Figure 1 Selected drivers. Top left: (Ribbon tweeter) Fountek Neo X 2.0, Bottom left: (Mid-Bass) HiVi F8, Right: (Sub-Woofer) Dayton Audio SD270-A, Not shown: (Passive Radiator) Dayton Audio DS270-PR 10- Visually similar to subwoofer. For size reference, the outer diameter of the sub-woofer is approximately 12”. It should be noted that approximately 17 g of mass is added to the subwoofer in the final implementation.

Figure 2 Initial cabinet prototype constructed from ½ in thick Owens-Corning Foamular® extruded polystyrene (XPS) insulation. The resulting construction was of very limited stiffness (additional effort would be required to reach a reasonable level of stiffness). PVC pipe was trimmed to desired length to be used as inexpensive venting/ports. Some improvement in bass response was observed with XPS. However, the improvement over enclosureless/baffleless operation was marginal and insubstantial compared to the final wooden construction.

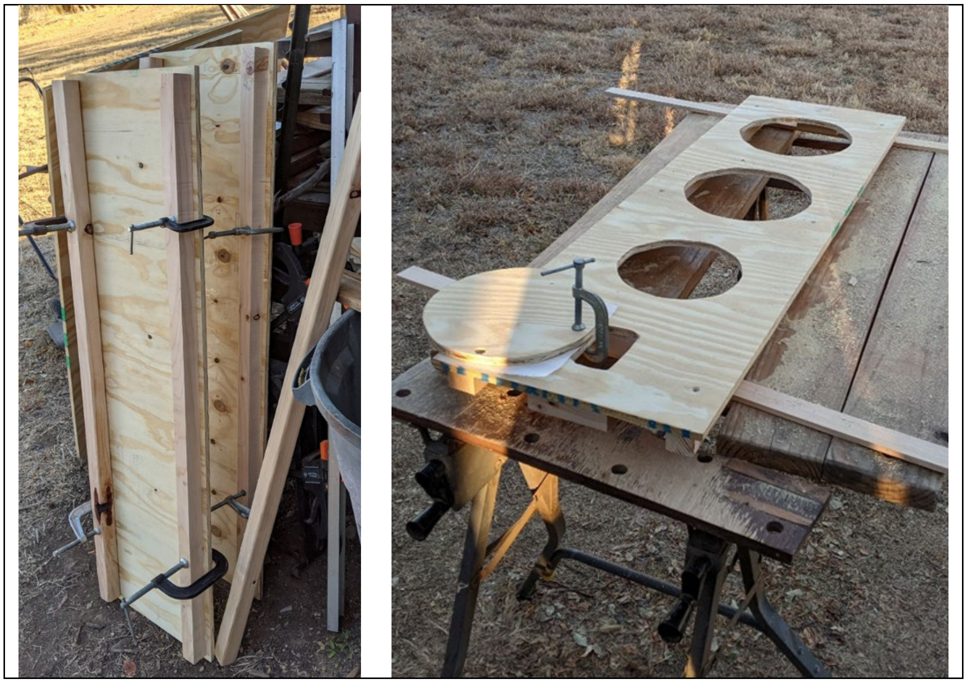

Figure 3 Intermediate construction of cabinets. Panels are made of 1/2” nominal Birch plywood with pine (1 ½)”x(1 ½)” vertical supports interior to the volume. Left: Vertical supports are clamped and glued to the front/rear face panels. Right: Holes for the drivers and passive radiator were free-hand cut with a jig saw. Full dimensions to be presented later.

Figure 4 Finished construction of speaker cabinets. Cabinets were stained with two coats of Minwax® PolyShades™ Natural Cherry stain (and polyurethane) with a satin finish. The included polyurethane makes the stain incompatible with other stains and generally impeded the intended construction, where the cherry was intended to warm the light tones of Minwax® Get Stain in a Mahogany finish. In total, the two coats consumed the better part of a quart of stain to finish both cabinet exteriors. Left: Cabinets stained and curing. Right: Cabinets with drivers added (bottom element is passive radiator).

