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LOUDSPEAKERS

7.1 INTRODUCTION

In the previous lesson, you have studied about microphones, their classification along with working principle. As a microphone converts sound vibrations into electrical entity (voltage/current), a speaker converts the voltage/current into vibrations in the air.

In this lesson, you will learn about the various categories of loudspeakers, their working, classification and specifications etc.

7.2 OBJECTIVES

After studying this lesson you will be able to:

- define a loudspeaker.
- identify what a loudspeaker is.
- explain the working procedure of loudspeakers
- classify the types of loudspeakers.

7.3 MEANING OF LOUDSPEAKER

Loudspeaker is an equipment that converts electrical signals/ impulses into sound. The term “loudspeaker” may refer to individual transducers, which are popularly known as “drivers” or to complete speaker systems consisting of an enclosure containing one or more drivers. In technical terms, a loudspeaker (Fig. 7.1) is an electro acoustic transducer that produces sound in response to an electrical audio signal input.

Therefore, it can be said that the loudspeaker is an equipment where the sound chain begins with the microphone, whose signal is sent to a console or mixer, hardware or software based for routing and then processed, recorded and is heard through a loudspeaker.



7.4 USES OF LOUDSPEAKERS

Primarily loudspeakers are used for following four purposes:

- (a) **Aural Communication** : Loudspeakers have been an integral part of our day to day life, serving the purpose of aural communication systems, conferencing systems etc., therefore, they perform the function of information dissemination through sufficient sound level to a large audience / group in a convenient and safer way.
- (b) **Sound reinforcement** : In various locations such as in auditoriums, amphitheatres etc., the sound created by the voice is not of sufficient loudness to be heard or understood satisfactorily, thus in those locations sound reinforcement system can provide the acoustic gain to overcome such problems and produce sound at sufficient level.
- (c) **Sound production** : In various stages of musical production, a loudspeaker can supplement recording the sounds of various types of musical instruments such as guitars, bass and keyboards etc.
- (d) **Sound reproduction** : Sound reproduction system is required where the recorded sound or music has to played again and again. For example, in movie theatres, announcement systems at railway or metro stations, recording studios, etc.

REMEMBER

There are many factors deciding which loudspeaker is the “best”. Among them are: *frequency response, linearity, amplifier power, distortion, dynamic range, sensitivity, polar response, and polarity*; the interaction between the room’s acoustics and loudspeaker; the loudspeaker’s placement within the room; and how the loudspeaker is mounted.



Fig. 7.1: A horn loudspeaker



DO YOU KNOW?

- Johann Philipp Reis installed an electric loudspeaker in his telephone in 1861.
- Alexander Graham Bell patented his first electric loudspeaker (capable of reproducing intelligible speech) as part of his telephone in 1876, which was followed in 1877 by an improved version from Ernst Siemens. The modern design of moving-coil (also called 'dynamic') drivers was established by Oliver Lodge in 1898. The first practical application of moving-coil loudspeakers was established by Danish engineer Peter L. Jensen and Edwin Pridham, in Napa, California. Jensen was denied patents, for years after the invention of the loudspeaker.
- The moving-coil principle commonly used today in direct radiators was patented in 1924 by Chester W. Rice and Edward W. Kellogg.
- About the same period, Walter H. Schottky invented the first ribbon loudspeaker together with Dr. Erwin Gerlach.

7.5 COMPONENTS OF LOUDSPEAKERS

A loudspeaker comprises of various parts . These are transducer, radiator, enclosure and crossover

- (a) Transducer:** An electro-mechanical transducer contains three elements: coil, diaphragm and suspension. The coil converts electrical energy into mechanical energy and the diaphragm converts mechanical energy into acoustic energy. A suspension supports the diaphragm, allows it to move in an appropriately constrained fashion , exerts a restoring force proportional to displacement from its equilibrium position and provides a dampening force proportional to the velocity of motion that serves to prevent the diaphragm from oscillating in an undesired manner.
- (b) Radiator:** A Cone type structure that help radiate sound energy at a wide angle.
- (c) Enclosure :** To house the loudspeaker body and reinforce the sound signal as well as provide front to back isolation.
- (d) Crossover:** Multi way loudspeakers incorporate crossover network which is a collection of electrical filters each of which allows a specific portion of the frequency spectrum to pass through it. The filtered signal is then applied to one of the bands in the loudspeakers. The types of electrical filters used



to execute the crossover function are low pass, high pass, and band pass to reproduce the sound in respective bands. Accordingly, using the speakers of smaller size cone reproduce higher frequencies and are called 'treble loudspeakers' While speakers with larger size cone reproduce lower frequencies and called 'bass loud speakers'. Rest are called 'midband loudspeakers'.

