Subject: Subwoofer Group Delay and such. Long post, but I hope its interesting, maybe :P
Posted by Adrian Mack on Fri, 12 Sep 2003 07:13:32 GMT
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Hey Wayne,I'd like to discuss a few things about subwoofer phase/group delay. The post Acoustic Suspension vs. Bass Reflex discusses the resonant-overring phenomomen. And I agree with it totally. But I want to discuss the phase shifts throughout the subwoofers passband (normally about 20-100Hz). A PiAligned cabinet takes advantage of the bass reflex box's port to reduce overring. Am I right in saying that the smaller the box, the air is stiffer so that impedes resonant overring more? And also tuning the system so that its not used near resonance means that resonance overring is not really that possible, or at least greatly attenuated. I think this is what PiAlign basically does in terms of keeping that awful ringing to a minimum. I've also found that the frequency Fs is kept about -10db down from where the subwoofer is flat in most cases in PiAligned cabinets. Most sealed systems (Qtc=0.707) generally arn't used near resonance either, just like a PiAligned cabinet. I realize that in the Acoustic Suspension vs. Bass Reflex post, you've made the point that port dampening is used on a PiAligned cabinet to reduce the ringing at resonance. Your probably right, but I'd like to know why this is so. Most say that in sealed systems, the air in the box is very stiff and is the best at impeding resonance overring. I guess we could describe damping by the impedance curve? If I recall, the higher the impedance peaks, the higher the system damping. I dont know if this relates to the damping at resonance however. I think the distance between the peaks also has an effect, but I'm not sure of what this does. I guess the question is, a PiAligned box and a Qtc=0.707 box have almost the same response curve (but PiAlign has a bit more bass extension which is good) I'd like to understand why the port makes the ringing at resonance less in a PiAligned box than a Qtc=0.707 sealed box. They are both small and used way away from resonance. I dont diagree with you, but I'd like to understand a bit better :-) That stuff above just came up in my mind when I was thinking of my real question. Besides resonance overring, along the subwoofers passband there is phase shifts, of course. And those phase shifts describe group delay, which is a difference in time. I've found that plugging the numbers into a box modelling program for a PiAligned box and a Qtc=0.707 box, that the phase shifts within the passband (I compared from the -3db point of the sealed system and up to 100Hz. Then I used the sealed systems -3db point to 100Hz, except on the vented system, instead of the vented systems -3db point which is a bit lower and hence a bit more phase shift) for both systems are just about the same. They came out to be about 10 to 40 degrees different in most cases. I think that this is just about nothing, is that right? So I then looked at the group delay curves. (By the way, I used the T/S parameters for the Eminence LAB12 for this discussion, for no reason. Have to pick some woofer to discuss :P). The vented systems group delay was slightly higher than the sealed one, which I expected as the PiAligned box had a slightly bigger phase shift than the sealed system. But it was not much at all. Would it be fair to say that a PiAligned box and a sealed Qtc=0.707 box, in terms of "group delay" throughout the passband - are equal, disregarding the tiny phase shifts of even like 40 degrees, which do our ears cant discern. So they are equal in this respect. Now the resonant phenomonen, you've said that the PiAlign cabinet has less resonance overring. Cool. So in terms of all this "crap stuff" like group delay, resonance overring, etc, a PiAligned box has no more audible group delay than a sealed box, but it does have less resonant overring, which makes it better in this respect. Correct? Man, this has taken a while to write. I'm not even sure if I've asked what I was trying to do in the first place! The Adire Audio DPL12 is a 12" woofer, with a very low Fs of 16Hz. For resonant overring to occur, the signal must have information right at box tuning frequency, or very near it. How far away would you say the maximum is before resonant overring does not occur? Say if Fb=20Hz, and we had a song with no information below 30Hz - can we say that resonant overring wont occur? And could we then say, for any vented box of any size will sound the same as a PiAligned one because theres no information at resonance to excite it into ringing? That is of course, any box that doesn't introduce absolutely huge phase shifts. Tuning the box lower or making it larger means that the group delay is maximum at a much lower frequency. I compared the phase shift between 20Hz and 100Hz on the Adire DPL12 for a PiAligned box (58L, 15Hz Fb), and then a much larger 5ft^3 box tuned at 16Hz. The PiAligned box had more phase shift, but it had lower group delay. I have thought that, the more phase shift, the higher the group delay. Whats happening here? True Audio also has an interesting paper on group delay if you want to check it out. Phase should be kept to a minimum for the original recording to be most properly reproduced (and therefore group delay too), providing the response curve is flat of course. I was going to say something about this, but I've forgotten it. I think it might have been how many cycles are allowed before group delay becomes a problem in the bass range? True Audio says 1-2cycles at maximum. BTW: Is one cycle 360 degrees? Is there a way to define a "cycle" using group delay, which is measured in milliseconds? Thanks!AdrianPS: Sorry for making it such a long post!

