# Loudspeakers

**by Arun Rama Varma**

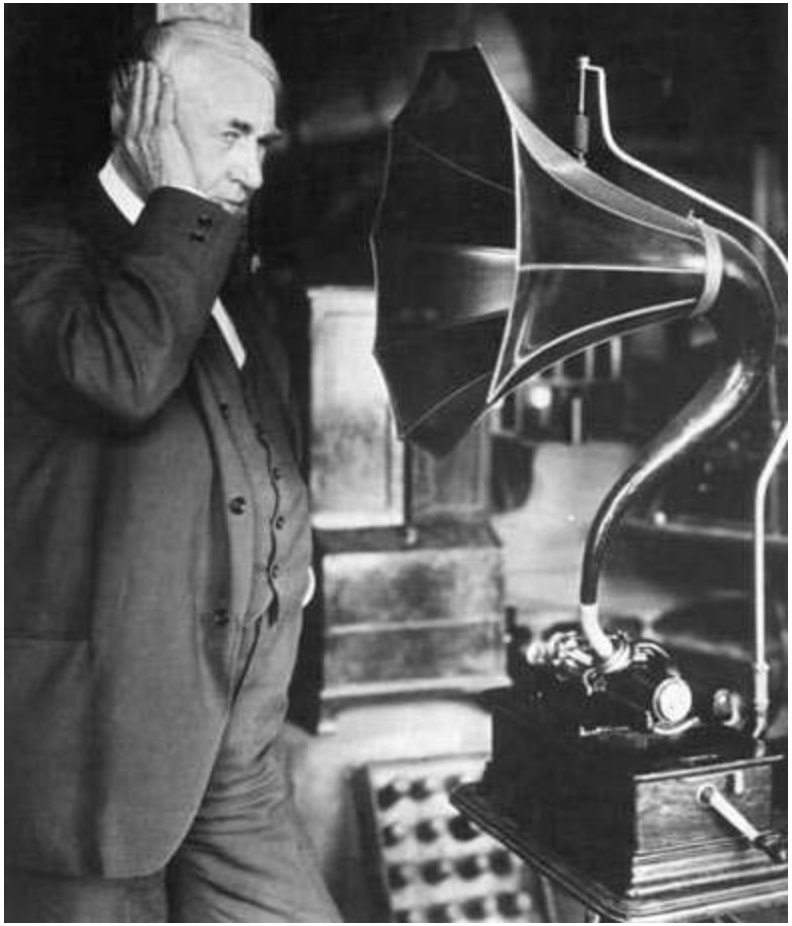
# Loudspeakers

- Loudspeakers are devices which convert electrical energy to acoustical sound energy
- The loudspeaker involves electromechanical processes where the amplified audio signal must move a cone or other mechanical device to produce sound like the original sound wave.
- A speaker is essentially, the reverse of the microphone

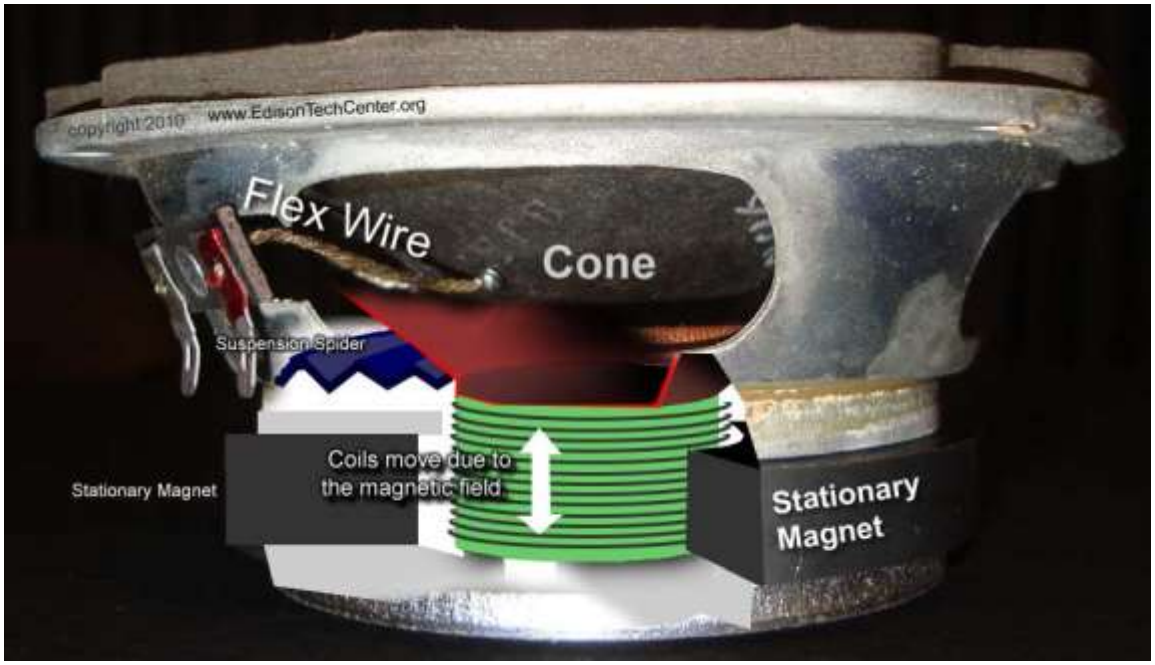
- **Dynamic loudspeaker** that we know of today was first built in the 1920's and uses a magnetic field to move a coil or magnet which is connected to a diaphragm.

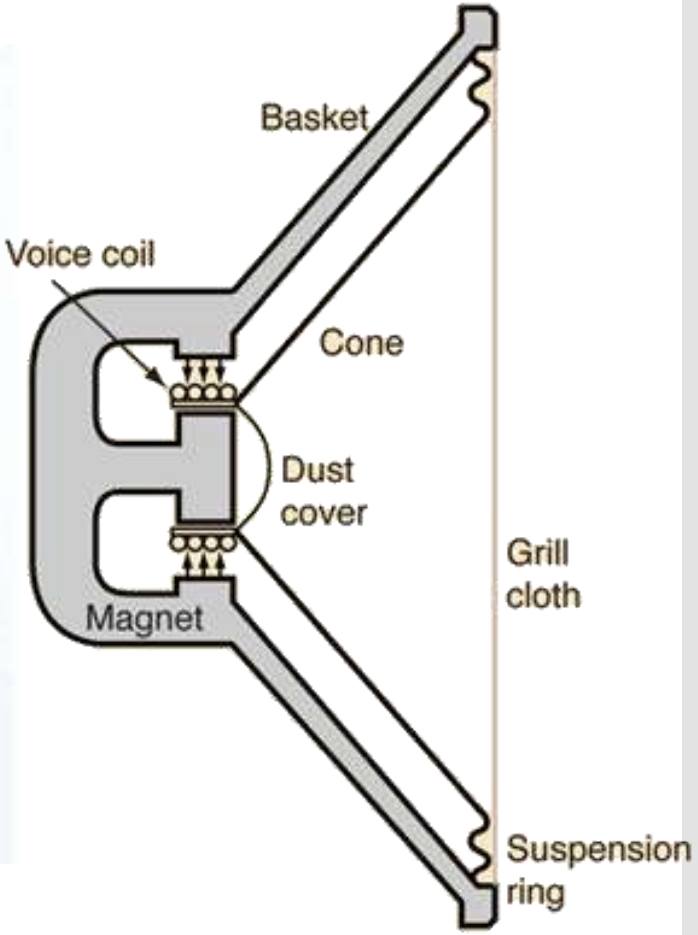
# Early Designs - Horns

- Horns were the earliest form of amplification.
- Horns do not use electricity.
- Thomas Edison, Magnavox, and Victrola all developed advanced and well-performing horns from 1880 to the 1920's.
- The problem with horns is that they could not amplify the sound very much.



# The Electrodynamic Loudspeaker



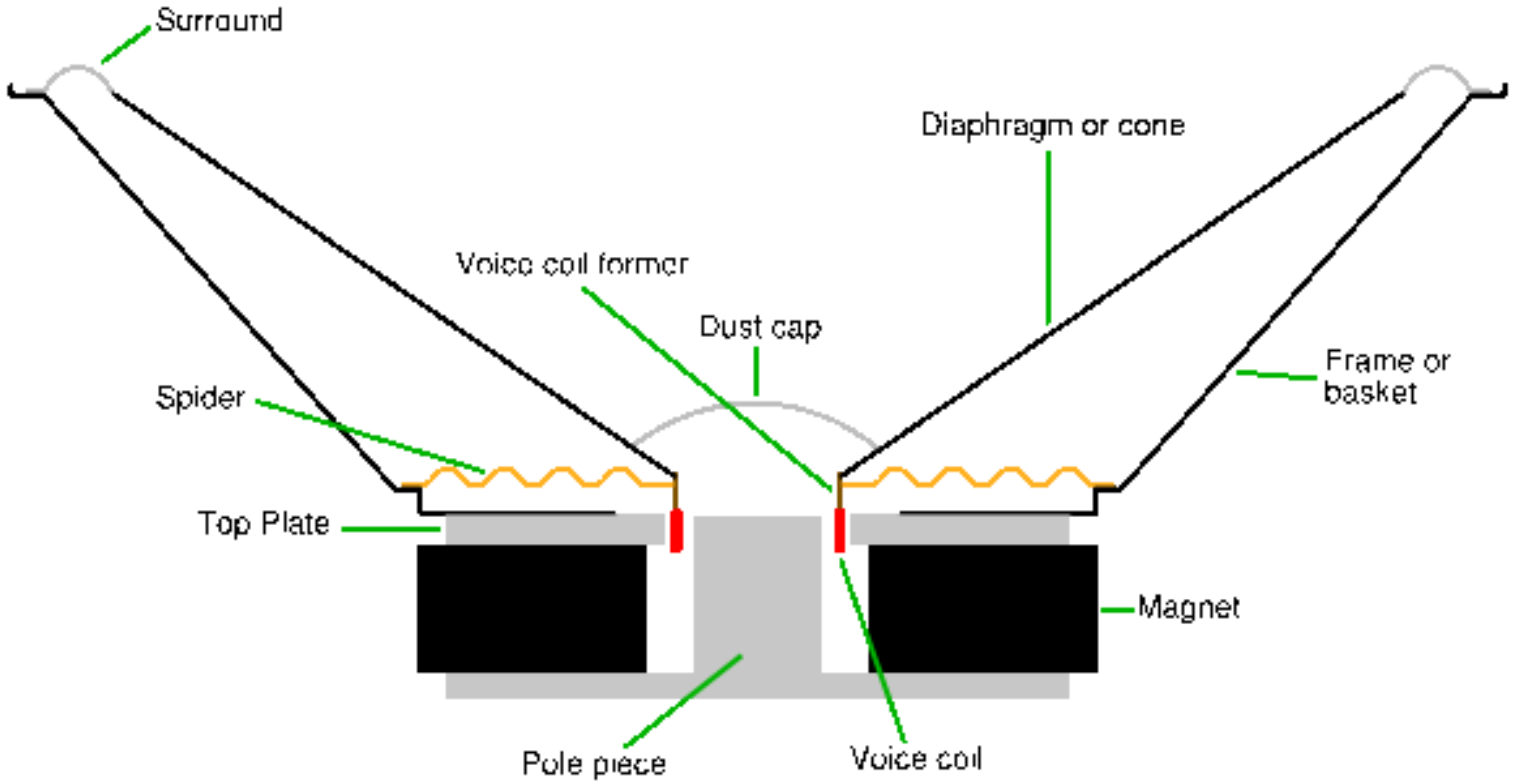

Basket
Voice coil
Cone
Dust
cover
Grill
cloth
Magnet
Suspension
ring

- **Voice Coil**
  - The voice coil is a basic electromagnet.
  - Voice coil is mounted so that it can move freely inside the magnetic field of a strong permanent magnet.
  - **When the electrical current flowing through the voice coil changes direction, the coil's polar orientation reverses.**
  - The coil is connected to a cardboard/paper/vinyl "cone".
  - The cone is a diaphragm that vibrates along with the coil.

- **Magnets**
  - The electromagnet (coil) is positioned in a constant magnetic field created by a **permanent magnet**.
  - When the electromagnet's polar orientation switches, the direction of repulsion and attraction varies.
  - The alternating current constantly reverses the magnetic forces between the voice coil and the permanent magnet. This pushes the coil back and forth rapidly, like a piston.

# Diaphragm

- A driver produces sound waves by rapidly vibrating a flexible **cone**, or **diaphragm**.
- The **cone**, 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 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.




- Electrical energy passed from an amplifier is converted into kinetic energy as the loudspeaker cone moves in and out via electro-mechano-transduction.

- The **voice coil** is attached to the **cone,** which is in turn held in a steel **basket** and fixed to a **surround**.
- Flux is generated by a magnet and guided by **steel plates** and a **pole piece** effectively forming a magnetic circuit.
- As a time varying current is passed through the coil the interaction with the flux generated by the **magnetic** causes a force.
- A **spider** is needed to centre the voice coil in the gap, these are generally made of steam pressed cotton.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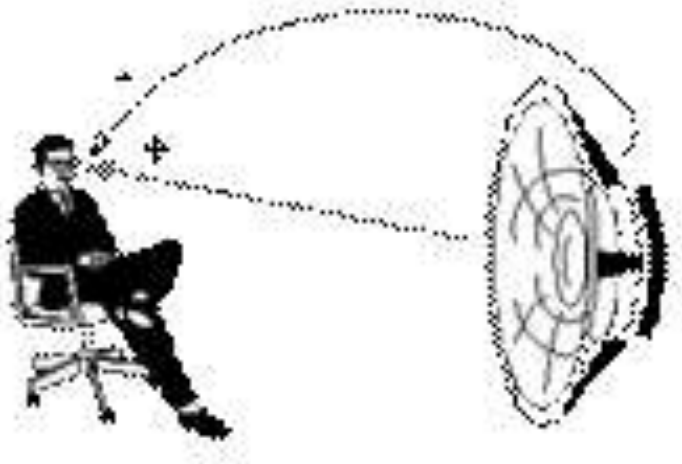
# Un-enclosed loudspeakers

- An un-enclosed loudspeaker radiates sound as an acoustic "dipole". This gives rise to a poor frequency response (*since sound from the back of the diaphragm cancels sound from the front*) and highly directional radiation.

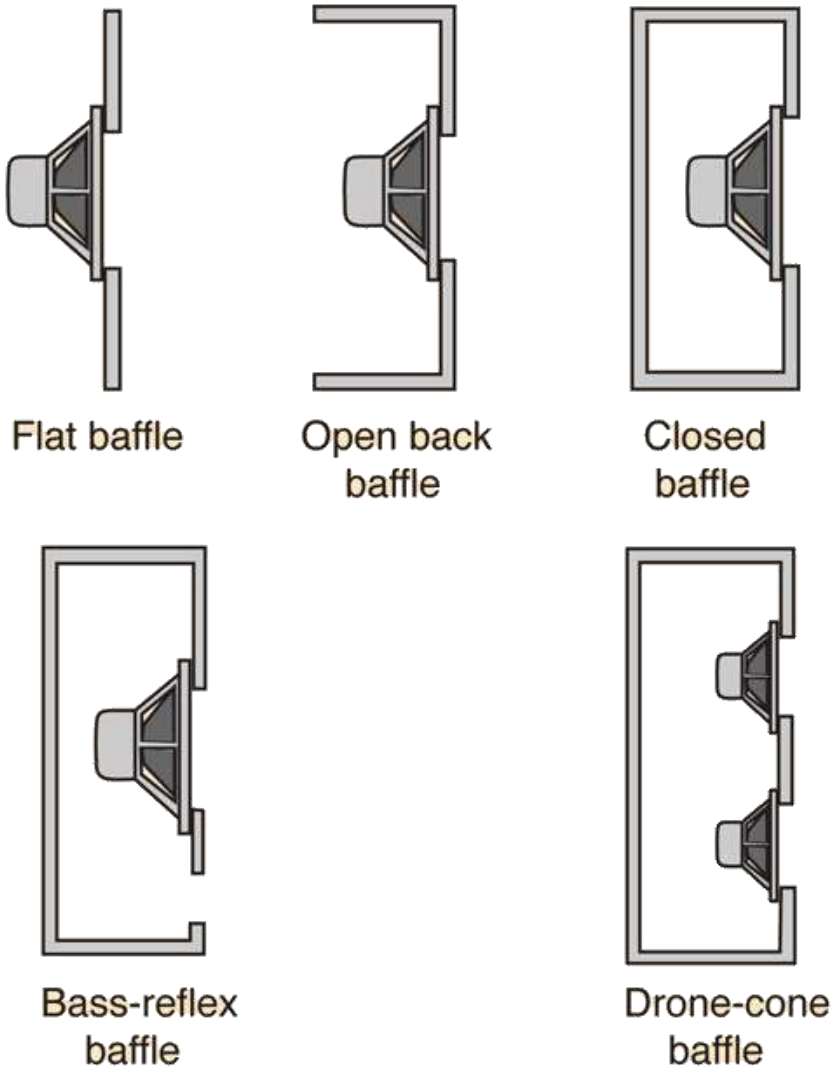


- Putting a single dynamic loudspeaker in a closed box will improve its sound quality dramatically.
- The nature of the enclosure can affect the efficiency and the directionality of a loudspeaker.

# Speaker Enclosures

- Designed to reduce the free-cone problems of cancellation and resonance
- Also referred to as “baffles” or “cabinets”
- Several types: two of the most common are the “sealed” enclosure and the “bass-reflex” enclosure

# Types of Enclosures

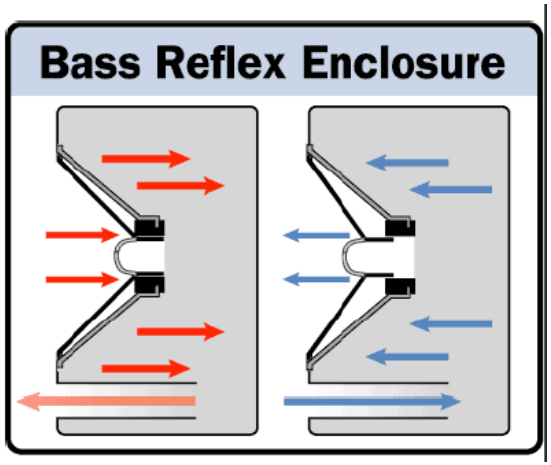


# Closed-box Enclosures

- Completely sealed, usually contains sound-absorbing material inside
- Soundwaves emitted from rear of driver do not reach open air
- Cheaper to manufacture, more common

# Bass Reflex Enclosures

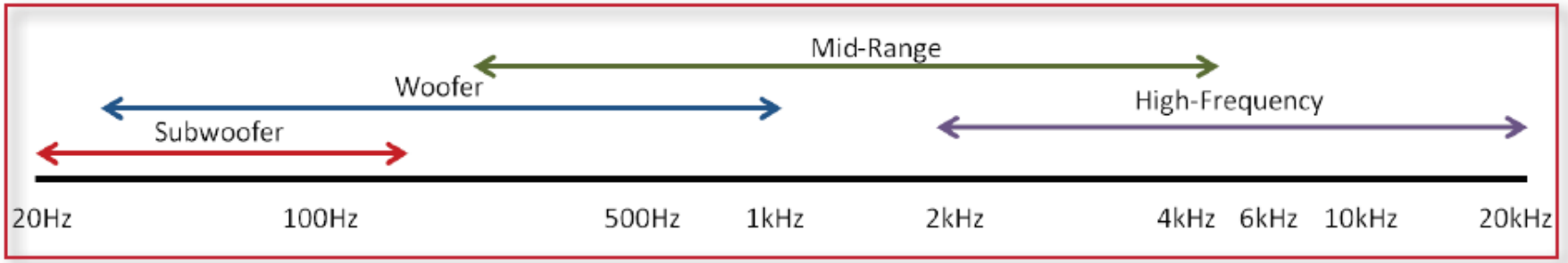
- The bass reflex enclosure is a closed box enclosure with a "port" in one of the enclosure walls
- Air inside bass port resonates at specified low frequency
- Reduces movement of speaker cone at bass port frequency ➔ increases efficiency and low frequency output



# Use of Multiple Drivers in Loudspeakers

- A single loudspeaker cannot be expected to deliver optimally balanced sound over the full audible sound spectrum.
- For the production of high frequencies, the driving element should be small and light to be able to respond rapidly to the applied signal. Such high frequency speakers are called "tweeters".
- A bass speaker should be large to efficiently impedance match to the air. Such speakers, called "woofers".

- From lowest to highest frequency, the most common types of drivers are **subwoofers, woofers, mid-range, and high frequency**.
- Full- or wide-range drivers, which provide good low and high frequency response, are also available




*Common loudspeaker driver types and the audio frequencies they reproduce*

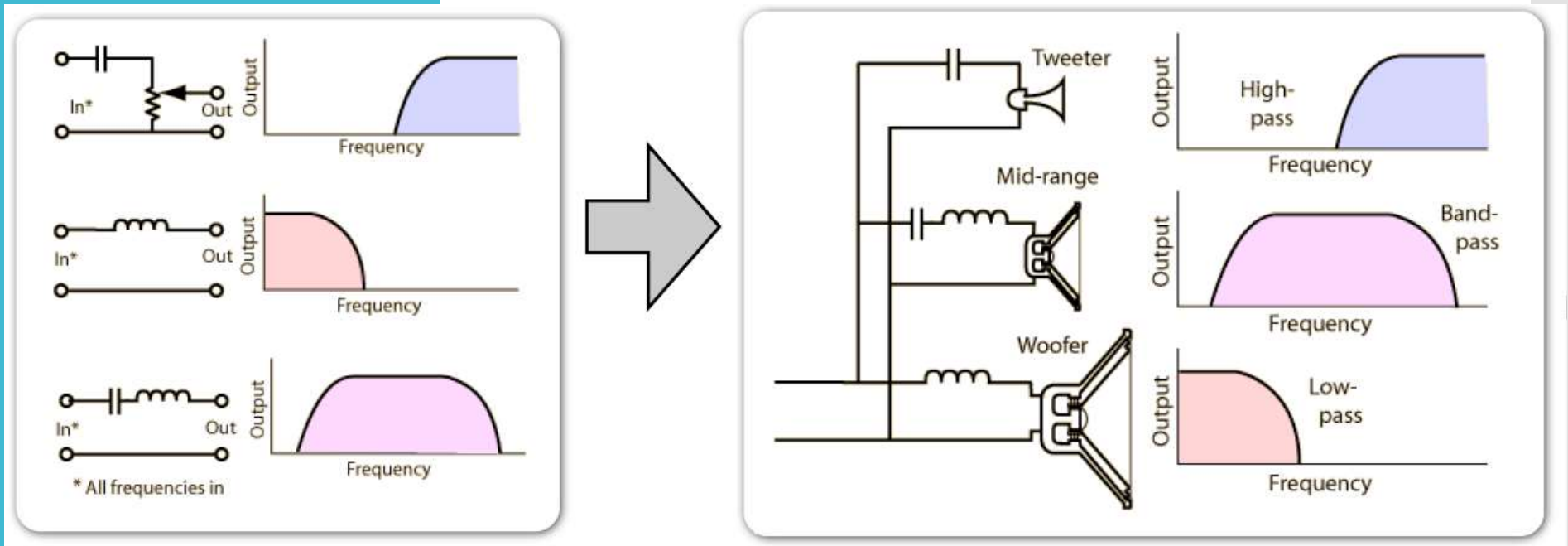

- Tweeter
  - small, light, very responsive
  - 3 kHz - 20 kHz
  - Often uses convex "dome" construction
- Bass/mid driver
  - larger, heavier, less responsive
  - 30 Hz - 3 kHz
  - Require more power to drive greater mass

# Cross-over Network

- Circuit which divides the signal into different frequency ranges, and sends them to corresponding drivers (woofer and tweeter)
- Active and Passive

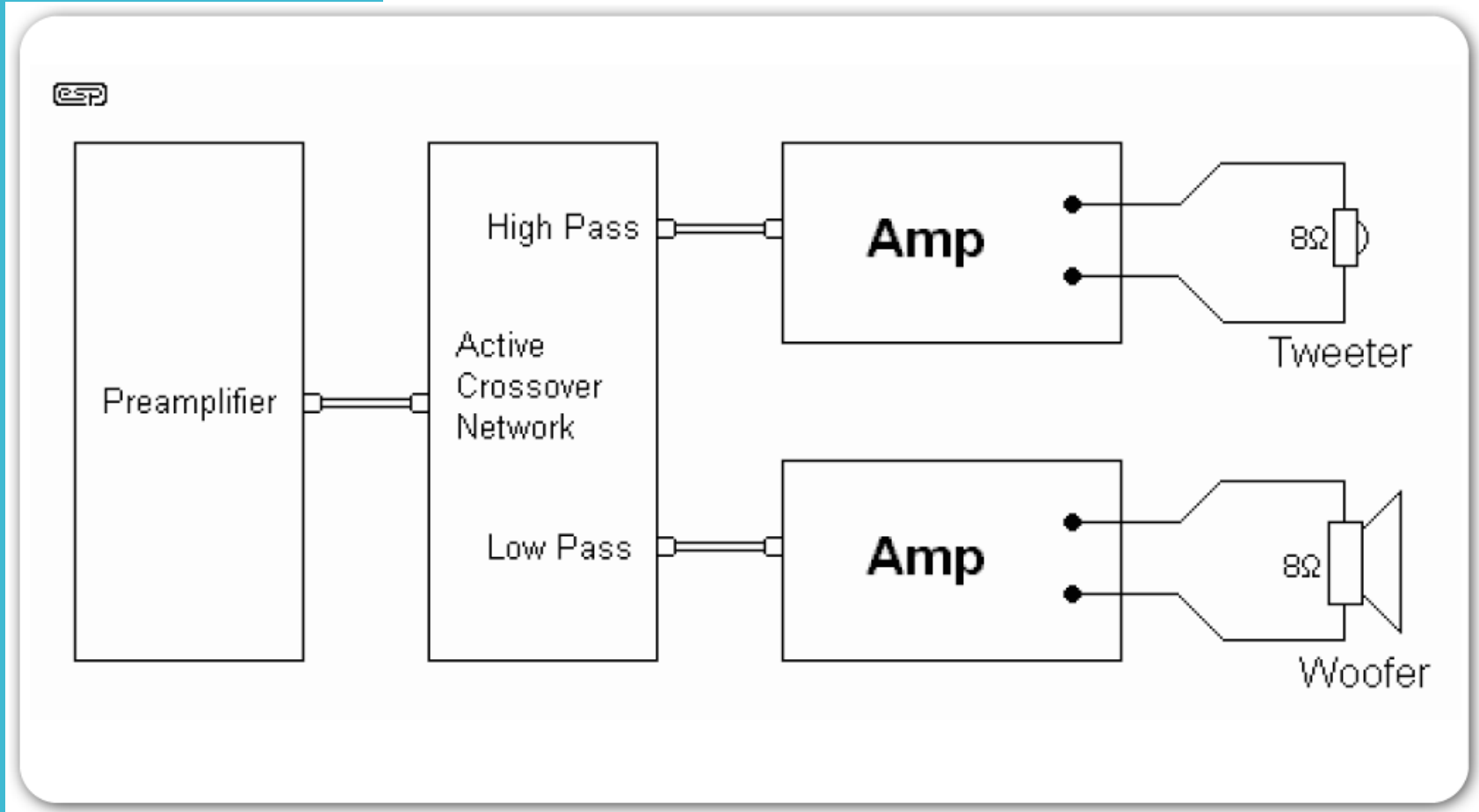
# "Passive" Crossover Network

- Uses passive components to divide signal: resistors, capacitors, inductors
- Hi-pass filter: capacitor with lower impedance for high frequencies
- Low-pass filter: inductor with lower impedance for low frequencies
- Band-pass filter: Capacitor and inductor in series


In*
Out
Output
Frequency
In*
Out
Output
Frequency
In*
Out
Output
Frequency
* All frequencies in
Tweeter
Mid-range
Woofer
Output
High-
pass
Frequency
Output
Band-
pass
Frequency
Output
Low-
pass
Frequency

# "Active" Crossover Network

- Uses "active" electronic circuitry (i.e. transistors, valves) to divide audio signal
- Each driver has own power amplifier
- Downsides: more expensive, complex
- Benefits: Lower distortion, greater flexibility of design, better control of frequency response, clearer highs, tighter lows


Preamplifier
Active
Crossover
Network
High Pass
Low Pass
Amp
Amp
8Ω
8Ω
Tweeter
Woofer

# Directivity

- At low frequencies sound propagation is omni directional (spreads out in all directions)
- for high frequencies, sound propagation becomes much more directional.
- This holds true for speakers where the placement of sub woofers is less important than higher frequency monitors.