INTEXT QUESTIONS 7.1

Choose any one of the following:

1. A loudspeaker is the equipment that converts into sound
 - (a) electrical impulses
 - (b) magnetic impulses
 - (c) ultrasonic impulses
 - (d) electro-magnetic impulses
2. The term " Bass loudspeaker" may refer to a type of loudspeaker which enhances frequencies
 - (a) Tracks
 - (b) Low
 - (c) high
 - (d) mid
3. installed an electric loudspeaker in his telephone in 1861
 - (a) Albert Einstein
 - (b) Walter H. Schottky
 - (c) Alexander G. Bele
 - (d) Johann Philipp Reis
4. The commonly used today in direct radiators was patented in 1924.
 - (a) moving-coil principle
 - (b) Moving-coil galvanometer
 - (c) Moving-coil aerostat
 - (d) Moving-coil magnetism
5. Walter H. Schottky invented the first together with Dr. Erwin Gerlach
 - (a) ribbon loudspeaker
 - (b) Carbon loudspeaker
 - (c) silica loudspeaker
 - (d) magnetic loudspeaker

7.6 CONSTRUCTION OF LOUDSPEAKERS

The cone of a loudspeaker, usually made of paper, plastic or metal, is attached on the wide end to the suspension. The suspension, or surround, is a rim of flexible

Loudspeakers

material that allows the cone to move, and is attached to the driver's metal frame, called the basket. The narrow end of the cone is connected to the voice coil. The coil is attached to the basket by the spider, a ring of flexible material. The spider holds the coil in position, but allows it to move freely back and forth (as shown in Fig. 7.2 and 7.3) and opened out details in the Fig. 7.4 and Fig. 7.5 show you the different parts/ components of loudspeaker, their mounting and working



Notes

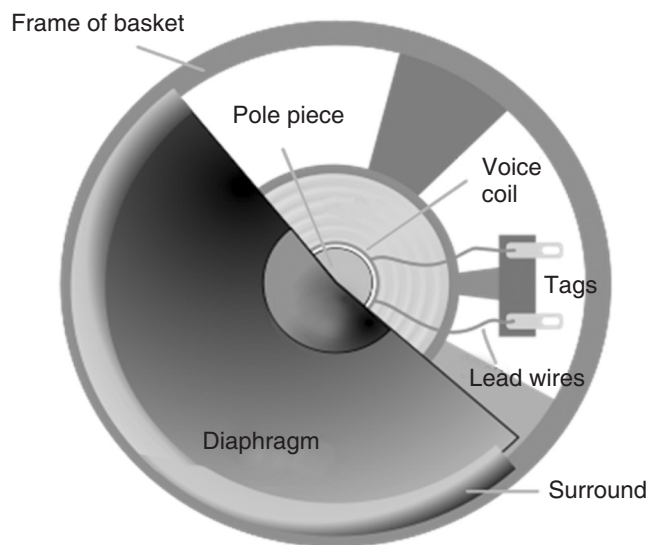


Fig. 7.2 : Constructional details of Loudspeaker

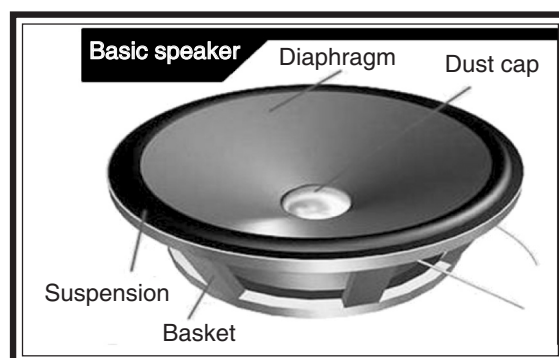


Fig. 7.3: Parts of a loudspeaker



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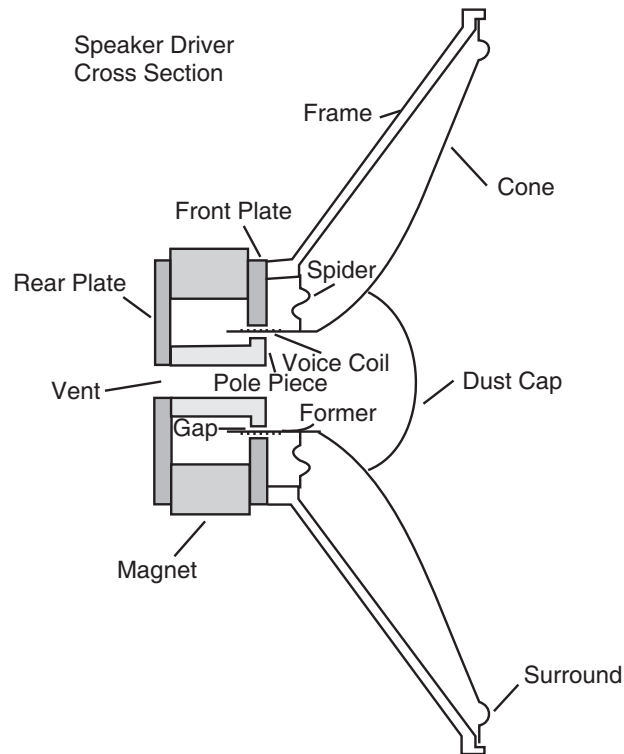