Subject: Aren't we
Posted by mollecon on Fri, 12 Sep 2003 10:59:58 GMT
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Is it that complicated? As far as I know, ANY reflexbox will have a phase shift at 180 at -3dB point - & ANY closed box a phase shift at 90 at -3dB...Impulse behaviour at resonance;A closed box with a Q close to 1 will have a ringing of a cycle or so at resonance, & a -3dB point 20% below

also the -3dB point. A closed box with a Q at 0.5 will show very little ringing - & you pay for that having the bass down -6dB at resonanse.A reflex box with a socalled B3 alignment (showing a 18dB/oct drop below resonance) will show a ringing almost similar to a closed box with Q at 1 - & the standard B4 alignment will be 'worse' in that respect. You can surely have reflex alignments that rings less than this - use a bigger box &/or lower the tuning...The fact the remains that there are pro's & con's for both reflex & closed box. The reflex box is a way to get better efficiency &/or deeper bass + reduced diaphragm excursion, with added smaller distortion at any given output, AND a higher output, up to 5.5dB compared to the closed box of similar size & bass response. BUT you pay with more ringing at bass resonance.And A LOT of variables goes into determining which to prefer, including the listener! The fact that most high efficiency enthusiasts use basreflex (when not horns in the bass - but those bastards are REALLY big) is no wonder - just look at what it offers compared to the closed box, WHEN you have high effeciency as a priority...With the danger of being accused of heresy, I would like to mention that it is possible to get a reasonably high efficiency with a closed box - a fairly large one that is! Put the Eminence Beta 15 in a box of aprox. 170 liters (~6 cu.ft.), & you will get a Q at 1, -3dB at 48Hz - & I bet it'll be tube friendly, too, considering the magnet size on those (running away before Wayne comes with his baseball bat).Just my (pretty long) two cents.

Subject: Possibly... but heres another thought
Posted by Adrian Mack on Fri, 12 Sep 2003 15:28:21 GMT
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Hey Mollecon (and others),> Is it that complicated?Possibly ;). This is an area where I have actually quite a large interest. I know I asked a hell of a lot, but thats what has been running around my mind lately! I think that delay is a pretty interesting and enjoying topic... sadly one that is misunderstood so much, which I guess is part why I am so determined to get it right. > As far as I know, ANY reflexbox will have a phase shift at 180 at -> 3dB point - & ANY closed box a phase shift at 90 at -3dB...Hmmm. That sounds like something I've heard before, I think, but the box modelling programs dont seem to show this :(I guess one of the main things in my discussion was PiAlign, and how it reduces resonant overring. Wayne has stated that it is better than a sealed system having the same -3db point (and its usually Qtc=0.707 or very near it) in that it has less resonant overring by making the -3db point of the system something like a half octave above Fs, and also using a smaller box size and port damping. I guess I want to know how this actually works... I too love vented boxes, and in almost all cases I just dont like the sealed box, mostly because of its limited output, limited bass extension, and high excursion (and therefore increased distortion). The Acoustic Suspension vs Bass Reflex post was very interesting indeed, but either it doesn't tell me exactly why "port damping" makes it better, or I didn't understand it completely.> A closed box with a Q close to 1 will have a ringing of a cycle or > so at resonance, & a -3dB point

resonance, which > is also the -3dB point. A closed box with a Q at 0.5 will show > very little ringing - & you pay for that having the bass down -6dB > at resonanse.Sounds good. One thing I'm a bit wary of, in that acoustic suspension vs bass reflex post, it says "A sealed box can only assist the motor by dampening it - in effect, decreasing compliance". Decreasing compliance is basically decreasing box volume... but isn't it, for a sealed box, the larger the enclosure (not smaller), that means the less overring it produces? The other part of my post was about the phase shifts through the passband, ignoring the resonance overring part. They introduce group delay. Can it be said that, these phase shifts are only minor? Because the rest of the group delay curve is very low, below 10ms or 5ms in most cases. People talk about group delay usually where it peaks, which is near resonance. And then they throw about all these numbers etc and say "higher group delay sucks" etc. But the real thing is resonance overring. The thing that has been troubling me... the signal has to be applied at the resonance frequency or very near it for it to be excited into ringing. If its not, then it doesn't ring (?). And of course, if Fb is like way down... like in a PiAligned cabinet, then any ringing at all is greatly attenuated. Lets say we had a box that wasn't though and it was flat to Fb, and Fb was 20Hz. A lot of music etc has no 20Hz information.. so on music like this, its fair to say that it wont ring? And therefore its going to be just as good in this sense as any other cabinet, like a sealed or PiAligned cab? (ignoring distortion in maximally tuned vented cabs which allow the system to be used near driver resonance where distortion is much higher. Of course if the music has no content here then it doesn't matter, and for this example I'm saying if the music had not content in this area). This is why I gave the example of a song having only above 30Hz information. Does 360 degrees correspond to one cycle? Or do we actually calculate how long the cycle is? On the True Audio Group Delay paper it says that 0.25 cycles is 4.5ms, so 4*0.25*4.5 = 18ms. So is one cycle 18ms? What happens when we have a vented system with a very large peak in group delay near resonance, but then goes down on either side? (this is common of very large boxes, regardless of tuning. EBS has this too). Maybe this is just an indicator that the box has high resonant overring. Finally, Adire Audio state that we should aim for 25ms or less at 20Hz in their Subwoofer Group Delay Comparison tech paper. They say "Lower group delay numbers are indicative of a "tighter" sound of the subwoofer" which is why I wanted to know about group delay in the passband too, and not just resonant overring. True Audio state that a phase shift of one cycle in the bass region is non-detectable by us (I assume the bass region covers from 0Hz to 100Hz or so). Therefore, between vented and sealed systems - none of these are making multi-cycle shifts. Therefore it means nothing??? As long as resonant overring is kept minimum, then both should sound as good as each other (providing both have flat response). Is this correct? Thanks!Adrian

