13.7 Crossovers

13.7.1 General Model

We have discussed low frequency and high frequency drivers and enclosures, each of which is designed only to reproduce a specific, limited frequency range. To reproduce the entire audio range, such drivers and enclosures are combined into multi-way systems.

Generally low and high frequency devices cannot be connected directly together to be driven by a single power amplifier's output. For one thing, the ragged acoustic outputs of the low and high drivers outside their respective frequency ranges may not add together properly. This would result in poor frequency response. Low frequencies, moreover, can actually damage high-frequency drivers (see Section 13.11, "Typical Failure Modes.")

For these reasons, it is necessary to somehow divide the full-range audio signal into its low and high frequency components, directing each only to the appropriate driver(s). This is the function of the crossover. Other terms for crossover are *frequency dividing network* or *crossover network*, all of which mean the same thing.

Figure13-18 (a) shows a two-way loudspeaker system consisting of a direct radiator (a vented enclosure with a cone type low frequency driver) and a horn loaded high frequency driver. An idealized version of the crossover characteristic typically used for such a system is shown in (b).

Above a certain frequency, the input to the low frequency driver gradually falls off. The input to the high frequency driver also falls off below a certain frequency. The point along the frequency axis of the graph where the two curves meet is called the crossover point.

We can see that the crossover point is, for each driver, 3 dB down in relation to the flat portion of each frequency band. Three dB is one half the power output; in this crossover region the acoustic outputs of the two drivers add together to fill the 3 dB hole.

Similar principles apply in three-way systems. Figure 13-19 (next page) shows an idealized crossover characteristic for a such a system.

The rate at which the level to each driver falls off beyond the crossover point varies in different designs, and is called the *slope* of the crossover. Typical crossover slopes are 6, 12, 18 and 24 dB per octave The filters that create these slopes are known, respectively, as first, second, third or fourth order filters (each order represents another 6 dB per octave, and another circuit section in the filter network).

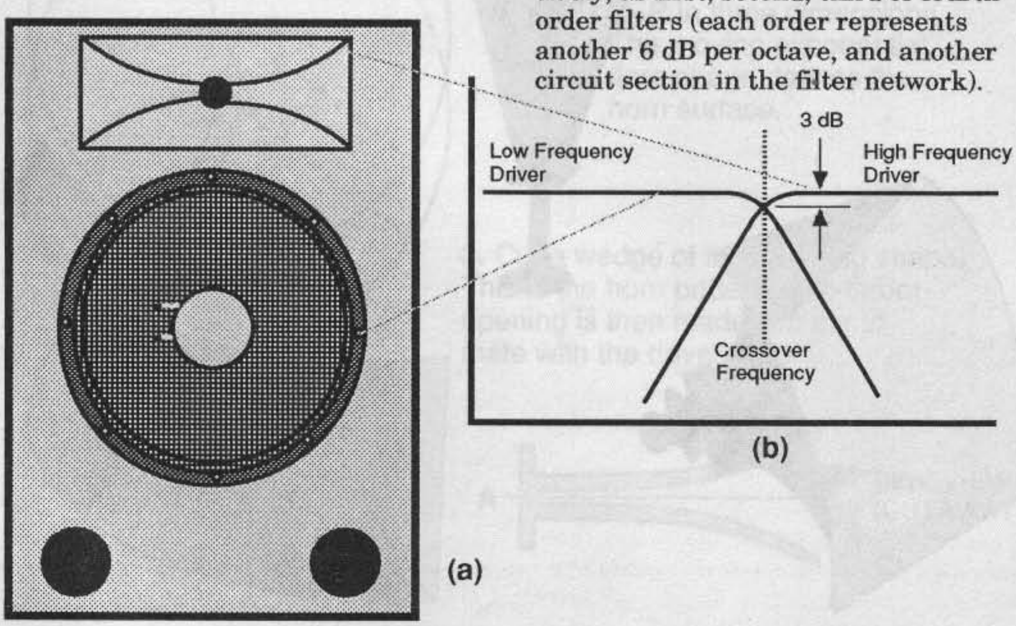

Figure 13-18. A typical 2-way loudspeaker system and its idealized crossover response characteristics

A 6 dB/octave slope generally allows for too much overlap between the drivers. It may be OK for a crossover between two cone type drivers (though such gradual rates do exacerbate time alignment problems), but it does not adequately protect the high frequency compression driver from damaging low frequencies. The most commonly used crossover slopes in high level professional sound systems are 12 dB per octave and 18 dB per octave.