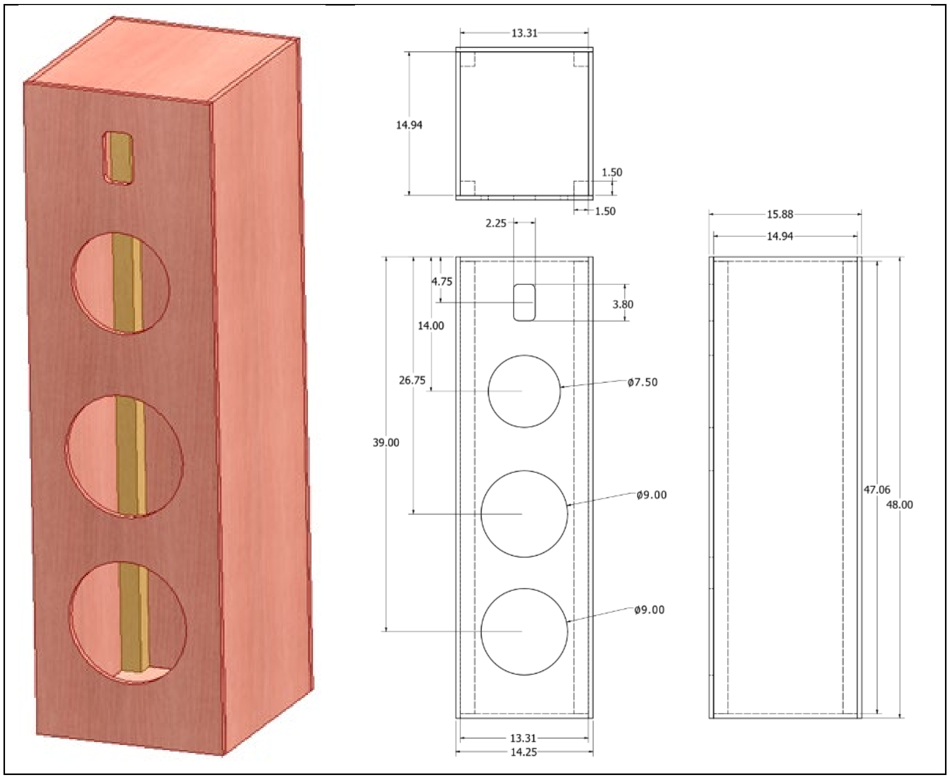

Figure 5 Cabinet design. Details are based on final measured results, rather than being the construction reference. Neglecting driver displacement, interior volume is approximately 5.17 cu. ft.