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Subject: An attempt at an answer...
Posted by mollecon on Fri, 12 Sep 2003 18:03:08 GMT
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Quote: " but isn't it, for a sealed box, the larger the enclosure (not smaller), that means the less overring it produces?"Yes it is - the larger the box, the lower the Q (which is basically how ringing is described in these terms) AND the resonance. These two follow each other in a linear manner in closed boxes - if you move the driver to a smaller box that raises the Q with, say, 30%, then the resonance will rise with with 30%, too.Quote: "But the real thing is resonance overring. The thing that has been troubling me... the signal has to be applied at the resonance frequency or very near it for it to be excited into ringing. If its not, then it doesn't ring (?)"I agree that 'the real thing' is resonance ringing. And the problem is, you DON'T have to be that close to the resonance to exite it. Let's say we have a system with a relatively high Q (well over 1) & a resonance at 50Hz - & let's say we feed it a powerfull 80Hz signal that just stops... Well, the 80Hz signal do stop, but not the ringing at 50Hz! The diaphragm has been set in motion, & WILL continue to move at system resonance untill the damping kills it. This is why poorly damped systems get a reputation for playing 'one note bass' - they insist on delivering their system resonance to the listener, no matter what note is played.Yes, 360 degrees is one cycle.I now next to nothing about group delay - I do know that a closed box have what is referred to as a minimum phase behaviour at & and on both sides of the resonance frequency. This means that if you use an equalizer to boost the lower frequencies back to level, you ALSO take care of the phase, basically. Btw., I forgot to say that the closed box actually have one advantage more compared to a reflex (I mentioned A LOT of advantages for reflex!) - it has an inbuild automatic 'subsonic' filter, which helps the cone from being overloaded below resonance - reflex boxes can be pretty 'hysterical' in that sense, since the driver in practice behaves almost as if there weren't any box at all below the systems working area. The use of rather stiff suspensioned pro type drivers in many high efficiency speakers does, however, help a lot in this respect.Quote: "As long as resonant overring is kept minimum, then both should sound as good as each other (providing both have flat response). Is this correct?"Yes, I think you interpreted that totally correctly.As you probably can see from my post, I know considerably more about closed boxes than reflex one! No wonder, they are far less complicated behaviour wise. In some manners, they are alike, though - for instance, the 'bigger box = better damping' (less ringing) is also true for reflex boxes, PROVIDED you keep the box tuning the same. And the same size box will be better damped the lower the tuning is (assuming same driver, of course!). But when you start fooling around with BOTH tuning & box size, it becomes a bit complicated. The 'puter programs usually can tell us what happens in the frequency domain, but are often more than reluctant to tell about system Q & ringing.The fact remains that all systems are compromises, & that well sounding systems can be made from using both reflex boxes & closed ones - not to mention the many other box principles that are being used. There is more than one way to good sound.Now will someone please tell me to shut up?

Subject: fl, fb and fh
Posted by Wayne Parham on Fri, 12 Sep 2003 20:18:18 GMT
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The most succinct way I can describe bass-reflex behavior is to say that the Helmholtz resonator has influence between fb and fh. It reduces cone excursion between fh and fb and augments bass output between fb and fl. Ported systems can generally be made to have a lower cutoff in a smaller box than sealed systems.The terms fl, fb and fh are discussed further in the posts called "Behaviour of vented loudspeaker systems" and "Measure impedance."

Subject: Impedance Peaks relating to damping and GD
Posted by Adrian Mack on Fri, 12 Sep 2003 22:03:55 GMT
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Hey Wayne and Mollecon,In the Behaviour of vented loudspeaker systems post of yours, at fl and at fh, impedance is very high. But at fb on a vented box, impedance is at its very lowest. Would this not dictate that system damping is the lowest here? In a sealed system, at resonance, impedance is highest. At fb, impedance is always a lot lower in a vented box than the sealed box is at resonance, which would seem that the sealed box offers better damping and less ringing at resonance. Mollecon said that larger boxes means less ringing (higher damping). I then wondered about PiAligned vented cabinets, because they use very small boxes. So I took out my box modelling program to look at the impedance curve, and found that, the two impedance peaks, fl and fh - when box size is large, the two impedance peaks are much closer togethor than when the box is small. But the smaller box also showed an impedance peak with less amplitude/lower impedance, but they were further apart. Its possible to get a vented box with fh at 60Hz, but use a crossover at 100Hz because we want to use it up to 100Hz. But anything above fh, the port does nothing, and therefore does nothing to stiffen the system/provide damping and impedance drops again. Then take a vented box with fh at 100Hz (this would have to be a smaller box), with crossover at 100Hz too, we can say this box has better damping between 60-100Hz than the larger one. But this is way away from resonance, and doesn't really matter then. So I guess, the thing that is (now) bothering me is that at resonance in a vented system, impedance is lowest, and that means lowest damping and highest ringing, to my knowledge anyway. But then comes marching-in that damn group delay curve included in so many computer simulation packages.... and if we go along Adires simple guideline of "Aim for below 25ms at 20Hz"... we can still get a vented system that has group delay at 20Hz which is way below 25ms... so thats a good thing. But that is the problem - the impedance curve shows lowest impedance at fb therefore lowest damping.... but the group delay curve still can show very low group delay here. ---- The sealed box I found always had slightly less group delay at resonance than the vented box did at the same point. I guess thats because impedance at resonance is way higher on the sealed system. This is comparing a Qtc=0.707 sealed box and PiAligned vented cab, which both have essentially the same response curve. But since the diff in GD was very minor, it seems that the larger impedance at resonance in the sealed box (meaning higher damping) does not do that much compared to the vented boxes very low impedance at resonance... they both had almost he same GD, and both systems had almost same response curve (has to be or we cant compare, it would make it unfair if they did not). So to sum up my ramblings in case they dont really make sense, they are:1: The vented system is damped most between fb and fh. Impedance is highest at fh so damping is highest here. At fb, impedance is still at its very lowest. That would dictate lower damping and therefore higher overring. The sealed box has highest impedance at resonance and therefore lower overring. Reflected back in the GD curve though, qtc=0.707 sealed box and PiAligned vented show roughly the same GD, only very small differences which do nothing. (This is all the stuff described in the last paragraph). 2: Mollecon said larger vented boxes means less ringing. But it can mean HUGE peak in Group Delay Curve near resonance. Does that not mean the larger box increases overring? 3: Is it better to use a smaller box which has larger distance between fl and fh, and therefore damping over a wider range than a larger box would?4: Larger boxes have higher impedance peaks, therefore more damping at fh (and fl but that doesn't matter they are out of phase). But as said before, the larger box can either show higher group delay near resonance, or if very larger, a massive peak in GD near resonance, then decreases on either side of this. Does this mean, the larger box provides better damping at fh, but not at fb and will ring more at fb? A smaller box would shift resonance upward of course limiting bass extension... but as mollecon pointed out, the signal does not need to be that near resonance to be excited into ringing so its best to have a system which wont ring much no matter where resonance is. Thats why I'm thinking smaller vented boxes ring less than larger ones.... 5: Box size, large or small, barely changes impedance in ohms at Fb.... its a matter of about 2ohms between a huge and small box. Fb is where overring occurs. Smaller boxes show lower group delay at Fb. This would dictate that a smaller vented box has less overring than a larger vented box... but mollecon has said that its the opposite, and a larger box provides less ringing at resonance.

