



User's Guide

Electronic Crossover Network

XM6 Variable Frequency

XM9 24 dB/octave

XM16 48 dB/octave

XM44 24/48 dB/octave

XM26 24 dB/octave Tube

XM46 24 dB/octave Passive Line Level

XM126 24 dB/octave Tube

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The electronic crossover is used to drive individual loudspeakers for separate portions of the audio frequency spectrum. A two way crossover is used for bass and high frequency speakers. A three way crossover is used when driving bass, midrange and high frequency speaker. The signal from the preamp is passed to the electronic crossover network. The outputs of the crossover network are then connected to the power amplifiers for the individual loudspeakers as in Figure 1 . A typical configuration like this might have the crossover frequency set at 300 to 1000 Hz, depending on the type of loudspeakers used. When used with subwoofers as low frequency speakers, the typical crossover frequency is around 100 Hz. The range is 50 to 150 Hz for most subwoofers. When the crossover frequency is below 100 Hz there usually is no stereo information present from the sound of the subwoofer, and a common subwoofer can be used. Figure 3 shows how to use the crossovers with a common subwoofer. The sum switch on the crossover front

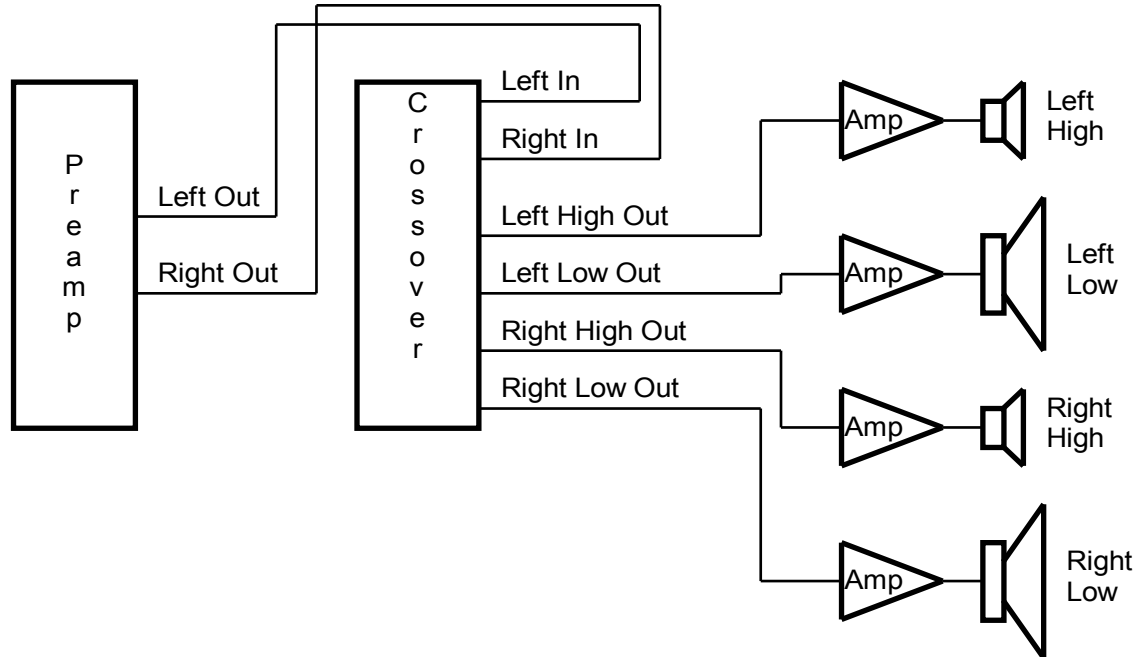


Figure 1

Two-way system has separate amplifiers for high and low range speakers

panel causes the outputs of both low pass channel to be summed together. Both outputs will have the same summed signal on them, and either one can thus be used to drive the common subwoofer. The advantage of a common subwoofer is more than just cost. Because there is only one subwoofer present, often a larger unit can be chosen, with an extended bass range. It is also possible to drive more than two speakers per channel. Figure 2 shows a three way system with woofers, midranges and tweeters.

Choosing the crossover frequency and slope

At frequencies below the crossover frequency the signal will go to the low pass outputs. At frequencies above the crossover frequency the signal will go to the high pass outputs. There is a region around the crossover point where the signal will come out of both the high pass output and the low pass output. For the crossover networks with a slope of 24 dB/octave (XM6, XM9 and XM26) the width of this region is about 1/2 octave. For the XM16, with a slope of 48 dB/octave, the width of this region is halved to 1/4 octave.

