



How to Connect a Three-Way (Six Speaker) Legatia Speaker System to a 4-Channel Amplifier in a Quasi-Active Crossover Configuration

Hybrid Audio Technologies highly recommends the use of active crossovers for the Legatia range of products. This white paper focuses on how to connect a 3-way, six-speaker Legatia system using a four-channel amplifier or two two-channel amplifiers with built-in lowpass and highpass electronic crossovers.

Advantages of Active Verses Passive Crossovers

A brief explanation of the benefits of using active crossovers verses passive crossovers is as follows:

Insertion Loss: Insertion loss is the passive crossover network “stealing” power from the amplifier; without passive crossovers between the amplifier and speakers, especially large inductors for the midbass and midrange speakers, you can effectively expect (up to) twice the “real” power of the amplifier being delivered to the speakers, and not being wasted as heat energy in the passive crossover.

Intermodulation Distortion Reduction: With the use of active crossovers, at least a small reduction in intermodulation distortion can be expected because the amplifier’s damping factor is greatly improved for the midbass and midrange loudspeakers in our three-way configuration.

Midbass Adjustability: The lowpass crossover network built into many amplifiers provides an effective way of fine-tuning the desired response of the midbass drivers in the three-way component set, effectively ensuring that the midbass speakers operate within their specified bandwidth, and that all vocal cues are sent to the midrange speakers.

Midrange Adjustability: The highpass crossover network built into many amplifiers provides an effective way of fine-tuning the desired response of the midrange driver in the three-way component set. Elimination of the low frequency passive crossover, its inherent losses, potentially poor linearity and crossover point inaccuracy will significantly improve the performance of the midrange driver in your Legatia three-way component set.

Tweeter Adjustability: The tweeter highpass passive crossover frequency, as detailed below, can be selected based upon the end-user’s desires for frequency response, musical taste, physical location of the speakers, and desired output. This provides an almost unlimited array of customization possibilities.

Cost Savings: Since complex passive crossover networks are not needed, there is a cost-savings. As will be detailed in this white paper, the parts to assemble the passive crossover portion of this crossover design are very inexpensive, and a variety of crossover values can be purchased to achieve the desired result for the tweeters, allowing to user fine-tuning and personalization.

Design Premise

The premise of this design takes advantage of the Legatia-series midranges ability to effectively reproduce the extent of their bandwidth into upper midrange and treble frequencies without significant cone break-up (distortion). In the vast majority of high-end sound systems, no lowpass crossover is needed for the Legatia midrange drivers. The only crossover that is required for the midbass is a lowpass crossover to remove the vocal information in music from the midbass, and the only crossover that is required for the midrange is a highpass crossover to protect the midrange speakers from low frequencies. In virtually every four-channel amplifier manufactured today, a lowpass and highpass electronic crossover is included.

In all cases, Legatia midbass and midrange drivers begin to attenuate (roll-off) at a rate of 6 dB to 9 dB per octave, on average, at the extent of their frequency response (for the Legatia L3 and L4, this can be as high as 10,000-12,000 Hz in most installations). This design takes advantage of the Legatia midrange natural roll-off; no additional lowpass capability is required, and the midranges are connected directly to the amplifier.

To couple with the natural roll-off of the midbass at an approximate six decibels per octave (6 dB/octave), this design calls for a 6 dB/octave filter for the tweeter. The only passive crossover network in this design is a simple, high-quality capacitor which presents a 6 dB/octave filter; the function of the capacitor is to essentially protect the tweeter from low midrange and bass frequencies at and near the tweeter's resonance. Fantastic results can be achieved in this scenario, since a 6 dB/octave crossover for both lowpass (midrange) via natural roll-off, and highpass (tweeters) via crossover capacitor, is considered "phase coherent", meaning that the component set will be in relative phase in their operational bandwidth.

