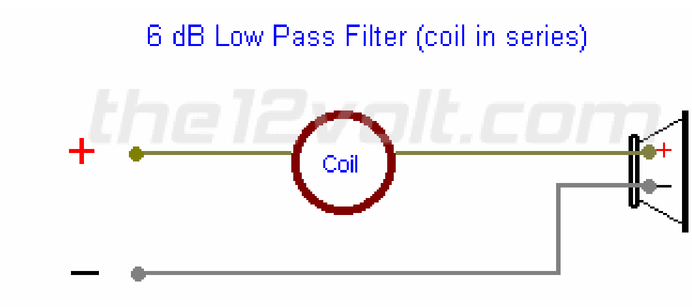
Passive Crossover Networks

With the use of passive crossovers, you can drive a woofer, midbass, midrange, and tweeter or more in parallel on each channel of an amplifier and maintain a safe load (impedance level) on the amplifier across the entire frequency range. Each of these loudspeakers receive a particular range of frequencies determined by one of three crossover filters: low pass, high pass, and band pass.

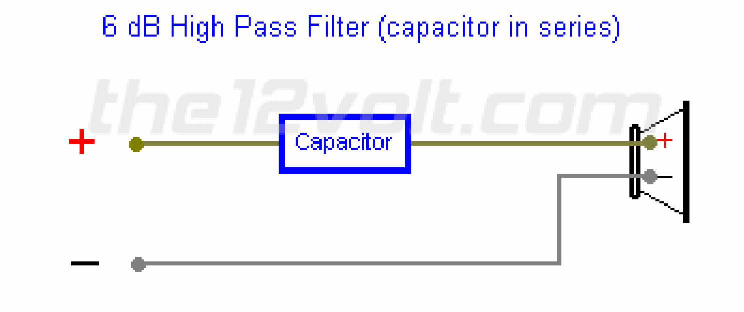
The components for these consist of coils and capacitors. The value of coils and capacitors are selected by the desired crossover frequency, which is determined by the efficient operating range of the loudspeaker, the desired slope (rate of cuttoff per octave), and the frequency at which the crossover components develop a particular impedance or resistance value in relationship to the loudspeaker's impedance or resistance value. The values of coils and/or capacitors used for a particular crossover frequency for a 4 ohm loudspeaker will not be the same for a loudspeaker with a different impedance.

Low Pass filters allow low frequencies to pass below a selected crossover frequency, filtering out all frequencies above it. In a first order (6dB per octave) filter, this consist of a coil in series with a loudspeaker. Just below the crossover frequency, the coil begins to add resistance to the circuit. At the crossover frequency enough resistance has been added to equal the resistance of the loudspeaker and reduce the power by 3 dB or 50 %. One octave above the crossover frequency, power has been reduced by 6 dB or 75%. Each octave higher reduces the power by an additional 6 dB. The size of the coil will be determined by the impedance of the loudspeaker(s) and the desired crossover point. The larger the size or amount of inductance (millihenries, mHy) is, not physical size, the lower the low pass frequency will be.



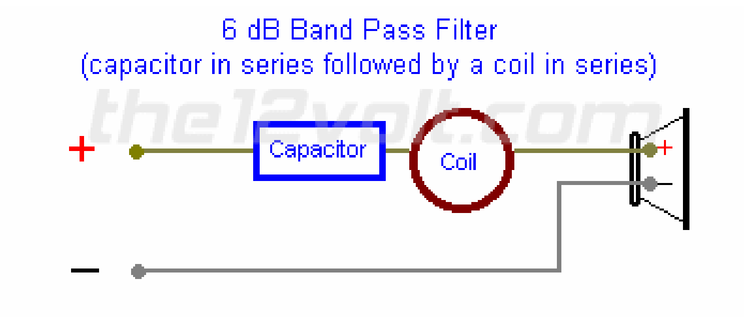
6 dB Low Pass Filter

High Pass filters allow high frequencies above a selected crossover frequency to pass, filtering out all frequencies below it. In a first order (6dB per octave) filter, this consist of a capacitor in series with a loudspeaker. Just above the crossover frequency, the capacitor begins to add resistance to the circuit. At the crossover frequency enough resistance has been added to equal the resistance of the loudspeaker and reduce the power by 3 dB or 50 %. One octave below the crossover frequency, power has been reduced by 6 dB or 75%. Each octave lower reduces the power by an additional 6 dB. The size of the capacitor will be determined by the impedance of the loudspeaker(s) and the desired crossover point. The smaller the size or value of a capacitor (microfarads, µfd or mfd) is, not physical size, the higher the high pass frequency will be.



6 dB High Pass Filter

Band Pass filters allow a range of frequencies to pass above a selected crossover frequency and below another selected crossover frequency, filtering out all frequencies outside this band. In a first order (6dB per octave) filter, this consist of a low pass filter (coil) and a high pass filter (capacitor) in series with a loudspeaker. Narrow Band Pass Filters are to be used when the bandwidth is less than two decades.

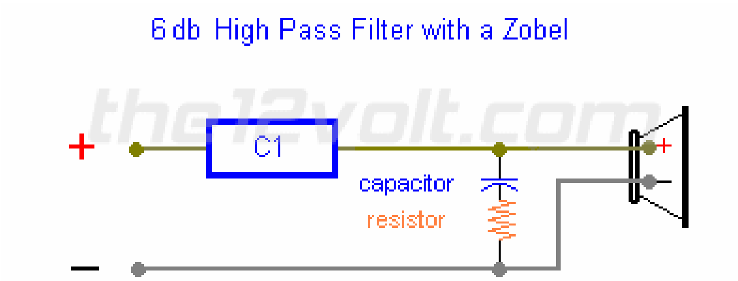


6 dB Band Pass Filter

Narrow Band Pass filters are commonly used with mid-bass loudspeakers. These allow a narrow band of frequencies to pass. The bandwidth is considered to be narrow when the low pass frequency is less than 10 to 20 times the high pass frequency ("less than 1 or 2 decades"). Different formulas apply to selecting coils and capacitors for a narrow band pass filter. These formulas should be used if the low pass frequency is less than 20 times the high pass frequency, if not, distortion will be evident.