Figure 4 shows the frequency response of the 24 dB/octave crossover networks (XM6, XM9 and XM26). The figure is drawn for a crossover frequency of 100 Hz. For other crossover frequencies

the same figure applies, with the frequency scale scaled. Note that both the high pass response and the low pass response are down exactly 6 dB at the crossover point of 100 Hz. This means that at this frequency the amplitude is exactly half. Adding the high pass and low pass together sum to unity. As a matter of fact the sum of the high pass and the low pass response is unity for all frequencies. This is why the filter is called a "constant voltage network. It is also called a Linkwitz-Riley network, after the two writers who first introduced this concept in the audio world. The frequency response of the phase of the 24 dB/octave network is shown in Figure 5. The frequency response of the phase is the same for the high pass and the low pass outputs. Note that at the crossover point the phase shift is exactly 180 degrees. Figure 9 shows the frequency response of the XM16 crossover network. This network has a slope of 48 dB/octave. Figure 8 shows the phase response of the XM16 crossover network. Note that the phase shift of the XM16 is twice that of the other networks. The XM16 does not have a

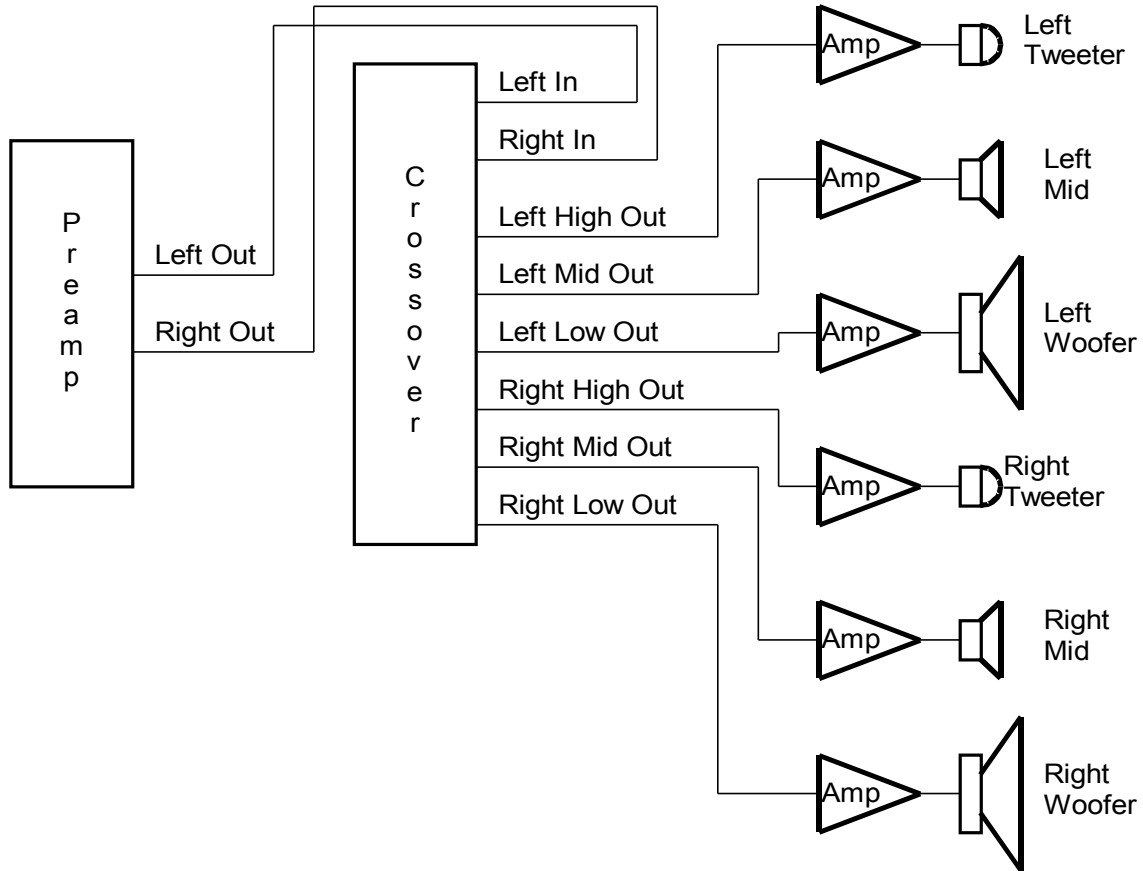


Figure 2

Three-way system has separate amplifiers for tweeters, midrange and woofers

damping control.

