections of a sound that arrive much later than the direct sound, the brain interprets those as echoes, and is able to separate them from the original sound. Once the reflections arrive soon enough after the direct sound to pass the threshold of 50 milliseconds, the brain is then able to fuse the reflected energy with the direct sound and use it to enhance the intelligibility of the speech being heard.

Acoustic design principles

The main driver behind acoustic design in auditoriums comes down to the phenomenon above: Strive to keep and enhance 'early' reflections to arrive at the listener not more than 50 milliseconds after the direct sound; and dampen and reduce 'late' reflections that would arrive at the listener more than 50 ms after the direct sound. At a given listener location, if there is more early acoustic energy than late, speech will be intelligible. To that end, surfaces should be provided and shaped to provide such early reflections, and reflection paths that provide late acoustic energy should be made acoustically absorptive.

This leads to certain rules of thumb

1. Shoebox-shaped rooms provide for strong early lateral reflections (even more important for music, but quite helpful for speech as well)
2. Reflections down from a ceiling can often provide early reflections, and therefore should be made acoustically hard (reflective)
3. The back walls of an auditorium have a risk of providing late reflections both to the audience and to the stage: Providing acoustic absorption

at such locations is usually helpful. This could be in the form of fabric panels, slatted wood finish, acoustic plaster or even acoustic drywall.

4. The audience seats and the audience themselves are usually the biggest acoustic absorption in the room. The use of the right amount of acoustic absorption in the seats can serve as a great way to achieve the acoustic goals of the space.

6.8 Power amplifier

6.8.1 Audio Amplifier using TDA 2030 IC

The fig 6.15 shows the circuit of the audio amplifier using TDA 2030 and Figure 6.16 shows the TDA 2030 Pinout. The IC is a monolithic IC, available in Penta watt package. It can be used as a low frequency amplifier. The IC includes high output current (900mA), low harmonic as well as crossover distortion. And also includes the protection system from the short circuit and very high temperature.

Construction and Working Function.

The circuit is constructed with the TDA 2030 IC, which has only 5 pins and all are function pins.

The audio input is given to pin 1 (Non Inverting Pin) of the IC. Pin 2 (Inverting Pin) is connected with capacitor (47mfd) and voltage divided resistors, which acts as a feedback path. Pin 3 is connected with negative voltage ($-V_s$) and the pin 5 is the connected with positive voltage ($+V_{s)}$. The speaker is connected between pin 4 and ground. This circuit provides a 14 watts output.

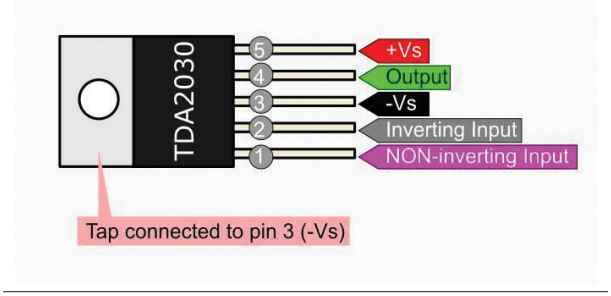


FIGURE 6.16 TDA 2030 Audio Amplifier Pinout

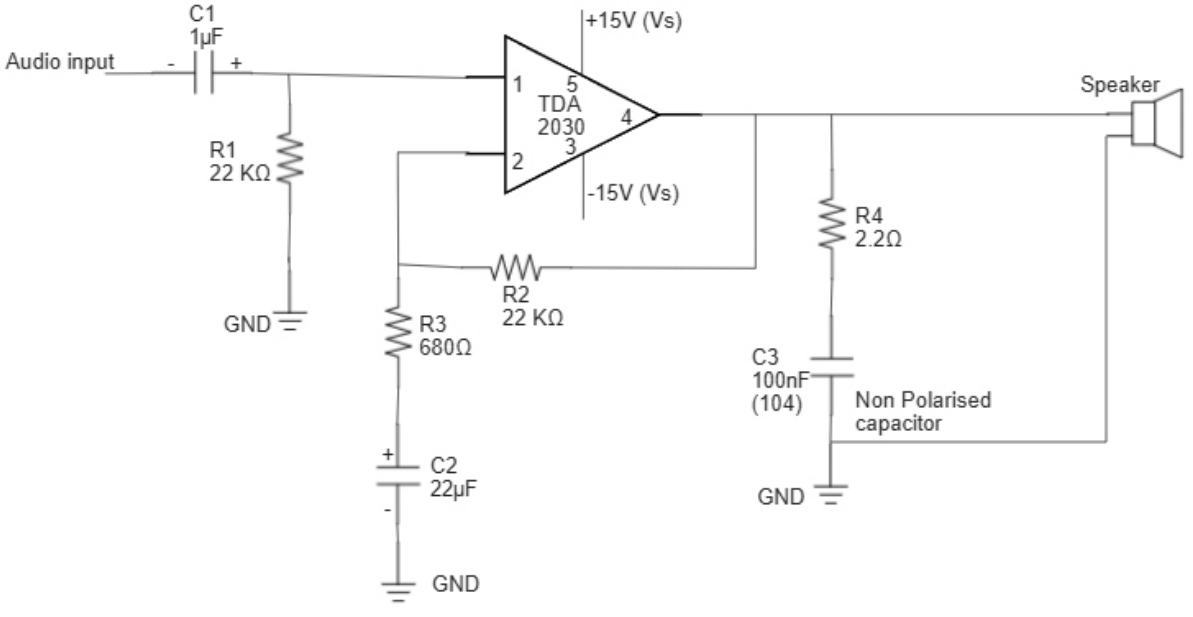


FIGURE 6.15 Audio Amplifier using TDA2030 IC

6.9 Audio effects

Mono and stereo are two classifications of reproduced sound. The main difference between mono and stereo comes with the number of audio channels used in each. Mono is the term used to describe the sound that is only from one channel while stereo uses 2 or more channels to provide an experience much like being in the same room where the sound was created.

6.9.1 Monaural sounds

Mono is a short version on monaural sound, having only one source for the audio.

From the fig 6.17 we can understand that the sound comes from only one source and even though it is transported to two different speakers, the content of the signal is always the same. When listening to music or other auditory speeches using headphones, we cannot hear any difference by removing one earphone.

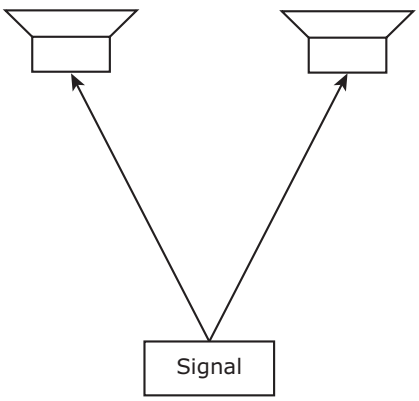


FIGURE 6.17 Monaural Sounds

Mono is still widely used today in situations where stereo only takes up bandwidth and offers no advantages. A good example for this is in voice communications like in talk radio and telephone calls. The equipment needed to record mono sound is only a single microphone and the data it acquires is automatically stored in magnetic tape or converted to digital formats for storage.

6.9.2 Stereophonic sounds

Stereo is a short version of stereophonic sounds. In stereo, several channels are used to transport audio signals to speakers and thus to a listeners ears. Generally, stereo uses two channel, but it can use more. In the most common set up, one channel is transported to one speaker and the other channel to another speaker.

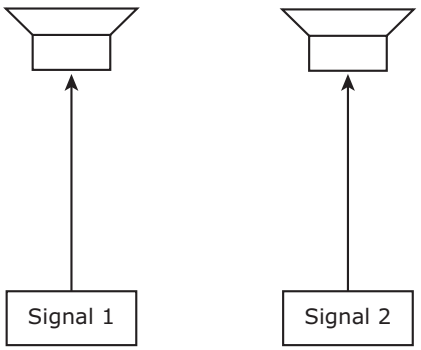


FIGURE 6.18 Stereo Sounds

The figure 6.18 shows the usual setup for stereo sounds. There are two different sources that send their individual signal to one speaker each.

In this system, the sounds that are transported entirely to the right speaker will appear to come from a listener's right side. The signal not only transported to one speaker in its entirely through. Sound can be transported proportionally as well. Meaning that a small proportion of the sound can be transported to the right speaker while the rest is sent to the left one, creating more 3-dimensional hearing experiences. Sounds that are equally transported to both speakers appear to come from the center.

This is all based on the typical set up of two sources of sound that are transported to

two speakers. Thus, stereo is used to create an inspiration of sounds coming from different directions, setting sound in perspective to one another and the listener. This is especially useful in movies and audio plays to emerge the listener / viewer into the story. It is also used in music. Particularly in film songs, the guitar part is send to one speaker, while the bass is send to the other. Headphone users are easily identifying the stereophonic sounds. Removing one earphone can reveal that a particular instrument or sound is only transported to your left or right ear.

6.10 PA System

The figure 6.19 shows the block diagram of public address system. The functions of different blocks are as follows.

Microphone

It converts sound to an equivalent electrical signal. Generally two or three microphone can be connected plus one auxiliary input for CD is also provided.

Mixer

The output of microphone is fed to the mixer stage. The mixer stage is used to isolate different channels from each other before they are fed to the amplifier.

Voltage Amplifier & Processing Circuits

The voltage amplifier is used to amplify the mixer output further. The processing circuit block consists of the 'master gain control' and the 'tone control circuits'. The tone control circuits consist of the base and treble control circuits. The base control circuit will amplify or cut the low frequency signals and the treble control will amplify or cut the high frequency signals.

Driver and power amplifier

The driver amplifier drives the power amplifier to give more power. It is basically a voltage amplifier gives the designed power amplification to its input signal. The push pull type of amplifier is generally used because this type eliminates the even harmonics from the output of amplifier and avoids the core saturation of the output transformer. The power amplifier drives the loud speakers. Matching transformers are used between them to match the low speaker impedance to the output impedance of the power amplifier.

6.11 Home Theater

Home theater system is a combination of electronic components designed to recreate the experience of watching a movie in a theater. When we watch a movie on a home theater system, and sense good experience than watch one on an ordinary television.

To build a home theater, we need to recreate these following elements.

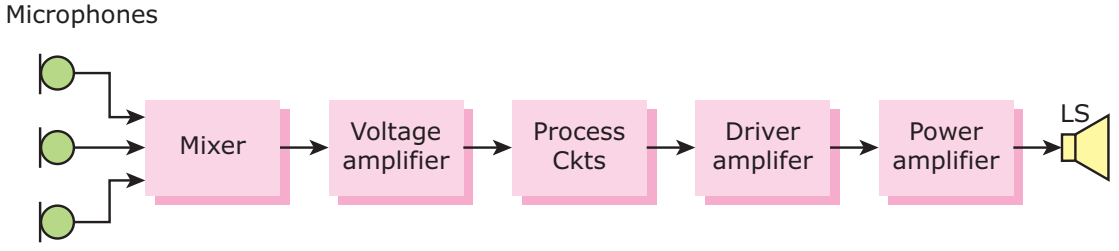


FIGURE 6.19 PA system

- A large screen television (32 inches) with a clear picture
- At least four speakers
- Equipments for splitting up the surround sound signal and sending it to the speakers.
- The main thing that sets a home theater a pact from an ordinary television setup is the surround sound. For a proper surround sound system, two or three speakers in front of the viewer. The audio signal is split into multiple channels so that different sound information comes out of the various speakers. The most prominent sounds come out of the front speakers. When someone or something is making noise on the left side of the screen, we hear it more from a speaker to the left side. Similarly in the right side, we hear from the right side speaker sits in the center, just under or above the screen. This center speaker is very important because it anchors the sound coming from the left and right speakers. It plays all the dialogue and front sound effects so that they seem to be coming from the center of television screen, rather than from the sides



FIGURE 6.20 Home Theater

- The speakers behind the viewer fill in various sorts of background noise in the movie dogs barking, rushing water, and the sound of a plan overhead. They also work with the speakers in front of the viewer to give the sensation of movement a sound starts from the front and then moves behind you.

6.12 Noise pollution

Noise pollution is a type of energy pollution in which distracting, irritating or damaging sounds are freely audible. It is a dangerous pollutant, even destroys bridges and produces cracks in buildings. The noise can cause skin and mental diseases.

Adverse effects of Noise Pollution

Noise effect is harmful to human beings, environment and animals many ways. Some of them are as follows.

1. Hearing Problems

Exposure to noise can damage one of the most vital organs of the body, the ear. Hearing impairment due to noise pollution can either be temporary or permanent. When the sound level crosses the 70 decibel (dB) mark, it becomes noise, for the ear. Above 80 dB produces damaging effects to the ear.

When ear is exposed to extreme loud noise, above 100dB for a considerable period of time, it can cause irreparable damage and may lead to permanent hearing loss.

2. Cardiovascular issue

A noisy environment can be a source of heart related problems.

High intensity sound causes a dramatic rise in blood pressure as noise

levels constrict the arteries, disrupting the blood flow. The heart rate also increases and become one of the reasons to the cardiovascular diseases.

3. Sleep disturbance

This is one of the noise pollution effects that can deter your overall well being. Noise can interrupt a good night's sleep, and when this occurs, the person feels extremely annoyed and uncomfortable. The disturbed person's energy level fall down considerably, and decreases that person's ability to work efficiently.

6.13 Government Rules and Regulations Regarding with Sound

The central pollution control board of India published a rule book, with title the noise pollution (regulation and control) rules, 2000' in the year of 2000.

In this rule book, they have decided all areas in four different zones and decided limits for noise level in respective zones.

1. industrial area : 75 dBA (Day time)
   70 dBA (Night time)
2. commercial area : 65 dBA (Day time)
   55 dBA (Night time)
3. residential area : 55 dBA (Day time)
   45 dBA (Night time)
4. silence zone : 50 dBA (Day time)
   40 dBA (Night **time)**

- 77 dBA for two wheelers between 80cc to 175cc engines
- 75 dBA for two wheelers more than 175cc engines
- 75 dBA for cars (less than 9 seater)
- 80 dBA for heavy vehicles

These are the standard noise limit which has been accepted by government of India.

Loudspeakers may be used with the permission of relevant authority.

The Public Address System (PAS) cannot be used in the night time except in closed areas.

Note

1. Day time shall mean from 6.00AM to 10.00PM
2. Night time shall mean from 10.00PM to 6.00AM
3. Silence zone is an area comprissing not less than 100 meters around hospitals, educational institutions, courts, religious places or any other area which is declared as such by the competent authority.
4. dBA (A – weighted decibel) is unit of noise

LEARNING OUTCOME

After studying this chapter, students can understand the following

1. Characteristics of sound waves
2. Microphones & Speakers
3. Audio mixers-types
4. Applications of Acoustic Engineering
5. PA system and Audio power amplifier circuits
6. Effects of noise pollution

QUESTIONS

Part – A (1 Mark)

I Multiple choice Questions

1. Sound is produced due to _____
   a) Friction
   b) Circulation
   c) Vibration
   d) Refraction



2. Sound waves travel at _____
   a) Same speed in different mediums
   b) Different speed in same mediums
   c) Different speed in different mediums
   d) Highest speed in vacuum
3. Sound wave do not travel through _____
   a) Vacuum b) Solid
   c) Liquid d) Gasses
4. The wavelength of a wave is measured in _____
   a) Meter b) Hertz
   c) Second d) Decibel
5. Sounds above 20 kHz is called _____
   a) Ultra cool
   b) Ultrasound
   c) Infra-audio
   d) Infrasound
6. The velocity of sound in air_____
   a) 300 m/s b) 334 m/s
   c) 1130 m/s d) 350 m/s
7. The voice coil and internal parts of the speaker is protected by _____
   a) Dust Cap b). Spider
   c) Diaphragm d) Magnet
8. _____ is early reflection of sound
   a) Echo
   b) Magnet
   c) Pure sound
   d) Intelligible sound
9. Multiple reflections are called _____
   a) Reverberations
   b) Refraction
   c) Echo
   d) Compressions
10. The noise level of industrial area decided by the central Government is between _____
    a) 40-50 dBA
    b) 45-55 dBA
    c) 55-65 dBA
    d) 70-75 dBA

Part – B (3 Marks)

II Answer in few sentences

1. What is sound? How is it produced?
2. What are the speed of sound in solids, liquids and air?
3. Define Velocity of sound.
4. What are the three types of polar patterns?
5. Write short notes on MEMS.
6. Define tweeter and woofer.
7. What is an audio mixer?
8. Define Noise Pollution.
9. Why is noise pollution dangerous?
10. What is decibel (dB)?

Part – C (5 Marks)

III Answer in a paragraph

1. Explain the two types of sound waves.
2. Explain about Lavalier Microphone.
3. What is the difference between analog and digital mixer? Explain
4. Explain monaural sounds?
5. Explain briefly about home theater.

Part – D (10 Marks)

IV Answer in One Page (Essay type Question)

1. Explain the various applications of Acoustic Engineering.
2. Explain the construction and working function of an audio power amplifier using TDA 2030 IC with a neat diagram.
3. Draw the block diagram of PA system and explain each block

Answers :

1. (c)	2. (c)	3. (a)	4. (a)	5. (b)
6. (b)	7. (a)	8. (a)	9. (a)	10. (d)



CHAPTER 07

POWER ELECTRONICS

LEARNING OBJECTIVE

The students can understand the following in this chapter

1. Applications of Power Electronics
2. Converting AC to DC
3. Types of Inverter
4. DC to DC Regulator
5. AC to AC Regulator
6. Switching Circuits
7. Switch Mode Power Supply

7.1 Introduction

Power Electronics is the study of switching electronic circuits in order to control the flow of electrical energy. Power Electronics is the technology behind switching power supplies, power converters, power inverters, motor drives, and motor soft starters.

Power electronics circuit convert electric power from one form to another using electronic devices. Power electronics circuit function by using semiconductor devices as switches, thereby controlling or modifying a voltage or current.

Applications of power electronics range from high-power conversion equipment such as dc power transmission to everyday appliances, such as power supplies for computers, cell phone chargers, and hybrid automobiles. Power electronics includes applications in which circuits process milliwatts or even megawatts.

Importance of Power Electronics

As the trend towards electrification and renewable energies increases, enabling technologies such as power electronics are becoming even more important. Power electronics is an umbrella term that encompasses the systems and products involved in converting and controlling the flow of electrical energy.

Applications of power electronics include conversion of,

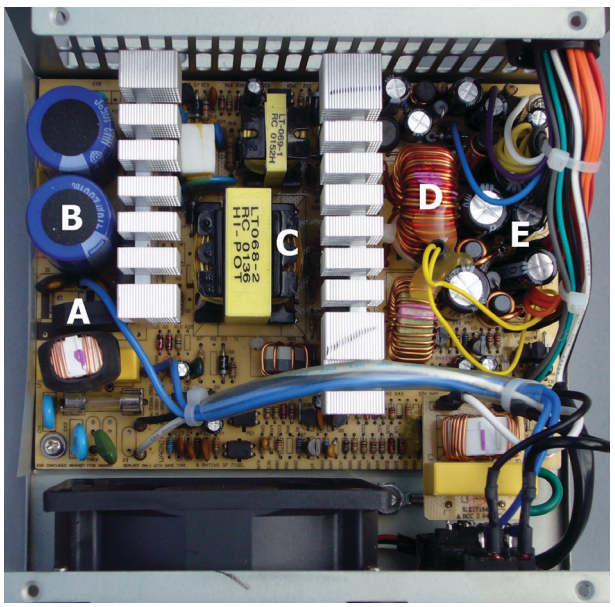
1. AC to DC (rectifier)
2. Conversion of DC to AC (inverter)
3. Conversion of an unregulated DC voltage to a regulated DC voltage (DC to DC converter)
4. Conversion of an AC power source from one amplitude and frequency to another amplitude and frequency. (AC to AC converter)

Applications of power electronics range in size from a Switched Mode Power Supply in an AC adapter, battery chargers, audio amplifiers, fluorescent lamp ballasts, through variable frequency drives and DC motor drives used to operate pumps, fans, and manufacturing machinery, up to gigawatt-scale high voltage direct current power transmission systems used to interconnect electrical grids. Power electronic systems are found in virtually every electronic device.

In Hybrid Electric Vehicles (HEVs), power electronics are used in two formats: series hybrid and parallel hybrid. The difference between a series hybrid and a parallel hybrid is the relationship of the electric motor to the internal combustion engine (ICE). Devices used in electric vehicles consist mostly of dc/dc converters for battery charging and dc/ac converters to power the propulsion motor. Electric trains use power electronic devices to obtain power, as well as for vector control using pulse width modulation (PWM) rectifiers. The trains obtain their power from power lines. Another new usage for power electronics is in elevator systems. These systems may use thyristors, inverters, permanent magnet motors or various hybrid systems that incorporate PWM systems and standard motors.



A battery charger is an example of a piece of power electronics



A PCs power supply is an example of a piece of power electronics, whether inside or outside of the cabinet.

The Difference between Electrical and Electronics Circuits

Both involve moving electricity around a circuit to ***power*** useful products and machines, but that is where the similarity ends!

The main ***difference between*** *electrical and* ***electronic*** circuits is that electrical circuits have no decision making (processing) capability, whilst ***electronic*** circuits do.

7.2 Converter Classification

The objective of a power electronics circuit is to match the voltage and current requirements of the load to those of the source. Power electronics circuits convert one type or level of a voltage or current waveform to another and are hence called converters. Converters serve as an interface between the source and load. This is shown in fig 7.1

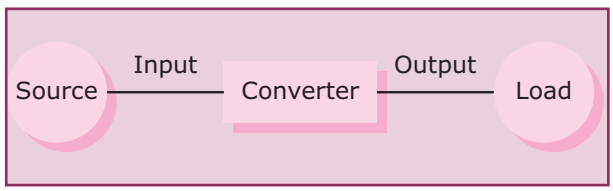


FIGURE 7.1 Power Electronics

Converters are classified by the relationship between input and output:

1. **AC input/DC output:** The AC-DC converter produces a dc output from an ac input. Average power is transferred from an ac source to a dc load. The AC-DC converter is specifically classified as a rectifier. For example, an AC-DC converter enables integrated circuits to operate from a 50-Hz AC line voltage by converting the ac signal to a dc signal of the appropriate voltage.

Application

AC/DC rectifiers are used in an electronic device radio, computer, television, etc. These may simply change AC to DC or can also change the voltage level as part of their operation.

2. **DC Input/AC Output:** The DC-AC converter is also called as an inverter. In the inverter, average power flows from the dc side to the ac side. Examples of inverter applications include producing a 220-V rms 50-Hz voltage from a 12-V battery and interfacing an alternative energy source such as an array of solar cells to an electric utility.

Application

DC/AC converters (inverters) are used primarily in UPS or renewable energy systems or emergency lighting systems. Mains power charges the DC battery. If the mains fails, an inverter produces AC electricity at mains voltage from the DC battery. Solar inverter, both smaller string and larger central inverters, as well as solar micro-inverter are used in photovoltaics as a component of a PV system.

3. **DC input/DC output**: The DC-DC converter is useful when a load requires a specified (often regulated) dc voltage or current but the source is at a different or unregulated DC value. For example, 5V may be obtained from a 12-V source via a DC-DC regulator.

Application

DC/DC regulator are used in most mobile devices (mobile phones, PDA etc.) to maintain the voltage at a fixed value, whatever the voltage level of the battery is. These converters are also used for electronic isolation and power factor correction. A power optimizer is a type of DC/DC converter developed to maximize the energy harvest from solar photovoltaic or wind turbine systems.

4. **AC input/AC output:** The AC-AC regulator may be used to change the level and/or frequency of an AC signal. Examples include a common light-dimmer circuit and speed control of an induction motor.

Application

AC/AC regulators are used to change either the voltage level or the frequency (international power adapters, light dimmer). In power distribution networks AC/AC regulators may be used to exchange power between utility frequency 50 Hz and 60 Hz power grids.

Some regulators circuits can operate in different modes, depending on circuit and control parameters. For example, some rectifier circuits can be operated as inverters by modifying the control on the semiconductor devices. In such cases, it is the direction of average power flow that determines the converter classification. In Fig. 7.2, if the battery is charged from the ac power source, the converter is classified as a rectifier. If the operating parameters of the converter are changed and the battery acts as a source supplying power to the ac system, the converter is then classified as an inverter.

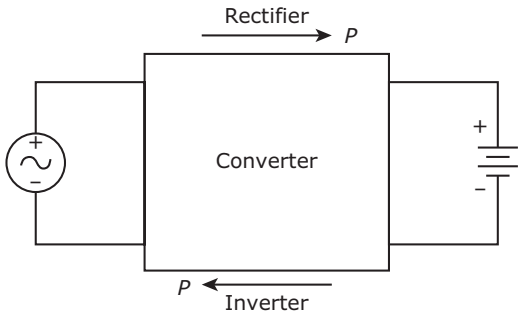


FIGURE 7.2 A converter can operate as a rectifier or an inverter, depending on the direction of average power P.

Power conversion can be a multistep process involving more than one type of converter. For example, an AC-DC-AC conversion can be used to modify an AC supply (source) by first converting it to direct current and then converting the dc signal to an ac signal that has an amplitude and frequency different from those of the original AC source, as illustrated in Figure 7.3.

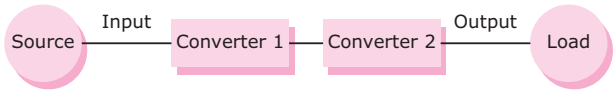


FIGURE 7.3 Two converters are used in a multistep process.

7.3 Converting AC to DC

Introduction

The objective of a full-wave rectifier is to produce a voltage or current that is purely DC or has some specified DC component. While the purpose of the full-wave rectifier is basically the same as that of the half-wave rectifier, full-wave rectifiers have some fundamental advantages. The average current in the ac source is zero in the full-wave rectifier, thus avoiding problems associated with nonzero average source currents, particularly in transformers. The output of the full-wave

rectifier has inherently less ripple than the half-wave rectifier.

In this chapter, uncontrolled and controlled single-phase and three-phase full-wave converters used as rectifiers are analysed for various types of loads. Also included are examples of controlled converters operating as inverters, where power flow is from the DC side to the AC side.

7.3.1 Single-Phase Full-Wave Rectifier

The bridge rectifier is the basic single-phase full-wave rectifier.

The Bridge Rectifier

For the bridge rectifier of Figure 7.4(a) and 7.4(b), these are some basic observations:

1. Diodes D_1 and D_2 conduct together, and D_3 and D_4 conduct together. Kirchhoff's voltage law around the loop containing the source, D_1, and D3 shows that D_1 and D_3 cannot be on at the same time. Similarly, D_2 and D_4 cannot conduct simultaneously. The load current can be positive or zero but can never be negative.
2. The voltage across the load is $+V_s$ when D_1 and D_2 are ON. The voltage across the load is $-V_s$ when D_3 and D_4 are ON.
3. The maximum voltage across a reverse-biased diode is the peak value of the source. This can be shown by Kirchhoff's voltage law around the loop containing the source, D_1, and D_3. With D_1 ON, the voltage across D_3 is $-V_s$.
4. The current entering the bridge from the source is $iD_1 - iD_4$, which is symmetric about zero. Therefore, the average source current is zero.
5. The rms source current is the same as the rms load current. The source current is the same as the load current for one-half of the source period and is the negative of the load current for the other half. The squares of the load and source currents are the same, so the rms currents are equal.
6. The fundamental frequency of the output voltage is 2ω, where ω is the frequency of the AC input, since two periods of the output occur for every period of the input.

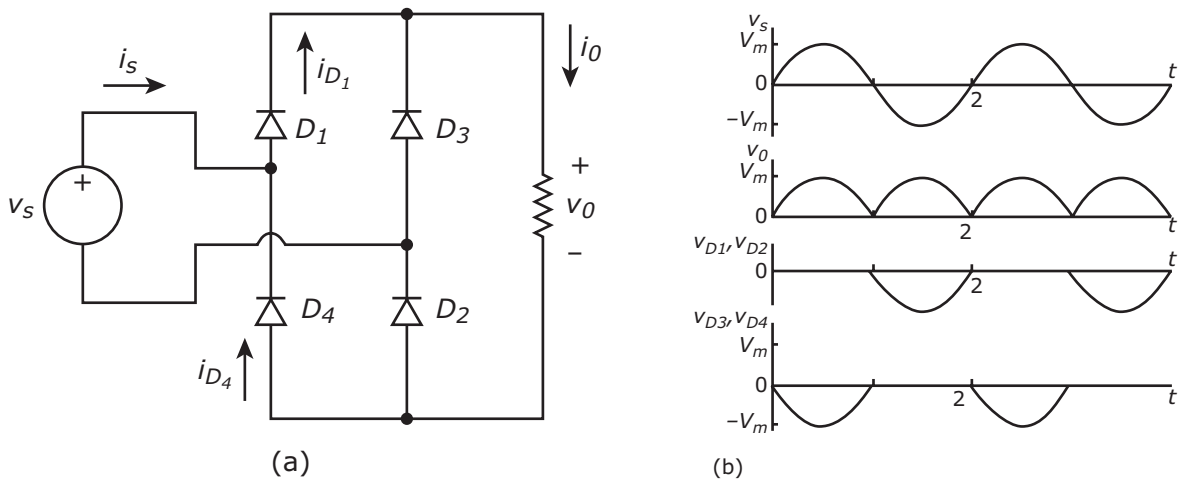


FIGURE 7.4 (a) Circuit diagram. (b) Voltage Wave forms

7.4 DC TO AC - Inverter

Inverter is an electronic circuit, which converts direct current (DC) into alternating current (AC). The input voltage, output voltage and frequency, and all power handling depend upon the DC source. A simple 12 V DC to 220 V AC inverter circuit shown in Figure 7.5 produces an AC output of 220 V AC at line frequency. In this circuit, the 555 is configured as a low-frequency oscillator, which is tuneable over the frequency range of 50 to 60 Hz by the potentiometer R_4. The output of the 555 (amplified by Q_1 and Q_2) is fed into the input of transformer T_1 (a reverse-connected filament transformer with the necessary step-up turns ratio). Capacitor C_4 and inductance coil L_1 are used to filter the high frequency noise and dc components in order to assure a sine wave output. The power output (in watts) of this circuit depends on the selection of required power rating of different components, especially for the transistor and the transformer.

7.4.1 Types of Inverters

There are three different types of outputs from inverters and hence the inverters can be classified into three primary types viz.

- Square Wave inverter
- Modified Sine wave inverter or quasi sine wave inverter
- Pure sine wave inverter

1. Square Wave Inverter

   The input power source for the inverter is a battery and the output is a square AC waveform, which can be used to drive less-sensitive AC devices. The output from the square wave inverter can result in noise. The output voltage, frequency, and waveform of the inverter depend on the design of the inverter.

2. Quasi sine wave inverter

   The first electronic inverters to be introduced were basic square wave inverters. As time and technology progressed, a second generation

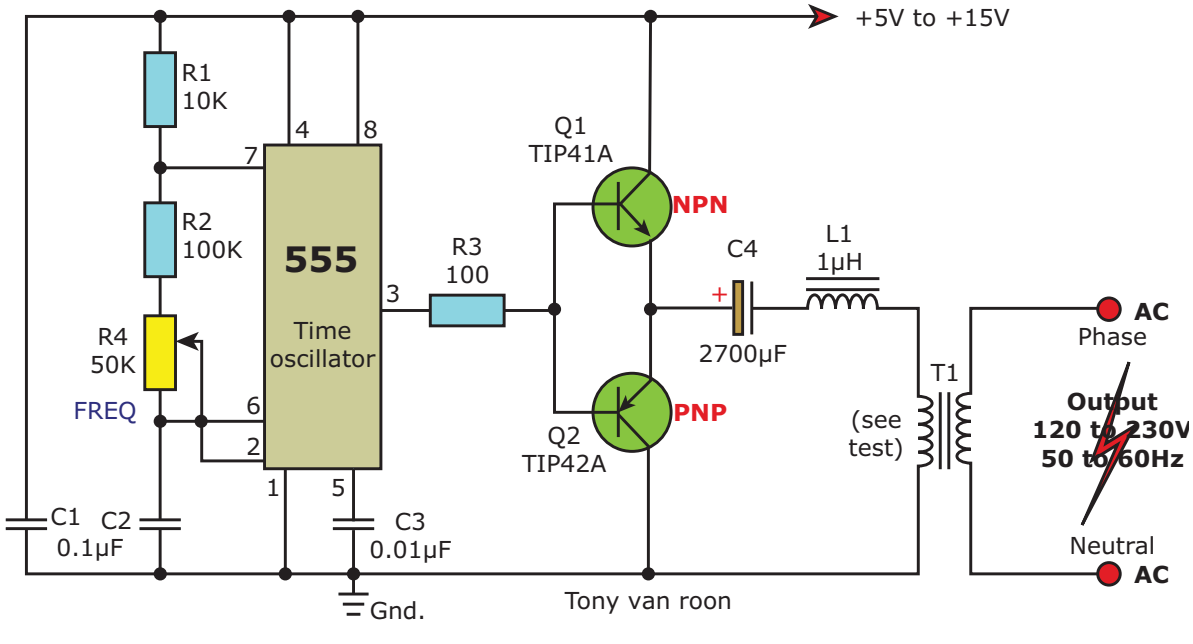


FIGURE 7.5 12 V DC to 220 V AC inverter using 555

power inverter became popular and was called a "modified square wave" or "quasi-sine wave" inverter. It could be more accurately called as modified-square wave.

3. Sine Wave Inverter

   In a sine wave inverter, the input is from a battery and output is a pure sine AC waveform. It is used to give supply to sensitive AC devices. The output is a sine-wave with very low harmonic distortion.

7.5 UPS (Uninterrupted Power Supply)

An Uninterruptible Power Supply (UPS) is a device that allows an electrical/ electronic gadget to keep in operation for at least a short time, when the primary mains power source is lost. It also provides protection from power surge.

Figure 7.6 shows the circuit diagram of a simple UPS circuit that can deliver 12 V unregulated and 5 V regulated DC outputs. The transformer T_1 step-downs the mains voltage to 12 V AC and then the bridge B_1 rectifies it. The rectified signal is smoothed by the capacitor C_1. When the mains supply is present, the battery will be charged via diode D_3 and the regulator IC gets supply via diode D_5. Thus, the 12 V and 5 V DC are available at the output terminals. When mains supply is not available, the battery supplies current to the regulator IC and to the 12 V DC terminal through diode D_4. Also, the diode D_3 blocks reverse flow of current during battery mode. Capacitors C_2 and C_3 act as filters.

Advantages

1. It supplies an un-interrupted power output.
2. AC mains power is present or not, the output is at constant level.
3. Simple and very low-cost circuitry.

7.6 DC to DC regulator

DC-DC regulators are power electronic circuits that convert a DC voltage to a different dc voltage level, often providing regulated outputs. The circuits described in this chapter classified as switched-mode DC-DC converters, also called switching power supplies or switchers. This section describes some basic DC-DC regulator circuits also called Voltage regulators.

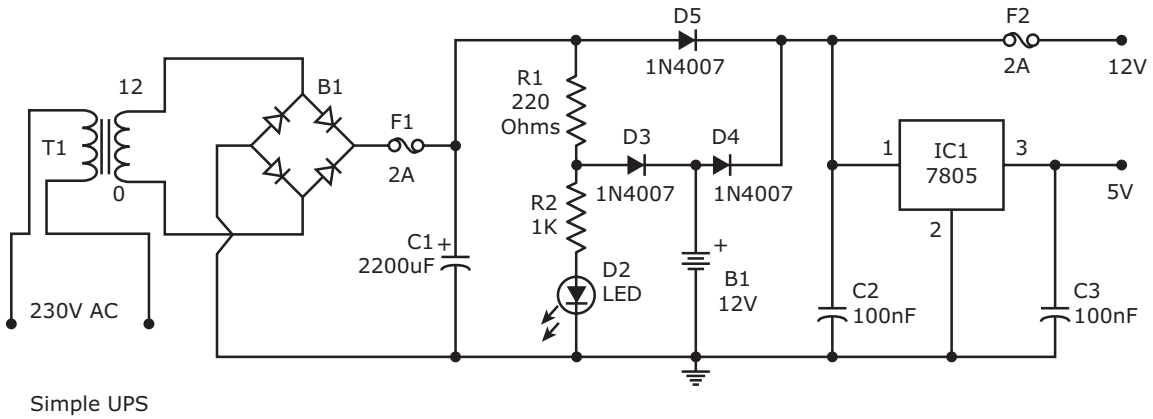


FIGURE 7.6 Simple UPS circuit

7.6.1 Voltage Regulator

A voltage regulator is a circuit used to regulate the output voltage level for a given application. When a steady, reliable and fixed output voltage is required, the regulator circuit provides a constant output voltage irrespective of the changes in the input voltage or load conditions. Also, it acts as a buffer for protecting components from damages.

Basically, there are two types of voltage regulators available

1. Linear voltage regulator and
2. Switching regulator

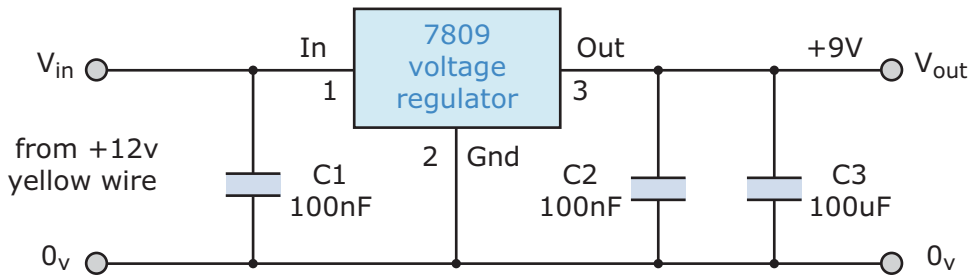
The linear voltage regulators are further classified into series and shunt type regulators. In the case of switching regulators, there are three sub-classes such as step-up, step-down and inverter type of voltage regulator.

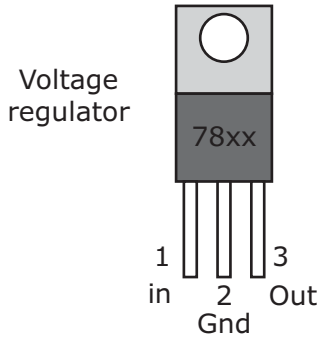
Figure 7.7 shows a 7809 based voltage regulator circuit. It is a member of 78xx series of fixed linear voltage regulator ICs. The input 12 V DC voltage source in the circuit may have fluctuations and would not give a fixed 9 V output voltage. The voltage regulator IC shown in Figure 7.7 maintains the output voltage at a constant value of 9V.

7.6.2 Voltage Regulator-7805

Figure 7.8 shows 7805-based 5 V voltage regulator circuit that regularizes the output voltage at 5 V for the input voltage range of 7-25 V. The pin description of the 7805 is given in the Table 7.1. Here, the 5 voltage regulator IC 7805 is given an reference voltage of 4.3V using a zener diode at the pin 2. This will increase the output voltage from 5V to 9V.

Figure 7.9 shows a complete circuit diagram of a 5V regulator using 7805. In this circuit, the mains 230 AC is converted into 12V AC using a step-down transformer. The voltage at the secondary of the transformer is connected to a bridge rectifier circuits, which converts the 12V AC into a fluctuating DC. The capacitors 1000 µF and 0.22 µF are used to filter- out





Type	Min. input voltage	Output voltage
7805	7V	+5V
7806	8V	+6V
7808	10V	+8V
7809	11V	+9V
7812	15V	+12V
7815	18V	+15V
7818	22V	+18V
7824	30V	+24V

FIGURE 7.7 7809 V DC to DC voltage regulator

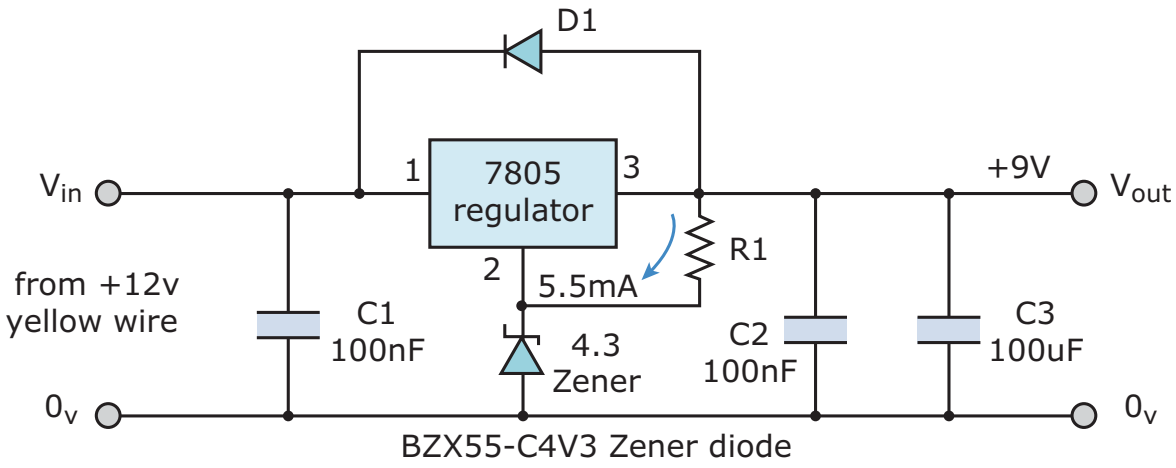


FIGURE 7.8 7805 dc to dc voltage regulator circuit

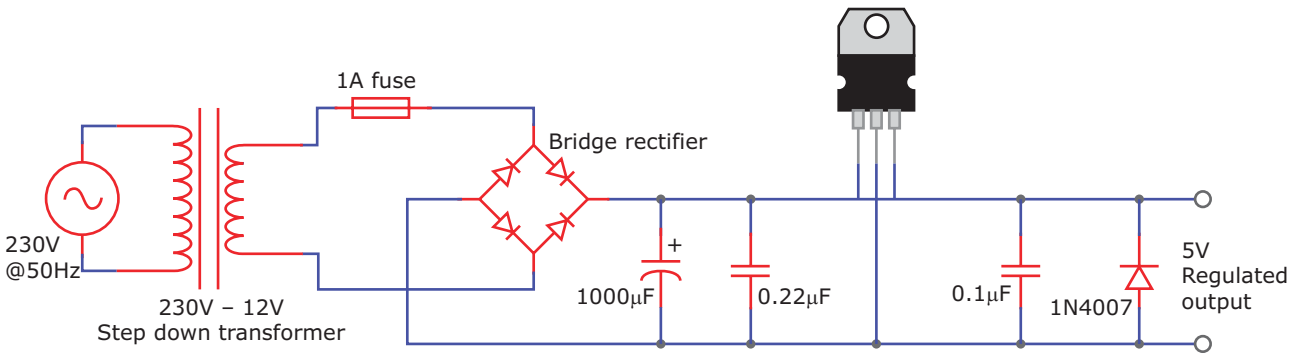


FIGURE 7.9 5 V regulator circuit using 7805

the 50 Hz and high frequency noises, respectively. Now, 12V pure DC voltage is generated, which is fed to the input terminal (pin 1) of the 7805 regulator. The reference terminal (pin 2) is connected to the ground terminal of the power supply. At pin 3, 5V regulated DC voltage is obtained, which is further filtered for high frequency noise. The diode IN 4007 in the output terminal of 7805 provides over-voltage protection.

Important Points on 7805 Voltage Regulator IC

- The input voltage should always be greater than the output voltage (7 to 25 V).
- The input current and output current are almost identical. This means that when a 7.5 V, 1 A supply is given at input, the output will be 5 V, 1 A.

