

# **Loudspeaker Design Project**

## *Stereo 2-Way Easy Listening System*

Transducer Theory – FA4740  
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### **Functional Goals:**

This loudspeaker design is based on fulfilling personal listening needs. The speakers will be used as a Left/Right pair for listening to music and movie playback in a home environment. Music is played at a significant volume in the workplace, so these speakers are designed to support a more relaxed listening environment. Portability of the loudspeakers is also very important due to the relatively mobile lifestyle of a college student. It is worth noting that the size limitation may adversely impact the performance of these loudspeakers.

### **Tweeters:**

Peerless V-line D27TG-45-06 tweeters have been selected for this project. Peerless V-line drivers used to be sold under the Vifa name and are currently made by Tympany Corporation. The tweeter is a 1 inch silk dome tweeter with a nominal impedance of 6 Ohms. The sensitivity of this tweeter is 90dB. It is an unshielded tweeter, but it has a small magnet and voice coil. This tweeter is unlikely to cause interference with other nearby electronic equipment. The D27TG-45-06 has a “doughnut” on the surface of the tweeter, surrounding the dome. This “provides subtle pseudo-horn loading [and] can help control diffraction effects (Stout).” According to Scott Blair, this particular tweeter includes many of the best features of more expensive tweeters.

The tweeter seems to offer the best performance out of tweeters in the same price bracket. Its visual difference drew attention from the beginning. Upon comparing this tweeter with others of similar pricing, this tweeter had more fitting characteristics for the type of loudspeaker design. The D27TG-35-06 is nearly identical in technical specifications; however, its on axis frequency response is not as smooth.

### **Woofers:**

Woofers with diameters of 6.5 and 7 inches were investigated to find a cost effective driver that would be suitable for use with or without an additional subwoofer. Woofers with a diameter smaller than 6.5 inches could not produce the lower frequencies that are desired for this particular loudspeaker. On the other hand, woofers larger than 7 inches

required a significantly larger internal enclosure volume than would be acceptable for an easily portable design. There was consideration of using the Peerless PL18WO09 7 inch woofer, however the internal enclosure volume required for an effective loudspeaker would reduce the portability factor of the speaker. The PL18WO09 required nearly double the internal volume to achieve a similar f3 to the chosen woofer, Peerless V-line P17SJ00. This woofer has a nominal impedance of 8 Ohms and a sensitivity of 87dB. The Free Air Resonance of this woofer is 41 Hz (P17SJ-00-08). The unshielded version of this woofer, the P17WJ00, has a Free Air Resonance of 37 Hz. The difference of 4 Hz does not outweigh the importance of having a shielded driver in this application. Many do-it-yourself loudspeaker builders who use the P17SJ00 agree to complement their system with the D27TG-45-06 tweeters.

### **The Enclosure:**

The cabinets are designed to achieve maximum functionality out of an easily portable enclosure design. The size and weight of the cabinet are major considerations for this project. One tweeter and one woofer will be used in each loudspeaker. The ideal internal enclosure volume for this project is 0.5 cubic feet, as computed using Winspeakerz. This volume computed an f3 of 60 Hertz. The enclosure will be made from two ½ inch layers; the inner being Medium Density Fiberboard, or MDF, and the outer being Baltic birch plywood. The cabinet's exterior dimensions will be 14 inches high, 10 inches wide, and have a depth of at least 12 inches.

The loudspeaker seems to be extra large because the crossover components will be in a separate internal enclosure than the drivers. The enclosure will have two back panels, one internal, and one on the exterior of the cabinet. The internal panel will allow a 0.5 cubic foot air volume for the woofer to be maintained independent of the size of the crossover. The crossover will be mounted on the rear panel, and will occupy its own space in the loudspeaker.

**Ported v. Sealed Box Design:**

Winspeakerz was used to model the frequency response of the P17SJ00 woofer in a 2<sup>nd</sup> Order Closed Box design as well as a 4<sup>th</sup> Order Vented Box design tuned to 45 Hz. The closed box model gave an f3 of 85 Hz, while the vented box had an f3 of 60 Hz. These graphs have been included in the Appendix. Because these speakers may or may not be used with a subwoofer, a vented box has been chosen for the design. If the loudspeakers become part of a sound system that includes a subwoofer, the vent can be sealed at a later time.

There are downsides to a vented enclosure as opposed to the sealed enclosure. According to John Murphy, “vented boxes are typically under-damped compared to closed boxes.” The under-damping is partly a result of only the surfaces being covered with damping material as opposed to filling a sealed box with damping material. If there is too much material in the enclosure, the functionality of the vent is hindered.

The advantage of a vented box is its increased bass response over a sealed box with the same volume. Since this design is for pleasure listening instead of critical listening, the phase and delay issues created by porting the enclosure are not as important. The loudspeakers will still sound good for their purpose, but they would not be suitable for use as reference monitors.

The vent dimensions will be calculated using Equation 1:

$$L_v = (1.463 \cdot 10^7 \cdot R^2) / (f_B^2 \cdot V_B) - 1.463 \cdot R \quad (1)$$

Where  $L_v$  is the length in inches;  $f_B$  is the tuning frequency in Hz;  $V_B$  is the box volume in cubic inches;  $R$  is the radius of the vent in inches. (Dickason)

The woofer and tweeter will both be located off-center on the front face. This is to reduce acoustical nulls as sound is bent over the edges of the face of the cabinet. The corners of the cabinet will be rounded to spread the null points over a wider frequency

band with a decreased drop in amplitude. Internal bracing as prescribed in the North Creek Music Systems Cabinet Handbook will be used to reduce cabinet resonances.

### **Crossover Design:**

The desired crossover point for this design is at 1.7 kHz. The frequency response plots of the woofer and tweeter included in the Appendix were used to determine the crossover frequency. The P17SJ00 woofer begins to show instability with a peak at 1.8 kHz, while the D27TG-45-06 tweeter has an effective lower bound at 1.5 kHz. As a result of the somewhat narrow overlap, a Fourth-Order Linkwitz-Reilly crossover will be used on both the tweeter and woofer.

The tweeter has a natural 3 decibel per octave high pass at 15 kHz. The Free Air Resonance for the tweeter is 650 Hz, which means that rolling off frequencies below 1.7 kHz should not be a significant problem. The woofer for this loudspeaker has a steady rise from about 1.25 kHz to just before 2 kHz. This will allow a fourth-order filter to be effective before cone breakup occurs, while still supporting sound through the crossover region. Due to this rise in response, the crossover point for the woofer may need to be lowered during tuning to avoid a significant peak in the frequency response of the finished loudspeaker at the crossover point.

**Summary:**

This loudspeaker design uses one Peerless V-line P17SJ00 woofer along with one Peerless V-line D27TG-45-06 tweeter for each cabinet. With an internal volume of 0.5 cubic feet, the vented enclosure will also include a false back to house the crossover components. The loudspeaker will be crossed over at 1.7 kHz using a Fourth Order Linkwitz-Reilly design. The finished design should have a frequency response of  $\pm 3$  dB from 60 Hz to 20 Hz. These loudspeakers will fulfill the need for a good quality stereo pair of speakers for home use, but will be easily movable to coincide with the mobile lifestyle of a college student.

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