Fig. 7.4: Inside components of a loudspeaker

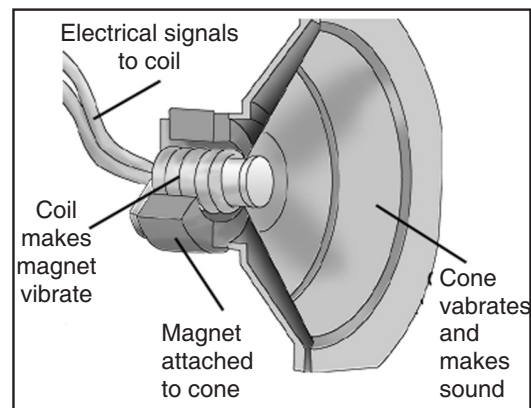


Fig. 7.5: How loudspeaker works

7.7 WORKING OF A LOUDSPEAKER

Whenever an electrical audio frequency signal is applied to the terminals/ coil of the loudspeaker, Fig. 7.5 above, the interaction between the force produced by the flow of current in the coil and the magnetic force of the magnet in the loudspeaker makes the suspended body of the coil to exhibit displacement motion or vibrates

in proportional to the strength and frequency of the audio signal. This motion of the coil through a diaphragm and the attached cone produces vibrations in the surrounding air converting the electrical energy into acoustical energy thus producing high level sound waves, The loud speaker thus reproduces the sound signal in correspondence to the audio signal applied which was in turn the replica of original low level sound signal.



7.8 SPECIFICATIONS OF SPEAKERS

Speaker specifications depend on -

- Speaker or driver type
- Size
- Rated Power
- Impedance
- Baffle or enclosure type
- Number of drivers
- Crossover frequency
- Frequency response
- Sensitivity
- Maximum sound pressure level

7.9 LOUDSPEAKER

Classification based on mounting arrangement:

1. Floor standing Speakers

Floor standing or tower loudspeakers are a set of loudspeakers which have been mounted in a vertical enclosures/boxes for floor stand as shown in Fig. 7.6.

Advantages

An extremely wide frequency response and dynamic range make floor-standers the choice where performance is the primary purchasing criteria. And while they tend to be large, many current models feature slender cabinets with small footprints, minimizing placement difficulties and visual impact.

Disadvantages

When space is at a premium towers simply might not fit. Floor-standers should be located 2-3 feet from nearby walls for best performance.



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Fig. 7.6: Floor standing speaker

2. Bookshelf Speakers

Bookshelf speakers (Fig. 7.7 below) work where towers do not. These speakers are not only more placement friendly but, since small enclosures are more rigid, they produce less sonically degrading box resonance than all but the best towers.

Advantages

Usually modest in price as well as size, bookshelf speakers fit rooms and budgets that cannot accommodate a pair of towers. The small, solid cabinets are both versatile and able to excel in bookcases, atop shelves or hung on walls-and feature excellent midrange clarity.

Disadvantages

Reduced cabinet volume and driver surface area limit the dynamic and bass frequency range of bookshelf speakers, and can also compromise power handling and efficiency. Fortunately, the addition of a subwoofer can overcome these problems.



Fig. 7.7: Bookshelf speaker



3. Subwoofer/Satellite Systems

When even the smallest bookshelf speakers are too visible to fit one's lifestyle, a subwoofer/satellite (sub/sat) system is required. By combining palm sized satellites with a subwoofer designed specifically to work with them, sub/sat systems have become one of the most popular categories in home audio. See fig 7.8 below.

Advantages

The big advantages here are size, placement flexibility and cosmetics. The satellites can be placed just about anywhere, on a shelf, on the wall, in a cabinet or on a table. Most are small enough to fit anywhere and are hard to spot when placed alongside books and bric-a-brac.

Disadvantages

Those little satellites cannot reproduce bass of their own, making it tough to achieve a seamless blend between satellite and sub. A sub/sat system may not be right for a very large room to fill with sound. The other issue is bass response. Some of the so-called subwoofers in these systems are passive.



Fig. 7.8: Subwoofer/Satellite System

4. In-Wall Speakers

For environments where box-type (tower or bookshelf) loudspeakers are unacceptable, in-wall speakers' flush-mount in holes cut into the walls are used (Fig. 7.9 below). Even the area of bass reproduction can be addressed with in-wall, in-floor and in-ceiling subwoofers. A completely invisible, no compromise sound system can be fairly easily obtained with this type of speaker.