TABLE 7.1 Pin Description of 7805

Pin No	Pin	Description
1	INPUT	Pin 1 is the INPUT Pin. A positive unregulated voltage is given as input to this pin. Voltage range 7-25 V.
2	GROUND	Pin 2 is the GROUND Pin. It is common to both Input and Output.
3	OUTPUT	Pin 3 is the OUTPUT Pin. The output is regulated at 5 V and the maximum current supplied is 1.5 A.

- The remaining power is dissipated as heat and hence a heat sink should be provided to limit the working temperature of the 7805 IC.

7.6.3 Negative Voltage Regulator-IC 79Xx (7905, 7912, 7915, 7918)

The 79xx voltage regulator series is designed to obtain negative power supply voltage required in some of the op-amp circuits. The input to these negative regulators should be a negative voltage, which is 2.5V greater than the required output voltage. The pin diagram of the 79xx series is shown in Figure 7.10. Pin 1 is given a reference voltage, usually the ground voltage. Pin 2 is input terminal where the input negative voltage is given. Pin 3 is the output terminal, where the negative output is drawn. The various negative voltage regulators and their output voltages are listed in Table 7.2.

TABLE 7.2 Negative Voltage Regulators and their output voltage

IC Number	Output Voltage
7905	-05 Volts
7912	-12 Volts
7915	-15 Volts
7918	-18 Volts

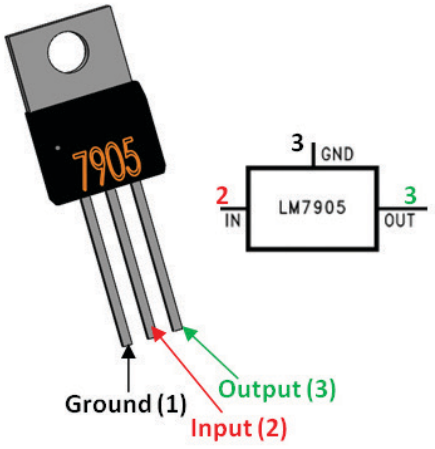


FIGURE 7.10 Pin diagram of Negative Voltage Regulators

Variable Voltage Power Supply: LM317T

LM317 is a popular adjustable positive linear voltage regulator. It was designed by Robert C Dobkin in the year 1976 at National Semiconductor. LM337 (negative voltage counterpart of LM317) is used to regulate negative voltages. LM317 is an adjustable 3–terminal positive voltage regulator capable of supplying in excess of 1.5A over an output voltage range of 1.2V to 37V. This voltage regulator is used two external resistors to set the output voltage. Figure 7.11 shows a variable voltage regulator circuit.

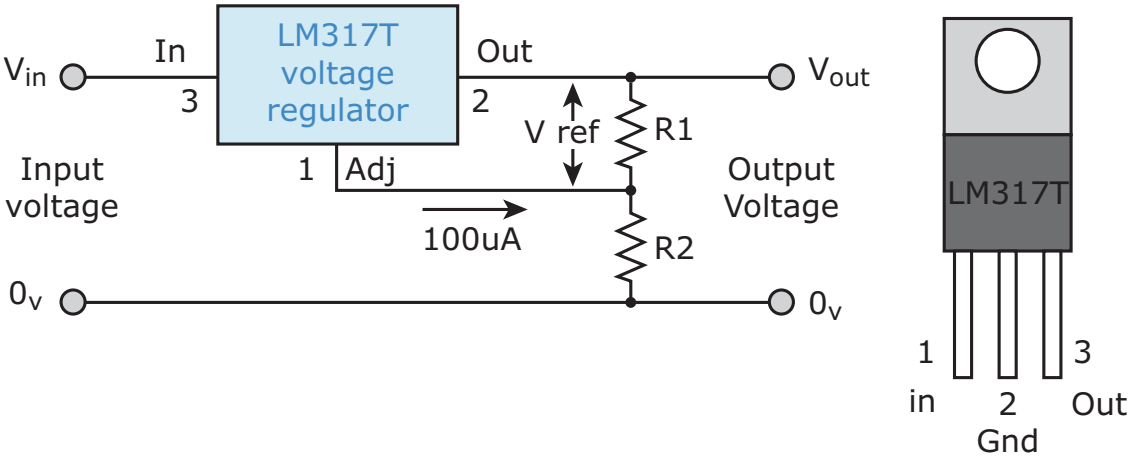


FIGURE 7.11 Variable Voltage Regulator using LM317

7.7 AC to AC Regulators

Introduction

An ac voltage controller is a regulator that controls the voltage, current, and average power delivered to an ac load from an ac source. Electronic switches connect and disconnect the source and the load at regular intervals. In a switching scheme called phase control, switching takes place during every cycle of the source, in effect removing some of the source waveform before it reaches the load. Another type of control is integral-cycle control, whereby the source is connected and disconnected for several cycles at a time.

The phase-controlled ac voltage controller has several practical uses including light-dimmer circuits and speed control of induction motors. The input voltage source is ac, and the output is ac (although not sinusoidal), so the circuit is classified as an AC-AC regulator.

7.7.1 The Single-Phase AC Voltage Controller

Basic Operation

A basic single-phase voltage controller is shown in Figure 7.12. The electronic switches are shown as parallel thyristors (SCRs). This SCR arrangement makes it possible to have current in either direction in the load. This SCR connection is called antiparallel or inverse parallel because the SCRs carry current in opposite directions. A triac is equivalent to the antiparallel SCRs. Other controlled switching devices can be used instead of SCRs.

The principle of operation for a single-phase ac voltage controller using phase control is quite similar to that of the controlled half-wave rectifier. Here, load current contains both positive and negative half-cycles. An analysis identical to that done for the controlled half-wave

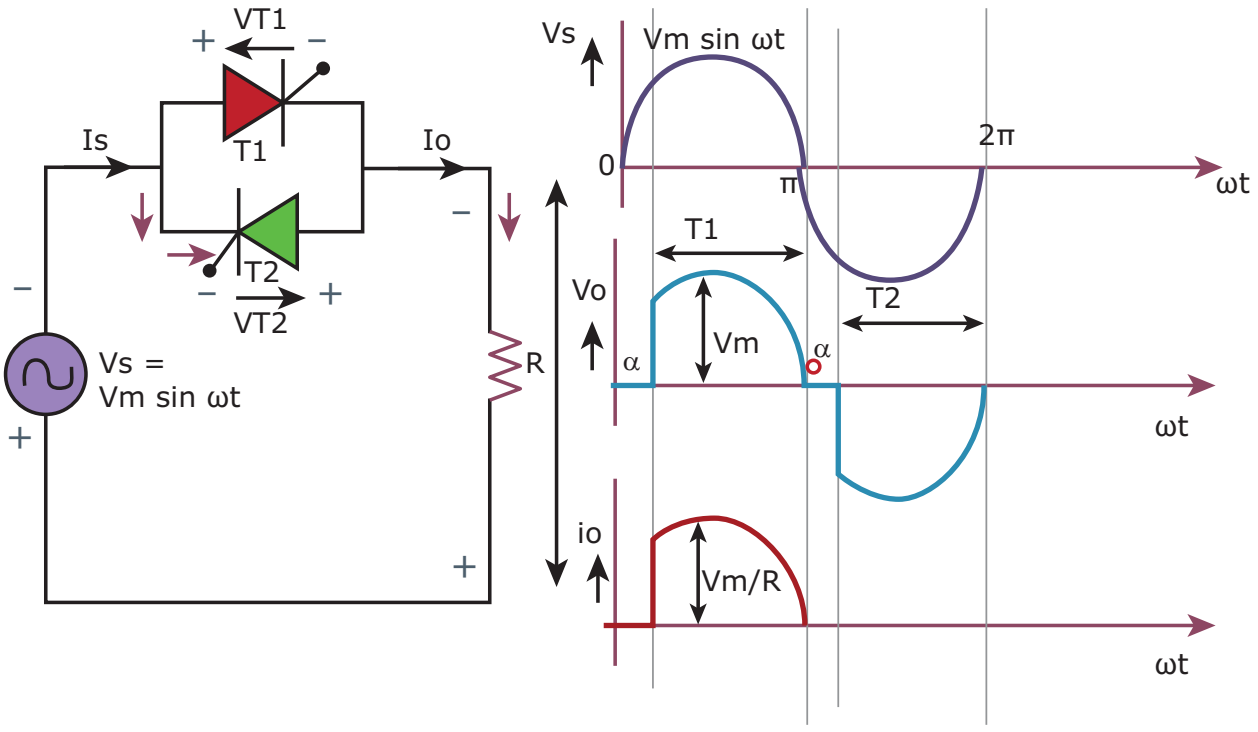


FIGURE 7.12 Single-phase ac voltage controller with a resistive load; (b) Waveforms.

rectifier can be done on a half-cycle for the voltage controller. Then, by symmetry, the result can be extrapolated to describe the operation for the entire period.

Some basic observations about the circuit of Fig 7.12 are as follows:

1. The SCRs cannot conduct simultaneously.
2. The load voltage is the same as the source voltage when either SCR is on. The load voltage is zero when both SCRs are off.
3. The switch voltage-V_{sw} is zero when either SCR is on and is equal to the source voltage when neither is on.
4. The average current in the source and load is zero, if the SCRs are on for equal time intervals. The average current in each SCR is not zero because of unidirectional SCR current.
5. The rms current in each SCR is $1/\sqrt{2}$ times the rms load current if the SCRs are on for equal time intervals.

For the circuit of Fig. 7.12, S_1 conducts if a gate signal is applied during the positive half-cycle of the source. Just as in the case of the SCR in the controlled half-wave rectifier, S_1 conducts until the current in it reaches zero. Where this circuit differs from the controlled half-wave rectifier is when the source is in its negative half-cycle. A gate signal is applied to S_2 during the negative half-cycle of the source, providing a path for negative load current. If the gate signal for S_2 is a half period later than that of S_1, analysis for the negative half-cycle is identical to that for the positive half, except for algebraic sign for the voltage and current.

7.8 Switching Circuits

Switching circuit is an electronic circuit used to electrically switch-ON or switch-OFF an electronic circuit used for power conversion circuits. An electrical switch is any device used to interrupt the flow of electrons in a circuit. Switches are binary devices: either it is in "ON" ("closed") state or "OFF" ("open") state using timing pulses. Transistor is a simple electronic switch, which conducts current across the collector-emitter terminals, when a voltage is applied to the base, i.e., the switch is ON or supress the flow of current across the collector-emitter terminal, when there is no base voltage, i.e., the switch is OFF.

7.8.1 NPN Relay Switch Circuit

Relays are electromechanical devices employing an electromagnet to operate a pair of movable contacts from an open position to a closed position. A relay switch circuit shown in Figure 7.13 consists of a NPN transistor (TR1) configured as a switch driving the coil of the relay, when switching pulse is applied at the base of the transistor. When the base voltage of the transistor is zero (or

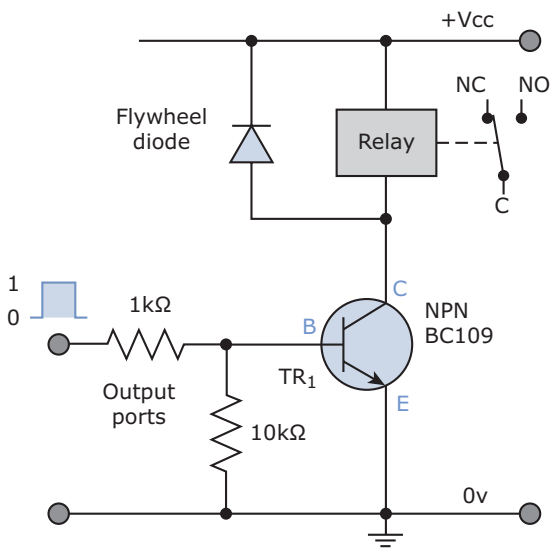


FIGURE 7.13 NPN Relay Switching Circuit

negative), the transistor is cut-off and acts as an open switch. In this condition, no collector current flows and the relay coil is de-energised. When a positive voltage is applied to the base, the transistor conducts and goes to the saturation state. At this condition, the transistor acts as a closed switch. Thus, the current flowing from collector to emitter controls the current flowing through the relay coil.

7.8.2 Microcontroller Relay Switching Circuit

In microcontroller, the input/output port pins are not able to drive high-current components such as relays, buzzer, etc. In such a situation, the output pin of the microcontroller is connected through a MOSFET switching circuit as shown in Figure 7.14. The MOSFET switch is an ideal electrical switch as it takes virtually no gate current to turn "ON", i.e., converting a gate voltage into a load current. Therefore, a MOSFET can be operated as a voltage-controlled switch.

In many applications, bipolar transistors can be substituted with enhancement-type MOSFETs offering faster switching action, much higher input impedance, and probably less power dissipation. The combination of very high gate impedance, very low power consumption in its "OFF" state and very fast switching capability makes the MOSFET suitable for many digital switching applications. Also, with zero gate current, its switching action cannot overload the output circuit of a digital gate or microcontroller. MOSFETs always use a flywheel diode across and relay coil to safely dissipate the back emf generated by the transistors switching action.

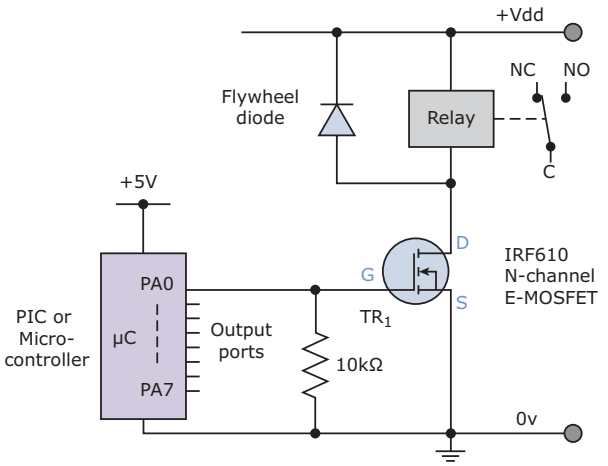


FIGURE 7.14 Microcontroller Relay Switching Circuit

7.8.3 Switching Circuit Using ULN2003a IC

ULN2003A is a relay driver IC consisting of a Darlington array. It is made up of seven open collector Darlington pairs with common emitter. ULN2003A has a capability of handling seven different relays, simultaneously. A single Darlington pair consists of two bipolar transistors and operates in the range of 500 mA to 600 mA current.

Figure 7.15 shows a relay driver IC switching an electro-magnetic relays to switch a light bulb ON and OFF which is connected to 220V mains supply. The IC ULN2003A comprises of 7-NPN Darlington pairs, which is typically configured to switch the inductive loads (dissipates voltage spikes if any, using suppression diode) and to drive stepper motors and lights. For switching eight such relays, ULN2803 can be used. This type of relay switching ICs are used to interface the output from microcontrollers to the actuators such as relays, buzzer, LED, lamps, etc. Here, the program in the microcontroller switches ON or OFF the relays by outputting either 1 or 0 in the respective output pins.

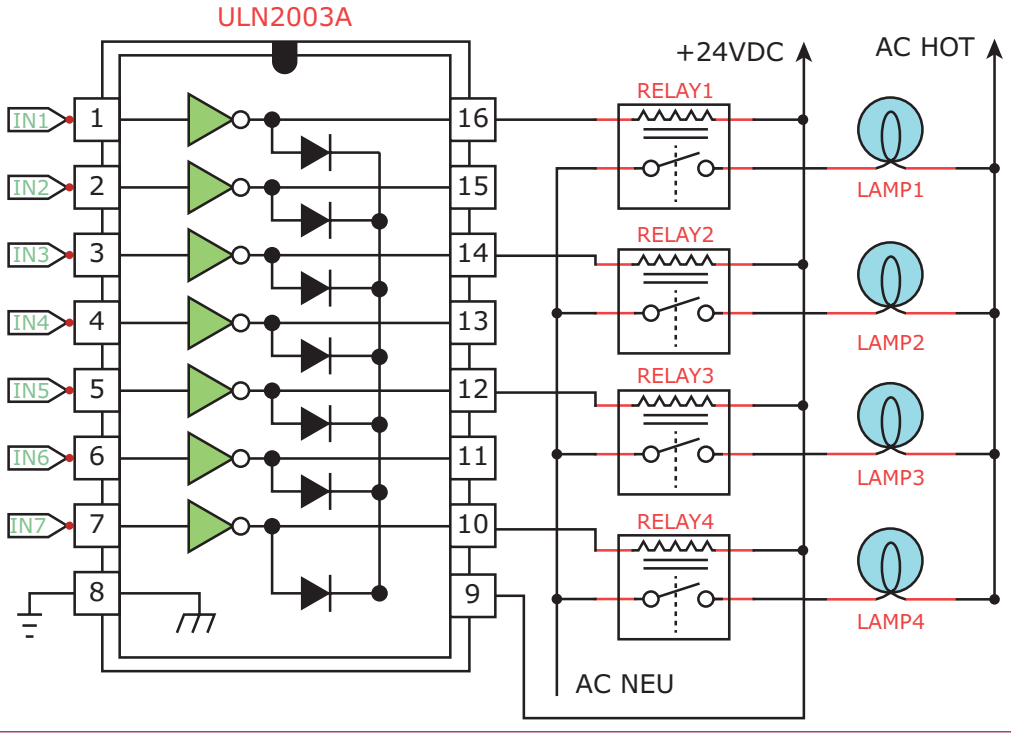


FIGURE 7.15 ULN2003A Relay Switching Circuit

7.9 Switch Mode Power Supply (SMPS)

A switched-mode power supply (SMPS) is an electronic circuit that converts power using switching devices that are turned on and off at high frequencies, and storage components such as inductors or capacitors to supply power, when the switching device is in its non-conduction state.

They are used in many places in a computer. In a modern computer, there is a SMPS that takes rectified AC input from the wall, performs power factor correction and then converts the output into one or more lower voltage DC outputs.

The Figure 7.16 shows the external structure of SMPS and Figure 7.17 shows the internal structure of SMPS.



FIGURE 7.16 External structure of SMPS

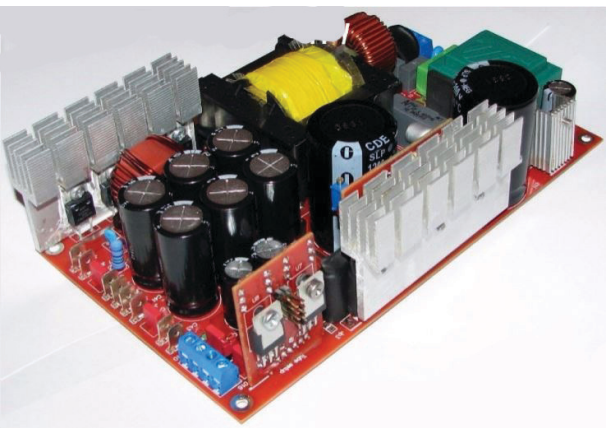


FIGURE 7.17 Internal structure of SMPS

SMPS is a power supply that uses a switching regulator to control and stabilize the output voltage by switching the load current on and off. These power supplies offer a greater power conversion and reduce the overall power loss.

Voltage regulation is achieved by varying the ratio of on-to-off time. In contrast, a linear power supply regulates the output voltage by continually dissipating power in the pass transistor. This higher power conversion efficiency is an important advantage of a switched-mode power supply. Switched-mode power supplies may also be substantially smaller and lighter than a linear supply due to the smaller transformer size and weight.

Switching regulators are used as replacements for linear regulators when higher efficiency, smaller size or lighter weight are required. They are, however, more complicated; their switching currents can cause electrical noise problems if not carefully suppressed, and simple designs may have a poor power factor. Figure 7.18 shows the block diagram of SMPS

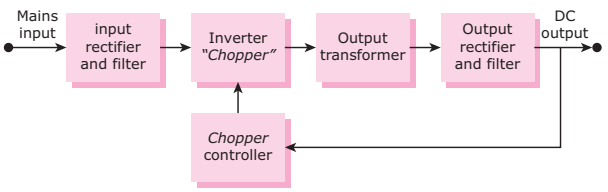


FIGURE 7.18 Block diagram of SMPS

Input Rectifier stage

If the SMPS has an AC input, then the first stage is to convert the input to DC. This is called rectification. An SMPS with a DC input does not require this stage. In some power supplies (mostly computer ATX power supplies), the rectifier circuit can be configured as a voltage doubler by the addition of a switch operated either manually or automatically. This feature permits operation from power sources that are normally at 115 V or at 230 V.

The rectifier produces an unregulated DC voltage which is then sent to a large filter capacitor. The current drawn from the mains supply by this rectifier circuit occurs in short pulses around the AC voltage peaks.

Inverter stage

This section refers to the block marked chopper in the diagram.

The inverter stage converts DC, whether directly from the input or from the rectifier stage described above, to AC by running it through a power oscillator, whose output transformer is very small with few windings at a frequency of tens or hundreds of kiloHertz. The frequency is usually chosen to be above 20 kHz, to make it inaudible to humans. The switching is implemented as a multistage (to achieve high gain) MOSFET amplifier. MOSFETs are a type of transistor with a low on-resistance and a high current-handling capacity.

Regulation

This charger for a small device such as a mobile phone is a simple off-line switching power supply with a European plug. The simple circuit has just two transistors, an opto-coupler and rectifier diodes as active components.

A feedback circuit monitors the output voltage and compares it with a reference voltage, as shown in the block diagram above. Depending on design and safety requirements, the controller may contain an isolation mechanism (such as

an opto-coupler) to isolate it from the DC output. Switching supplies in computers, TVs and VCRs have these opto-couplers to tightly control the output voltage.

Transformer design

Any switched-mode power supply that gets its power from an AC power line (called an "off-line" converter) requires a transformer for galvanic isolation. Some DC-to-DC converters may also include a transformer, although isolation may not be critical in these cases. SMPS transformers run at high frequency. Most of the cost savings (and space savings) in off-line power supplies result from the smaller size of the high frequency transformer compared to the 50/60 Hz transformers formerly used. There are additional design trade offs. The skin effect is exacerbated by the harmonics present in the high speed PWM switching waveforms. The appropriate skin depth is not just the depth at the fundamental, but also the skin depths at the harmonics. In addition to the skin effect, there is also a proximity effect, which is another source of power loss.

LEARNING OUTCOME

After studying this chapter, students can understand the following

1. Applications of Power Electronics
2. Converting AC to DC
3. DC TO AC – Inverter
4. Types of Inverter
5. DC to DC Regulators
6. AC to AC amplitude and frequency regulators
7. Switching Circuits
8. Switch Mode Power Supply

QUESTIONS

I. Choose the best answer from the given four options.

1. Conversion of alternating current into direct current is _____
   a. Rectifier b. Inverter
   c. Regulator d. Voltage doubler

2. Conversion of direct current into alternating current is _____
   a. Rectifier
   b. Inverter
   c. Regulator
   d. Voltage doubler

GAC4T

3. The Objective of a power electronic circuit is
   a. To reduce power consumption
   b. To avoid current shock
   c. Match the voltage and current requirements of the load
   d. To minimize expenditure

4. _____ type of power electronics is used in cell phone.
   a. AC to AC regulator
   b. DC to AC inverter
   c. DC to DC regulator
   d. AC to DC rectifier

5. A voltage regulator _____
   a. gives a steady, reliable and fixed output voltage
   b. Unregulated voltage
   c. Unregulated current
   d. Low power output

6. In IC7805 Voltage regulator, the input voltage should always be _____ than the output voltage.
   a. Less b. Greater
   c. Infinity d. Zero

7. In single phase AC voltage controller, the SCR connection is called as _____.
   a. Series connection
   b. Parallel connection
   c. Anti-parallel or inverse parallel connection
   d. Series and Parallel connection

8. Relay switch circuits are _____ device.
   a. Electrical b. Electronics
   c. Mechanical d. Electromagnet

9. In ULN 2003A IC the number of Darlington pairs used are_____.
   a. 3 b. 4 c. 5 d. 7

10. The function of SMPS is _____.
   a. Rectification
   b. Inversion
   c. Voltage regulation
   d. All the above

II. Answer in few sentence.

1. Define the term power electronics.
2. Write the applications of Power Electronics.
3. What is the objective of power electronics?
4. Write down the three primary types of inverters.
5. What is the purpose of UPS?
6. Write about AC to AC Regulator.
7. Write down the pin diagram of LM317T.
8. Write the advantages of UPS.
9. Draw the Pin diagram of 7805 IC.
10. What is switching circuits?

III. Explain the following questions.

1. Write about the DC input/DC output and its application.
2. Draw the single phase full-wave rectifier.
3. Write short notes on DC to AC-Inverter.
4. Write down the important points on 7805 voltage regulator IC.

IV. Briefly explain the following questions

1. Draw the circuit diagram of UPS and explain its working.
2. Explain the working of voltage regulator using IC 7805.
3. Draw the circuit diagram of switching circuit using ULN 2003 A –IC.
4. Draw the block diagram of SMPS and explain each block briefly.

Answers:

1.(a)	2.(b)	3.(c)	4.(c)	5.(a)
6.(b)	7.(b)	8.(d)	9.(d)	10.(d)



CHAPTER 08

Introduction to Biomedical Instruments

WMR94

LEARNING OBJECTIVE

The students can understand the following in this chapter

1. Electrocardiograph (ECG)
2. Blood Pressure (BP) Monitor
3. Pulse Oxi-meter
4. Endoscopy
5. Ultrasound Scanner
6. Computed Tomography (CT) Scanner

8.1 Introduction

Human body consists of biological, chemicals, physical, electrical, thermal, hydraulic, pneumatic, acoustical, magnetic and mechanical systems, all interacting with each other. It also contains a powerful computer (brain), several types of communicating systems (nerves), and a great variety of control systems (muscles).

Human body is a source of various biopotential signals, which are most useful for estimating the physiological, clinical, therapeutic and biological activities of living body. These signals can be picked up from the surface of the body or from within the body.

Figure 8.1 shows the biopotential recorded from nerve and muscle, respectively. The biopotential was first recorded in the year 1786, by an Italian Physician Dr. Luigi Galvani.

Later on, several advancements in electronics, material science and computing technology shaped the biomedical instruments in various forms like dedicated, portable, wearable, PC-

based, MEMS/NEMS-based and wireless based devices.

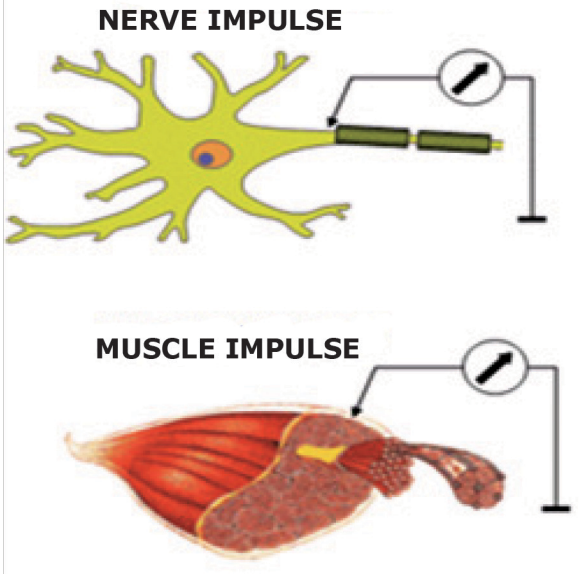


FIGURE 8.1 Biopotential from nerve and muscle

8.1.1 Definition of Biopotential:

- An electric potential that is measured between points in living cells, tissues, and organisms, which accompanies all biochemical processes.
- Ionic voltages produced as a result of the electrochemical activity of excitable cells.

DO YOU KNOW?

The difference between the electric current and bioelectric current?

Electric current is due to the movement of electrons in a circuit, whereas bioelectric current is due to movement of ions across the cell membrane.

8.1.2 Characteristics of Biopotential signals

The important characteristics of a biopotential signals recorded from our body are summarized in Table 8.1

TABLE 8.1 Types of Biopotential Signals and their characteristics

Parameter	Signal Characteristics
Electro cardiogram (ECG)	Frequency range: 0.05 to 500 Hz 0.05 to 120 Hz is adequate Typical signal voltage: 1 mV Voltage range: 10μV to 5 mV
Electro encephalogram (EEG)	Frequency: 0.1 to 100 Hz 0.5 to 70 Hz is adequate Voltage: 2 to 200 μV Typical voltage: 50 μV
Electromyogram (EMG)	Frequency: 5 to 2000 Hz Voltage: 25 to 5000 μV
Electro retinogram (ERG)	Frequency: DC to 20 Hz Voltage: 0.5μV to 1mV Amplitude: 0.5 mV
Electro culogram (EOG)	Frequency: DC to 100 Hz Voltage: 10 to 3500 μV Amplitude: 0.5 mV

8.1.3. Measurement of Biopotential

Using transducers, the ionic potential generated by our body is converted into electrical potential. Bioelectric potential waveforms generally end with the suffix gram.

For example, Electrocardiogram, Electroencephalogram. Instruments used to measure biopotential generally ends with the suffix graph, e.g., Electrocardiograph, Echocardiograph.

Biomedical instruments are devices that can be used to make measurements of biologic or medical quantities and give quantitative (or sometimes qualitative) results.

Have you ever seen a biomedical instrument? Some of the simple

biomedical instruments everybody knows are thermometer, stethoscope, etc. as shown in Figure 8.2.



FIGURE 8.2 Basic Medical Instruments

8.2 Components of Biomedical Instrument:

Figure 8.3 shows the basic components of a biomedical instrument. Any biomedical instrument comprises of sensor that senses the physiological parameter of interest such as temperature, blood pressure, pulse rate, etc.

The sensor's output signal is of low-amplitude and comprises of unwanted signals called noise, artefacts, etc. Therefore, the sensor output signal is processed in the processor unit, which may be an electronic circuit, or a computer with related software.

The processed output signal can be either stored in the memory for future usage or it can be shown in a display for monitoring/diagnosis.

In this Chapter, some of basic biopotential as well as biomedical imaging instruments and their working principles are discussed.

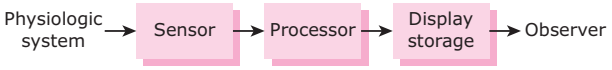


FIGURE 8.3 Basic Component of a Biomedical instrument

8.3 Electrocardiograph (ECG)

Electrocardiograph records small voltages of about one millivolt (mV) that appear on the skin as a result of cardiac activity.

The voltage differences between electrodes are measured; these differences directly correspond to the heart's electrical activity.

The first ECG machine developed by Augustus Waller in the year 1887 using capillary electrometer is shown in Fig. 8.4.

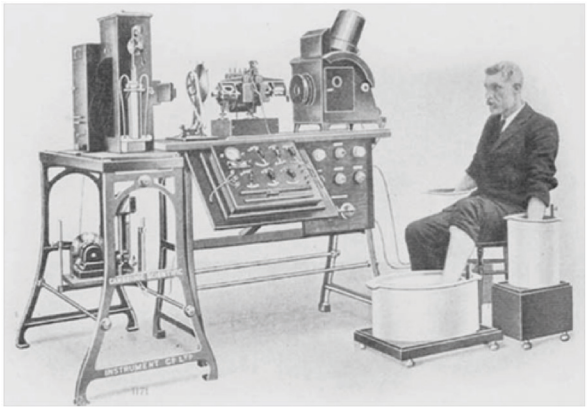


FIGURE 8.4 First ECG machine

Later, the physician standardized the ECG machine, which comprises of 12 standard leads for knowing the different perspective of the heart's electrical activity.

The ECG waveforms consist of P wave, QRS complex, and T wave, which are vary in amplitude and polarity. Typical 12-lead ECG waveforms are shown in Figure 8.5.

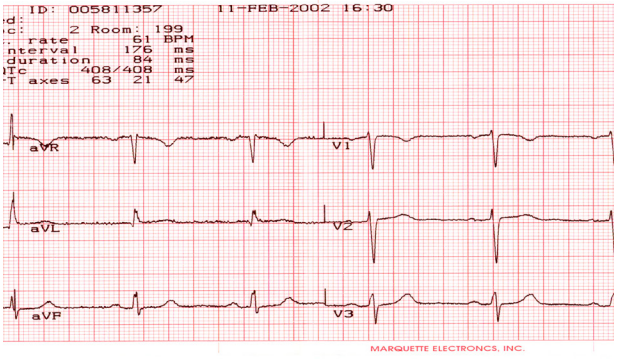


FIGURE 8.5 Standard 12 leads ECG recordings

8.3.1 Working Principle of Electrocardiograph Machine

Figures 8.6(a) shows a 12 lead ECG machine, Figure 8.6(b) depicts the various electrodes and Figure 8.6(c) illustrates the block diagram of the ECG machine, respectively.

For acquiring the ECG signal from human body, four electrodes are placed on the four arms of the body viz., Right Arm (RA), Left Arm (LA), Right Leg (RL) and Left Leg (LL).

The signals picked up by the four electrodes are fed into a resistor/switching network to select one of the 12 leads viz., Lead I, Lead II, Lead III, aVR, aVL, aVF, V1, V2, V3, V4, V5, and V6. The selected/ acquired signals from the switching network has very low-amplitude and is amplified by an instrumentation amplifier.

In analog type of ECG machines, further processing like noise removal, base line correction and final amplification are performed using complicated circuits.

But, in the digital ECG machine the signal from the instrumentation amplified is digitised using Analog-to-Digital Converter (ADC) and stored in digital form.

The digitized ECG data is further processed for noise removal, base line

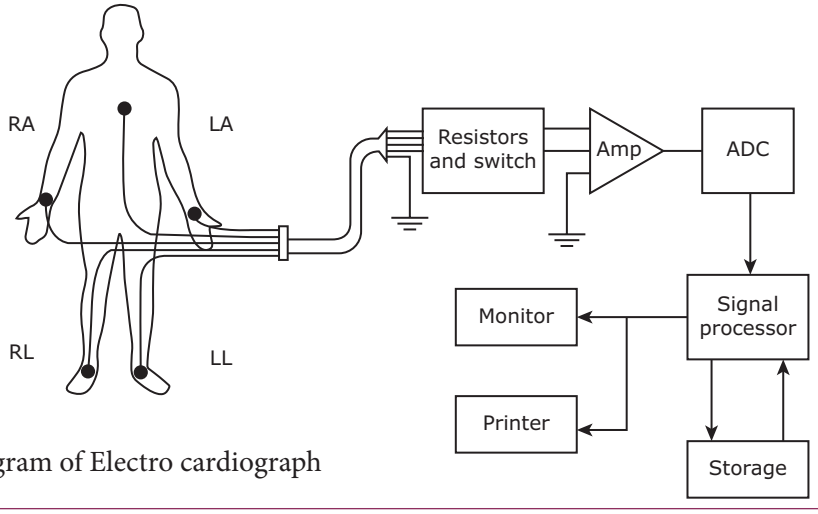


(a) 12 Lead ECG Machine





(b) Different types of ECG electrodes

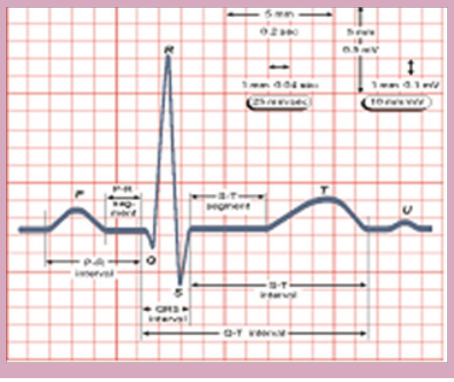


(C) Block Diagram of Electro cardiograph

FIGURE 8.6

DO YOU KNOW? The components of ECG and their relationship with cardiac activity?

ECG comprises of P, QRS, T and U waves. P wave represents the contraction of the atria or the depolarization of atria, QRS complex corresponds to relaxation of the atria and initiation of ventricular contraction or the depolarization of ventricle, T wave corresponds to ventricular relaxation and the U wave origin is unknown.



correction and final amplification using signal processing hardware or software.

The processed ECG data is stored for future use or displayed on the monitor or printed as hardcopy.

Applications of ECG

Diagnosis of

1. Ischemia
2. Arrhythmia
3. Conduction defects

8.4 Blood Pressure Monitor

The abbreviated term 'BP' become very familiar in our life. In every one's mind a question may arise. Why the blood needs pressure. Dear students to understand this, just you think about the water supply system in your town or a city. Houses are located in various places and in various elevations and in different ground levels. But the water has to reach all the houses. Without giving necessary pressure, is it possible to send the water to all the houses? No.

Certainly we need some pressure to send the water to all the houses. To do that, we are pumping the water by using a powerful motor.

Just like, the blood in our body has to reach each and every part and corner of our body. To perform this, its need some pressure. This is called Blood Pressure (BP).

Here the task of giving enough pressure is done by our vital and important organ "The Heart".

Blood transports O_2 and nutrients to the cells and carries the metabolic waste and CO_2 gas from the cells through a pressurized vessel system comprising of arteries, vein, arterioles, venuoles and capillaries (covering approximately 1,00,000 km distance). The pressure is provided by the mechanical pump called, heart. Measuring this pressure at various locations of our body reveals significant clinical information. The Blood Pressure (BP) is measured as Systolic (Pressure exerted by the heart during pumping) and Diastolic pressure (Pressure exerted when the heart relaxes between beats). The optimal values of Systolic and Diastolic pressure for an adult should be 120 mm Hg and 80 mm Hg, respectively. BP can be measured using direct (invasive) or indirect (non-invasive) methods.

1. Invasive – Catheter with external or internal sensor
2. Non-invasive – Sphygmomanometer and Ultrasound Doppler method

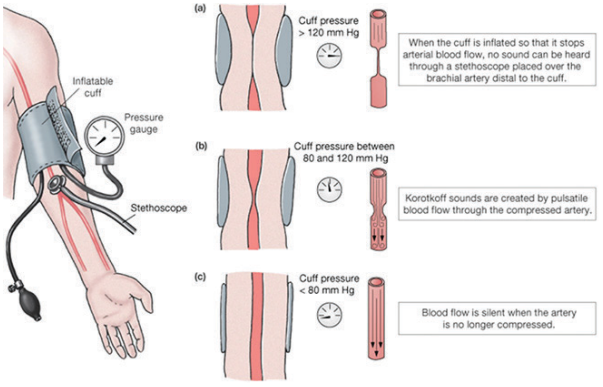


FIGURE 8.7 Working Principle of Sphygmomanometer

In this Section, the BP measurement using Sphygmomanometer is presented. Figure 8.7 shows the Sphygmomanometer comprises of an inflatable cuff, needle valve, pressure gauge, mechanical pump and Stethoscope. During measurement of BP, the cuff is inflated using the mechanical pump and the heart sound called Korotkoff sound is heard, which is listened using a stethoscope placed on the hand below the cuff. In the inflation phase, if the korotkoff sound is not heard, the physician stops pressurizing the cuff. Then, the needle valve is opened for deflation and pressure across cuff decreases and once again the korotkoff sound is heard in the stethoscope. This point is noted and the reading in the pressure gauge is noted, which corresponds to the Systolic pressure. This will continue a while and once again the korotkoff sound is not heard, that point in the pressure gauge is noted as a diastolic pressure. In the case of automatic Sphygmomanometer, inflation, deflation, pressure sensing, etc., are controlled by a microcomputer with respective sensors and electronic circuitry as shown in Figure 8.8.

8.5 Pulse Oximeter

This is the most important instrument to identify and diagnose the real situation of the patient.

Oxygen is carried in the blood by hemoglobin which has two forms: Hb and HbO_2. These two forms have different absorptions at different wavelengths in the red to infra–red frequency band.

By measuring the absorption of the two different wavelengths and taking appropriate ratios, it is possible, in theory, to evaluate the percentage of hemoglobin carrying oxygen.

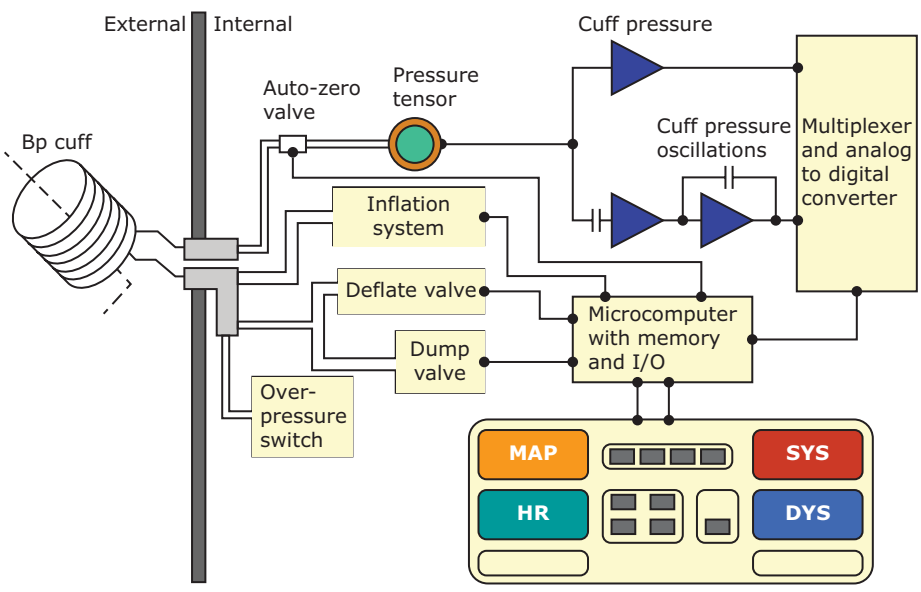


FIGURE 8.8 Components of Automatic BP Monitor: Here, MAP-Mean Average Pressure, SYS-Systolic Pressure, DYS-Diastolic Pressure and HR- Heart Rate

The principle of pulse oximetry is based on the red and infrared light absorption characteristics of oxygenated and deoxygenated hemoglobin. Oxygenated hemoglobin absorbs more infrared light and allows more red-light to pass through, whereas deoxygenated hemoglobin absorbs more red-light and allows more infrared light to pass through.

Red-light is in the 600-750 nm wavelength light band, whereas infrared light is in the 850-1000 nm wavelength light band. The figure 8.9 (a) shows the image of Pulse Oximeter and the figure 8.9 (b) shows the absorption relationship of Hb and HbO_2.

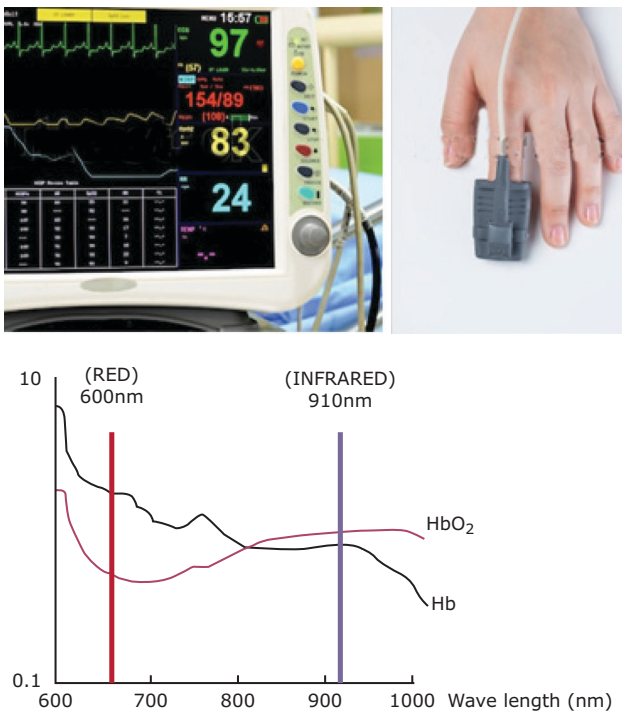


FIGURE 8.9 (a) Pulse Oximeter, (b) Absorption Characteristics of HbO_2 and Hb

8.5.1 Applications of Pulse Oximeter

The SpO_2 values are used to diagnose the conditions such as Apnea, Bronchopulmonary dysphasia and cardiac diseases. For normal patients, the SpO_2 will be in the range of 95-100 %, for Mild Hypoxemia, it will be in the range of 91-94%, for Moderate Hypoxemia, it will be in the range of 86-90% and for severe Hypoxemia, it will be in the range of <85%.

