Subject: Tuba18 Sub
Posted by GarMan on Mon, 12 Sep 2005 13:16:52 GMT
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I had a couple of weeks off prior to Labour Day and was able to work on a few projects fulltime, including this Tuba18 horn subwoofer. Details on this speaker design can be found at Bill's forum: http://audioroundtable.com/BillFitzmaurice/Design ObjectivesFirst off, I think typical subwoofers are ugly. They are large bland boxes that, even when hidden in corners, are still ugly. You can never completely hide them, so I opted to blend this one in as a piece of furniture. The subwoofer was built for my sister to supplement a pair of Tangband ELF1.5's, so I leaned towards the "girly" side on its design.Material and ConstructionThe unit was built entirely from two 5x5 sheets of baltic birch ply. One sheet of 1/2" and one 3/4" with very little leftover. The only panels that were not BB-ply were the drawer bottom and the top backing panel. These were 1/4" V.C. oak ply that I had leftover from a previous project.All internal dimensions for the Tuba were the same as per Bill's plans. However I deviated from the plan in a few areas:- Obviously, the sides were extended up to accommodate the drawers and table top.- Sides, Tuba top, bottom and table top were 3/4" ply.- 1/4" deep rabbets instead of 1/8" were used to attached inside panels to sides- 1/2" braces instead of 1/4"Pre-FinishingHorns are unique in that you have visual access to internal panels on the completed unit. I like to ensure that anything you see, even if it's in the back is finished consistently. Pre-finishing these internal panels and braces prior to assembly (or cutting) makes life a lot simpler.LayoutBill's plans make it straightforward to layout the horn-path on the side panels. However, instead of marking up the right and left side panels individually with measurement tools, it's simpler and more accurate to mark one side and then transfer that directly to the second panel. I did this by extending all the key-lines out to the edge of the first panel, transfer the edge markings to the second, then use the edge marking to draw key-lines on the second panel.By the way, Bill recommends you test for driver fit in the back chamber after glue up. I recommend you do that after layout before any cuts are made.I also made the rough cut of the porthole right after dado cuts instead of after glue-up. Here why: tear-outs from a jigsaw happen on surface top. If you rough cut the porthole after glue-up, you risk tear-out on your outer surface. Rough-cut before glue-up allows you to cut from the inside of the panel where tear-out doesn't matter (as much).Tools and JigsI'm not saying you can't build this sub without a tablesaw, but it makes life a whole lot easier if you had one. Bill said 90 degree cuts for internal panels are fine as long as there's enough glue to fill the edges. But if you have a tablesaw, it's very easy to cut exact angles. Just copy the angles from your side panels to your saw with a sliding bevel.For routing out the dadoes on the side panels, a routing guide is indispensable. If you don't have one already, spend 15 minutes to make one. It'll save you hours. The routing guide works on exactly the same principle as a cutting board.Glue-upI did not use the dado-to-edge/slide-in-panel assembly method recommended by Bill. Dadoes were routed only where they were needed. Internal panels were first glued to one side panel and each other. The second side panel was then attached to the assembly. Rounding-over the edges of the internal panels helped a lot with fitting the second side panel. The 3/4" outer panels were rabbet down to fit the 1/2" dadoes.Port CoversBill recommended that you trace the shape of the port from the inside onto a piece of material and cut it out freehand. In my efforts to make things more complicated than they need to be, I took a template approach. After flush cutting the port hole, cut a 7/16" rabbet. I used a template guide on my router and cut a template out on 1/4" hardboard. Template was then used to cut port covers. Use a block plane to shave down for a snug fit. Gaskets were cut from sub-flooring

material.DrawerI was taught to fit drawers the old fashion way, meaning each panel edge is shaved down with a plane until you get a snug fit. Esoteric, but in this case, I thought it would be very important to ensure no rattles or buzz from the vibrations.Dovetails are handcut. I learned how to cut dovetails over a year ago and have not practiced since then, so some of the corners are a little sloppy. I've never had much patient for blind dovetails so I cut a set of fake ones for the drawer front (ie. Cut through-dovetails then glue a panel over it)FinishBaltic birch does a decent imitation of cherry if stained properly. In this case, I used cherry coloured gel for the colouring. I fell in love with water-based aniline dye this summer but did not want to through the hassle of grain-raising for this project. Baltic birch is terrible when it come of fuzzing when hit with water. Kind of regret not using the aniline dye though as the gel stain does not even come close to the depth, uniformity and colour of dye.I also love the new Miniwax Wipe-on finish I discovered this summer. However, it has a bit of that hard plastic shine that all poly finish tends to show. To soften up the finish, I first coat the surface with tung-oil and let it "semi-dry" for about three hours. Then I wipe on the Poly-Wipe to get a soft smooth and slippery finish. Three to four coats of Poly-Wipe usually does it. Always wipe everything off; never leave a film to dry to ensure a mark-free finish.Final ThoughtsThis project took me four full days (approx 40 hours) to complete, not including final finishing which took 15 minutes each day for another four consecutive days. Of course, I made it a lot more complicated than it needed to be. I'd imagine that if a builder had a couple of bass-reflex projects under his belt, a simple T18 would only take a full days, provided a tablesaw is available.The design looks daunting at first, but it's no more complicated than a very well braced BR sub. If you follow Bill's plans for bracing, you end up with a very stiff and well braced box. In fact, walls and other furniture around the T18 tend to vibrate more than the T18 itself.When I look at the unit now, there's close to a hundred things I would have changed or wished I did better, but overall, I'm very happy on how it turned out.Gar.
Tuba18 Photos

