Skill Based – III
Audio and Video Systems

Microphones and Loudspeakers

Unit- 1 and 2

Content

Loudspeakers

- Crystal Loudspeaker,
- Dynamic Loudspeaker,
- Electrostatic loudspeaker,
- Permanent Magnet Loudspeaker,
- Woofers and
- Tweeters.

Microphones

- Microphone Characteristics,
- Crystal Microphone,
- Carbon Microphones,
- Dynamic Microphones and
- Wireless Microphones.

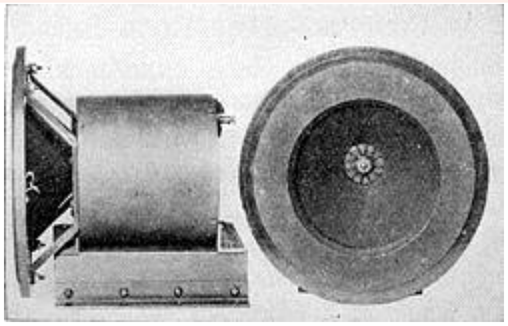
Introduction

- **Consumer electronics** or **home electronics** (i.e. analog or digital) are equipment intended for everyday use, typically in homes.
- Consumer electronics include devices such as
  - Entertainment (flat screen TVs, DVD players, video games, remote control cars, etc.),
  - Communications (telephones, cell phones, e-mail-capable laptops, etc.), and
  - Home-office activities (e.g., desktop computers, printers etc.)

History

Component	Inventor	Year	Application
Loud speaker	Johann Philipp Reis	1861	An electric loudspeaker installed in his *telephone*
	Alexander Graham Bell	1876	He patented his first electric loudspeaker (capable of reproducing intelligible speech) as part of his telephone

First commercial version of the speaker

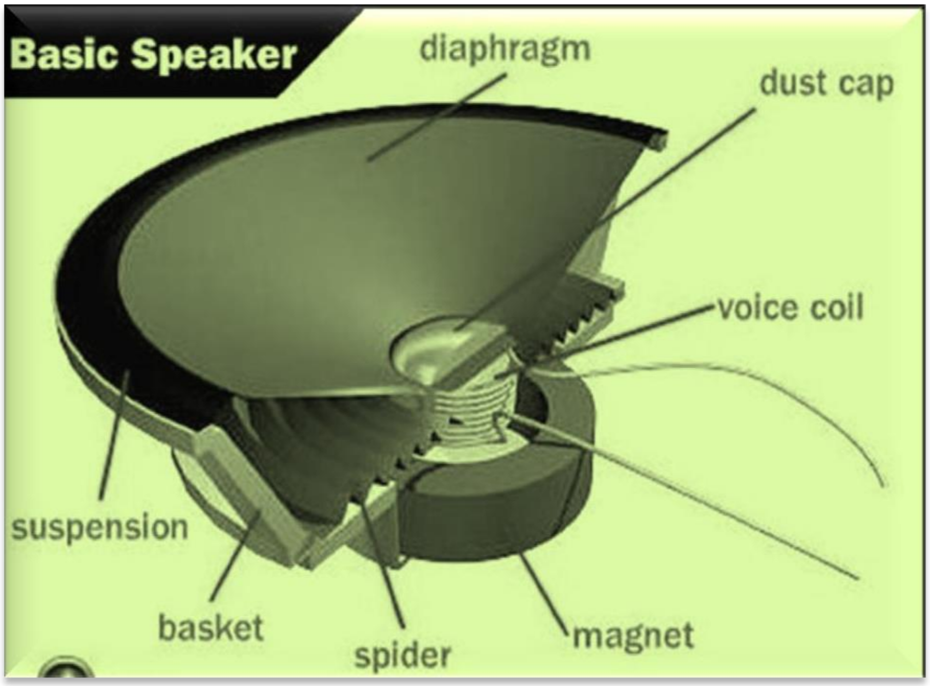


Loudspeaker

Loudspeaker is a transducer which converts an electrical signal into sound signal.

A device that converts variations in a physical quantity, such as pressure or brightness, into an electrical signal, or vice versa called as transducer.
Eg:- Microphone, Speaker.

The lowest frequency that a human ear can hear is 20 Hz



Speaker Parts

Characteristics

- There are a number of *interrelated factors* that must be considered in designing transducer for converting *electrical energy* into *acoustic energy.*
  - sound travel fastest in Steel and cannot travel through a vacuum

- These include
  - Electroacoustic efficiency,
  - Uniformity of frequency response,
  - Linearity of amplitude response,
  - Transient response,
  - Power handling capacity,
  - Size,
  - Durability and
  - Cost.

Ideal Loudspeaker

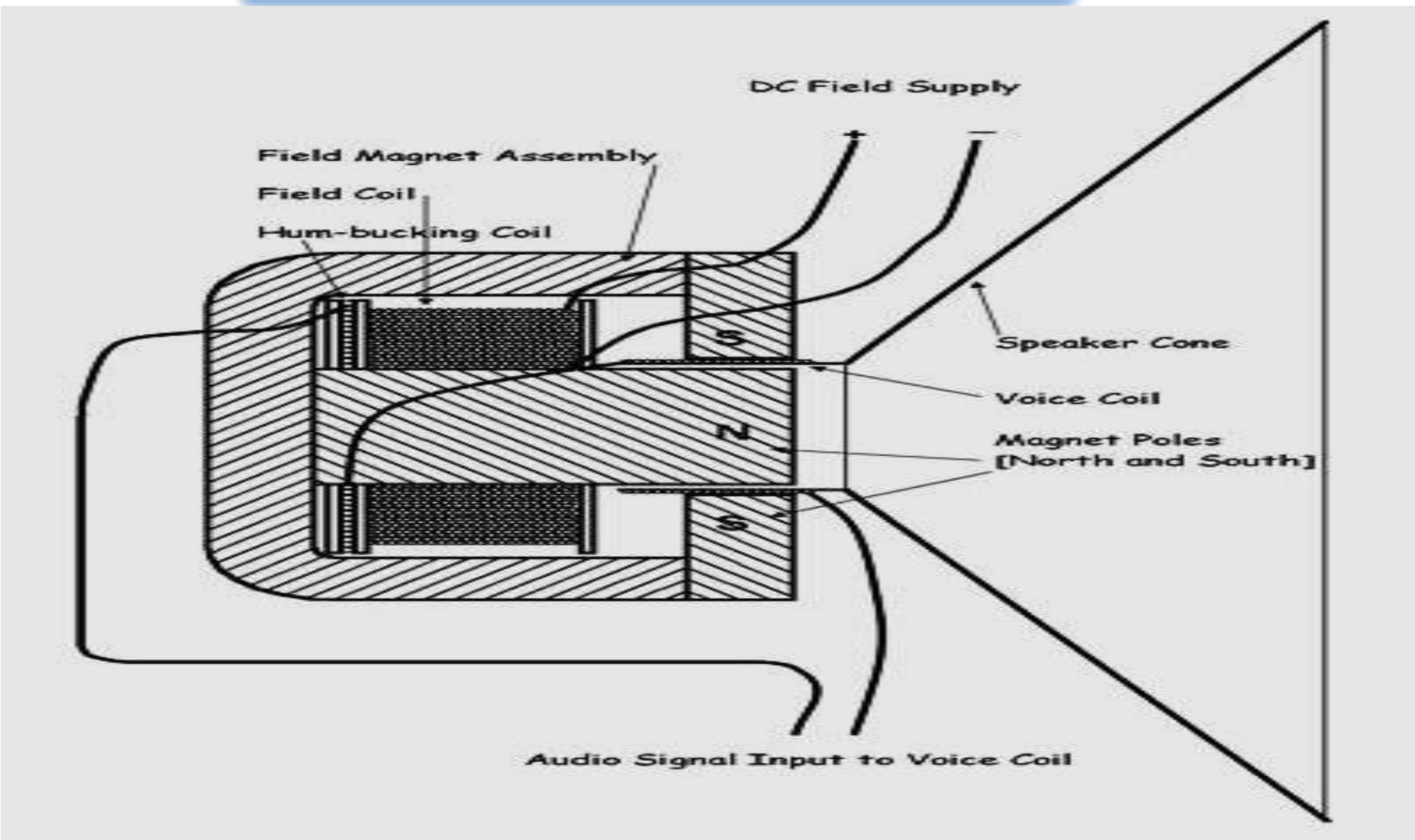
- Would have an *electroacoustic efficiency* approaching 100 per cent.
- Would have an *acoustic output response* that is independent of frequency over the entire audible range.
- Would introduce neither harmonic nor intermodulation *distortion* into its output.
- Would *faithfully reproduce* transients as well as steady input signals.
- Would be capable of producing a *nondirectional* radiation.

No single transducer has been designed that is capable of satisfying all the above requirements.

Note

- *A loudspeaker must be able to reproduce a wide range of audio frequencies (i.e., 20 Hz to 20 kHz).*
- *Sound wave has two main characteristics, which are Pitch and loudness*

Cross Section View



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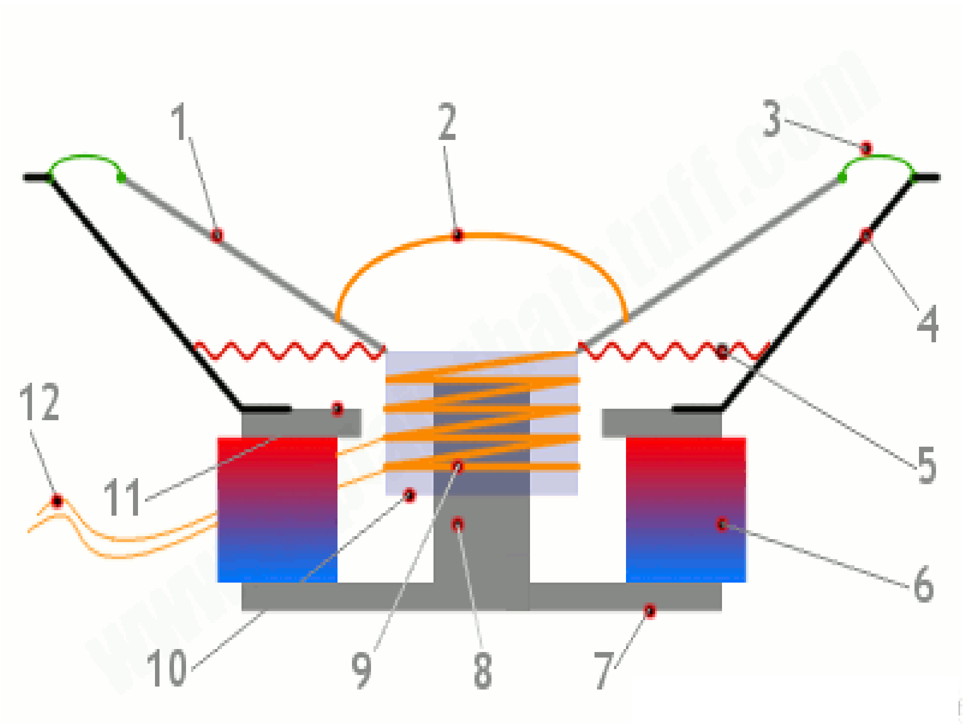
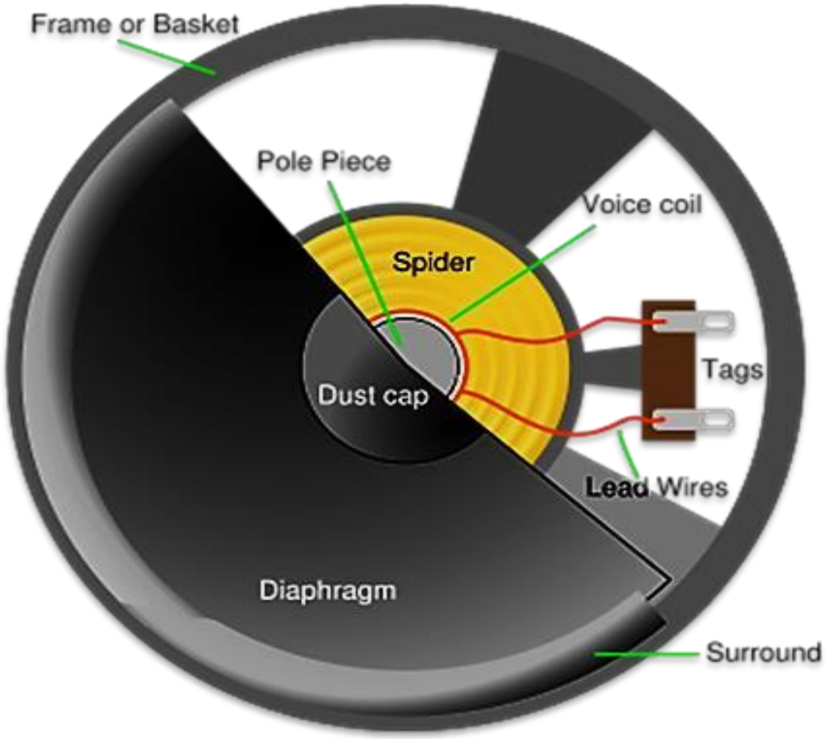
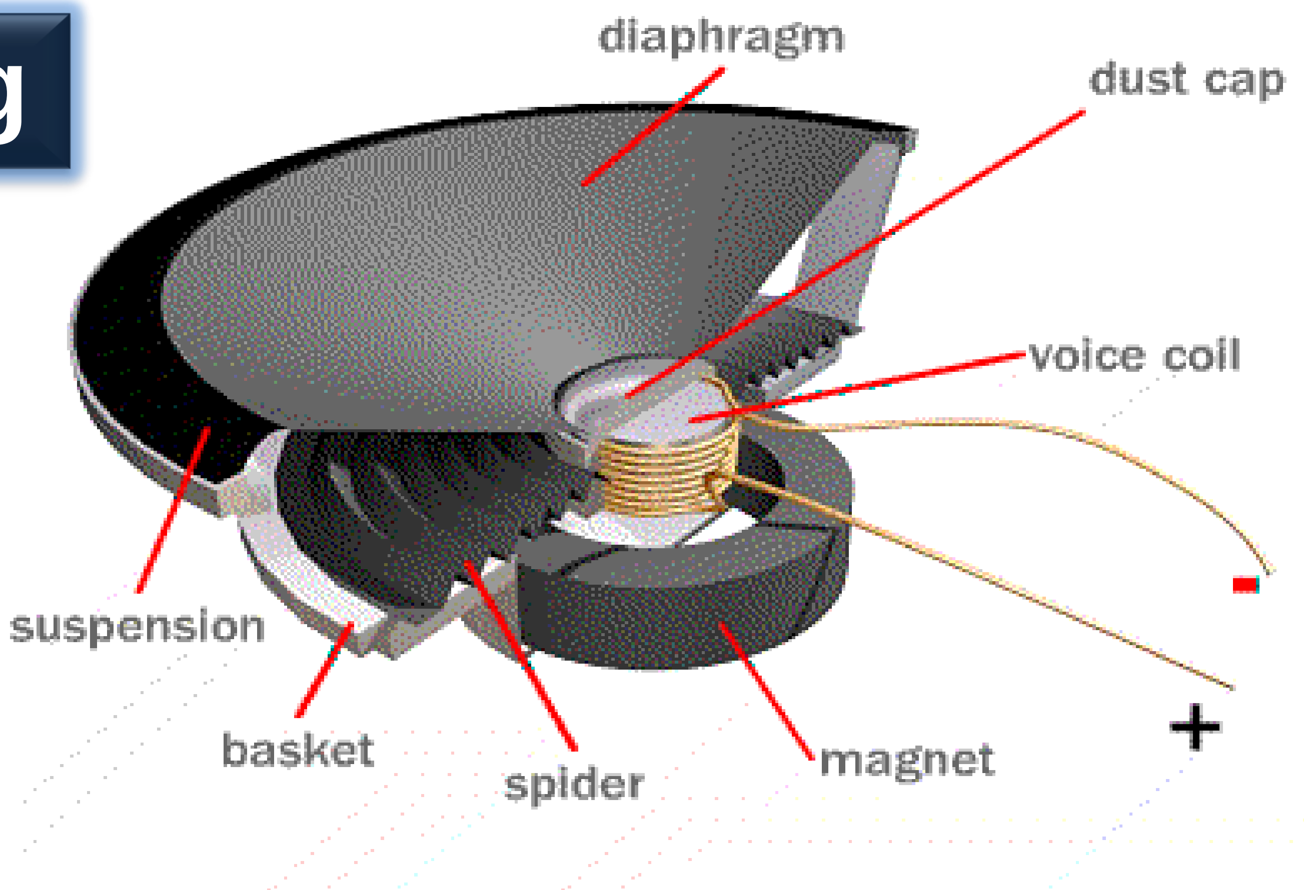




working



Cone

The body of the cone can be made from paper, black polypropolene, carbon fiber, aluminum, titanium, magnesium, etc. Today's replacement cones may or may not be available in all materials to match the originals.

Voice Coil

It is a set of windings wound on an aluminum or other material form that fits into the magnetic voice coil gap.

The length of the former and length of the windings are customized to the component. It can be made using flat wound or round wound wire.

Common nominal impedances are 2, 4, 6, 8, 10, 16 or 32 ohms.

Spider

The Spider fits around the speaker voice coil and is attached to the speaker basket. It is one of the components (along with the cone) that help to keep the voice coil centered in the magnetic gap and affects excursion (movement).

It can be soft or hard (stiffness), has different size voice coil openings, different widths and can be flat or cup shaped.

Terminal

The Pigtail or Tinsel Lead connect the voice coil to the speaker Terminal.

Dustcap

The Dustcap, Dustcover or Center Dome.

It fits on top of the voice coil former and it attaches to the cone. It protects the magnetic gap from dirt. It can be made of paper, felt, screen, aluminum, rubber or polypropolene.

Gasket

The Gasket or Ring fits over the edge of the cone annulus onto the outside of the speaker frame and acts as a spacer.

They can be foam, rubitex (rubber) or chip (cardboard).

Not all speakers have a ring.

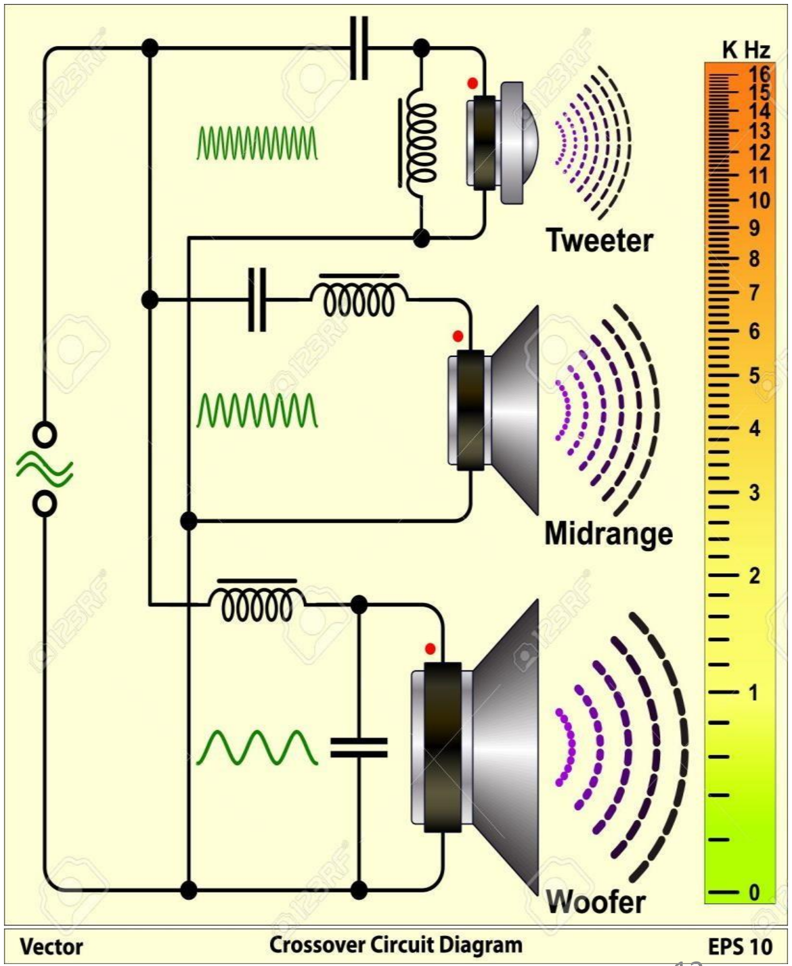
Other components in the loudspeaker

Description	Function
Rigid / frame /Basket	A metal frame which holds the speaker together, which in turn is held by the speaker case.
Magnet	The voice coil is suspended above the center of a large magnet with the end of the voice coil attached to terminals on the basket.
Top plate	Typically made of iron.
Bottom Plate	Holds the pole piece and magnet
Pole Piece:	Directs the voice coil magnetic field
Cables	The wires that connect to the voice coil from whatever the input source.

Cont.

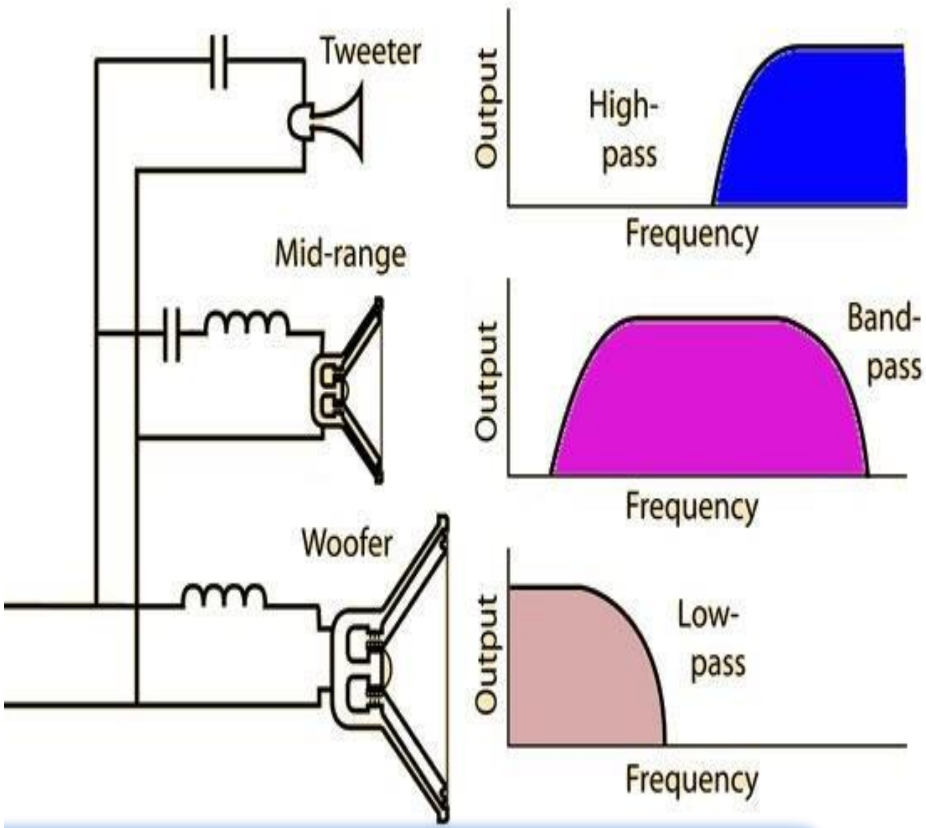
A Loudspeaker consists of a number of drivers to reproduce a wide range of frequencies for high sound pressure level or high fidelity applications.

- These drivers comprise of
  - ✓ *subwoofers for very low frequencies,*
  - ✓ *woofers for low frequencies,*
  - ✓ *squawkers for middle frequencies,*
  - ✓ *tweeters for high frequencies and*
  - ✓ *super tweeters for very high frequencies.*



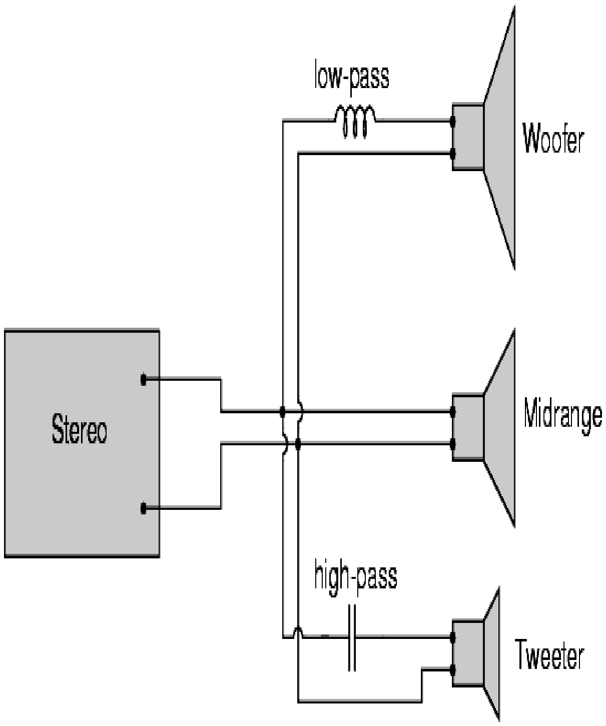
Format	Stand Mount
Bass/Mid Driver	165mm
Tweeter	25mm
Suitable Amplifier Power	20 - 100 w
Nominal Impedance	6 Ω
A/V Shielded	yes
Sensitivity (1W @ 1M)	86 dB
Nominal Frequency Range	40-24kHz
HF Limit (-10dB)	44kHz
Freq. Fb	42Hz
Crossover Frequency	1.8kHz
Dimensions (mm)(H * W * D)	364 * 223 * 301

Specification
(For reference Only)



Frequency response

Speakers



A Woofer is driver that reproduces a band of frequencies generally between 0–1 kHz

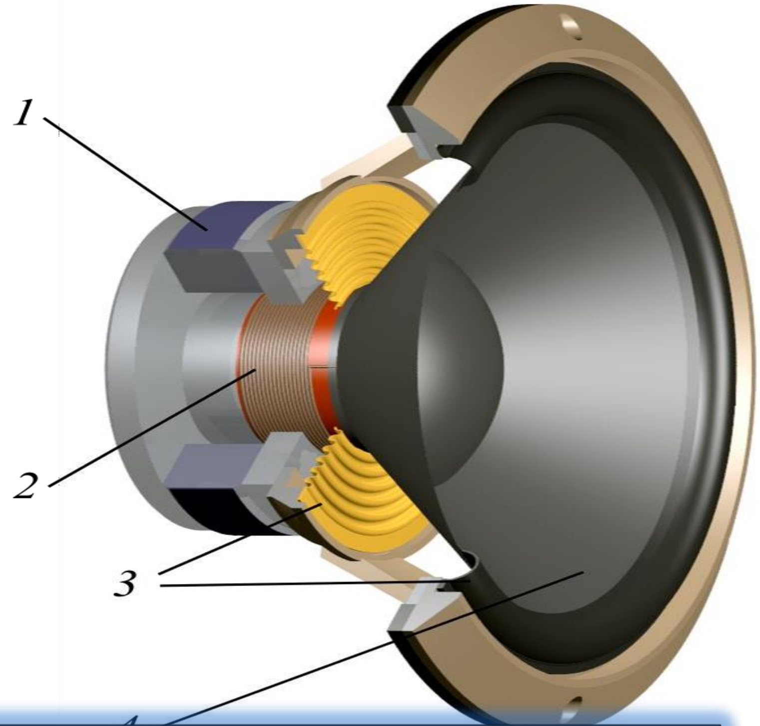
A mid-range speaker is driver that reproduces a band of frequencies generally between 2–6 kHz

A Tweeter is driver that reproduces a band of frequencies generally between 10–16 kHz

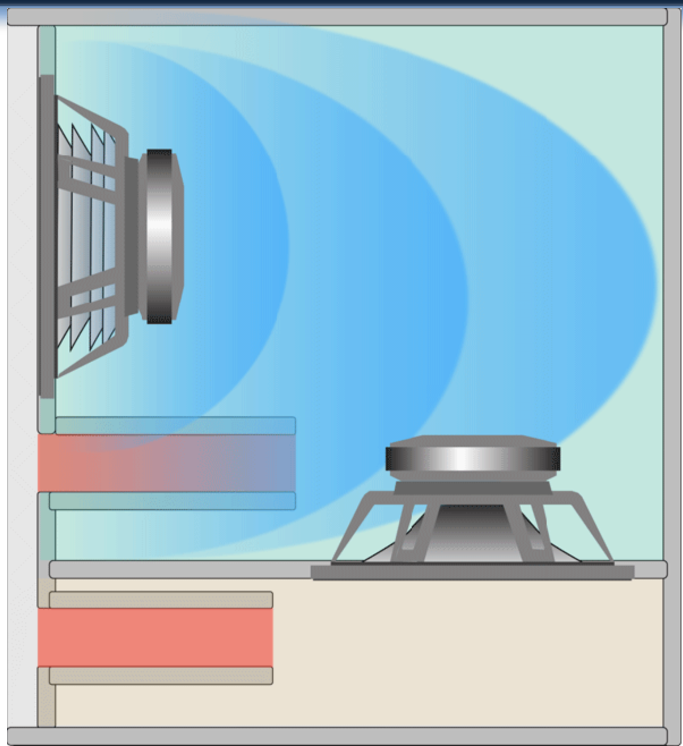
Woofer

A Woofer is driver that reproduces a band of frequencies generally between 0–1 kHz

A subwoofer is a woofer driver used only for the lowest-pitched part of the audio spectrum: typically below 200 Hz for consumer systems, below 100 Hz for professional live sound, and below 80 Hz in THX- approved systems

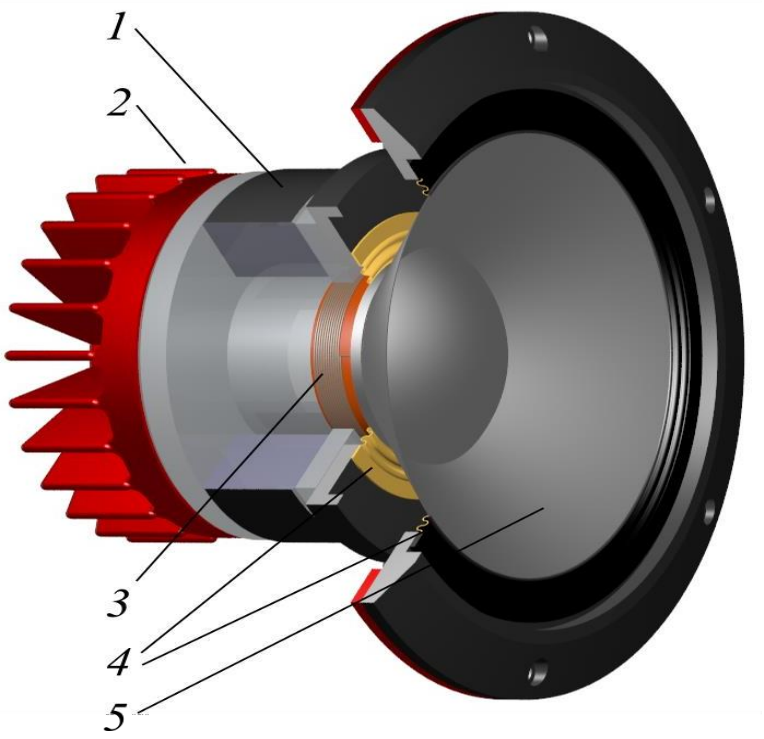


Woofer



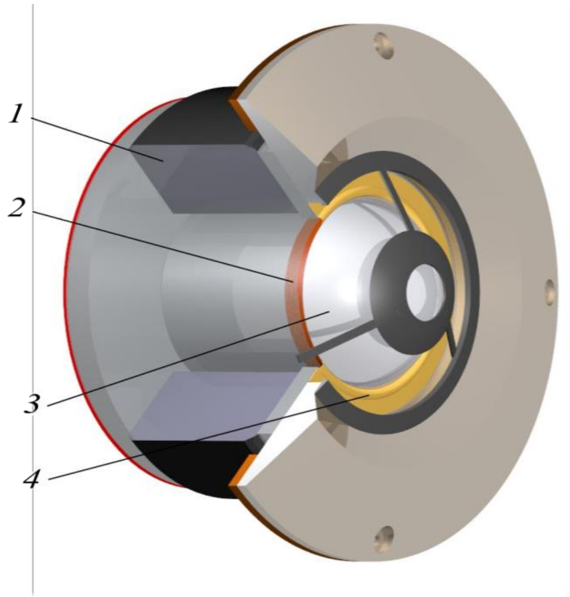
Mid-range

A mid-range speaker is driver that reproduces a band of frequencies generally between 2–6 kHz

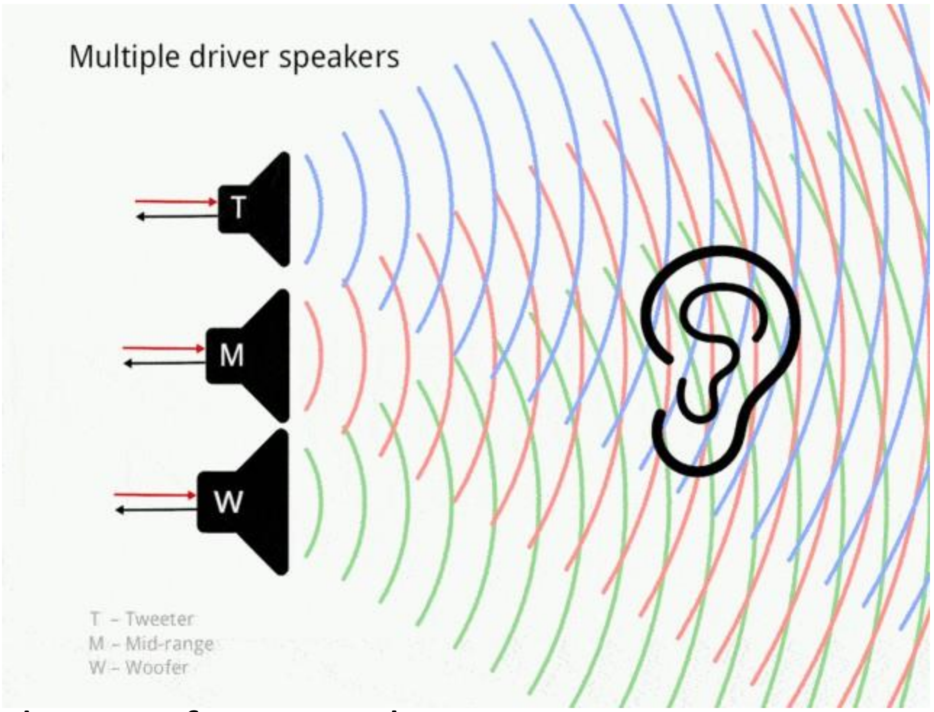


Tweeter

A Tweeter is driver that reproduces a band of frequencies generally between 10–16 kHz



Size of the voice coil is vary for all speakers with respect to output frequency



- Two mostly used loud speaker is
  - *Dynamic*
  - *Horn*
- The speaker system itself can be divided into 3 functional parts
  - *Electromagnetic*
  - *Mechanical*
  - *Acoustic*

Cont.

- The electromagnetic part consisting of the Voice coil and the field magnet. Audio frequency electric current in the coil causes mechanical motion of the cone or diaphragm on which it is mounted. This part is often referred to as the driver or motor of the system.
- The mechanical part, in which the driving coil is usually mounted and which is set into mechanical motion by the audio frequency electrical current in the driving coil.
- The acoustic part, which transmits the sound energy developed by the mechanical part of the area served by the system in the most efficient and faithful manner.

Note

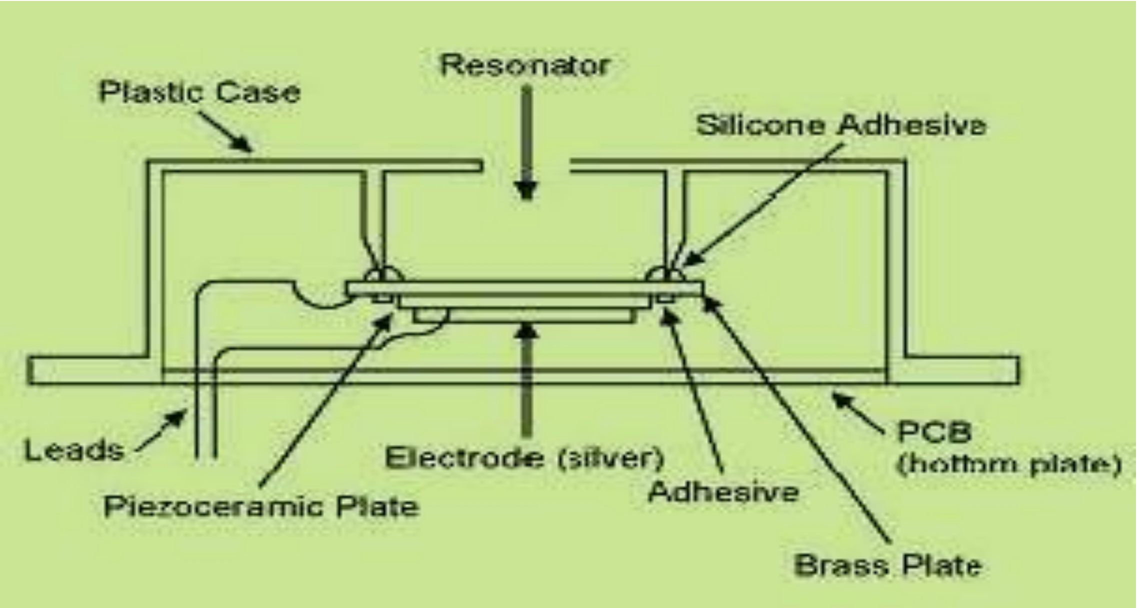
- A low value of impedance tells us that the air moves easily in response to an applied pressure (low pressure, high velocity), and a high value of impedance tells us that it is hard to move (high pressure, low velocity).
- Manufacturers of loudspeakers give us a nominal impedance of 4, 6, 8 ohms as this is the dominant characteristic.
- Most loudspeakers have a power response that drops 10dB to 20dB from low to high frequencies.

Crystal Loudspeakers

- Rochelle-salt crystals have the property of becoming physically distorted when a voltage is applied across two of their surfaces. This property is the basis of the crystal type speaker, illustrated in Fig.

- The crystal is clamped between two electrodes across which the audio frequency output voltage is applied. The crystal is also mechanically connected to a diaphragm.

- The deformations of the crystal caused by the audio signal across the electrodes cause the diaphragm to vibrate and thus to produce sound output.



Piezoelectric Speakers

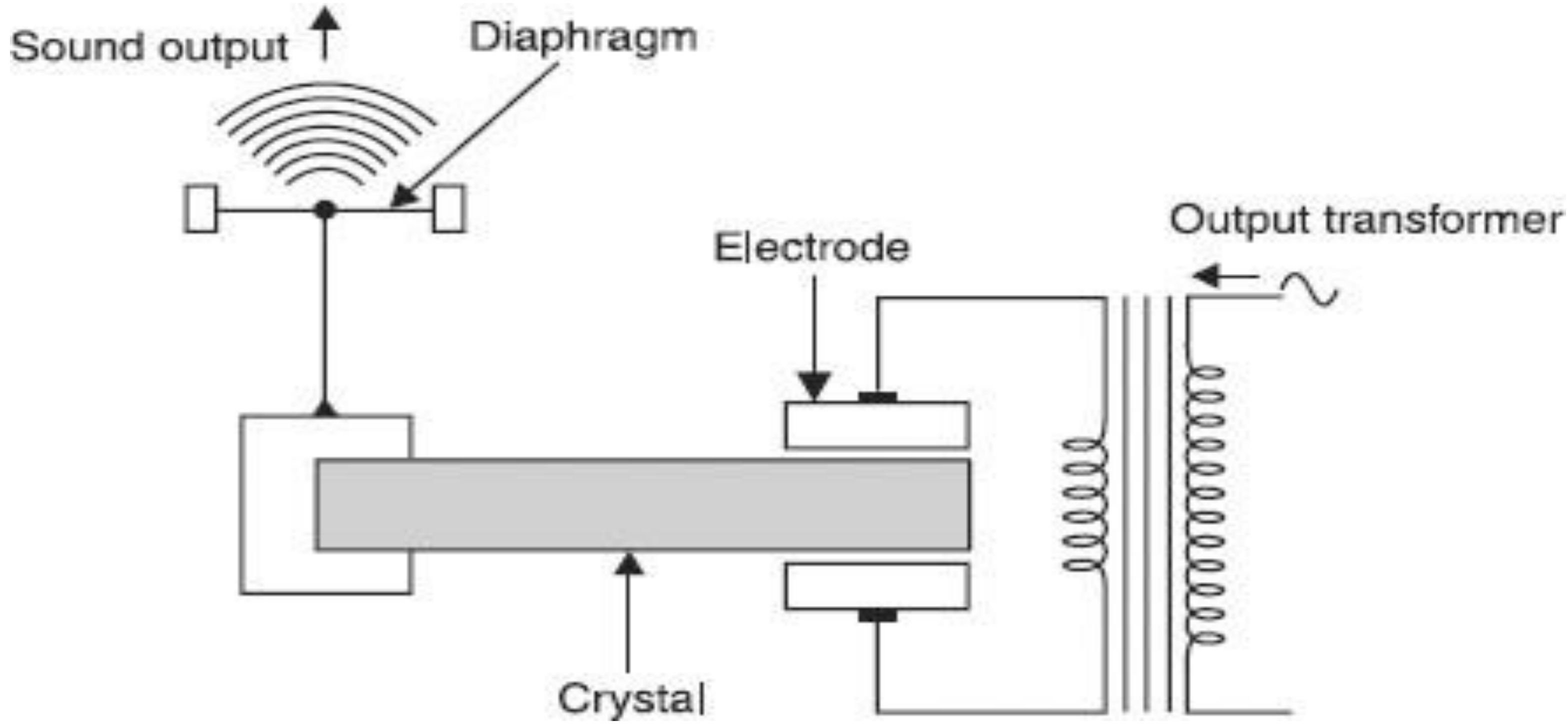
Cont.

- 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.
- Piezoelectric speakers have several advantages over conventional loudspeakers: they are resistant to overloads that would normally destroy most high frequency drivers, and they can be used without a crossover due to their electrical properties.
- There are also disadvantages: some amplifiers can oscillate when driving capacitive loads like most piezoelectrics, which results in distortion or damage to the amplifier.
- This is why they are generally used in single frequency (beeper) or non-critical applications.

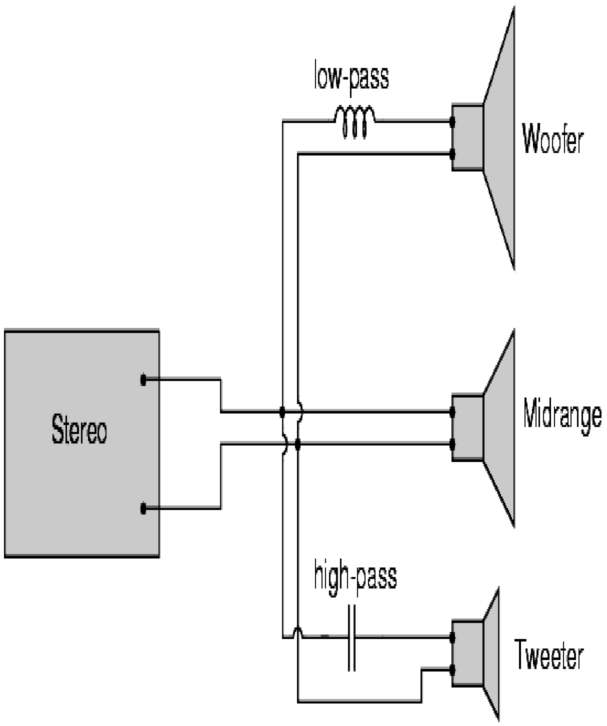
Piezoelectric Speakers

The white ceramic piezoelectric material can be seen fixed to a metal diaphragm

Schematic view for a crystal speaker



Mid-Range



A mid-range speaker is driver that reproduces a band of frequencies generally between 2–6 kHz

Permanent magnet Loud speaker

(Moving Coil)

Permanent magnet Loud speaker
(Moving Coil)

- Function
- Working
- Advantages
- Disadvantages
- Applications

Permanent magnet Loud speaker

(Moving Coil)

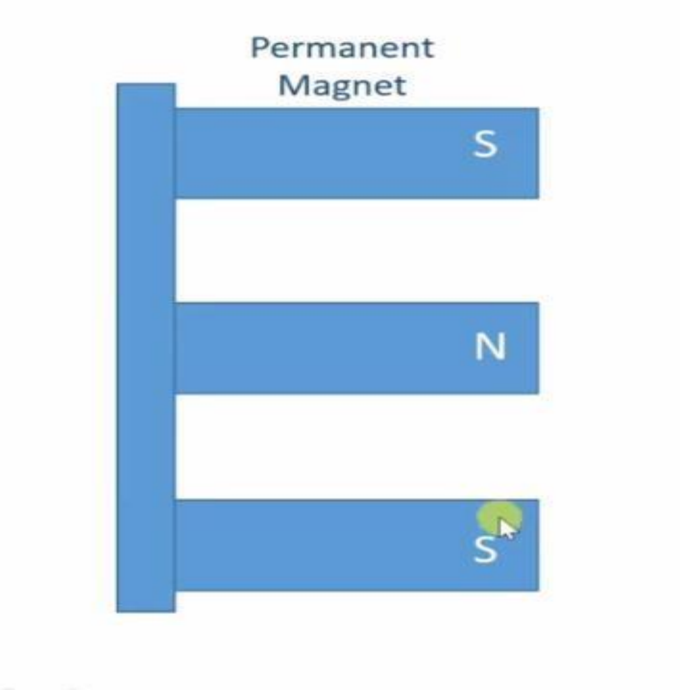
Function

- *The most popular type* of loudspeaker today is the permanent magnet.
- Working is based on interaction between Magnetic and Electric field.
- A coil is placed in a uniform magnetic field and we pass audio signal through the coil and that current through the coil will result in mechanical force.
- Generated force is directly proportional to audio current, hence it to it produces vibrational motion in coil, and that is what resulting into generation of sound.

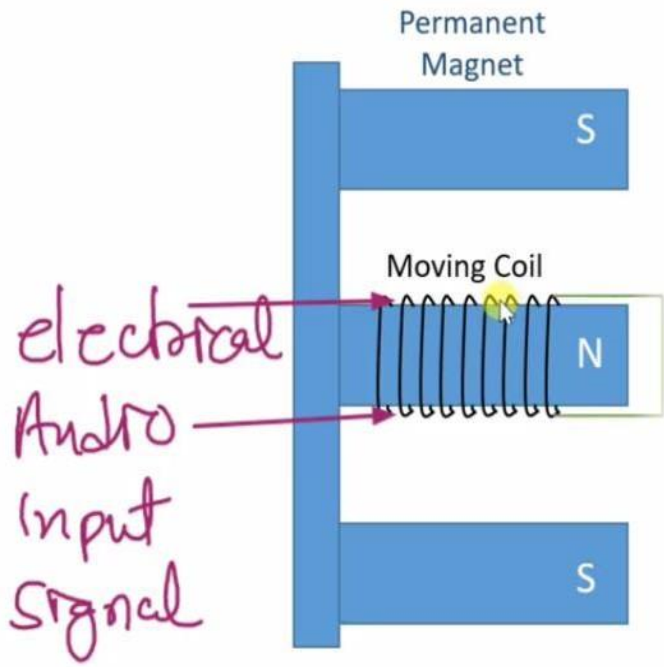
Working

- Because of its comparative simplicity of construction and design, the precision that may be built into it, and ease with which it is interfaced with other equipment.
- An electromagnet called a voice coil attaches to the center of the cone. A permanent magnet - a magnet that keeps its magnetic field without electricity - sits behind the voice coil on the other side of the cone.
- This means that a speaker uses two different types of magnets, which is what gives speakers the power to push and pull against the atmosphere rapidly.

- The PM speaker contains a very light coil of wire affixed to the diaphragm and located concentrically around or within the permanent magnet.
- In operation, a steady current flows through the field coil, magnetizing the field as shown in the next figure.
- The coil and the driver's magnetic system interact, generating a mechanical force that causes the coil (attached with cone) to move back and forth, accelerating and reproducing sound under the control of the applied electrical signal coming from the amplifier.

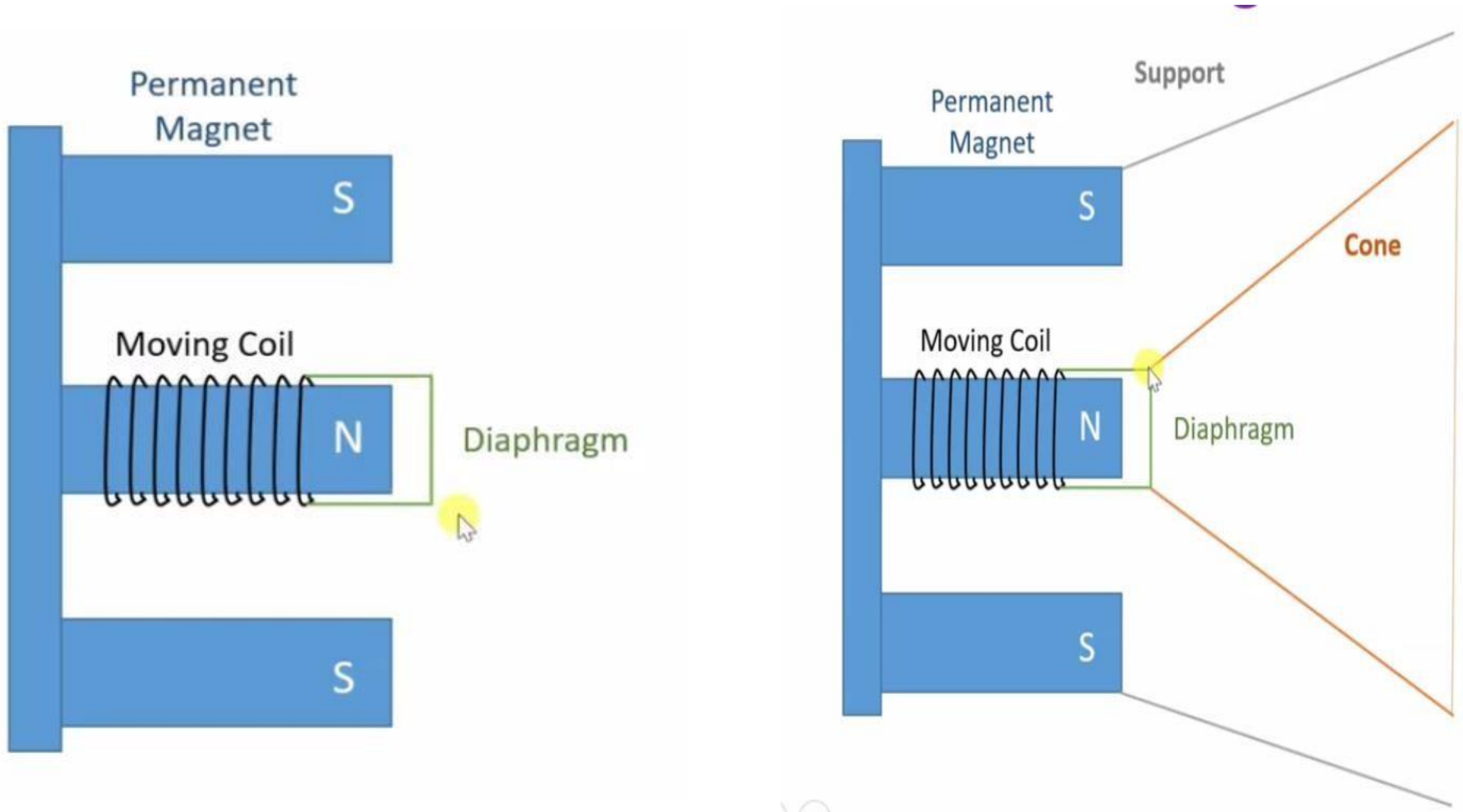


Magnets have two poles

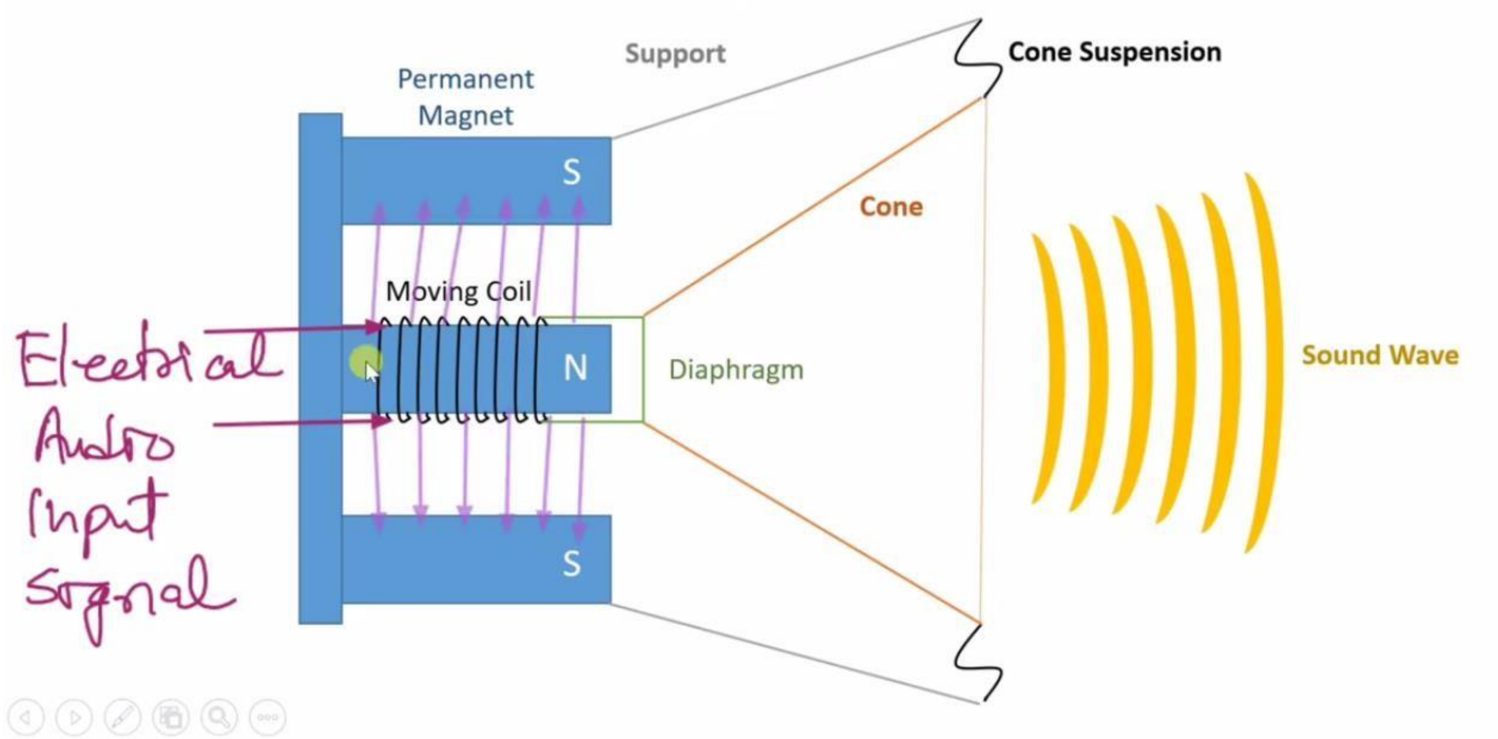


electromagnet's poles can switch

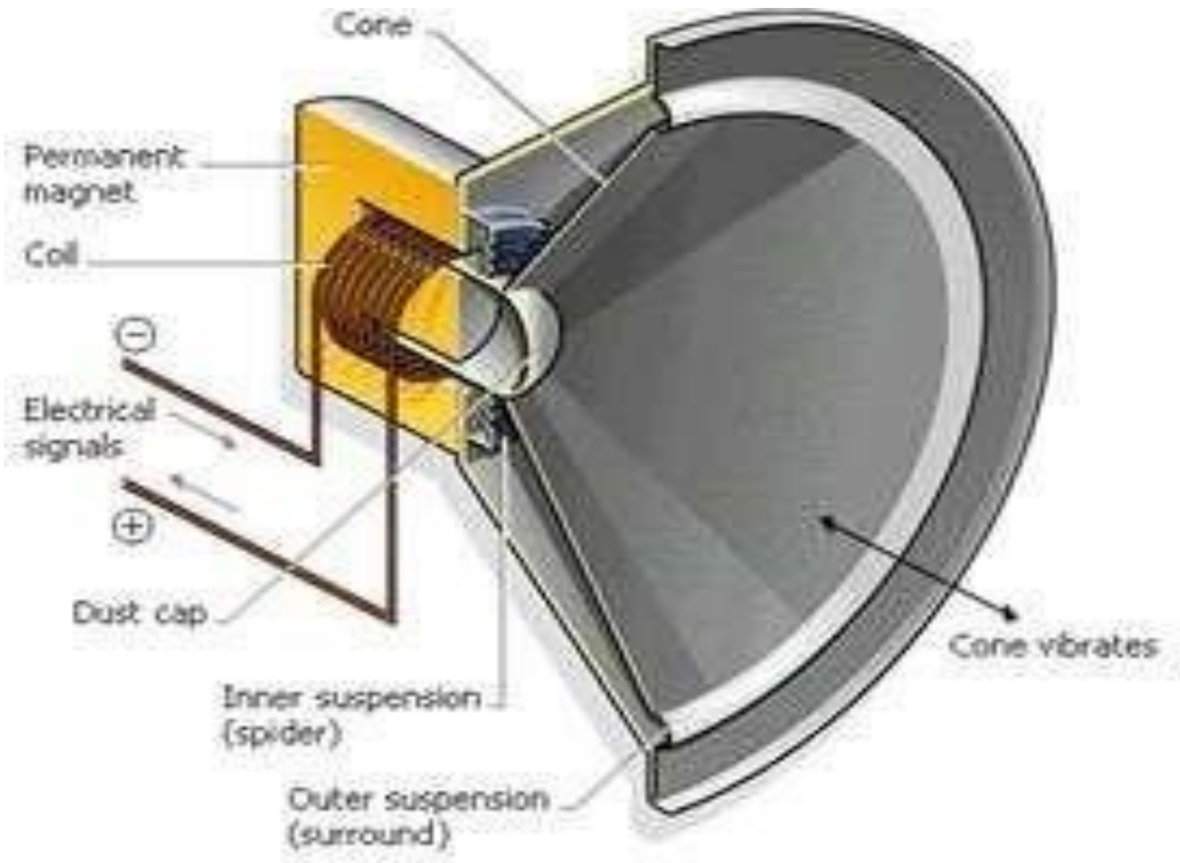
- When current flows in one direction through the voice coil, it creates a magnetic field which reacts with the field in the gap and makes the cone move slightly to the right. When the audio signal current reverses direction, it makes the cone move to the left.
- The audio signal is always an alternating current, so as the current fluctuates in response to the power amplifier's output signal, the speaker cone faithfully reproduces the variations of the audio signal as mechanical motion, and the large surface area of the cone effectively generates a sound wave which is replica of audio signal.



- The arrangement is such that the voice coil lies in the gap between the north and south magnet poles.
- The coil (voice coil) is free to move in the field of the magnet. Electrical impulses, varying at an audio rate, are applied to the *voice coil* by the amplifier.
- Because these impulses are constantly changing in amplitude and direction, a changing magnetic field is set up in the voice coil. This field *reacts* with the constant field of the permanent magnet.



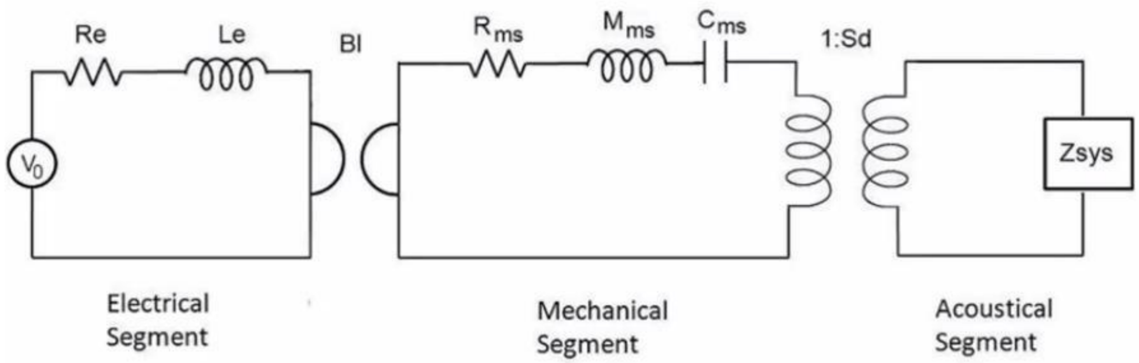
- Applying electrical signal in voice coil, change in current, change in force in coil,
- So the diaphragm get move front and back, then the sound will produce.



Force on moving coil

- Force on coil due to interaction of current and magnetic field is given by
- $F = BIL \times sin\theta$
  - F is force on coil
  - B is magnetic field
  - I is current through coil
  - L is length of coil
  - θ is angle between coil and field
  - Force is maximum for 90 degree angle
- Audio current flows through voice coil
- Force = B*I*L

- Two types of transformation
  - Electro mechanical
  - Mechanical acoustic



- Electro mechanical - electrical signal is fed in to coil, coil contains – (resistance and inductance)
- When Coil get energized, diaphragm gets motions produce acoustic signal
- In force to voltage analogy
  - Damping constant B = R
  - Mass M = L
  - Compliance K = 1/c

Characteristics

SNR	30dB
Frequency response	For woofer up to 40Hz Tweeter up to 10khz
Directivity	Omni Directional
Distortion	10%
Efficiency	Low
Impedance	2 to 32ohms
Power handling	Milli to 25W

Application

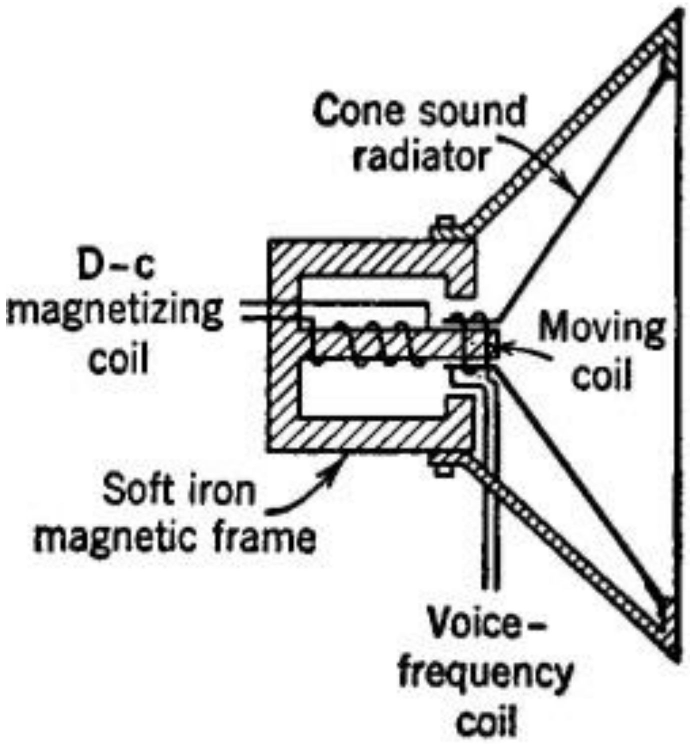
- You can find small permanent magnets in toys, handheld gadgets such as electric razors, and clasps for bracelets and watches.
- It is found in the smallest pocket radios and is a major component of the most elaborate theatre systems.
- Larger permanent magnets are useful in household appliance motors and in stereo speakers.
- The electric motors in hybrid vehicles use very strong permanent magnets.

Dynamic Loudspeaker

Dynamic Loudspeaker

- There are two varieties of dynamic loudspeakers : electrodynamics and permanent magnet (PM) speakers. Both work in exactly the same way, the difference is in their construction.
- The *electrodynamics* speaker has a *soft iron* magnetic circuit, non-retentive of magnetism, around whose centre leg, a large, multilayer field coil is wound, as shown in Fig. 4.7.
- When dc flows through this field coil, it magnetizes the iron core. *A magnetic flux field directly proportional to the strength of the current through the coil is thus set up across the air gap. The iron core is not permanently magnetized, it stays magnetized only as long as current flows through the field coil.*

The *dynamic loudspeaker* has found acceptance in all kinds of reproducing systems.



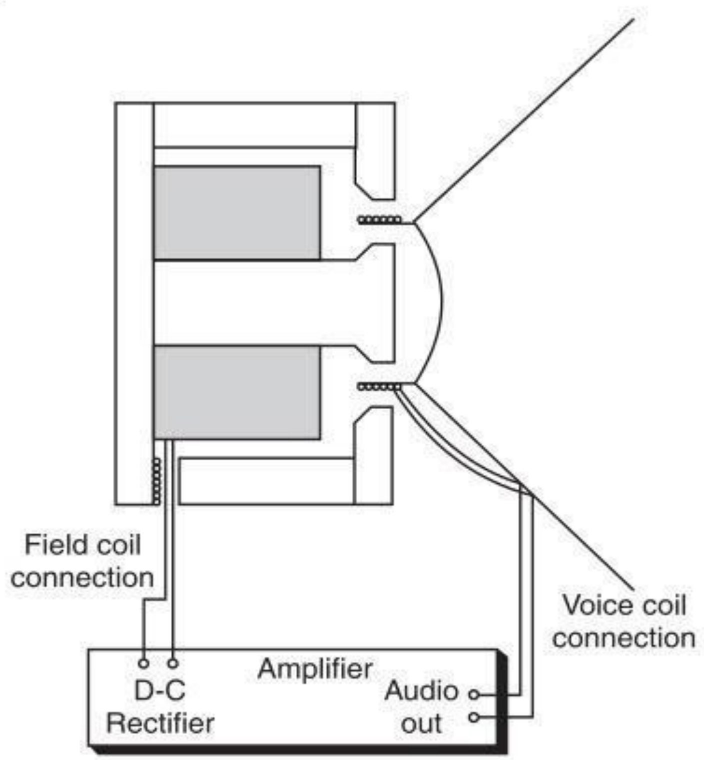
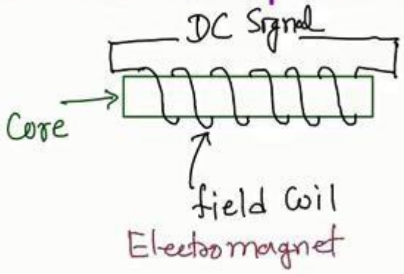


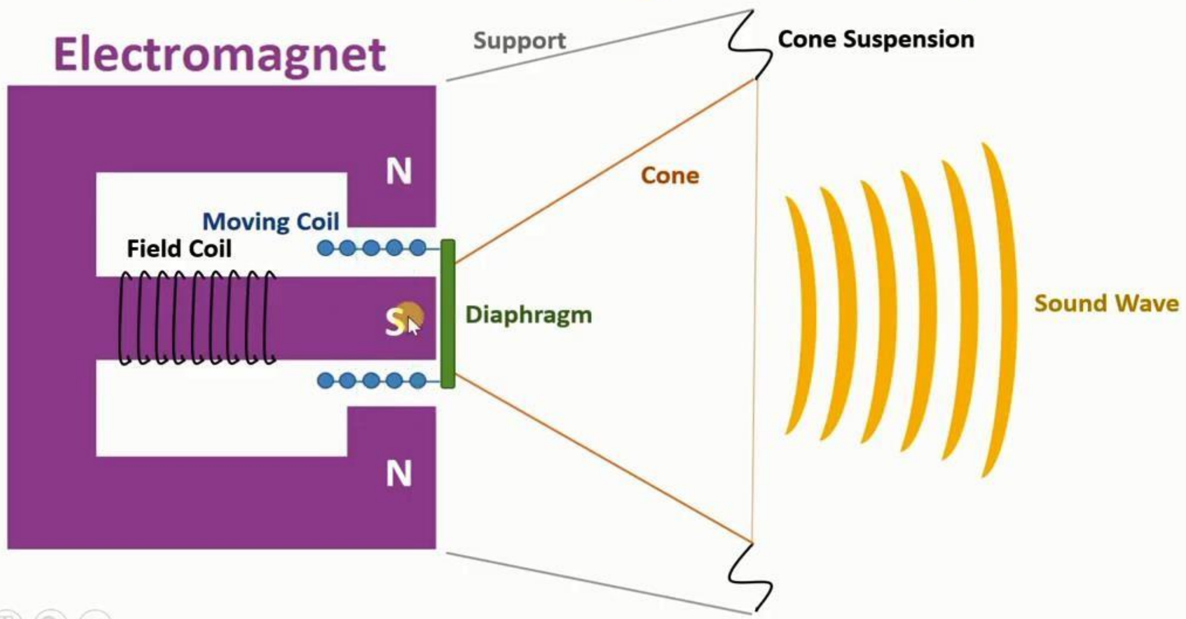
Fig 4.7 *Electrodynamic speaker*

Basics

- To provide very strong magnetic field for high wattage speakers, Electro magnet is used instead of permanent magnet.
- Working principle is same as permanent magnet type loudspeaker.
- Loudspeakers of more 25Watt and up to a few hundred watt are of electrodynamic type.
- The strong and steady magnetic field is produced by a large field coil wrapped around a core. The shape of the magnet is pot type with south pole in the center and north pole in the periphery.



Structure of Electromagnet Loudspeaker



Working

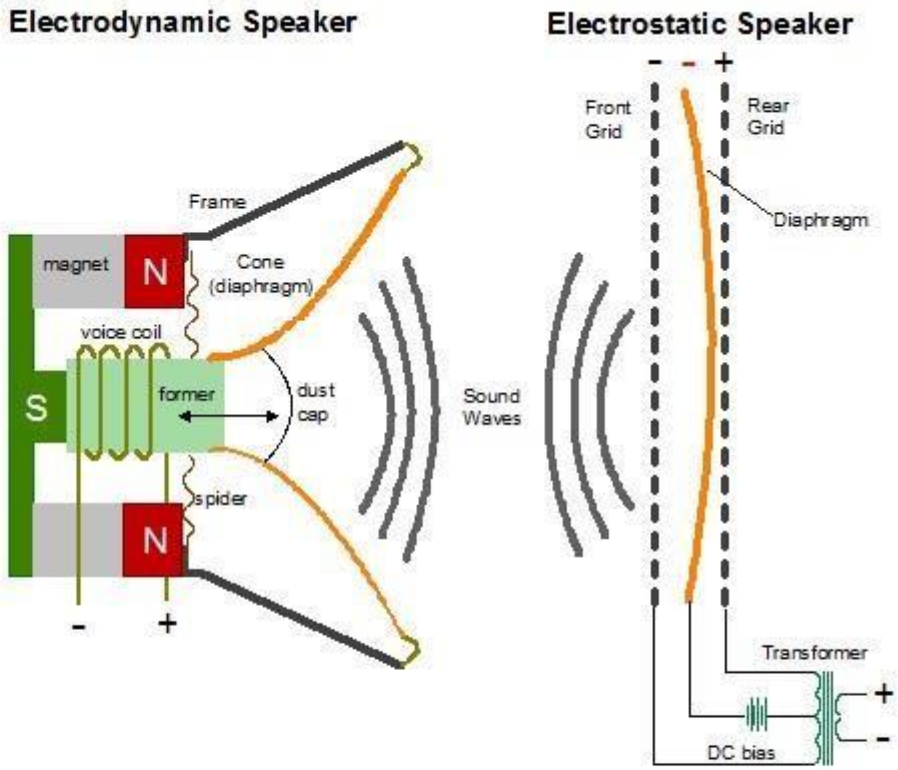
- The special shape of the core allows magnetic flux to remain concentrated in the annular gap between pole pieces.
- The voice coil is placed in annular gap. The audio signal is given to voice coil.
- This signal causes a varying magnetic force. Which gives vibrations to coil assembly.
- Coil is connect with diaphragm which generates voice of same frequency sound.

Advantages

- Higher power can be obtained
- Frequency response is better

Disadvantages

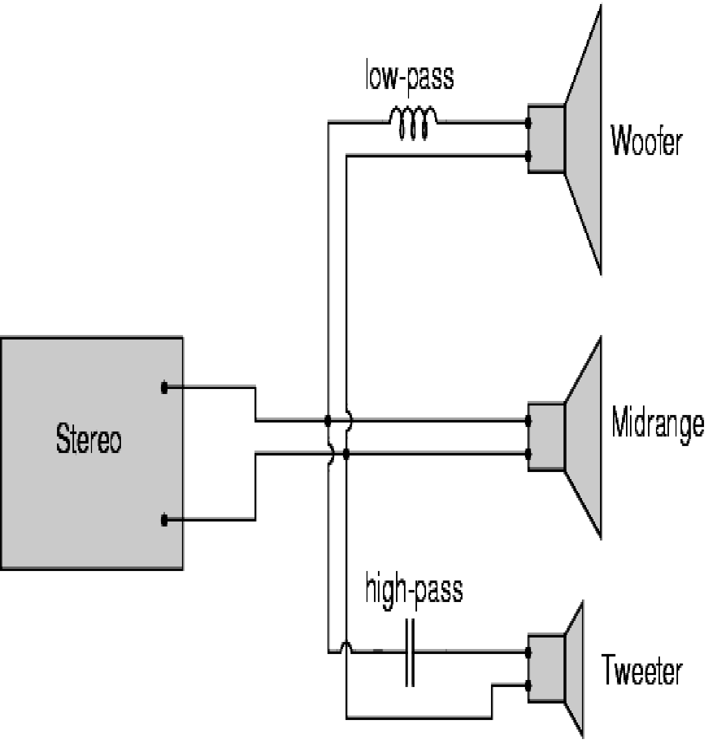
- External power supply is need for field coil
- Heavy in weight
- Costlier



Dynamic and Electrostatic Speakers

There is a huge difference between dynamic and elect rostatic speakers. For more information, see electrostat ic speaker.

Woofer



A Woofer is driver that reproduces a band of frequencies generally between 0–1 kHz

- A woofer is a driver that reproduces low frequencies. The driver works with the characteristics of the enclosure to produce suitable low frequencies.
- Some loudspeaker systems use a woofer for the lowest frequencies, sometimes well enough that a subwoofer is not needed.
- Additionally, some loudspeakers use the woofer to handle middle frequencies, eliminating the mid-range driver.
- *This can be accomplished with the selection of a tweeter that can work low enough that, combined with a woofer that responds high enough, the two drivers add coherently in the middle frequencies.*

Cont.

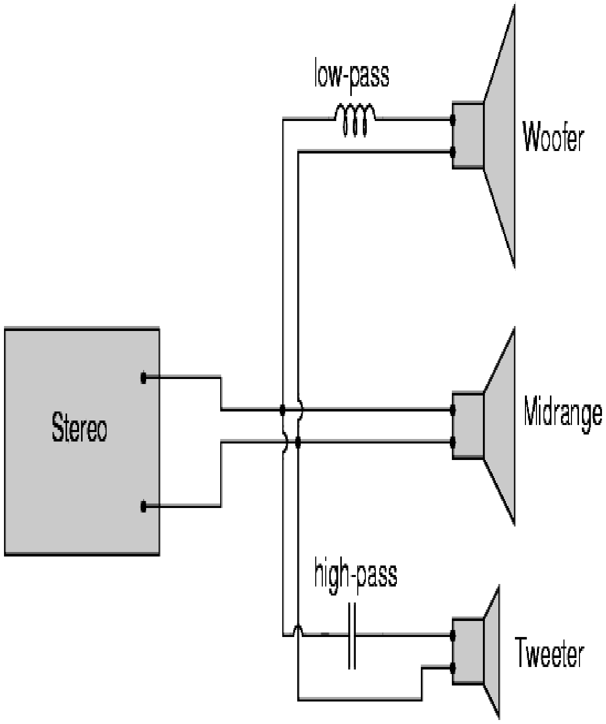
- Woofer is the term commonly used for a loudspeaker driver designed to produce low frequency sounds, typically from around 40 Hz up to about a KHz or higher.

- There are two types of low frequency speaker, the commonly known woofer, and the more recent addition the subwoofer.

- The latter is used for the reproduction of frequencies below those produced by the woofer and it is generally purchased as an add-on to an existing system.

- The low frequencies speaker provides the bass of any hi-fi system. The prime requisite for low frequency reproduction is a large *diaphragm* the larger the better.
- In addition to large size, the diaphragm must *be of fairly heavy construction* Light diaphragms just can't hold up under the vibrations encountered under the lower audio ranges.
- A woofer must be able to vibrate back and forth very easily *i.e* have *high compliance*. One way to accomplish this is to have the diaphragm loosely connected to the frame. The gasket that holds the edge of diaphragm to the frame basket is fastened, so that it barely keeps the diaphragm from slipping loose.
- Rather than the loose suspension system, the cone is supported by a very flexible material, so that it can be moved very easily by the voice coil. *The suspension is tight cabin the sine wave at the diaphragm edge is made very flexible.*
- A woofer must also have a *large voice coil* to handle considerable heat. The larger the voice coil, the more the current *produced* by the amplifier output circuit and, therefore, the more the power the woofer can handle.
- Finally, a *strong magnet* can be *of* great help to move the heavy voice coil and cone assembly too well. The better the woofer, the heavier the magnet assembly (unless it's ceramic).

Tweeter



A Tweeter is driver that reproduces a band of frequencies generally between 10–16 kHz

Tweeters

- A **tweeter** is a loudspeaker designed to produce high audio frequencies, typically from around 2,000 Hz to 20,000 Hz.
- Some tweeters can manage response up to 65 kHz.
- Nearly all tweeters are electro-dynamic drivers, using a voice coil suspended within a fixed magnetic field.
- There are two main types of high frequency speakers; the well-known *tweeter* and the more recent *super tweeter.*

Six basic high-frequency tweeters

i. The *cone* is a physically disincentive version of the woofer.

ii. The *dome*, so called because of its dome-shaped diaphragm.

iii. The *horn*, so named because it is a horn.

iv. The *Heil air-motion transformer* which uses the principle of lever in its operation, named after its inventor, Dr. Oskar Heil.

v. *High polymer molecular-film* tweeter, uses the piezoelectric effect for its principle of operation (used exclusively by Pioneer).

vi. The *electrostatic* tweeter works on the principle of attraction or repulsion between two metal plates.

Types

- **Types of tweeters**
  - Cone tweeter
  - Dome tweeters
  - Horn tweeters

- Cone tweeters have the same basic design and form as a woofer with optimizations to operate at higher frequencies. The optimizations usually are:

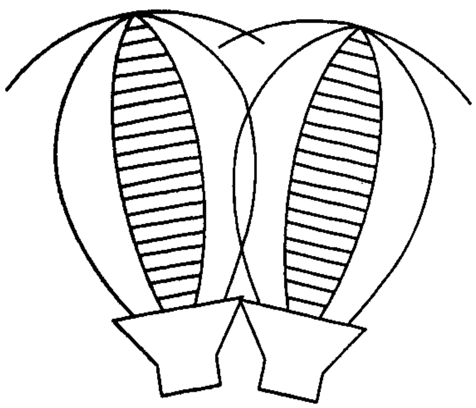
- A very small and light cone so it can move rapidly;

- Cone materials chosen for stiffness (e.g., ceramic cones in one manufacturer's line), or good damping properties (e.g., silk or coated fabric) or both.

- The suspension (or spider) is stiffer than for other drivers—less flexibility is needed for high frequency reproduction;

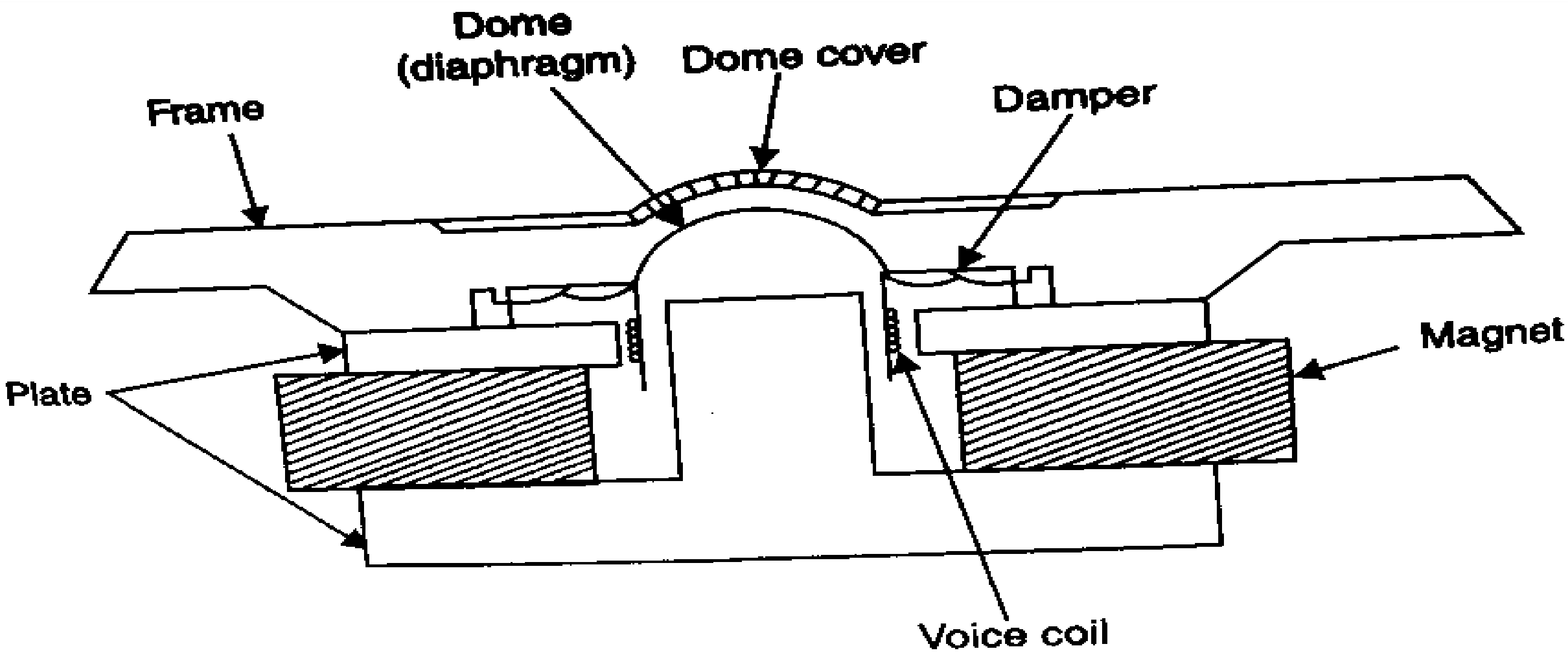
- Small voice coils (3/4 inch is typical) and light (thin) wire, which also helps the tweeter cone move rapidly.

- Cone tweeters are relatively cheap, but do not have the dispersion characteristics of domes. Thus they are routinely seen in low cost applications such as factory car speakers, shelf stereo systems, and boom boxes. Cone tweeters can also be found in older stereo hi-fi system speakers designed and manufactured before the advent of the dome tweeter. They are now a rare sight in modern hi-fi usage.



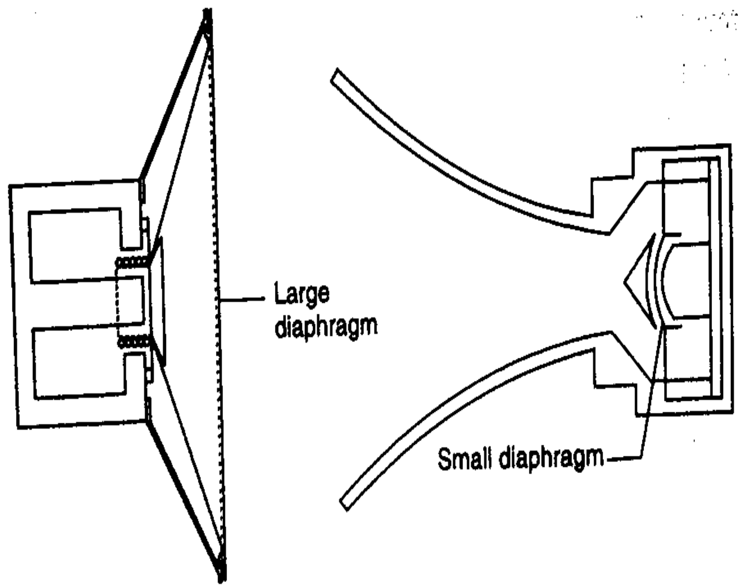
Dome tweeters

- A dome tweeter is constructed by attaching a voice coil to a dome, which is attached to the magnet or the top plate via a low compliance suspension. These tweeters typically do not have a frame or basket, but a simple front plate attached to the magnet assembly.
- Dome tweeters are categorized by their voice coil diameter. The majority of dome tweeters presently used in hi-fi speakers are 25 mm (1 in) in diameter. A variation is the ring radiator in which the 'suspension' of the cone or dome becomes the major radiating element. These tweeters have different directivity characteristics when compared to standard dome tweeters.



Horn tweeters

- A horn tweeter is any of the above tweeters coupled to a flared or horn structure. Horns are used for two purposes — to control dispersion, and to couple the tweeter diaphragm to the air for higher efficiency.
- The tweeter in either case is usually termed a compression driver and is quite different from more common types of tweeters (see above). Properly used, a horn improves the off-axis response of the tweeter by controlling (i.e., reducing) the directivity of the tweeter. It can also improve the efficiency of the tweeter by coupling the relatively high acoustic impedance of the driver to the lower impedance of the air.
- The larger the horn, the lower the frequencies at which it can work, since large horns provide coupling to the air at lower frequencies. There are different types of horns, including radial and constant directivity (CD). Horn tweeters may have a somewhat 'different' sonic signature than simple dome tweeters.
- Poorly designed horns, or improperly crossed-over horns, have predictable problems in the accuracy of their output, and the load that they present to the amplifier. Perhaps concerned about the image of poorly designed horns, some manufacturers use horn loaded tweeters, but avoid using the term. Their euphemisms include "elliptical aperture" "Semi-horn" and "Directivity controlled". These are, nonetheless, a form of horn loading.



Microphones

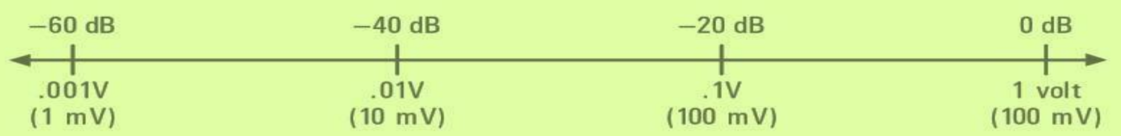
History

Component	Inventor	Year	Application
Microphone	first microphone was invented by Alexander Graham Bell	1876	It was a liquid device and that was not very practical.
	Thomas Alva Edison invented the first practical carbon microphone.	1886	The carbon microphone was used for radio transmissions and extensively in telephone transmitters until the 1970s when they were replaced by piezoelectric ceramic elements.

Microphones Characteristics

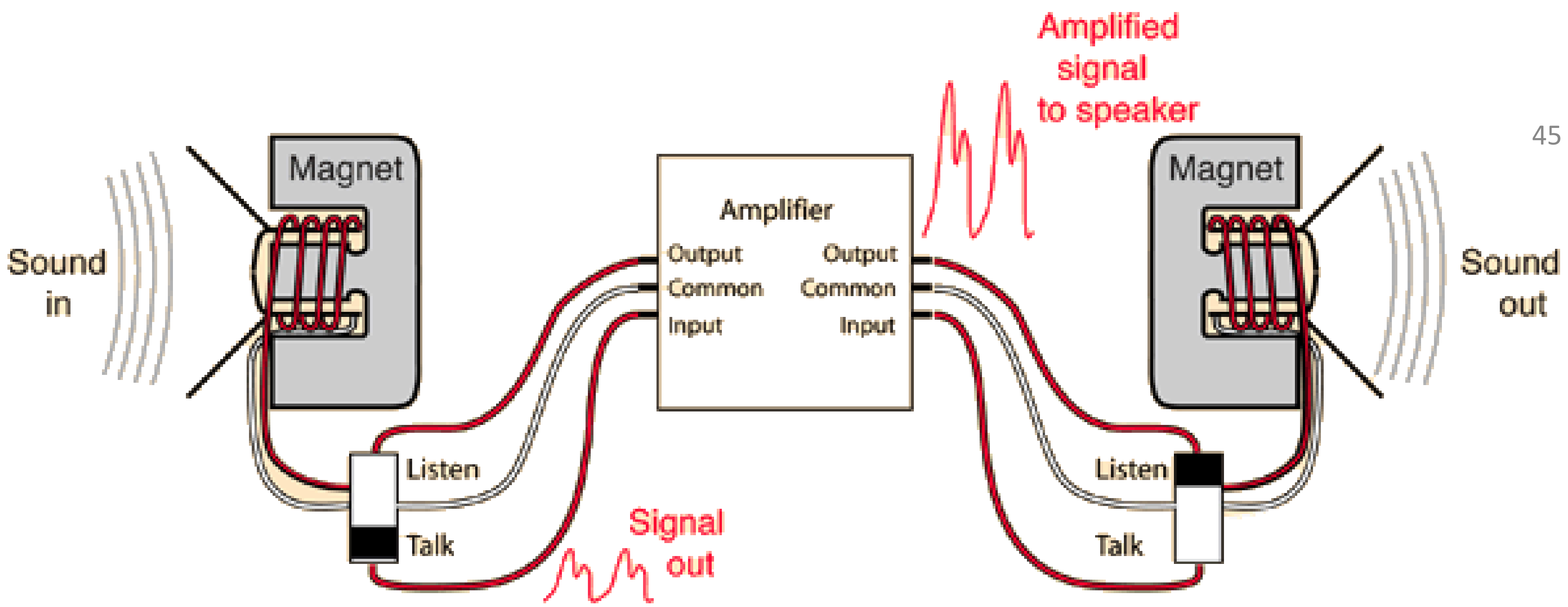
- In order to provide some background for these techniques it is useful first to understand some of the important characteristics of the microphones.
- For live sound applications are their operating principle, frequency response and directionality.
- Impedance
  - Generally, microphones can be divided into low (50–1,000 ohms), medium (5,000–15,000 ohms) and high (20,000+ ohms) impedance
- Sensitivity
  - Typically, the microphone output (in a sound field of specified intensity) is stated in dB (decibels) as reference level.

Figure 15: "dB re 1V"



Microphones

- Microphones are a type of *transducer* - a device which converts acoustical energy (sound waves) into electrical energy (the audio signal). Different types of microphone have different ways of converting energy but they all share one thing in common.
- *Diaphragm*. This is a thin piece of material (such as paper, plastic or aluminium) which vibrates when it is struck by sound waves. In a typical hand-held mic, the diaphragm is located in the head of the microphone. When the diaphragm vibrates, it causes other components to vibrate. These vibrations are converted into an electrical current which becomes the audio signal.



In a simple intercom, the same device can be used as a dynamic microphone and a dynamic loudspeaker.

Microphones

- It is a transducer, which converts sound pressure into electrical signal with same phase, same frequency and same amplitude proportion.
- Quality of microphone is defined by following characteristics
  - Sensitivity
  - SNR
  - Frequency response
  - Distortion
  - Directivity
  - Output Impedance

Sensitivity

- It explains, how much week sound signal is detected by microphone.
- It is defined as output of microphone (in terms of mV) for the sound pressure (in terms of 0.1 Pa) at 1000 Hz.
- As the normal speech sound has pressure of 0.1 Pa, sensitivity based on this criteria is more appropriate.
- however, some manufacturer quotes sensitivity in terms of dBm.

SNR

- Some noise is generated in microphone due to resistance of circuit and built in transformer.
- It is represented in terms of Sound Pressure Level (SPL)
- Instead of quoting noise alone, manufacturer quotes Signal to Noise ratio (SNR)
- It is ratio of dB of output (with SPL of 0.1Pa) to the output in absence of sound.

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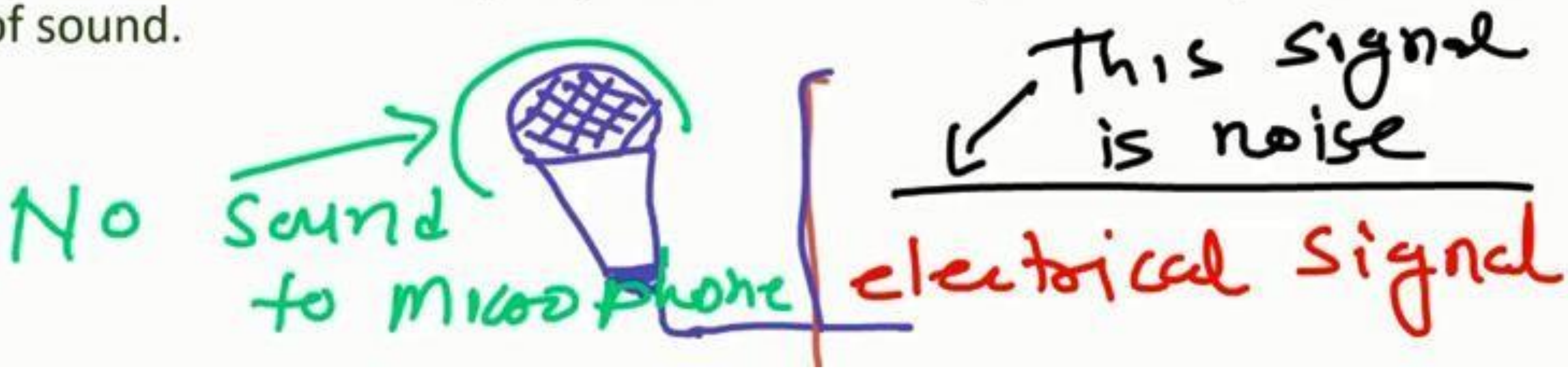
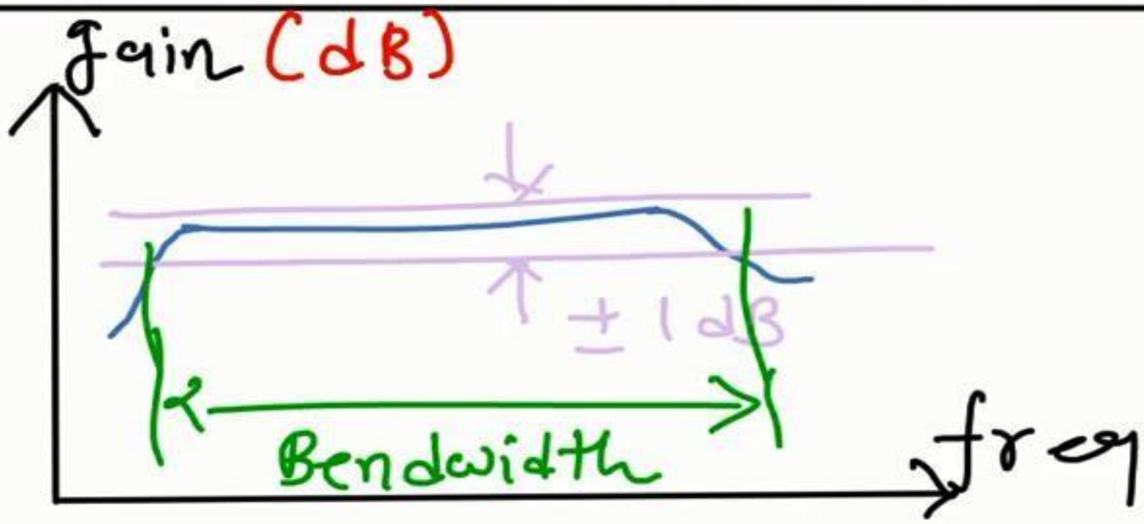


Frequency Response

Frequency Response

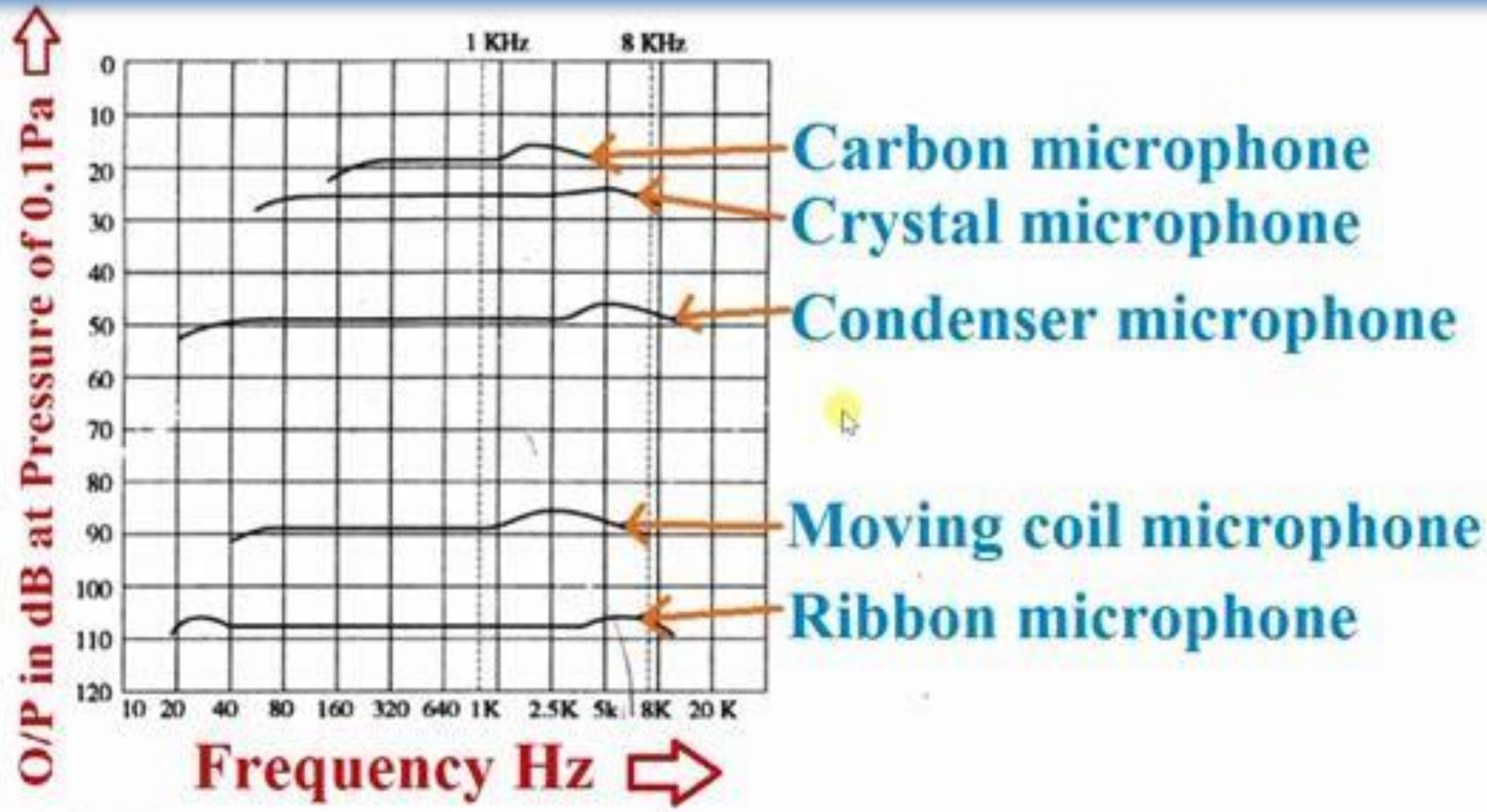
- The BW of audio frequency in the output of microphone within ±1 dB of the output. Although complete audible frequency range is 20 Hz to 20 kHz.



Frequency Response

- The BW of audio frequency in the output of microphone within ±1 dB of the output. Although complete audible frequency range is 20 Hz to 20 kHz.
- Microphone which gives flat response within ±1 dB for frequency 40Hz to 15000 Hz is considered good for hi-fi Audio systems.
- Lower BW of 80Hz to 8000Hz is acceptable for normal microphone.
- Mass of vibrating system is equivalent to Inductance and Capacitance in electrical system. This mass causes attenuation at high frequencies and compliance at low frequencies.

Frequency Response



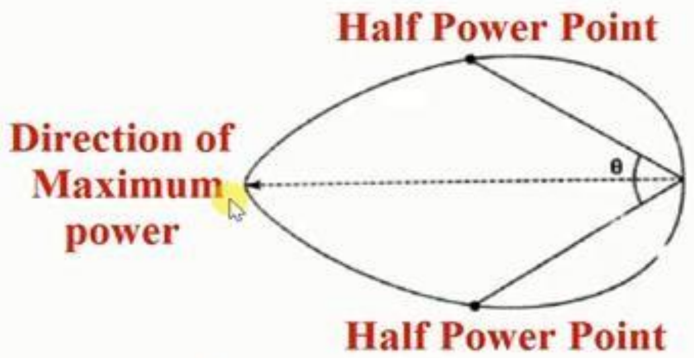
Distortion

- There are basically two types of distortion
  - Non linear distortion
  - Phase distortion
- Non linear distortion :
- It is created by distorted harmonics in amplitude.
- For quality microphone, It should be less than 5%.
- For hi fi microphone, it should be less than 1%.
- Phase distortion :
- It happens when multiple microphone are used with different path of source of sound.

Directivity

Directivity

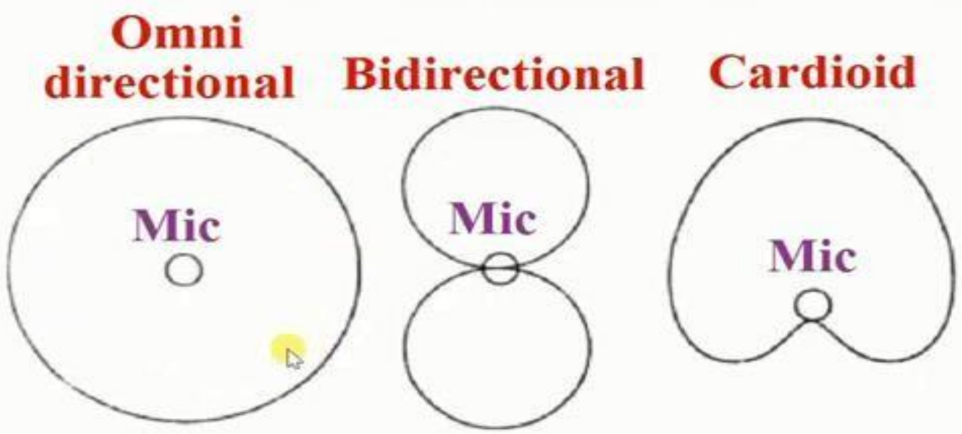
- ❖ It shows directional characteristics of sound reception by microphone.



- ❖ Mathematically, $D = \frac{E}{E_0}$
- ❖ Where, E = Actual maximum output of microphone
- ❖ E_0 = Output of omnidirectional microphone.

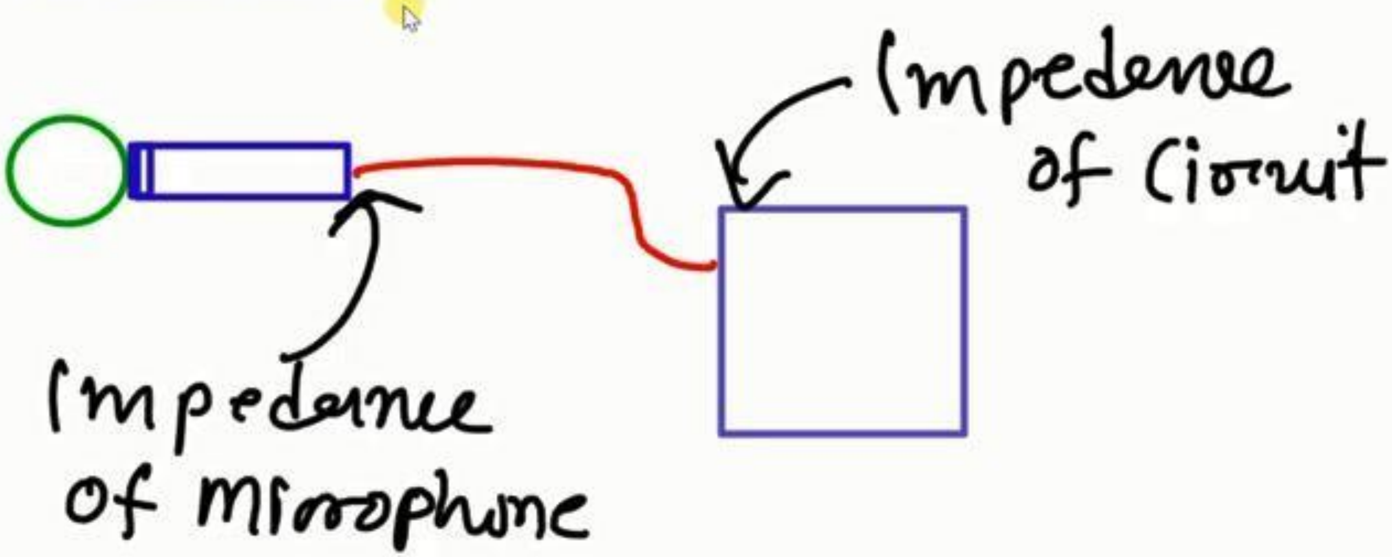
Directivity

- ❖ Omni – directional microphone (Pressure microphone)
- ❖ Bidirectional microphone (Ribbon microphone)
- ❖ Cardioid microphone (series combination of pressure and ribbon)



Output Impedance

❖ It is used to determine which type of matching transformer would be needed to transfer the power efficiently from μP to the transmission line and then to the amplifier.



Crystal Microphone

Outline

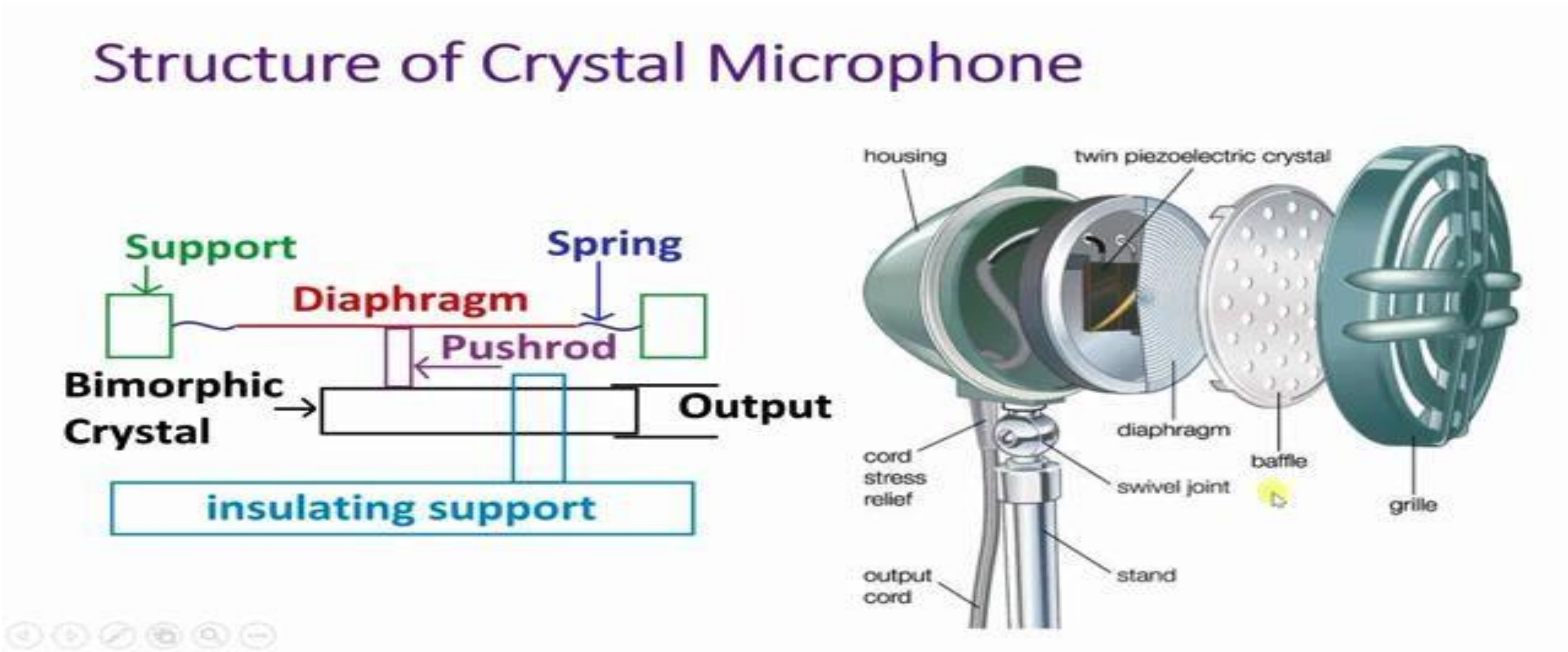
- Basics of Crystal Microphone
- Structure of Crystal Microphone
- Elements of Crystal Microphone
- Working of Crystal Microphone
- Characteristics of Crystal Microphone
- Features of Crystal Microphone
- Applications of Crystal Microphone

Basic

- based on the principle of 'Piezo Electric Effect'
- 'Difference of potential between the opposite faces of some crystals is produced when these are subjected to mechanical pressure.'
- crystals : Quartz, Tourmaline, Rochelle salt and ceramic.
- Rochelle Salt : high piezo electric effect but is susceptible to moisture – cannot withstand with high temperature of 50° C
- Quartz and Tourmaline : low piezo electric effect
- Ceramic : most suitable for crystal microphones as it is not susceptible to moisture and can withstand high temp up to 100° C

Crystal Microphone

- Crystals which demonstrate the piezoelectric effect produce voltages when they are deformed. The crystal microphone uses a thin strip of piezoelectric material attached to a diaphragm.
- The two sides of the crystal acquire opposite charges when the crystal is deflected by the diaphragm. The charges are proportional to the amount of deformation and disappear when the stress on the crystal disappears.
- Later microphones used ceramic materials such as barium titanate and lead zirconate.
- The electric output of crystal microphones is comparatively large, but the frequency response is not comparable to good as dynamic microphone, so they are not serious contenders for the music market.



Elements

- Crystal is cut along certain planes to form a slice
- Metallic foil electrodes are attached to two surface to carry the potential difference to the output terminals
- Two thin crystal slices suitably cut are placed in an insulating holder with an air space between them. Large number of such elements are combined to increase emf
- Diaphragm : made of Aluminum, is attached to the crystal surface through a push road
- The whole unit is enclosed in a protective case.

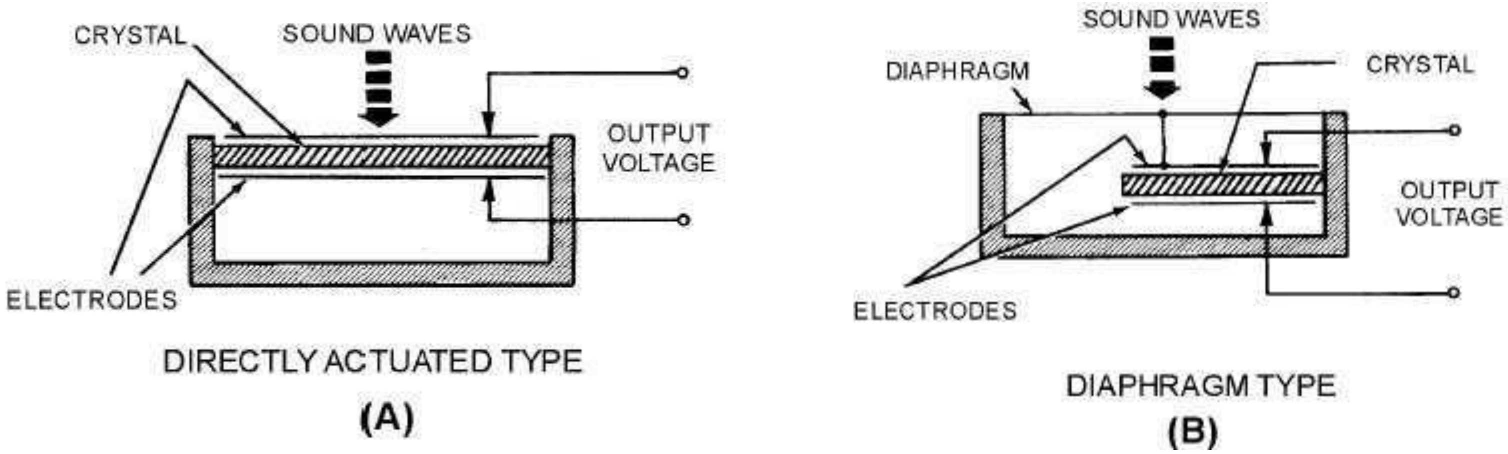
Working

- This means that when mechanical stress is placed upon the material, a voltage electromagnetic force (EMF) is generated.
- Since Rochelle salt has the largest voltage output for a given mechanical stress, it is the most commonly used crystal in microphones.
- View (A) of figure is a crystal microphone in which the crystal is mounted so that the sound waves strike it directly.
- View (B) has a diaphragm that is mechanically linked to the crystal so that the sound waves are indirectly coupled to the crystal

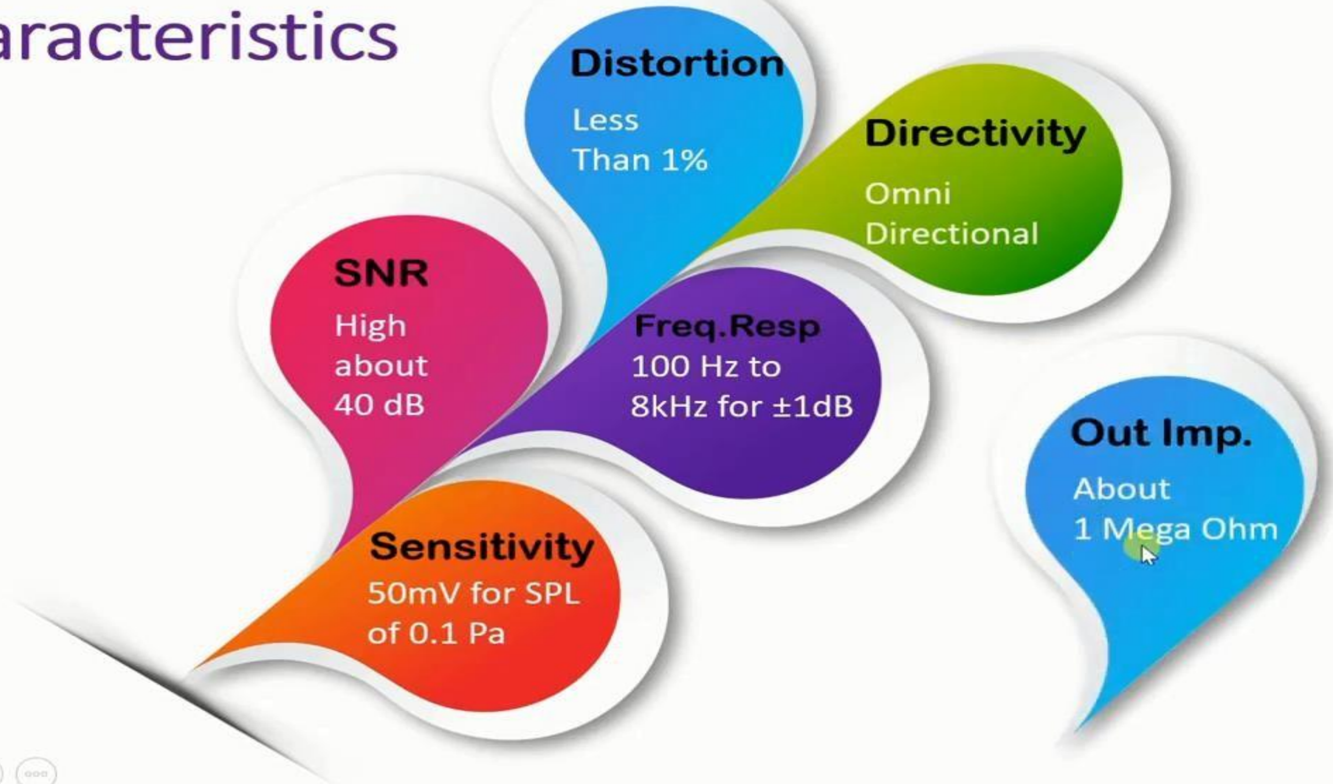
Cont.

- Sound wave compression – compress crystal
- Refraction – converse take place – crystal is extended and is under tension
- Due to this compression and extension – varying potential difference is generated which is proportional to the mechanical pressure applied to the crystal by the sound waves – pressure microphone

Internal structure



Characteristics



Features

Applications

1. Home recording System
2. Amateur Communication
3. Mobile Communication

Carbon Microphone

Outline

- Principle of Carbon Microphone
- Structure of Carbon Microphone
- Working of Carbon Microphone
- Characteristics of Carbon Microphone
- Features of Carbon Microphone
- Applications of Carbon Microphone

Carbon Microphone

- The carbon microphone was widely used for many years being one of the earliest reliable microphones. But it was not widely used now a days.

Construction

- The basic concept behind the carbon microphone is the fact that when carbon granules are compressed their resistance decreases. This occurs because the granules come into better contact with each other when they are pushed together by the higher pressure.

- The carbon microphone comprises carbon granules that are contained within a small contained that is covered with a thin metal diaphragm. A battery is also required to cause a current to flow through the microphone.

- The carbon microphone is consisting of two metal plates separated by granules of carbon.
- One plate faces outward and acts as a diaphragm.
- When sound waves strike this plate, the pressure on the granules changes, which in turn changes the electrical resistance between the plates. (Higher pressure lowers the resistance as the granules are pushed closer together.)

Operation

"When fine carbon granules enclosed in a case are subjected to pressure variations, the resistance of granules changes."

Compression — high pressure

Rarefaction — low pressure

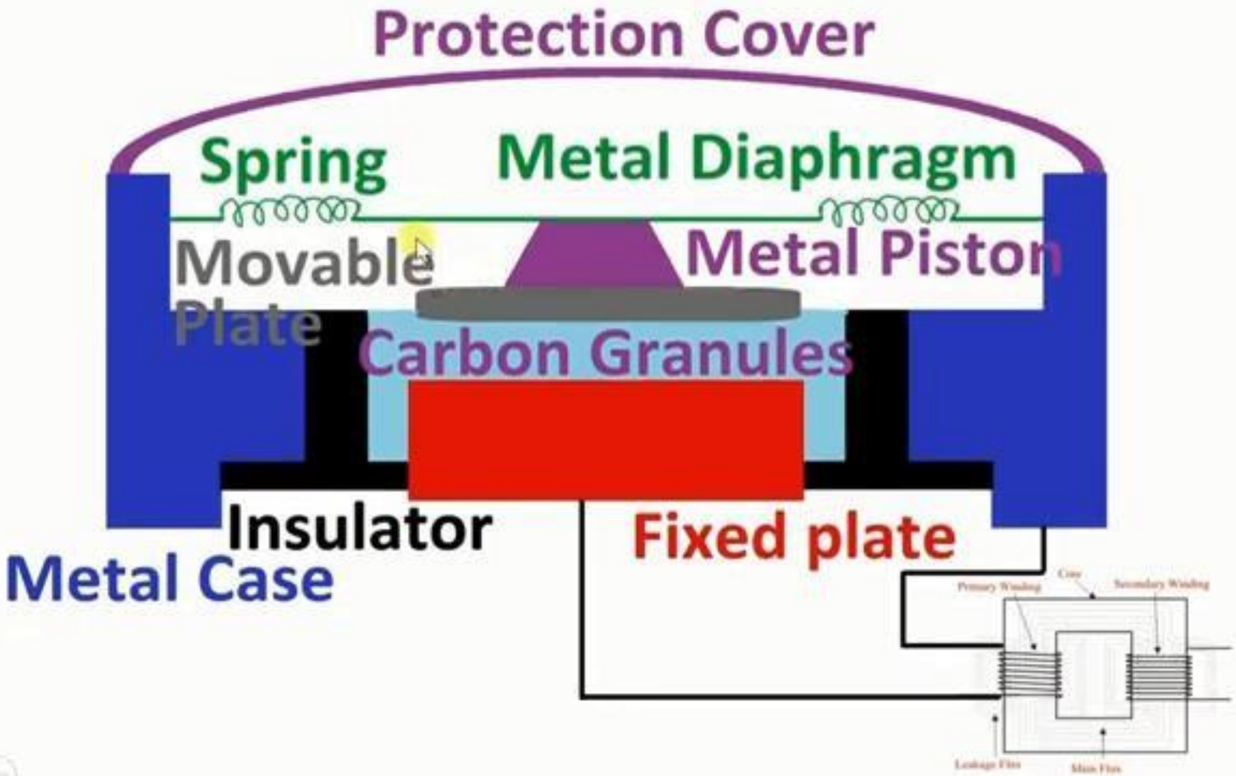
Operating Principle

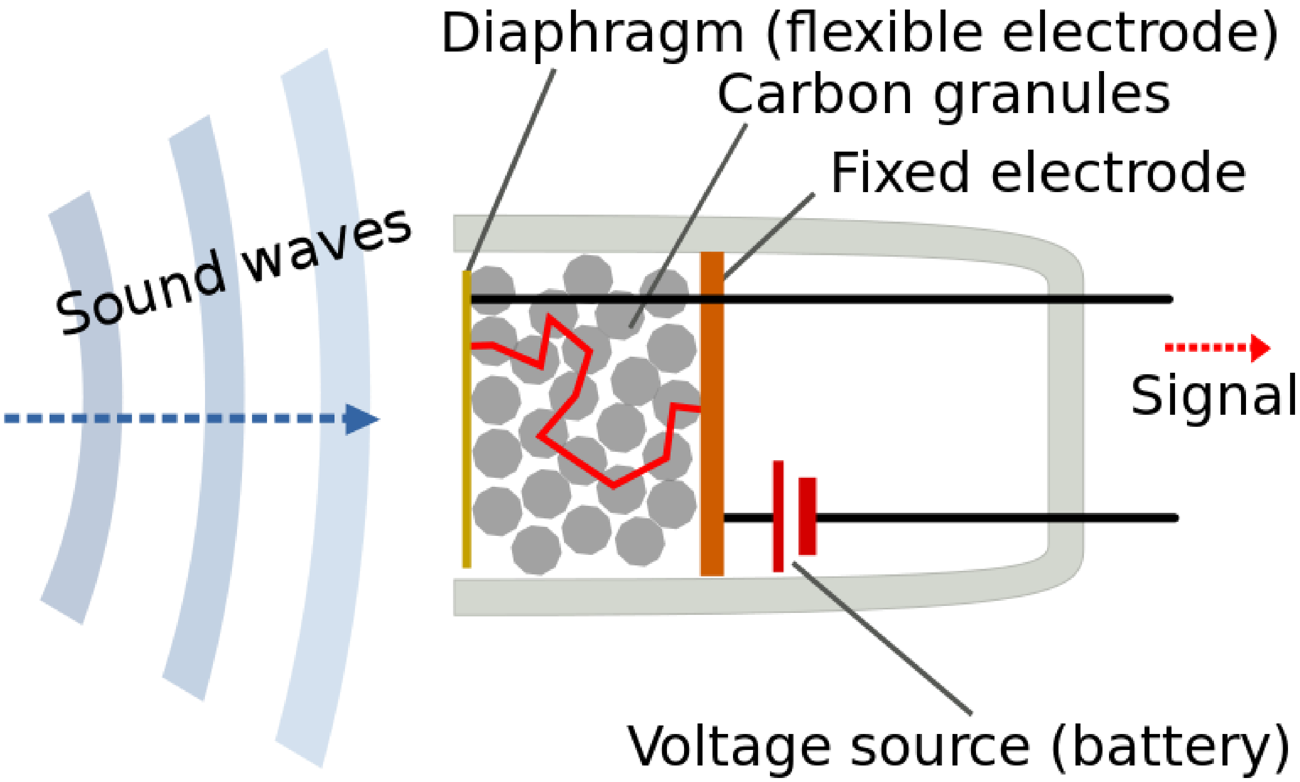
"When fine carbon granules enclosed in a case are subjected to pressure variations, the resistance of granules changes."

When connected in series with a load through DC supply – current changes according to changes in resistance.

At different pressure carbon granules has different resistance

Structure


Protection Cover
Spring
Metal Diaphragm
Movable Plate
Metal Piston
Carbon Granules
Insulator
Fixed plate
Metal Case


Diaphragm (flexible electrode)
Carbon granules
Fixed electrode
Sound waves
Signal
Voltage source (battery)

Working

- Sound waves – diaphragm
- Compression – presses carbon granules – R decreases – current through circuit increases – vive versa for rarefaction
- Absence of sound – steady current flows
- Net resistance of carbon granules is given by,

$r = R_0 + \delta r$

r = Net resistance in ohms

R_0 = Steady resistance for no sound

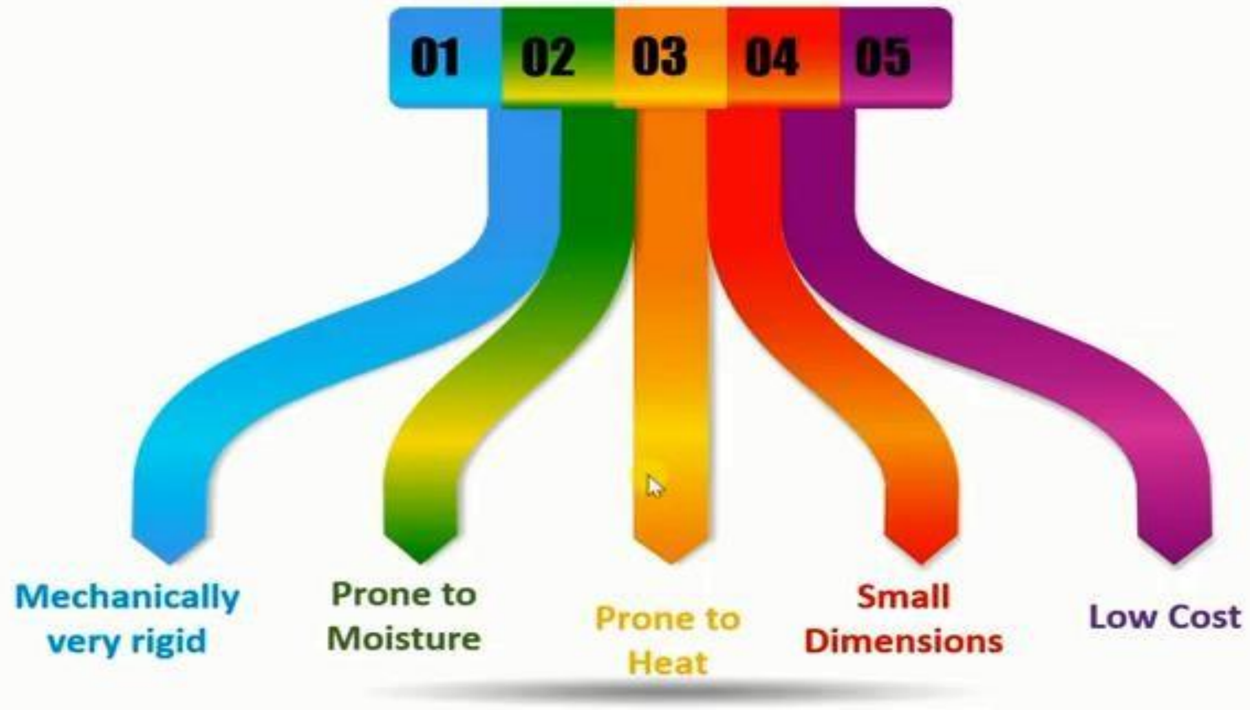
δr = Variation of resistance due to sound pressure.

- The varying current can be passed through a transformer or a capacitor to enable it to be used within a telephone, or by some form of amplifier.
- The frequency response of the carbon microphone, however, is limited to a narrow range, and the device produces significant electrical noise.
- Often the microphone would produce a form of crackling noise which could be eliminated by shaking it or giving it a small sharp knock. This would shake the carbon granules and enable them to produce a more steady current.

- The change in contact resistance causes a current from a battery connected in series with the carbon button and the primary of a transformer to vary in amplitude, resulting in a current waveform similar to the acoustic waveform striking the diaphragm.
- One of the main disadvantages of the carbon microphone is that it has continuous high frequency hiss caused by the changing contact resistance between the carbon granules.

Characteristics

Features



Application

- Carbon microphones were an ideal choice of microphone in the early days of the telephone. Because they gave a high output which meant no amplification was used.
- It is also used in portable radio communication set

Carbon microphones were used in telephones like this vintage British GPO 300 series telephone

advantages

- High output
- Simple principle & construction
- Cheap and simple to manufacture

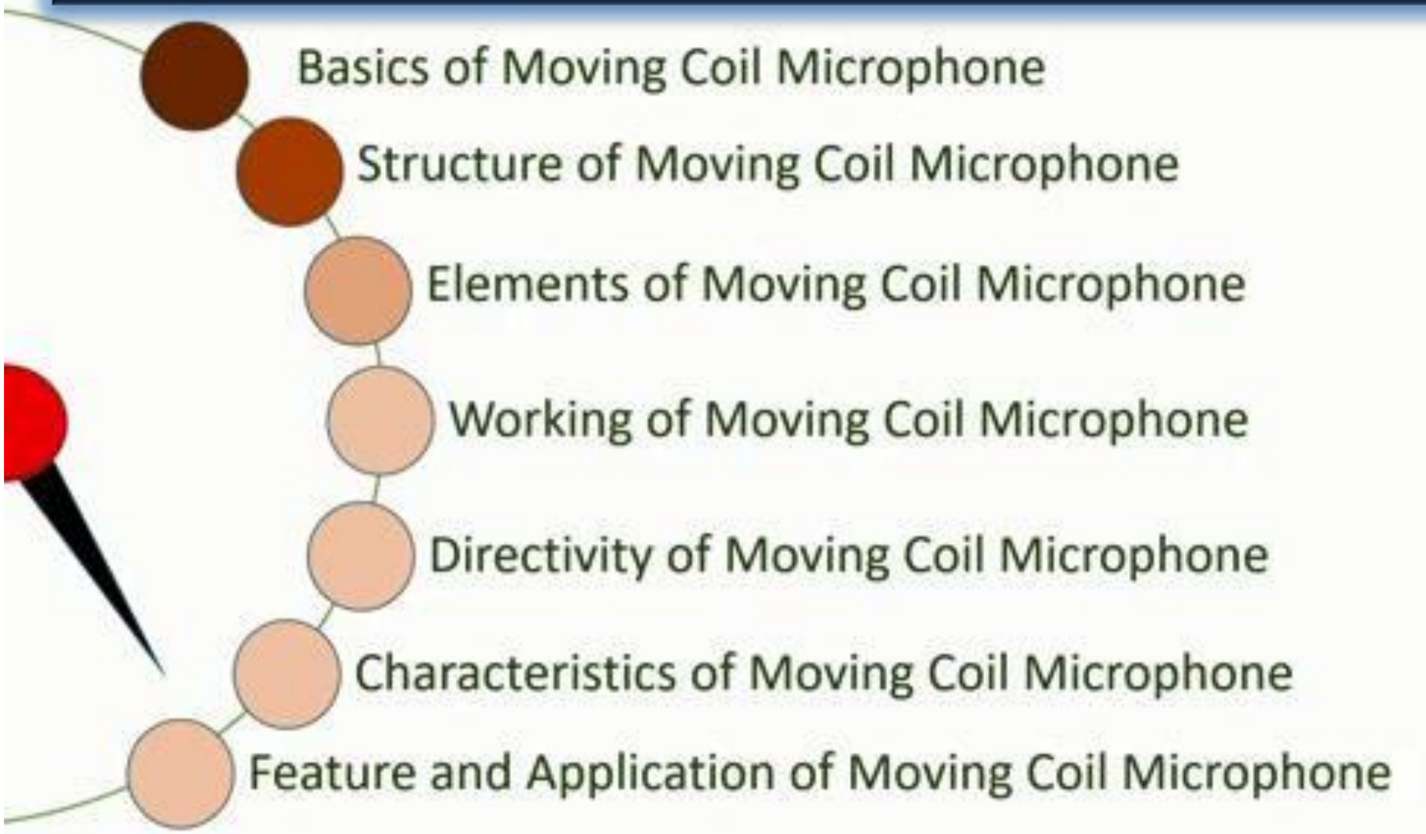
disadvantages

- Very noisy - high background noise and on occasions it would crackle. (Constant BACKGROUND HISS (hissing noise)which results from random changes in the resistance between individual carbon granules).
- Poor sensitivity and frequency response.
- Requires battery or other supply for operation

- The disadvantages, however, are offset by advantages that make its use in military applications widespread. It is lightweight, rugged, and can produce an extremely high output.

Dynamic Microphone

Outline



Basics

It is also called Dynamic μP, it also uses the principle of Electromagnetic induction.

sound pressure – moves coil placed in magnetic field – change in flux – emf is produced – forms output of μP

- Dynamic microphones are versatile and ideal for general-purpose use. They use a simple design with few moving parts.
- They are relatively strong and flexible to rough handling. They are also better suited to handling high volume levels, for examples they will deal better with certain instruments are amplifiers.
- They have no internal amplifier and do not require batteries or external power. When a magnet is moved near a coil of wire, an electrical current is generated in the wire.
- Using this electromagnet principle, the dynamic microphone uses a wire coil and magnet to create the audio signal.

- The diaphragm is attached to the coil. When this vibrates (due to sound waves) the coil moves backward and forward to the magnet.
- This creates a current in the coil, which is channeled from the microphone along wires.
- A physical cone act like a lens to concentrate the incoming sound waves. It employs a diaphragm, a voice coil, and a magnet.
- The voice coil is surrounded by a magnetic field and is attached to the rear of the diaphragm. The motion of the voice coil in the magnetic field generates the electrical signal corresponding to the picked up sound.

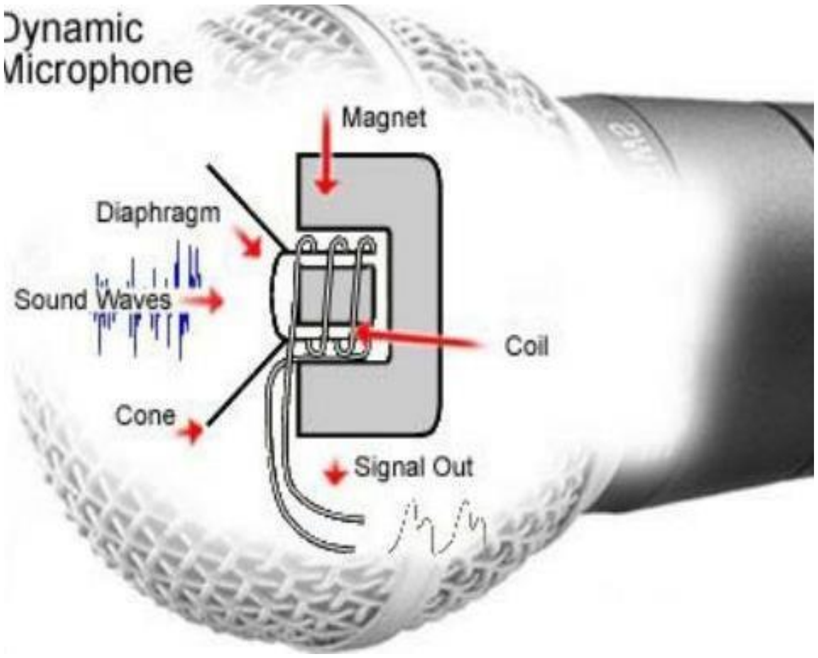
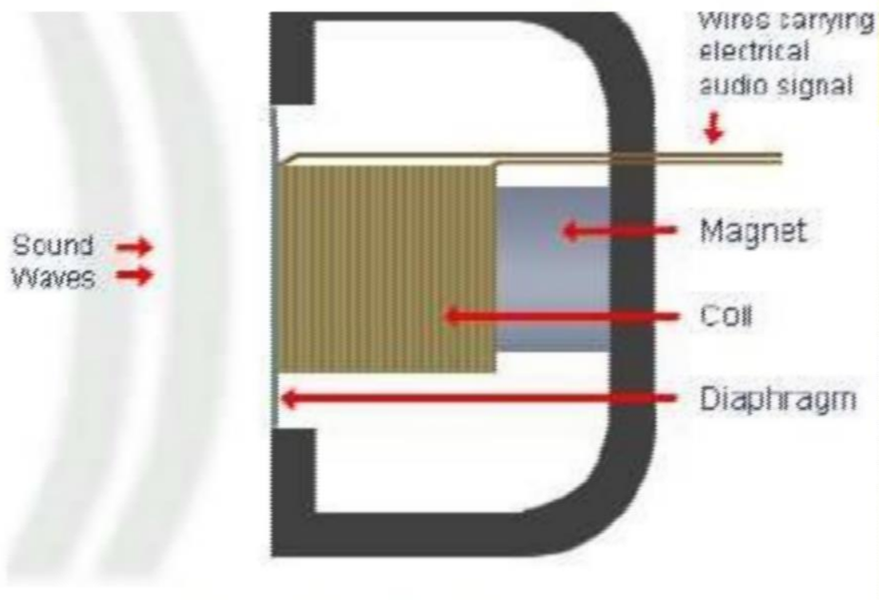
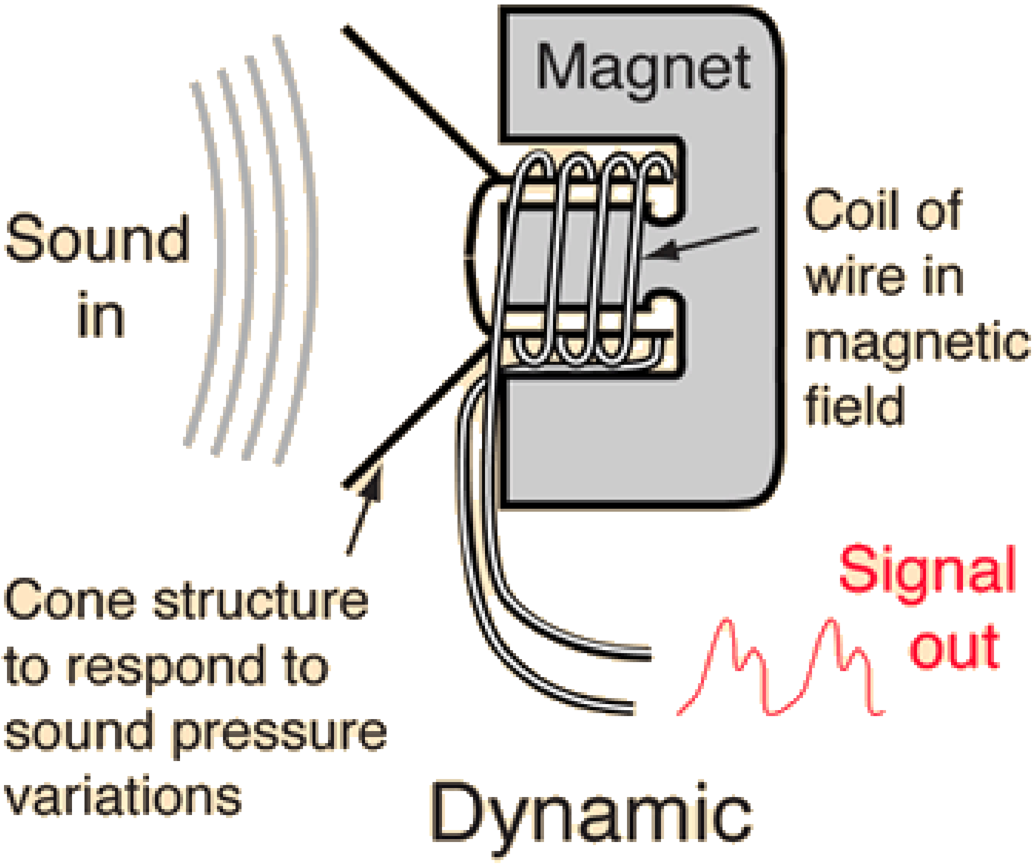
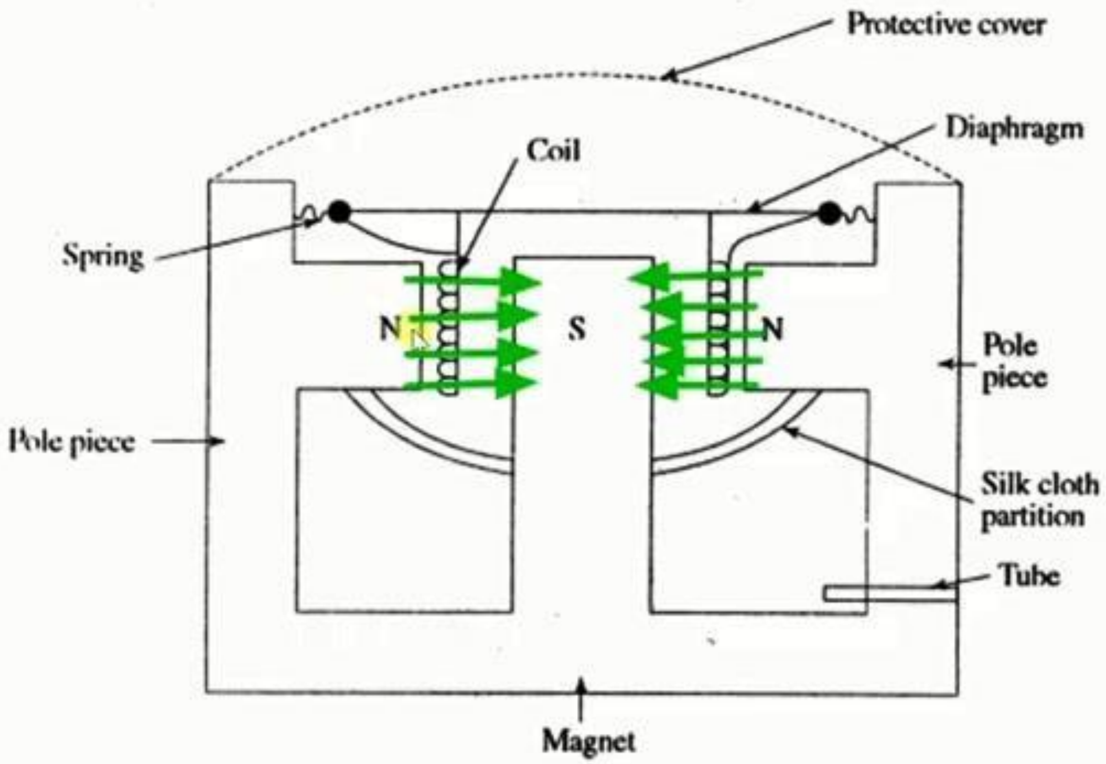


Fig. No. 6: Part of Dynamic microphone.



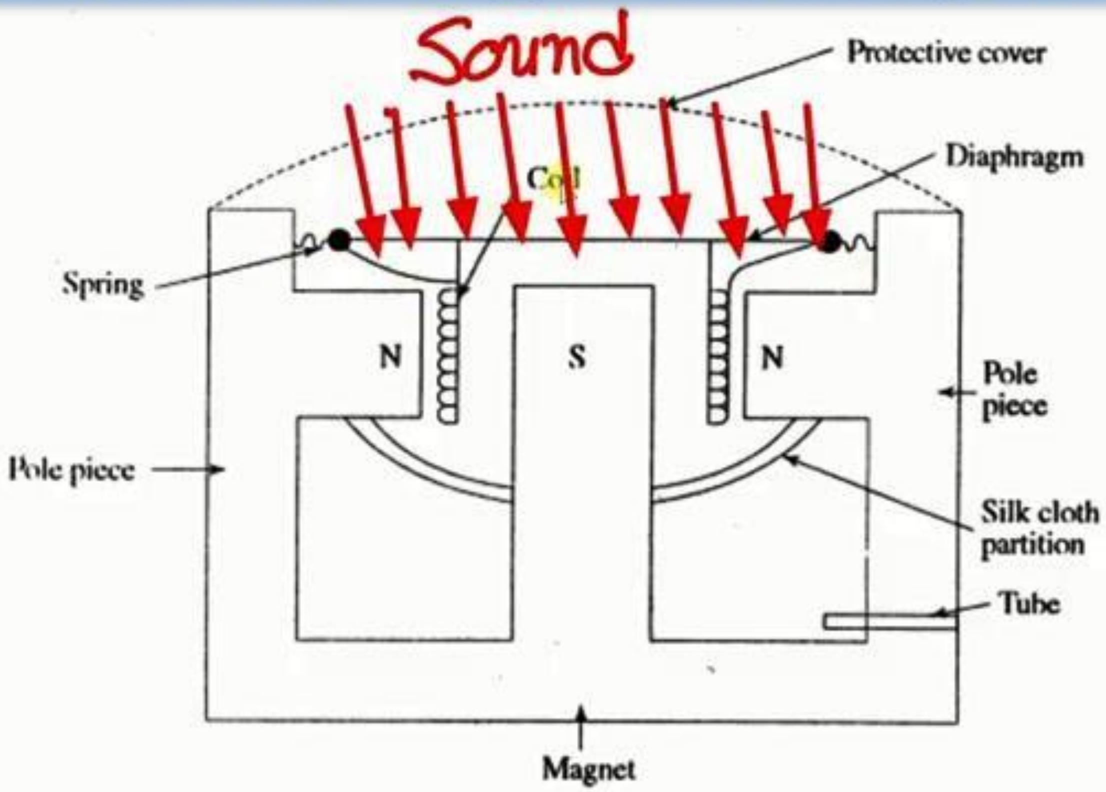


Structure



Protective cover
Diaphragm
Coil
Spring
N
S
N
Pole
piece
Pole piece
Silk cloth
partition
Tube
Magnet

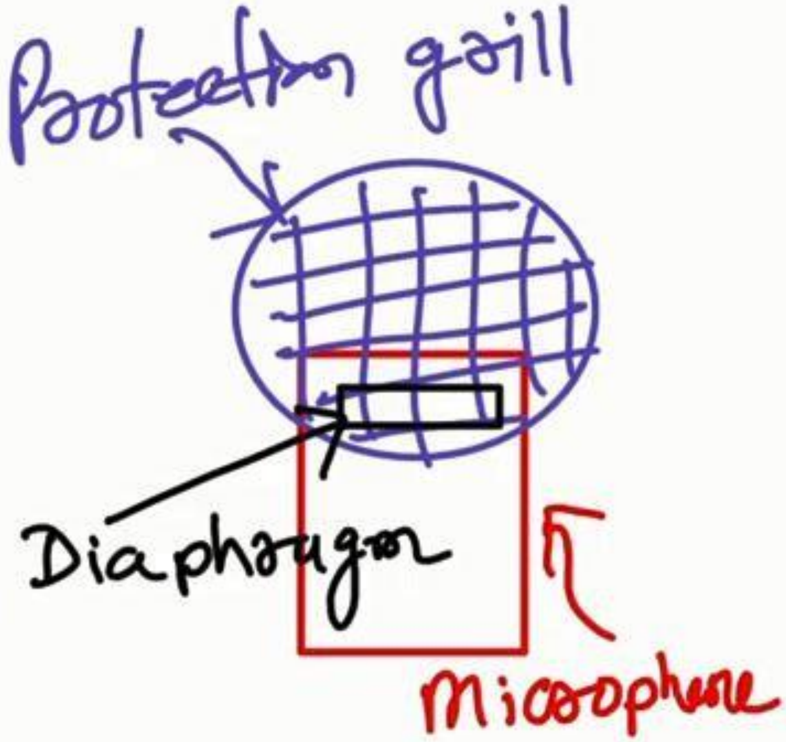
Structure



Sound
Protective cover
Diaphragm
Coil
Spring
N
S
N
Pole piece
Pole piece
Silk cloth partition
Tube
Magnet

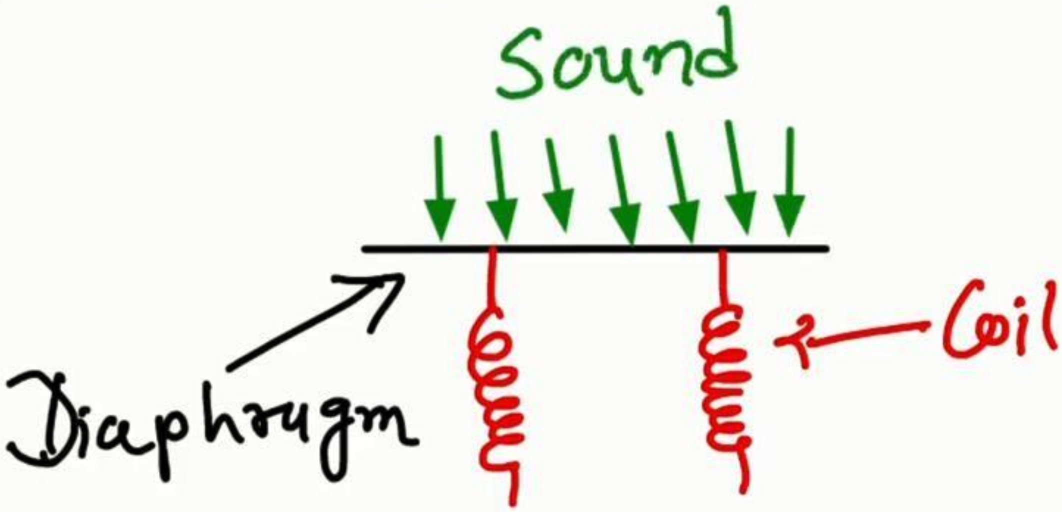
Elements

- **Magnet** :
  - permanent POT Type
  - gives uniform magnetic field in the gap
- **Diaphragm** :
  - thin circular sheet of nonmagnetic material
  - It is of light weight
  - slightly domed for extra rigidity
  - fixed with the help of springs
- **Springs** :
  - provides compliance to the motion of diaphragm
- **Mass of the diaphragm and coil assembly** :
  - provide inductive effect
- **Protective cover** :
  - metal grill
  - To save delicate diaphragm and coil assembly from being mishandled



Working

- Sound strikes the diaphragm – coil moves in and out in magnetic field – changes flux through the coil – results in emf being produced in coil



Working

- Sound strikes the diaphragm – coil moves in and out in magnetic field – changes flux through the coil – results in emf being produced in coil
- value of emf depends on the rate of change of flux and hence on the motion of coil
- displacement of coil depends on sound pressure – 'Pressure Microphone'
- B : flux density in tesla (or Wb/m^2) | l : length of coil in meters | v : velocity of diaphragm in m/s | Then induced voltage :

$$e = \frac{d\emptyset}{dt} = B \times l \times v$$

73

- This classification includes ribbon mics (velocity mics).
- Rugged, resistant to hand noise.
- Standard equipment used by musical performers.
- Handle extremely high sound levels.
  - 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.

Directivity

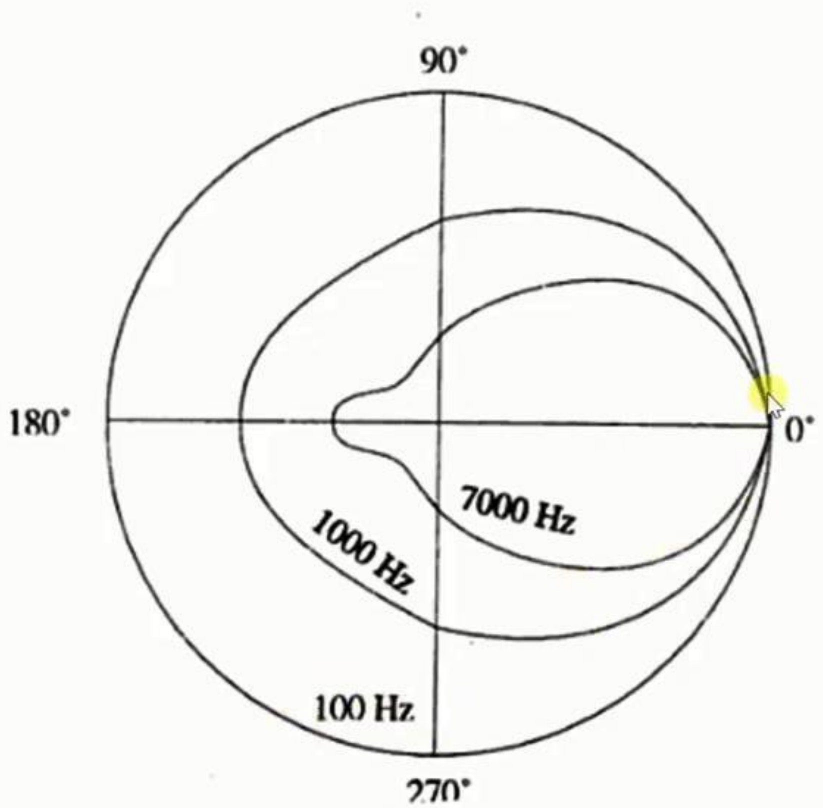
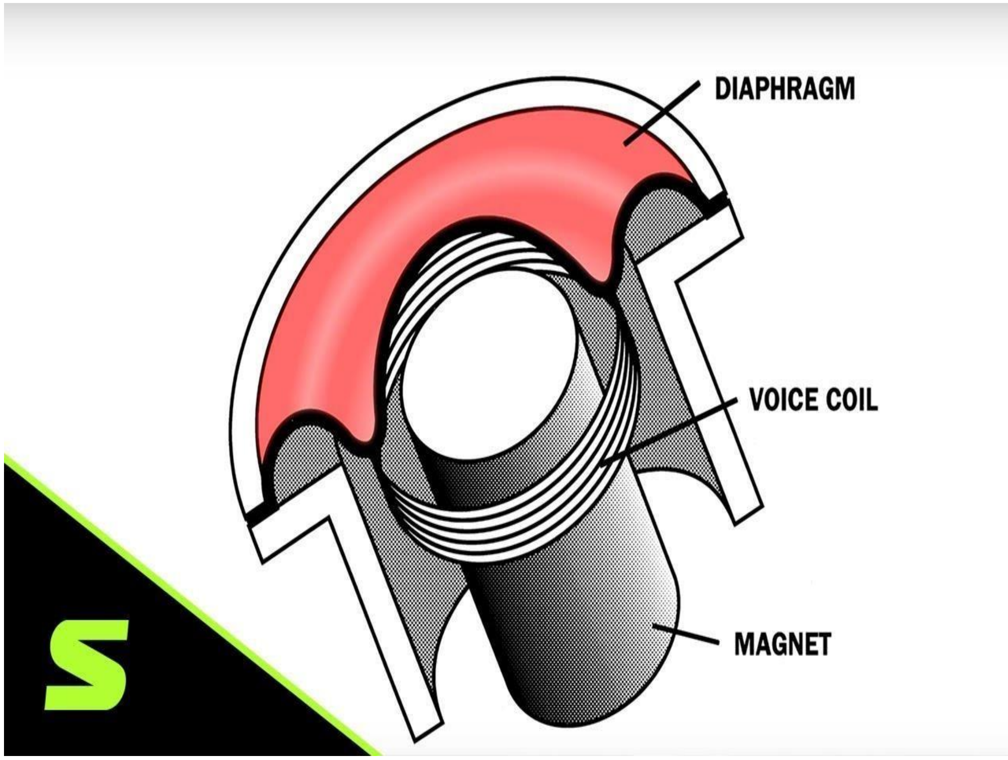


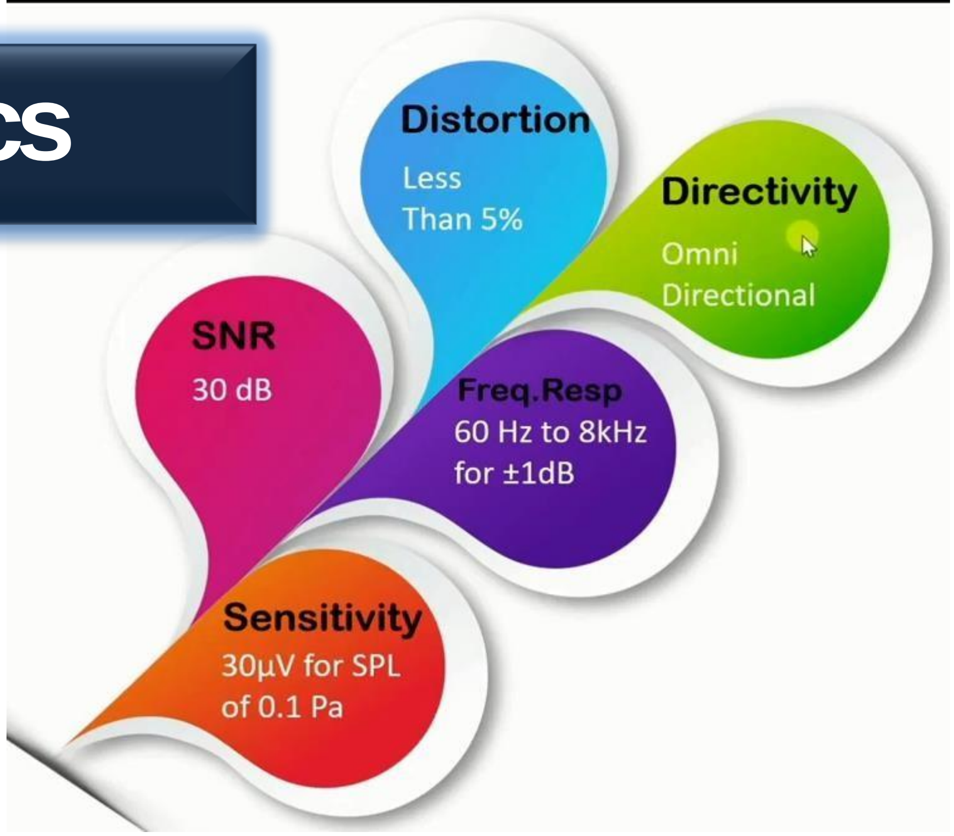
Fig. 2.6 . Directivity of moving coil microphone vs. frequency

- *Shaped frequency response*
- *Designed for professional vocal use in live performances*.

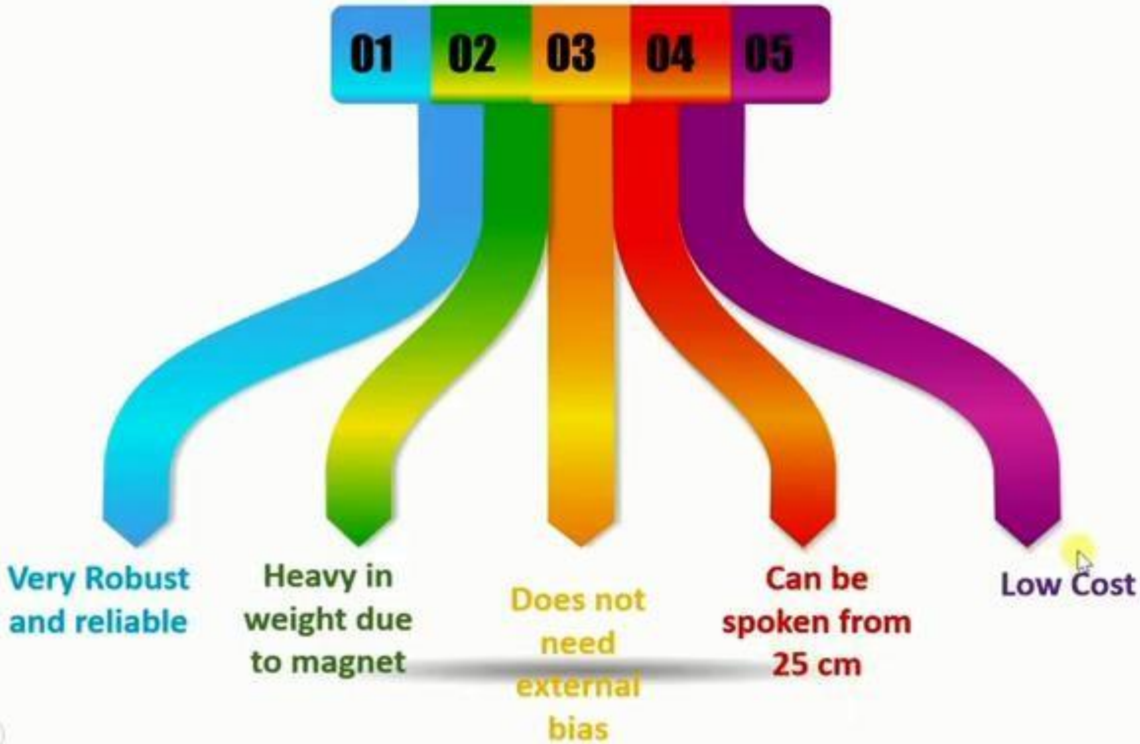


Characteristics

- relatively inexpensive
- they are not sensitive to change in humidity
- they do not need internal or external power to operate
- they usually have a resonant peak in the mid frequency response
- can be weak in the high frequency response about 10khz



Features



Applications

1. Suitable for PA systems
2. Broadcast studios

Wireless or Cordless Microphone

- A wireless microphone is a microphone without a physical cable connecting it directly to the sound recording or amplifying equipment with which it is associated.
- It has a small, battery-powered radio transmitter in the microphone body, which transmits the audio signal from the microphone by radio waves to a nearby receiver unit, which recovers the audio.
- The other audio equipment is connected to the receiver unit by cable.
- Wireless microphones are widely used in the entertainment industry, television broadcasting, and public speaking to allow public speakers, interviewers, performers, and entertainers to move about freely while using a microphone to amplify their voices.
- These are Hand held and collar type as shown in figure

Advantages

- Greater freedom of movement for the artist or speaker.
- Avoidance of cabling stressing problems common with wired microphones.
- Reduction of cable "trip hazards" in the performance space

Disadvantages

- Some wireless systems have a shorter range, while more expensive models can exceed that distance.
- Possible interference with or, more often, from other radio equipment or other radio microphones.
- Operation time is limited relative to battery life.