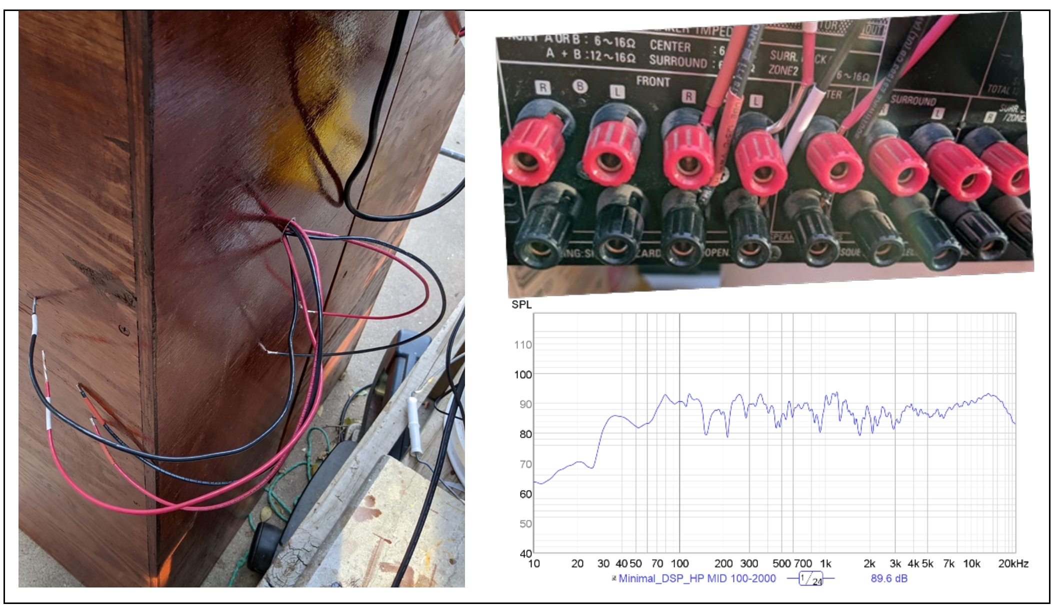

Figure 6 Rear output of speaker cabinet. Drivers are independently wired (without a passive crossover) and must (presently) be amplified and driven separately- requiring a total of 3 external amplifier channels per cabinet. Cables with white heat-shrink correspond to the ribbon tweeter which has a 47 μF, 400 V, Audyn polypropylene (PP) foil capacitor placed in series to protect the ribbon from DC/short-circuit operation. Cables with red heat-shrink are connected across the dual voice coils of the subwoofer. The subwoofer coils are in a series configuration for a (measured) nominal impedance of 12 ohms (6 ohms / coil). The mid-bass is attached to the pair of wires without heat shrink. Positive polarity is denoted in red, negative in black. The measured outdoor response (MiniDSP UMIK-I) with crossover filtering provided by a MiniDSP 2x4 HD is shown bottom right. The test signal was generated by the integrated soundcard on a laptop, the downward frequency response near 20 kHz may be a consequence of this or the bandwidth limitation of the measurement microphone.

