Subject: Re: Phase Delay and Group Delay
Posted by Wayne Parham on Fri, 09 Aug 2002 19:10:44 GMT
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The behavior of reactive circuits is pretty simple stuff really. Power developed across a speaker motor is phased - moved in time - by the reactive behavior of the crossover circuit, and any other filters in the system. The problem is that phase moves with respect to frequency, and therefore, so does the amount of delay. The delay wouldn't be so bad if it were uniform, but it isn't. So interactions between components that have been phased differently can cause cancellation of selective frequencies in some cases, which causes response anomalies.Adjacent second-order networks are an excellent example of this phenomenon, and their behaviour is easy to understand. When a woofer uses a second-order Butterworth low-pass filter, it's apparent distance is shifted further from the listener (than it's actual position, or "where it is" at very low frequencies) by exactly 90 degrees at the -3dB crossover point. The distance is equivalent to 1/4 wavelength of the crossover frequency, which is a specific amount.The tweeter, using a second-order Butterworth high-pass filter is shifted nearer to the listener - again, referenced to it's actual position, or "where it is" at very high frequencies - by exactly 90 degrees at the -3dB crossover point. The distance here too is equivalent to 1/4 wavelength of the crossover frequency.This makes the total phase difference be 180 degrees, which is 1/2 wavelength. It is also a "bad mode" where destructive interference is maximized. So in this case, the difference in the phase of the power applied to the motors is presented at a different time, it has moved by exactly 1/2 wavelength and the diaphragms then move delayed from one another in a fashion that cancels each other out. That's why second-order networks are usually "cross-connected" by reversing the connections to one of the motors. We have a time domain issue that has manifested itself in the frequency domain. So by cross-connecting, we have reduced the effects in the frequency domain, but we have not reduced them in the time domain. We have only changed the conditions and found a good working solution to the problem that is causing a frequency anomaly.So the fact that there is a quantifiable time offset created by the crossover is the reason why baffle offsets are sometimes incorporated. And there is some merit in doing so - if the apparent distance between the listener and adjacent sound sources is equal at the crossover frequency, then the idea is that it will move a little one direction above the crossover frequency and a little in the other direction below the crossover frequency, and that the position chosen is then a good compromise.But another fact is that by moving the diaphragms forward or backward, we now create a situation where specific phasing issues happen at different frequencies that where they would if the diaphragms were exactly in physical alignment. Since the apparent distance moves with frequency, if we choose one frequency to focus on - say the crossover frequency - then we can align diaphragm phase at this frequency. But as frequency changes, the diaphragms move out of phase with one another. We could have chosen a slightly different offset, which brought them into alignment at a slightly different frequency than the crossover frequency instead. Then the crossover frequency wouldn't be in alignment anymore. And then there is also the troublesome issue that as we move at angles, we change the distances between the listener and the adjacent diaphragms. So we can set alignment for specific frequencies in specific positions, but we can't align the system overall.In my way of thinking, this makes an answer very clear: Shoot for controlled directivity and make the target area be the region for which the system can