Parts You Will Need

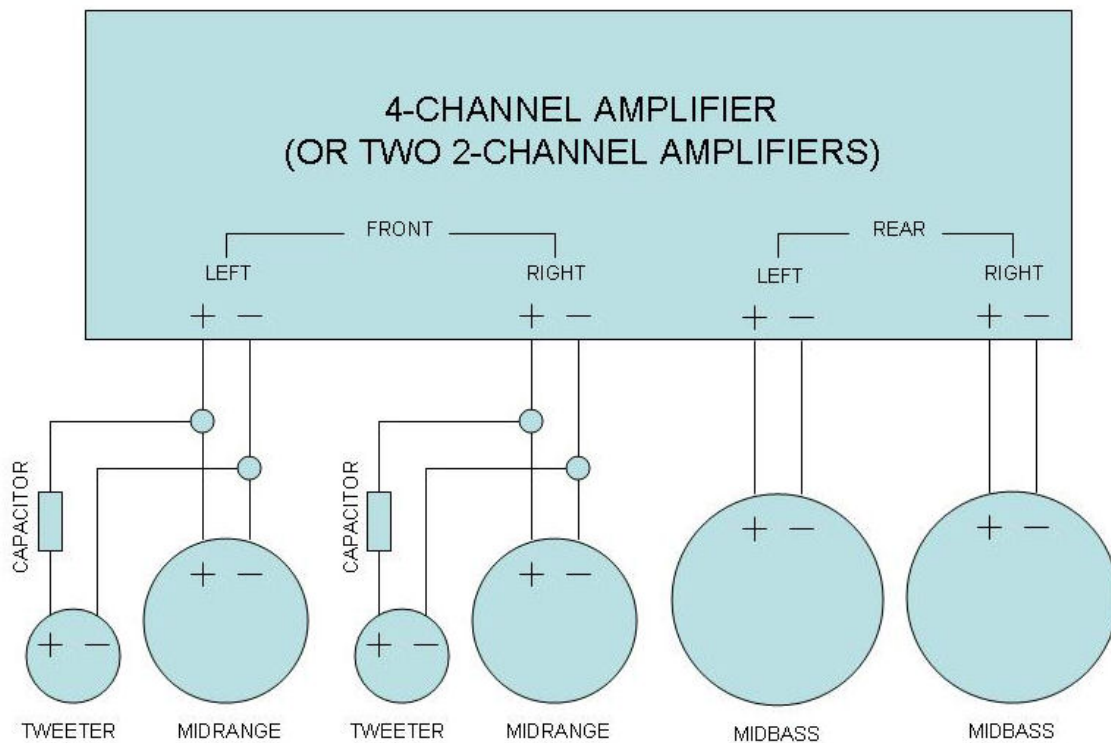
You will need to purchase a good-quality Mylar or Polypropylene capacitor rated at 200 volts or higher for each tweeter you install. If you are installing a Legatia three-way kit, which includes a pair of tweeters, you'll need to purchase two capacitors. Hybrid Audio Technologies recommends Parts Express (<http://www.partsexpress.com>) as a good source for capacitors; most capacitors at Parts Express are between \$2.00 and \$5.50 each, depending on capacitance value and brand. We recommend that you purchase a small variety of capacitor values to "fine tune" the system to your liking.

IMPORTANT: We recommend values between **2.0** and **4.0** microfarad (μF) for "high-resonance" tweeters such as the Clarus C1 and the Legatia L1V2, and between **2.0** and **5.1** μF for "low-resonance" tweeters such as the Legatia L1 Pro, L1 Pro SE, and the L1 Pro R2. Do NOT exceed these recommended values!

The higher the value, the lower the crossover point for the tweeter. For example, a 4 μF capacitor is a first-order Butterworth filter at 10,000 Hz. Since the first-order filter is only six decibels per octave (6 dB/octave), there is still an extraordinary amount of information one octave below the crossover point, so select capacitors carefully so that you provide adequate protection for your tweeters, and so they don't "see" an appreciable amount of power at their resonance frequency.

Wiring and Connection

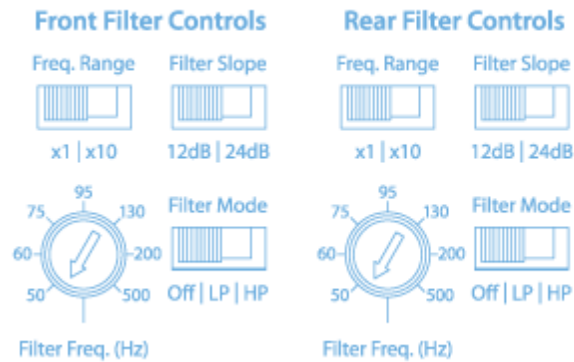
Connect the midbass drivers to the “rear” channels of the amplifier directly with no filters in between the amplifier and midbass speaker. Connect the midrange drivers to the “front” channels of the amplifier directly with no filters in between the amplifier and midrange speaker. For the tweeters, you can run a second pair of speaker wires from the “front” channels on the amplifier (there are advantages to this; it’s called bi-wiring), or simply connect the tweeter wiring right off of the midrange or midrange wiring. You will then install the capacitor on the positive lead of the tweeter’s speaker wire. It is irrelevant where the capacitor is placed, as long as it is somewhere on the tweeter’s positive lead (whether the capacitor be installed at the amplifier, in between, or at the tweeter is of little consequence). Wherever you install the capacitors should be easily accessible so that you can experiment with different capacitor values and fine-tune your system. We recommend that you start with a conservative value for the tweeter’s crossover frequency, such as 2.0 μF , and then work from there. Refer to the following connection diagram:



Set-Up and Adjustment

Midbass Speakers

Once all speakers are connected, first adjust the midbass lowpass frequency on the “rear” channels of the amplifier. For reference, the following is how the crossover is shown on the JL Audio Slash Series V2 amplifier (source: JL Audio website, <http://www.jlaudio.com>):



Using the above example, “Filter Mode” for the midbass speaker would be set to “LP” (lowpass). The filter slope can be adjusted at the user’s discretion; Hybrid Audio Technologies normally recommends 24 dB/octave on the midbass lowpass slope, if it’s available and is an option on the amplifier you are using. The actual crossover frequency is denoted in the bottom left-hand corner of the above diagrams, and is typically a potentiometer that can be adjusted with a flat-blade screwdriver. In the above example, the choices are between 50 and 500 Hz. Hybrid Audio Technologies recommends a lowpass filter in the 200 Hz range for the midbass.

To adjust the crossover potentiometer properly, listen carefully to your selection with just the midbass speakers playing; there should be only a very small amount of vocal (voice or singing) information coming from the midbass drivers. Adjust the midbass crossover setting until you find the desired response. Remember, you can come back to this later and make further adjustments to fine-tune the system to your own liking; that’s the beauty of active crossovers. Finally, “Freq. Range” is a device that multiplies the crossover setting immediately beneath it; if your amplifier has this selection, more often than not you will choose the setting that multiplies by one.

Midrange Speakers

Next to be adjusted is the midrange highpass frequency on the amplifier. Once again, using the above example, “Filter Mode” for the midrange speaker would be set to “HP” (highpass). Like the midbass speakers, the filter slope can be adjusted at the user’s discretion; Hybrid Audio Technologies normally recommends 24 dB/octave on the midrange highpass slope, if it’s available and is an option on the amplifier you are using. The actual crossover frequency is denoted in the above example; the choices are between 50 and 500 Hz. Hybrid Audio Technologies recommends a highpass filter in the 200 Hz range for the L3 and L4 midrange. If a 24 dB/octave selection is not an option on your amplifier, and the amplifier only allows for shallower slope crossovers, such as 12 dB/octave or 18 dB/octave, adjust the frequency higher, to 300 or even 400 Hz. Similar to that of the midbass adjustment, above, “Freq. Range” is a device that multiplies the crossover setting immediately beneath it; if your amplifier has this selection, more often than not you will choose the setting that multiplies by one.

To adjust the crossover potentiometer properly, select a dynamic track of music and advance your head unit’s amplitude control (volume control) to about three quarter volume and listen specifically to the midrange for distortion or over-excursion (which can be manifested as a popping noise or distortion of vocals in heavy bass tracks). Adjust the crossover until all forms of distortion are no longer audible. In many instances, it is advisable to continue to advance the crossover potentiometer slightly further to ensure that the midbass speakers are being protected from the lowest frequencies for all forms of music.

There should be virtually no movement of the midrange cone during dynamic tracks. If the cone of the L3 or L4 is moving more than about 1-2mm, adjust the frequency higher to avoid damage to your midrange drivers. If you need help on setting your crossover frequency, seek the help of an authorized Hybrid Audio Technologies dealer. Within a few short minutes, the midrange crossover should be set and not require any additional adjustment.

Tweeter Speakers

With the midbass and midrange frequency adjusted, the tweeter's crossover can now be adjusted. As mentioned previously, it is best to start with a conservative crossover on the tweeter. Listen to music tracks that you are familiar, specifically to the upper midrange and treble frequencies. Experiment with different capacitor values to custom-tailor the system to your music taste. Remember to not exceed the recommended values as this will cause damage to the tweeters during high-amplitude listening. Once a capacitor value has been selected after listening tests, permanently install the capacitors.

In some systems, depending on where the tweeters are with respect to the midbass and midrange drivers, the treble might be slightly over-powering, and will need to be adjusted. An elementary, but very effective way of equalizing the treble amplitude with respect to the midbass amplitude is via the head unit's treble adjustment, common on most factory and aftermarket decks. On most head units, the treble adjustment is a wide Q factor equalization at 8,000 or 10,000 Hz, and when adjusted down slightly can help to equalize the amplitude of the midbass verses the tweeter speakers. You might find that an adjustment of 1 or 2 dB to be an effective way of doing this.

You have now set-up your Legatia three-way set with a very simple active/passive crossover system. Congratulations! Should you need any additional assistance, please drop us a line at support@hybrid-audio.com or by calling 1.770.888.8200.