The choice of the crossover point is a difficult one, and often some trial and error is needed for achieving best results. With the 24 dB/octave crossover networks a good rule of thumb is to set the crossover point at least one half to one octave away from the cutoff frequency of the speaker. Thus a satellite with a cutoff frequency of 50 Hz at the low and that is used with a subwoofer requires a crossover frequency of 75 to 100 Hz. The subwoofer should then also have a range extending half to one octave above the crossover frequency. In this case, if 100 Hz was chosen, the subwoofer should have a range of at least 200 Hz.

A 48 dB/octave crossover should be chosen if this choice is not practical. This crossover with the steep slopes can be used with a crossover frequency 1/4 octave away from the loudspeaker cutoff point.

Changing the crossover frequency Frequency modules

The XM6 crossover network has a control on the front panel to change the crossover frequency. The frequency is shown on a four digit LED numeric display on the front panel of the unit. The range is 20 Hz to 5000 Hz, and the frequency can be changed in steps of about 5%. A total of 160 frequencies are thus available. This nice feature comes with a cost. The XM9, XM16 and XM26 use frequency modules to change the crossover frequency. These low cost modules are plugged into a connector in the unit. The power has to be shut off and the top cover of the unit removed. The module for the XM9 has 4 resistors on it. The module for the XM16 has 8 resistors

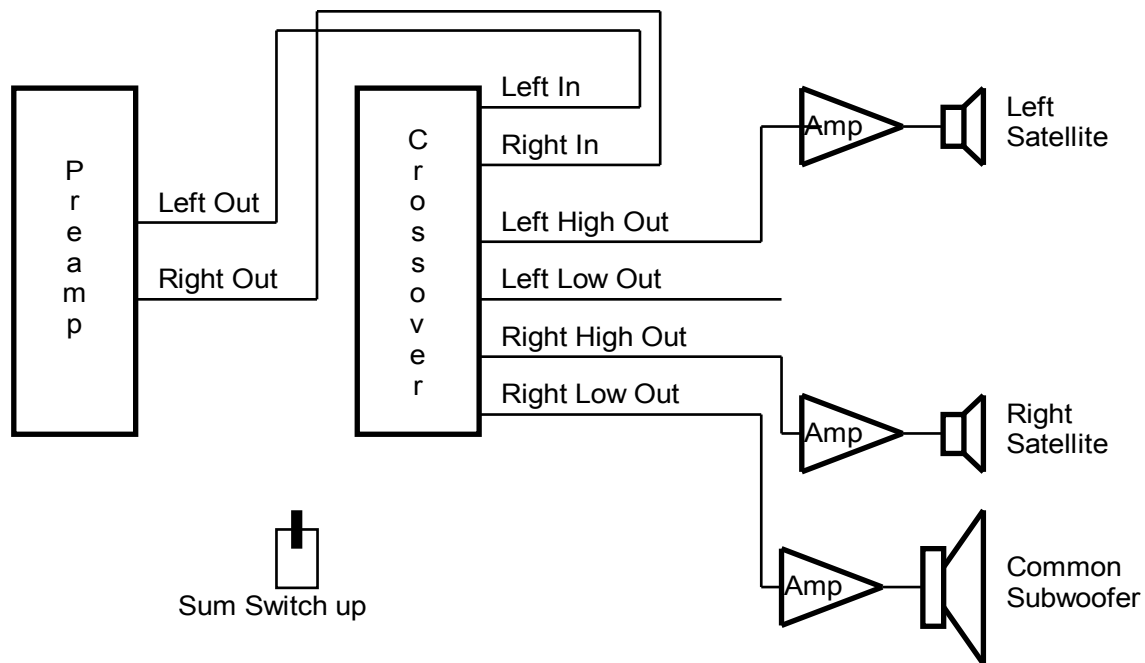


Figure 3

Two-way system with common subwoofer. The two low pass channels are summed when the sum mode is selected.