8.6 Biomedical Imaging Instruments

The earliest medical images used light to create photographs, either of the anatomic structures, or of the histological specimens using microscopes. Light is still an important source for the creation of images. However, visible light does not allow us to see inside the body.

X-rays were first discovered in 1895 by Wilhelm Conrad Roentgen, who was awarded the 1901 Nobel Prize in physics for this achievement. This discovery caused worldwide excitement, especially in the field of medicine, since then, diagnostic X-ray technology has evolved from film-based to completely digital, where images are manipulated and viewed in a digital data format.

Advanced imaging modalities such as computed tomography (CT), endoscopy - ultrasonagraphy were developed late in the 20th century and in the 21st century.



What is the first X-ray taken by Rontgen?

The first X-ray image of Rontgen's wife was taken in the year 1985 and is shown here.



8.6.1 Endoscopy

Endoscopy is the insertion of a long, thin tube directly into the body to observe an internal organ or tissue in detail.

The first real endoscope that was developed was made by Phillip Bozzini in the year 1805 to examine the urethra, the bladder and vagina. It can also be used to carry out other tasks including imaging and minor surgery.

Endoscopes are minimally invasive and can be inserted into the openings of the body such as the mouth or anus. Alternatively, they can be inserted into small incisions, for instance, in the knee or abdomen. Surgery completed through a small incision and assisted with special instruments, such as the endoscope, is called keyhole surgery.

Since modern endoscopy has relatively few risks, which delivers detailed images in a reasonably quicker time and hence it has proven incredibly useful in many areas of medicine.

8.6.2 Components of an Endoscopy

The endoscope consists of a slender, flexible or rigid tube equipped with lenses and a light source. CCDs are used as detector to acquire the video from the respective organs and display in a monitor.

Through the accessory channels of the endoscope, water and air is supplied to wash and dry the surgical site. Also, it has a channel through which surgeons can manipulate tiny instruments, such as forceps, surgical scissors, and suction devices.

A variety of instruments can be fitted to the endoscope for different purposes. Figure 8.10 shows the various components of an Endoscope.



FIGURE 8.10 Endoscopy machine and its components

8.6.3 Types of Endoscopy

Endoscopy is most useful for investigating many systems within the human body and is named based on the applications. They are summarized in Table 8.2.



What is Capsule Endoscopy?

Recently a disposable flash camera slightly larger than a vitamin pill was devised to perform imaging of the small intestine. This procedure is called capsule endoscopy in which the patient swallows the minicam, which then takes pictures inside the small intestine. On its journey through the digestive tract, the tiny tumbling camera transmits images that are stored in a recorder that the person wears around the waist. After 8 hours, the camera's battery runs out, and the capsule is eliminated in the faeces.



TABLE 8.2 Types of Endoscopy	
Name of the Endoscopy	**Application**
Gastroscopy	To see the gullet, stomach and upper small intestine.
Colonoscopy	To see the large intestine.
Laparoscopy	To see the "stomach cavity" and the organs therein.
Proctoscopy	This is used to check for piles and other conditions of the anus and rectum.
Cystoscopy	To see the urinary bladder.
Bronchoscopy	To see the air passages to the lungs.
Laryngoscopy	To see the larynx or voice box.
Nasopharyngoscopy	To see the nose and related cavities.
Arthroscopy	To see inside joints such as the knee joint.
Thoracoscopy	To see inside the chest cavity.

8.7 Ultrasonography

Ultrasonography is a medical imaging technique that uses high frequency sound waves and their echoes.

These frequencies are between 1 MHz and 10 MHz and such frequencies cannot be heard by humans. The technique is similar to the echolocation used by bats, whales and dolphins, as well as SONAR used by submarines.

8.7.1 Principle of Ultrasonography

The typical image of Ultra sound scanner is shown in the Figure 8.11(a). The ultrasound machine transmits high-frequency (1 to 10 MHz) sound pulses into the body using a probe.

The sound waves travel into the body and hit a boundary between tissues (e.g. between fluid and soft tissue, soft tissue and bone). Some of the sound waves get reflected back to the probe, while some travel on further until they reach another boundary and get reflected.



FIGURE 8.11(a) Ultrasound Scanner, (b): Ultrasound image of a growing foetus inside a mother's uterus.

The reflected waves are picked up by the probe and relayed to the machine. The machine calculates the distance from the probe to the tissue or organ (boundaries) using the speed of sound in tissue (1,540 m/s) and the time of the each echo's return (usually on the order of millionths of a second).

The machine displays the distances and intensities of the echoes on the screen, forming a two dimensional image like the one shown in Figure 8.11(b).

8.7.2 Components of Ultrasound Machine

Figure 8.12 shows the components of a basic ultrasound Machine and the functions of each component are described below:

1. Transducer probe

The transducer probe generates and receives sound waves using a principle called the piezoelectric (pressure electricity) effect, which was discovered by Pierre and Jacques Curie in 1880.

The probe also has a sound absorbing substance to eliminate back reflections from the probe itself, and an acoustic lens to help focus the emitted sound waves.

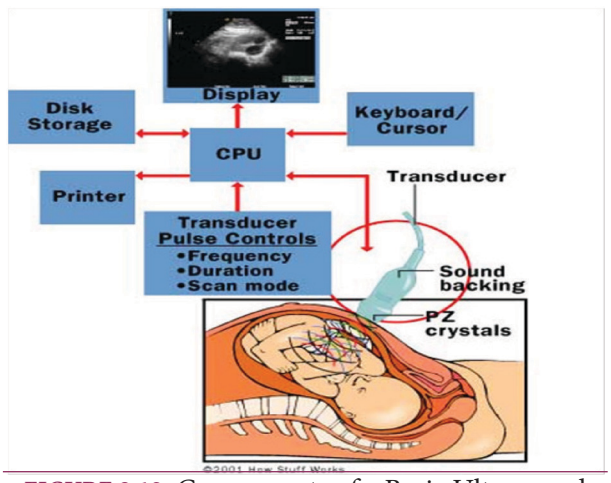


FIGURE 8.12 Components of a Basic Ultrasound Scanner

When an electric current is applied to these crystals, they change shape rapidly or vibrations of the crystals produce sound waves that travel outward.

Conversely, when sound or pressure waves hit the crystals, they emit electrical currents. Therefore, the same crystal can be used as transmitter and receiver of the sound waves.

2. Central processing unit (CPU)

The CPU is basically a computer that contains the microprocessor, memory, amplifiers and power supplies for the microprocessor and transducer probe. The CPU sends electrical currents to the transducer probe to emit sound waves, and also receives the electrical pulses from the probes that were created from the returning echoes.

The CPU does all of the calculations involved in processing the data. Once the raw data are processed, the CPU forms the image on the monitor. The CPU can also store the processed data and/or image on disk.

3. Transducer pulse controls

The transducer pulse controls allow the operator, called the ultrasonographer, to set and change the frequency and duration of the ultrasound pulses, as well as the scan mode of the machine.

The commands from the operator are translated into changing electric currents that are applied to the piezoelectric crystals in the transducer probe.

4. Display

The display is a computer monitor that shows the processed data from the CPU. Displays can be black-and-white or color, depending upon the model of the ultrasound machine.

5. Keyboard and Cursor

Ultrasound machines have a keyboard and a cursor, such as a trackball, built in. These devices allow the operator to add notes and to take measurements from the data.

6. Disk storage device

The processed data and/ or images can be stored on disk. The disks can be hard disks, floppy disks, compact discs (CDs) or digital video discs (DVDs).

7. Printer

Many ultrasound machines have thermal printers that can be used to capture a hard copy of the image from the display.

8.7.3 Uses of Ultrasonography

Ultrasound has been used in a variety of clinical fields including obstetrics and gynecology, cardiology and cancer detection. The main advantage of ultrasound is that certain structures can be observed without using radiation. Ultrasound can also be done much faster than X-rays or other radiographic techniques.

8.8 Computed Tomography Imaging

Tomography is imaging by sections or sectioning. A device used in tomography is called a tomograph, while the image produced is a tomogram.

Computed Tomography (CT) or Computed Axial Tomography (CAT), utilizes X-ray technology and sophisticated computers to create images of cross-sectional "slices" through human body.

CT produces cross-sectional images and also has the ability to differentiate tissue densities, which creates an improvement in contrast resolution.



FIGURE 8.13(a) CT-Scanner

Figure 8.13(a) shows the image of a CT-Scanner. Figure 8.13(b) shows the principle, operation and the image of CT.

In CT, the X-ray source is tightly collimated to interrogate a thin slice through the patient. The source and detectors rotate together around the patient, producing a series of one-dimensional projections at a number of different angles.

The basic processes of CT consist of four steps viz., Data acquisition, Image reconstruction, Image display and Image archive (recording).

After placing the patient in the proper position of the scanner, the operator selects the correct protocols and technical parameters and starts running the machine.

At the initialization of the scan, X-rays passing through the patient are attenuated depending on the tissue type. A detector system located opposite to the X-ray tube measures the attenuation values as an analogue signal.

This signal is transmitted to the Analogue to digital converter (ADC), which converts the signal of attenuated values from analog to digital form and sending to computer for further processing.

The computer reads this digital data and employs a mathematical formula,

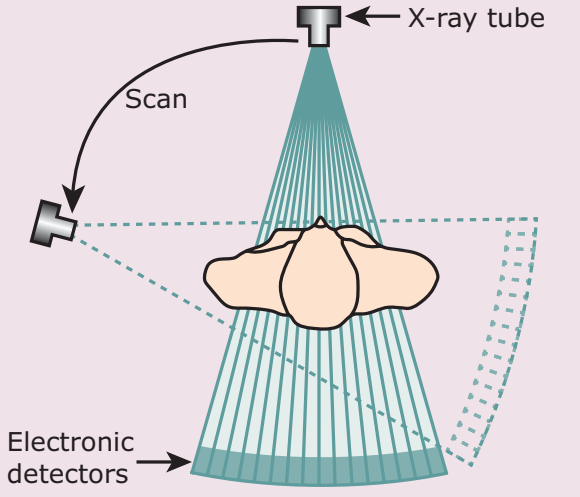
called a reconstruction algorithm, to generate the cross-sectional image. The mathematical basis for reconstruction of an image from a series of projections is the Radon transform.

The image reconstruction, involving millions of data points, which is usually performed in less than a second by a group of array processors. The reconstructed image is displayed on a LCD monitor as an image suitable for manipulation by the operator.

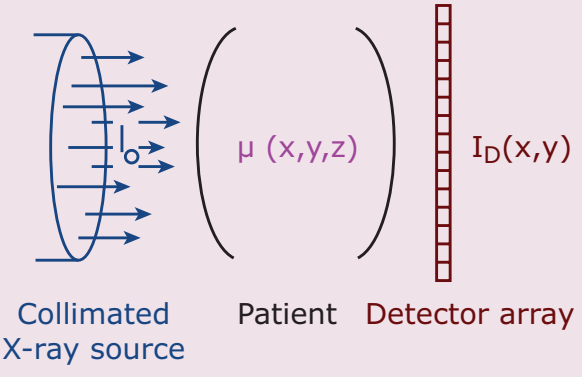
In the image archive, three processes such as image manipulation, Archiving on a Picture Archiving and Communication System (PACS) and storage are performed.

For this, a wide range of software is available to enhance the image on the monitor before storage. These include altering the density and brightness, changing the plane of the image from axial to sagittal or coronal, producing three dimensional images and demonstrating detailed angiography.

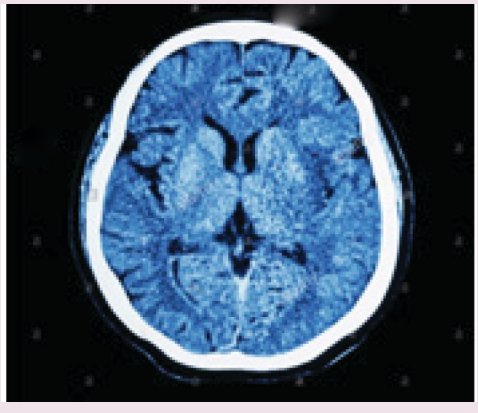
Recent developments in spiral and multi-slice CT have enabled the acquisition of full three-dimensional images in a single patient breath-hold.



CT Principle



Operation of CT



CT image of brain

FIGURE 8.13(b) Principle, Operation and Image of the CT

Advantages:

- Desired image detail is obtained
- Fast image rendering
- Filters may sharpen or smooth the reconstructed images

Disadvantages

- Multiple reconstructions may be required if significant detail is required from areas of the study that contain bone and soft tissue
- Need for quality detectors and computer software
- X-ray exposure

Do you know? Who invented the CT?

In 1950, Allan M. Cormack developed the theoretical and mathematical methods used to reconstruct CT images. In 1972, Godfrey N. Hounsfield and colleagues of EMI Central Research Laboratories built the first CAT scan machine, taking Cormack's theoretical calculation into a real application. For their independent efforts, Cormack and Hounsfield shared the Nobel Prize in medicine and physiology in 1979.

LEARNING OUTCOME

After studying this chapter, students can understand the following

1. Electrocardiograph (ECG)
2. Blood Pressure (BP) Monitor
3. Pulse Oximeter
4. Endoscopy
5. Ultrasound Scanner
6. Computed Tomography (CT) Scanner

QUESTIONS

I. Choose the best answer from the given four options. (1 Mark)

1. The full form of ECG is
   a) Electricity cardiac Group
   b) Electrocardio Group
   c) Electrocardium Granules
   d) Electrocardiograph
2. The optimum values of systolic and diastolic pressure for an adult is _____
   a) 150 mm Hg and 110 mm Hg
   b) 140 mm Hg and 100 mm Hg
   c) 130 mm Hg and 90 mm Hg
   d) 120 mm Hg and 80 mm Hg
3. The instrument used to measure Blood Pressure is
   a) Manometer
   b) Sphygmomanometer
   c) Barometer
   d) Thermometer
4. Which instrument used to measure the oxygen level in blood?
   a) BP Monitor b)PulseOximeter
   c) Spirometer d) Oscilloscope
5. The endoscope used to examine the stomach is called.
   a) Cystoscope b) Gastroscope
   c) Bronchoscope d) Anthroscope

6. Bioelectric waveforms and Instruments ends with the suffixes ---------- and ---------- respectively
   a) Graph, gram
   b) Gram, graph
   c) Graphy, gramy
   d) Gramy, graphy
7. Ultrasound transducers are made from _____
   a) Piezoelectric material
   b) Photovoltaic material
   c) Thermoelectric material
   d) Polymer Material
8. In CT machines, which source is used?
   a) Gamma Ray b) X-ray
   c) Ultrasound d) Infrared
9. The Ultrasound machine transmits high frequency _____ sound pulses into the body using a probe
   a. 20Hz to 20 KHz
   b. 2 KHz to 20 KHz
   c. 10 KHz to 20 KHz
   d. 1 MHz to 10 MHz
10. Sphygmomanometer is used to estimate blood _____
   a) Sugar b) Sodium
   c) Pressure d) Flow

II. Answer in few sentence.(3 Marks)

1. Define bioelectric current.
2. Draw the basic component of a biomedical instrument.
3. Compare the Analog & Digital ECG machine.
4. What are the applications of ECG?
5. State the value of blood pressure for a normal adult.
6. Enumerate the purpose of a Pulse Oximeter.
7. Name any four types of Endoscopy.
8. What is the role of fibre-optics in Endoscopy?
9. State the uses of ultrasonography.
10. What are the advantages of Computed Tomography?

III. Explain the following questions. (5 Marks)

1. Briefly explain the principle of operation of an Electrocardiograph with a neat sketch.
2. Give the instrumentation details of a Pulse Oximeter.
3. Write a short note on the operations of a Blood Pressure Monitor.

IV. Briefly explain the following questions. (10 Marks)

1. Explain Sphygmomanometer with neat diagram.
2. Write a note on the basic function of an Ultrasonagraphy.
3. Describe the operating principle of CT scan using functional block diagram.

ANSWERS

1(d)	2(d)	3(b)	4(b)	5(b)
6(b)	7(a)	8(b)	9(d)	10(c)



CHAPTER 09

Computer Maintenance and Troubleshooting with Safety Practices

LEARNING OBJECTIVE

A student can understand the following in this chapter

1. Basics of computer maintenance and its categories.
2. Troubleshoot, Rectify and Replace the common hardware problems.
3. Troubleshoot, Rectify and Replace the common software problems.
4. Customer complaints.
5. Computer ergonomics.
6. Basic electrical safety at workplace.

9.1 Introduction

It is hard to imagine our lives without computers. We use computers to pay bills, play games, surf the internet or other activities. Most of the people needs computers to do their professional work. Since computers are such an integral part of our lives, it is important that we have to take care of them by proper maintenance.

Computer maintenance is the practice of keeping computers in a good state. Computer maintenance is very important for keeping your computer running smoothly. Whether your computer is new or old, problems can pop up at any time. Computers can be unpredictable, and we all know that small issues can cause huge problems. A computer works well when they are taken



FIGURE 9.1 Computer Maintenance

care of, but without regular maintenance, you may not get the best results. Regular Maintenance will help to clean the computer and make sure to work properly.

Need for Maintenance:

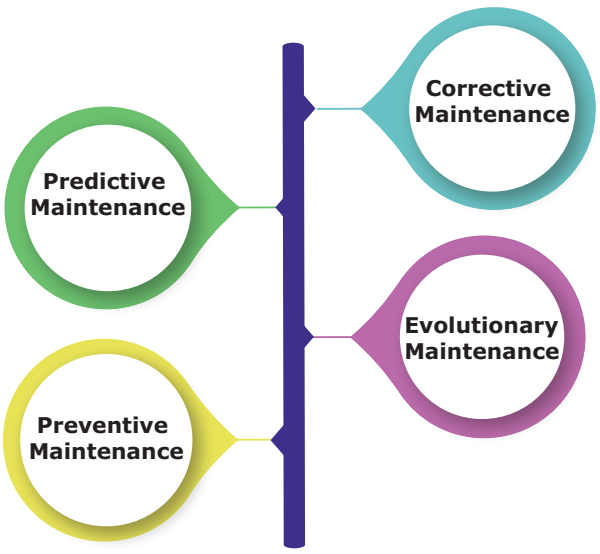
Computer Maintenance is essential for the below listed reasons.

1. Detecting issues early, before they become problems.
2. Prevention against Viruses and Malware.
3. Speeding up the Computer.
4. Increasing the life of parts
5. Maximize Software Efficiency

9.2 General Maintenance Procedure of Computer

9.2.1 Computer Maintenance – Categories

There are several Categories of computer maintenance, they are



1. **Predictive Maintenance**

This is a common way is monitoring computer system and checking whether it works properly. This tool can control and inform the battery levels, the temperature of the CPU, and other features.

2. **Preventive Maintenance**

Preventive software maintenance usually includes scanning and cleaning through antivirus, the creation of backups, freeing-up of disk space and RAM.

3. **Corrective Maintenance**

Common corrective measures involve removing viruses or malware, uninstalling harmful programs, reformatting, and running a system restore, among others. Many common computer problems are easily fixed. To perform corrective maintenance, it is important to first diagnose the problem and figure out the root cause.

4. **Evolutionary Maintenance**

This type concerns both hardware and software, so update the windows and change various parts of the PC for better performance.

9.3 Troubleshoot, Rectify and Replace the Common Hardware Problems

Problem 1: PC Overheating

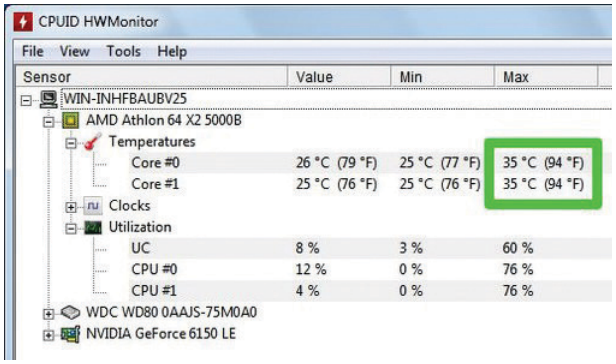
A heating PC slows down the whole system and leads to frequent crashes. Additionally, PC components may also get permanently damaged due to constant exposure to heat.

There are two main reasons your PC heats up, i.e. either the cooling system isn't working properly or the PC is heating to the point your cooling system can't handle it anymore.

To take a suitable action, we first need to see how much is your PC is heating up. For this purpose, HW Monitor is a great free tool that will show you the current and max temperature of your CPU and GPU.

Launch the tool and you will see both GPU and CPU temperatures along with some other hardware related information. Here check the "Max" temperature. Going

up to 55°C max isn't too much of a problem if you use your PC for gaming or using heavy, applications. If it's anywhere over 60°C while your PC is heating, then it should be of concern and you should follow all the below-mentioned solutions to fix your heating PC.



Below are some ways you can fix cooling system problems.

- Check if the fan is working or not
- Avoid blocking the vents
- Clean up the PC
- Reapply thermal paste

External methods to cool down your PC

The above solutions should be enough to cool down your PC if there was a problem with cooling system or the damage wasn't too much. However, if your PC is still heating up, you may like to give an external cooling system as try.

Laptop users can use a portable cooling pad to increasing cooling power of the PC. These pads usually use fans that attach to your laptop and increase the airflow, such as the HAVIT cooling pad.

Problem 2: Dysfunctional USB Port

If your USB port stops working, it's not necessary that it's broken. Below are some solutions that can fix this issue:

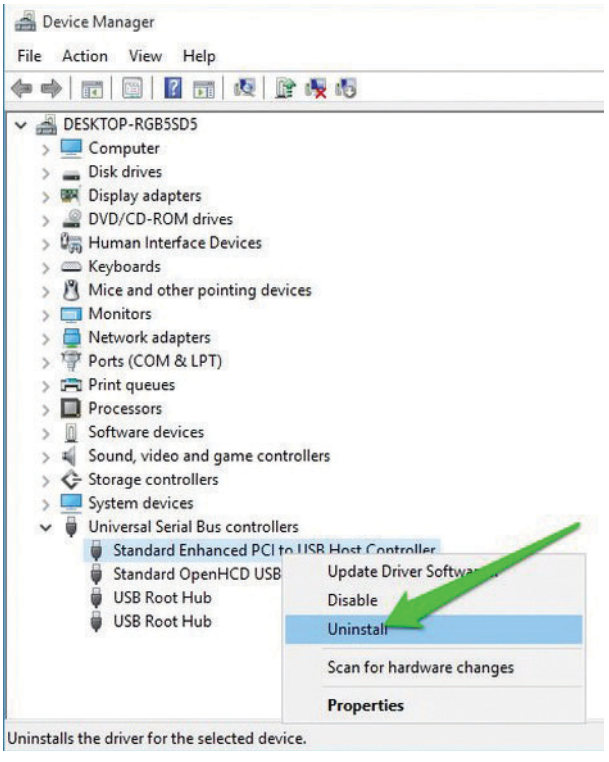
Method 1: Restart the PC

Restarting the PC is the answer to many problems and it is a common solution to USB port problem as well.

Method 2: Uninstall USB port driver

Uninstalling the driver of the USB port will force Windows to reinstall it when you will restart the PC. This may fix the problem. Here is how to do it:

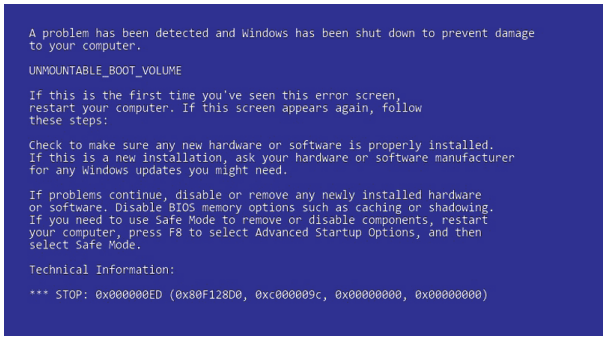
1. Press Windows + R keys and enter devmgmt.msc in the Run dialog to open the Device Manager.
2. Here, expand Universal Serial Bus controllers option.
3. Now right-click the entry USB Host Controller and then click on Uninstall.
4. Repeat this for all entries with USB Host Controller to uninstall drivers for all the USB ports.
5. Once deleted, restart the PC and Windows will automatically reinstall the drivers and fix any driver issues.



Problem 3: Blue Screen of Death.

The dreaded Blue Screen of Death (BSOD) can occur due to both software and hardware problems, but usually, it's a hardware problem. Whatever the cause, BSOD requires immediate attention as it's a sign of a big problem.

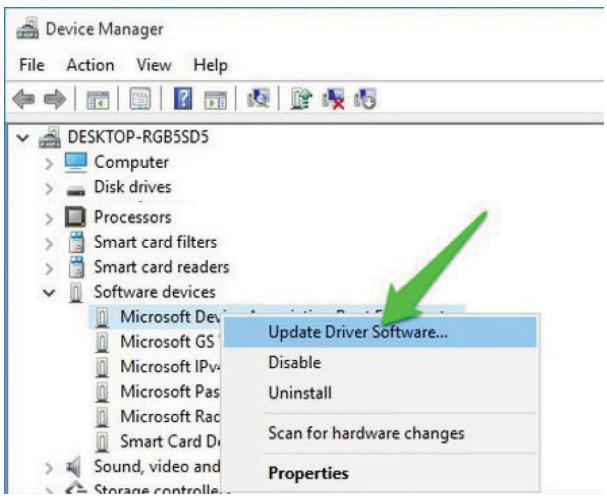
BlueScreenView is a great Nirsoft utility that will show important information if you have recently suffered a Blue Screen of Death. You should be able to identify and solve the problem using this information. Below are some common reasons for BSOD and their solutions.



Solution 1: Corrupted drivers

A corrupt driver may be the cause of BSOD. To find that out, use the following steps:

1. Open Device Manager by typing devmgmt.msc in the *Run*.
2. Here expand each menu and look for a yellow triangle icon next to each driver.
3. If you find any, right-click on it and select Update Driver Software to update its driver.



You can also use a third-party app like IObit Driver Booster to automatically find and fix driver problems.

Solution 2: Too much pressure on the RAM

If you open too many programs that RAM can't handle, then it may freeze the system and show BSOD. For that, you should either stop opening too many programs or upgrade the RAM.

Solution 3: Faulty hard disk

BSOD is also a sign of a dying hard disk, to identify hard disk problems.

Solution 4: Heating PC

Heating PC also leads to BSOD if too much pressure is put on the components.

Problem 4: Blank Monitor

If your monitor isn't showing anything, then this could be a problem with the monitor itself or the graphics card. You should connect the monitor to another PC to see whether the problem is with the PC or the monitor.

If the monitor isn't powering on at all, then replace the power cable with a working one and see if it helps.

Problem 5: Monitor goes black after few seconds

If the monitor goes black after few seconds of display, then it could be a problem with the colour quality or screen adjustment. Press the auto-adjust button on your monitor to see if it fixes it. If not, then you will have to change display colour from 32 bit to 16 bit.

You can connect the PC to another monitor to adjust colours from your graphics card settings. Pressing the auto-adjust may show the display for few seconds. You can use this to your advantage and adjust the colour while pressing auto-adjust.

Problem 6: Computer won't turn ON

If your PC is not powering on at all – not even a single light in it, then it must be a problem with the power source.

Desktop users: Check the "lights on" in the front or back of the tower. If not, the power supply unit (PSU) may be turned off. Next, you can open up your tower and look at the motherboard. Most have a small LED light built-in to show if power is running to the motherboard. If it is turned off, you can either try using a PSU tester, or replace the PSU. Never try to open a PSU and try to repair it yourself as this is extremely dangerous.

Now check, if your PC's extension cord, power outlet, and other connections are working fine, then the problem may be with the PC's power cable. Replace the power cable of the monitor with the CPU's (if you don't have a spare) to see if it turns on. You'll have to get a new power cable if this fixes the problem.

Laptop users: Take out the battery and put it back before starting the laptop. If this doesn't work, then take out the battery again and connect the charging cable to the laptop. Start the PC on charger power and see if it works. You will have to replace the battery, if it fixes the problem.

Problem 7: Computer turns on, but still doesn't work.

If power is obviously flowing to the computer system and its peripherals, there may be a component issue. If you hear any beep sound when your computer turns on, they can help you troubleshoot common PC hardware problems. Here's a list of beep codes.

No beep - The power supply is not plugged in or turned on. Or, the power supply is completely dead.

Steady, short beeps - The power supply may be bad or the voltages might be wrong. A replacement would usually be necessary.

Steady, long beeps - The power supply has gone bad.

Long, continuous beep - If the RAM inside your PC gets loose or out of place, then your PC will beep 2-3 times and won't boot at all. The solution is simple, Here's how:

- Take out the RAM completely and clean any dirt inside the slot using a cotton bud.
- Now insert back the RAM and put enough pressure on both ends to ensure it is fully inside.

Afterward, close the clips and make sure they're properly locked. Even a slightly loose RAM will be unable to work.

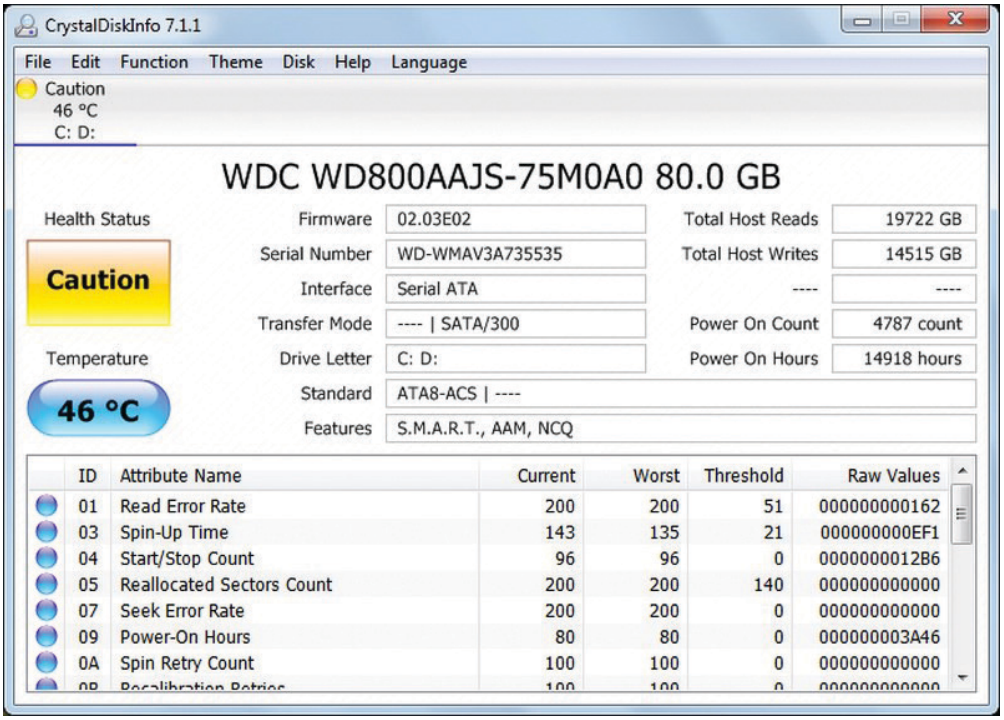
One long, two short beeps- There has been a video card failure. Your first action is to try reseating the video card. This often solves the problem when the computer system is connected to projectors because the VGA/DVI/Video cable gets moved so often that the card can be slowly unplugged. If reseating doesn't work, replace the video card.

Recently added hardware - A damaged or wrongly installed hardware component could lead to beeps. Take out any newly added hardware components and see if it solves the problem. If the PC works fine afterward, then either get it installed properly or get it fixed (or replaced).

Problem 8: Noisy hard drive

If you hear clicking or grinding sound from the hard drive, then it might be time to get a new one. Hard drives have a limited lifespan and loud sounds are the main sign of a near hard drive failure. You can use CrystalDiskInfo hard drive monitoring tool to check the health of your hard drive. The tool will tell you the current health of the hard drive with signs like "Good", "Caution" or "Bad".

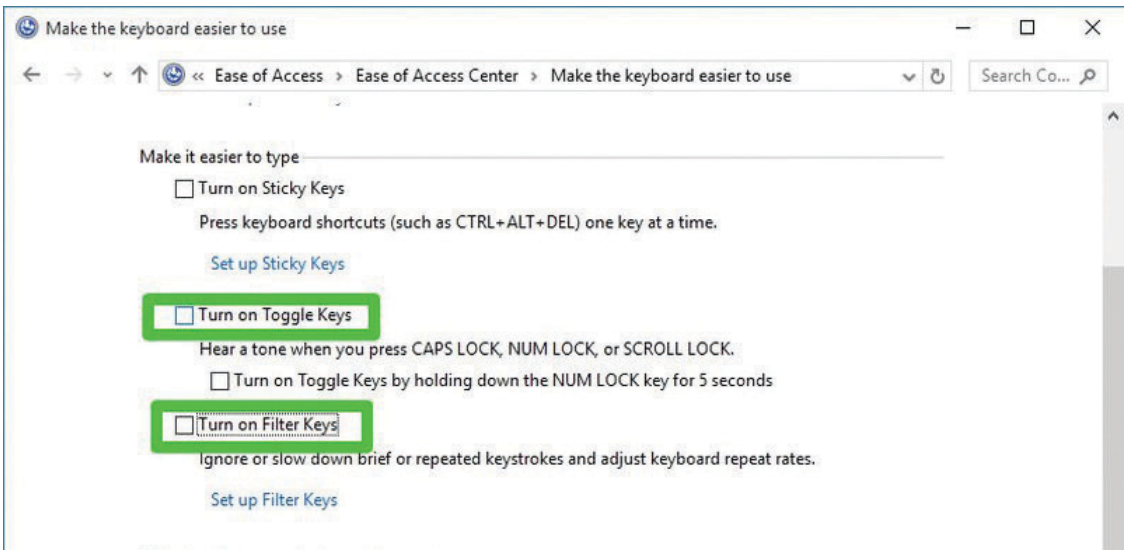
You should back up all your data immediately and try to get another hard disk before this one fails.



Problem 9: Keyboard Issues

If your keyboard is making noise and won't type repeated words properly, then there is no problem with the keyboard. You must have enabled toggle keys and filter keys in Windows settings that cause such a problem. To disable them:

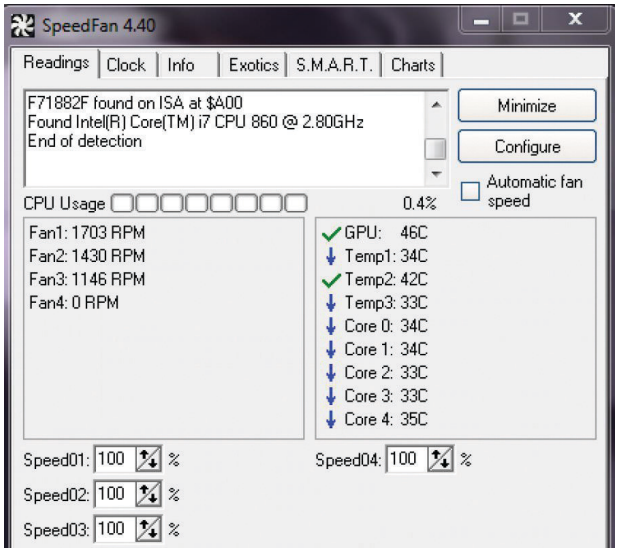
1. Open the Control Panel and click on Ease of Access.
2. Here click on Change how your keyboard works button.
3. Now uncheck the checkbox next to Toggle keys and Filter Keys to solve this problem.



Problem 10: PC Fan Not Working

If you notice one or more fans in your PC aren't working, then it could be due to the dirt inside. You will have to open up the PC and use a compressed air can or a leaf blower to clean up the fans and other components.

If dirt wasn't the problem, then you can also use the **SpeedFan** app to see what is the problem. The app will let you control the fans to make them work again. Although your PC motherboard must support fan control to use this app.



Problem 11: PC crashes before loading the OS

If your PC only shows manufacturer logo and then crashes right before it was supposed to load the operating system, then it's a problem with RAM or hard disk. As the OS is unable to load, then either the RAM is corrupted and can't hold the boot loader or the hard drive is damaged and can't load data inside it.

If you have multiple RAM slots, then taking out each one of them one by one and starting the PC will help find the culprit. In the end, you will have to replace the corrupted RAM or the hard disk, whichever has the issue.

Problem 12: CMOS error

The CMOS (complementary metal-oxide semiconductor) is an onboard chip that stores information ranging from the time and date to system hardware settings. If you get a CMOS alert message showing up on your screen, it's likely you need to replace the CMOS battery located on the motherboard. Remove it carefully, insert a new battery that is exactly the same as the old one, and enter the CMOS values to the defaults.

Problem 13: Computer has insufficient memory

Receiving an "insufficient memory or disk space" error message can usually be solved (at least temporarily) by closing extra windows to free up some RAM. If you've done that and the error still comes up, you can try rebooting your computer and installing the latest operating system update.

If you really don't have enough available memory and space (which can be checked in Windows 10 by pressing the Windows-R button and typing perfmon in the Open field to run the Performance Monitor), you can uninstall or delete any unused or unnecessary files, especially those of the video/music type. Your final solution is to add more RAM.

9.4 Troubleshoot, Rectify and Replace the Common Software Problems

Problem 1: Inability to Access Email

Emails play an important role in your daily operations today. Inability to run emails can lead to a few problems. The right way to fix email issues is to log out from your app and then restart it. Once you restart it, log back in with your credentials.

Try logging in through the web. If you are able to login through the web and not through your app, the problem is with the app.

Problem 2: Windows Displaying Blue Screen

Your Windows or Operating System could be displaying a blue screen for many reasons:

- If the screen shows up when you start your system, you can go for the 'start

windows normally' option and check if you see an improvement.

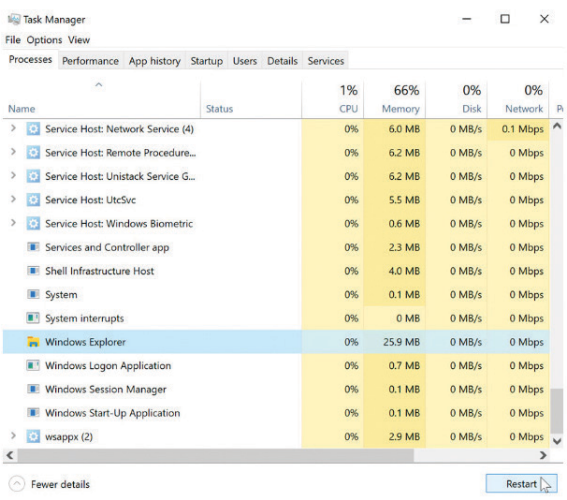
- You can force restart the system by clicking Ctrl, Alt and Delete together. Now go back to the windows option and see if it still shows the blue screen.
- You can press the F8 menu and choose safe mode from the Windows Startup Menu. Running the computer in a safe mode usually helps clear away errors.
- Go for the 'last known good configuring option', which will restart your system based on the last setting that worked.
- If none of the techniques above work, go for a system restore.

Problem 3: The computer is frozen

Sometimes your computer may become completely unresponsive, or frozen. When this happens, you won't be able to click anywhere on the screen, open or close applications, or access shut-down options.

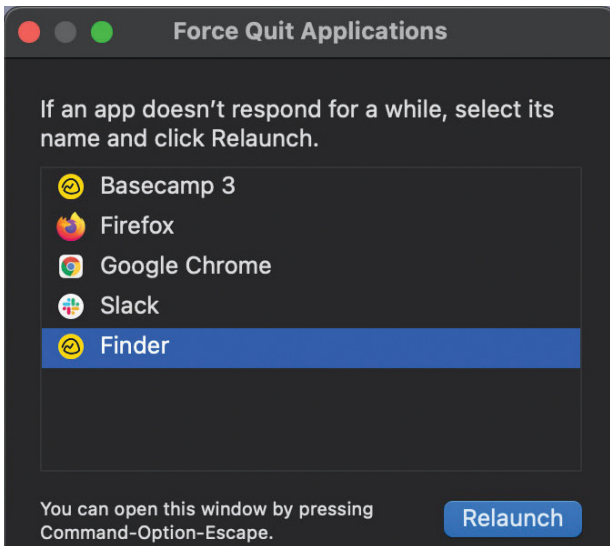
Solution 1: (Windows only)

Restart Windows Explorer. To do this, press and hold Ctrl+Alt+Delete on your keyboard to open the Task Manager. Next, locate and select Windows Explorer from the Processes tab and click Restart. You may need to click More Details at the bottom of the window to see the Processes tab.



Solution 2 (Mac only):

Restart Finder. To do this, press and hold Command+Option+Esc on your keyboard to open the Force Quit Applications dialog box. Next, locate and select Finder, then click Relaunch.



Solution 3

Press and hold the Power button. The Power button is usually located on the front or side of the computer, typically indicated by the power symbol. Press and hold the Power button for 5 to 10 seconds to force the computer to shut down.

Solution 4

If the computer still won't shut down, you can unplug the power cable from the electrical outlet. If you're using a laptop, you may be able to remove the battery to force the computer to turn off.

Problem 4: Unable to install a software program

- Verify the diskettes or CD are readable by reading the files on the drive. For example, Microsoft Windows users can explore the drive in Windows explorer. If the CD attempts to AutoPlay, you may need to right-click the drive and click *Explore* to browse the drive.

- If the CD reads fine with no errors, verify your computer meets the minimum requirements of the software program. If your computer does not have enough disk drive space or does not meet the requirements, the program will not install.
- Make sure the program or utility you are installing is compatible with the version of operating system you have on your computer. For example, many older utilities such as a virus protection program may only work with a specific version of Microsoft Windows.
- If you are getting stopped at the CD key or product key verification, verify you are entering your correct number. If you lost your number or key or it does not work, you need to contact the developer of the program. Computer Hope will not provide any users with an alternate identification number.

Problem 5: Error during installation

- Verify your computer to meet the requirements of the program or utility. For example, if your computer runs out of disk space during the installation, this would cause an error during the installation.
- If you are running Microsoft Windows 95 or higher, try installing the program from Safe Mode.
- Verify the CD for clean and no significant scratches.

Problem 6: Unrecognized file format

One of the most common reasons why you can't open an e-mail attachment is because your computer doesn't have the necessary program installed to recognize the file format. For example, if someone is sending you a .PSD image file and you don't have Adobe Photoshop or another program that supports it, the file format cannot be opened.

In this situation, we recommend you, have the sender save the file as a different format that the computer supports and re-send the attachment. If you are going to be working with this file format often, install a program or viewer on the computer that supports the file format.

9.5 Appreciate the Customer Complaints

For Regular Maintenance or troubleshoot any problem in computer, customer needs to raise a complaint to the expert to get solution. Customer Complaints are considered very important and major information that can be utilized to attain customers' satisfaction.

9.5.1 Concept of complaint

A complaint is a statement in which you express your dissatisfaction with a particular situation or it is a report from a consumer providing documentation about a problem with a product or service.

9.5.2 Nature of complaint

Before solving the complaint expert should identify the nature of the Complaint raised by the customers. There are three different natures are available as listed below.

1. Networking
2. Software
3. Hardware

1. Networking

Of all the types of computer problems you can have, network issues are one of the worst. Though our computers can do a lot on offline, being cut off from the

internet is not fun. Network problems happen when something interrupt the connection between your computer and the content you're trying to access. Due to this, connection errors may come, duplication of IP address can happen or sometimes it may slow down the system performance.