Subject: A short comment.
Posted by mollecon on Sat, 13 Sep 2003 00:35:28 GMT
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As I said, I don't know zilch about group delay (have a vague idea).Quote: "Mollecon said larger vented boxes means less ringing. But it can mean HUGE peak in Group Delay Curve near resonance. Does that not mean the larger box increases overring?"Ehh, no, & definetely NOT in the case of a closed box. Larger box means lower Q, hence less ringing. And I'm almost certain that the same is the case for a reflex box, basically (not taking manipulation with the tuning into consideration).A couple of other things of interest: The alignment B2 (Q=0.7) for a closed box AND the alignment B4 for a reflex box is in both cases the optium box size for the lowest possible -3dB point for any given driver. Optium does not always mean IDEAL, mind you!Reducing box size (again, this goes for both box types) have one advantage: It gives smaller impedance peaks on/around the resonance & therefore represents an easier load on the amplifier. On the other hand it could be argued that the resonance also might go up into an area where the bass content is larger, so the strain put on the amp will in practice remain the same - life isn't easy! ;-)

Subject: An even shorter comment
Posted by Adrian Mack on Sat, 13 Sep 2003 03:37:13 GMT
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Hey Mollecon,Ok then. Say we had the DPL12 woofer then. A PiAligned cabinet produces a -3db point of 25Hz with this woofer in a 58L, 15Hz tuned box (pialign). A vented cabinet of 140L tuned to 15Hz with this woofer produces a -3db point of a much lower 16Hz. Would the PiAligned cabinet, or the larger cabinet with deeper -3db point (both same 15Hz Fb though) produce least overring? My idea is just a little confused. The PiAligned box is tuned 15Hz, but -3db point is 25Hz, and at its 15Hz Fb, its about -10db down. But the larger cabinet with same tuning is -3db at its Fb. The larger cabinet, as it seems, offers more damping and less ringing. But on the smaller cabinet, resonance is -10db down so would that not mean ringing is even less in the smaller box because resonance itself is attenuated so greatly compared to the larger box?Thanks!Adrian

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Subject: Choices and optimizations
Posted by Wayne Parham on Sat, 13 Sep 2003 04:28:25 GMT
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Remember that group delay is a function of rolloff slope. If you have a steep rolloff slope, then group delay is high. If the rolloff is gradual and slow, then group delay is small. Also unerstand that group delay goes up as cutoff frequency goes down. So to talk about group delay in isolation is meaningless. Unless you're comparing speakers with the same lower cutoff, you can't really compare group delay. The one with greater bass extension will tend to have greater group delay just because it is going deeper.Let's say you're comparing a two speakers with the same woofer. One is in a large box with deep flat bass response and sharp roloff at cutoff. Another is in a smaller box with higher cutoff aligned to be slightly overdamped.There are some trade-offs with both designs; Each has its own strengths and weaknesses. The most noticable real-world difference between the two is size. The little cabinet is much easier to carry and place, but the larger cabinet goes deeper.The little box doesn't go as deep, but its response is still pretty flat and being slightly overdamped makes it relatively insensitive to parameter shifts. In this speaker, response is good even when the woofer heats up at high power levels. It doesn't develop a peak from Qes going up as resistance rises. It also isn't going to be as likely to sound peaky in a small room with a lot of room gain.The larger box obviously has the benefit of deeper response. It also has more group delay, but that is a direct result of its deeper extension and steeper rolloff. You can't get the extension without the corresponding group delay so I'm not sure it is meaningful to judge the speaker by its higher group delay.The thing that I think is potentially more troublesome is the fact that most bass-reflex system that are pushed for maximum extension are also much more sensitive to parameter shift. A speaker with a max-flat response curve also may not work well in a small room because it may pressurize the room too much and get peaky. I'm not talking about room modes here, although those may be a problem too. I'm talking about room gain, which is usually paired better with a speaker having a slightly overdamped response curve. Woofers that go down deep and then rolloff quickly usually work best outdoors or in very large rooms.All in all, I think there are different conditions that lend themselves to different alignments. I tend to prefer slightly overdamped bass-reflex alignments because they provide smooth response, are relatively tolerant of thermal shifts and environmental conditions and they limit bass excursion. They seem to work well in most cases. But if you need the deepest bass extension, then an alignment that pushes for max-flat response might be worthwhile. It will have a higher cutoff slope though, and the combination of deeper response and faster cutoff slope will make group delay be much higher.

