

C4 Compound Mobile Subwoofer System

The Polk Speaker

Technical Information from Matthew Polk and the Design/Engineering Team



The design goals of this project were to directly address the many shortcomings of current pre-fabricated, aftermarket, autosound subwoofer enclosures. Box type enclosures and tube type enclosures currently dominate the marketplace. The box type subwoofers are usually very large and cumbersome, making them rather difficult to integrate into the interior of many cars. The cylindrical, tube type subwoofers tend to roll around in vehicles and are difficult to mount properly. The performance of both types is usually severely compromised if the enclosures are made small enough to easily fit in most vehicles. Our objective then, was to design a

mobile automotive subwoofer small enough to fit most applications, without compromising sonic performance. Ultimately, both a unique shape and sophisticated technology were necessary to

achieve the required level of performance, given the physical constraints.



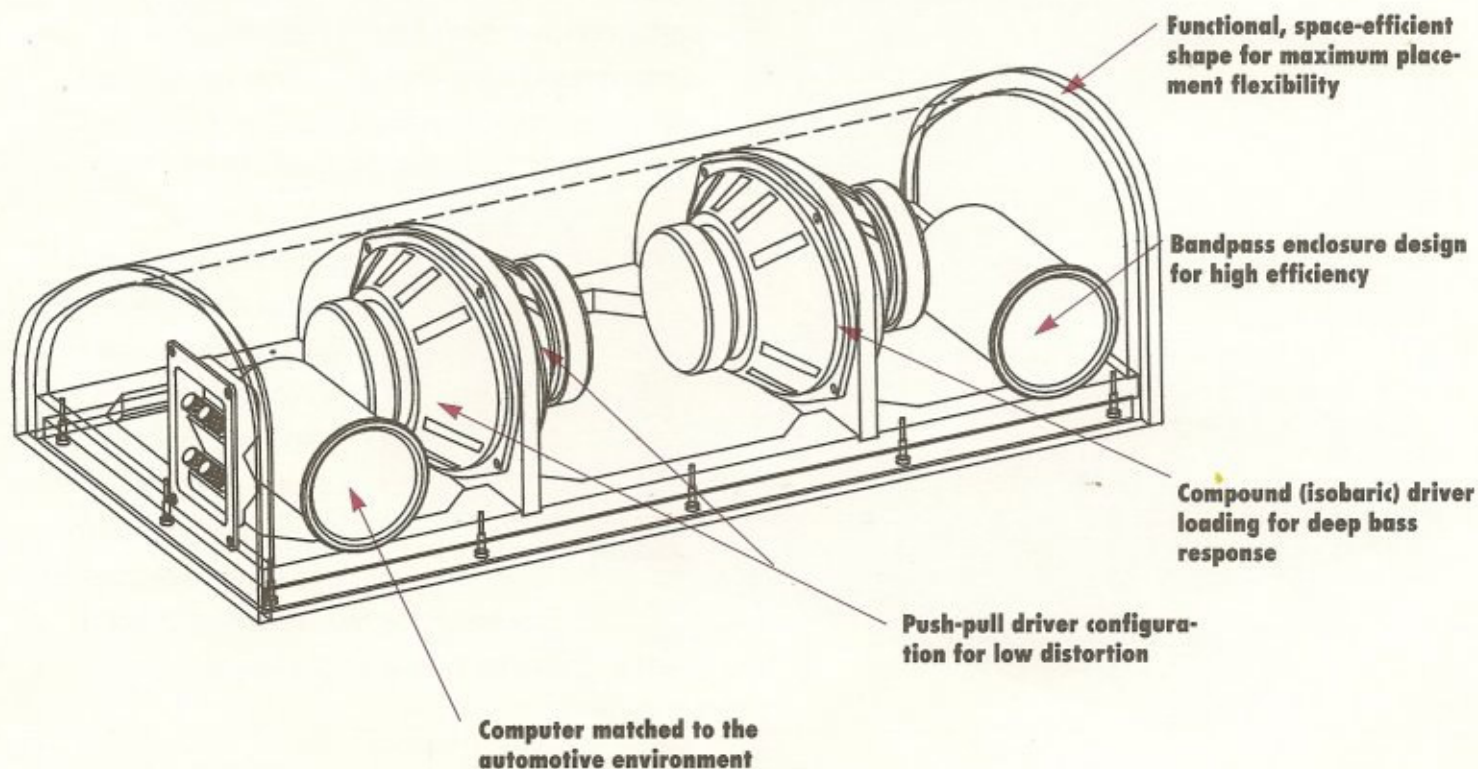
The Design Goals

The design which meets this goal begins with a .82 cu. ft. truncated, teardrop-shaped cabinet constructed of molded, high density plywood over a particle board monocoque chassis. This unique shape allows for flexibility of installation placement while providing stability in moving vehicles. The recessed, flat bottom and supplied hardware prevent the subwoofer from sliding about when the vehicle is in motion. The enclosure shape is also inherently rigid and free from internal standing waves; thus, cabinet resonances are practically nonexistent.

The drivers were designed from the ground up to provide the performance and features envisioned for this product. Four (4) identical 26.5 sq. in. drive units were used to allow maximum linear excursion and bass extension. Thiele/Small parameters were optimized for the extremely small enclosure volume using a unique drive unit arrangement (patent pending) that permits the system to achieve both a wide bandwidth and high efficiency.

Other aspects of the system design used to achieve our goal of uncompromised performance in a small enclosure were a compound (isobaric) driver loading, a push-pull driver configuration and a bandpass enclosure. The compound driver configuration, in particular, allowed us to reduce the required enclosure volume by approximately 50% without sacrificing bass extension or efficiency.

Since each pair of drivers is mounted push-pull (ie, each driver is bolted face to face with its mating driver), asymmetric nonlinearities and harmonic distortion are significantly reduced. This occurs by virtue of the fact that as one driver's voice coil enters the magnetic gap, its mating driver's voice coil is leaving the magnetic gap. Since the two drivers are connected electrically, asymmetric nonlinearities cancel.



The Bandpass Enclosure

The bandpass enclosure provides four extremely important benefits to this subwoofer design.

1. Frequencies above 150 Hz are attenuated at a rate of 12 dB/octave. This acoustic filtering effect removes not only music signal information above the subwoofer's range, but also any electrical or acoustic distortion generated anywhere in the signal chain. It is important to note that excess (lower) midrange information and harmonic distortion, when produced by a subwoofer, will sacrifice bass clarity and quality as well as severely compromise the abilities of a subwoofer to remain sonically nondirectional and blend properly with the rest of the system. With the C4's bandpass design, the use of a subwoofer crossover, while still desirable for optimal performance, is now optional. (See Graph 1)

2. The subwoofer's low frequency roll-off rate is also 12 dB/octave. This rate of attenuation has been proven to naturally compliment the 12 dB/octave rate of boost typical in most automotive environments. The resulting system response is extremely flat and extended. In a car the C4's bass reproduction will extend significantly deeper without becoming boomy. Transient response (the relative quickness and precision of the bass) is also superior to conventional vented designs. (See Graph 2)

3. Each driver pair is loaded by a small, sealed volume without sacrificing bass extension. The real benefit here is that driver excursion is minimized and does not increase below system resonance as in conventional vented systems. Higher output is achieved while keeping driver excursion within the limits of linear movement. (See Graph 3)

4. Complete control of system response is possible. By carefully controlling tuning frequency, bandwidth and efficiency, we have created a subwoofer with performance optimised for the automotive environment. Extensive research into automotive acoustic loading effects, computer modeling and painstakingly accurate, in-car measurement techniques have given us the power to match the performance of this subwoofer to the environment of a typical car. The C4 will sound best in the environment for which it was optimised - your car.

The Applications Side

In order to allow for the maximum in application flexibility, we have designed the C4 with multiple impedance capability. Each C4 can be configured in one of three impedance modes: 4 ohm stereo, 2 ohm mono or 8 ohm mono. Any combination of stereo or mono amplifiers can now be used without compromise. The C4 can be used with dedicated stereo or bridged mono subwoofer amplifiers or with only one full-range stereo amplifier (powering the entire system).

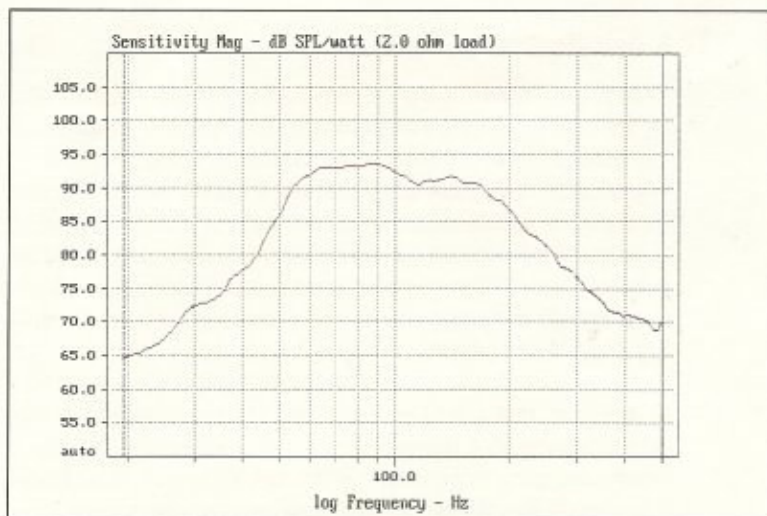
In addition, the appearance of the C4 matches its stellar performance. We have designed an extremely durable fabric covering to protect the C4 from the daily abuse of the automotive environment. The neutral color, high level of fit and finish and unique shape enable the C4 to integrate well into the interior of any vehicle. We've even used high quality, gold-plated input terminals for long term reliability and the highest possible fidelity.

We believe that through the application of sophisticated technology, the C4 has not only overcome the major shortcomings of currently available mobile subwoofer enclosures, but also has set a new standard of quality in bass performance. With the C4 compound mobile subwoofer system many of the limitations and compromises of existing mobile subwoofers no longer apply.

A Note on Performance

The performance of the C4 has been modeled by computer, measured in the lab and measured in typical cars. Nominal impedance is 4 ohms per channel. Minimum impedance with both channels bridged for mono is 2.5 ohms. Sensitivity, measured at 1 meter, one watt input power (2.00 Vrms), at a frequency of 80 Hz, is 94 dB. In-car measurements indicate a f-3dB low frequency cutoff of below 25 Hz and a high frequency cutoff of 150 Hz.

It is important to remember that these measurements are only a rough indicator of the quality of bass produced by the C4. The best way to experience this unique quality of bass reproduction is to listen to the C4 in a car with a wide variety of musical selections. We have found the best performance under the following conditions: use a high quality electronic crossover with independently adjustable high pass and low pass outputs, use separate power amplifiers for the C4 and the rest of the system, use only high quality electronic equipment (eg, CD versus tape) and use only high quality speakers elsewhere in the system (the quality of lower midrange and treble is extremely important in the perception of bass quality).

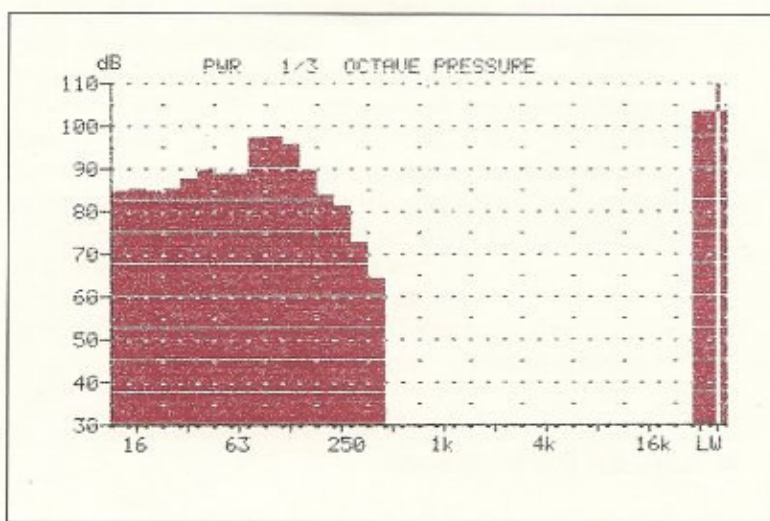


Frequency Response and Sensitivity

Graph 1 shows the measured frequency response and sensitivity of the C4. This measurement was performed using the "ground plane" technique in a semi-anechoic chamber, with one watt (1.414 Vrms) input and the microphone at one meter (on axis). The C4 was wired for a 2 ohm mono input. Note the smooth, extended bass and the 12 dB/octave acoustic roll-offs at both the low frequency and the high frequency limits of the C4's bandpass response. The high sensitivity of the C4 is also apparent, 94 dB with one watt (1.414 Vrms) input into 2 ohms. At the standard 2.83 Vrms input, the C4's measured output was an amazing 99.5 dB!

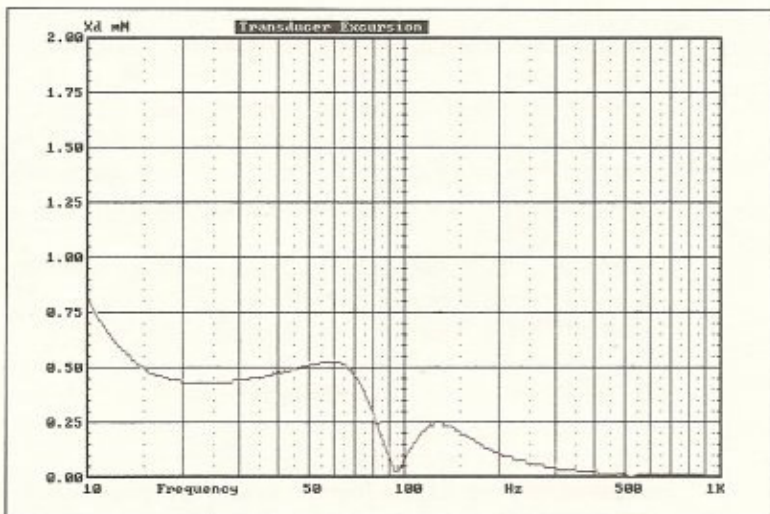
Frequency Response in a Typical Car

Graph 2 shows the measured frequency response of the C4 in a typical automobile. The measurement was performed using a 1/3 octave real time analysis (RTA). No crossover was used in this measurement. Note the extra extension and flatness of the bass response of the C4 in a car as well as the natural attenuation above 200 Hz. The peak at 100Hz is the automobile's natural resonant frequency and not a characteristic of the C4. The optimization of the C4's performance within a typical car is quite evident - frequency response flat and extended to 20 Hz!



Transducer Excursion

Graph 3 shows the transducer (driver) excursion of the C4 with one watt input. The peak excursion or movement of the driver is well controlled and minimized to about .5 millimeters (.0197 inches). This is less than half that of a typical vented enclosure with similar performance. The result of such low excursion is more linear performance, with dramatically less distortion and no driver "bottom-out" at high levels.



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Specifications

Driver Complement: Four 6 X 9 inch woofers in an isobaric push-pull configuration . **Enclosure Type:** 4th order bandpass .
Frequency Response: 25 Hz - 150 Hz . **Sensitivity:** 94 dB / 1 watt / 1 meter . **Recommended Amplification:** 25 - 200 Watts/channel
Nominal Impedance: 4 ohm (stereo), 2 ohm or 8 ohm (mono) . **Dimensions:** 8"H x 14.125"D x 26.25"W, (20.3cm x 35.9cm x 66.7cm)
Weight: 26 lbs. (11.8 kg)