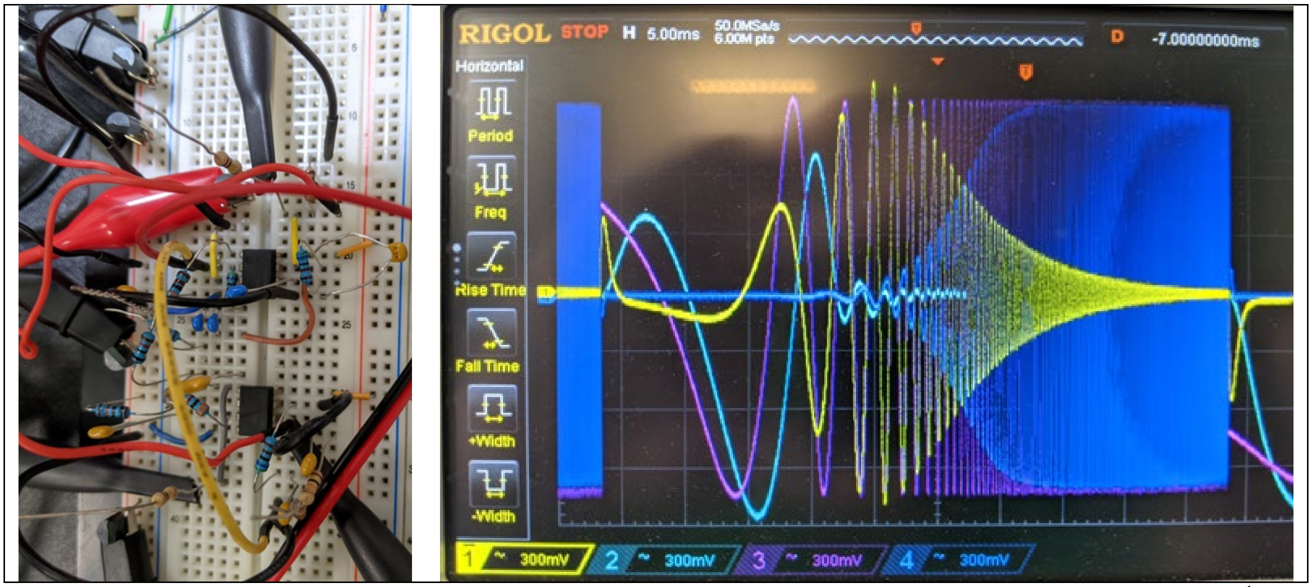

Figure 7 Final implementation is intended to be with an active crossover implemented with discrete components. A simple, three-way, 2nd order, active crossover prototype is constructed and measured. Due to oscilloscope limitations, direct frequency response measurement with any substantial frequency resolution was impossible. Instead, a logarithmically spaced frequency chirp was used. The magnitude response of the filter is captured in the envelope of the observed waveforms. Channel 3 (Purple) is the source signal. Channel 1 (Yellow) is the band-pass filter response. Channel 2 (Cyan) is the low-pass filter response. Channel 4 (Blue) is the high-pass filter response. This design is not the final outcome, and will be informed based on the tuning efforts with the MiniDSP digital crossover.

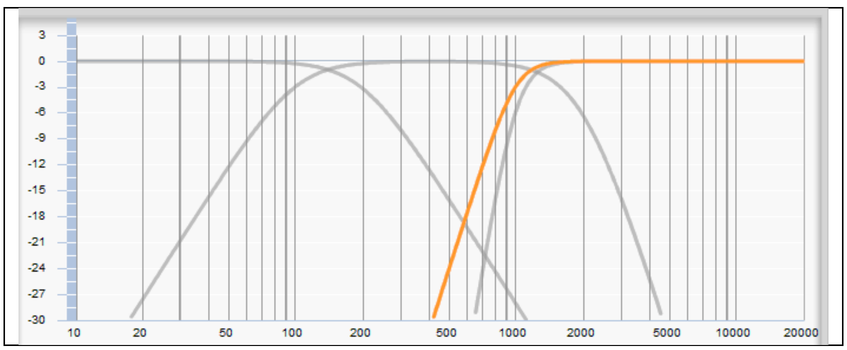

Figure 8 (Predicted, Normalized) Magnitude response of MiniDSP digital crossover. All three outputs (low pass- grey, band pass-grey, and high pass-orange) are implemented as Butterworth filters. The low pass is a 2nd order ($12 \frac{\text{dB}}{\text{oct}}$) filter with a 200 Hz cut off, 4 dB of gain is applied to the output. The band pass consists of a 2nd order high pass with a 100 Hz cut off and a 4th order ($24 \frac{\text{dB}}{\text{oct}}$) lowpass with a 2 kHz cut off. The output of the bandpass is inverted in phase. The high pass is a 4th order filter with 1 kHz cut off. Half a dB of gain is applied to the output of the high pass.

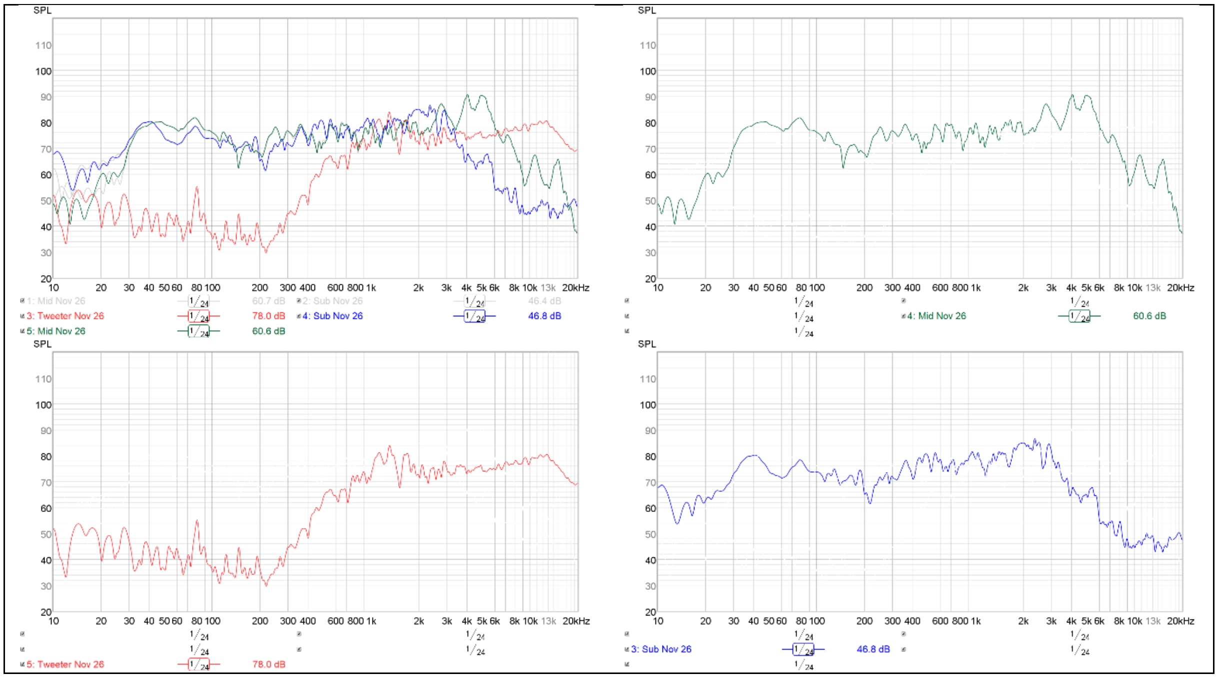

Figure 9 Measured SPL vs. Frequency for each of the drivers installed into the cabinet. Again, the MiniDSP UMIK-I was used to measure the response (in a high noise floor environment) with the Dayton Audio DATS v3 powering the individual drivers. Drivers not powered were shorted to approximate a low-impedance source of their own. The tweeter (Red) measures a SPL well below the 95 dB on-axis response that is quoted in the datasheet but exhibit the same general trends beyond 1 kHz. This likely is due to difference in the absolute accuracy of the microphone and the measurement setup. The subwoofer (Blue) generally agrees with datasheet, with exception of the difference in absolute level. The Mid-Bass (Green) disagrees the most with the datasheet. A predicted roll-off starting near 100 Hz is replaced with an extension well into 30 Hz. The cabinet may work well as a two-way system of tweeter + mid-bass, possibly requiring the subwoofer and passive radiator as a pair of passive radiators. The extension is not predicted by WinISD when modeling the Mid-Bass and a single passive radiator.

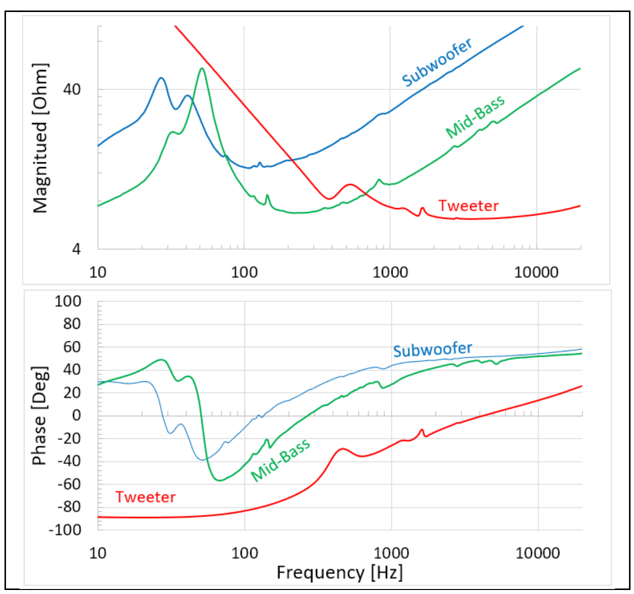

Figure 10 For completeness, the impedance of each driver was measured under fully installed conditions. Testing methodology was the same as described above (Figure 9). The second impedance peak of the subwoofer at (30 to 40) Hz. Is not predicted by the datasheet and may be attributed to the cabinet or the added mass. Similarly, the impedance peak at 30 Hz seen in the mid-bass is not predicted. The subsequent peaks may be predicted, the graph provided on the datasheet is of limited quality. The datasheet for the tweeter suggests a peak in the (1.0 to 1.5) kHz range is to be expected. The impact of the series capacitance is clearly visible in the Sub. 300 Hz range. Data for below 1 kHz is not reported.