



CALIFORNIA STATE SCIENCE FAIR 2003 PROJECT SUMMARY

Name(s) Frederick J. Meyer	Project Number J0720
Project Title How Inductors and Capacitors Filter Waveforms	
<p style="text-align: center;">Abstract</p> <p>Objectives/Goals The purpose of this science project was to explore the fundamental properties of inductors and capacitors and to then show how they can be combined to create useful electronic filters. I used the data gathered to design a combination high-pass / low-pass filter crossover network for a 2-way speaker system. I decided to work with audio frequencies so I could use my ears to measure filter performance instead of using expensive electronic test equipment.</p> <p>Methods/Materials I began by winding a number of coils with inductances that have -3dB cutoff frequencies in the audio frequency range. I measured how a number of different inductor-capacitor combinations could change the output frequencies of 'white noise' input signals. And I measured how the filters attenuated the amplitude of sine wave test signals. Then I added different values of capacitors to the circuit to create 2nd order low pass filters. By rearranging the inductors and capacitors I created high-pass 1st and 2nd order filters. With a shareware computer program, I captured spectrum analysis plots for each of my filter designs. Finally, I combined my filters to make bandpass and bandstop filters. I also modeled each of my filters with a circuit analysis program to see how my real circuits compared to simulated ones.</p> <p>Results I was surprised at the results when the circuit resistance was higher than expected. In the case of a bandstop filter, even small increases in circuit resistance had a huge effect on the filter shape. My test equipment did not seem to be very accurate in measuring very low or very high frequencies, but this did not affect the overall results. The use of large coils, with their long wire resistance, tended to flatten out the filter plots and decrease their slope. I did not expect this when I started.</p> <p>Conclusions/Discussion In all cases, my filters had a dramatic effect on the audio waveforms I was testing. However, I found designing a good crossover network was difficult and challenging. But my passive electronic filters did enable two speakers to sound much better than they would otherwise and the filters protected the speakers from too much power of the wrong frequency. If I continue further on this topic, I plan to explore how active filters and DSP filters work and compare them to my passive designs.</p>	
Summary Statement The goal of this science project was to explore the properties of inductors and capacitors and to use the data gathered to design working electronic filters that improve the sound quality of audio speakers.	
Help Received My Mom helped me do the signs for my display board and printed my photos and my Dad help me type my paper (but I drew all the graphics). Both my parents helped me do my Internet research. My school advisor gave me suggestions how to make my project better. Inspired by Ron Skelton W6WO.	