Subject: Electrical, mechanical and pneumatic properties
Posted by Wayne Parham on Sat, 13 Sep 2003 05:25:00 GMT
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In a sealed box, Q and resonance are set by only one thing outside the woofer itself, and that is cabinet size. But in a bass-reflex system, you have both the Helmholtz frequency and the cabinet size as variables. This means you have the option of making a low Q system in a relatively small box.System Q is a measure of damping, and it describes the response curve. Being overdamped will give a high cutoff and a slowly falling response curve, as frequency goes down. Being underdamped will give a peak, and this peak represents augmentation from rather uncontrolled movement. This is a region that will "ring," and in fact, that is why a sound is generated by a bottle when blowing across the neck. Resonant ringing is the process that creates sounds from and object when it is excited in some way, such as by striking a drum or bell, pushing a pendulum or swing, or blowing across a bottle neck or flute.In a loudspeaker, there are a few things that act as filters, which means they can be tuned to ring or to damp. The amount of ringing or damping is described by the term "Q." Values of Q range from just above zero to just below infinity, although most (Qes, Qms and Qts) values are between 0.15 and 20.0.High Q describes a tendency to ring and is easily excited; Low Q describes a damped condition which is more controlled. A similar condition is found in reverse - Resonating dampers are things that tend to draw energy from a system, and when used, a high Q resonator draws more energy over a narrow frequency range, whereas low Q resonators draw less energy over a wider range. So there are a handful of filters in a loudspeaker system, and it's the appropriate balance that we're looking for.The speaker cone is a mass/spring system, so it acts like the spring and shock on a car. The weight of the diaphragm and moving assembly sets the mass, the stiffness of the surround and spider act like a spring and the resistance of the surround and spider act like the shock absorber. These properties are purely mechanical.We also have the characteristics of the cabinet. A sealed cabinet acts like a cushion, much like a shock absorber does. It modifies the mechanical properties of the speaker driver by changing its resonant frequency and Q. It acts as though it changes the speaker's mechanical suspension by modifying the spring's stiffness and resistance. But a bass-reflex cabinet also adds another resonator to the system - the Helmholtz resonator - so the bass-reflex system has two. One resonator is the mass/spring system of the cone and the second is the Helmholtz resonator of the box. And horns and transmission lines have similar cone loading properties as direct radiating speakers with the addition of having additional multiple standing-wave resonances spaced within their passbands. Each of these types of systems interacts and modifies driver characteristics according to its configuration, tuning and dimensions.Then there are the electrical characteristics. The motor is accelerated and decelerated when forward or back-EMF is applied. This causes a mechanical effect to be created by an electrical property, fundamentally setting a large part of overall system Q. If the motor is very strong, it can accelerate a large mass and overcome a large stiffness and/or resistance. The acceleration can be from stop to start, from movement in one direction to movement in another direction, or from movement in one direction to another speed in the same direction. So the point is that "acceleration" also includes the ability to "decelerate." The motor not sets the cone in motion, but also stops the cone or changes its speed.The speaker's motor is installed in a circuit that partially determines the characteristics of the electrical system. Motor strength is a function of magnet stength, voice coil current, and the amount of coupling between the magnetic fields of the voice coil and of the drive magnet. And the drive circuit is an integral part of the motor system, since it determines voice coil current capacity. Acceleration and deceleration require current sourcing and sinking by the amplifier and through any components in the line. So the amplifier, resistance of the connection wires, and any passive components in the circuit form a part of the electrical characteristics of the system.The point of all this is that we have a handful of things that act to damp the system. We have the mechanical properties of the driver, itself. We have the pneumatic properties of the air and the interaction between the box and driver. We have the electrical properties of the voice coil and amplifier. Motor damping is most effective when impedance is low, because that's when current flow is highest, and power is transferred to do work. The speaker motor can damp the system most when current capacity is high, which means impedance is low, both in the loudspeaker and the amplifier.So you can see that some mechanical or pneumatic properties that damp the speaker might raise impedance, such as when the system is in certain resonance modes. Where impedance is low, the motor is able to damp the system provided voice coil current and magnetic flux are strong enough. And so the balance of these properties is what we strive to optimize when we design our speakers for best performance.