Two generic types of crossover are in common use in sound reinforcement: high level passive networks, and low level active networks.

13.7.2 Passive, High Level Crossovers

Passive, high level crossovers are simple networks that are designed to pass high signal levels. They are inserted between the power amplifier output and the drivers. Passive cross-overs are most often enclosed in the loudspeaker cabinet, as shown in Figure 13-20, although some are mounted externally.

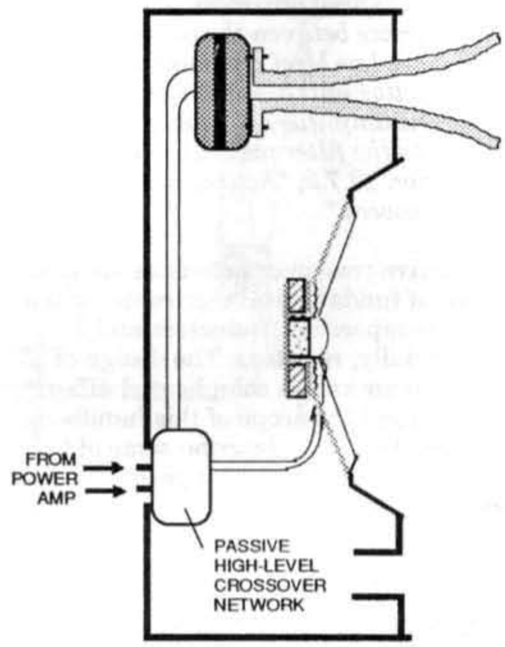

Figure 13-20. Typical location of a passive, high-level crossover network inside a loudspeaker enclosure

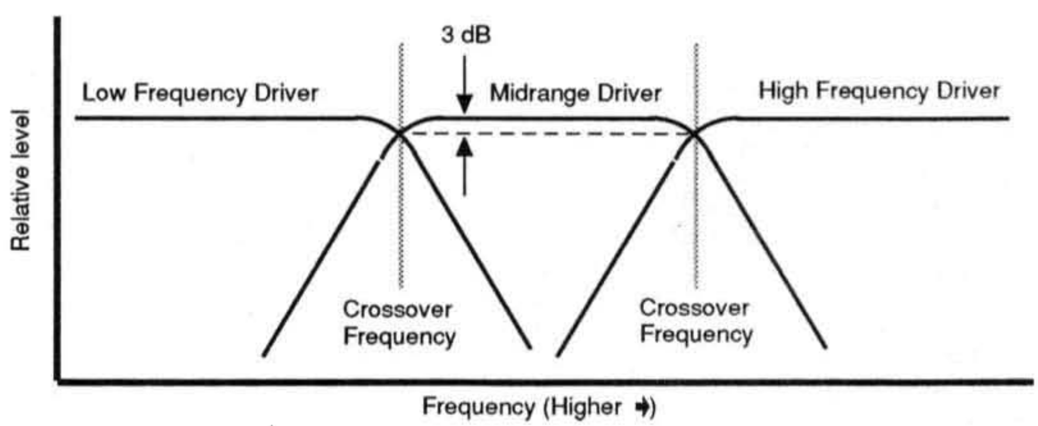

Figure 13-19. Idealized crossover response characteristics for a 3-way loudspeaker system

13.7.3 Active, Low Level Crossovers

Active crossover networks are designed to be inserted in the signal chain before the power amplifier.They thus work at far lower signal levels (milliwatts) than do passive, high level crossovers (hundreds of watts). Since active crossovers divide up the total frequency range before the power amplifier, separate amplifier channels are required for each driver or set of drivers, as shown in Figure 13-21. Another term for this type of unit is an *electronic crossover*.

