

Passive vs Active Loudspeakers

Revised, February 2024, Ben Lilly.

What are the differences between passive and active loudspeakers?

Passive loudspeakers employ crossover filters that only use passive components: capacitors, inductors, and resistors. They can attenuate the signal, and whilst amplification is achievable over limited frequency bands, it is only via resonant 'ringing' circuits which are undesirable. The position of the filters within the signal chain is between the power amplifier(s) and loudspeaker drive units, so they operate at 'high level' and are exposed to high voltages and currents, resulting in components that are physically large and with high power handling. The filters are loaded with relatively low impedances, so the component capacitance and inductance values are high. The combination of high-power handling, large size and high component value results in expensive parts.

Active loudspeakers employ active (powered) crossover filters that can attenuate and amplify the signal. They may also include filters that affect the phase/timing of the signal plus limiters to ensure amplifiers do not 'hard clip'. The position of the filters within the signal chain lies between the pre-amplifier and the power amplifiers. Their nominal operating level is around 1 volt, and the filters operate at relatively high impedance, resulting in filter components of modest size and value. Each loudspeaker frequency band has its own dedicated power amplifier; typically, two in a 2-way system and three in a 3-way system. Small to medium sized active loudspeakers typically feature all the electronics within their loudspeaker enclosure. Larger systems featuring more powerful amplifiers may have a separate enclosure(s) for the electronics.

While it is possible to design a high-performance loudspeaker using passive components – and ATC make some outstanding passive systems - an active design will always outperform its passive equivalent due to many benefits. These are listed below:

1. More Accurate Crossovers

- 1.1. Typical loudspeaker loads - or impedances – found in commercial products are 4, 6 and 8 ohms. When designing passive crossover filters, the component choices are based on the load the crossover filter 'sees' which, in the case of a passive loudspeaker, are the loudspeaker drive units. Herein lies a problem as the load a loudspeaker driver presents to a passive filter varies with both frequency and temperature. When the listening volume and amp power increases, so does the driver voice coil temperature. This results in a passive filter with a crossover point and damping factor that changes according to the listening level and input power and results in a loudspeaker system which has a different 'voicing' at lower vs higher volume levels.

Conversely, the performance of an active filter does not change with listening level and input power as they are not connected directly to the loudspeaker drive units. Instead, they are connected to the active speaker power amplifiers which provide a fixed load and consistent listening experience, regardless of volume level.

- 1.2. The phase response of both passive and active crossover filters is tightly linked to the filter frequency, order and Q-factor. Modifying any of these filter parameters will also change the phase response, which may result in an undesirable phase difference at the

crossover point. Further subsequent changes to improve the phase response will lead to compromises elsewhere.

Within an active system we can include additional all-pass filters. These are circuits which pass all frequencies equally but change the phase relationship between different frequencies, therefore offering the ability to optimise the phase response through the crossover region. With a well-engineered active system, the crossover filter and resulting active loudspeaker system will have a superior phase response to the passive equivalent, with an improved tonal balance, and far superior imaging.

2. Wider Practical Choice of Crossover Type/Shape

The large value, high power components used in passive crossover networks are bulky and expensive. As a result, if the ideal filter choice is of a more complex design, practical space and cost considerations may lead to a compromise.

Once the choice has been made to implement an active crossover, increases in circuit complexity result in modest space and cost increases, and the final design is unlikely to be compromised, resulting in higher performance and a better listening experience.

3. Greater Dynamic Range

Passive crossover filters are driven by power amplifiers and operate at 'high level' and low impedance. Even if a designer is willing to ignore practical limitations in relation to physical size and cost, the large high-power inductors required for passive filters will have series resistance that results in a reduction in system efficiency (power dissipated as heat in the inductor).

Active crossover filters are located before the power amplifiers and operate at line level loaded with relatively high impedances. As a result, the circuits offer virtually zero loss, and an active loudspeaker system will offer improved dynamic range when compared to its passive equivalent.

4. Ideally Matched Amps and More Efficient use of Power

Amplification for passive loudspeaker systems is usually selected based on customer and retailer experience alongside the loudspeaker manufacturers published data. Due to a lack of clarity, amplifiers can easily be under specified resulting in poor performance or over specified resulting in far higher costs.

As an active loudspeaker system is designed and engineered by a single company with the greatest level of insight into the requirements of the loudspeaker; all aspects of the amplifier performance can be perfectly matched. Not only that, but as power is not wasted in passive crossover networks, the designer has the option to use smaller amplifiers or alternatively, to offer greater dynamic range.

5. Improved Frequency Response and Stereo Matching

Passive loudspeaker frequency response and stereo matching relies on drive unit and crossover component tolerances. The adjustment of production units to match a 'golden

reference' would require the replacement of large, soldered components. In practice, this is too difficult and time consuming.

Within an active system, it is simple and cost effective to implement individual gain trims for the two, three or four amplifiers involved. This allows fast and effective fine tuning of the loudspeaker response, ensuring that active systems have better stereo matching, a flatter frequency response and are more enjoyable to listen to.

6. Better Driver Control

Any electrical resistance that exists between an amplifier output and drive unit input reduces an amplifier's damping factor and its ability to control the drive unit motion. A conventional passive loudspeaker features series inductors within the crossover circuit and, typically, 3 metres (10 feet) of speaker cable between the amp output and driver input. Both resistances reduce driver control and, at worst, can result in undesirable ringing/resonance over certain frequency bands.

An active speaker employing active crossover filters and on-board amplifiers results in the best possible driver control, as there is only a short length of speaker cable between the amp output and driver input.

7. Lower Intermodulation Distortion

Passive systems are usually driven by a single amplifier that operates over the full audio band. The amplifier is burdened by the heavy workload of low frequency reproduction whilst also having to amplify the subtle details in the mid and high-frequency range. The high-power demands from the low frequencies can cause the amplifier to clip, generating subsequent loss in quality in the higher frequency bands.

Not only must the amplifier drive the speaker, it must also act to damp any voltage generated by the driver(s) in operation. High-performance amplifiers are designed to have a very low output impedance and subsequent high damping factor, so their output is affected as little as possible by voltages generated by the loudspeaker drivers. But they must also contend with intermodulation distortion caused by nonlinearities or time variance in the signal processing, which produces additional components (spikes) in the frequency response. Inserting a resistive passive crossover between the driver and amplifier is likely to increase intermodulation distortion.

Active systems feature multiple amplifiers dedicated to each frequency band, and as the amplifiers are located after the crossovers, they operate over a limited bandwidth. In addition, the amplifiers have the lowest possible resistance connection to the drive units, leading to optimal damping of reverse voltages generated by the drivers. This reduces intermodulation distortion, and, in comparison to a passive system (even a bi or tri-amped passive system) an active system will show 15-to-20dB lower intermodulation distortion, resulting in greater clarity and less listening fatigue.

8. Better Value

For a very long time, improvements to a Hi-Fi system have relied on small incremental improvements to separate components within a system, whilst often overlooking the fact that the loudspeaker (and its environment) are the weakest elements.

Active loudspeakers offer a significant improvement in performance to the weakest link in the signal chain, resulting in outstanding value. In addition, because an active system is designed, engineered, and manufactured by a single company into as compact a package as the design allows, cost is saved on electronics case work and packaging. The manufacturer can invest in real performance enhancing changes or pass the saving on to the customer.