Subject: Re: Choices and optimizations
Posted by Adrian Mack on Sat, 13 Sep 2003 06:25:13 GMT
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Hey Wayne,It sounds like theres a large range of possibilities by varying box size and tuning. I think that in a ported system, theres no way to say how larger or smaller boxes change the overring because the port will have a huge impact. So it sounds like a box that is a little overdamped will have the least ringing, and one where the port tuning/box size combo makes an underdamped response will tend to ring more (and I think Fb is shifted upward). Is there also benefit in attenuated overring by making Fb about 10db lower than the part which is flat?Could we liken it toward a sealed system. Say a Qtc=2.0 sealed box, and a ported box with its underdamped response made to closely follow it with same -3db point, will both produce high overring, and about the same amount of it too. And then take a Qtc=0.5 sealed system which rings very little, and a ported system which is made to resemble this overdamped response with the same -3db point, regardless of the ported boxes size, will both ring about the same? (and for that fact, they will both ring very little). I hope this is right, because I feel pretty comfortable with this.If so, then I'd say the PiAligned cabinet will ring about the same as a Qtc=0.707 cabinet. But the PiAligned one is better in that it has reduced excursion and therefore distortion too. Or something like this anyway... the sealed one could of course be used lower because excursion doesn't shoot up below resonance like it does on a vented system, although I guess not really because the rolloff means its the extra bass is just too much attenuated, and using it here also means distortion is higher.Would it distort more too if the sealed is used below cutoff and EQ'ed up to make it flat? And if the ported one was wanted to make lower bass, then we could alter the box size/tuning to make it produce the same sort of flat/slighlty overdamped curve, just with a lower -3db point. Using a vented with lower -3db point lowers excursion more than sealed with higher -3db that is used under resonance for the extra bass. So we can achieve the same results in terms of overring with vented as we can sealed, but vented has lower distortion and we can make it go deeper too with less distortion and still better overring than a sealed made to go deep. Phase shifts in the passband are still too minor, the ringing at resonance is the problem. And the signal does not have to be very near resonance for it to be excited (although it does say this in the Acoustic Suspension vs Bass Reflex post) but either way, doesn't matter. Vented all the way! I hope I've gotten this right this time!Thanks!Adrian

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Subject: Re: Choices and optimizations
Posted by Wayne Parham on Sat, 13 Sep 2003 08:39:19 GMT
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Looks to me like you've got this deal down pretty well. Basically, systems that are highly damped have better control of their moving mass, so they won't ring as much. But the trade-off is that they sacrifice some on the low end. Then again, the larger the woofer is, the lower it will go even when overdamped. Bigger motors, bigger diaphragms with more mass. It just takes power, I suppose. So you can have a system that is very well controlled, as long as it's big and powerful. Pretty much common sense really.

Subject: Cool.
Posted by Adrian Mack on Sat, 13 Sep 2003 13:35:30 GMT
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Hey Wayne,Cool. Its been very interesting to me too this discussion, and I've definitly learnt from it. Hopefully others have too, if they could be bothered to read something this large :PI have one other quick thing. As an example, the LAB12 woofer, in a Qtc=0.707 sealed box has resonance at 41Hz (thats where impedance peak is too of course). PiAligned LAB12 has Fb at 21Hz. Both have similar -3db points around 35-40Hz. Does this mean, the resonance overring on the sealed box will ring at 41Hz, and on the vented will ring at 21Hz? That would indicate to me that the vented cabinet has another advantage, because resonance is at the -10db point (about), but on the sealed box for this example, the 41Hz resonance is about the -3db point. That would seem to me the PiAligned resonance overring is at a freq greatly attenuated (by ~10db) but on the sealed box, is only attenuated 3db, which is really nothing. That also means for most music with no below 30Hz content it will be harder to make the PiAligned cab ring than the Qtc=0.707 sealed box, simply because resonance on the vented is way lower. Could this be the reason why you said in another post that a PiAligned cabinet still has less overring than sealed cab with same -3db point?Thanks!Adrian

Subject: Almost...
Posted by mollecon on Sat, 13 Sep 2003 21:33:56 GMT
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Hmm, yes, but the basics still kicks in. This is real life, & you always have to pay for an advantage one place by a dis-advantage somewhere else. The reduced distortion by reduced diaphragm excursion in a reflex loaded box will still be have to payed for; it will take a little longer to recover from impulses, compared to the closed box.As I've stated before, it's more a matter of priorities - what is the best for you & your music? The overhang on impulses from a reflex box doesn't necessarily have a bad impact. AND, I might add, your room & loudspeaker placement are VERY important in this area! I think, in real life, they may have more impact on the bass sound than different alignments, as long as we are talking sound bass design (& we are, aren't we? ;-))

Subject: Re: Cool.
Posted by Wayne Parham on Sat, 13 Sep 2003 22:22:00 GMT
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You're right that the Eminence LAB12 will be highly damped in a PiAlign'ed enclosure.Nice flat repsonse curve too, having f3 at 35Hz and f10 at 20Hz from a cabinet smaller than 2ft3. Very small size, and good extension.For even deeper extension, consider a cabinet twice that size. It will be a little more sensitive to parameter shifts, like we're talking about here, but as a subwoofer that may be a valid trade-off. Room modes will likely dominate in-room response anyway, hence the reason for multiple subs. As I said before, it's all about intended purpose.