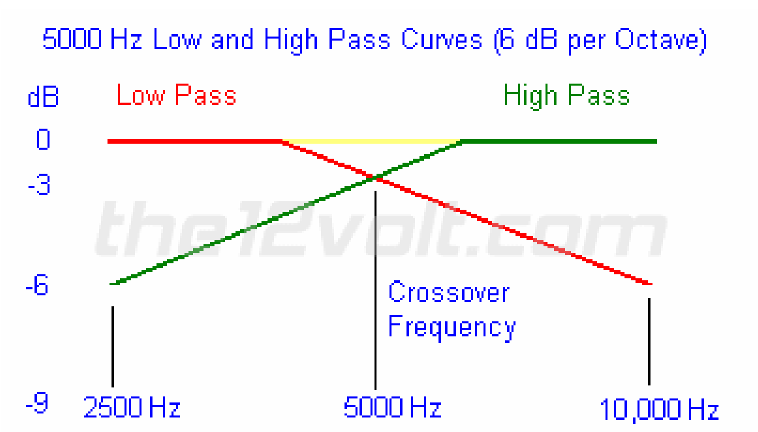
Impedance rise occurs more often in midrange loudspeakers (usually at the upper frequency range of the loudspeaker). Most of the time the rise is well beyond the crossover frequency and is not necessary to limit the high frequencies to it. If a Zobel is not used, only use a high pass filter and not a band pass filter.

A Zobel is a filter used to stabilized loudspeaker impedance in a crossover-speaker circuit. This consists of a capacitor with a value equal to one which gives a crossover frequency at the frequency where the impedance has doubled, in series with a resistor which has a value equal to 1.25 times the nominal loudspeaker impedance. This is connected parallel to the loudspeaker between the loudspeaker and crossover. Zobel Calculator



6 dB Narrow Band Pass Filter with Zobel

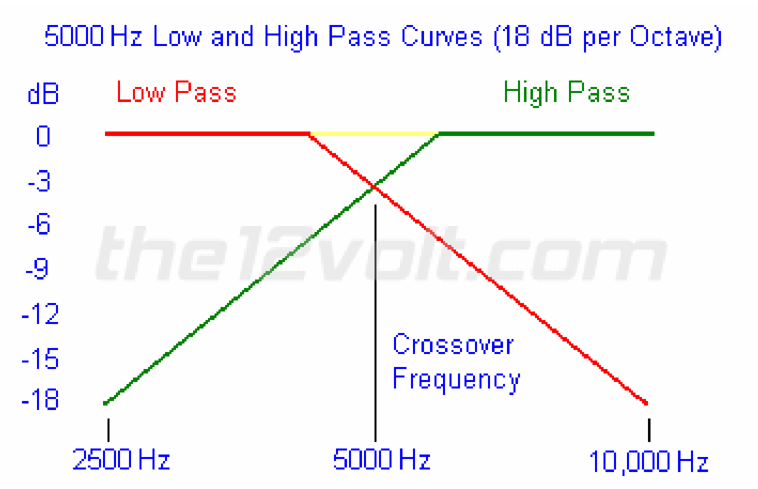
Whenever two loudspeakers are playing the same frequencies in phase, in the same location, there will be up to a 3 dB rise in the acoustical output. When crossovers are used, both the low pass filtered loudspeaker and the high pass filtered loudspeaker are down by 3 dB at the crossover frequency. Their combined output will be up to 3 dB higher at the crossover point. The net result is neither a rise or fall in resistance to the amplifer or acoustical output at the crossover frequency as indicated by the yellow line between the low pass and high pass curves. This means if both loudspeakers are 4 ohm, the amplifier will see a 4 ohm load below, at, and above the crossover frequency (*excluding the natural impedance curves of the loudspeakers).



5000 Hz Low Pass and High Pass Curve, 6 dB per Octave

An amplifier rated at an output of 100 watts per channel into a 4 ohm load will produce 50 watts per channel into an 8 ohm load, and only 25 watts into a 16 ohm load. The same amplifier will also produce 200 watts per channel into a 2 ohm load if the amplifier is capable of full output at a 2 ohm load. The crossover not only separates the frequency ranges for the different loudspeakers in a speaker system, but also separates these frequency ranges and impedance (resistance) ranges for the amplifier.

In some cases it is necessary to increase the cut off rate or slope to higher than 6 dB per octave (first order). With tweeters this is especially important. Low frequencies will damage tweeters. Using a second order (12 dB per octave) or third order (18 dB per octave) high pass filter will reduce the lower frequencies at a steeper rate than a first order filter. A tweeter with a third order high pass filter with a crossover frequency of 5000 Hz driven by the 100 watt amplifier used in the power chart above, will recieve about 1.6 watts at 2500 Hz versus 25 watts with a first order filter at full output. The use of higher order filters allows loudspeakers to be played at the limits of their efficiency. Higher order filters can also be beneficial in compensating for natural peaks within the listening enviroment (vehicle).



5000 Hz Low Pass and High Pass Curve, 18 dB per Octave

Different orders may be used in your design. You can have a first order low pass filter for a woofer, a third order narrow band pass filter for a mid-bass, a second order band pass filter for a midrange, and a third order high pass filter for a tweeter. When building passive crossovers, be sure to calculate for the correct impedance of each loudspeaker. **Impedance is relative to frequency.**