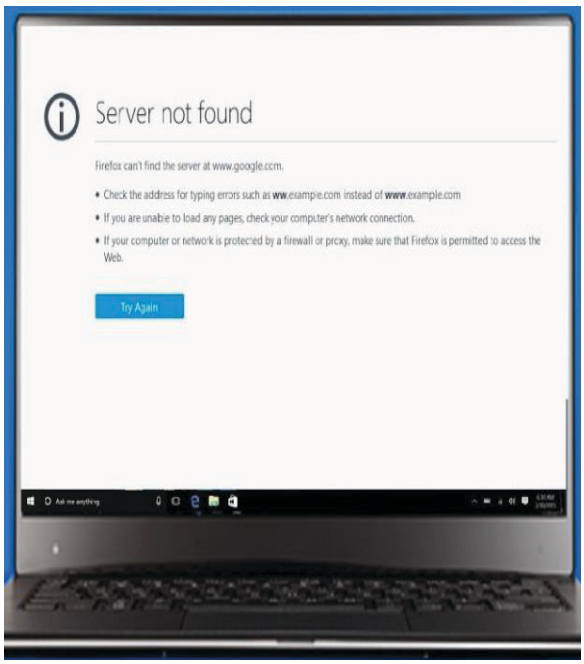


FIGURE 9.2 Network issue

2. Software

Software is a collection of data or computer instructions that tell the computer how to work. The problem lies in the software," meaning that there is a problem with the program or data, not with the computer itself. Common software issues are Computer freezes, Google performing oddly, app command not working, computer is slow, computer keeps restarting.

3. Hardware:

Hardware is typically directed by the software to execute any command or instruction. A malfunction within the electronic circuits or electromechanical components includes the physical parts of a computer, such as Central Processing Unit (CPU), monitor, mouse, keyboard, computer data storage, graphics card, sound card, speakers and motherboard. Recovery from a hardware failure requires repair or replacement of the defective part, Contrast with software failure.

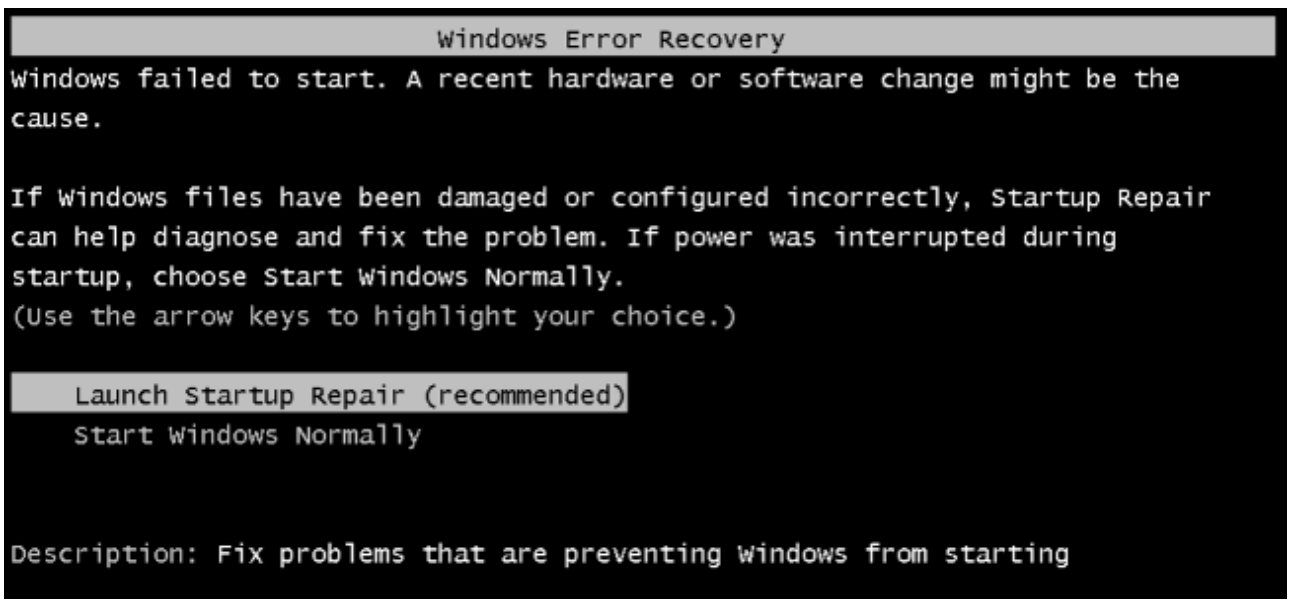


FIGURE 9.3 Software Issue

9.5.3 Types Of Complaint

The most commonly occurring complaints are listed below.

Problem	Network	Software	Hardware
Computer is slow		Could be malware, too many start-up items (Windows) or build up of temporary files	Could hard drive is fragmented or starting to fail, not enough RAM or an old CPU
Internet is slow	Network cable is loosely connected	Could be an app in background is consuming the bandwidth	Could be hard disk failing
Computer Hang	-	Yes – There may be Software problem	-
Attachments won't open	-	Yes - There may be Software problem	-
PC blue screen of death	-	-	Yes - There may be Hardware problem
Pop-up ads		Yes - There may be Software problem	
Duplicate IP Addresses	Yes – Network problem	-	-
Keyboard, mouse, printer or other peripherals aren't working properly	-	Could be driver issues	Could be computer port issues or peripheral component issues
Computer keeps restarting	-	Could be an automatic OS update problem, adware, virus or other malware	Problem in graphics card, motherboard or network card drivers
App command not working	-	Software - if it is happening in only one app	Hardware if it is happening in more than one app
Unable to Connect to the Internet	Yes – Network problem	-	-
Corrupt files or long delays in accessing files	-		Yes - Network problem
Sudden shut off…or sudden anything	-		Yes - Network problem

9.5.4 Various Ways To Make Complaint

Complaint can be explained to the experts in the following ways.

1. Personal reporting

   Customer can walk into the Service Centre or Helpdesk to file their complaint about their system. It is considered as one of the effective way to get a solution or quick response.



FIGURE 9.4 Personal reporting an issue

2. **Telephone**

   If the service centre or helpdesk is not nearby to the customers, they can report their complaint through the telephone. Customer care support should be available 24/7 to attain customer satisfaction.



FIGURE 9.5 Reporting an issue through phone

3. **Email or Messaging**

   If the service centre or helpdesk is not nearby to the customers, they can report their complaint through Messages or Email services. Any screen shots or photos need to be attached with the complaint then it is the best way to report. Since problem can be explained in detail by attaching the photocopies.

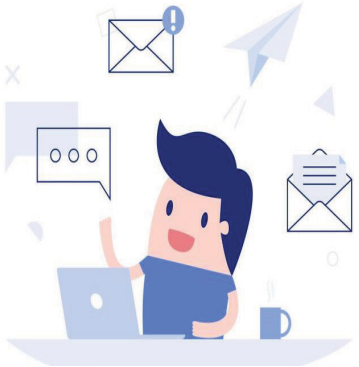


FIGURE 9.6 Reporting an issue through SMS/Email

9.5.5. Concept Of Customer Support:

Siva wants to do business and had an idea to open a net cafe. He purchased new computer system with modems. He runs his business smoothly. After few days, he had a problem with his computer system. He is getting trouble to use scanner and printer. So he feels that he had a hardware problem. He needs customer service representative help to resolve his problem.

Now what is the next step Siva has to do? Do you have any idea.



FIGURE 9.7 Customer support

Let us discuss about the concept of customer support, Customer support is defined as the services. The consultant in

an organization have to guide customers to resolve their problems. Customer support includes the process of,

1. Answering customer questions.
2. Providing assistance for troubleshooting.

Customer service representatives interact with customers on behalf of an organization. They provide information about products and services, take orders and respond to customer complaints. Many customer service representatives work in customer care centres. Customers will interact the service representatives through,

1. Cell phone / Landline
2. Online service registration
3. E – Mail
4. Direct visit



FIGURE 9.8 Customer interaction

9.5.6. Registration / log of complaint:

If customers have any complaints in their computer system, at first they have to register their complaints by the help of customer service representatives in an organization.

Complaint

A complaint is an expression of dissatisfaction with a product or service.

Registration/ log of complaint:

A process of registering a customer complaint is called registration of complaint. Here the model complaint registration form is given below.

COMPLAINT REGISTRATION FORM

Name of complainant : _____

_____

Address : _____

_____

Mobile number : _____

E - Mail : _____

Date and time of complaint submission :

_____

Nature of complaint : (i) Networking
(ii) Hardware (iii) Software

Brief description of complaint :

_____

_____

Product name : _____

Product model number : _____

Product purchase date : _____

Invoice number : _____

Guarantee / Warranty details :

_____

Signature of the complainant :

_____

For office use only

Complaint registration number :

_____

Complaint recorded by (consultant) :

_____

Date and time : _____

Signature of consultant :

_____

Signature of person in-charge :

_____

9.5.7 Work flow to solve the complaint

There should be some protocol to be followed for solving the complaints. So every organization will follow the four process one by one to receive and resolve the customer complaints. The following diagram represents the work flow to solve the complaints.



FIGURE 9.9 Work flow to solve the complaint

Receiving the complaint

Customer service representative in an organization is responsible to receive complaints from the customers. Customers have to register their complaints through mobile phone, online service registration, E – mail and written format. Customer service representatives have to receive the complaints through various sources and have to resolve their problems.

Assessing the complaint

Received complaints have to assess by the experts and have to satisfy the customers. It's a major response for the service representative to assess the customer complaints whether they have a problem in hardware, software or in network.

Investigating the complaint

Investigation is the process of enquiring the complaint in depth. While registering the customer's complaint, it is necessary to investigate the brief description of the complaint.

Resolving the complaint

Major role for the customer service representatives is to resolve the customer's complaint. Main thing of the representative is to satisfy the customer.

9.5.8 Identify The Complaints On Field

9.5.8.1 - Interacting With Customer For Understanding The Nature Before Visit

Customer will interact the resource person of company through,

- Online service registration
- Cell phone / landline
- Direct visit
- E – Mail

The customer complaint was recorded through any of the customer services mentioned above. The expert interact with the customer's through

phone call to understand the nature of the problem. So that he can have an idea to solve the problem.

Elements of Customer Interaction:

- Reliability
- Empathy
- Assurance
- Responsiveness

Reliability

The quality of being trust worthy or of performing consistently well.

Example: Raja works in a computer manufacturing industry. He has a record of 5 star rating from all the customers he served.

Assurance

A positive declaration intended to confidence, a promise. A strong feeling of confidence about yourself or about being right.

Example: Vijay assured to deliver 100 keyboards to a software company within 2 days.

Empathy

Empathy is sharing the joy at a friend's wedding. Empathy is defined as the ability to understand the thoughts feelings or emotions of someone else.

Responsiveness:

The quality of reacting quickly and positively, responsiveness as a concept of computer science, which refers to the specific ability of a system or functional unit to complete assigned tasks within a given time.

9.5.8.2 Field Trip With Tools And Devices

Your friend Lisa has a computer in her home. She is a photographer. At the time she was doing some editing work regarding her career, the computer suddenly went to off condition. She calls to the service centre and explains the situation. They understand the situation and came forward to clear the problem with some of the tools. They don't know the exact problem. So they came with two types of tools. One is Hardware and another one is software tools.

Computer Hardware Tools

The physical components of a computer such as the machine and wiring, or tools and machinery. The computer case and wiring are examples of hardware.

- Flat –tip Screwdrivers
- Philips –Head Screwdrivers
- Torx Screwdrivers and Nut Drivers
- Wire Cutter
- Needle-Nose Pliers
- Wire Strippers
- Crimpers

Computer Software Tools

Software or a programming tool is a set of computer programs that are used by the developers to create, maintain, debug, or support other applications and programs. The tools are as follows

- OS (Operating System)
- Device drivers
- Anti Virus
- Basic software

External Devices

A device is an object that has been invented for a particular purpose, for example for recording or measuring something.

- External hard disk
- Pen drive
- SFC(System File Checker)
- External CD Drive

9.5.8.3 Understand The Nature Of Problem On Field By Interacting With Customer:

If we want to know the system complaint, it is important to have conversation with the customer. Because if the problem is caused by physical damage or liquid contact means we can easily find out by interacting with the customer.

We can discuss about the key points to discuss with the customer.

1. Time duration of the problem,
2. PC overheating,
3. Application running slowly,
4. Internet or network connectivity issues,
5. Hardware drive failure,
6. Unable to install Application.
7. Computer suddenly shut off or restarts

First you have to ask the customer how many days they are having that problem. Because problems may increases periodically according to the maintenance of the computer. Ask types of problem facing by them, and then you find out the problem in that system (hardware problem "or" software problem). Then you check all the part of computer system. (Check the wire connections, board damage), if no problems found, then it is a software Problem. Due to software problems the computer works slow, keeps restarting, keyboard and mouse are not working properly; find the problem and resolve it.

9.6 Concept of Computer Ergonomics

Computer ergonomics is the practice of fitting the setup of the computer and the workspace to fit the user and the user's work needs in order to minimize physical stress on the computer user.

Ergonomics is a field of study that attempts to reduce strain, fatigue, and injuries by improving product design and workspace arrangement. The goal is a comfortable, relaxed posture.

Arrange Your Workstation

Every time you work, take time to adjust workstations that aren't quite right in order to minimize awkward and frequently performed movements.

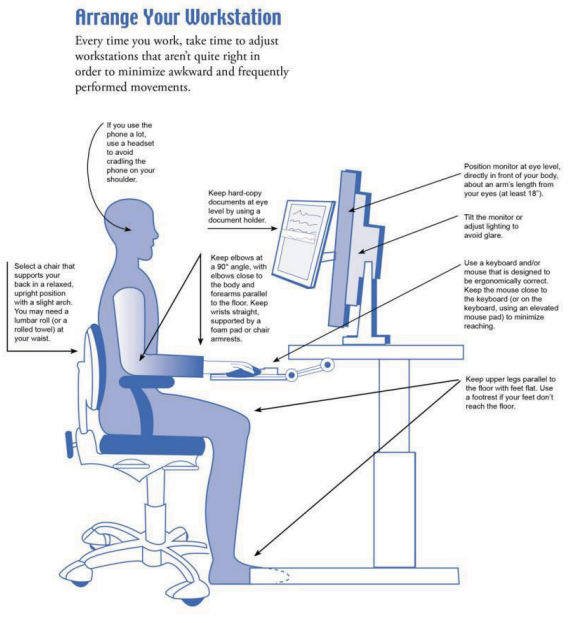


FIGURE 9.10 Arrange your workstation



FIGURE 9.11 Modify your body mechanics

Modify Your Body Mechanics

Do you wear eyeglasses? Make sure they fit properly to avoid tilting your head. Type with light strokes, and try to keep your muscles relaxed.

Adjust Your Work Patterns

Reduce prolonged computer time whenever possible. Break work into smaller segments and switch between tasks that use different motions.

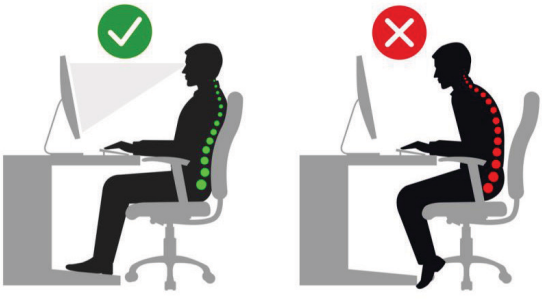


FIGURE 9.12 Position

Move

At least every 10 minutes, take a short (10-20 second) break. Take your hands off the keyboard and move! Every 30-60 minutes, take a brief (2-5 minute) break to stretch and/or walk around.

Exercise at Your Computer

Neck Rotation: Slowly rotate your head as far as comfortable to the right, then left.

Shoulder Rotation: Circle your shoulders, then reverse directions.

Head Side to Side: Bend your neck so left ear approaches left shoulder, then repeat for right. Add a little resistance by pressing your hand against the side of your head

Arms

Arm Relaxation: Drop your arms and hands to your sides. Gently shake them for a few seconds

Hands and Wrists

Wrist Flex: With your elbows on desk, gently use left hand to bend right hand back toward forearm. Hold for a few seconds, then relax. Repeat on other side

Feet

Toe Curl: Flex toes up, then curl toes under. Release.

Foot Rotation: Circle foot slowly from the ankle, then reverse.

Eyes

Eye Rolls: Roll your eyes clockwise then counter clockwise briefly.

Palm Eyes: Without touching your eyes, cup hands lightly over eyes for 30 seconds to rest them from light.

9.7 Basic Electrical Safety at Workplace

Electricity is everywhere in our lives. Electricity lights up our homes, cooks our food, powers our computers, television sets, and other electronic devices. Electricity (DC Current) from batteries starts our cars and makes our flashlights shine in the dark. You need to have safe and functional electricity within the workplace, so that you can effectively function and allow for the most production from the employees.



FIGURE 9.13 Electrical Safety

Electricity does indeed power computers, either directly for desktop units or indirectly through uninterruptible

power supplies (batteries charged by the power system) for large computers, so that we need to know the electrical safety, when working with computer.

Electrical safety

Electrical safety refers to any safety precautions taken against electricity. Electricity is undoubtedly one of the most basic needs in modern life, but electrical hazards are very dangerous.



FIGURE 9.14 Electrical safety tips

Some of the serious injuries you can receive from electricity include electrical shocks, electrical burns, and electrocution,

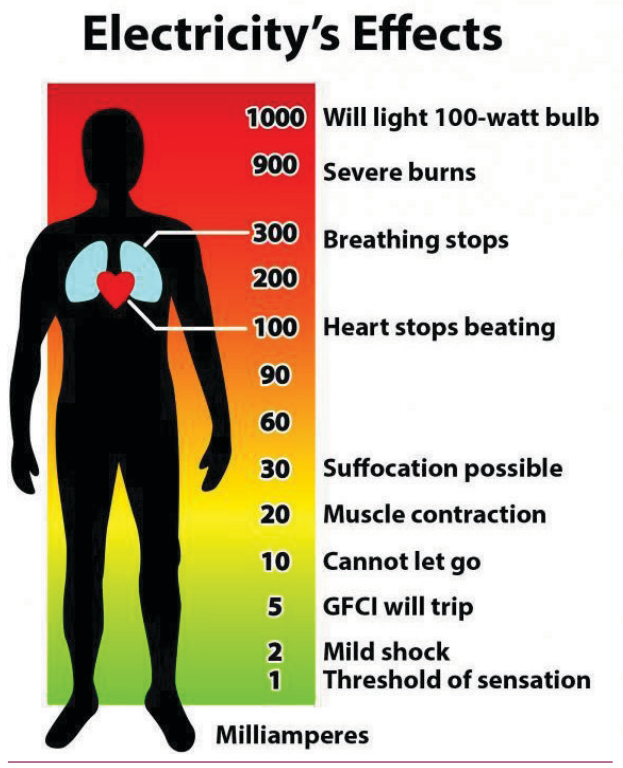


FIGURE 9.15 Electricity effects

which could be fatal. Electrical safety precautions can protect against electrical shocks and burns.

Concept of safety of work infrastructure

Today's computer workstation has few hazards other than ergonomic that the typical worker will be exposed to if all components are functioning properly. Many injuries or illnesses associated with a computer workstation will be of an ergonomic nature and thus may be difficult to diagnose.

A safe place of work

1. Make sure your buildings are in good condition.
2. Maintain the workplace and any equipment so that it is safe and works efficiently.
3. Make right any dangerous defects immediately, or take steps to protect anyone at risk.
4. Fence or cover floor openings, e.g., vehicle examination pits, when not in use.
5. Have enough space for safe movement and access.
6. Provide safety glass, if necessary.
7. Make sure floors, corridors and stairs etc., are free of obstructions, e. g., trailing cables.
8. Provide good drainage in wet processes.
9. Make sure any windows capable of being opened can be opened, closed or adjusted safely.
10. Make sure all windows and skylights are designed and constructed so that they may be cleaned safely.

Lighting

1. Good light – use natural light where possible but try to avoid glare.

2. A good level of local lighting at workstations where ever it is necessary.
3. Suitable forms of emergency lighting.
4. Well-lit stairs and corridors.
5. Well-lit outside areas.

Moving around the premises

1. Safe passage for pedestrians and vehicles – separate routes may be necessary.
2. Level, even floors and surfaces without holes or broken boards.
3. Hand-rails on stairs and ramps where ever it is necessary.
4. Safely constructed doors and gates.
5. Floors and surfaces which are not slippery.

Cleanliness

1. Provide clean floors and stairs, with effective drainage where necessary.
2. Provide clean premises, furniture and fittings.
3. Provide containers for waste materials.
4. Remove dirt, refuse and trade waste regularly.
5. Clear up spillages promptly.

Hygiene and welfare

1. Drinking water.
2. Use clean toilets and hand basins. With running hot or cold or warm water clean with soap and dry with towel or any other means of drying.
3. Somewhere to rest and eat meals, including facilities for eating food which would otherwise become contaminated.
4. Showers for dirty work or emergencies.
5. Accommodation or hanging space for personal clothing not worn at work (and somewhere to change if special clothing is worn for work).

LEARNING OUTCOME

After studying this chapter, students can understand the following

1. Basics of computer maintenance and its categories
2. Troubleshoot, Rectify and Replace the common hardware problems.
3. Troubleshoot, Rectify and Replace the common software problems.
4. Customer complaints.
5. Computer ergonomics
6. Basic electrical safety at workplace.



QUESTIONS

I. Choose the best answer from the given four options. (1 Mark)

1. _____ is a combination of hardware and software.

   a) Firmware b) Hardware
   c) Software d) Fireware

2. Main Hardware components of the system BIOS is _____.

   a) BIOS
   b) BIOS ROM
   c) BIOS CMOS Memory
   d) BIOS POST

3. CMOS stands for _____.
   a) Complementary Metal Oxide Semiconductor
   b) Complex Metal Oxide Semiconductor
   c) Common Metal Oxide Semiconductor
   d) Central Metal Oxide Semiconductor
4. The physical parts of a computer are called _____
   a) Software b) Hardware
   c) ALU d) Memory unit
5. What is the name of the on board chip that stores the date, time and system configuration?
   a) RAM b) CMOS
   c) JFET d) FET
6. How many beeps will a speaker sine on the failure of RAM?
   a) 2 - 3 times b) 4 - 5 times
   c) 1 - 2 times d) 3 - 4 times
7. Which of the following is computer hardware tool?
   a) Crimpers b) Device drivers
   c) Antivirus d) OS
8. _____ is a software or a programming tool.
   a) Crimpers b) OS
   c) Wire strippers d) Nose plier
9. Which of these software is also called firmware?
   a) Operating System
   b) System BIOS
   c) Installation drivers
   d) None of the above
10. What component of the computer processes data?
   a) The RAM
   b) The storage devices
   c) The processor
   d) The monitor

II. Answer in few sentence.

1. What is computer maintenance?
2. Define predictive maintenance.
3. What is BIOS? Why it occurs?
4. What is blank monitor?
5. Write short notes on 'Noise Hard Drive'.
6. Why CMOS alert message showing up on our screen? How will you react?
7. What are the ways a customer can interact with a resource person of a company?
8. What are the elements of computer interaction?
9. What is computer ergonomics?
10. What is electrical safety? Why it is important?

III. Explain the following questions.

1. Why computer maintenance is essential?
2. What are the reasons of over heating of PC? How will you overcome the problems?
3. List out the computer hardware and software tools.

IV. Briefly explain the following questions.

1. What are the types of computer maintenance? Explain each in detail.
2. Explain any five common software problems in a computer with rectification procedures.
3. Explain about electrical safety and the concept of safety of work infrastructure.

ANSWERS

1(a) 2(b) 3(a) 4(b) 5(b)
6(a) 7(a) 8(b) 9(b) 10(c)



CHAPTER 10

Network Maintenance- Troubleshooting and IT Securities

LEARNING OBJECTIVE

The students can understand the following in this chapter

1. Common network problem
2. Hardware troubleshooting
3. Problems related with network operating system
4. Over view of hacking
5. Cyber crime
6. Security policy
7. Functioning of Firewall
8. ITIL V4

10.1 Introduction

A computer network consists of collection of computers, printers and other equipment that are connected together so that they can communicate with each other. So there is a possibility of rising hardware or software error at any point of time. Troubleshooting helps us to deal with the error that rising in computer network. Troubleshooting is the process of identifying and solving problems related with computer and other components in a systematic manner. Troubleshooting will always be a process of trial and error – in some cases you may need to use several different approaches before you find a solution. Troubleshooting is a skill that you refine over time. Each time you solve a problem, you are increasing your troubleshooting skills by gaining more experience and comes to know when to combine steps or skip steps to reach a solution quickly.

10.2 Steps involved in troubleshooting

Troubleshooting steps may vary depends on the problems we are dealing with but there are certain basic steps that need to be remember while troubleshooting; they are:

- Identifying the problem

  In this step, gather as much information as possible about the error and make backup of the system before moving on.

- Test probable cause.
  Create your technical procedural form which will help to identify probable cause.
- Execute the plan.
  Once the actual cause is identified then apply the relevant troubleshooting method.
- Verify system functionality
  After troubleshooting, you need to verify that the system is fully functional.
- Documentation.
  Document the findings, actions and outcomes. When the problem occurs again it would be helpful.

10.3 Common Network Problems

This section will discuss some of the potential problems that occur commonly in a computer network.



FIG 10.1 Power Failure

10.3.1 Power Failure

Symptom: A system that is completely dead or spontaneous rebooting. Display of "No Signal" message in the monitor, electric shock felt on the system connectors, small brownouts or smoke from the system are some of the common symptoms of power failure.

Cause: Overload power supply or overheating due to fan failure. Loose cable connection and UPS failure can be the cause of power failure

Solution:

1. Check AC power input: Make sure the cord is firmly seated in the wall socket and in the power supply socket. Try a different cord.
2. Check DC power connection: Make sure the motherboard and disk drive power connectors are firmly seated.
3. Check DC power output: Use digital multimeter to check the voltage at the Power Cord pin for +3 to +6V power. If the measurement is not within the range, the power supply is bad and must be replaced.
4. Check Installed peripherals: Remove all boards and drives and restart the system. If it works, add back in items until the system fail again. The last item added before the failure return is likely defective.



FIG 10.2 Digital Multimeter

10.3.2 Wiring Problems

Symptom: Frequent electrical surge or power sags and dips. Flickering light, loose outlets and cable burning are the symptoms of failed wiring.

Cause: Improper installation of cables and not maintaining the distance

limits between the cables. Atmospheric temperature or running network cable parallel to electrical cables.



FIG 10.3 Wiring Connection

Solution

1. Ensure your connections are well made. Don't over fix wire nuts, but ensure they are firmly tight.
2. Securely test the fixture with an extra cord to check whether it works. If it doesn't, check the wiring installation. If required, replace the cable.
3. Make sure the network cable and network port you are using are working properly.
4. Inspect cable for any pinching or breaks.
5. Keep cables away from electromagnetic interference.

10.3.3 Device Not Working

Symptoms: Printer, fax machine, Wi-Fi or other electronic devices attached to the network may not work properly.

Cause: Device driver might be outdated or not properly installed. Connection or device failure can be the cause of device not working.

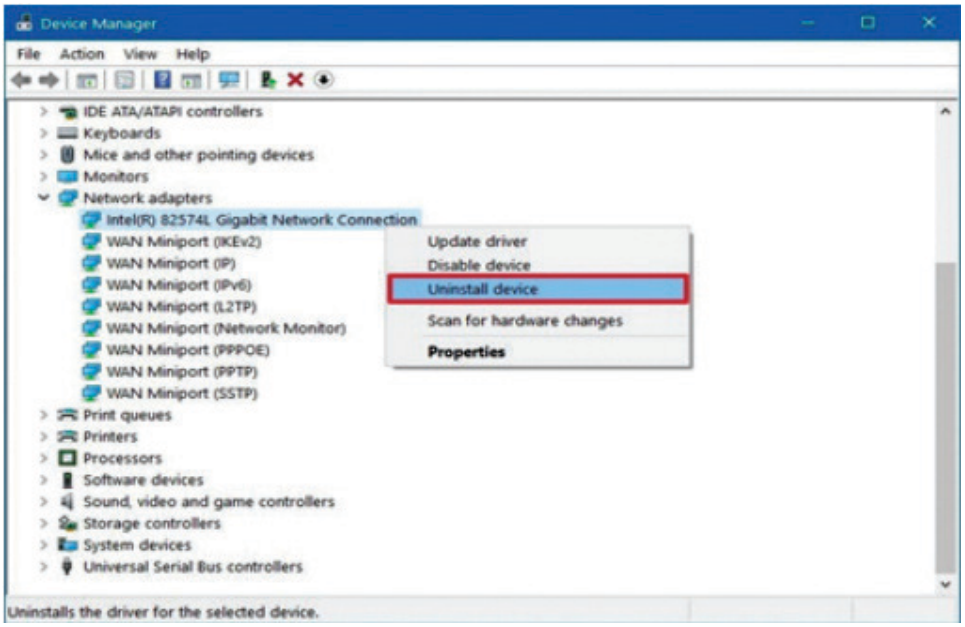


FIG 10.4 Device Connected To Wi-Fi

Solution

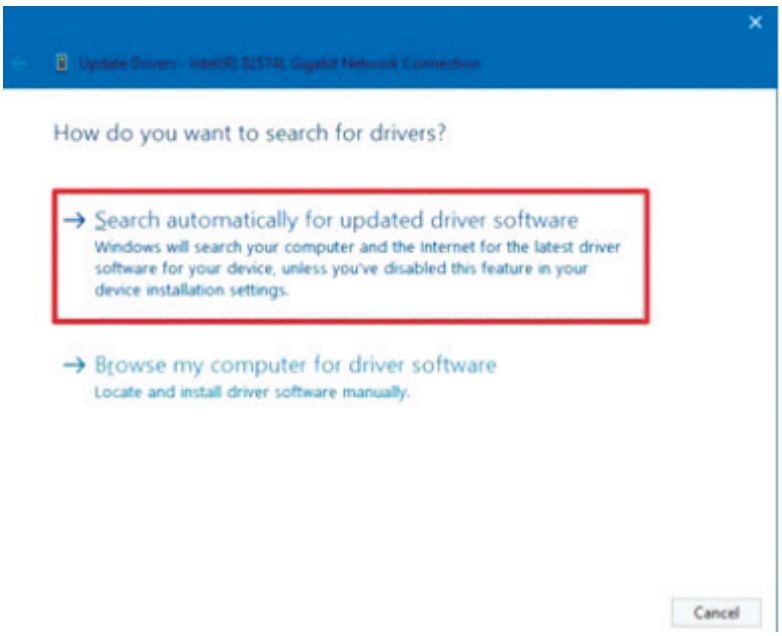
1. Unplug and reinstall the device then restart the system.
2. Use the Device Manager to identify the device problem by following the steps below.
   a. Go to start->control panel->device manager
   b. Expand the branch with the device you want to check
   c. Right click the device and select the Properties option
   d. Click the General tab
   e. Under Device status section, confirm the status of the component
   f. If the component isn't working properly, then you'll see the description of the problem with an error code.
3. Follow the below steps to fix the device problem
   a. Goto start> control panel> device manager
   b. Expand the branch with the device you want to fix
   c. Right click the device and select uninstall device option
   d. Click the uninstall button and restart your devices.

e. Else select Update driver option to look for automatic update then restart the device



d. Click the uninstall button and restart your devices.

e. Else select Update driver option to look for automatic update then restart the device.



10.3.4 Non Availability of Network Resources

Symptoms

Sometimes while installing a program in windows 10 you may receive error message "The feature you are trying to use on a network resource is unavailable" and this error prevents you from installing or uninstalling programs on your PC.

Cause

This error may occur due to the original application might be removed or is no longer available, while uninstalling anything from the window installer service.

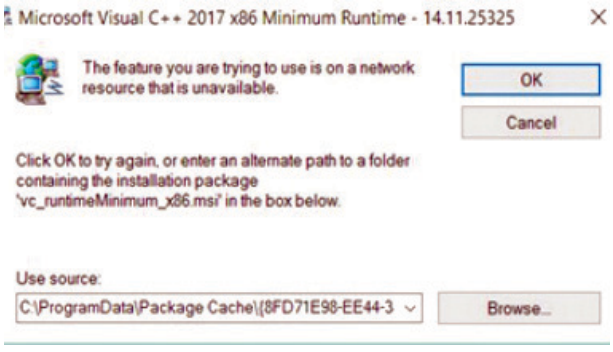
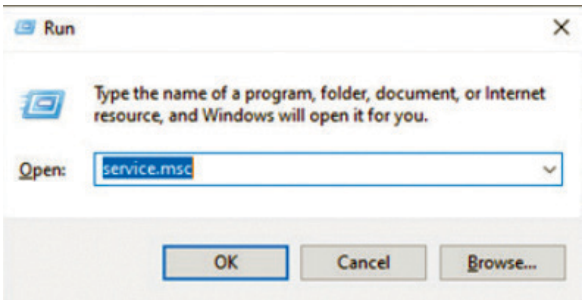


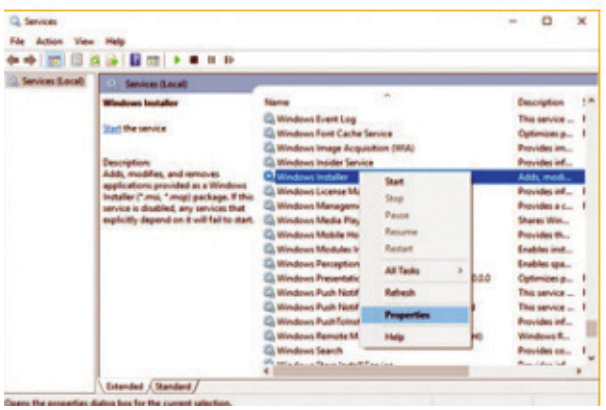
FIG 10.5 Resource Unavailable Error Message

Solution

1. Press the windows key + R to open a Run dialog box
2. Type services.msc into the Run dialog and press Enter



3. In the service manager, locate Windows Installer in the list of available services. Right click and select properties in the resulting context menu.



4. In the properties window, make sure that the Startup Type is Manual or Automatic.
5. Proceed to Service status. Check if the service is running. If not, click Start.
6. Click on Apply and then OK.
7. Restart and Check if the issue has been resolved.
8. If still the error occurs, then you can remove the sub key of the specified application from the Registry Editor

10.3.5 Internet Not Working

Symptoms

"No Internet Connection" or "Connection Failed" are the common message that arise when the system is not connected to the internet

Cause

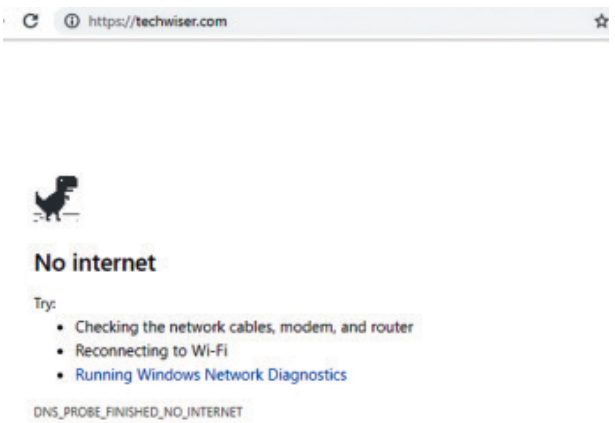


FIG 10.6 No Internet Connection

There are lots of possible reasons for why internet isn't working. Your modem or router may be out of date, DNS (Domain Name System) cache or IP address may be experiencing a glitch, or internet service provider could be experiencing outages in your area. The problem could be as simple as faulty Ethernet cable or running out of data.

Solution

1. Check if the computer is properly connected to the network
2. Restart the network settings. This changes everything back to default settings.
3. Restart modem and router.
4. Clear computer DNS cache and browser cache
5. Perform virus and malware scan.

10.3.6 Server Connectivity Problems

Symptoms

If you have a problem connecting to a website, you may see error message like Server Not Found, Error 404 not found or The site can't be reached

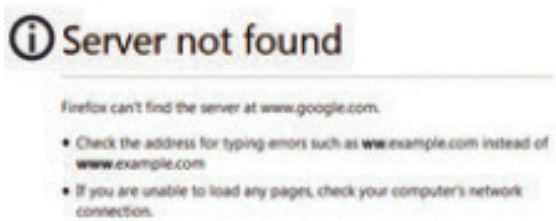


FIG 10.7 Server Not Found Error

Cause

The server you're trying to connect may no longer exist or the DNS is set up incorrectly on the name servers. It could also because of temporary issue in the DNS system of machine doing the lookup.

Solution

1. Check the URL for spelling mistake and reload the page
2. Use different browser and search engines
3. Check your modem and router, if required reset
4. Check the firewall and antivirus settings to ensure that the site is not in the blocked list
5. Check for malware and harmful browser extension
6. Avoid proxy server or VPN

10.3.7 Network Hang

Symptoms

Browser become freeze or unresponsive and getting message like "The page cannot be displayed". Taking long time to load a page can be the symptoms of network hang.

Cause

Network hang have varied causes, including hardware and software defects, slow network, misconfiguration and compatibility problem.

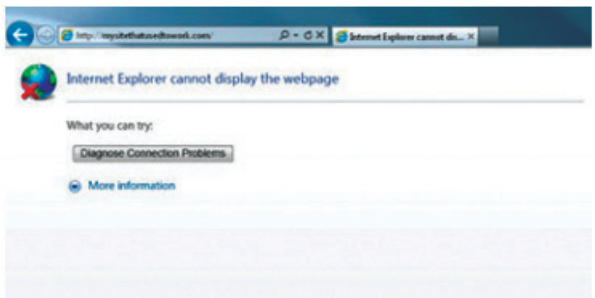


FIG 10.8 Network Hang

Solution

1. Right click on the computer internet connection icon at the bottom-right corner of the computer and select "Troubleshooting problems"
2. Reset your modem and router
3. Reboot the computer
4. Temporarily shut down the firewalls, and other system protection application that runs continuously
5. Install all recommended windows updates

10.3.8 Downloading and Uploading Issues

Symptoms

Takes longer time than usual to upload and download files.

Cause:

Website traffic, age of computer, pending windows updates and virus

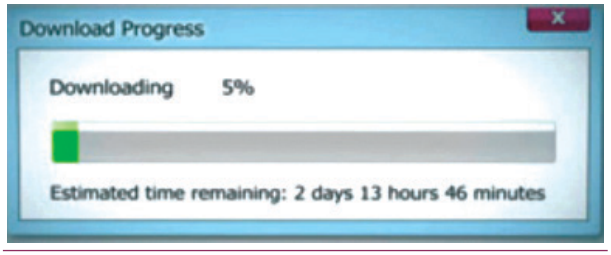


FIG 10.9 Slow Downloading

Solution

1. Update windows application, device drivers and browser to the latest version
2. Scan for any virus and malware
3. Reset router and modem
4. Delete Temporary files by typing %temp% in run dialog box.
5. Use Ethernet connection instead of Wi-Fi
6. Remove unnecessary background application
7. Limit the devices connected to the router

10.4 Hardware Troubleshooting

There is a wide variety of possible hardware problem that can lead to a total network interface failure. These problems include the following:

10.4.1 Problems with Hardware Devices

Old, damaged, and malfunctioning NICs are the top of the Hardware Problem list. It is frequently necessary to replace suspect component systematically with good known parts. Follow the below troubleshooting technique to avoid common hardware problems:

- **Minimize ESD:** Electrostatic discharge, or ESD is a reality, so handle NICs with care and make sure you are properly grounded.
- **NIC standardization:** Ensure there is no damage to the Network Internet Controller (NIC) port or to the cable. Check the configuration and install latest driver
- **Cleanliness:** Keep the network equipment clean and at the proper temperature
- **Power:** Check for power surge using Digital Multimeter.
- **Cabling:** Ensure the standards of cabling such as 568A and 568B. Check whether the cable is properly installed with required distance.

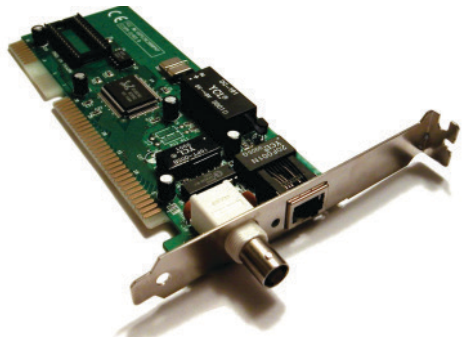


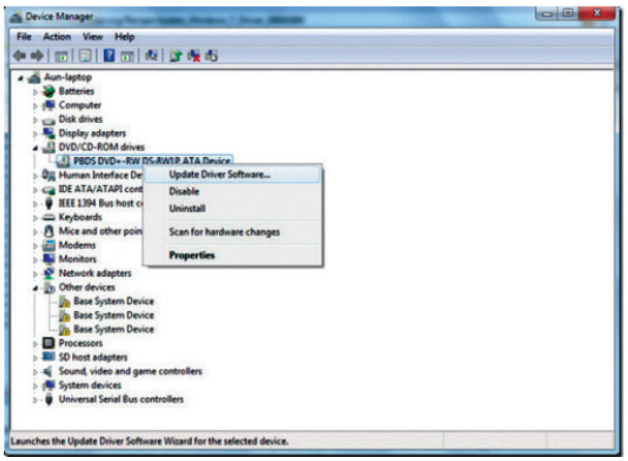
FIG 10.10 Network Interface Controller

10.4.2 Hardware Configuration Problems

The ability to configure your server hardware properly is essential for the smooth running of the operating system. Hardware

configuration references the details and system resource setting allotted for specific device. With newer technology most of the computers have Plug and Play, (PnP) allowing OS to detect and configure external and internal peripherals as well as most adaptors. Follow the below troubleshooting technique to avoid common hardware configuration problems.

1. Go to the Device Manager. Locate the device you want to update.
2. Right click and select Update Driver



3. If still not properly configured, then Uninstall and reinstall that Device again.
4. Make sure the hardware is properly attached to the system.
5. Finally, replace the device.

10.4.3 Replace Old Device

The technology is constantly advancing, so the network device is either need to replaced or updated to avoid compatibility issue. Network devices need constant attention and any non functional old device should be replaced. Following are some of the reason could look towards upgrades:

- **Security Issue:** This is the most important reason. Cyber crime has been increasing in both frequency and severity for couple of decades, and is almost certainly going to be one of the biggest challenges for IT in the 21st century.
- **Wi-Fi Advances:** Wi-Fi is the fastest changing field in the network hardware. Wi-Fi lags behind connection in terms of bandwidth and speed, but as data demands: continues to increase.
- **Ports and Wiring:** Newer connection types require connectors and wiring which can keep up with them.

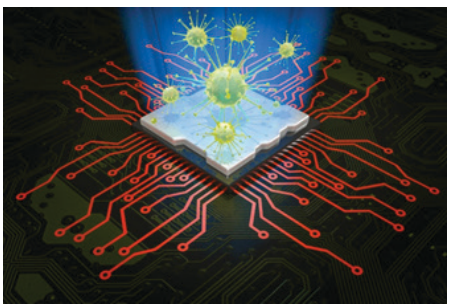


FIG 10.11 Computer Virus

Solution

1. Upgrade firewall to avoid security issue.
2. Replace the network internet connection to the latest Wi-Fi environment.
3. Upgrade wiring / cabling, since an upgrade to new network hardware requires wiring update to get better performance.
4. If any hardware is replaced then check with device manger for its proper installation and working status.
5. Ensure that there is no problem with the network setup due to the replacement of old device.
6. Keep regular watch over the performance of network devices to capture the faulty one at the earliest.



