Bandpass Enclosure Characteristics

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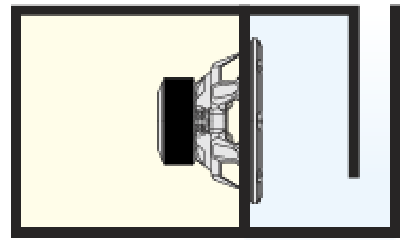
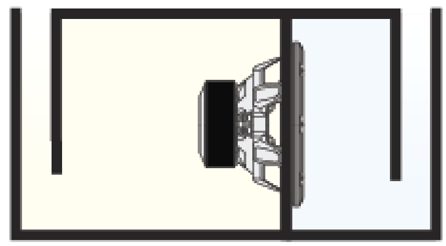
Single Reflex Bandpass Enclosure Dual Reflex Bandpass Enclosure



These enclosures have, at times, been popular in the car audio world. It would probably surprise many people to know that this is a very old design. The first patent for a bandpass enclosure was filed in 1934 by Andre d'Alton. Many home sub/satellite speaker systems currently use bandpass designs for low frequency reproduction.



Advantages

- Can pass lots of output through a small opening

In a bandpass box design, the woofer no longer plays directly into the listening area. Instead, the entire output of the subwoofer system is produced through the port or ports. In a conventional sealed or ported subwoofer system the low frequency extension is controlled by the interaction of the speaker and the enclosure design, but the high frequency response is a result of the speaker's natural frequency response capability (unless limited by a crossover). In a bandpass enclosure, the front of the speaker fires into a chamber which is tuned by a port. This ported front chamber acts as a low pass filter which acoustically limits the high frequency response of the subwoofer system. The name "bandpass" is really pretty descriptive in that it refers to the fact that the enclosure will only allow a certain frequency "band" (range) to "pass" into the listening environment.

So what? Couldn't the same thing be accomplished by placing a low pass crossover on the subwoofer system? Yes, it could, but a bandpass enclosure can produce significant performance benefits in terms of efficiency and/or deep bass extension that would not be possible in conventional designs of equal size.

By adjusting the volumes of the front and rear chambers and the tuning of the port or ports, significant performance trade-offs can be created. When box parameters are adjusted for a narrower bandwidth, the efficiency of the subwoofer system within that bandwidth increases and can reach gains of up to 8dB (sometimes even higher.) As box parameters are adjusted for wider bandwidths, very impressive low frequency extension can be produced from extremely compact enclosures at the expense of efficiency and good transient response. Intermediate bandwidths can also be designed which create a compromise between all these characteristics. As if that is not confusing enough, within each bandwidth range, the designer can also manipulate box parameters to shift the range of operation up or down the sub-bass range which also has an effect on efficiency.

As you can see, bandpass enclosures can have very different sound characteristics based on the designer's choice of box parameters. As such, it is not always possible to make blanket statements as to the performance benefits and drawbacks of bandpass enclosures in general.

One characteristic of bandpass enclosures which is universal is that they exert greater control over cone motion over a wider frequency band than conventional designs. Due to controlled, rapidly changing air pressure on either side of the woofer, the woofer is capable of producing high levels of acoustic output without physically moving very much. This means that the woofer is less likely to encounter excursion limits in the main part of the sub bass range. However, just because the cone isn't moving as much doesn't mean that the speaker’s motor assembly isn’t still trying to drive the cone hard; it just means that the speaker cone is encountering resistance to motion. This resistance can be very hard on speakers, especially when crazy car audiophiles are at the controls. The conflict between the force generated by the motor assembly and the air pressure in the enclosure can impose extreme stress on the glue joints and suspensions of the woofers. You can literally tear a speaker apart in a bandpass enclosure if you apply too much power. Because the speaker is not moving as much and because noises are masked by the front chamber, it is also very difficult to hear when a woofer is in serious trouble. Many people have been known to crank bandpass enclosures up and blow the speaker to bits within a few minutes because they did not realize that the speaker was having a heart attack. Choosing the right amount of power and carefully setting amplifier gains is very important in order to ensure long term reliability.

Bandpass enclosures can be divided into two basic types: single reflex and dual reflex. In a single reflex design, the rear chamber is sealed and the front chamber is ported. In a dual reflex design, both front and rear chambers are ported into the listening area. A variation of the dual reflex and single reflex, known as “series tuned,” has a port which connects the rear and front chambers.

The differences between single reflex and dual reflex bandpasses are similar to the differences between sealed and ported enclosures. A single reflex typically exhibits a shallower low frequency roll off rate (approximately12dB/octave) and better transient response. A dual reflex is more efficient and controls cone motion over a wider range but typically has a sharper (18–24dB/octave) low frequency roll off. Because of the difference in low frequency roll-off rates, a dual reflex usually has to be larger in size to produce the same low-frequency extension as a single reflex design.

As compared to more conventional enclosure designs, bandpass enclosures are very complex to design and build. The rules governing the performance of bandpass enclosures leave no room for error. Slight volume miscalculations or sloppy construction can turn a good design into a poor performing box. Integrating the proper size port or ports can be extremely challenging and often renders designs that looked great on paper completely impractical. The design of these boxes should definitely be left to people with extensive enclosure- building experience.

For many years now, bandpass enclosures have been quite popular both for their aesthetics and performance. A properly designed, constructed and implemented bandpass enclosure can and often will out-perform the same driver or drivers in a more conventional sealed or ported design in terms of sheer output and/or low frequency extension. A bandpass alignment also allows the installer to funnel a potentially large amount of low frequency energy into the vehicle’s cabin through a relatively small opening. This can be particularly useful in some vehicles such as European sedans whose tank-like construction does not facilitate a satisfactory transfer of low frequency energy from the trunk into the cabin.