A two way loudspeaker with an active crossover and two power amplifiers (or two halves of a stereo amplifier) each handling a different frequency band, is called a *biamplified* system. Similarly, a three way loudspeaker with active crossovers and three sections of power amplifier is a *triamplified* system.

NOTE: *Some systems combine active, low level crossovers with passive, high-level crossovers. For example, a three way loudspeaker system may utilize an active crossover to split the lowest from the mid and high frequencies, feeding each band to a separate power amplifier. The high frequency amplifier's output is then fed to a passive crossover, whose output goes to the mid and high frequency drivers. Such a system is biamplified, but is a three way system. Similarly, there are four way triamplified systems. This illustrates that bi- and tri- refer to the number of amplifier sections handling different frequency bands, not to the number of sections in the loudspeaker system.*

In spite of the fact that they can increase the total cost of a smaller system, active crossovers are widely used in professional sound because they offer significant advantages in system performance, as detailed in the following text. They can actually save money in larger (multi-speaker system) installations.

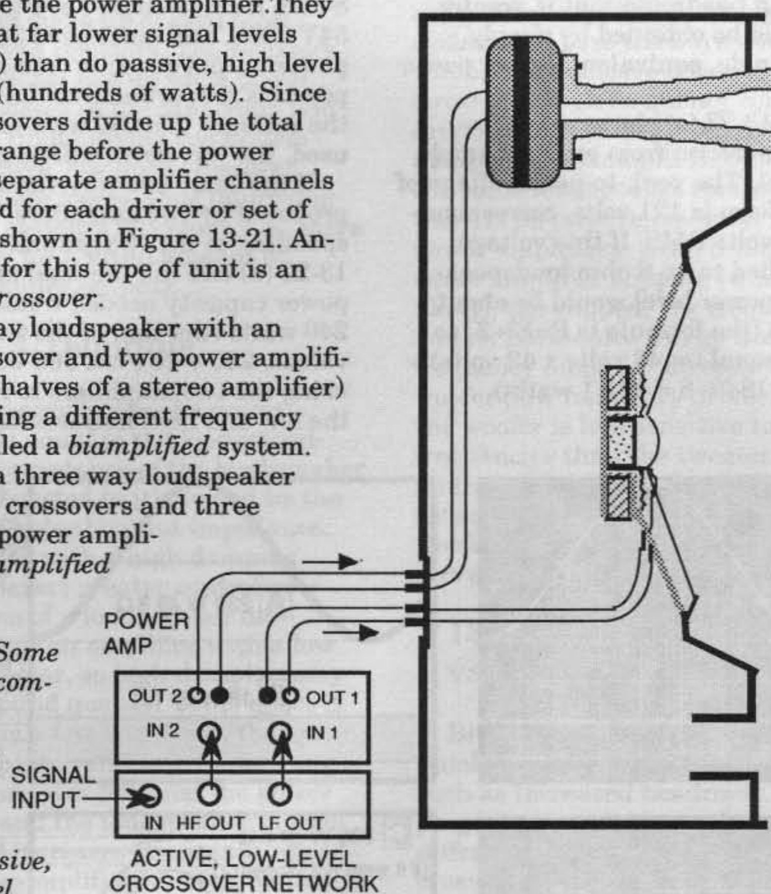

Figure 13-21. Typical location of an active (electronic) crossover network, just ahead of the power amplifiers

13.7.3.1 Headroom

Program material (music or speech) is made up of many different fundamental frequencies and their harmonics. Most music, especially popular music, is bass heavy; there is much more energy at low frequencies than at high frequencies. When both high and low frequency material are present in a program, such as a flute and a bass guitar, the high energy bass frequencies can use up most of the power in the power amplifier, leaving none for the high frequencies. The result can be severe clipping (distortion) of high frequency material. With an active, low level crossover, the high frequency material can be routed to its own