FIG 10.12 Firewall

10.4.4 Maintenance of Services

Network maintenance is essentially what you need to do to keep your network up and running smoothly. There are basically three main approaches to handling network maintenance: they are:

- **Structured Driven:** In this approach, you have system in place to prevent problems before they happen. Even if problems arises, you are well prepared to handle the situation. This protective approach reduces the frequency and quantity of problems and addresses them more efficiently.
- **Interrupt Driven:** In this method, you wait for the problem to happen and then fix it as quickly as possible. This method has most cost-effective and less down time compared to structured approach.
- **Standards-Based Maintenance:** Several well known network maintenance methodologies have been defined by a variety of organizations such as:
- Information Technology Infrastructure Library (IITL)
- Telecommunication Management Network (TMN)
- Cisco Lifecycle Services
- FCAPS (Fault, Configuration, Accounting, Performance, Security)
- The choice of maintenance methodology will determine the type and variety of maintenance tools required.

Network Maintenance Tasks:

Some of the more common network maintenance task includes the following general activities:

1. **Installing, Replacing or Upgrading both Hardware and Software:** It is a common network task to replace older or failed hardware and installing device software and creating backup of device configuration.
2. Monitoring, Tuning and Optimizing the network: Verifying the performance of the network and all inter-network devices in the network. Identifying and troubleshooting potential network issue.
3. Securing Network from both Internal and External Threats: Network security is an integral component of network operation and maintenance. Structured maintenance approach can also be used to discover vulnerabilities or potential security threats, which can then allow for the appropriate action to be taken before an incident occurs.
4. An Inventory of all network Devices, Components and Modules: Maintaining an inventory for interconnected component in the network helps to know when to replace the device or update.
5. Writing and Updating Documentation: Documentation is the critical component of network maintenance as well as troubleshooting and support. From best practices perspective, network documentation should include the following information at a minimum:
   a. Information about the interconnects between devices for LAN and WAN connections

b. IP addressing and VLAN information
c. A physical topology diagram of the network
d. A logical topology diagram of the network
e. Configuration information
f. Data or traffic flow patterns

10.5 Problems Related with Network Operating System

10.5.1 Installation of Software

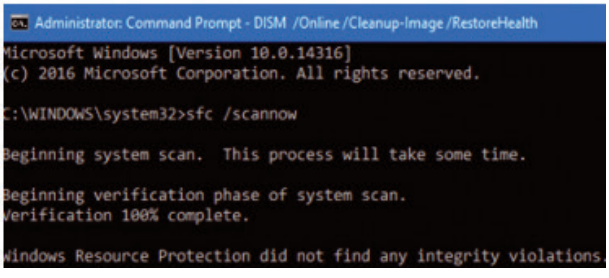
Possible problems during software installation and troubleshooting methods are described below:

Problem1

System cannot find the file specified

Solution

1. If you have a CD-ROM containing new software, make sure it is installed in the drive of the server that you're currently logged into.
2. Install windows updates
3. Check the system log files
4. Uninstall and reinstall the drivers
5. Restore or repair the missing files using the following steps:
   a. Open Command Prompt (cmd) as Admin
   b. Type "sfc/scannow" into command prompt and press enter, wait a while, chkdsk tries to repair your files



   c. Type exit and press enter to leave the cmd.
6. Undo any recent hardware or software changes
7. Scan for virus and malware
8. Check for firewall conflict.
9. Close other background running programs and free up RAM
10. Boot up system in safe mode.

Problem 2:

Software Installation failed

Solution:

1. Copy or download the software properly.
2. Install, if the software requires any supporting software
3. Follow the installation procedure as given
4. Remove temporary files and earlier installation of that software, if any
5. Install with administrative rights

10.5.2 Problems in Software Configuration

Software misconfigurations are time-consuming and hard to troubleshoot. The behavior of software system often depends on how the system is configured. Small configuration errors can lead to hard-to-diagnose undesired behaviors.

- Software Configuration Management (SCM) is a process to systematically manage, organize and control the changes in document, codes, and other entities during the Software Development Life Cycle.
- The primary goal is to increase productivity with minimal mistakes.

SCM is part of cross-disciplinary field of configuration management and it can accurately determine, who made and which revision.

- It provides tool to ensure that changes are being properly implemented
- The four procedures typically found in reliable software configuration management system are:
- **Configuration Identification:** It is the process of identifying all of the components of a project and ensuring that these components can be found quickly throughout the project life cycle. It also breaks a project into smaller, more manageable sub-projects.
- **Configuration Change Control:** It is a set of processes and approval stages required to change a configuration object's attributes and to rebase them newly.
- **Configuration Status Accounting:** It is used to record and report on the configuration baselines associated with each configuration object at any point in time.
- **Configuration Auditing:** It is a process that confirms that a software or intranet project is on track. By developing a series of checklist that specify what components are in a given baseline, which a project or intranet is complete.

10.5.3 Software Maintenance and Updation

Software maintenance is an inclusive activity that includes error corrections, enhancement of capabilities, deletion of obsolete capabilities and optimization. Software maintenance is need for:

- Correct errors
- Change in user requirement with time
- Changing software/hardware requirements
- To improve system efficiency
- To optimize code to run faster
- To modify the components

Software maintenance is classified into the following categories:

1. Corrective Maintenance: This aims to rectify bugs observed while the system is in use, or to enhance the performance of the system.
2. Adaptive Maintenance: This includes modification and Updation when the customers need the product to run on new platforms or the product to interface with new hardware and software.
3. Perfective Maintenance: It defines improving efficiency or performance of the software and adding new features that the users want or change different types of functionality according to the needs.
4. Preventive Maintenance: This type of maintenance includes modification and Updation to prevent future problems of the software.

10.5.4 Replacement and Re-installation of Software

System need to be updated in order to maintain smooth network operation. While updating, it is necessary to replace the older version of software with newer version and also driver software need to be updated for any hardware changes. Changing or reinstalling software without affecting the routine is a challenging task in network. Below are the some of the troubleshooting technique that need to be followed when reinstallation take place.



FIG 10.13 Driver Installation

1. Back up Data: Before replacing any software, back up everything it contains that you wish to keep. Data can be stored in either hard drive or cloud drive.
2. Create a Recovery Disc: To reinstall operating system on a computer, create a recovery disc that the computer can use to boot up the new, blank drive after it is installed.
3. Remove Old Drive: Make sure the computer is turned off and unplugged before starting, locate the hard drive and remove the power cables and data connectors from the drive itself. Now replace with the new drive and reinstall the driver software
4. Uninstall older version: Before reinstalling or replacing any software, first remove the older version from the system and make sure the data is backed up. Then proceed to reinstall the software.
5. Check for malware: Software installation may interrupt or fail due to the malicious software present in the computer or network. Hence, make sure you have a strong firewall to protect your network.

10.6 Problems related to Network Users

Network authentication verifies the user's identification to a network service to which the user tries to gain access. Network users may experience problems with login, authentication, rights, permission and access to network. This section will discuss the troubleshooting technique for the common problems related with network users.

10.6.1. Authentication Problem

Symptoms

Authentication failed error message appear while trying to login or access certain resource. This error message indicates that the authentication process between your local computer and the remote host computer has failed for some reasons.

Cause

The common cause of failed authentication is an incorrect password, trying to access non permissible resource and security attack.

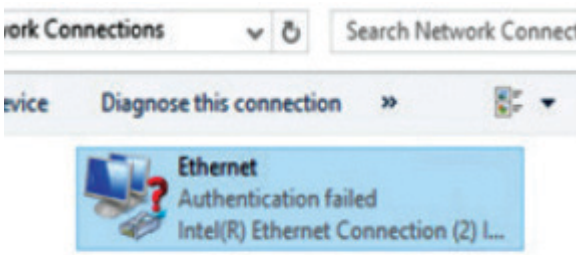


FIG 10.14 Authentication Failed

Solution:

1. Ensure username and password is typed correctly
2. Check your rights and permission before accessing the resource

3. Clear cookies and reconnect to the network by typing password
4. Reset the wireless network connection
5. Update device driver for router and modem

10.6.2 Login and Password Issues

Incorrect password or security attack could prevent network user from login into their system or account. Following are some of the troubleshooting technique to deal with login issues:

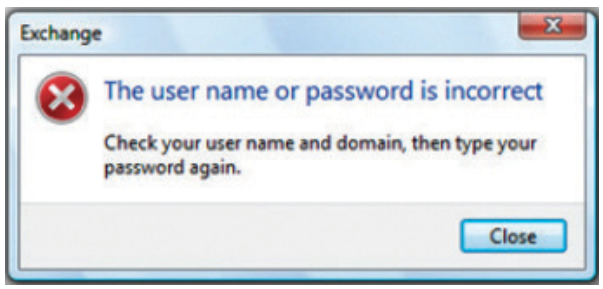
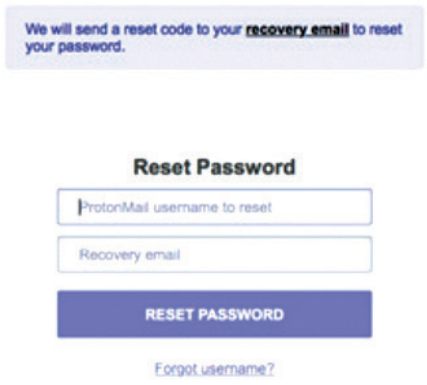


FIG 10.15 Login Error Message

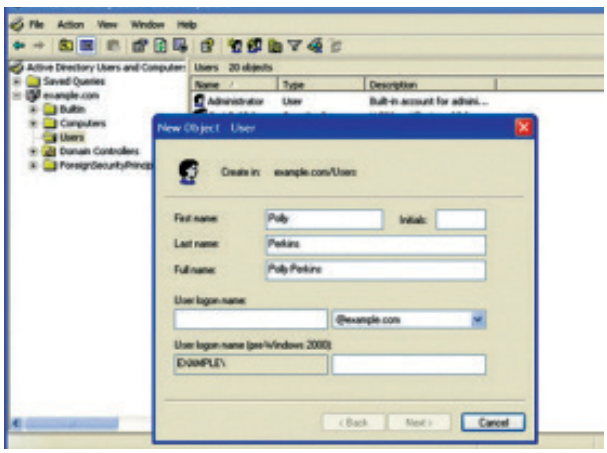
- **Reset your password**: If you forget your password, you can easily reset it using forget password link on the login page.



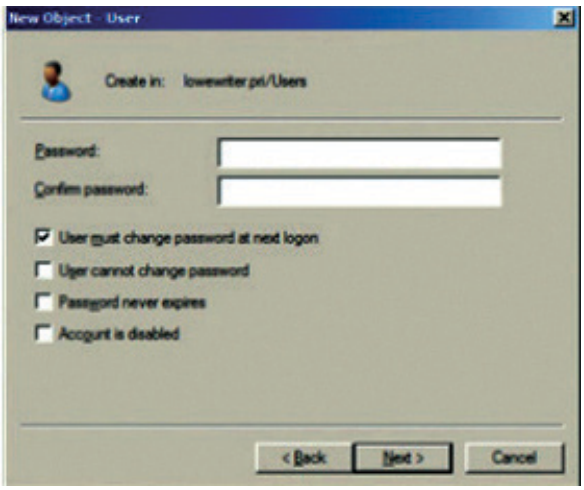
- **Password Expiry:** Check for the availability of your password, if it is expired then reset.
- **Typing Mistake:** Make sure there is no spelling mistake in the username and password you entered.
- **Make sure cookies are enabled:** Some website use cookies to authorize user to access certain section of the website. Make sure cookies are enabled in your browser preferences.
- **Clear your Browser Cache:** Sometimes cookies and cache might stored your old credentials so you need to clear your cache and restart the browser.

10.6.3 Addition and Deletion of Users

1. Add User:
   a. Choose start-> administrative->Tools->Active Directory Users and Computers.
   b. Right click the domain that you want to add the user to and then choose New->User

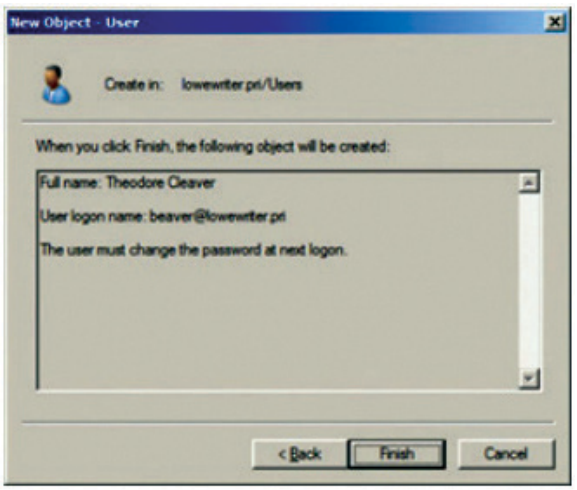


   c. Type the user's first name, initial, last and full name in the respective field.
   d. Type the user log-on name.
   e. Click Next.
   f. Set new password by typing it twice.
   g. Specify the password option that you want to apply.



h. Click Next.

i. You are taken to the final page of New Object- User Wizard.



Workshop: Create or add a new user account using the above steps.

2. Delete User

   a. Login as an administrator

   b. Choose Start->Administrative tools->Active Directory Users and Computers

   c. Click Users in the Console tree

   d. In the details pane, right click the user you want to delete and then choose Delete

   e. Click Yes to remove the user account.

Workshop: Delete the existing dummy user account using the above steps

10.6.4 Permission to Access Network Resources

Network users only have restricted access to the resources unless the ownership right is given to them by an administrator. For example: when you create files on your network, all users are granted read-only access to the share. If you want to allow users to modify files in the share or allow them to create new files, you need to add permissions. Follow the below steps to change the permission of the user.

1. Right click on the folder you want to share and then choose properties form the contextual menu.
2. Click sharing tab; then click advanced sharing
3. Click permissions



4. This dialog box list all the users and groups to whom you have granted permission for the folder.
5. Click add button
6. Enter name of the user or group to whom you want to grant permission and then click OK.

7. Select the appropriate Allow and Deny check boxes to which permissions to allow for the user or group.
8. Repeat steps 5-7 for any other permission that you want to add.
9. When you are complete the work click OK.

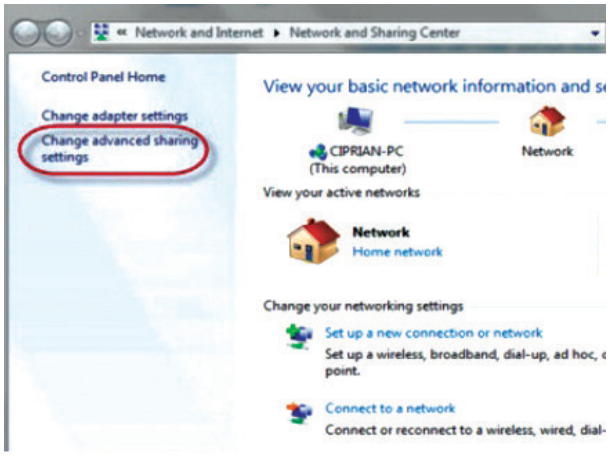
Problem:

While accessing printer getting error message as "you might not have permission to use this network resource"

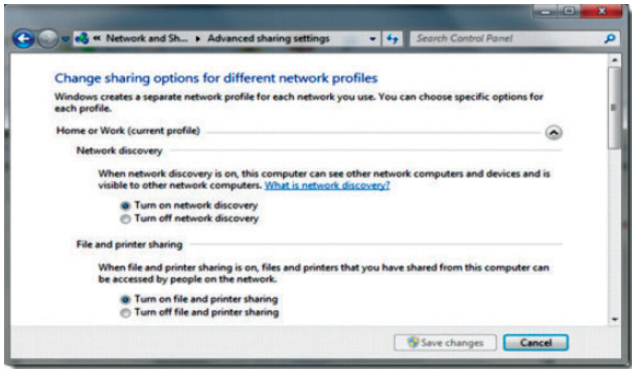
Solution:

The most important thing is to ensure that you turned on File and Printer Sharing on the machine hosting the printer

1. Right click on your network icon in the Notification Area and select Open Network and Sharing Center
2. Select Change advanced sharing settings on the upper left



3. Expand the appropriate network profile (typically private)
4. Select the radio button to Turn on file and printer sharing



5. Select Save Changes button

10.7 Overview of Hacking

Hacking is the act of finding the possible entry points that exist in a computer system or a computer network and finally entering into them. Hacking is usually done to gain unauthorized access to a computer system or a computer network, either to harm the system or to steal sensitive information available on the computer. Hacking is usually legal as long as it is being done to find weaknesses in a computer or network system for testing purpose. This sort of hacking is what we call Ethical Hacking.

For example: login into an email account that is not supposed to have access, gaining access to a remote computer that you are not supposed to have access, reading information that you are not supposed to read is considered as hacking. There are a large number of ways to hack a system.

A computer expert who does the act of hacking is called a "Hacker". Hackers are those who seek knowledge, to understand how systems operate, how they are designed, and then attempt to play with these systems.

10.8 Types of Hackers

Hackers can be classified into different categories such as white hat, black hat, and grey hat, based on their intent of hacking a system. Here, we are going to discuss about some of hackers.

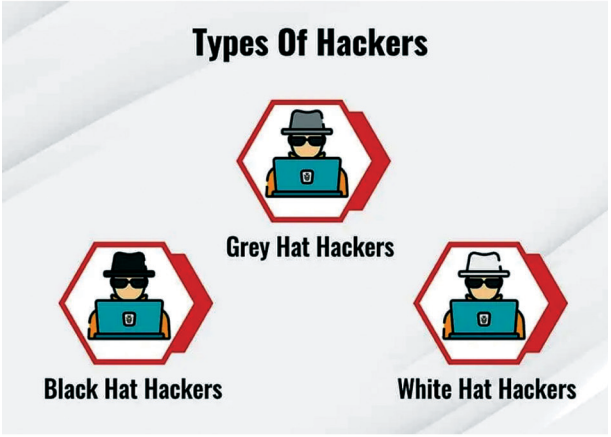


FIG 10.16 Hackers

White Hat Hackers

White Hat hackers are also known as Ethical Hackers. They never intent to harm a system, rather they try to find out weaknesses in a computer or a network system as a part of penetration testing and vulnerability assessments.

Ethical hacking is not illegal and it is one of the demanding jobs available in the IT industry.

Black Hat Hackers

Black Hat hackers, also known as crackers, are those who hack in order to gain unauthorized access to a system and harm its operations or steal sensitive information. Black Hat hacking is always illegal because of its bad intent which includes stealing corporate data, violating privacy, damaging the system, blocking network communication, etc.

Grey Hat Hackers

Grey hat hackers are a blend of both black hat and white hat hackers. They act without malicious intent but for their fun, they exploit a security weakness in a computer system or network without the owner's permission or knowledge. Their intent is to bring the weakness to the attention of the owners and getting appreciation or a little bounty from the owners.

10.9 Ethical Hacking

Hacking

Ethical hacking is the act of locating weaknesses and vulnerabilities in computers and information system by replicating the intent of actions of malicious hackers.

Ethical hacking is also known as White hat Hacking or Penetration Testing. Ethical hacking involves an authorized attempt to gain unauthorized access to a computer system or data. Ethical hacking is used to improve the security of the systems and networks by fixing the vulnerability found while testing.

10.10 Cyber crime

Cybercrime is a criminal activity that either targets or uses a computer, a computer network or a networked device.

Most, but not all, cybercrime is committed by cybercriminals or hackers who want to make money. Cybercrime is carried out by individuals or organizations.

Some cybercriminals are organized, use advanced techniques and are highly technically skilled. Others are novice hackers.

Rarely, cybercrime aims to damage computers for reasons other than profit. These could be political or personal.

Types of cybercrime

Here are some specific examples of the different types of cybercrime:

- Email and internet fraud.
- Identity fraud (where personal information is stolen and used).
- Theft of financial or card payment data.
- Theft and sale of corporate data.
- Cyberextortion (demanding money to prevent a threatened attack).
- Ransomware attacks (a type of cyberextortion).
- Cryptojacking (where hackers mine cryptocurrency using resources they do not own).
- Cyberespionage (where hackers access government or company data)

How to protect yourself against cybercrime

- Keep software and operating system updated
- Use anti-virus software and keep it updated
- Use strong passwords
- Never open attachments in spam emails
- Do not click on links in spam emails or untrusted websites
- Do not give out personal information unless secure
- Contact companies directly about suspicious requests
- Be mindful of which website URLs you visit
- Keep an eye on your bank statements

10.11 Security Policy

Security policies are a formal set of rules which is issued by an organization to ensure that the user who are authorized to access company technology and information assets comply with rules and guidelines related to the security of information. It is a written document in the organization which is responsible for how to protect the organizations from threats and how to handles them when they will occur.

Need of Security policies

1. It increases efficiency.
2. It upholds discipline and accountability
3. It can make or break a business deal
4. It helps to educate employees on security literacy

A well-written security policy can also be seen as an educational document which informs the readers about their importance of responsibility in protecting the organization sensitive data. It involves on choosing the right passwords, to providing guidelines for file transfers and data storage which increases employee's overall awareness of security and how it can be strengthened.

We use security policies to manage our network security. Most types of security policies are automatically created during the installation. We can also customize policies to suit our specific environment. There are some important cybersecurity policies recommendations describe below.

1. **Virus and Spyware Protection policy**

It helps to detect, removes, and repairs the side effects of viruses and security risks by using signatures.

It helps to detect the threats in the files which the users try to download by using reputation data from Download Insight.

It helps to detect the applications that exhibit suspicious behaviour by using SONAR heuristics and reputation data.

2. Firewall Policy

It blocks the unauthorized users from accessing the systems and networks that connect to the Internet. It detects the attacks by cybercriminals. It removes the unwanted sources of network traffic.

3. Intrusion Prevention policy

This policy automatically detects and blocks the network attacks and browser attacks. It also protects applications from vulnerabilities. It checks the contents of one or more data packages and detects malware which is coming through legal ways.

4. LiveUpdate policy

This policy can be categorized into two types one is LiveUpdate Content policy, and another is LiveUpdate Setting Policy. The LiveUpdate policy contains the setting which determines when and how client computers download the content updates from LiveUpdate. We can define the computer that clients contact to check for updates and schedule when and how often clients computer check for updates.

5. Application and Device Control

This policy protects a system's resources from applications and manages the peripheral devices that can attach to a system. The device control policy applies to both Windows and Mac computers, whereas application control policy can be applied only to Windows clients.

6. Exceptions policy

This policy provides the ability to exclude applications and processes from detection by the virus and spyware scans.

7. Host Integrity policy

This policy provides the ability to define, enforce, and restore the security of client computers to keep enterprise networks and data secure. We use this policy to ensure that the client's computers who access our network are protected and compliant with companies? securities policies. This policy requires that the client system must have installed antivirus.

10.12 Firewall

Already we discussed about the basic terms of firewall in 11th Standard. Here we are learning about the

10.12.1 Functioning of Firewall at different layers

Packet Filter

The simplest form of a firewall is a packet-filtering firewall. A packet-filtering firewall is typically a router that has the capability to filter on some of the contents of packets.

Act by inspecting packets. If it matches set of filtering rules, it silently drops packet or reject it with error message back to source.

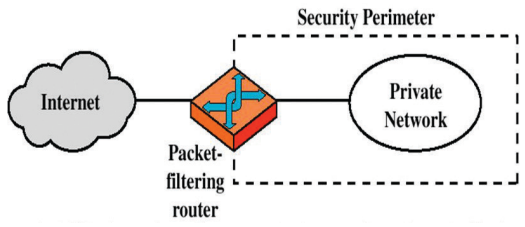


FIG 10.17 Packet- Filtering Router

The mechanism does not look at whether the packet is part of a connection stream,

etc. Thus, it doesn't really maintain a state. It rejects based on looking at combination of source, destination address, protocol, port number, etc.

Most of the time, the firewall works on the first three layers of the OSI model It does look into transport layer sometimes for source/destination port numbers.

Stateful Filter

It records all connections passing through it and determines if a packet is a part of current connection or new connection. Known as stateful packet inspection.

Operates up to Layer 4 (Transport Layer). Achieved by retaining enough packets in the buffer until enough information is available to make a judgment about its state.

Stateful firewalls have advantages over packet-filtering firewalls

- Stateful firewalls are aware of the state of a connection.
- Stateful firewalls do not have to open up a large range of ports to allow communication.
- Stateful firewalls prevent more kinds of DoS attacks than packet-filtering firewalls and have more robust logging.

10.12.13 Application Filter

Application gateway firewalls (AGFs), commonly called proxy firewalls, filter information at Layers 3, 4, 5, and 7 of the OSI reference model,

Useful to detect if unwanted protocol is trying to use standard port from known applications (e.g. HTTP) to bypass firewall.

Key benefit is that it can understand certain Application Layer protocols (FTP, HTTP, DNS).

Fig 10.18 shows the application gateway firewalls and the OSI reference model

10.13 Introduction to ITIL V4

ITIL, an acronym for Information Technology Infrastructure Library, is a set of detailed practices for IT service management (ITSM) that focuses on aligning IT services with the needs of business. ITIL V4 (Version 4) released by Axelos in February 2019 is a globally recognized, world leading framework for IT Service Management that delivers business value. ITIL V4 provides support and flexible foundation to the organization which intends to integrate various approaches into their service management operating models. ITIL helps

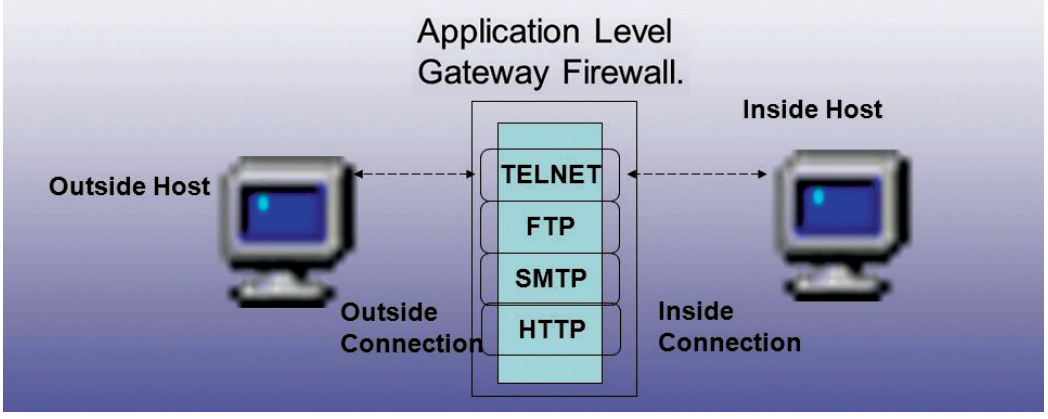


FIG 10.18 Application level Gateway

IT sector to solve business issues, improve the capability of IT and implements new capabilities to provide business value.

10.13.1 Problems in IT service sector

Information Technology (IT) aims to store and retrieve a huge volume of information very quickly with the help of hardware and software networks at a lesser costs. IT is a developing field which has changed our lives and acted as a pioneer to drive globalization. The main advantages we gain from IT are its faster communication, electronic storage and protection of records. The problems found in IT sector are shown in Fig 10.19.

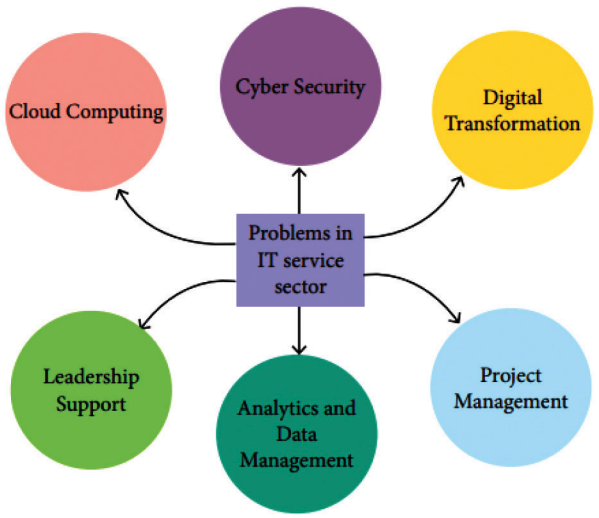


FIG 10.19. Problems in IT Service Sector

1. Cloud Computing

All organizations in the IT industry are using the cloud to perform a wide variety of tasks like data backup, disaster recovery, email, virtual desktops, software development and testing. Instead of purchasing physical data centers and servers, we can access services such as computing power, storage and databases from the cloud provider. However, there are number of issues associated with cloud like cost, service provider, reliability, downtime, data overload, password, security issues and data privacy.

2. Cyber security

Cyber security is the protection of Internet-connected systems, including hardware, software, and data from cyberattacks. Cyber is related to the technology which contains systems, network and programs or data. Whereas security related to the protection which includes system security, network security and application and information security.

3. Digital Transformation

Digital transformation is the process of integrating digital technologies to create or modify business processes, culture, and customer experiences and focus on how an organization operates and delivers value to its customers. The four types of digital transformation are

1. Business process,
2. Business model,
3. Domain, and
4. Organizational culture.

4. Leadership support

The support of leadership improves organizational productivity and growth through engagement and motivation. The position of leadership possesses both influence and authority. The main characteristics of leadership are empathy, consistency, honesty, direction and communication. The main issues with leadership are Failure to communicate, fear of firing, lack of clear vision and poor execution.

5. Analytics and Data Management

Data analytics is the science of analyzing raw data in order to make conclusions about that information. This information can then be used to optimize processes to increase the overall efficiency of a business or system. Data Management

is an administrative process to store, protect, clean the data, keep back up of the data, prepare for analysis, maintain records for processing and archiving the data for future use. New data is constantly accumulating, creating a host of storage and security risks that must be addressed.

6. Project Management

Project management is the application of processes, methods, skills, knowledge and experience to achieve specific project objectives. It also includes planning, initiation, execution, monitoring and completion. The challenges in project management are managing risks, careful resource management, smart budgeting and clear communication across multiple teams and stakeholders. It takes experience and strategic thinking to align projects with departmental and organizational goals.

LEARNING OUTCOME

After studying this chapter, students can understand the following

1. Common network problem
2. Hardware troubleshooting
3. Problems related with network operating system
4. Over view of hacking
5. Cyber crime
6. Security policy
7. Functioning of Firewall
8. ITIL V4

QUESTIONS

I. Choose the best answer from the given four options.

1. A computer network consists of collection of _____
   a) Hardware
   b) Software
   c) Both
   d) None



2. Troubleshooting always a process of _____ Method
   a) Try and Error
   b) Trial and Error
   c) Organized
   d) Systematic
3. Which of the following comes under common network problem?
   a) Software Maintenance
   b) Authentication Problem
   c) Hardware Configuration
   d) Server Connectivity Problem
4. NIC stands for _____
   a) Network Interface Card
   b) Network Interface Controller
   c) Network Information Center
   d) Network Interrupt Card
5. What can be the cause for login issue?
   a) Software update
   b) Hardware update
   c) Internet failure
   d) Security Attack

6. Which is the legal form of hacking based on which jobs are provided in IT industries and firms?
   a) Cracking
   b) Non ethical Hacking
   c) Ethical hacking
   d) Hactivism
7. _____ Hackers are called as Ethical hackers
   a) Black hat hackers
   b) Grey hat hackers
   c) Red hat hackers
   d) White hat hackers
8. _____ locates itself in memory ; then it can remain active or be activated as a stand alone program, even after its attached program ends.
   a) Transient virus
   b) Resident virus
   c) No virus
   d) Memory virus
9. What qualities virus writer may find appealing in a virus?
   a) It is hard to detect
   b) It is not easily destroyed or deactivated
   c) It spreads infection widely
   d) All of the above
10. DNS stands for
   a) Domain Network Server
   b) Digital Network Server
   c) Domain Name Server
   d) Domain Name System

II. Answer in few sentence.

1. Define Troubleshooting
2. List some of the common network problems
3. What are the symptoms for internet not working?
4. List some of the problems related with network operating system
5. Write about Security policy
6. Define Hacking.
7. What is Internet security?
8. Write about Cybercrime
9. Define Firewall.
10. Write a note on different layers of firewall.

III. Explain the following questions.

1. Define any two categories of software maintenance in detail
2. Write down the steps involved in Troubleshooting
3. Define Packet filter.
4. Write about different data threats.

IV. Briefly explain the following questions

1. Explain the symptom, cause and resolution for Wiring Problem in a network
2. Explain software maintenance and updation in detail
3. Explain permission to access network resources with an example

Answers

1.(c)	2.(b)	3.(d)	4.(a)	5.(d)
6.(c)	7.(d)	8.(b)	9.(d)	10.(c)

Theory

Model Question Paper

BASIC ELECTRONICS ENGINEERING

TIME : 3:00 HRS MARKS : 90

PART A 15 X 1=15

I. Choose the best answer from the given four options.

1. An OR gate performs logical _____

a) Addition b) Subtraction c) Multiplication d) Division

2. A Half adder is characterized by_____

a) Two inputs & Two outputs b) Three inputs & Two outputs

c) Two inputs & Three outputs d) Two inputs & One outputs

3. The types of modulation used in satellite is _____

a) Amplitude modulation b) Frequency modulation

c) Phase modulation d) Angle modulation

4. Intermediate frequency of FM radio receiver is _____

a) 100 KHZ b) 10.7 MHZ c) 88 MHZ d) 455 KHZ

5. The mobile phone battery usually comes with _____ voltages .

a) 3.0 to 3.2 b) 3.3 to 3.4 c) 3.7 to 4.2 d) 4.8 to 4.9

6. _____ works as a microwave repeator.

a) Amplifier b)Satellite c) Antenna d) SONAR

7. _____ is the term used mostly widely to denote the elements of picture element.

a) Amplitude b) Intensity c) Pixel d) Grey level

8. Sound above 20 kHZ is called _____

a) Ultra cool b) Ultra sound c) Infra audio d) Infra sound

9. The voice coil and internal parts of the speaker is protected by _____

a) Dust cap b) Spider c) Diaphragm d) Magnet

10. _____type of power electronics is used in cell phone .

a) AC to AC regulator b) DC to AC regulator

c) DC to DC regulator d) AC to DC rectifier

11. The optimum values of systolic and diastolic pressure for an adults is _____

a) 150 mm Hg and 110 mm Hg b) 140 mm Hg and 100 mm Hg

c) 130 mm Hg and 90 mm Hg d) 120 mm Hg and 80 mm Hg

12. In CT machines, which source is used ?

a) Gamma Ray b) X-ray c) Ultra sound d) Infrared

13. What is the name of the on-board chip that stores the date ,time and system configuration?

a) RAM b) CMOS c) JFET d) FET

14. Which component is used to process the data in computer?

a) RAM b) Storage devices c) Processor d) Monitor

15 What can be the cause for login issues ?

a) Software update b) Hardware update

c) Internet failure d) Security attack

PART B **10 X 3=30**

II. Answer any 10 questions. Question number 28 is compulsory.

16 Draw the construction of AND gate with Truth table.

17. What is MODEM ?

18. What are the advantage of OLED?

19. What is the major difference between GPS and GPRS?

20. Write about weather satellite.

21. Define Seismograph.

22. What is meant by IPT?

23. What is an audio mixer?

24. Write down the three primary types of inverter

25. Define bioelectric current.

26. What is blank monitor?

27. Write about cybercrime.

28. Draw the pin diagram of 7805 IC.

PART C 5 X 5=25

III. Answer any 5 questions. Question number 35 is compulsory.

29. Explain about counters.
30. Draw the block diagram of AM Radio Receiver.
31. Write any five applications of mobile phone.
32. What are the uses of Radar?
33. Write down the importance points on 7805 voltage regulator IC.
34. Give the instrumentation details of a pulse oximeter.
35. List out the computer hardware and software tools.

PART D 2 X 10=20

IV. Answer all the questions.

1. What are the three basic Boolean laws. Define each with example.

   Or

   Explain in detail about the morphological process and their operation.

2. Explain the various applications of Acousting engineering.

   Or

   Explain permission to access network resources with an example.

BASIC ELECTRONICS ENGINEERING

Practical

CONTENTS

Practical

Title	Page No.	Month
Exercise 1 Verification of Logic gates	195	
Exercise 2 Construction of Encoder and Decoder	199	
Exercise 3 Functions of Cathode Ray Oscilloscope	201	
Exercise 4 Front panel controls of Function Generator	204	
Exercise 5 Construction of FM Receiver - CXA1619BS	206	
Exercise 6 Audio Power Amplifier (TDA-2030)	210	
Exercise 7 Dismantling & Assembling of Smartphone	213	
Exercise 8 Flashing method of OS in Smartphone	216	
Exercise 9 Simulation of image display, colour component and edge detection by using MATLAB	218	
Exercise 10 Resolve the Common Hardware Problem	221	
Exercise 11 Resolve the Common Software Problem	224	
Exercise 12 Installation of network with HUB Switch, Input output Boxes and Patch Panel in computers	229	
Exercise 13 Installation and configuration of TCP/ IP protocol	232	
Exercise 14 Setting up Peer-to-Peer Network in Windows 10.	235	
Exercise 15 Demonstrate and Troubleshoot on Network related Problems	238	
Exercise 16 Restrict sites using Windows firewall	242	
Exercise 17 Setting Up Public Address System	245	
Project work Guidelines	248	

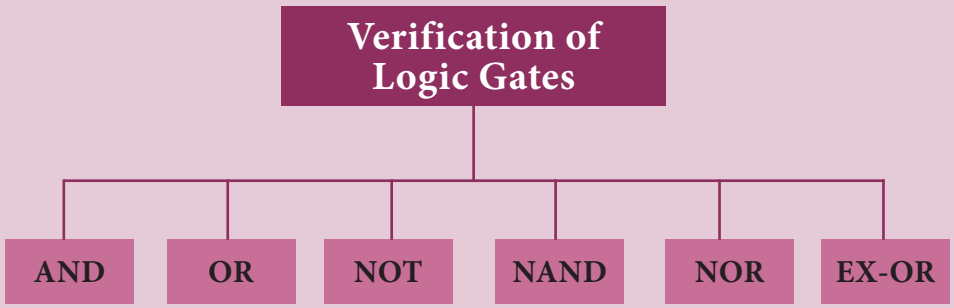
Verification of Logic gates

EXERCISE 1

Aim:

Verifying logic gates with their respective truth tables.

PROCEDURE FLOW DIAGRAM



TOOLS & EQUIPMENT REQUIRED

Activity Title	S. No	Name of the apparatus/ components	Range/Value	Quantity
Verification of Logic gates	1	Bread board	2.2 X 7 inches	1
	2	IC - 7404, 7408, 7432, 7486, 7402, 7400	-	Each 1
	3	Connecting wires	M-F, F-M, M-M, F-F	As Required

Safety Precautions:

1. Before using IC, Check the pins whether it is broken or bent.
2. IC should be fixed properly on the bread board.
3. Vcc should be given after checking the connections.

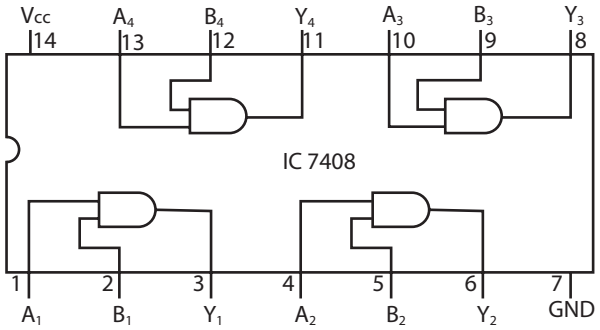
PROCEDURE:

1. Fix the IC on the Trainer kit.
2. Connect the circuit as per the circuit diagram.
3. + 5 V DC (Vcc) should be applied to the pin. No 14
4. Common terminal ground should be connected to Pin No 7 . Check the IC pins to keep it straight before it is installed in the bread board.

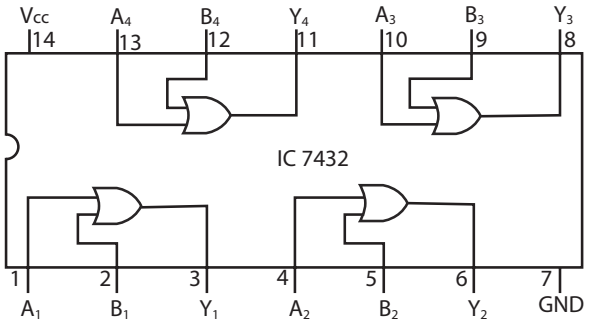
5. Logic inputs are to be connected to corresponding pin numbers of the respective ICs.
6. Output Terminals of the IC should be connected to corresponding Logic O/P s of the trainer kit.
7. Apply Logic inputs and verify the outputs according to the truth table of the Logic gates.
8. Repeat the above steps for all the IC's and show the output to verified by your teacher.