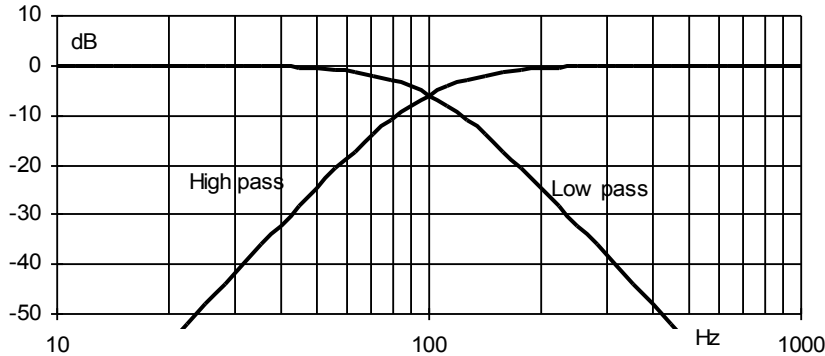
and the module for the XM26 has 4 resistors and four capacitors. The XM9 requires two modules and the XM16 and XM16 require four modules for each crossover frequency chosen. These modules are available for most frequencies. The manuals for the individual units have formulas in them to compute the value of the resistors and capacitors. When ordering replacement modules only the desired frequencies need be specified.

In order to replace the frequency modules the top cover of the unit needs to be removed. Undo the two screws on each side of the unit and lift the cover. Make sure the power to the unit is turned off. Proceed as follows:

XM9 Each circuit board has one frequency module. The same module sets both the high pass and the low pass crossover point. It is inserted in a socket. The frequency module has four resistors on it. Replace each module with the new module.

XM16 Each circuit board has two frequency modules on it, one for the low pass and one for the high pass crossover point. The two points are usually set at the same frequency. Each module has eight resistors on it. Replace each module with the new module.

XM26 Each circuit board has two frequency modules on it, one for the low pass and one for the high pass crossover point. The two points are usually set at the same frequency. Each module is



Frequency response of the amplitude of the fourth order crossover network. The slopes are 24 dB/octave. The amplitude of low pass and high pass add up to unity (0 dB).

Figure 4

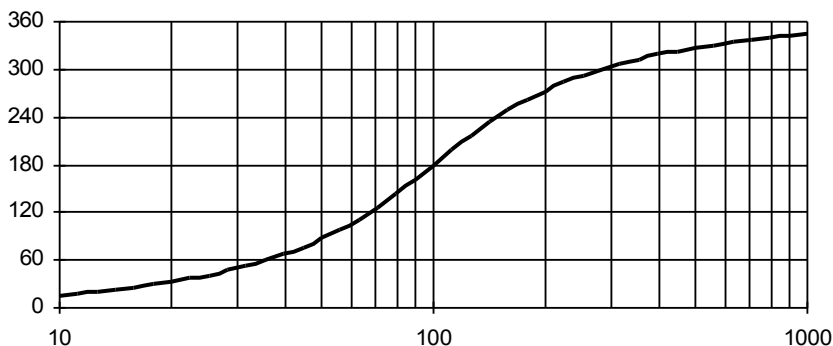
a small circuit board with 10 gold plated contact fingers. Modules have precision capacitors and resistors on them. The module on the left of each circuit board is the low-pass module; the other one is the high pass module. Make sure to insert the modules so that the components on it face away from the tubes. The tubes get hot and might melt the capacitors.

After replacing the module put the cover back on and install the four screws.

Level controls

The level controls on the front of the cabinet are used to set the volume of each loudspeaker. There are several ways to adjust these controls. A good way to do this is to start out by setting all controls in the center (12 o'clock) position. Listen to some music and adjust the controls for proper volume from each speaker.

If a frequency generator is available, hook the generator up to the input of the crossover. Sweep the frequency from way below the crossover point to way above the crossover point. When the frequency crosses the crossover point the sound should shift from one speaker to the other, but the volume should remain the same.



Frequency response of the phase for the fourth order network. The phase for both high pass and low pass are the same.

Figure 5

A third way is to use a pink noise generator and a spectrum analyzer with a good microphone. Adjust the level controls for a flat response across the crossover point.

Sometimes the methods that use instruments result in settings that are not quite pleasing. If that is the case try to adjust the controls until the sound is best. After all, it is the final sound that is important.