At JL Audio, we only recommend single reflex bandpass designs (as opposed to dual reflex or series tuned bandpass designs). Cubic foot for cubic foot, a single reflex bandpass characterized by a sealed “rear” chamber(s) and ported “front” chamber(s), typically offer better transient response and low frequency extension than its more elaborate cousin. In addition, while still a fairly difficult system to construct properly, single reflex designs are a bit more forgiving of minor errors in calculation and assembly when compared to more sophisticated bandpass types. All things considered, we have found that single reflex designs offer the best combination of reasonable enclosure size, good transient response and predictable behavior.

For the duration of this document, the term “bandpass” or “bandpass enclosure” will refer only to single reflex bandpass enclosures unless noted otherwise.

So how do they work?

A bandpass enclosure is, by definition, simply a sealed enclosure with an acoustical filter in front of it that serves to limit the upper-end of the driver’s frequency response. This natural limiting of the high-frequency response of the system makes the selection of midbass drivers critical. If your vehicle cannot fit larger midbass drivers (such as a 6 1/2" or larger), a bandpass enclosure is probably not the best choice for you. Using a bandpass enclosure with insufficient midbass reinforcement will lead to sluggish, sloppy, muddy, low frequency response. In short, it will sound like a soggy pancake hitting a cardboard box.

Once adequate midbass reinforcement has been selected to complement the subwoofer system it will be necessary to add additional electronic filtering to further limit the upper frequency output of the enclosure. Contrary to popular belief, a bandpass enclosure (of any type; single reflex, dual reflex, series tuned, etc.) does require the use of an electronic crossover to achieve optimum performance since the acoustical low pass filter is not a very effective filter. What proponents of “crossover-less” bandpass enclosures neglect is that there is a considerable amount of high frequency output (called “out-of-band noise”) that can get to be quite annoying. It is for this reason that JL Audio recommends that all bandpass enclsoures be supplemented with an electronic crossover. If you would like to find out more about electronic crossovers, see your local authorized JL Audio dealer.

In order to understand how a bandpass enclosure works, it helps to break the enclosure itself into three parts: the sealed (rear) chamber, the ported (front) chamber, and the port itself; but before we get started, we need to define some of the basic terminology used in this tutorial so we can make sure everyone is on the same page.

The Sealed Chamber

The sealed chamber's primary purpose is to serve as a high-pass acoustical (as opposed to electrical) filter and it's volume controls the lower –3dB point or **Fl**. By changing the size of the sealed chamber, we can see a corresponding shift in **Fl** that follows these simple guidelines:

> The bigger the sealed chamber is, the lower the **Fl** will be. The smaller the sealed chamber is, the higher the **Fl** will be.

Any changes made in the rear box volume require a corresponding change in the tuning of the front chamber(s) of the enclosure. Failure to retune the front chamber(s) will result in a mis-tuning and the box will more than likely sound really, really bad. As is Mother Nature's style, we can't get something for nothing so as we adjust the volume of the rear chamber(s) it is important to keep the following in mind:

- The bigger the sealed chamber is, the lower the driver's mechanical (also called "displacement-limited") power handling will be.
- If the rear chamber(s) is/are too big, the amount of power the system can handle is reduced.
- The smaller the rear chamber(s) is/are, the higher the driver's displacement limited power handling will be but of course, the low frequency extension will suffer as a result.

The Ported Chamber

The ported chamber controls the bandwidth and efficiency of the system and behaves as follows:

- As front chamber volume(s) increase, the system becomes more efficient.
- As front chamber volume(s) decrease, system effiency decreases.

As always, Mother Nature has her dirty little hands in our enclosure design so we have to consider what she is doing:

- As the size of the ported chamber increases, the bandwidth decreases. So, the more efficient we make the system, the smaller the passband will be. If the system is made too efficient (outrageously large front chamber), we'll wind up with "one note" bass so typical of a myriad of mistuned bandpass enclosures on the market today. On the other hand, as the front chamber volume increases, the better the transient response of the system will be, and this is good.
- As the size of the ported chamber decreases, the bandwidth increases. This may sound desirable (especially to those with smaller midbass drivers), but of course Mother has dictated that as the ported chamber shrinks the group delay becomes undesirably large and the system starts to sound very sluggish and muddy thus ruining our hopes of using a bandpass system with our factory installed 4-inch speakers!

The Port

The port is probably the single most critical variable in the bandpass equation. The port **must** tune the front chamber to the exact center of the passband or the box will sound like total garbage. The center of the passband corresponds directly to the sealed box resonant frequency or fc of the rear chamber. If for some reason the port is of the incorrect dimensions and tunes the front chamber too high, the frequency response will be skewed creating a really nasty response peak in the lower midbass range, whereas if it is tuned too low the response will be very peaky in the lower frequencies and the bass will sound unnatural and boomy.

"Universal" Bandpass Designs

The term "universal bandpass" itself is really an oxymoron (like "fresh-frozen", "jumbo-shrimp", "one size fits all", etc.) in that there truly is no one design that will work with all drivers! To imply that such a design is feasible is to totally ignore the very nature of bandpass enclosures: they are extremely driver sensitive and enclosure sensitive! If you have read all of this tutorial up until this point, it shouldn't take much persuasion to lead you to believe that "yes, bandpass designs are picky and easy to mess up". Not all 10" drivers are alike…not all 10-inch drivers from one manufacturer are alike, so why should they use the exact same box?