Pin Diagram

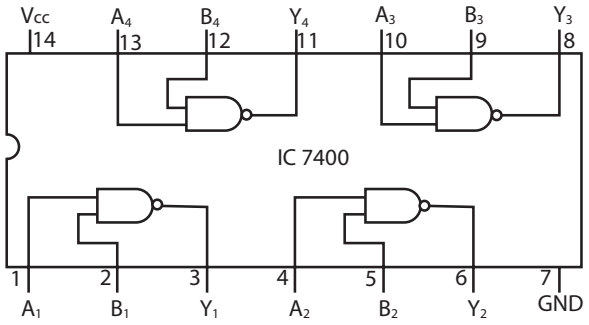
AND gate



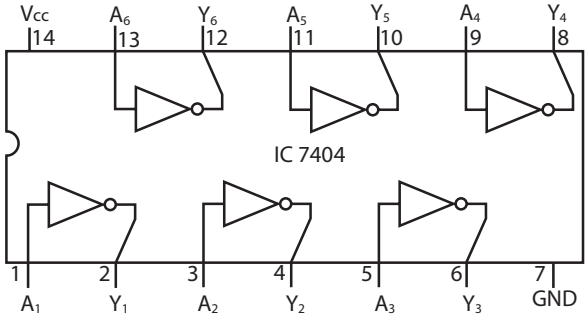
OR gate



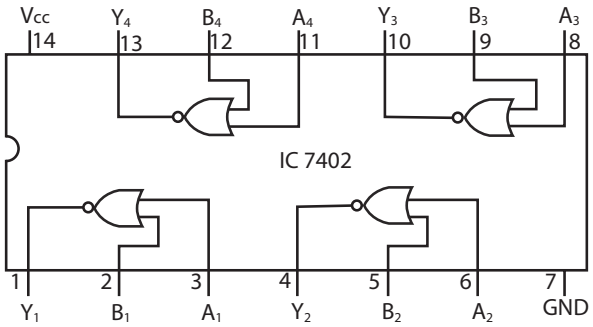
NAND Gate



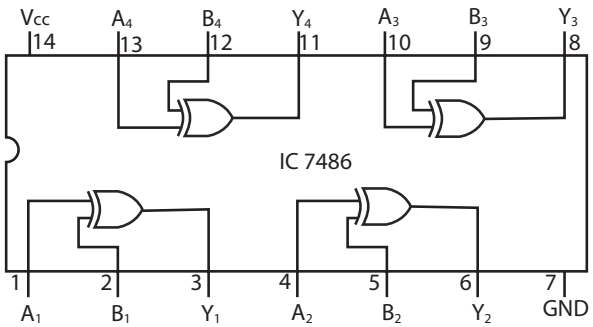
NOT Gate



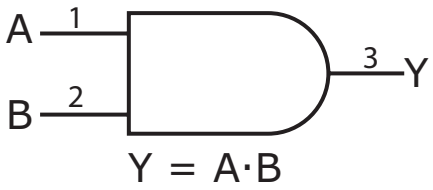
NOR Gate



X OR gate



AND gate



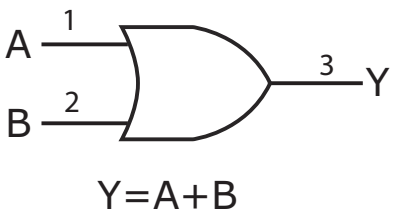
Truth Table

Input		Output
A	B	A.B
0	0	0
1	0	0
0	1	0
1	1	1

Observed Table

Input		Output
A	B	A.B
0	0	
1	0	
0	1	
1	1	

OR gate



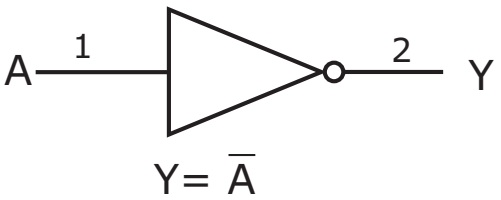
Truth Table

Input		Output
A	B	A+B
0	0	0
1	0	1
0	1	1
1	1	1

Observed Table

Input		Output
A	B	A+B
0	0	
1	0	
0	1	
1	1	

NOT Gate



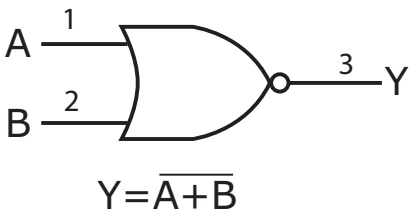
Truth Table

Input	Output
A	$\bar{A}$
0	1
1	0

Observed Table

Input	Output
A	$\bar{A}$
0	
1	

NOR Gate



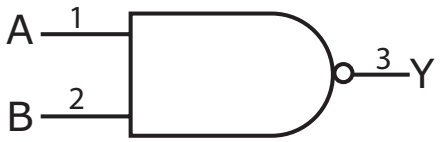
Truth Table

Input		Output
A	B	$\overline{A+B}$
0	0	1
1	0	0
0	1	0
1	1	0

Observed Table

Input		Output
A	B	$\overline{A+B}$
0	0	
1	0	
0	1	
1	1	

NAND Gate



$Y = \overline{A \cdot B}$

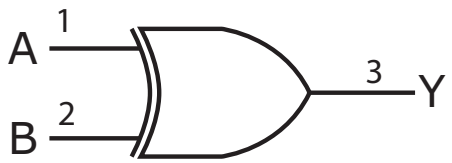
Truth Table

Input		Output
A	B	$\overline{A \bullet B}$
0	0	1
1	0	1
0	1	1
1	1	0

Observed Table

Input		Output
A	B	$\overline{A \bullet B}$
0	0	
1	0	
0	1	
1	1	

XOR Gate



$Y = A \oplus B$

Truth Table

Input		Output
A	B	$A \oplus B$
0	0	0
1	0	1
0	1	1
1	1	0

Observed Table

Input		Output
A	B	$A \oplus B$
0	0	
1	0	
0	1	
1	1	

Result:

Thus the logic gates are verified successfully

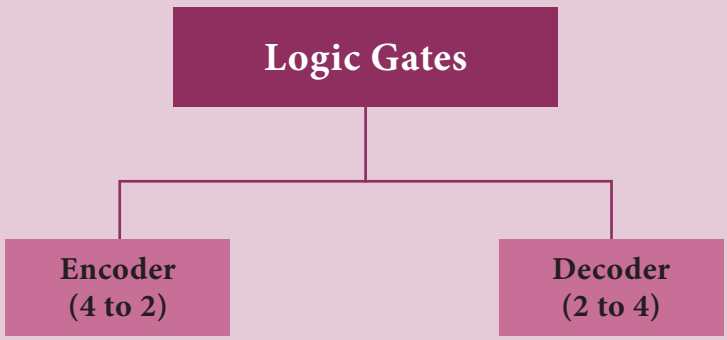
Construction of Encoder and Decoder

EXERCISE 2

Aim:

1. To understand the Construction of Encoder by using logic Gates
2. To understand the Construction of Decoder by using logic Gates

PROCEDURE FLOW DIAGRAM



TOOLS & EQUIPMENT REQUIRED

Activity Title	S. No	Name of the apparatus/ components	Range/Value	Quantity
Encoder and Decoder	1	NOT, AND, OR gates	IC 7432, IC 7404, IC 7408	Each 2
	2	IC Trainer kit	-	1
	3	Connecting wire	-	As required

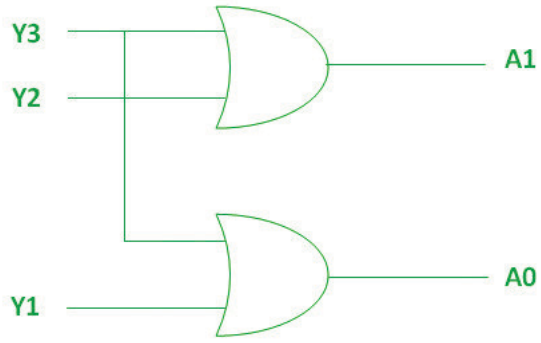
Procedure:

Construction of Encoder & Decoder

1. Fix the IC on the Trainer kit.
2. Connect the circuit as per the circuit diagram
3. Check the IC pins to keep it straight before it is installed in the bread board and refer the previous practical pin diagram.
4. + 5 V DC (Vcc) should be applied to the pin. No 14
5. Common terminal ground should be connected to Pin No 7 .
6. Logic inputs are to be connected to corresponding pin numbers of the respective ICs

7. Output Terminals of the IC should be connected to corresponding Logic O/P s of the trainer kit.
8. Apply Logic inputs and verify the outputs according to the truth table of the 4 to2 Encoder and 2 to 4 Decoder

Circuit Diagram of 4 to 2 :



Logical expression for A1 and A0

A1 = Y3 + Y2

A0 = Y3 + Y1

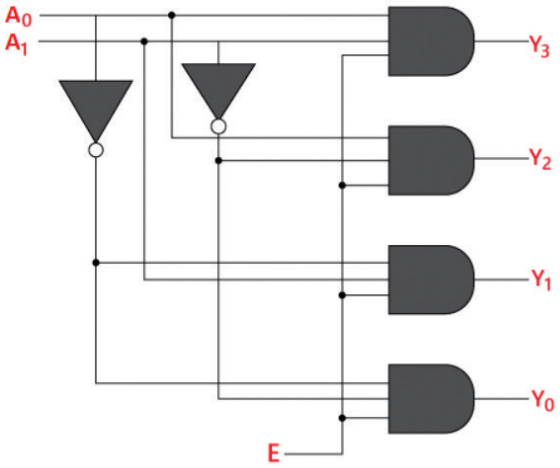
Truth table:

Input				Output	
Y3	Y2	Y1	Y0	A1	A0
0	0	0	1	0	0
0	0	1	0	0	1
0	1	0	0	1	0
1	0	0	0	1	1

Observed Table:

Input				Output	
Y3	Y2	Y1	Y0	A1	A0
0	0	0	1		
0	0	1	0		
0	1	0	0		
1	0	0	0		

Circuit Diagram of 2 to 4 :



Logical expression for Y3, Y2, Y1 and A0 :

$Y_3=E.A_1.A_0$ $Y_1=E.A_1'.A_0$

$Y_2=E.A_1.A_0'$ $Y0=E.A_1'.A_0'$

Truth table:

Enable	Input		Output			
E	A1	A0	Y3	Y2	Y1	Y0
1	0	0	0	0	0	1
1	0	1	0	0	1	0
1	1	0	0	1	0	0
1	1	1	1	0	0	0

Observed Table:

Enable	Input		Output			
E	A1	A0	Y3	Y2	Y1	Y0
1	0	0				
1	0	1				
1	1	0				
1	1	1				

Result

Hence, the construction of encoder and decoder circuits using logic gates are understood and the output is verified.

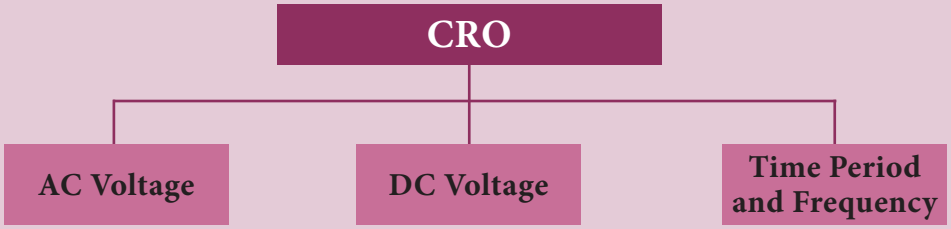
Functions of Cathode Ray Oscilloscope

EXERCISE 3

AIM:

- Observe the front panel controls of CRO
- Measuring of DC voltage using CRO
- Measuring of AC voltage using CRO
- Measuring the frequency and time period of a wave form using CRO

PROCEDURE FLOW DIAGRAM



TOOLS & EQUIPMENT REQUIRED

Activity Title	S. No	Name of the apparatus/ components	Range/Value	Quantity
Functions of CRO	1	Oscilloscope	(20 MHz)	1
	2	Low voltage regulator power supply	(0 – 30v / DC)	1
	3	Step down transformer	(6v – 0v – 6v/500 mA)	1
	4	Dry cell	(1.5V / DC)	1
	5	Hook – up wire		As Required
	6	Soldering set		1
	7	Multimeter		1
	8	Function generator		1

Procedure:

A. Observe the front panel controls of CRO

1. Connect the power supply to CRO and switch it 'ON'
2. Adjust the focus and Intensity control to get the sharp trace line on the screen.
3. Connect the CRO signal probe to the built-in calibration (cal) OFF.

4. Observe the signal and adjust the horizontal and vertical position control to set the wave form in a proper position
5. Adjust the volt/ Div and time/Div controls to calculate the No. of division of a full cycle.

B. To Measure the DC Voltage:

1. Set the LVPS O/P voltage is equal to +3v D.C
2. Connect the positive end of the LVPS to the signal probe of CRO
3. Connect the Negative end of the LVPS to the GND probe of CRO
4. Switch "ON" the LVPS and CRO
5. Observe the D.C. waveform on the screen
6. Observe the No. of divisions of the wave form and record it in the table
7. Calculate the DC voltage and verify with the Input voltage
8. Solder hook up wires (Red and Black) with battery ends.
9. Connect the CRO probes to the +ve and -ve leads of the dry cell.
10. Repeat the above steps for calculating DC voltage

S.No	LVPS (Voltage)	No of Divisions	Voltage measured in CRO
1.			
2.			
3.			
4.			

C. To Measure AC Voltage using CRO

1. To measure A.C Voltages set the AC – DC switch in AC position
2. Connect the secondary leads of the step-down transformer with the CRO probes
3. Switch "ON" the oscilloscope and adjust the trace on the screen.
4. Connect the primary side of the transformer with plug top
5. Switch "ON" the transformer, measure the secondary voltage and record it in a table
6. Observe the waveform, measure the No. of divisions and record it in a Table
7. Calculate the peak – to – peak voltage and verify with secondary o/p

S. No	Secondary O/P of the transformation (v)	No of division CRO	Measure voltage in CRO (V)
1.			
2.			

D. Measurement of amplitude and time period of CRO

1. Set sinusoidal waveform in function generator.
2. Connect the function Generator output with CRO.
3. Switch "ON" function Generator and CRO.
4. Vary the Time / Div control to set the full cycle of the waveform.
5. Count the No. of divisions for one complete cycle and record it in a table.

6. Calculate the time period of the waveform using formula.
   Time Period (T) = Time base range X No.of. div/cycle
7. Calculate the frequency of the waveform using formula
   F = 1/T (H2)
8. Verify the measured frequency with the function Generator O/P frequency

S.No	No. of div/ cycle	Function Generator frequency (F)	Time period (T)	Frequency(F)
1.				
2.				

Result:

Thus I understood the functions of front panel controls of CRO and the method of to measure the voltage (DC, AC) frequency and time period of waveform through the CRO .

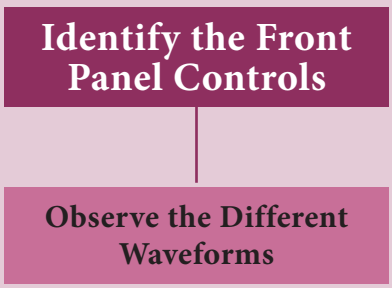
Front panel controls of Function Generator

EXERCISE 4

Aim:

1. Identify the front panel controls of function generator
2. Observe the different waveforms in a function generator through a CRO.

PROCEDURE FLOW DIAGRAM

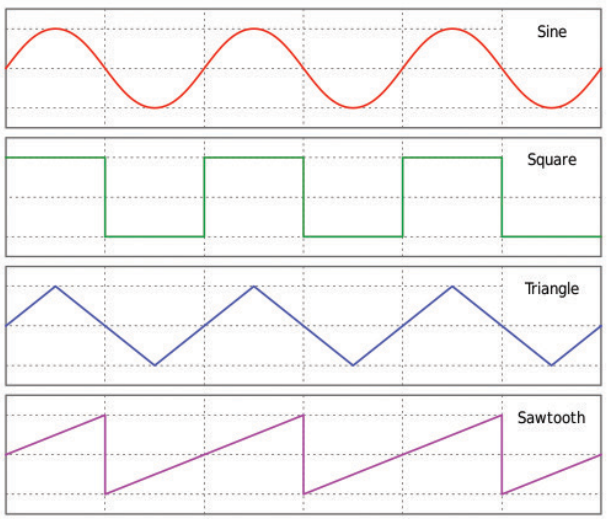


TOOLS & EQUIPMENT REQUIRED

Activity Title	S. No	Name of the apparatus/ components	Range/Value	Quantity
Identify the Front Panel Controls & observe the different waveforms	1	Function generator		1
	2	CRO	(20 MHz)	1
	3	Connecting Wire	-	As Required

Procedure:

1. Connect the output of the function generator to the input of the CRO.
2. Switch 'ON' the CRO and function generator.
3. Vary the frequency control and amplitude control in the function generator.
4. Observe the waveform on CRO by adjusting the horizontal and vertical position controls.
5. Plot the wave form in a graph sheet with corresponding no. of directions in X – axis and Y – axis.
6. Repeat the above steps for all waveforms (Sine, Square, Triangle etc....) in the function generator and plot it in a graph sheet.





Identify the front panel controls and note down the functions of each control in the table: 1

S. No	Name of the control	Function

Result:

Thus I identified Front Panel Controls of Function Generator and observed the different waveforms by using CRO is Completed Successfully.

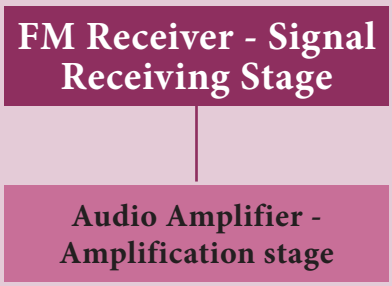
Construction of FM Receiver - CXA1619BS

EXERCISE 5

Aim:

To understand the construction method of FM Receiver by using the IC-CXA1619BS

PROCEDURE FLOW DIAGRAM



TOOLS & EQUIPMENT REQUIRED

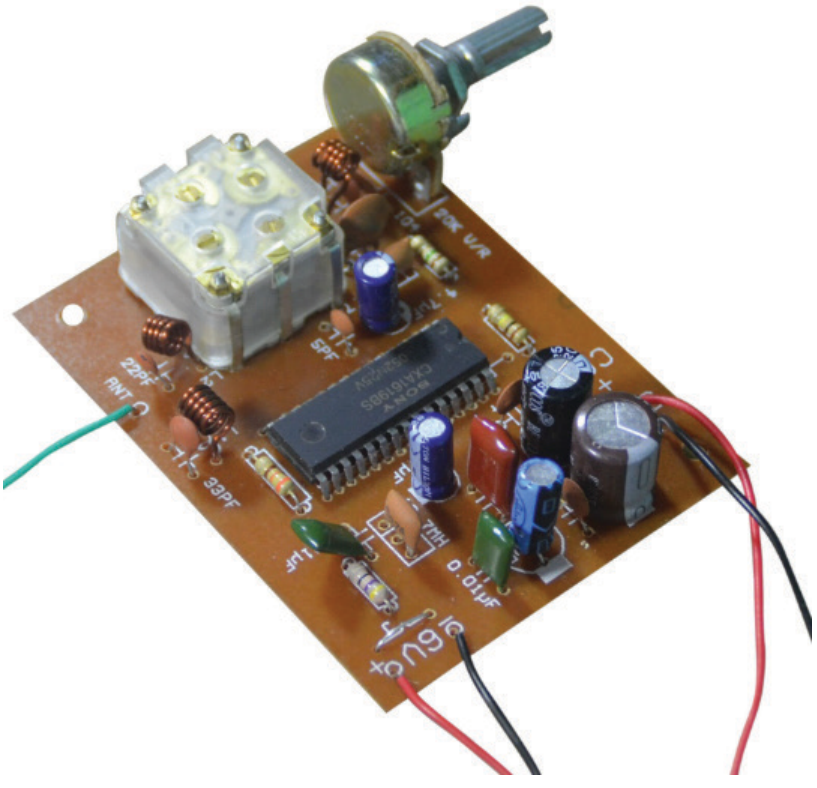
Activity Title	S. No	Name of the apparatus/ components	Range/Value	Quantity
Construction of FM Receiver	1	Step down transformer	12-0-12 V (1 Amp)	1
	2	Diode	IN4007	4
	3	Capacitor	1µfd, 22 µfd, 25 V	2
	4	Integrated Circuit (IC)	TDA 2030	1
	5	Non polarized capacitor	100 nF (104)	1
	6	Resistor 1/4 watt	22 KΩ, 680Ω	2
	7	Resistor 1/2 watt	2.2Ω	1
	8	Potentio meter	47 KΩ	1
	9	Speaker	4 to 8 Ω	1
	10	Antenna	-	1
	11	FM Receiver kit	CXA1619BS	1

	12.	Single strand Wire	-	As Required
	13	Heat Sink	-	1
	14	Insulator stand for heat sink	-	1
	15	Soldering kit	-	1

Procedure:

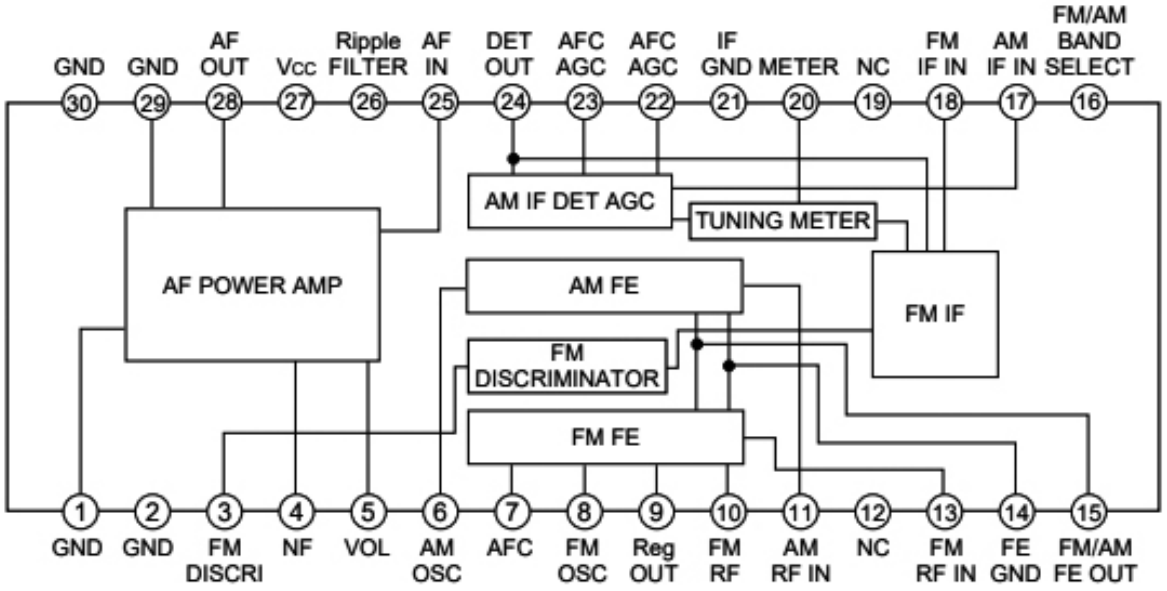
Task 1: FM Receiver - Signal Receiving stage

1. Connect the output of Regulated Power Supply (RPS) to the input of FM receiver kit
2. The lead which is taken from the output i.e., +Vs (+15/16V) and the other lead is taken from the output i.e., -Vs(-15/16V), now connect +Vs to pin 5 and -Vs to pin 3 of TDA2030 IC as shown in the circuit diagram.
3. Connect the output of Regulated Power Supply (RPS) to the input of Amplifier kit
4. At the other end of the resistor we receive 12V, now connect this 12V supply to the FM receiver (pin 27, Vcc).
5. Connect the transformers centre tap to the common Ground and to FM Receiver (pin 29, Gnd).
6. Connect the antenna to FM receiver (pin 13).

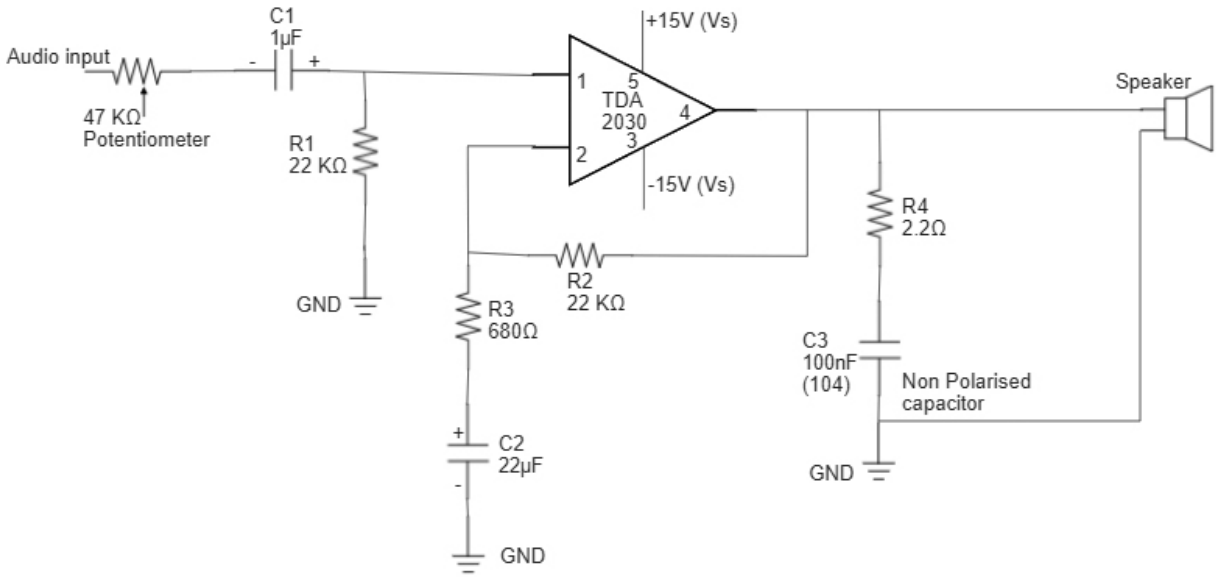


FM receiver CXA1619BS kit

Pin Diagram of CXA1619BS



Task 2: Audio Amplifier - Amplification stage



1. Connect the potentiometer (47KΩ) and negative end of capacitor C1(1µF) in series as shown in the circuit diagram. Give the Audio input - between the potentiometer (47KΩ) and ground.
2. Connect the +Vs of the power supply unit to the 5th pin of the IC and connect the –Vs to the 3rd pin of the IC.

   Note: After connecting the -Vs to the 3rd pin of the IC the heat sink acts as negative. So be aware of the heat sink don't touch the ground.
3. Connect the positive terminal of Capacitor C1(1µF) with one end of Resistor R1 (22 KΩ) and connect the junction to the pin no 1 of the IC as shown in the circuit. The other end of the resistor should be grounded.

4. Connect the one end of resistor R3 (680 Ω) and one end of resistor R2 (22 KΩ) together and is connected with the pin no 2 of the IC. The other end of resistor R2 is connected with pin no 4 of the IC and this path is called the feedback path.
5. The other end of resistor R3 (680 Ω) is connected with positive terminal of capacitor C2 (22μF) and the negative terminal is grounded. (To increase the gain we can use various ranges of the resistor).
6. Connect one end of resistor R4 (2.2 Ω) with the one end of the capacitor C3 (104 nF) and the junction is connected with the pin no 4 of IC and from there the output lead is taken to speaker.
7. Connect a speaker at the output.
8. Now switch on the power supply and vary the frequency of the FM Receiver and set the exact frequency. Then vary the range of potentiometer to increase or decrease the sound and we can get the output through the speaker.

Result:

Thus I understood how to construct an FM Receiver using IC CXA1619BS.

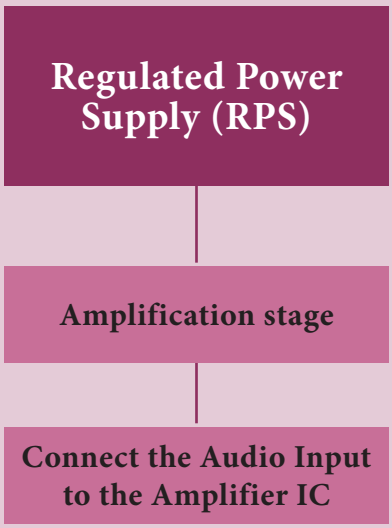
Audio Power Amplifier TDA-2030

EXERCISE 6

Aim:

To construct the Audio Power Amplifier using the IC TDA 2030

PROCEDURE FLOW DIAGRAM



TOOLS & EQUIPMENT REQUIRED

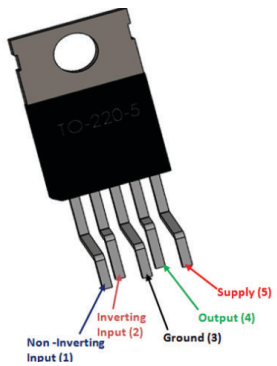
Activity Title	S. No	Name of the apparatus/ components	Range/Value	Quantity
Construction of Audio Amplifier	1	Step down transformer	12-0-12 V (1 Amp)	1
	2	Diode	IN4007	4
	3	Capacitor	1µfd, 22 µfd, 25 V	2
	4	Integrated Circuit (IC)	TDA 2030	1
	5	Non polarized capacitor	100 nF (104)	1

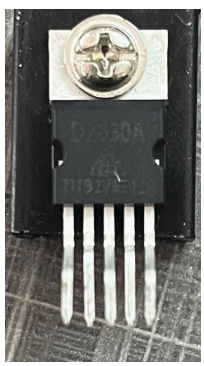
	6	Resistor 1/4 watt	22 KΩ	2
			680Ω	1
		Resistor 1/2 watt	2.2Ω	1
	7	Speaker	4 to 8 Ω	1
	8	Mobile Phone	-	1
	9	Stereotype cable	-	1
	10.	Single stand Wire	-	As Required
	11	Heat Sink	-	1
	12	Insulator stand for heat sink	-	1
	13	Soldering kit	-	1

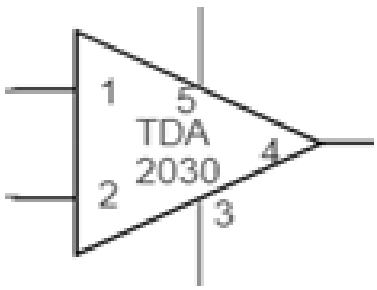
Procedure:

Task 1: Amplification stage

1. Connect the output of Regulated Power Supply (RPS) to the input of Amplifier kit
2. The lead which is taken from the output i.e., +Vs (+15/16V) and the other lead is taken from the output i.e., -Vs(-15/16V), now connect +Vs to pin 5 and -Vs to pin 3 of TDA2030 IC as shown in the circuit diagram.
3. Clearly visualize the pin numbers 1,2,3,4 and 5 of the IC with reference to the below picture



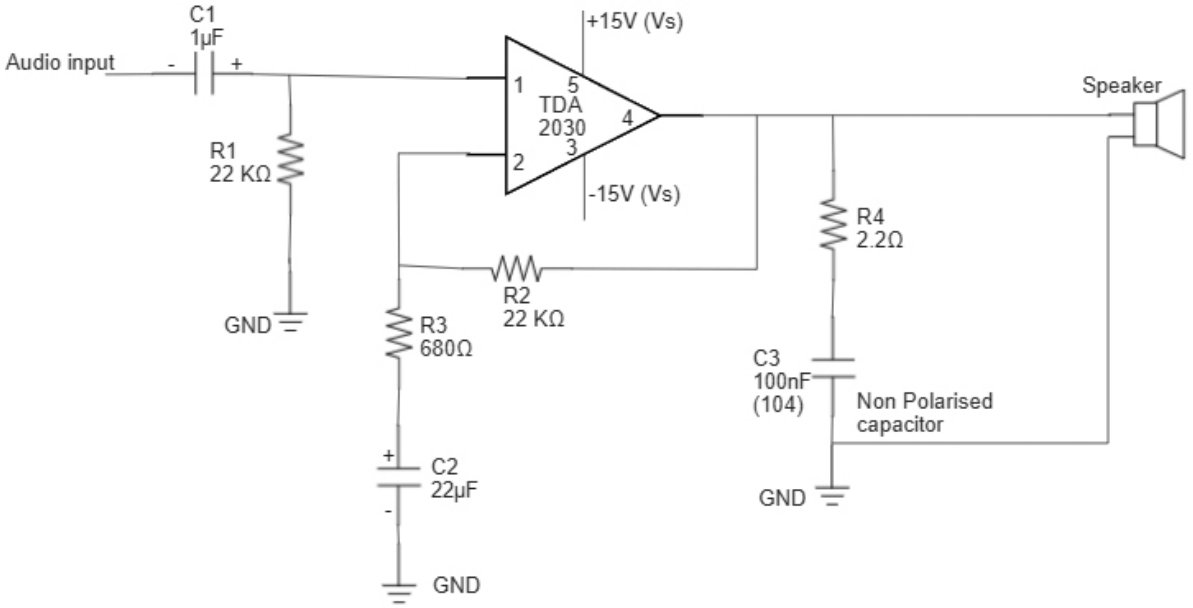




2. Tight the IC screw to the heat sink by using a hand tool.
3. Connect the +Vs of the power supply unit to the 5th pin of the IC and connect the –Vs to the 3rd pin of the IC.

   Note: After connecting the -Vs to the 3rd pin of the IC the heat sink acts as negative. So be aware of the heat sink don't touch the ground.
4. Connect the one end of resistor R3 (680 Ω) and one end of resistor R2 (22 KΩ) together and is connected with the pin no 2 of the IC. The other end of resistor R2 is connected with pin no 4 of the IC and this path is called the feedback path.

5. The other end of resistor R3 (680 Ω) is connected with positive terminal of capacitor C2 (22μF) and the negative terminal is grounded. (To increase the gain we can use various ranges of the resistor).
6. Connect one end of resistor R4 (2.2 Ω) with the one end of the capacitor C3 (104 nF) and the junction is connected with the pin no 4 of IC and from there the output lead is taken to speaker.



Task 2: Connect the Audio Input to the amplifier IC.

1. Connect the positive terminal of Capacitor C1(1μF) with one end of Resistor R1 (22 KΩ) and connect the junction to the pin no 1 of the IC as shown in the circuit. The other end of the resistor should be grounded. Connect a speaker at the output.
2. Give the Audio input - mobile (audio input) between the Capacitor C1(1μF) and the ground.
3. Now switch on the power supply and play a song on the mobile phone (audio input) and we see the output covers from the speaker.

Result:

Thus I understood the construction of the audio power amplifier using IC TDA 2030.

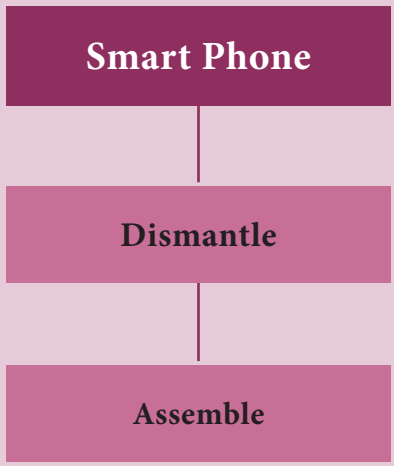
Dismantling & Assembling of Smartphone

EXERCISE 7

Aim:

To understand the method of dismantling & assembling of Smartphone

PROCEDURE FLOW DIAGRAM



TOOLS & EQUIPMENT REQUIRED

Activity Title	S. No	Name of the apparatus/ components	Range/Value	Quantity
Dismantling & Assembling	1	Smart Phone		1
	2	Trainees Tool Kit		1
	3	screw driver set		1
	4	Digital Multimeter with probes	Digital	1
	5	Suction cup		1

PROCEDURE

Dismantling the Smartphone

1. Switch OFF the smartphone and remove SIM slot and screws



2. Attach a suction cup near the bottom of the screen and pull it to lift the screen.



3. Run your plastic tool along both sides of the screen.



4. Carefully disconnect the ribbon cable with the help of nylon spudger.



5. Lift the screen up and remove the all Screws of smart phone
6. Use a nylon spudger to gently dry the battery connector up from its socket on the logic board.



7. Two ribbon cables need to be disconnected, indicated in figure. and make sure ribbon cables 2 and 3 are disconnected at both ends.
8. Remove the screws and lift the circuit board from the frame.



Note: The circuit board is still connected by the ribbon cable on the other side, so lift the circuit board up and turn it over, from right to left

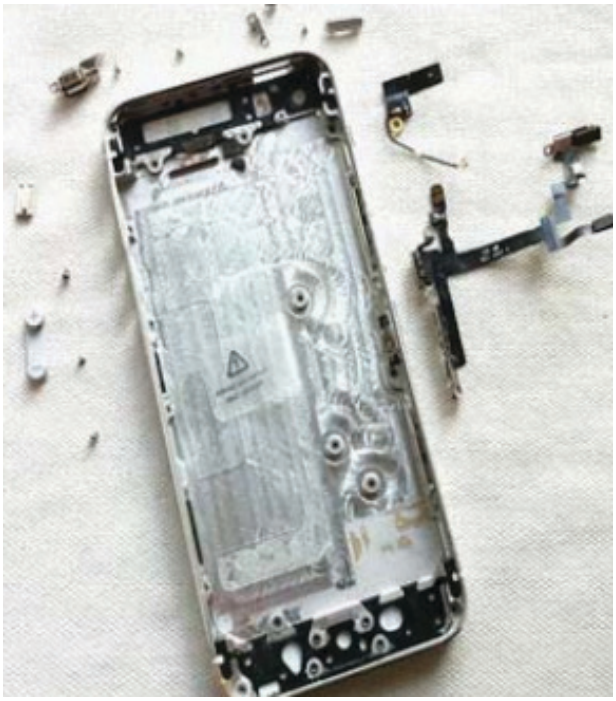
9. Disconnect the ribbon cable circled in figure, it has a plug and socket connector, so disconnect it in the same way as the others.



10. Now remove the 7 screws, circled in Figure, and you can lift the loudspeaker/ lightning port assembly free.



11. Remove the screws so that volume buttons, mute switch, power button and the ribbon cables can be disconnected.



12. Disassembly is now complete.



13. Reverse the whole procedure for reassembly.

14. Get the work checked by the instructor.

Result:

Thus I understood the the method of dismantling & assembling of Smartphone.

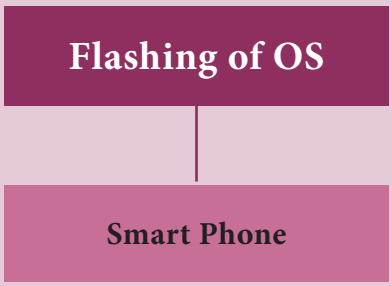
Flashing method of OS in Smartphone

EXERCISE 8

Aim:

To understand the flashing method of OS in Smartphone

PROCEDURE FLOW DIAGRAM



TOOLS & EQUIPMENT REQUIRED

Activity Title	S. No	Name of the apparatus/ components	Range/Value	Quantity
Installation of OS in Smart Phone	1	Computer	I3 processor 64 bit	1
	2	Smart Phone	-	1
	3	USB Cable	-	1
	4	Flashing Software	-	1
	5	Android USB driver	-	-
	6	Custom ROM software	-	-

Safety Measures:

1. Ensure the software is compatible with the mobile or device.
2. Check whether the mobile has sufficient memory.
3. Make sure the battery has sufficient charge.
4. Make sure the internet connection is stable.
5. Always install from authorized company or licensed sources.

Procedure:

1. Download and install Android USB driver on your computer.
2. Power OFF the Android phone and remove the battery (if it is removable).
3. Download the stockroom or custom room software.
4. Download and copy smartphone flash tool on your computer.
5. After following all these steps, now open the SP flash tool.
6. Open the SP flash extracted file and right click on the SP flash application. Then click the run as administrator then SP flash to file software will be opened completely.
7. Click the choose button of scatter – loading file. The file will be downloaded. Then click the open option.
8. The loading process will start and the file will be loaded . Then click on the download button
9. Connect your computer to your android phone through the USB data cable.

Note: Remember to power OFF your android mobile or to remove the battery before connecting through the USB cable.

10. As you connect, then the flashing process will start
11. After completing the flashing process a message will be displayed "Downloaded ok"
12. Now your android phone will be successfully flashed or software is installed

Result:

Thus, I understood how to install the OS in Smart Phone.

Simulation of image display, colour component and edge detection by using MATLAB

EXERCISE 9

Aim:

To Simulation and Display of an Image, colour component of image , canny edge detection algorithms by using MATLAB

PROCEDURE FLOW DIAGRAM



TOOLS & EQUIPMENT REQUIRED

Activity Title	S. No	Name of the apparatus/ components	Range/Value	Quantity
Digital image processing	1	Computer	-	1
	2	MATLAB SOFTWARE	-	-

Procedure

1. Open MATLAB software .
2. Click on “File “ menu . select “New” >> script file.
3. MATLAB EDITOR open. Then save the file with filename
4. In the MATLAB EDITOR window command prompt will typed. In this two segment such as

   MATLAB COMMAND WINDOW - create variable and value.

   WORK SPACE WINDOW - stored variable and value
5. Some of the COMMANDS used in MATLAB

Clc -Clear the screen or display.

Clear - Clear temporary memory variable and value in command window .

Imread - To read the image.

Imshow - To display / show the image.

Imread ("filepath with file name") - To select the image file in correct location

subplot(m , n , p)- divides the current figure into an m -by- n grid and creates axes in the position specified by p .The first subplot m is the first column of the first row, the second subplot n is the second column of the first row

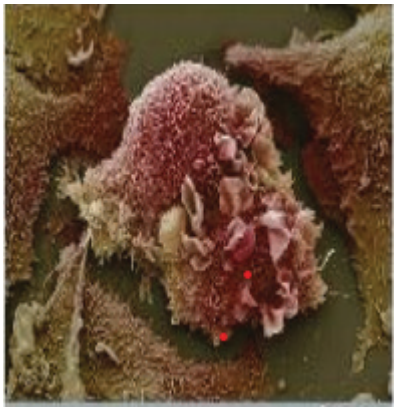
6. Execution of practical/ program.

To run the program PRESS F5 or Click triangle symbol in menu bar.

Initially program run with ADD PATH option to be click and second time it will be run automatically.

Task 1 : Image read and display

```
%Image read and display
Clc;
Clear;
imread ('D:/matlab  tutorial/pen.jpg');
I=imread('r');
imshow();
title('Original Image');
```

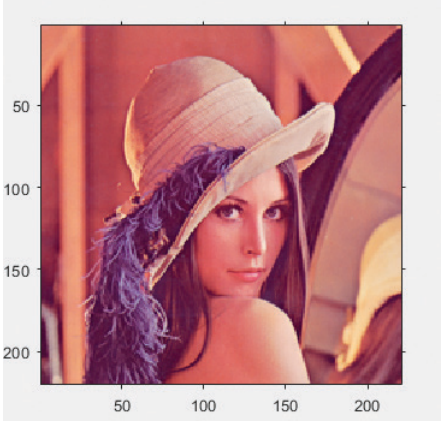


Original Image

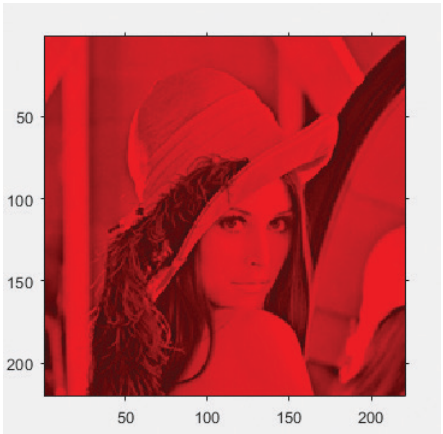
Task 2 : Display RED, BLUE, GREEN and GRAY components of image

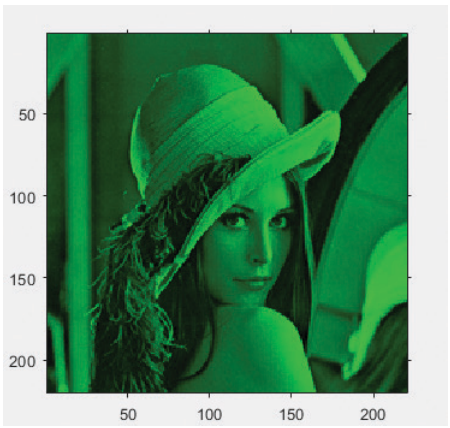
```
% read the image
I = imread('lenna.png');

% rows and columns in the image
r = size(I, 1);
c = size(I, 2);

% creating zero matrices
R = zeros(r, c, 3);
G = zeros(r, c, 3);
B = zeros(r, c, 3);

% storing the corresponding color plane
% red plane
R(:, :, 1) = I(:, :, 1);
% green plane
G(:, :, 2) = I(:, :, 2);
% blue plane
B(:, :, 3) = I(:, :, 3);

% displaying the images
figure, imshow(uint8(R));
figure, imshow(uint8(G));
figure, imshow(uint8(B));
```

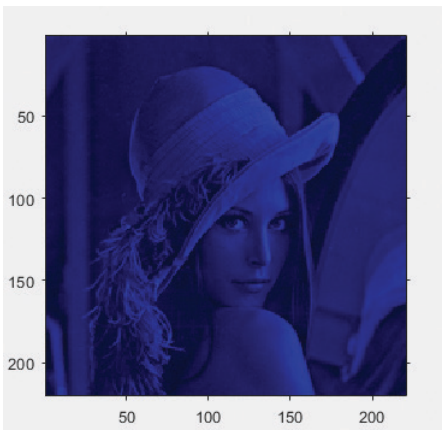
Input :



Output :

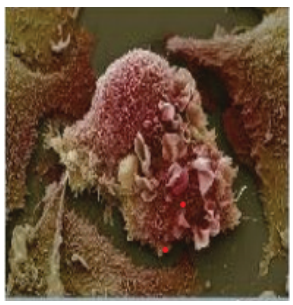




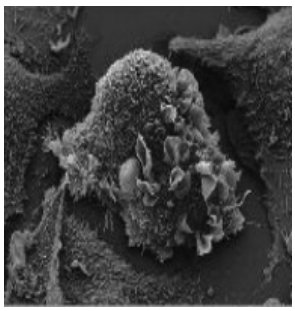


Task 3 : Canny edge detection Algorithm

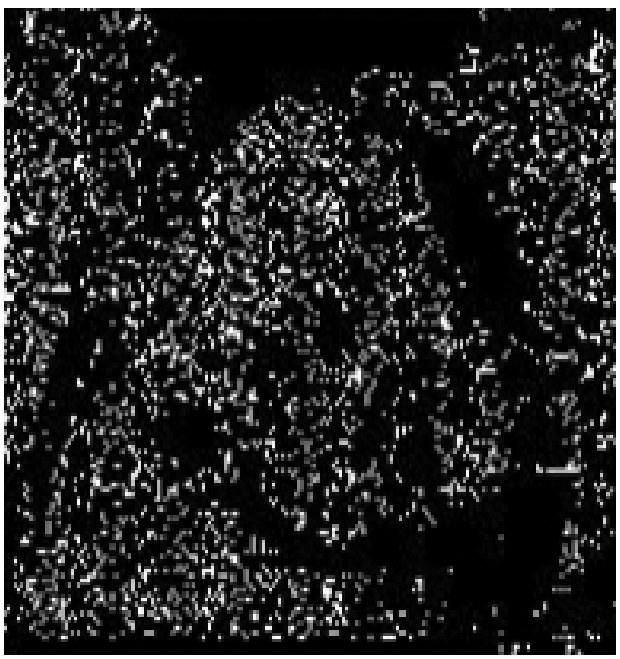
```
i= imread('cancercell.jpg');
g=rgb2gray(i);
subplot(2,2,1);
imshow(i);
title('Original Image');
subplot(2,2,2);
imshow(g);
title('Gray Image');
c=edge(g,'canny');
subplot(2,2,3);
imshow(c);
title('Canny output')
```



Original image



Gray image



Canny output

Result

Thus the display of an image, Colour component of an image and Edge detection by canny operator using MATLAB was completed successfully.