Subject: Re: Cool.
Posted by Adrian Mack on Sun, 14 Sep 2003 05:45:30 GMT
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Hey Wayne,Great. LAB12 is pretty cool ey, except it uses Kapton instead of aluminium or black aluminium voice coil former, kapton is supposed to heat quicker and handle less power which isn't good. I think they could have used it, apparantly its not much cost difference, it would be especially good for that "high powered labhorn". I was reading one of your older posts made in 2001 today on the high efficiency forum where you described basically what this thread is about. The post is called "Tune the cabinet as appropriate for the woofer" and it talks about Davies and your implementations etc, and more importantly, why resonance behaviour is better controlled in a vented cab and its better transient performance than the sealed. You said The motor is a tuned resonant system, and stronger motors are more controlled at resonance, but they still lose motor control at resonance. "Sloppy" motors lose nearly all control at resonance, and can be quite loud at frequencies near resonance, but completely uncontrolled.. I agree too, at FS, the motor is more uncontrolled. Then you say In a sealed box - we have damping, but we have no acoustic impedance rise at the woofers resonant frequency. . What I thought is, in free air, all woofers have rise/peak in impedance at its fs. In a sealed box, isn't this shifted upward to the box resonance point? Because thats where the impedance peak shows up on the box modelling programs, the peak is shifted to the sealed box resonance. I thought that in the box, resonance overring is at box resonance, and not woofer fs, and in a sealed system woofer resonance is usually about 10db down from the passband on a qtc=0.707 system, so would that not mean its more important for impedance rise to be at box resonance and not woofer resonance? (or maybe the sealed box shifts woofer resonance up to box resonance which could be why I dont understand this, I'm not sure). And lastly, you state And in a bass reflex system, the acoustic impedance of the enclosure becomes very high at the Helmholtz resonant frequency, which serves to limit cone movement. What I've thought is the vented box creates two impedance peaks, and the Helmholtz (Fb) is at the trough of this, or the lowet point between the two impedance peaks. But you say its the opposite? You do say acoustical impedance though, I think that might be different from electrical impedance which I'm talking about. I have never heard of acoustical impedance before though or what it does except that you can graph it in Hornresp :P Can you please explain the difference to me? BTW: It said in the sealed box, theres no impedance rise at woofer resonance. But for the vented box you said it is (so its better damped, lower cone movement/ringing), but you said the acoustical impedance rise is at Helmholtz resonance. Helmholtz is not always at woofer fs... can you please explain to me what this meant? I think computer programs should simulate acoustical impedance then if its important to damping, but I guess its not absolutely needed that we see it because we can see damping from the FR. Thanks!Adrian

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Subject: Re: Cool.
Posted by Wayne Parham on Sun, 14 Sep 2003 06:37:44 GMT
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In an air-suspenson speaker, there is really only one resonant frequency, and it is that of the woofer/box system. You can think of it as being just the woofer, with the box stiffening it and shifting the resonant frequency higher. That's basically what is happening - There is only one moving system and it's a mass/spring system that has some resistance for damping. It's very much like the spring and shock absorber on a car.But in a bass-reflex speaker, we have one extra item - the Helmholtz resonator. Since there are two resonant systems, we can have conditions that cause the two to be in-phase and others that cause them to be out-of-phase. That introduces additional reactive components for damping, by introducing an additional resonator. It's sort of like adding another spring with a counterweight.These are mechanical and pneumatic properties.

The electrical impedance will reflect these conditions, and the electro-magnetic system will add some properties of its own. But even without the electro-magnetic part of the system, you still have a mass/spring resonant system in a sealed box, and a pair of resonators in a vented box.

Subject: Sowy for budging in again
Posted by mollecon on Sun, 14 Sep 2003 21:39:49 GMT
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Adrian, ELECTRIC impedance & ACOUSTIC impedance isn't the same! When you look at the frequency/impedance curves from drivers, you're seeing the ELECTRIC impedance - not the acoustic one...Actually, the reason why horns are working so well is that they work as impedance transformers - on the acoustic side! A driver is 'born' with a natural high acoustic impedance (speaking in popular terms, we have a rather heavy diaphragm trying to move some light air), & the air's acoustic impedance is low. So the horn offers a high acoustic impedance at the throat (for the benefit of the driver), & through the length of the horn this is converted to a low acoustic impedance, at the mouth.Closed & reflex boxes aren't very good at this transformation, sad to say, they stink - so the efficiency for them is max ~5%. But they are MUCH easier to handle when it comes to size in the bass area. The pay (again!) - bigger amps.Btw., the LAB 12 offers very good performance in reasonably sized boxes - too bad they are not easy to get a hold on in my country.

Subject: Re: Cool.
Posted by Adrian Mack on Mon, 15 Sep 2003 06:22:16 GMT
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Hey Wayne,So it seems that the sealed box shifts resonance upward. The resonant frequency of the box/woofer system is Fo. But does this shift Fs upward too..... ? I'd assume that any ringing will occur at Fo too, where the electrical impedance peak is. If the box shifts Fs up to form box resonance Fo, then we can say that Fs=Fo in a sealed box. So fs may be 20Hz free air, fs may be shifted to say 40Hz in a sealed box. All motors are more uncontrolled near resonance. If the new Fs is 40Hz, thats pretty bad because instead of being uncontrolled at 20Hz, its now uncontrolled at 40Hz, which is much higher, and its also the sealed box resonant so that means it will be more uncontrolled and also ring at the same time more and sealed box resonance is usually in the passband too which makes it even worse. The vented cabinet has the Helmholtz resonator too, and its this frequency where any ringing is. Does the vented box shift Fs at all? If it doesn't, then thats good because it may be that neither Fb or Fs is in the passband. But if a sealed box shifts Fs upward to box resonance so that Fs=Fo, that means the motor is uncontrolled at higher freq, and the box is also making it ring here too and usually in the passband. Is this correct? Half correct?The "Frequencies of interest" post says the bass reflex cab has Fo too, I thought it was only on a sealed, unless we block the port. It says however the enclosed woofers resonant freq in a vented box is Fo, and is near Fh, which indicates that the vented box might shift Fs up to near Fh. Or something :P Maybe I'm being too picky. Thanks!Adrian