Advantages

Since they consume no floor or bookshelf space and can be easily concealed, in-walls work when and where other speakers will not. They are also useful as rear surround speakers when the room configuration makes it impossible to properly place box speakers.



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Disadvantages

These days there aren't very many since this speaker category has made significant strides in the past few years. They can produce the same level of high performance sound quality as any other type of speaker.



Fig. 7.9: In-wall Speaker

7.10 TYPES OF LOUDSPEAKERS

1. **Horn loudspeakers** are the oldest form of loudspeaker system. The use of horns as voice-amplifying megaphones dates at least to the 17th century, and horns were used in mechanical gramophones as early as 1857.
2. **Piezoelectric speakers** are frequently used as beepers in watches and other electronic devices, and are sometimes used as tweeters in less-expensive speaker systems, such as computer speakers and portable radios.
3. **Magnetostrictive transducers**, based on magnetostriction, have been predominantly used as sonar ultrasonic sound wave radiators, but their usage has spread also to audio speaker systems.
4. **Electrostatic loudspeakers** use a high voltage electric field (rather than a magnetic field) to drive a thin statically charged membrane they are driven over the entire membrane surface rather than from a small voice coil.
5. **Ribbon speaker** consists of a thin metal-film ribbon suspended in a magnetic field. The electrical signal is applied to the ribbon, which moves with it to create the sound.
6. **Bending wave transducers** use a diaphragm that is intentionally flexible. The rigidity of the material increases from the center to the outside. Short wavelengths radiate primarily from the inner area, while longer waves reach the edge of the speaker.



7. **Flat panel loudspeakers**, most accurately called exciter/panel drivers can be made in a neutral color and hung on walls where they are less noticeable than many speakers, or can be deliberately painted with patterns, in which case they can function decoratively.
8. **Heil Air Motion Transducer**, a pleated diaphragm is mounted in a magnetic field and forced to close and open under control of a music signal. Air is forced from between the pleats in accordance with the imposed signal, generating sound.
9. **Plasma arc loudspeakers** use electrical plasma as a radiating element. Since plasma has minimal mass, but is charged and therefore can be manipulated by an electric field, the result is a very linear output at frequencies far higher than the audible range.
10. **Digital speakers** have been the subject of experiments performed by Bell Labs as far back as the 1920s. The design is simple; each bit controls a driver, which is either fully 'on' or 'off'.
11. **Transparent ionic conduction speaker** was introduced in 2013, which is a 2 layers transparent conductive gel and a layer of transparent rubber is there in between to make high voltage and high actuation work to reproduce good sound quality. The speaker is suitable for robotics, mobile computing and adaptive optics fields.
- 12 **Thermo-acoustic speaker** is based on the working mechanism of 'thermo acoustic effect'. Sound frequency electrical currents are used to periodically heat the Carbon Nanotube (CNT) thin film of the speaker and thus result in sound generation in the surrounding air.

7.11 HEADPHONES/ EARPHONES

Headphones/ earphones are very small size paired speakers mountable over the head or place in the ears. These work on the same principle as a loudspeaker of converting an electrical audio signal into sound waves. Since headphones are worn over the ears directly, their sound is not affected by the environmental interference from the room. Headphones help prevent feedback when live microphones are around. These require low power drivers as the output required is not high. These are widely used in the studios for sound monitoring etc.

There are three types of headphones:

- (a) **Ear bud headphones:** These are mostly used with all kinds of portable music players and mobile phones. Also known as earphones. (Fig 7.10)



Notes



Fig. 7.10: Ear phones

- (b) **On ear headphones:** These headphones sit on the ears rather than over them; thus they are smaller and lighter than over the ear models. Since they don't cover the ears, ambient noise tends to enter the ears, making it difficult to monitor audio in critical conditions.



Fig. 7.11: On ear headphone

- (c) **Over the ear headphones:** These headphones were traditionally used, which enclose whole ear thus making them comfortable to wear for long. Such headphones are best suited for audio monitoring purposes in the studio as well as in the field. (Fig. 7.12).



Fig. 7.12: Over the ear headphone



7.12 WHAT HAVE YOU LEARNT

In this lesson, you have learnt about loudspeakers and their classifications based upon the working principle and mounting arrangement. The construction details and the components of loudspeakers was explained to provide in-depth knowledge about loudspeakers. Later in the section different type of other loudspeakers were also discussed based upon their working principle.

7.13 TERMINAL QUESTIONS

1. How does a Loudspeaker work?
2. What do you mean by drivers?
3. Mention the specifications of speakers
4. What are the different types of loudspeakers?
5. Discuss the advantages and disadvantages of floor standing speakers?

7.14 ANSWERS TO IN TEXT QUESTIONS

1. A 2. B 3. D 4. A 5 A

7.15 REFERENCES

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