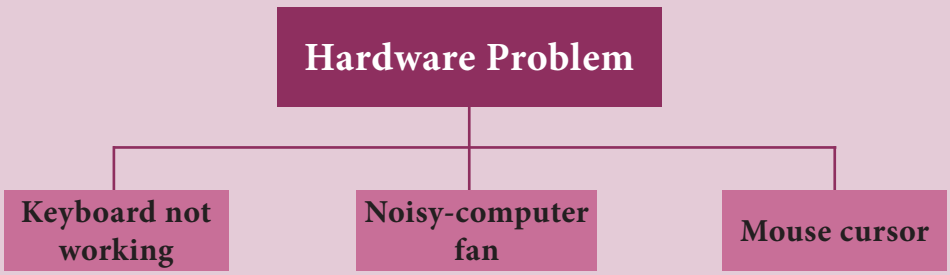
Resolve the Common Hardware Problem

EXERCISE 10

AIM:

To understand the Common Hardware Problem and its solutions

PROCEDURE FLOW DIAGRAM



TOOLS & EQUIPMENT REQUIRED

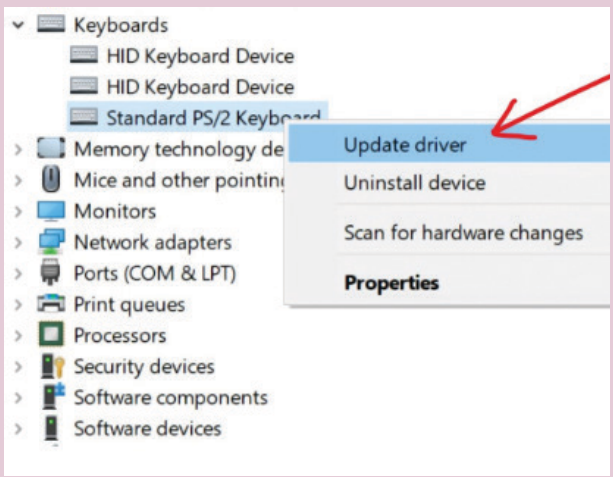
Activity Title	S. No	Name of the apparatus/ components	Range/Value	Quantity
Hardware Problems	1	Computer / Laptop	-	1

Procedure:

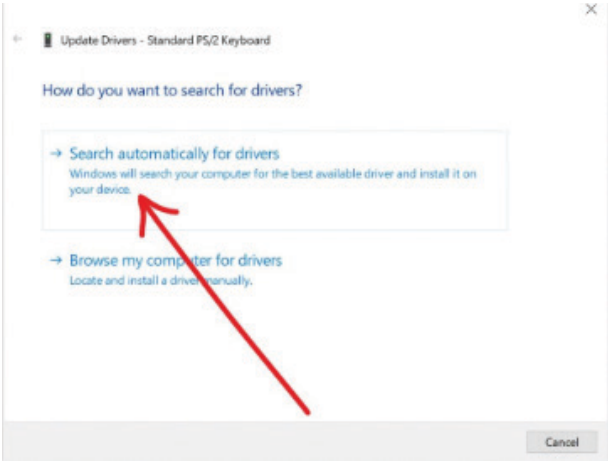
Task 1: Keyboard Not Working.

Solution : Update the Keyboard Driver

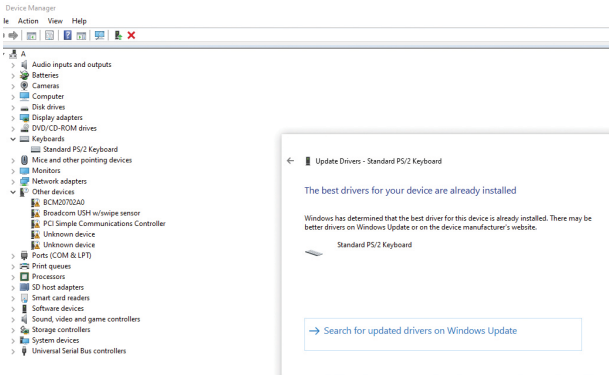
1. Right-click on Start then and select Device Manager.
2. Click and Expand Keyboard option.
3. Right-click on the "Standard PS/2 keyboard" and select the "Update driver" option.



4. Click on “Search automatically for drivers’ ‘to update the keyboard software.



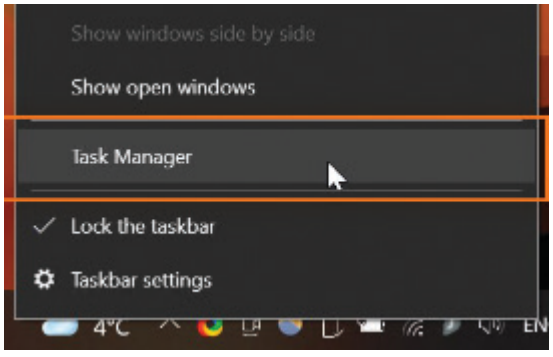
5. If there is no driver problem you will get a window as “The best driver for your device are already installed”.



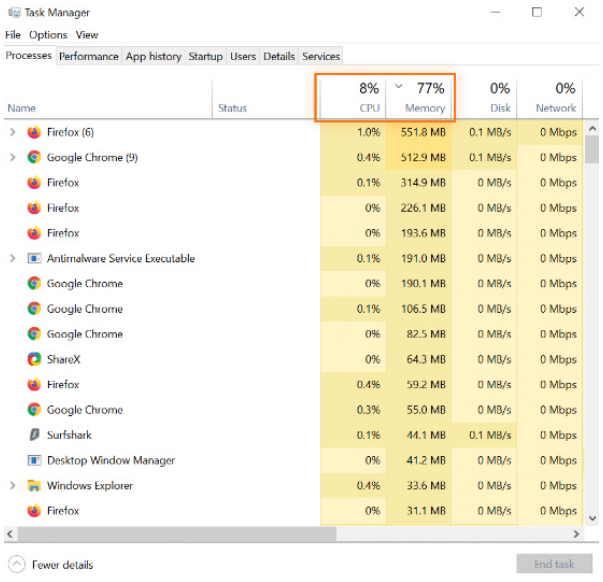
6. If the keyboard problem still persist then change with a new one

Task 2: Noisy Computer Fan

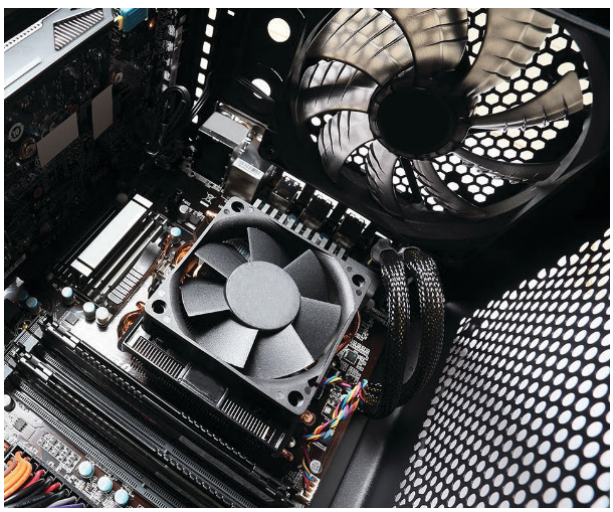
1. Right-click on the Taskbar and select “Task Manager” or “Alt+Ctrl+Del”



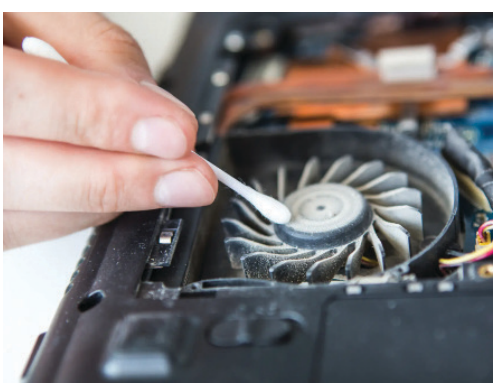
2. Close unwanted background applications.



3. Increase airflow around your computer’s vents.



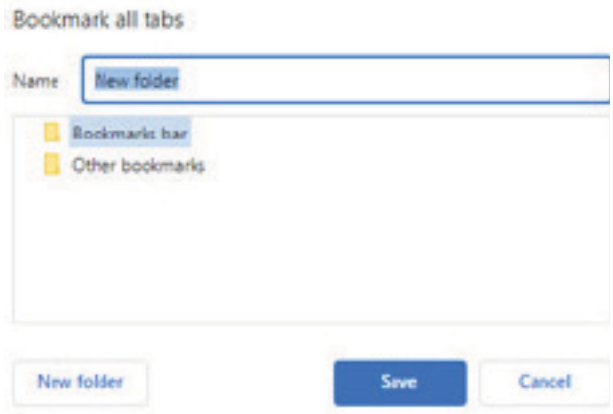
4. Clean out dust in ports and vents.



5. Run a malware scan

The best PC cleaning software will help you get rid of temporary files and other junk files on your computer and automatically fan noise is reduced.

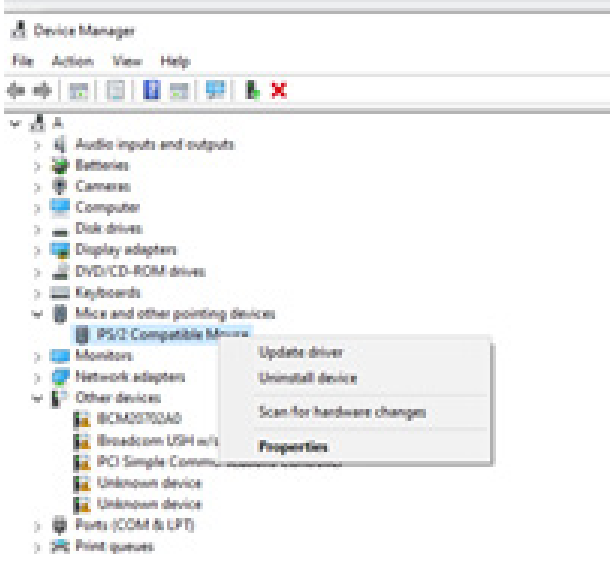
6. Press "Ctrl+Shift+D" and Click save to bookmark all the currently working tabs and then shut down your browser, your fan noise should quiet down.



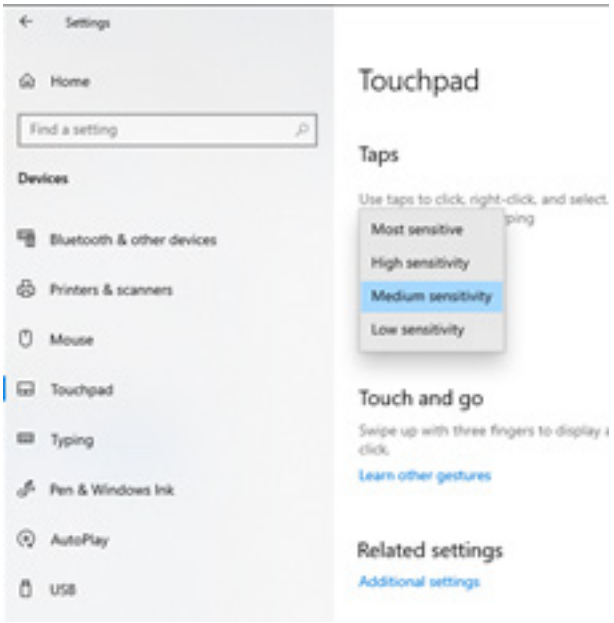
7. Turn off your computer, wait for a few minutes, and then turn it back "ON" again.

Task 3: Mouse cursor jump automatically

1. Go to "Device driver" and click on "Mice and other pointing devices" and then Right-click on the "Standard PS/2 compatible mouse" and select the "Update driver" option.

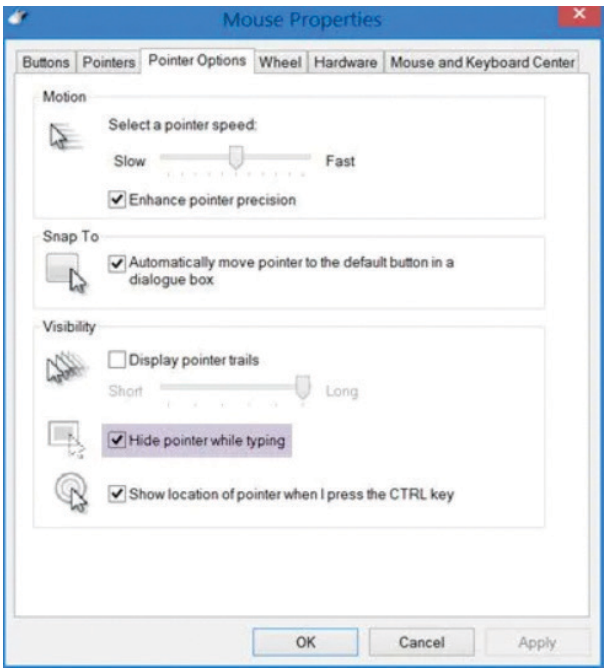


2. Open Settings → Devices → Touchpad and Change the Touchpad sensitivity as "Low".



3. In the search box on the taskbar, type control panel.

   Open Control Panel → Mouse → click Pointer option - uncheck "Hide a pointer while typing".



Result:

Thus I understood Common Hardware Problem arising in desktops & laptop and solutions to resolve it.

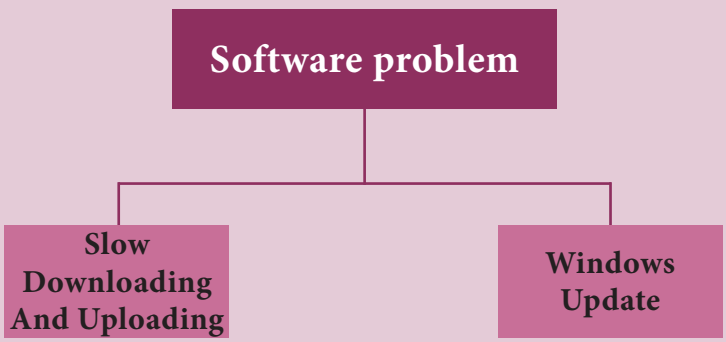
Resolve the Common Software Problem

EXERCISE 11

AIM:

To understand how to resolve Common Software Problems in a desktop and laptop.

PROCEDURE FLOW DIAGRAM



TOOLS & EQUIPMENT REQUIRED

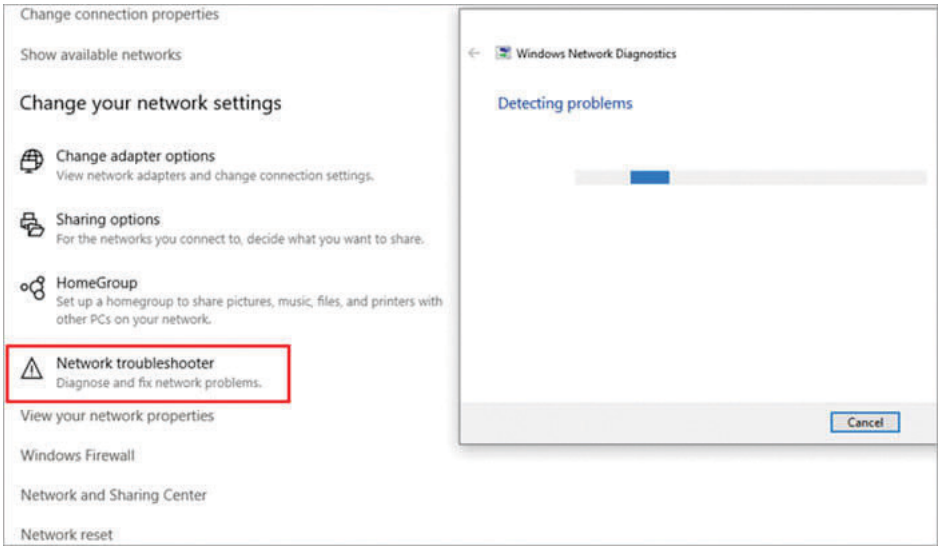
Activity Title	S. No	Name of the apparatus/ components	Range/Value	Quantity
Software Problems	1	Computer	-	1

Procedure:

Task 1: Slow Downloading and Uploading Problem

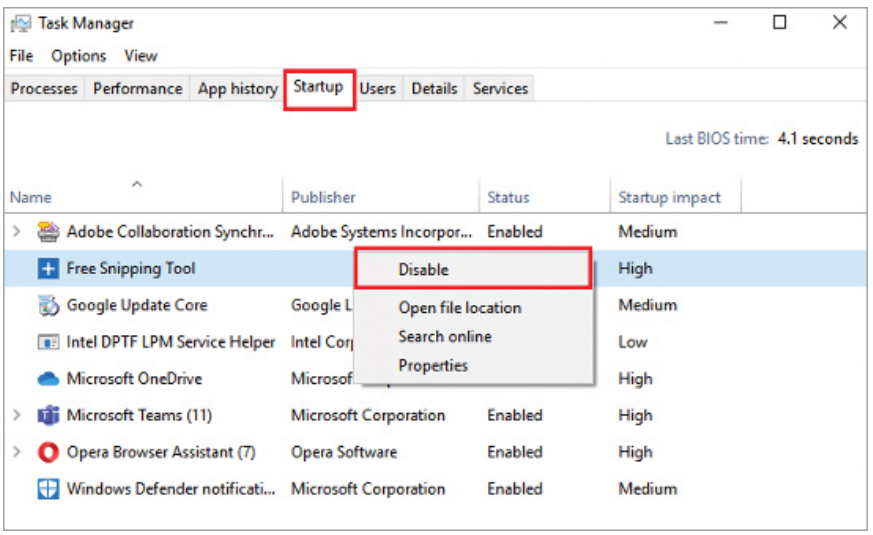
A) Run Troubleshooter :

1. Click on Start Menu→ Setting → Network and Internet → Network Troubleshooter
2. It will start to diagnose the problem.
3. If any problem is identified. It will display the problem.
4. If it cannot identify any problem "Troubleshooting couldn't identify the problem" menu will be displayed.



B) Disable Background Applications :

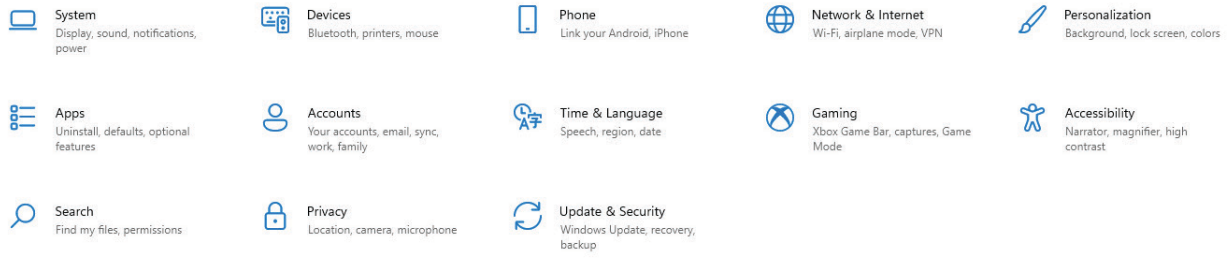
1. Turn ON the computer.
2. Click on search for "Task manager"
3. Click on the "Task Manager" and open it.
4. Now, click on "Startup" and right-click on the application you want to disable.
5. Click on "Disable" to disable the application in the background.



Task 2: Windows Update Problem:

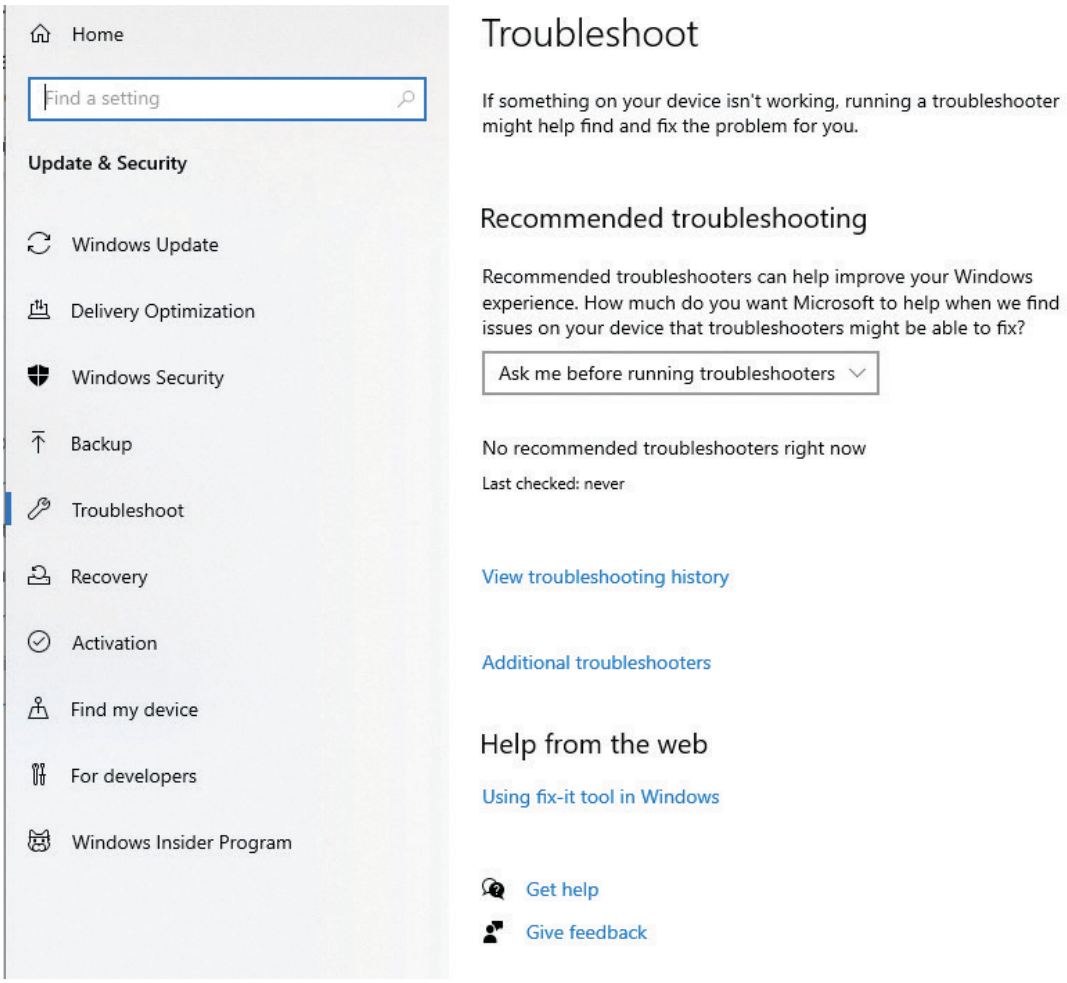
A) Run the Windows Update Troubleshooter tool

1. Click on Start menu → Settings →Update and Security.

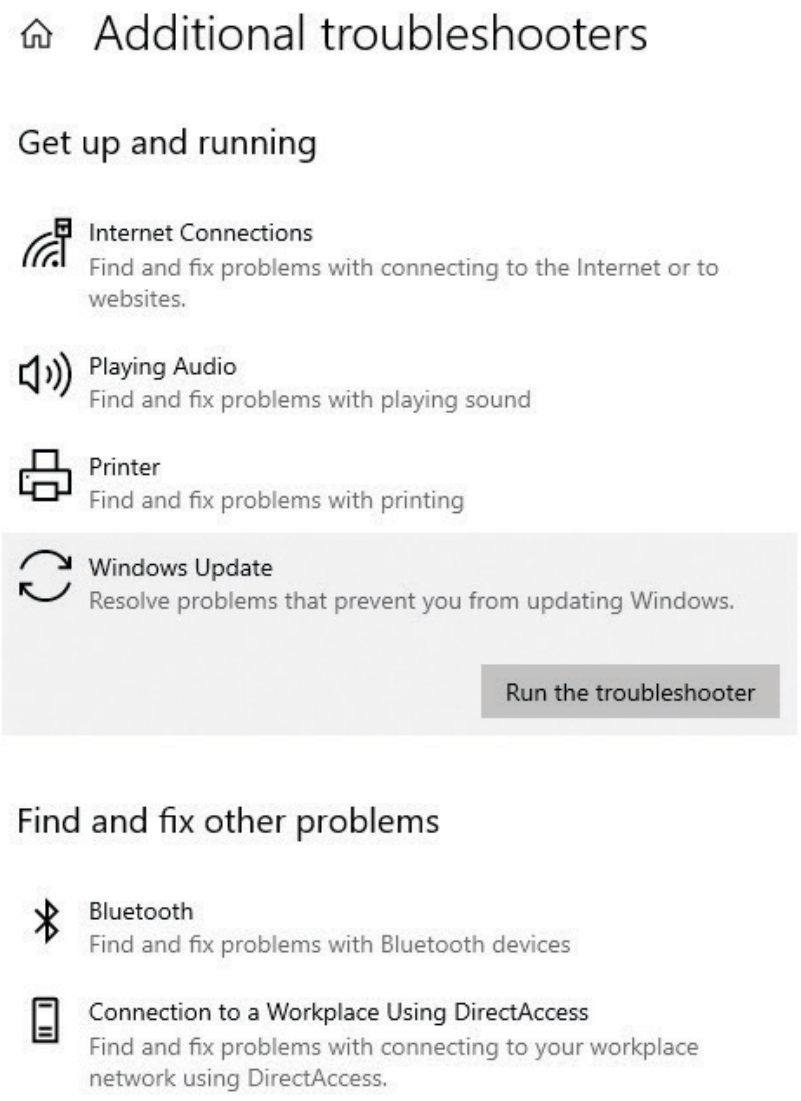




2. Click on "Troubleshoot" and click the "Additional troubleshooter" option.



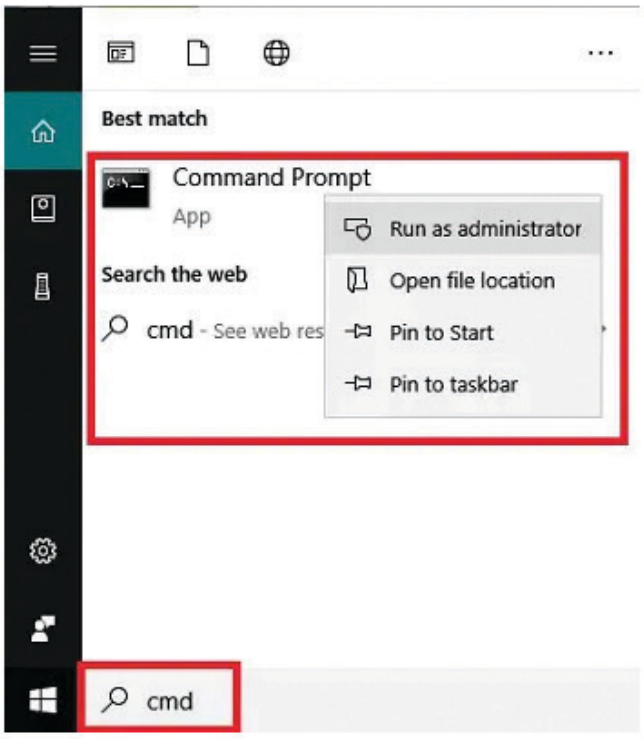
3. Under the “Get-up and Running”. Section select the Window UpdateOption.



4. Open the”Windows Update”.This will launch the troubleshooter window.
5. Click and run the troubleshooter button which can identify any issues.
6. Simply click on them to automatically fix the issues or get more information.

B) Run the System File Checker (SFC) scan

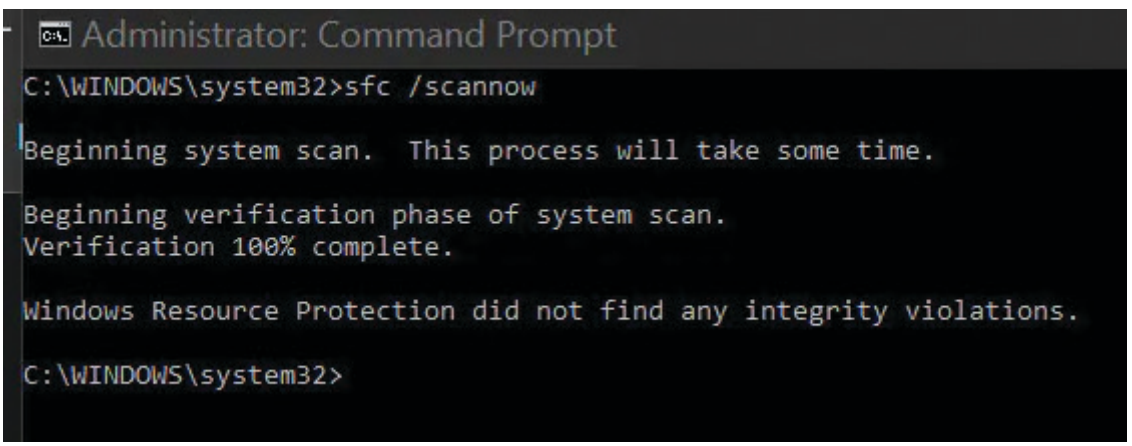
1. Press the Windows + R



2. Type in "cmd" and press the Ctrl + Shift + Enter
3. Click Yes to allow the Command Prompt to make changes on your device.



4. On getting the Command Prompt, type the following command and press Enter to execute it: "SFC / scannow"



5. Wait for the SFC scan to finish scanning your computer and repairing corrupt files.
6. Restart your device after the scan is complete.
7. Check if you're able to update Windows 10 after the restart has finished.

Result:

Thus I understood the Common Software Problem (desktop & laptop) and the step by step approach to resolve it.

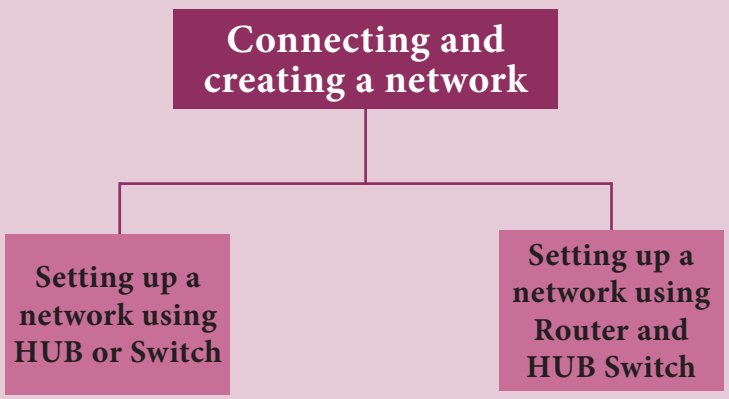
Installation of Network with HUB Switch, Input output Boxes and Patch Panel in computers

EXERCISE 12

Aim:

To Connect and creating a network with HUB Switch, Input/output Boxes and Patch Panel in computers.

PROCEDURE FLOW DIAGRAM



TOOLS & EQUIPMENT REQUIRED

Activity Title	S. No	Name of the apparatus/ components	Range/Value	Quantity
Setting up a Network	1	Computer	I3 processor 64 bit	4
	2	HUB / Switch	-	1
	3	Straight through Cable	-	As Required

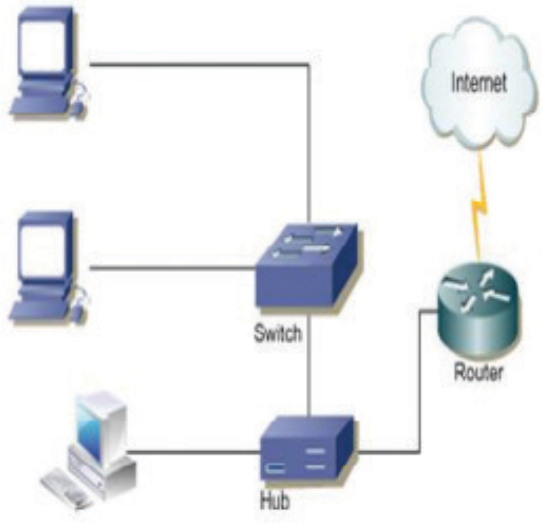
Procedure:

Task 1: Setting up a network using Hub or Switch.

1. Connect the one end of the power adapter to the electrical socket and connect the other end (Output) to the DC Connector of the Hub or switch.
2. Now power ON the computer.



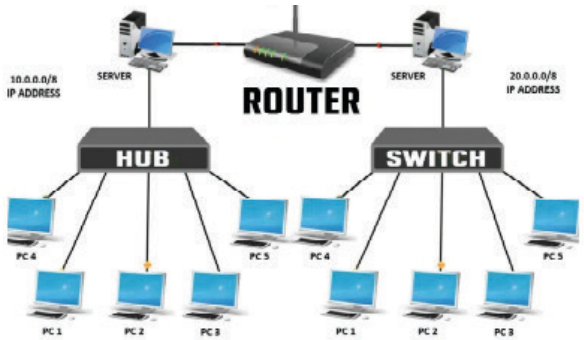
3. Plug one end of the straight through-cable into a port (avoid the up-link port) of the hub or switch.
4. Plug the other end into the computer's network jack.



5. Repeat steps 2 to step 4. To all the computer connected into the network

Task 2: Setting up a network using router and Hub switch (Optional)

1. If you have Hub or Switch, Connect the one end of the power adapter to the power socket and connect the other end (output) to the DC connector of the Hub switch.
2. If you are not using Hub or switch, go with Step 3.
3. Connect the one end (Output) of power adapter to the dc Connector of router and other end to the electrical socket.



4. If you are using a hub or switch, connect the one end straight through network cable to the uplink port on the hub or switch.
5. Connect the other end of the cable to the uplink part of the router.
6. If the Router has only one part, you can use the LAN port, and set the switch on the back of the router as Goss over (x).
7. Turn ON your computer.
8. If you are using a Hub or switch, connect one end of the straight through-cable to any other part of

the Hub switch except the uplink port.

9. Connect the other end of the cable to the network port into the computer. After each computer is connected to the Hub or Switch, if the corresponding LED on the front of the hub switch lights up, then the connection is in good condition.
10. If you are using a router without using of Hub or switch, connect one end of the straight through-cable to any port used to connect the router to DSL or cable modem.
11. Connect the other end of the cable into the computer network port. After each computer is connected to the router, if the corresponding green LED on the front of the router lights up, then the connection is in good Condition.
12. Repeat the Step 8 to step 14, to each computer connected in the network.
13. In case of Internet connection, insert the one end of the straight through-cable to the router's WAN – Part and plug the other end to the ethernet jack of a DSL or cable modem.

Result:

Thus I understood how to Connect and creating a network with HUB Switch, Input/Output Boxes and Patch Panel in computers.

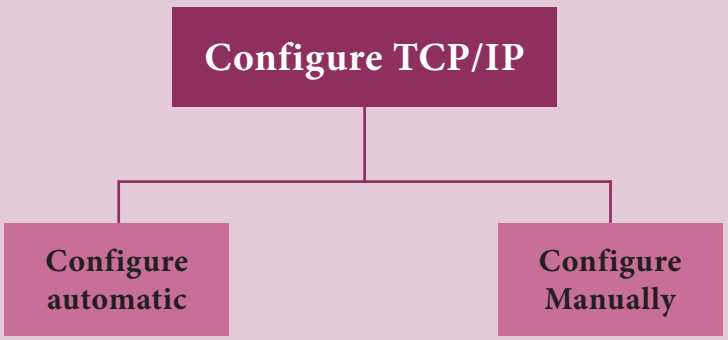
Installation and Configuration of TCP/IP protocol

EXERCISE 13

AIM:

To understand the methods of Installation and Configuration of TCP/IP protocol

PROCEDURE FLOW DIAGRAM

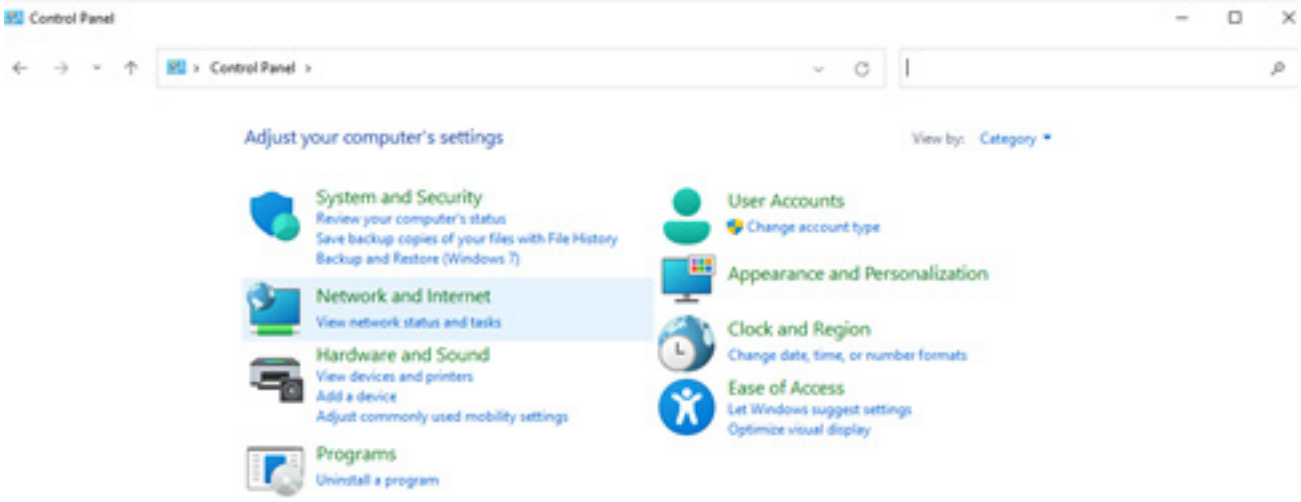


TOOLS & EQUIPMENT REQUIRED

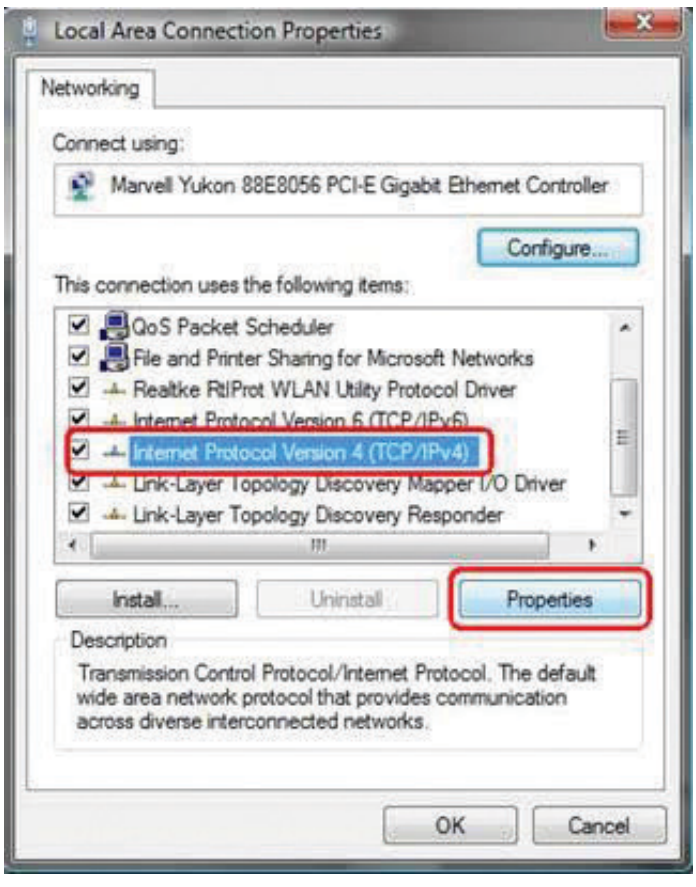
Activity Title	S. No	Name of the apparatus/ components	Range/Value	Quantity
Configuring TCP/IP	1	Computer	I3 processor 64 bit	1
	2	Key Board	108 keys	1
	3	Mouse	Optical	1
	4	Monitor	LCD	1

Procedure:

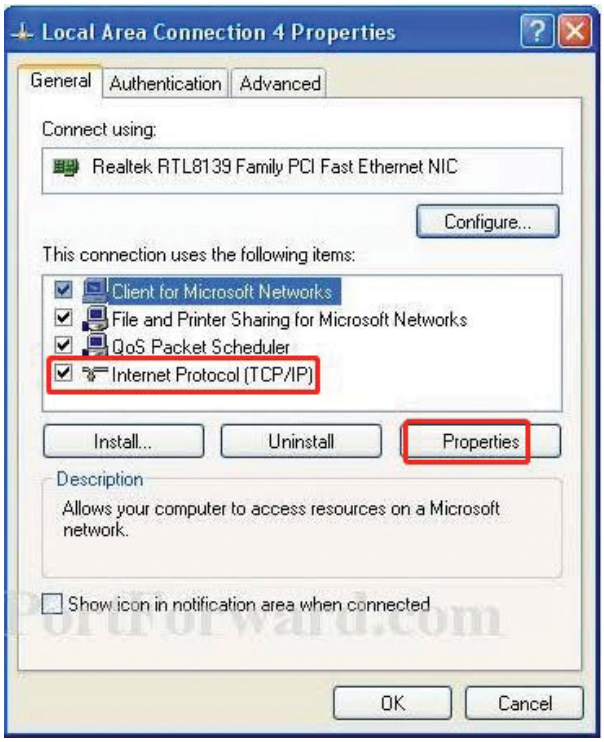
1. Click Start > Settings > Control Panel.
2. On the control panel, double-click Network and Dial-Up Connections.



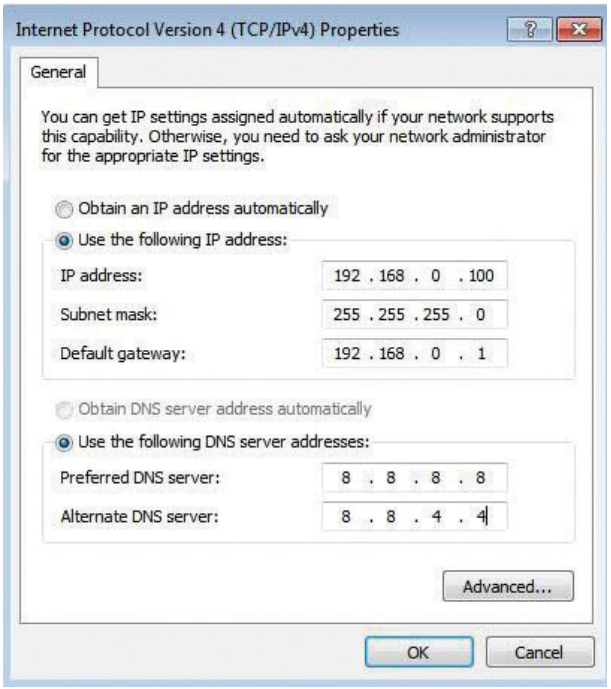
3. Right-click Local Area Connection
4. Click Properties. If Internet Protocol (TCP/IP) does not appear in the list, do the following:
   - Click Install.
   - Select Protocol, and then click Add.
   - Select Internet Protocol (TCP/IP).
   - Click OK. This returns you to the Local Area Connection Properties window.