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Subject: Ah, I figured most of it out
Posted by Adrian Mack on Mon, 15 Sep 2003 06:40:04 GMT
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Hi Wayne,I just re-read your Electrical, mechanical and pneumatic properties post. The sealed box modifies the speakers mechanical properties and it raises Fs and changes its Qts. It does that by changing its spring stiffness and resistance because of the air pressure in the box. Therefore we can say that Fs=Fo, right? So the question is: All motors are more uncontrolled near Fs. Because the sealed system shifts Fs upward by modifying its spring stiffness, does that mean its now uncontrolled at the shifted frequency instead of the lower free air Fs. I think it might not, because the motor strength is not changed and is helping damp the driver. I would think the new boxed-Fs is more controlled than free-air Fs because the box would lower the drivers Qms. That seems like the reason its different, but doesn't make it worse, only better which I guess is how sealed system damping works, in a basic way. The vented box has a port, so I'd assume it does not modify its spring stiffness/resistance and therefore a driver in a vented box won't change Fs. The Helmholtz resonator tunes the system instead. Does it change any of the drivers Q pameters like the sealed box does? I guess not either. Thanks!Adrian

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Subject: Horn phase
Posted by Wayne Parham on Mon, 15 Sep 2003 07:22:19 GMT
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I think it was good to point out the distinction between acoustic impedance and electrical impedance. There is a reflection of acoustic impedance in the electrical impedance though, through the mechanical system. The acoustic load modifies the mechanical load which then in turn causes an effect in the electrical load.

The best examples are those that that are highly loaded acoustically, i.e. horns. I've noticed that horns exhibit electrical peaks where the horn's acoustical load becomes more reactive. The acoustic phase angle of horn forms a rippled curve, which is caused by the changing acoustical reactance and resistance. It acts very much like a series of resonators and as such, generates ripples in the acoustic impedance curve. These are translated into the mechanical system and, in turn, in the electrical system. So while acoustic impedance is not the same thing as electrical impedance, there is some inter-relationship between the two.

The relationship between phase and impedance is determined by the following formula:

where,

i is the imaginary or reactive impedance, and
r is the real or resistive impedance

Considering this, you can easily find the phase where impedance is known.

So let's look again at the response chart for a horn:

You can see that the horn is intended to be used from 40Hz to 400Hz, so that's the region of interest. You'll notice that the device is quite reactive, meaning that it has non-zero phase. And it

at 200Hz and 20° at 400Hz, where the horn has reached upper cutoff. Phase isn't consistent either, but instead is a series of ripples representing large closely-spaced changes in phase. You'll find this reflected in the electrical impedance, where you'll see ripples in the impedance curve.

Subject: Re: Horn phase
Posted by Adrian Mack on Mon, 15 Sep 2003 11:32:12 GMT
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Could we liken it to a simplification as well; As the acoustical impedence gets higher (by means of compression chamber in horn, for example), then efficiency is greater and maximum output is therefore increased. And as the acoustical impedence gets higher, excursion is reduced. This seems to be what happens in a horn, and ones with higher acoustical impedance reduce excursion more and increase efficiency and therefore total output. I guess it happens sort of in a vented system too, but to a much smaller degree. Technically speaking its +3db in efficiency over a same-sized sealed cabinet. So it has a slightly higher acoustical impedence, and also means excursion is reduced. Generally horns have more response ripple than direct radiating cabinets. The acoustical impedence you shown in your graphs have lots of ripples, which show up in the frequency response. Maybe some horns don't do this, but it looks like most do.Adrian

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Subject: Pneumatic loading
Posted by Wayne Parham on Mon, 15 Sep 2003 12:14:56 GMT

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In a sealed box, there is only one mass/spring resonant frequency, and that is fo. Fs could be said to no longer exist, because it has been shifted up to become fo. Of it could be said that fo = fs, because there is only one resonant frequency. The distinction is maintained because the speaker's free-air resonant frequency is not determined by the system, and is a stand-alone parameter.When the speaker is removed from any system - electrical, mechanical or pneumatic - it will resonate at its natural free air resonance, fs. Energies will tend to excite the moving system at fs. If you short the voice coil, that will provide some motor braking which will add moving resistance and help control the cone.If you put the speaker a sealed box, the air in the box will act as a shock absorber and that will help control the cone and shift the resonant frequency up a bit. If you put a weight on the cone, it will shift the resonant frequency down and if you place something on the cone that interferes with its movement without adding mass, that will damp the resonance without altering the frequency.Fo is where the sealed system resonates, so that's where control is the least. But remember that the sealed system acts to damp the cone pneumatically, so a well-designed system will have better control of the cone at fo than the speaker alone would have at fs.

Subject: Re: Horn phase
Posted by Wayne Parham on Mon, 15 Sep 2003 12:54:06 GMT
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I agree with you, 100%

Subject: Re: Pneumatic loading
Posted by Adrian Mack on Mon, 15 Sep 2003 13:14:36 GMT
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Cool, makes sense.One last thing, the sealed box resonantes at Fo, so thats where control is the least. On a vented box, is control the least at Fb because thats where it resonants? Or is it Fo and Fb because theres a Helmholtz resonator and the shifted mechnical resonance of the cone? I wouldn't think its Fo because apparantly thats right no near Fh. Thanks!Adrian

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Subject: Re: Pneumatic loading
Posted by Wayne Parham on Mon, 15 Sep 2003 13:44:44 GMT

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In a bass-reflex system, excursion dips at fb. This doesn't happen in a sealed system.