The damping control

The damping control allows adjusting the frequency response at the crossover point. Figure 6 show the effect of the damping control. The figure shows the frequency response for the maximum and minimum settings. This control is only available on the XM6 and the XM9. The XM16 and the XM26 do not have a damping control. The damping control adjusts both high pass and low pass simultaneously. This control is useful for fine-tuning the room frequency response. Sometimes it happens that at the crossover point there is a small peak or dip in the frequency

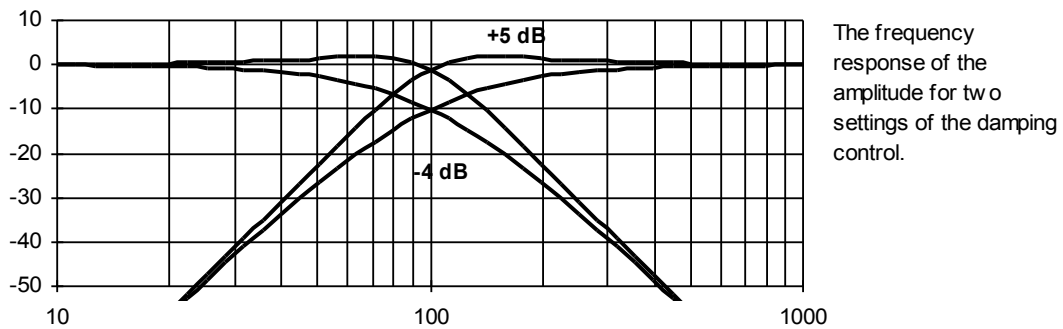


Figure 6

response. This is caused by the fact that at this frequency the sound is produced by both high and low speakers simultaneously. It is often very hard to hear this dip, but it can easily be seen if a frequency spectrum analyzer is used.

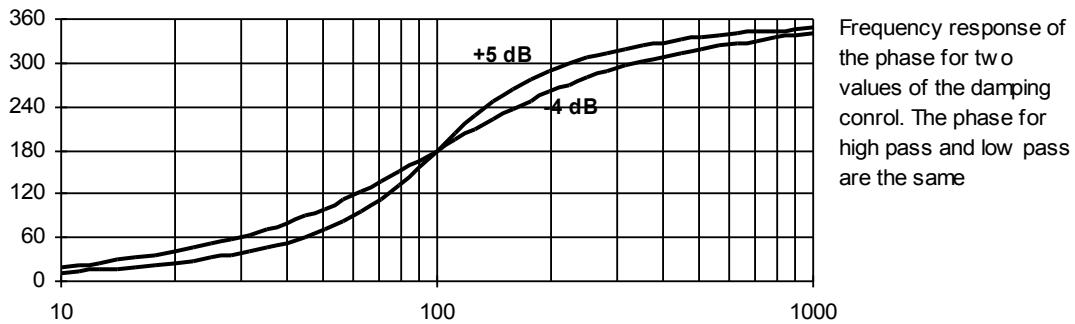
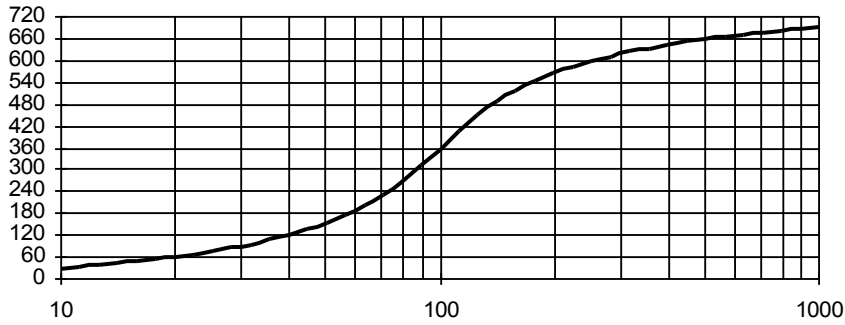
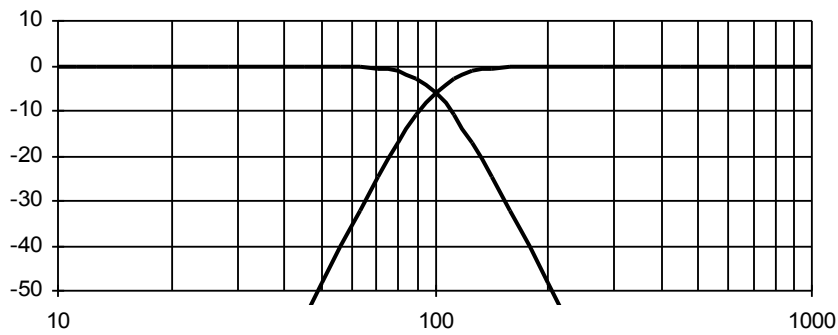


Figure 7



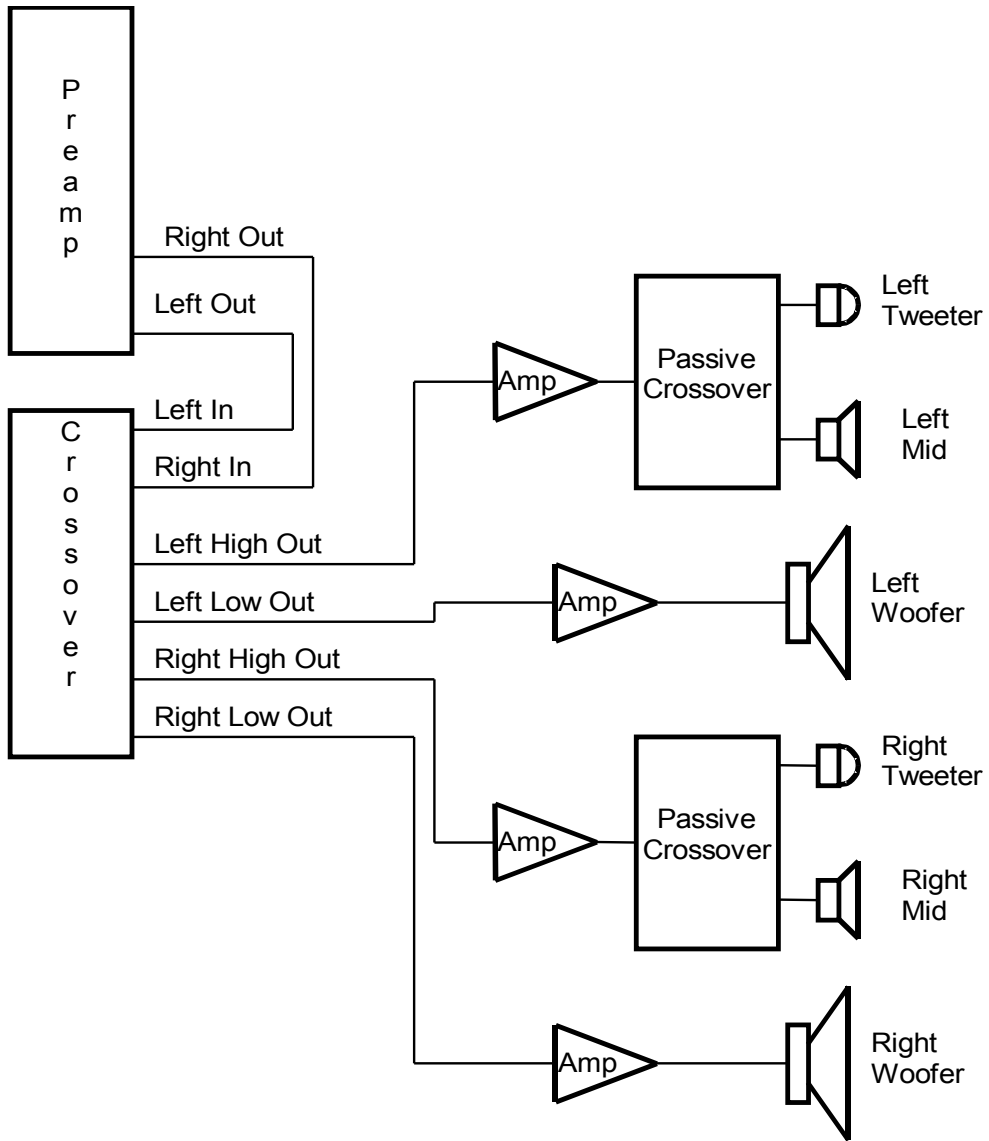
Frequency response of the phase for the XM16 eighth order crossover network. The phase for high pass and low pass are the same

Figure 8



The frequency response of the amplitude for the XM16 eighth order crossover network.

Figure 9



Hybrid system with passive crossover on the highs and active crossover on the lows