5. Select Internet Protocol (TCP/IP), and then click on Properties.



6. Select Using the Following IP Address. Check with your network administrator to determine the correct settings for this tab. If your PC does not automatically obtain IP and DNS addresses, do the following:
   - Enter the IP address of your PC (for example, 192.168.0.100).
   - Enter the subnet mask (for example, 255.255.255.0).
   - Enter the default gateway (for example, 192.168.0.1).
   - Enter the preferred DNS server (for example, 8.8.8.8)
   - Enter the alternate DNS server (for example, 8.8.4.4).



7. If you are using a Windows Internet Name Server, click the Advanced tab, select WINS Address, and do the following:
   - Click Add.
   - Enter the primary WINS server (for example, 199.5.83.205).
   - Enter the secondary WINS server (for example, 199.5.83.206).
   - The remaining settings should remain as the defaults.
8. Click OK on the Local Area Connection Properties window.
9. When you are done, select save and It is not necessary to restart your PC.

Result:

Thus I understood the step by step procedure to install and Configure of TCP/IP Protocol

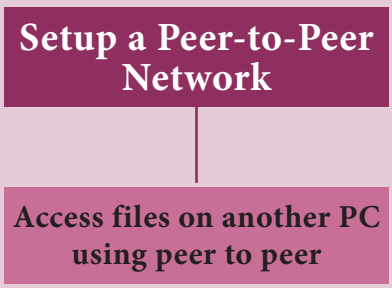
Setting up Peer-to-Peer Network in Windows 10

EXERCISE 14

Aim:

To understand the step by step procedure to Configure Peer to Peer network connection in windows 10.

PROCEDURE FLOW DIAGRAM



TOOLS & EQUIPMENT REQUIRED

Activity Title	S. No	Name of the apparatus/ components	Range/Value	Quantity
Peer-to-Peer Network Setting in windows 10	1	Computer	I3 processor 64 bit	1
	2	Key Board	108 keys	1
	3	Mouse	Optical	1
	4	Monitor	LCD	1

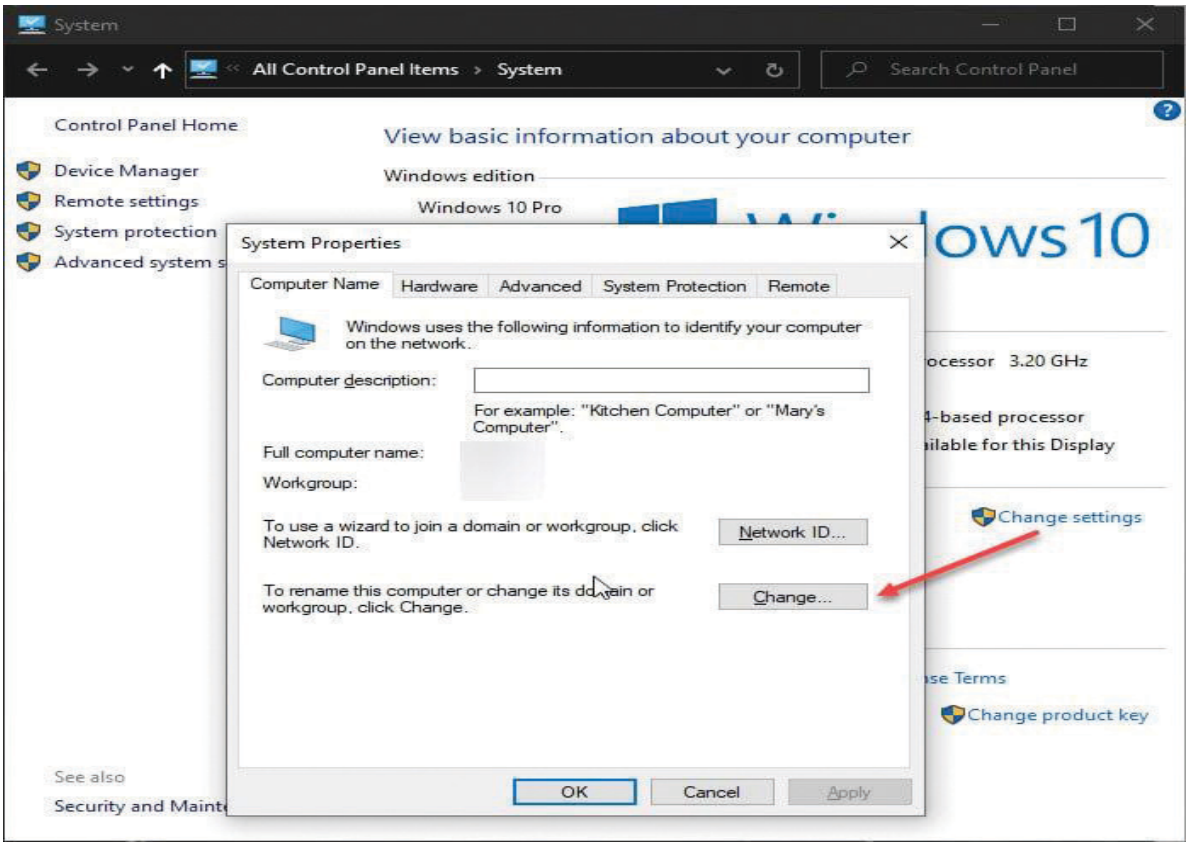
Safety measures:

1. When using a Wi-Fi router, make sure that the connection is set to Private.
2. Each computer should have its Internet connection protected with a firewall.
3. Windows should be updated with the latest updates from Microsoft Windows Update.

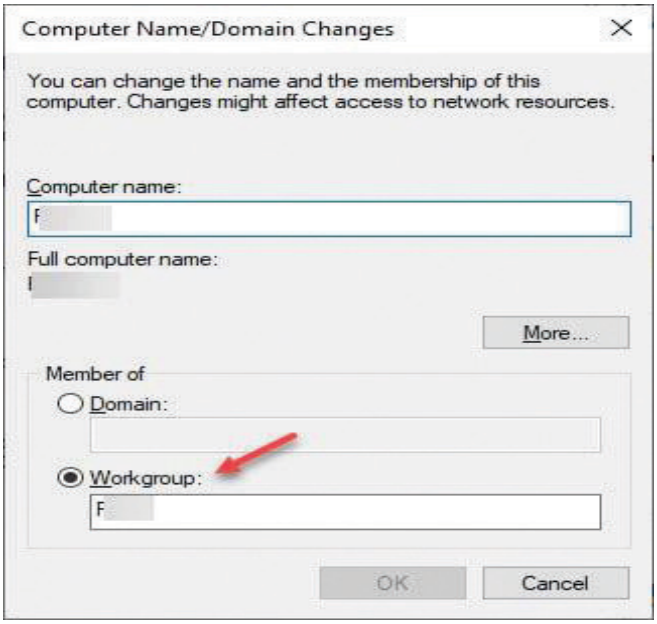
Procedure:

Task 1: How to Setup a Peer-to-Peer Network in Windows 10.

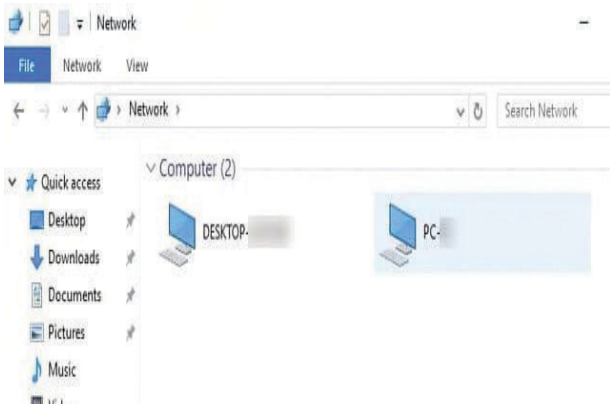
1. Turn On your desktop, right-click on the PC to reveal the context menu and select Properties. This should open a control panel window.
2. Locate and right-click on Change Settings in the window that opens. This will open a System Properties
3. Under the Computer Name tab, click on the Change button.



4. Click on the radio button next to how you wish to connect to the P2P network.
5. If the network you wish to connect has a domain, enter the name next to the Domain radio button.
6. If you wish to connect through a local Workgroup, enter the name of the Workgroup after selecting the radio button for the same.



7. Click on OK. You will see a prompt for restarting your PC
8. Restart your PC.
9. After your PC has rebooted, open File Explorer. You can use the keyboard shortcut Win + E
10. From the left quick access menu, click on Network.
11. You should see the other computers on your Network in the top row. If you do not see your computers, you will instead be presented with a yellow bar saying Network computers are not visible. Click on this bar to change the settings.
12. Select Turn on network discovery and file sharing
13. Refresh the explorer by pressing F5, or from the right-click context menu.
14. You should see all your computers present on the network now



Section 2: How to Access files on another PC using peer to peer connection.

1. To share a file, open the folder of the file in File Explorer.
2. Right-click on the file that you wish to share to reveal the context menu.
3. However over 'Give access to' to reveal additional settings. Select Home group (view and edit).
4. On another PC, create a peer-to-peer network using the steps given above.
5. Double click on any PC to access the files on your PC.
6. Enter the credentials of the PC that you wish to gain access to and click on OK.
7. You will be able to see the folders that you shared in step 3.

Result:

Thus, I understood the entire process of Peer-to-Peer network settings.

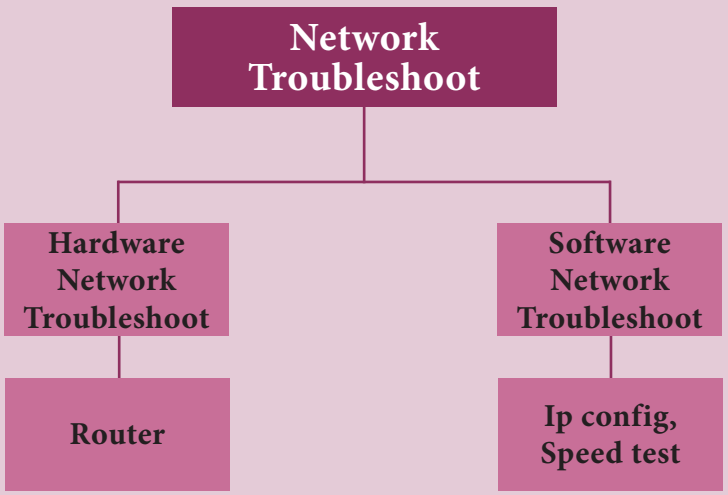
Demonstrate and Troubleshoot of Network related Problems

EXERCISE 15

AIM:

To understand the demonstrate and Troubleshoot of Network related Problems

PROCEDURE FLOW DIAGRAM



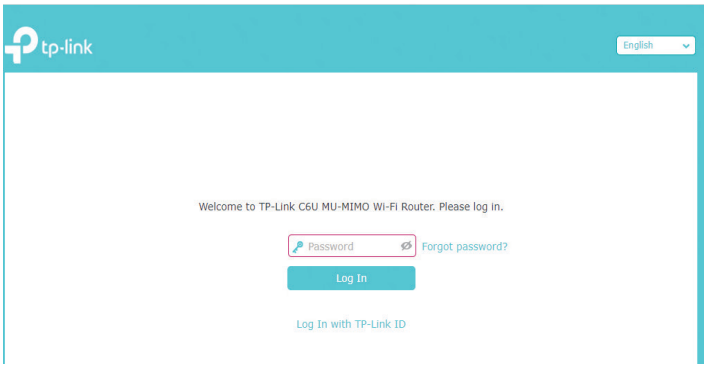
TOOLS & EQUIPMENT REQUIRED

Activity Title	S. No	Name of the apparatus/ components	Range/Value	Quantity
Network Troubleshoot	1	Computer	I3 processor 64 bit	1
	2	Router	-	1

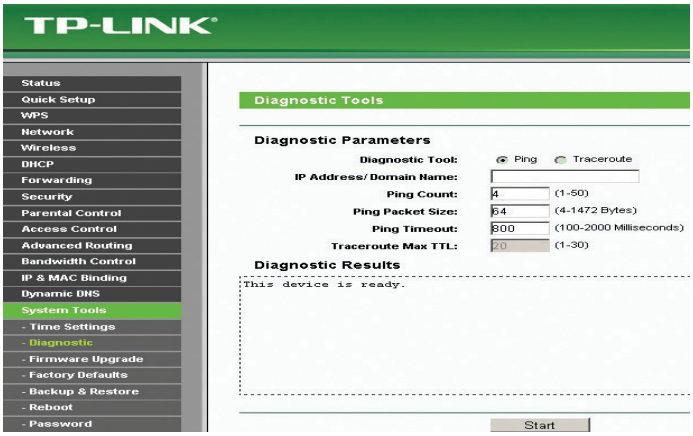
Procedure:

Task 1: Router Troubleshooting:

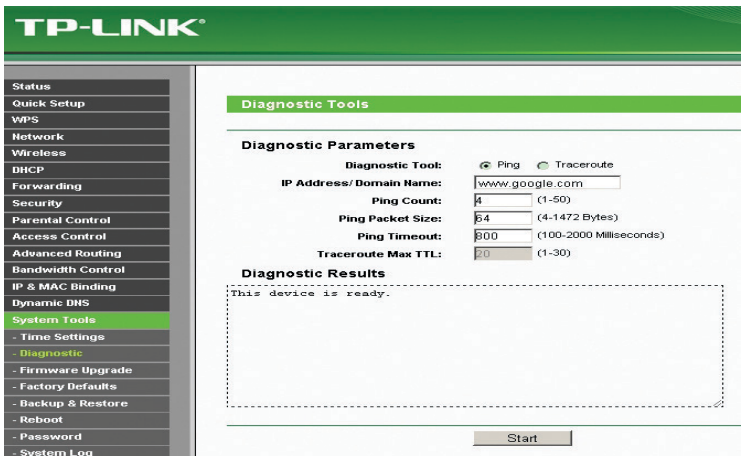
1. Open a web browser and type http://tplinkwifi.net and press enter.
2. Use the password provider purchasing the router ISP (Internet Service Provider)



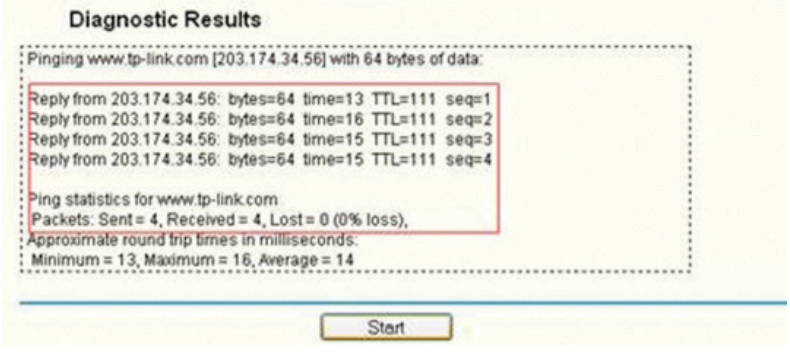
3. Click System Tools and Diagnostic.
4. Select one of the diagnostic tools: Ping.



5. Type the IP Address/Domain name of the PC/server you want to ping the IP Address/ Domain Name.



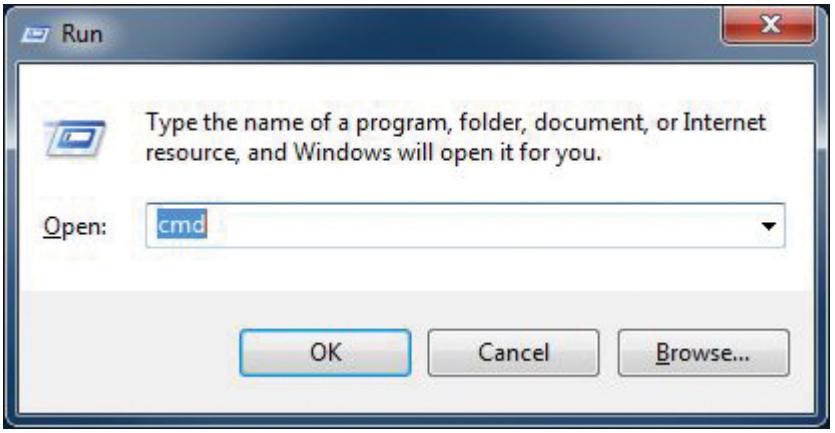
6. Click Start to diagnose. The following result indicates the connection is ok.



Task 2: Software Troubleshooting:

A) IP configure:

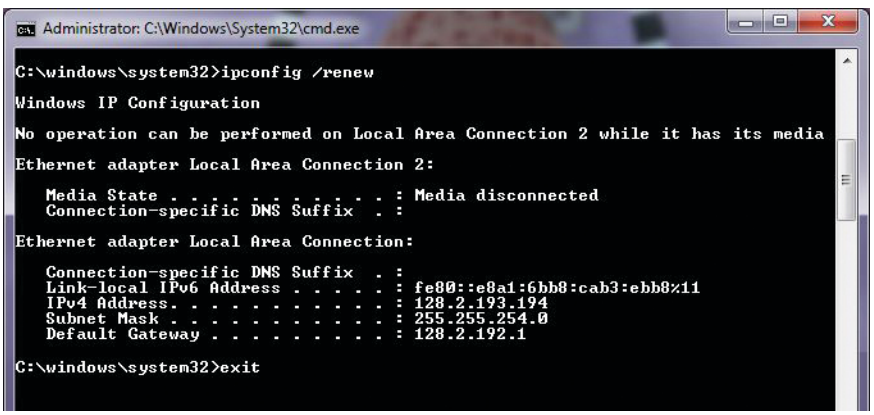
1. Go to "Start > Run" and type "cmd", then select "OK". you will get the command prompt



2. If the command prompt open then type " ipconfig / release" and press "Enter"



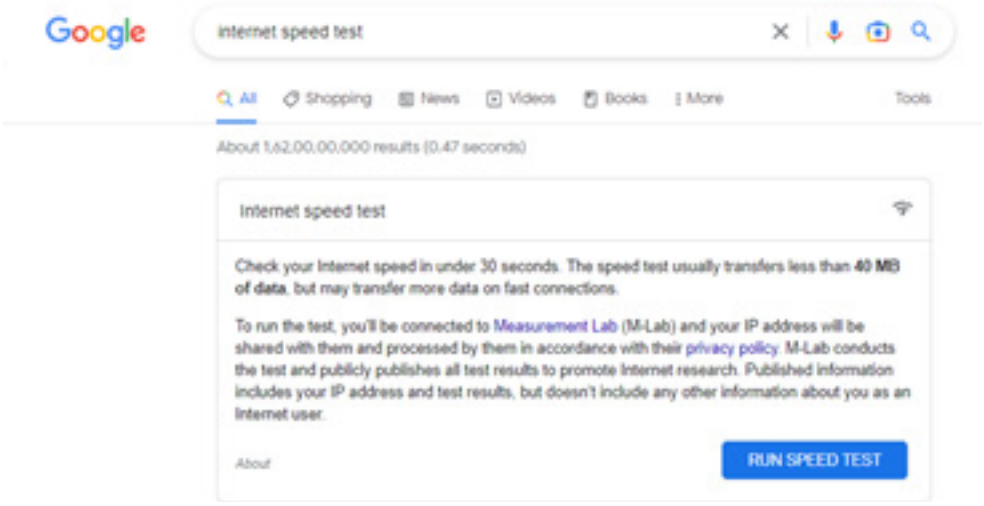
3. Once the prompt returns, type "ipconfig/renew" then press "Enter,"



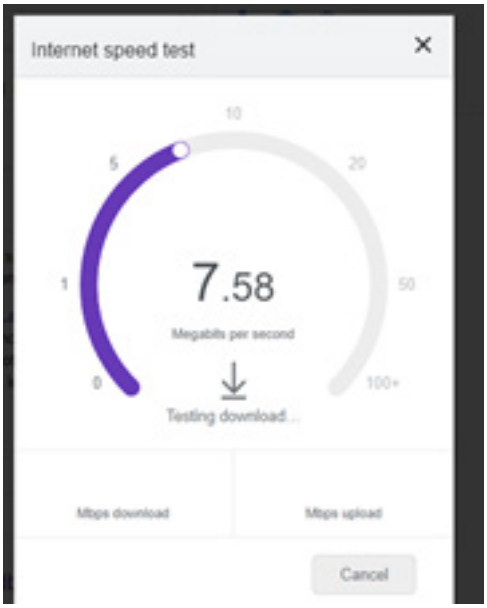
4. Finally, type "exit" then press "Enter" to close the window

B) Speed test:

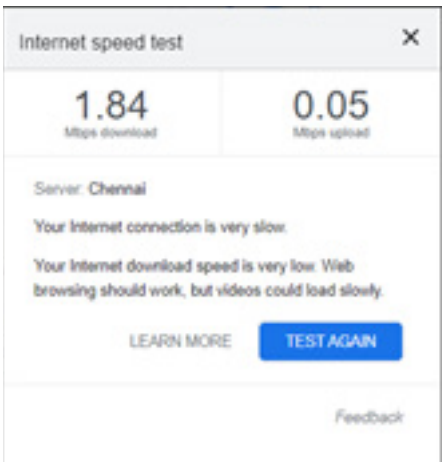
1. Go to the Google speed test page.
2. Type internet speed test into the search field.



3. Click "RUN SPEED TEST".



4. Wait for the speed test to complete. Google measures three aspects of your Internet's speed such as upload speed, download speed, and latency.



5. Review the test results. In addition this will tell you whether your Internet qualifies as "fast" or "slow".

Result

Thus I understood the step by step procedure to resolve network related problem

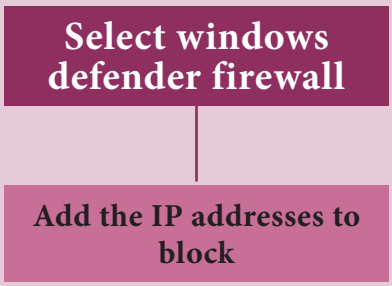
Restrict sites using Windows firewall

EXERCISE 16

Aim:

To understand the step by step procedure to block websites with windows defender firewall.

PROCEDURE FLOW DIAGRAM

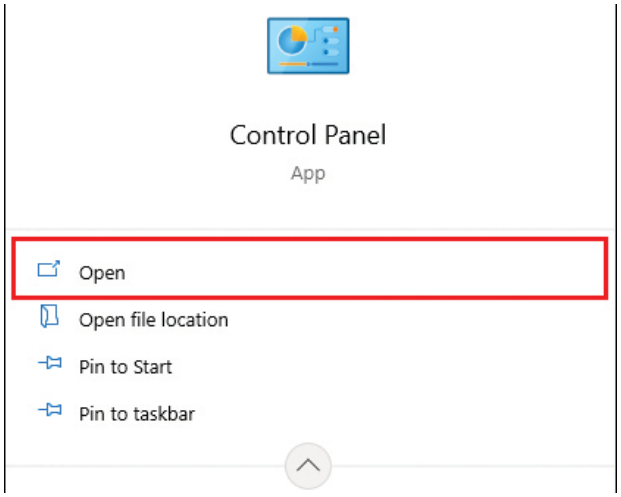


TOOLS & EQUIPMENT REQUIRED

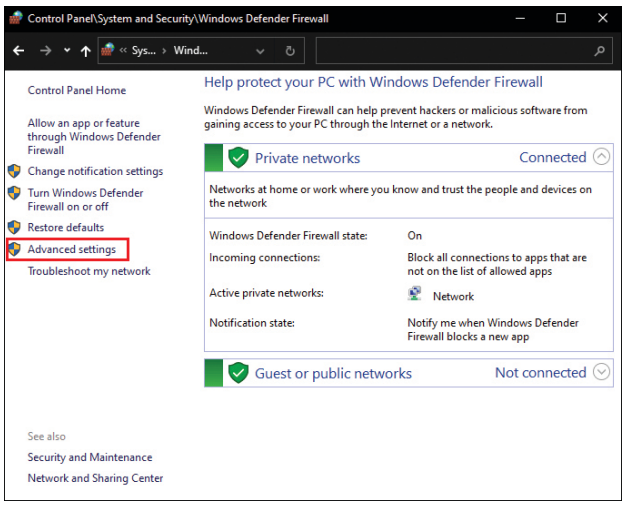
Activity Title	S. No	Name of the apparatus/ components	Range/Value	Quantity
Demonstrate to restrict sites using Windows firewall	1	Digital Computer with windows	Pentium Processor	1
	2	Key Board	108 keys	1
	3	Mouse	Optical	1
	4	Monitor	15” LCD	1

Procedure:

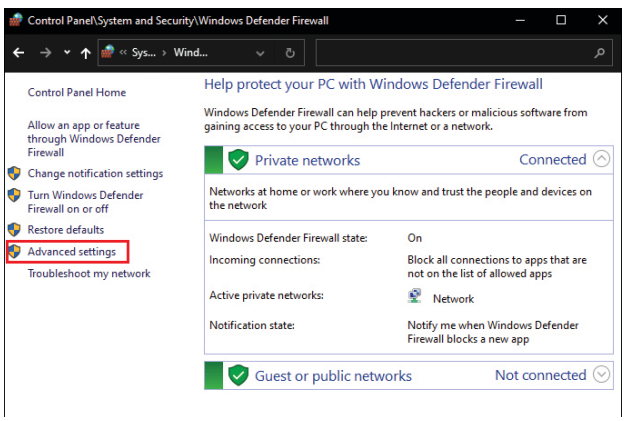
1. Launch the Control Panel on your computer.



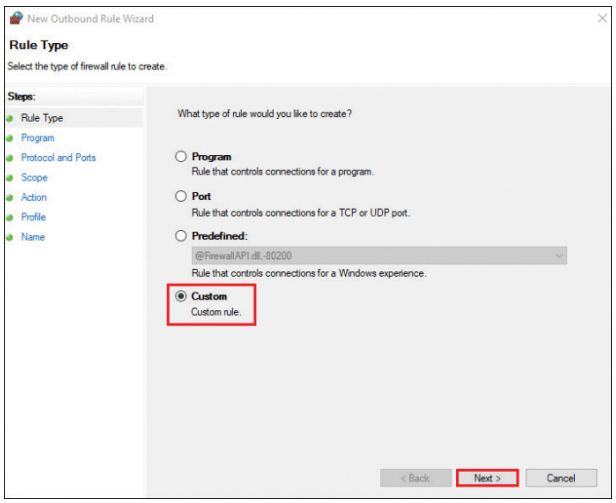
2. Select System and Security → "Windows Defender Firewall" followed by "Advanced Settings" on the left-side panel.



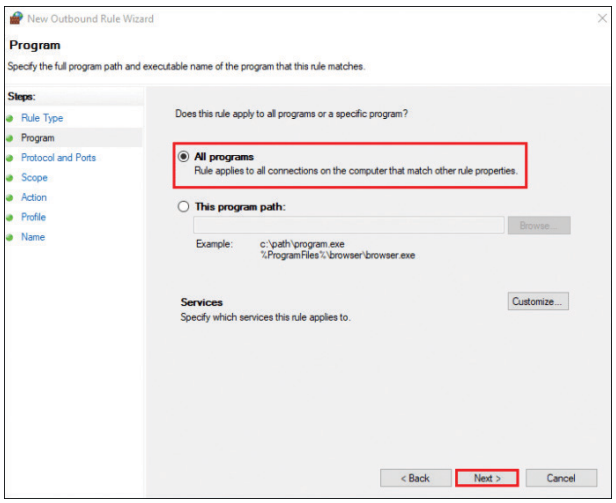
3. Right-click on "Outbound Rules" from the menu on the left and select "New Rule."



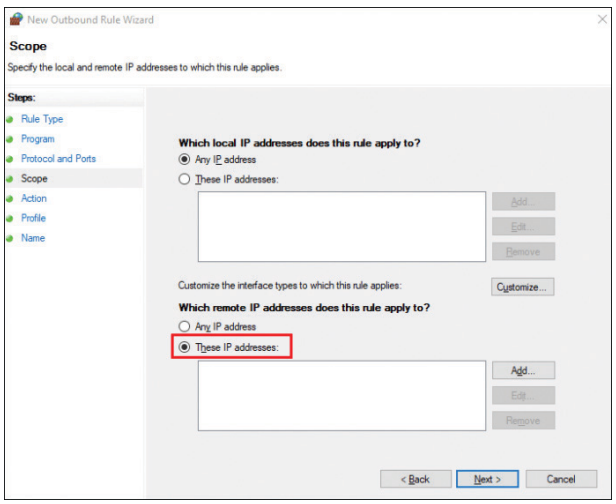
4. When a new window pops up, select the "Custom" option followed by "Next."



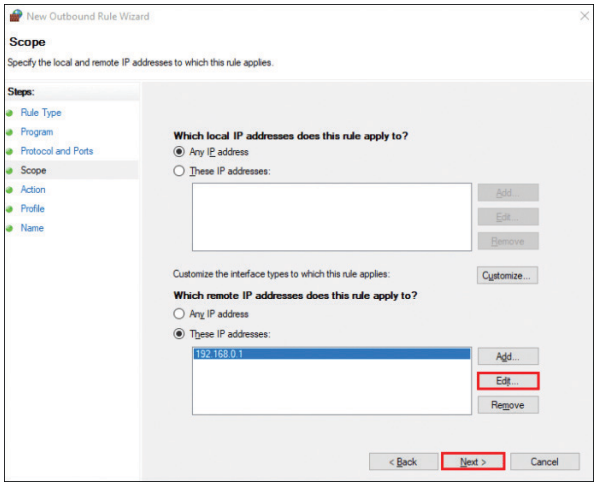
5. On the next window, select "All programs" and again select "Next."



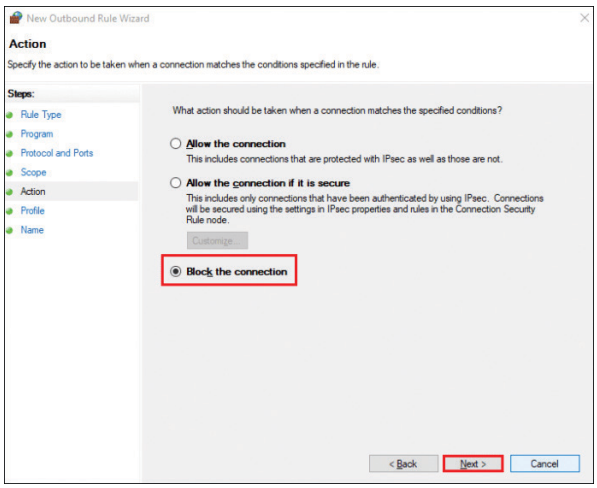
6. Select the" These IP addresses" option under "Which remote IP addresses does this rule apply to?"



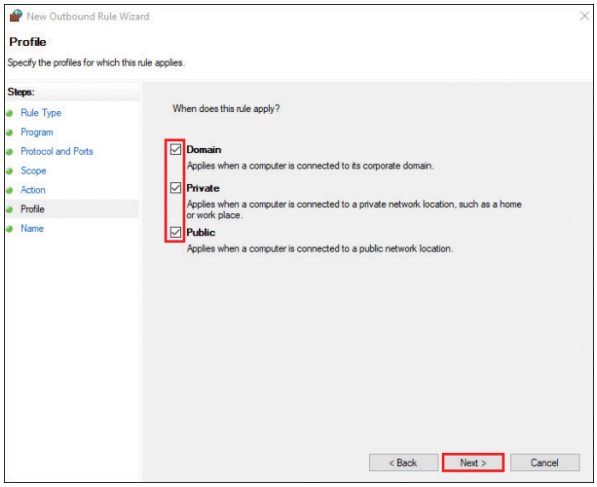
7. Click on “Add” and enter the IP addresses you want to block. Then select “Next.”



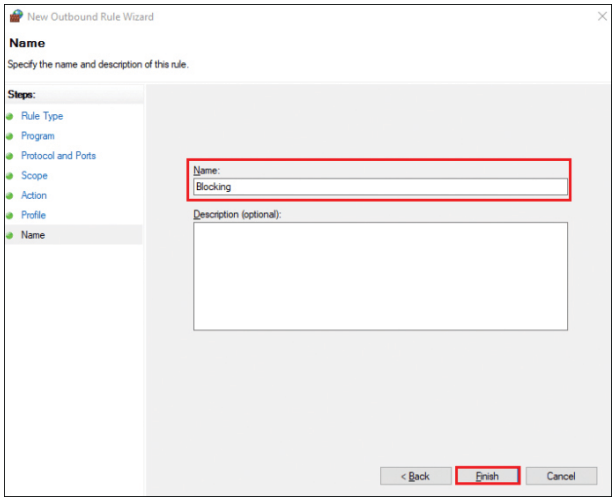
8. Make sure to choose the “Block the connection” option and click on “Next.”



9. Choose whether the rule applies to Domain, Private, or Public. You can also select all three.



10. Select “Next,” add a name or description for this rule, and select “Finish” to complete the action.



Result:

Thus I understood the step by step procedure to block Websites with Windows Defender Firewall.

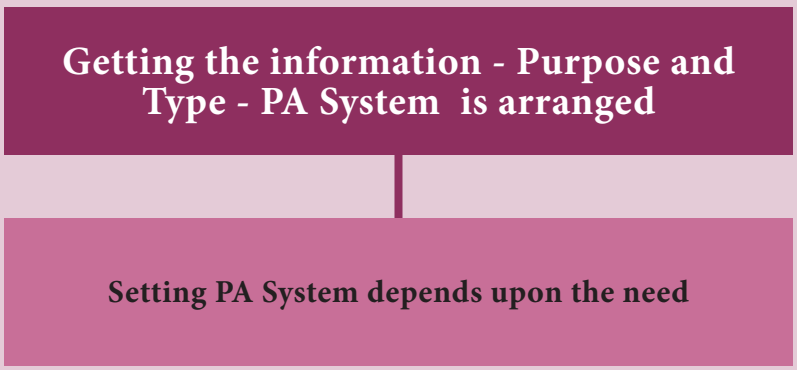
Setting Up Public Address System

EXERCISE 17

Aim :

To Understand the basic concepts of setting Public Address System.

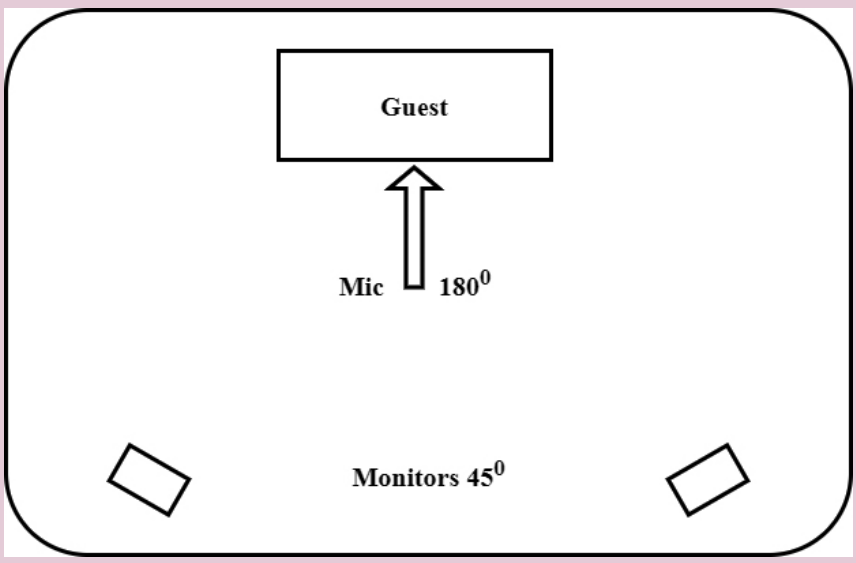
Procedure Flow Diagram:



Procedure

I. Setting up PA System at open ground assuming participants of 500 audience.

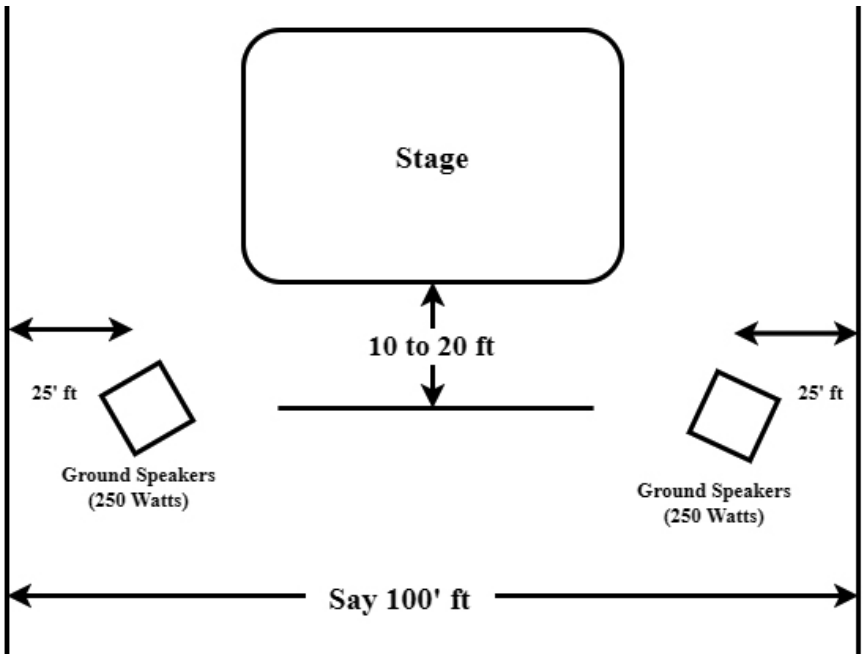
Task A. Stage & Selection of Amplifier and Speaker



1. Absorb the above diagram.
2. The stage monitors can be placed in 45° with reference to the microphone and the stage.
3. Microphone should be kept 180° out of phase with reference to the stage speakers in order to avoid feedback so as whistling noise can be avoided when the volume is raised.
4. Keep the mixer and Amplifier in between stage and ground speakers or at 10 feet distance from the stage.
5. Amplifier and mixer must be chosen depends upon the crowd or the purpose/style of the function.
6. Normally the requirement of amplifier depends upon the wattage of speaker.
7. Simple calculation is the Wattage of speaker is equal to the maximum expected audience.
8. Assuming the audience as 500 the requirement of speaker wattage is 500 Watts so as the amplifier Wattage.
9. Mixer is depends upon number of inputs i.e. Mics. (5 channel to 20 channel)
10. If we want to give more (Heavy) sound we can go upto 1000 Watts.

Note: when we are putting extra wattage of speakers, it will give over noise where it will affect our ears.

Task B. Arrangements of Ground Speaker



1. Assume that the breadth of the audience ground is around 100 feet.
2. Divide the area into 4 (25 ft each)
3. Place two 250 watt speaker box at the left and right side of the stage facing the audience.

4. Keep the speaker box at the distance of 10 to 20 feet from the stage. If it exceeds 20 feet distance, connect the speaker wire in Volts range at the amplifier. Besides make sure the speaker has 100 V matching transformer.
5. The speaker should be kept at the distance of 25 ft from the right and let end of ground as shown in the diagram.
6. Its very important to keep the speaker in 35 to 45o inclined towards audience so as the centre portion of the audience can also hear the audio clearly.
7. Selection of speaker wire is also equally important.
8. The speaker wire should have thick insulation but thin multi-strand copper cable.
9. Since the speaker carries the voltage range from amplifier, it would give better audio effect if it has many number of thin copper multi strand wires.
10. The Volume can be adjusted depends upon the audience level.

Result

Thus I understand the basic concepts of setting Public Address System.

Project work Guidelines

Electronics Department

All the students will submit their project reports (in duplicate) with in period of 5 days. The duration of the project work 1 to 2 weeks. This period shall be counted from the last day of completion of their project work.

OBJECTIVES

After the completion of a project the student should be able to:

1. Demonstrate a systematic understanding of project contents.
2. Understand methodologies and professional way of documentation.
3. Know the meaning of different project contents.
4. Understand established techniques of project report development.

IMPORTANCE OF THE PROJECT

The Project is not only a part of the coursework, but also a **mechanism to demonstrate student abilities and specialization.** It provides the opportunity for them **to demonstrate originality, teamwork, inspiration, planning and organization in project**and to put into practice some of the techniques they have been taught throughout this course.

It provides students with:

1. Opportunity to specialize in specific areas of Electronics.
2. Opportunity to demonstrate a wide range of skills and knowledge learned.
3. He had a chance of to apply the skill and knowledge they gained.

PROJECT: TABLE OF CONTENTS

The project report should contain a full and coherent account of student's work.

The suggestive structure of a project report should be as givenbelow:

1. Title Page
2. Table of Contents
3. Table of Figures

CHAPTER 1: INTRODUCTION

1. Background
2. Objectives
3. Purpose
4. Scope
5. Applicability
6. Achievements
7. Organization ofReport

CHAPTER 2: SURVEY OF TECHNOLOGIES

1. Identifying the feasible technology and it tools.
2. Costing of the project.

CHAPTER 3: REQUIREMENTS AND ANALYSIS

1. Problem Definition
2. Requirements Specification
3. Planning and Scheduling
4. Software and Hardware Requirements
5. Preliminary Product Description
6. Conceptual Models

CHAPTER 4: SYSTEM DESIGN

1. Basic Model / Demo model-with one or more modules

CHAPTER 5: IMPLEMENTATION AND TESTING

1. Implementation Approaches
2. Testing Approach
3. Unit Testing
4. Modifications and Improvements

CHAPTER 6: RESULT

1. Test Reports
2. User Documentation

CHAPTER 7: CONCLUSION

1. Conclusion
2. Future Scope of the Project

Higher Secondary Class XII
Basic Electronics Engineering
List of Authors and Reviewers

Acadamic Advisor & Expert

Dr. P. Kumar,
Joint Director (Syllabus),
State Council of Educational Research and Training,
Chennai.

Chair Person

Dr. D. Nedumaran,
Professor& Head,
Central Instrumentation & Service Laboratory,
University of Madras,
Guindy Campus, Chennai.

Academic Co-ordinator

Dr. A. Ilangovan (State Awardee – 2018)
Assistant Professor,
State Council of Educational Research and Training,
Chennai.

P. Malarvizhi
BT Assistant,
State Council of Educational Research and Training,
Chennai.

K.Gomathi
Lecturer,
DIET, Thirur,
Thiruvallur District.

Layout

Arockiam Felix
Chennai

Wrapper Design

In-House QC

Co-ordination

Ramesh Munisamy

Authors

Mr. A. Idayaselvan,
Vocational Teacher,
Govt. Hr. Sec. School,
Mettur Dam, Salem District.

Mrs. G. Anbarasi,
Vocational Teacher,
Govt. Boys Hr. Sec. School,
Mangalampet, Cuddalore District.

Mr. V. Ramana Sundaram,
Vocational Teacher,
General Cariappa Hr. Sec. School
Saligramam, Chennai.

Mr. S. Thinagaran,
Vocational Teacher,
TTN-Swami Dayananda Hr. Sec. School,
Manjakkudi, Thiruvarur District.

EMIS Technology Team

R.M. Satheesh
State Coordinator Technical,
TN EMIS, Samagra Shiksha.

K.P. Sathya Narayana
IT Consultant,
TN EMIS, Samagra Shikaha

R. Arun Maruthi Selvan
Technical Project Consultant,
TN EMIS, Samagra Shiksha

This book has been printed on 80 G.S.M.
Elegant Maplitho paper.

Printed by offset at: