Department of Electronics and Tele-communication

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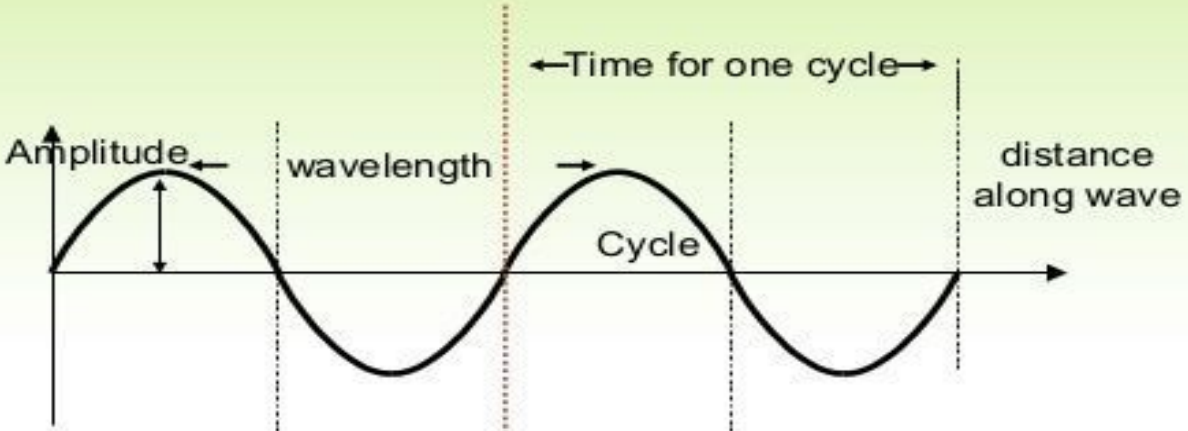
Unit No.1 Audio Fundamentals

- Basic Characteristics of Sound Signal
- Audio amplifier
- Microphone
- Speakers
- Crossover network
- Troubleshooting procedure for audio amplifier

Basic Characteristics of sound

- Sound travels in the form of a wave. Waves are characterized by three basic quantities. They are frequency, speed, and amplitude. Two of the main characteristics of sound are pitch and loudness, which in turn are determined by the frequency and amplitude of the wave, respectively. Therefore, to understand what pitch and loudness mean, we will first need to study the characteristics of waves. We will use the example of oscillations of a simple pendulum to explain the terms amplitude and frequency.

Characteristic of Sound Waves



Sound characteristics

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). We know that 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.
- *Note:* The distance between the centers of a compression and an adjacent rarefaction is equal to half of its wavelength i.e. λ/2. The S.I unit for measuring wavelength is meter (m).

Sound Characteristics

- **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 S.I unit of measurement of amplitude is meter (m) though sometimes it is also measured in centimeters. Do you know that the amplitude of a wave is the same as the amplitude of the vibrating body producing the wave?

Sound Characteristics

- **Time period**
- The time required to produce one complete wave or cycle 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).

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. For example: if 10 complete waves or vibrations are produced in one second then the frequency of the waves will be 10 hertz or 10 cycles per second. Do you know that the frequency of a wave is fixed and does not change even when it passes through different substances?
- The S.I unit of frequency is hertz or Hz. A vibrating body emitting 1 wave per second is said to have a frequency of 1 hertz. That is 1 Hz is equal to 1 vibration per second.
  Sometimes a bigger unit of frequency is known as kilohertz (kHz) that is 1 kHz = 1000 Hz. The frequency of a wave is denoted by the letter f.
- The frequency of a wave is the same as the frequency of the vibrating body which produces the wave.

What is the relation between time-period and frequency of a wave?

- The time required to produce one complete wave is called time-period of the wave. Suppose the time-period of a wave is T seconds.
  In T seconds number of waves produced = 1
  So, in 1 second, number of waves produced will be = 1/T
  But the number of waves produced in 1 second is called its frequency.
  Therefore, **F = 1/Time-period**
  f = 1/T
  where f = frequency of the wave
  T = time-period of the wave

Velocity of Wave (Speed of Wave)

- 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 S.I unit for measuring the velocity is meters per second (m/s).
- **What is the relationship between Velocity, Frequency and Wavelength of a Wave?**
- Velocity = Distance travelled/ Time taken
  Let $v = \lambda / T$
  Where T = time taken by one wave.
  $v = f \times \lambda$
  This formula is known as wave equation.
  Where v = velocity of the wave
  f = frequency
  λ = wavelength
  Velocity of a wave = Frequency X Wavelength

Characteristics of sound

- Sensitivity-is defined as the ability to detect weakest sound(low intensity)
- Selectivity-is defined as the ability of human ear to select sound signal of particular frequencies over those of some other frequencies of same intensity
- Fidelity-is defied as the ability of audio amplifier to reproduce all the sound frequencies faithfully i,e, amplify all of them equally.

Frequency response

- The range of audible frequencies is from 16hzto20khz however this entire rage is obtained for satisfactory audio transmission for every application

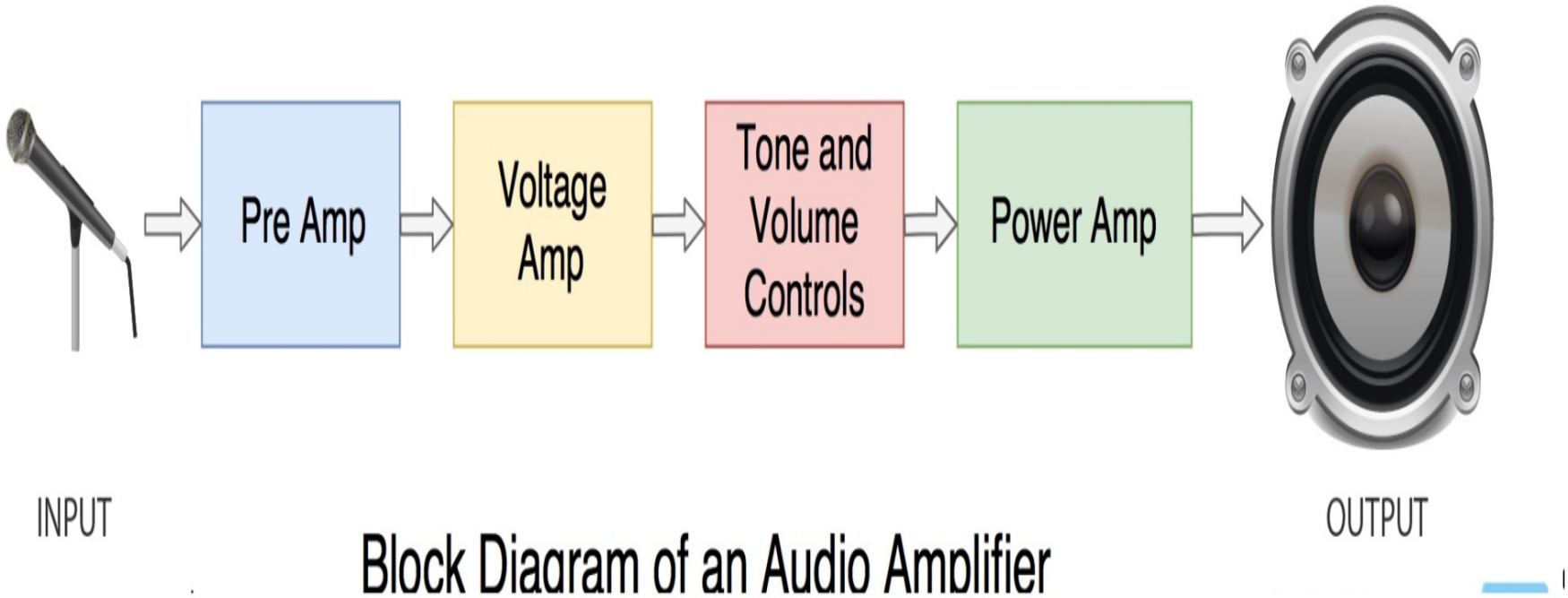
Audio amplifier

- Power amplifier
- Mono amplifier
- Stereo amplifier

Power amplifier

- A power amplifier is an electronic amplifier designed to increase the magnitude of power of a given input signal. The power of the input signal is increased to a level high enough to drive loads of output devices like speakers, headphones, RF transmitters etc. Unlike voltage/current amplifiers, a power amplifier is designed to drive loads directly and is used as a final block in an amplifier chain.
- The input signal to a power amplifier needs to be above a certain threshold. So, instead of directly passing the raw audio/RF signal to the power amplifier, it is first pre-amplified using current/voltage amplifiers and is sent as input to the power amp after making necessary modifications. You can observe the block diagram of an audio amplifier and the usage of power amplifier below.

Block diagram of Audio Amplifier



Block Diagram of an Audio Amplifier

Audio Amplifier

- In this case, a microphone is used as an input source. The magnitude of signal from the microphone is not enough for the power amplifier. So, first it is pre-amplified, where its voltage and current are increased slightly. Then the signal is passed through a tone and volume control circuit, which makes aesthetic adjustments to the audio waveform. Finally, the signal is passed through a power amplifier and the output from power amp is fed to a speaker.
- **Types of Power Amplifiers**
- Depending on the type of output device that is connected, power amplifiers are divided into the following three types:
- Audio Power Amplifiers
- RF Power Amplifiers
- DC Power Amplifiers

Audio Power Amplifiers

- This type of power amplifiers are used for increasing the magnitude of power of a weaker audio Signal. The amplifiers used in speaker driving circuitries of televisions, mobile phones etc. come under this category.
- The output of an audio power amplifier ranges from a few mill watts (like in headphone amplifiers) to thousands of watts (like power amplifiers in Hi-Fi/Home theatre systems).

Radio Frequency Power Amplifiers

- Wireless transmissions require modulated waves to be sent over long distances through air. The signals are transmitted using antennas and the range of transmission depends on the magnitude of power of signals fed to the antenna.
- For wireless transmissions like FM broadcasting, antennas require input signals at thousands of kilowatts of power. Here, Radio Frequency Power amplifiers are employed to increase the magnitude of power of modulated waves to a level high enough for reaching the required transmission distance.

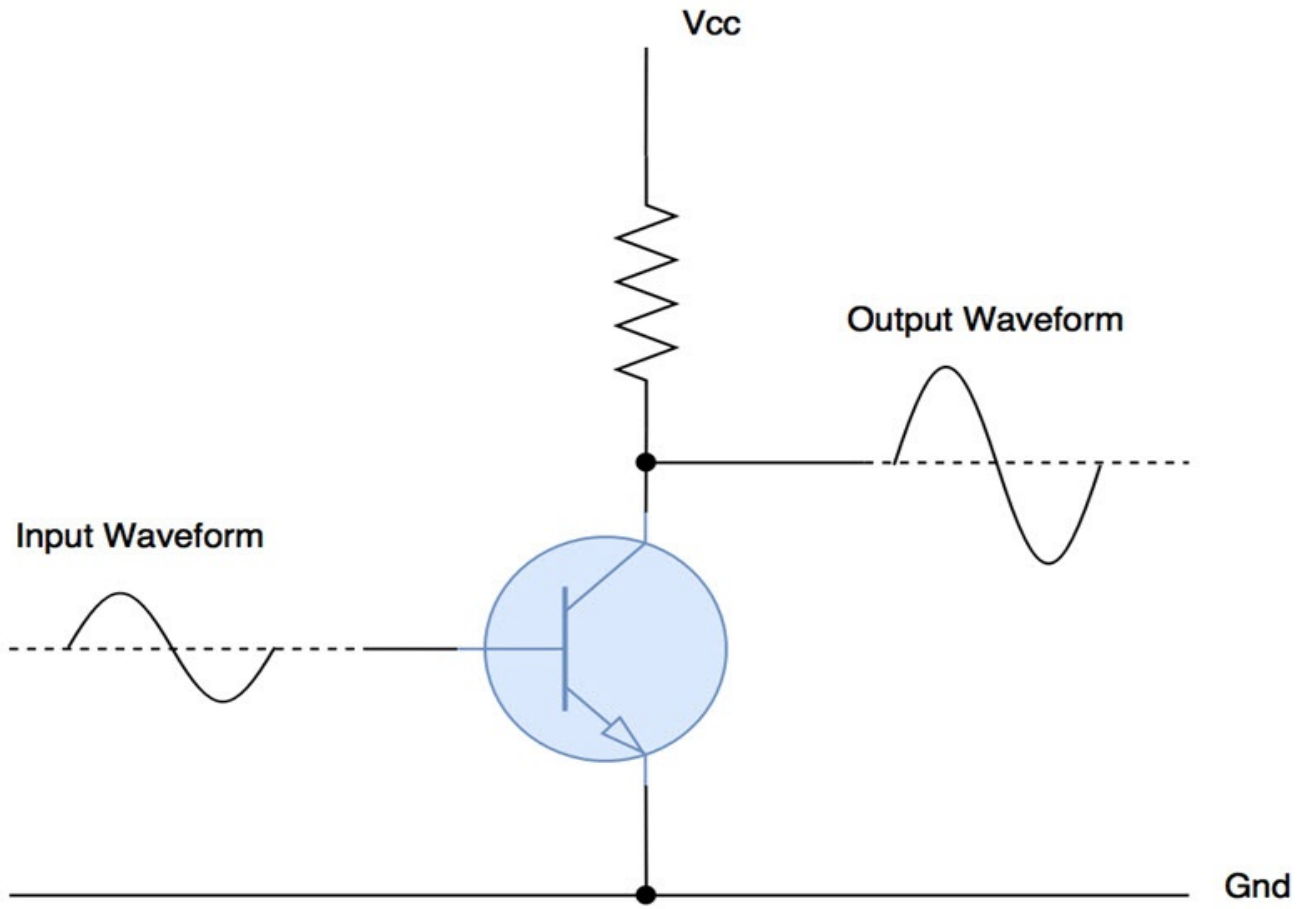
Audio Amplifier

- **DC Power Amplifiers**
- DC power amplifiers are used to amplify the power of a PWM (Pulse Width Modulated) signals. They are used in electronic control systems which need high power signals to drive motors or actuators. They take input from microcontroller systems, increase its power and feed the amplified signal to DC motors or Actuators.
- **Power Amplifier Classes**
- There are multiple ways of designing a power amplifier circuit. The operation and output characteristics of each of the circuit configurations differs from one another.
- To differentiate the characteristics and behavior of different power amplifier circuits, Power Amplifier Classes are used in which, letter symbols are assigned to identify the method of operation.
- They are broadly classified into two categories. Power amplifiers designed to amplify analog signals come under A, B, AB or C category. Power amplifiers designed to amplify Pulse Width Modulated (PWM) digital signals come under D, E, F etc.
- The most commonly used power amplifiers are the ones used in audio amplifier circuits and they come under classes A, B, AB or C. So, let's take a look at them in detail.

Class A power Amplifier

- Analog waveforms are made up of positive highs and negative lows. In this class of amplifiers, the entire input waveform is used in the amplification process.
- A single transistor is used to amplify both the positive and negative halves of the waveform. This makes their design simple and makes class A amplifiers the most commonly used type of power amplifiers. Although this class of power amplifiers are superseded by better designs, they are still popular among hobbyists.

Class A power amplifier



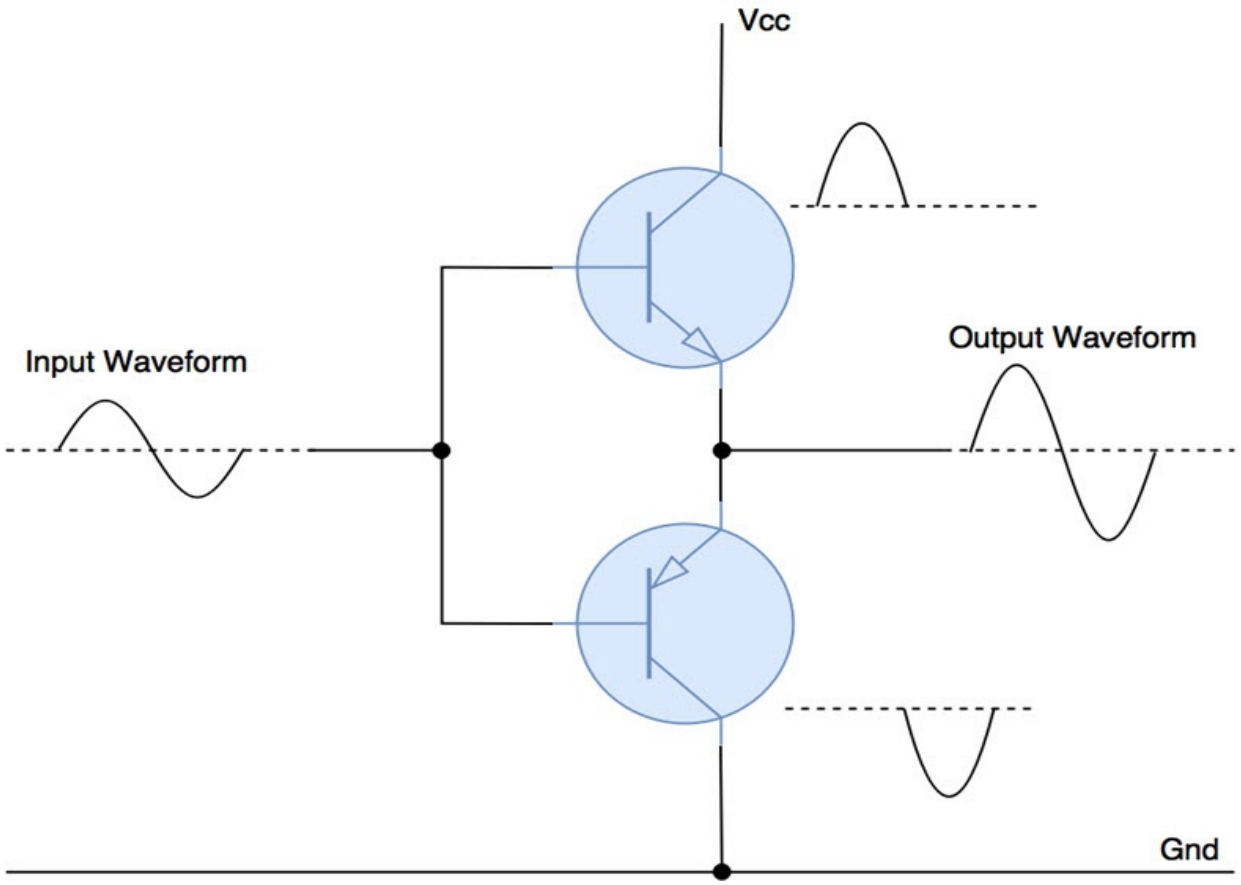
Class A Power amplifier

- In this class of amplifiers, the active element (the electronic component used for amplifying, which is transistor in this case) is in use all the time even if there is no input signal. This generates lot of heat and reduces the efficiency of class A amplifiers to 25% in case of normal configuration and 50% in case of transformer coupled configuration.
- The conduction angle (the portion of waveform used for amplification, out of 360°) for class A amplifiers is 360°. So, the signal distortion levels are very less allowing better high frequency performance.

Class B Power Amlifier

- Class B power amplifiers are designed to reduce the efficiency and heating problems present in the class A amplifiers. Instead of a single transistor to amplify the entire waveform, this class of amplifiers use two complementary transistors.
- One transistor amplifies the positive half of the waveform and the other amplifies the negative half of the waveform. So, each active device conducts for one half (180°) of the waveform and two of them, when combined, amplify the entire signal.
- The efficiency of class B amplifiers is improved a lot over class A amplifiers because of two transistor design. They can reach a theoretical efficiency of about 75%. Power amplifiers of this class are used in battery operated devices like FM radios and transistor radios.
- Because of superposition of two halves of the waveform, there exists a small distortion at the crossover region. To reduce this signal distortion, class AB amplifiers are designed.

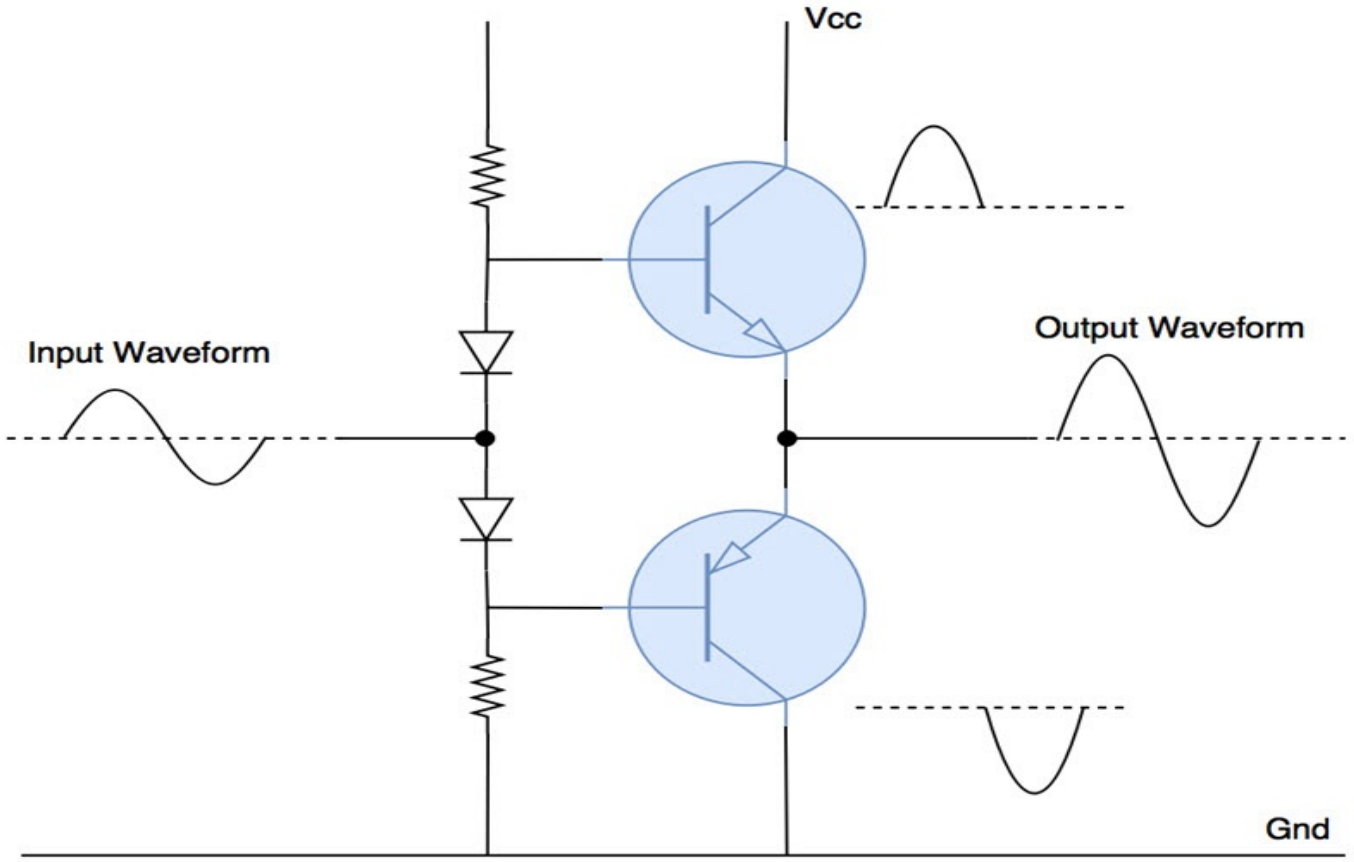
Class B power amplifier



Class AB power amplifier

- Class AB amplifiers are a combination of class A and class B amplifiers. This class of amplifiers are designed to reduce the less efficiency problem of class A amplifiers and distortion of signal at crossover region in class B amplifiers.
- It maintains high frequency response like in class A amplifiers and good efficiency as in class B amplifiers. A combination of diodes and resistors are used to provide little bias voltage which reduces the distortion of waveform near the crossover region. There is a little drop in efficiency (60%) because of this.

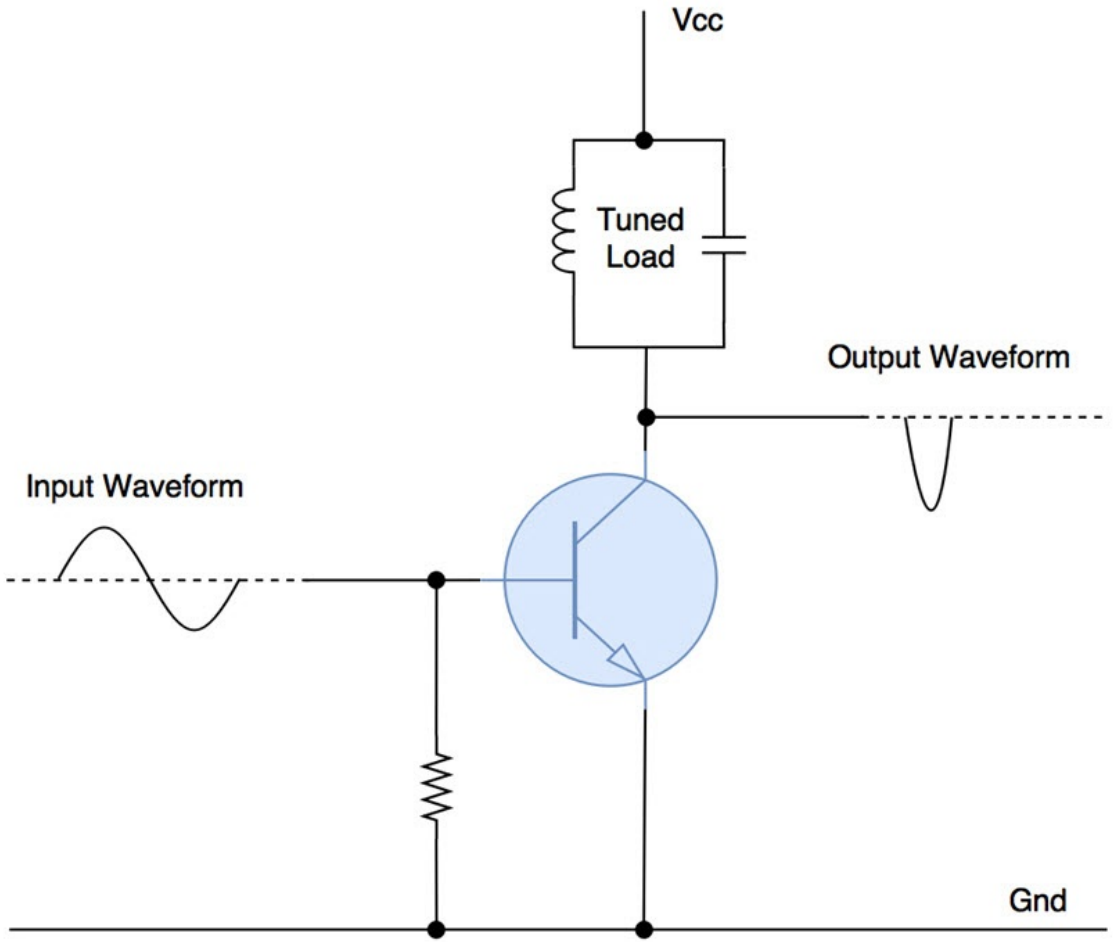
Class AB power amplifier



Class C power amplifier

- The design of class C power amplifiers allows greater efficiencies but reduces the linearity/conduction angle, which is under 90°. In other words, it sacrifices quality of amplification for increase in efficiency.
- Lesser conduction angle implies greater distortion and so this class of amplifiers are not suited for audio amplification. They are used in high frequency oscillators and amplification of Radio Frequency signals.
- Class C amplifiers generally contain a tuned load which filters and amplifies input signals of certain frequency, and the waveforms of other frequencies are suppressed.
- In this type of power amplifier, the active element conducts only when the input voltage is above a certain threshold, which reduces power dissipation and increases efficiency.

Class C power amplifier



Other power amplifier classes

- Power amplifier classes D, E, F, G etc. are used to amplify PWM modulated digital signals. They come under the category of switching power amplifiers and turn the output either constantly ON or constantly OFF without any other levels in between.
- Because of this simplicity, power amplifiers falling under the above-mentioned classes can reach theoretical efficiencies of up to (90-100)%.

Application

- Below are the applications of power amplifiers across different sectors:
- **Consumer Electronics:** Audio power amplifiers are used in almost all consumer electronic devices ranging from microwave ovens, headphone drivers, televisions, mobile phones and Home theatre systems to theatrical and concert reinforcement systems.
- **Industrial:** Switching type power amplifiers are used for controlling most of the industrial actuator systems like servos and DC motors.
- **Wireless Communication:** High power amplifiers are important in transmission of cellular or FM broadcasting signals to users. Higher power levels made possible because of power amplifiers increases data transfer rates and usability. They are also used in satellite communication equipment.

Mono Amplifier

- The word monophony means one sound or one source sound
- In monophonic sound ,only one amplifier is used ,such as single amplifier in monophonic system is known as mono amplifier

Stereo phonic amplifier

- The word stereophony is derived from two Greeks words stereos and phone means solid and sound
- Thus stereo phony means solid sound or three dimensional sound

Comparision of stereo phonic and mono phonic amplifier

- With respect to dimensional sound
- number of amplifier used
- sense of direction
- naturalness

Microphone

- What is a microphone? A microphone is a transducer that converts mechanical wave energy (sound waves) into electrical energy (mic/audio signals). There are many types of mics, and they nearly all utilize a diaphragm (reacts with sound); transducer element (converts energy); and circuitry (carries/outputs mic signal).

Classification of microphones

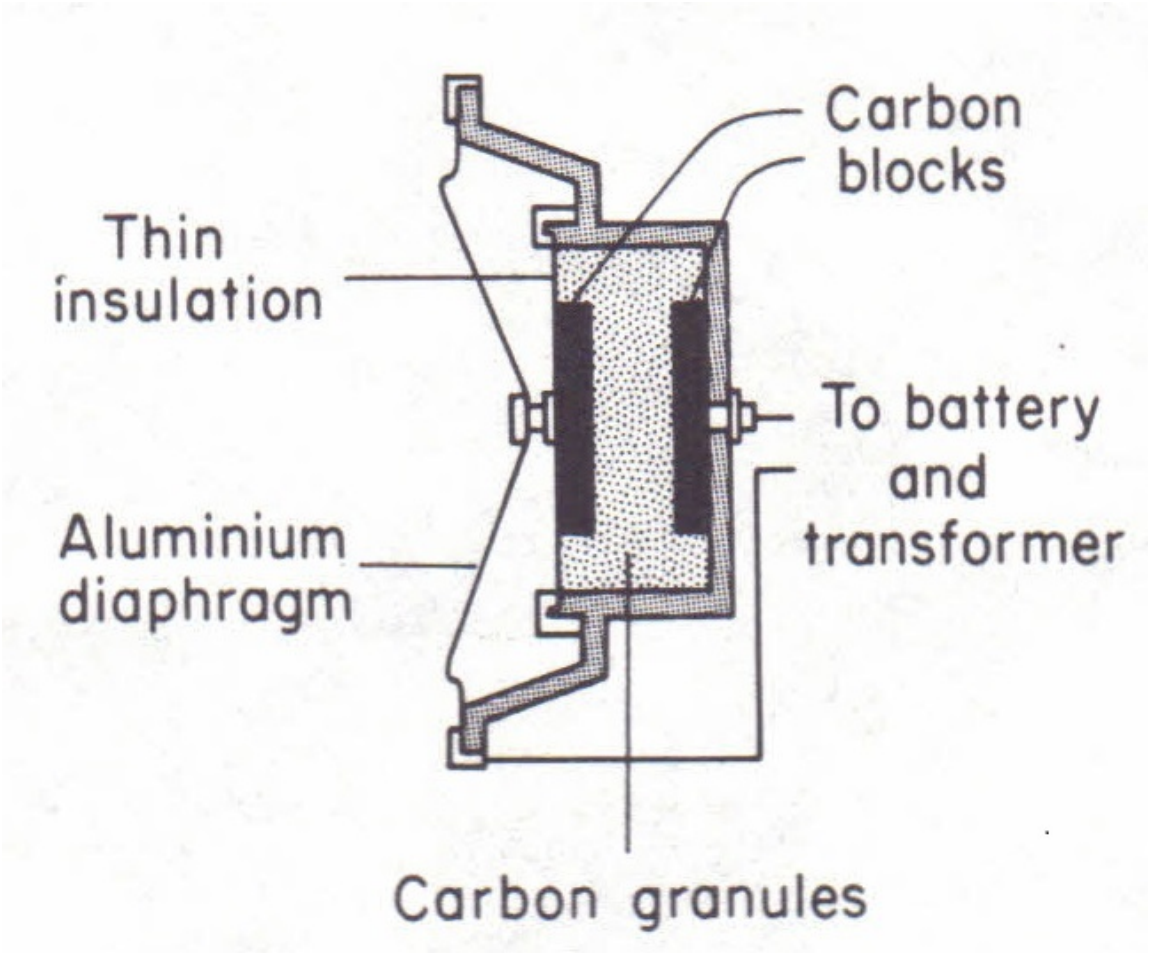
- **Pressure Type**-Carbon,Crystal,Capacitor,Dynamic
- **Velocity Type**-Ribben

- **Classification based on pickup patterns**
- Omni directional Bidirectional Unidirectional(Cardioid or heart shaped),Super Cardioids, Hyper Cardioids

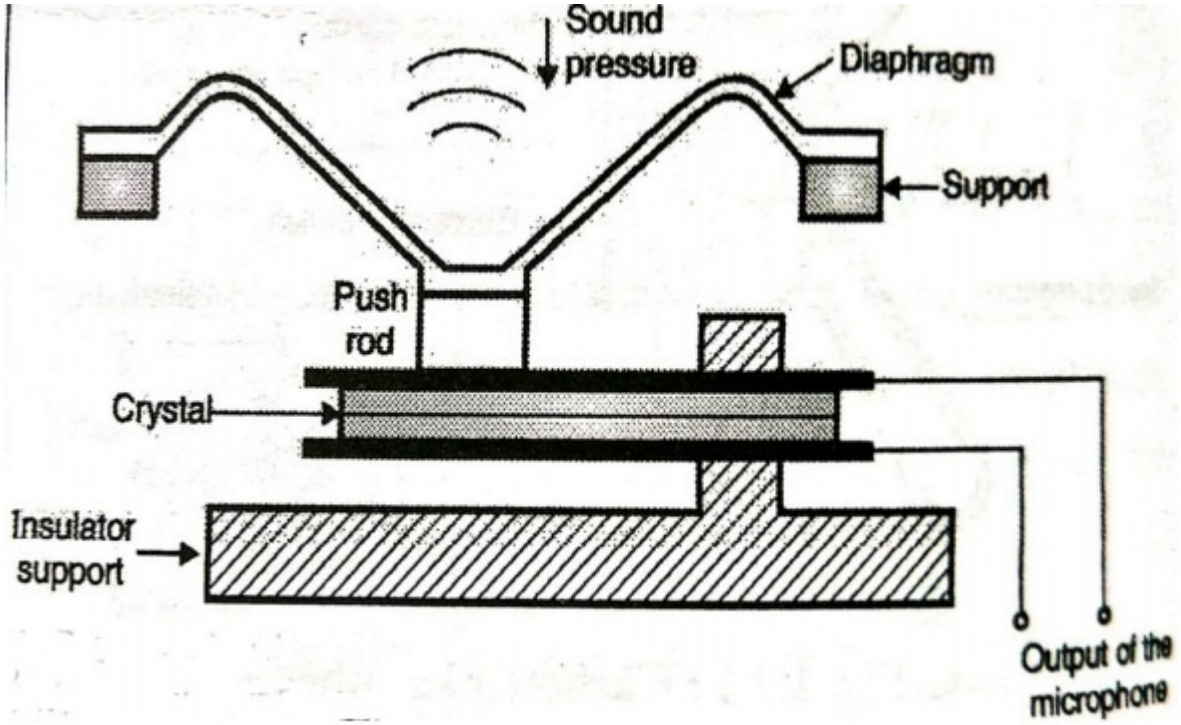
Microphone characteristics

- Sensitivity
- Output impedance
- Signal to Noise ratio
- Frequency response
- Directivity
- Distortions in the electrical output

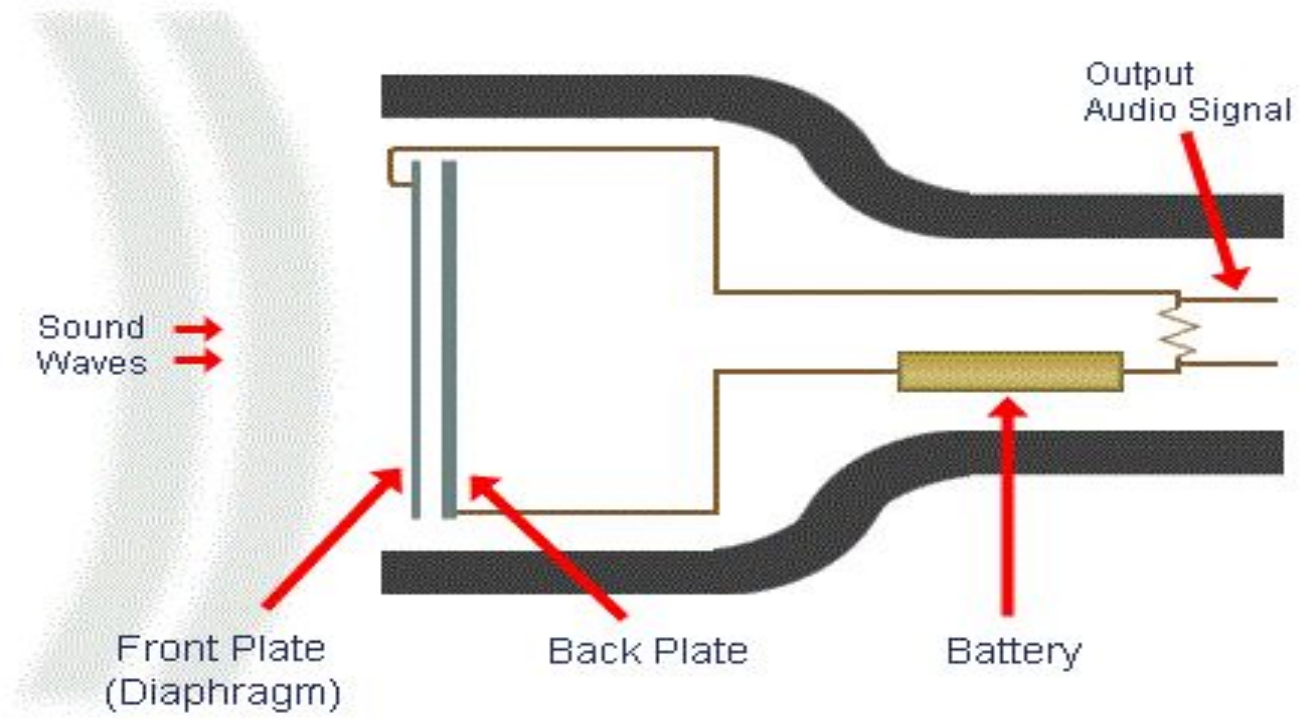
Carbon Microphone



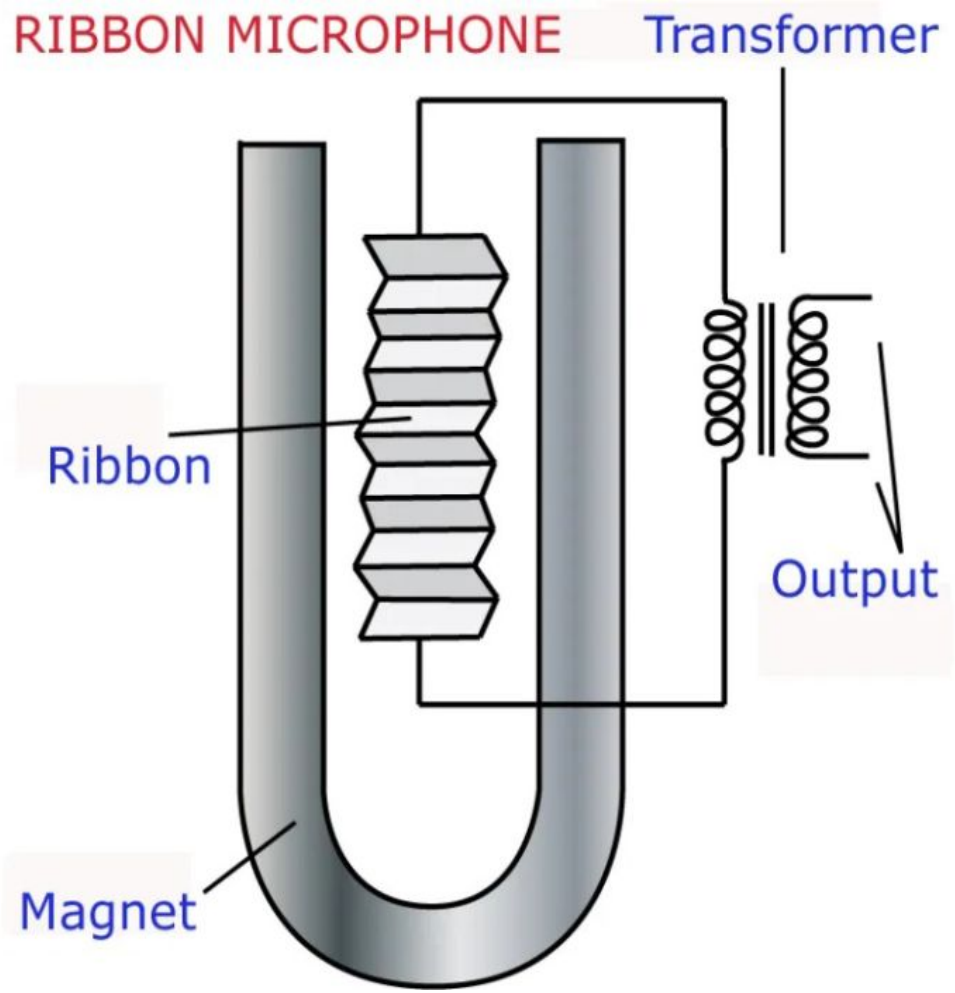
Crystal Microphone



Condensor Or Capacitor Microphone



Ribben Microphone



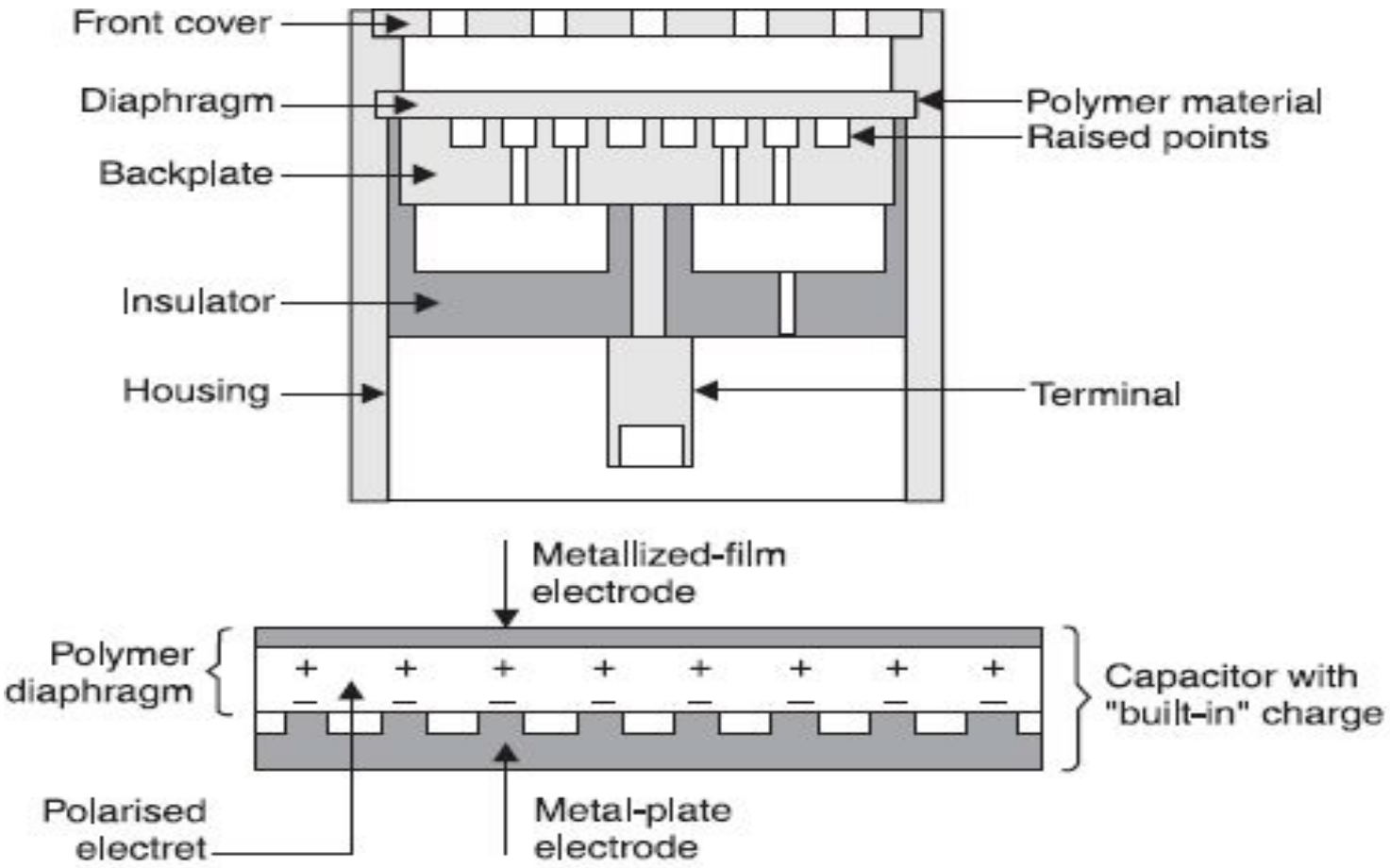
Ribben Microphone

- A ribbon microphone has a thin, often corrugated, electrically conductive ribbon-like diaphragm and acts as a transducer, converting sound waves into audio signals. Ribbon mics work on the principle of **electromagnetic induction**, making them “dynamic” just like their moving-coil counterparts.

Ribben Microphone

- In ribbon microphones, **a light metal ribbon (usually corrugated) is suspended between the poles of a magnet**. As the ribbon vibrates, a voltage is induced at right angles to both the ribbon velocity and magnetic field direction and is picked off by contacts at the ends of the ribbon.

Electret Microphone



Tie Clip Microphone

- This is very small microphone
- It can be clipped on to a tie or a caller or any other convenient part of the clothing It is battery operated light weight microphone because an amplifier in the form of a tiny clip is used inside inside this microphone

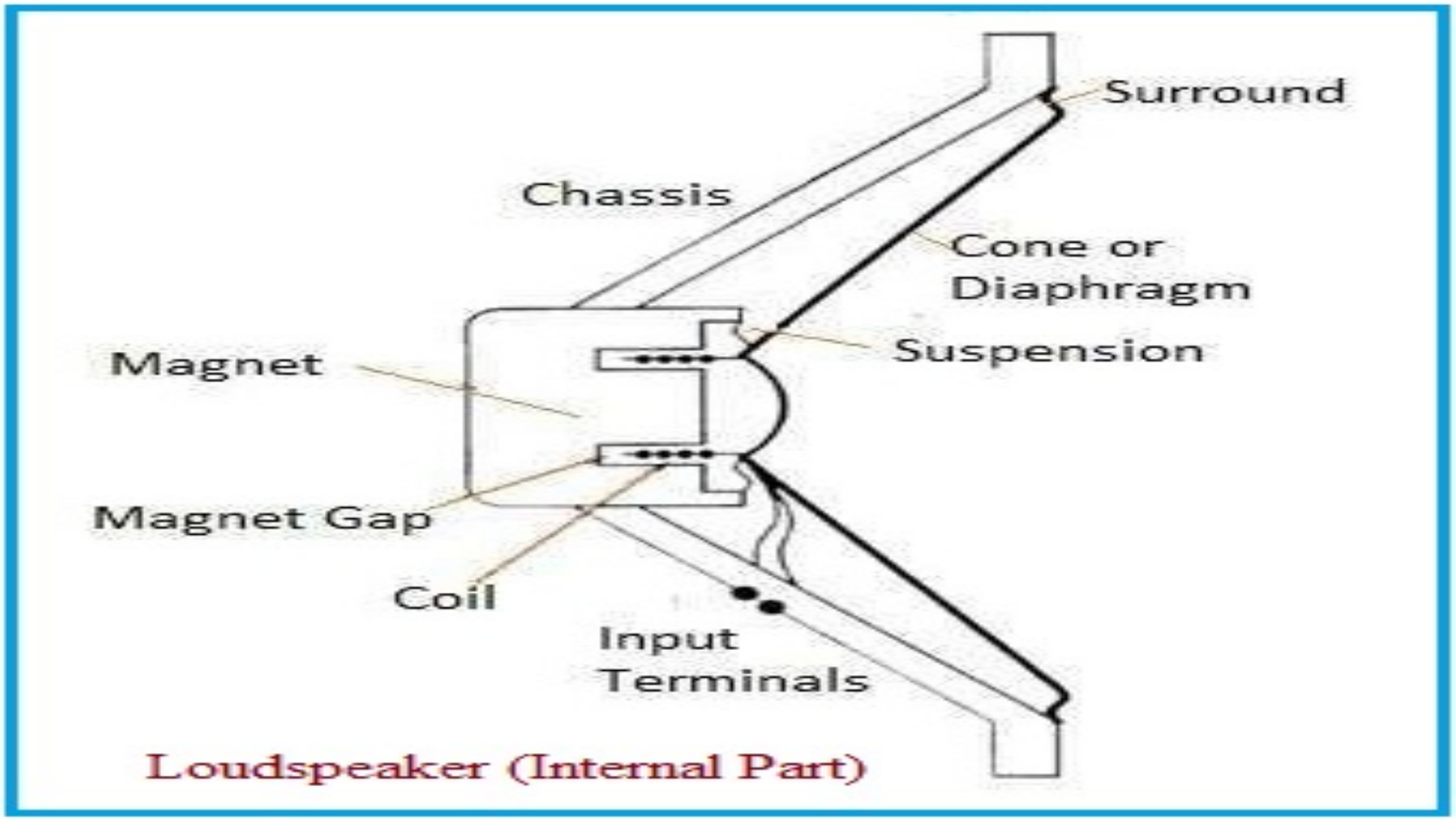
Loudspeaker

- Loudspeaker is an electro caustic transducer which converts the electrical signal at audio frequencies into sound waves
- The frequency of the sound waves will be same as that of the electrical signal and the intensity of sound ill be proportional to the magnitude of the electrical signal

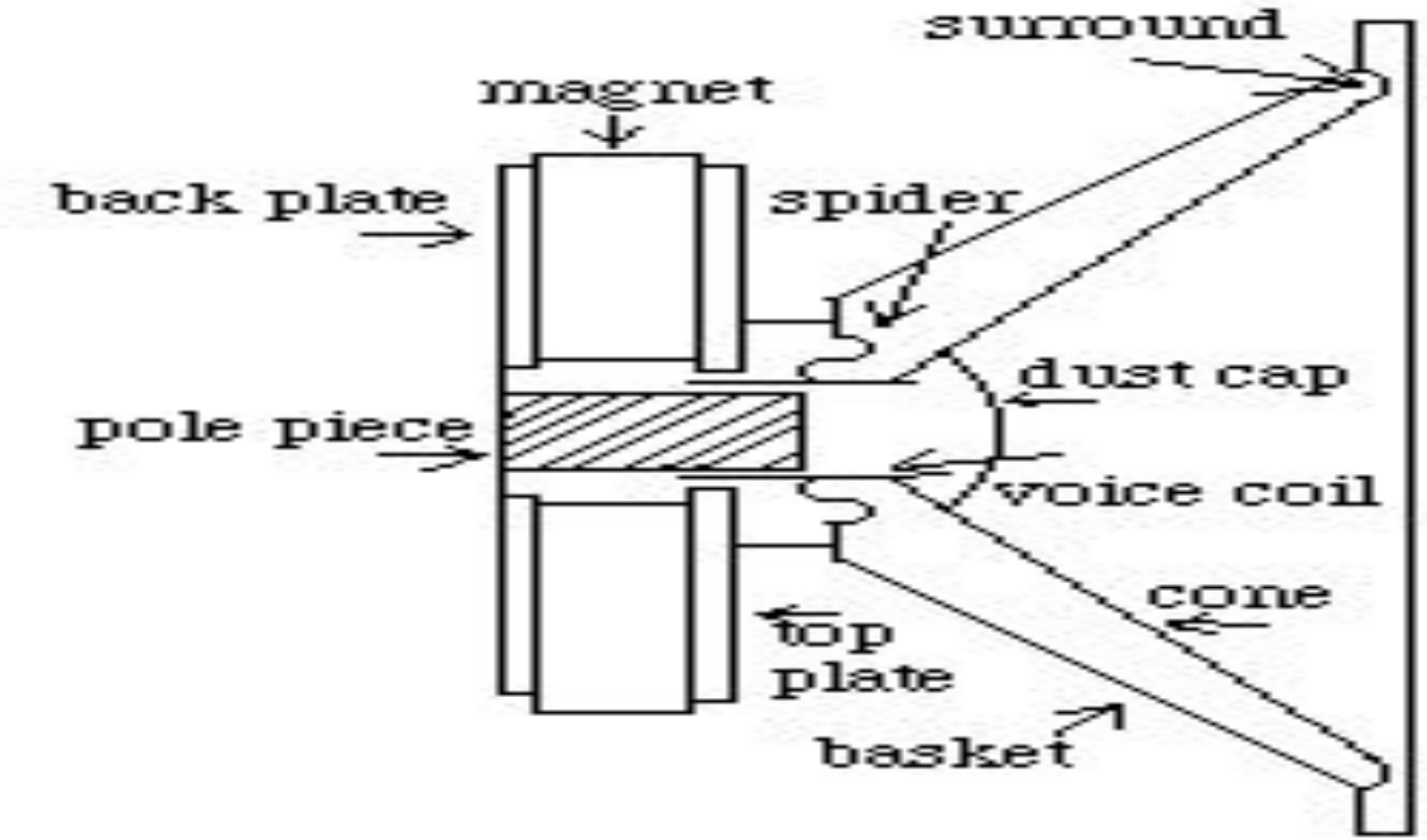
Characteristics of Loudspeaker

- Directivity
- Signal to noise ratio
- Efficiency
- Frequency response
- Distortion
- Speaker coil impedance
- Power handling capacity

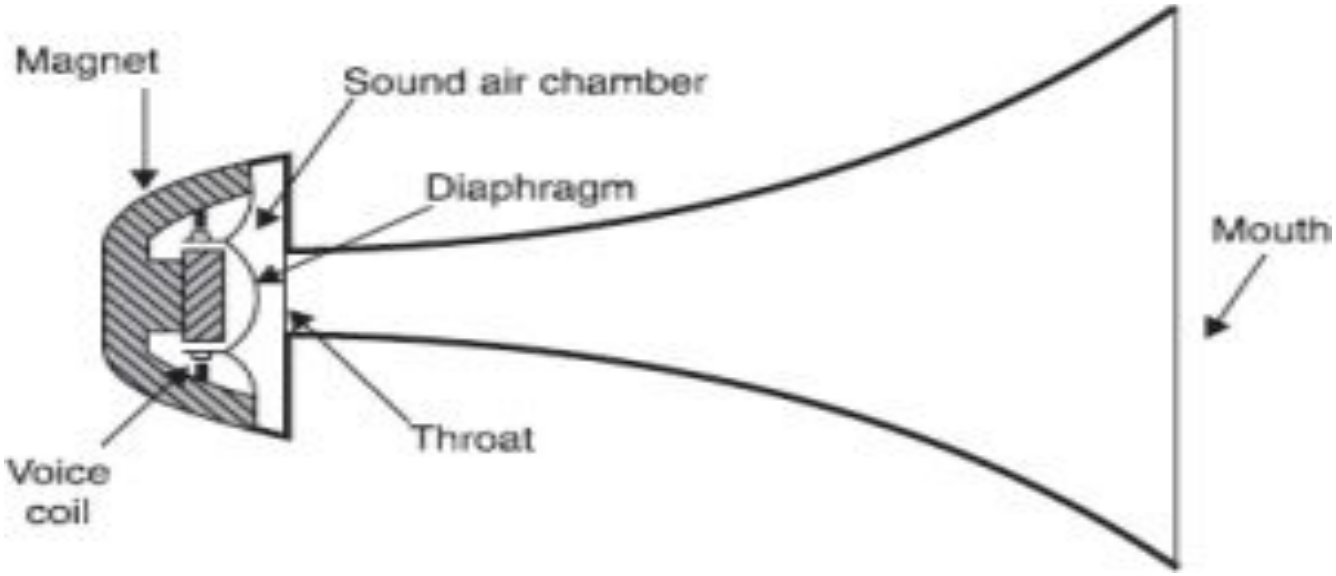
Moving coil or cone type



Electrodynamic Loudspeaker



Horn Type Loudspeaker



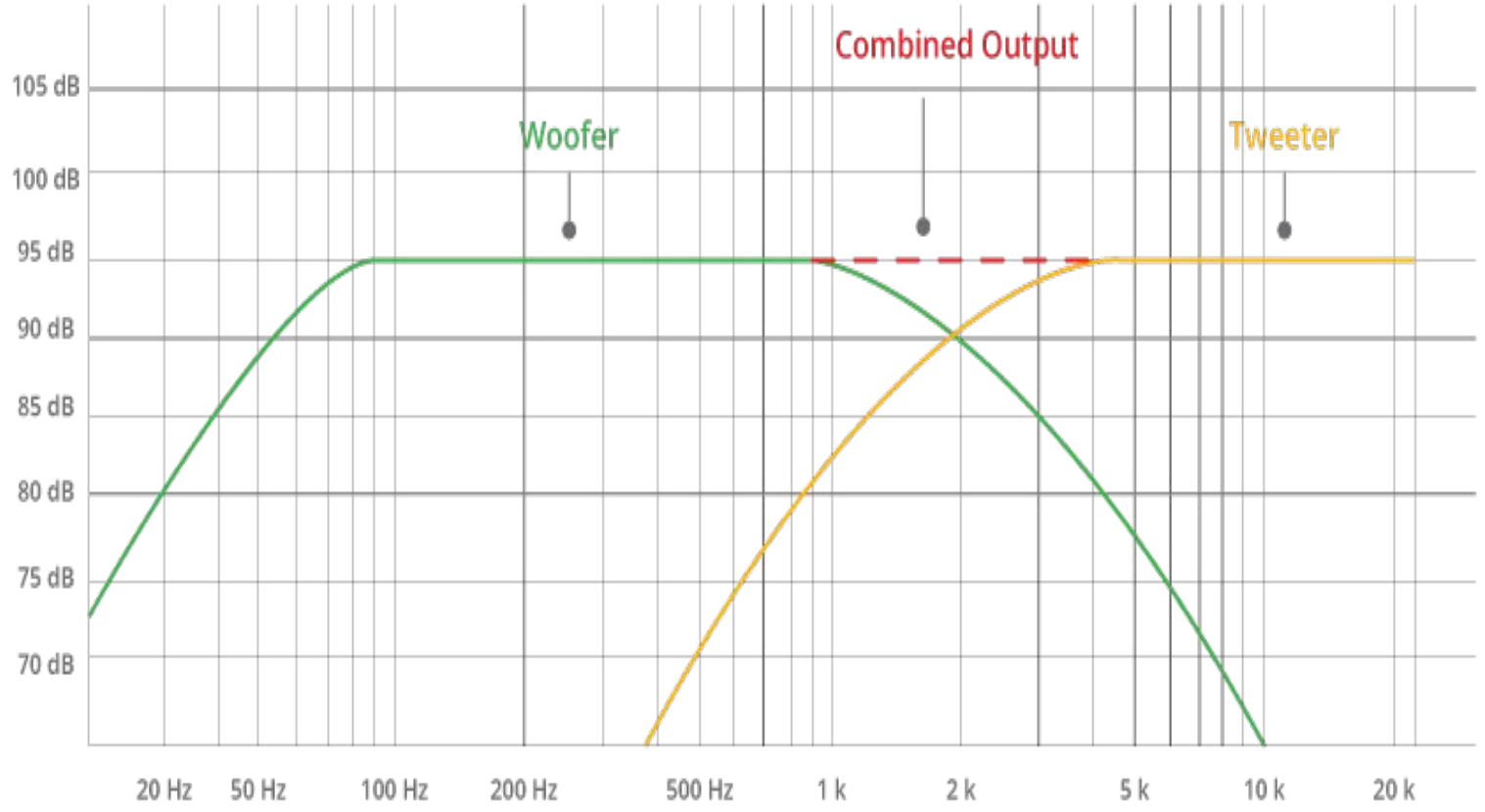
Comparision of Cone Type,Electrodynamic type and Horn Type

- Principle Of operation
- Directivity
- S/N ratio
- Efficiency
- Frequency Response
- Distortion
- Speaker impedance
- Power handling capacity
- Radiation of sound
- Impedance matching
- Size
- Cost

Multispeaker system

- Woofers
- Squawkers
- Tweeters

Frequency response of multispeaker system



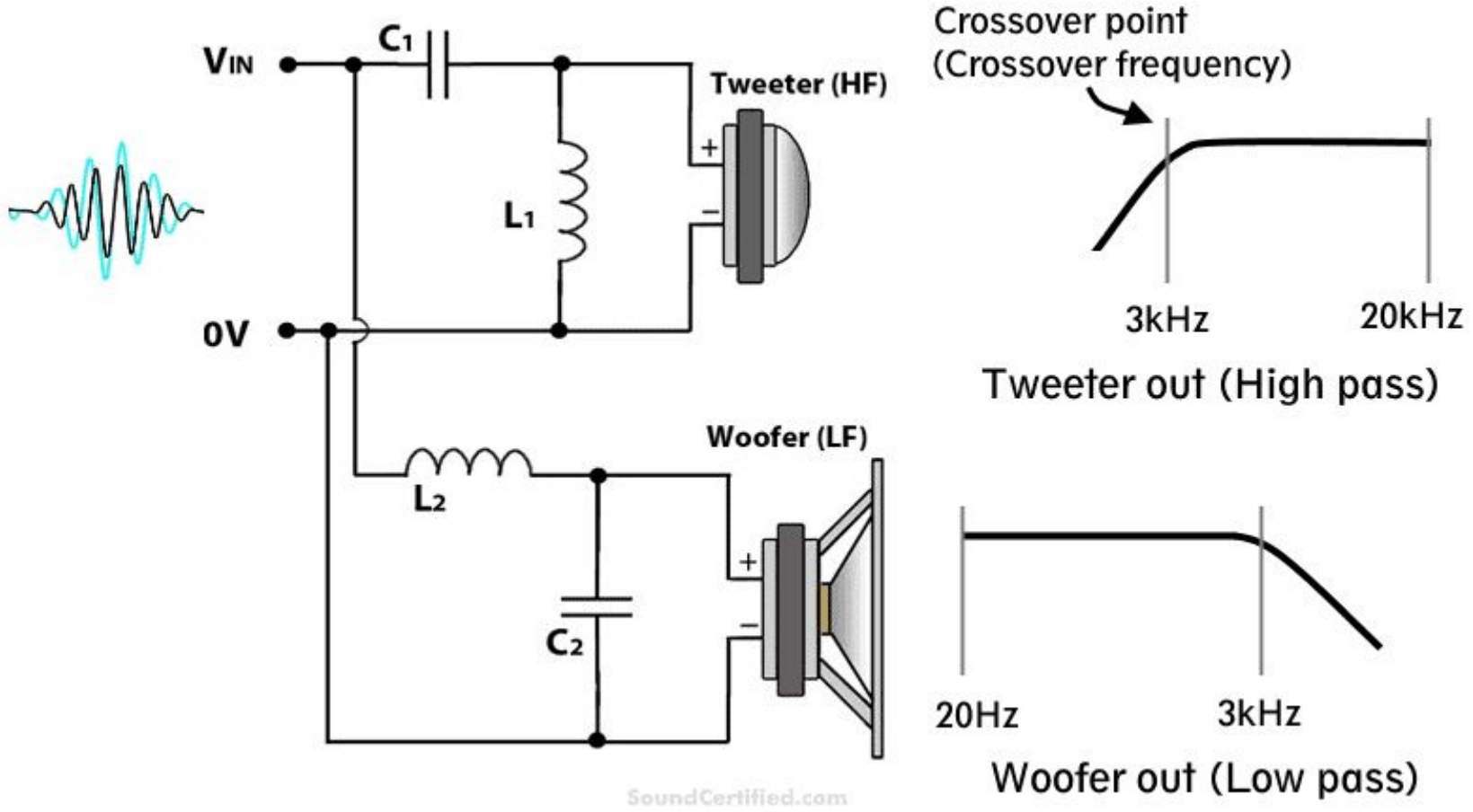
Comparision of Woofer Squawker and Tweeter

- Frequency Range
- Size
- Placement inside the enclosure
- Attenuation
- Application
- Cost
- Cross over network
- Frequency Response
- Weight

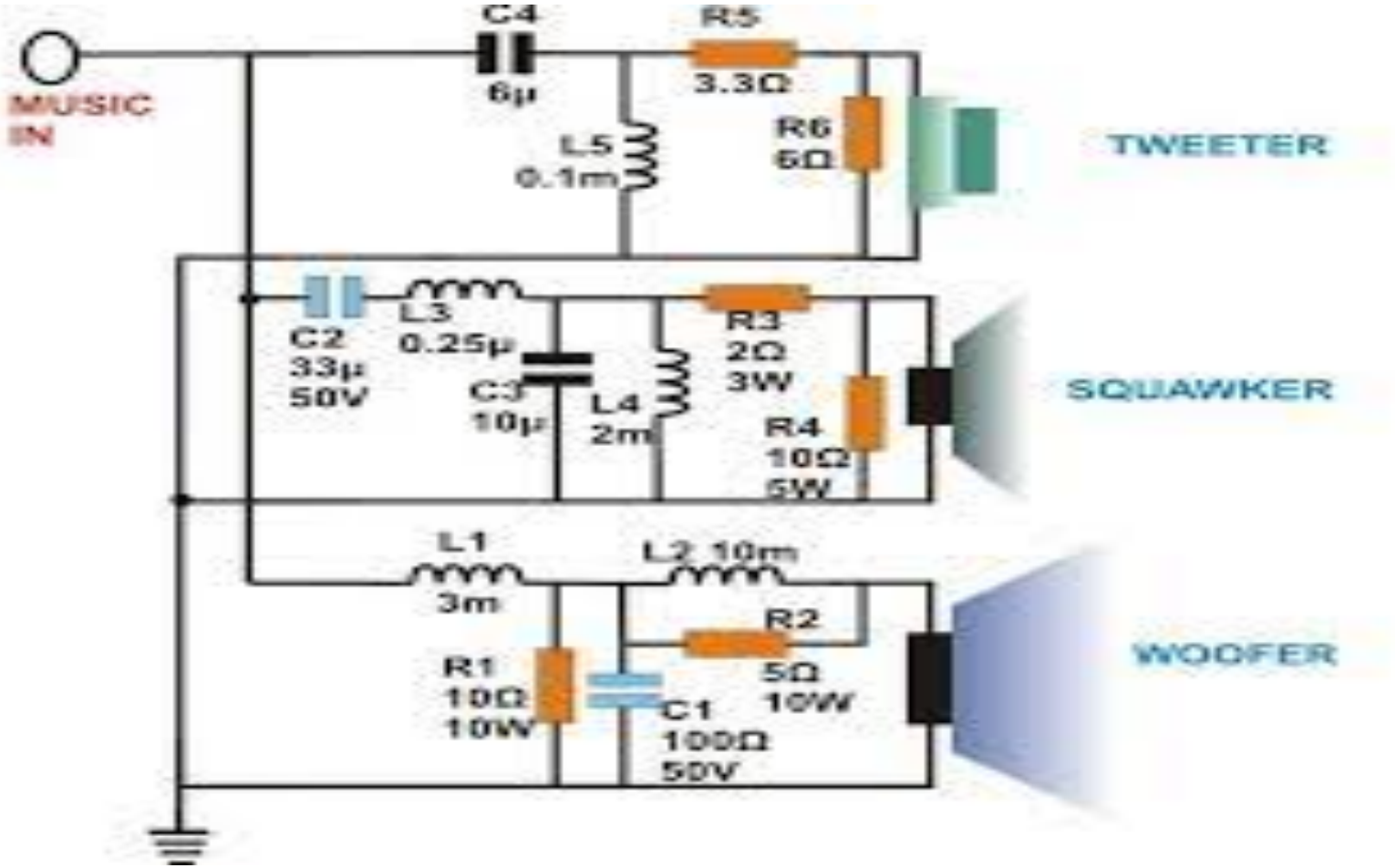
Cross over network

- Introduction
- Need
- Types of cross over network
- Two way cross over network
- Three way cross over network

Two way cross over network



Three way cross over network



Troubleshooting Steps in Audio and Video Equipment

- Inspect the Equipment physically
- Test the power supply
- Identify the Faulty section
- Identify the faulty stage and component
- Determine the cause of the fault
- Rectify the fault