Analysis of Crossover Design in Custom-Built Stereo Speakers

Project Objectives:
• Determine if a higher order filter provides flatter speaker response
• Analyze the impact of additional corrective circuits on speaker response flatness

Selected Design
• HiVi B4N Woofer
• HiVi T20-8 Textile Dome Tweeter
• Ported Poplar Enclosure
• Crossover Options
  • 1st Order Butterworth Filter
  • 2nd Order Linkwitz-Riley Filter
  • Tweeter Attenuation Circuit
  • Zobel Woofer Impedance Compensator Circuit

Test Methods
• Oscilloscope Test
  • Woofer and tweeter removed from enclosure
  • Probe connected to driver wires
  • Crossover settings adjusted
  • Voltage measured at 20-20,000 Hz test tones
• Sound Level Meter Test
  • Speaker placed in anechoic chamber
  • Crossover settings adjusted
  • Sound output measured at 20-20,000 Hz test tones
• Listening Test
  • Musical selection analyzed with each crossover setting

Fabrication Methods
• Wood cut using table saw, miter saw, drill press, CNC mill
• Enclosures assembled using wood glue, clamps
• Crossover circuit boards assembled and soldered by hand

Results

<table>
<thead>
<tr>
<th>Filter Order</th>
<th>Attenuation</th>
<th>Average Output (dB)</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Order</td>
<td>Off</td>
<td>73.4</td>
<td>6.0</td>
</tr>
<tr>
<td>2nd Order</td>
<td>Off</td>
<td>71.1</td>
<td>5.2</td>
</tr>
<tr>
<td>2nd Order</td>
<td>On</td>
<td>68.4</td>
<td>4.7</td>
</tr>
<tr>
<td>2nd Order</td>
<td>On</td>
<td>70.7</td>
<td>4.5</td>
</tr>
<tr>
<td>2nd Order</td>
<td>On</td>
<td>67.5</td>
<td>3.1</td>
</tr>
</tbody>
</table>

Table 1: Analysis of Sound Level Meter Test Data

Conclusions
• There was a marginal improvement in flatness between 1st and 2nd order filters alone
• The second order filter with attenuation and impedance compensation provided the flattest response
• Tweeter attenuation and woofer impedance compensation were critically important for flat response
• More signal processing provided flatter response at the expense of sound output
• The tweeter required substantially less voltage than the woofer for the same sound output

Next Steps
• Explore woofer voltage peak in second order filter
• Finish speaker enclosures (sand and stain)
• Experiment with other types of filters and circuit elements
• Experiment with more speaker drivers (midranges, etc.)