Subject: Re: Wow! Slip fit drawers!
Posted by Bill Epstein on Tue, 13 Sep 2005 00:31:02 GMT
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Air tight and the test was pulling a vacuum. Yeah, Gramps made me make a lot of those to get it right.Hats off to GarMan for helping to preserve centuries old techniques.So how does it sound?

Subject: Re: Tuba18 Sub
Posted by lon on Tue, 13 Sep 2005 03:37:43 GMT
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GarMan, I'm glad someone tackled this design. I got about as far as the the 2 labyrinth panelsand then developed arthritis in my wrists. The project just sits now. But I'm curious as to what sort of sound you're gettingwith it and what kind of plate amp you will use. I started the project in MDF and don't have a good place towork, nor do I have a good dust removal system.

Right nowI've only got a couple bucks into the project. After lookingat all the measures, I wound up eyeballing quite a bit. Bill says that these designs are mostly fitted one pieceat a time. The detail of sliding in the panels was anexcellent design concept. Fitz is something else. So what do you hear?

Subject: How does it sound?
Posted by GarMan on Tue, 13 Sep 2005 13:14:33 GMT
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Hi Lon,I work outdoors and even then, MDF dust is a problem. Last I heard, you'll working with a rotary-tool instead of a real router, which can't be easy. Honestly, I don't recommend this T18 as a first project unless you have a lot of patience, willingness to learn, enjoy the process, and time to spend on it. For the right person, this can be a great and enjoyable learning experience. For others, it might be better for them to build a bass-reflex design.Below is a thread where I worked with Bill to toubleshoot my T18. The thread contains the amp and driver used. I found the sub to be sensitive to placement and settings, but not difficult to set up.I don't have a lot of benchmarks to judge how the T18 as I have no prior experience with other dedicated self-powered subs. I found the T18 to be a great match for my Studio One-PI's and also can go low enough to augment my Theatre 3-PI's for home theatre. There's plenty of headroom to match high eff speakers. With the PI speakers, gain setting on the plate amp was only at the 1 o'clock position.In my rooms (and bass is very sensitive to rooms), I found the bass to be more laidback than forceful, enough to provide a foundation but not drawing attention to itself. I think some people would be very disappointed by this as it has very low "wow-factor" in its sound. For me, I'm more than happy to trade in "wow-factor" for livability, which this T18 has plenty of. It's hard to tell it's there, but you'll notice when it's not.I would rate the output of the T18 to be better than my Theatre 3-PI but poorer than my JBL 2235H cabinets. The JBL goes deeper and sounds better than the T18, but the JBL's sit in 5 cubic ft cabinets and each driver costs $300-$350 used.I think the T18 is a competent sub that's able to give very good performance with a $30-$50 driver in a relatively small package. If you enjoy woodworking, it's a fun project to build, but you've got to enjoy the process. Also, the design has high cool-factor and can certainly be a converation starter. I wouldn't go as far as to call it a novelty design because it does deliver on performance and value.Gar.
Troubleshooting Tuba 18

Subject: Re: Wow! Slip fit drawers!
Posted by GarMan on Tue, 13 Sep 2005 18:07:10 GMT
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The only reason why I made it that way was because it's the only way I know how. And as you know, the difference between a snug fit and loose fit is only a few shave of a plane. I'd be happy if I never have to plane down the edge of BB ply again.

Subject: Clarification
Posted by Wayne Parham on Wed, 14 Sep 2005 05:48:33 GMT
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two-way design, not a subwoofer. I suppose it could be used as a sub, if the crossover were omitted. It provides response down to 30Hz, and has a nice response curve. But it was designed for use as a full-range loudspeaker.If I were to recommend a physically small inexpensive subwoofer to match it with, I would suggest a LAB12 in a 3.5ft3 cabinet tuned to 22Hz. Crossover

Subject: Re: Clarification
Posted by GarMan on Wed, 14 Sep 2005 14:38:28 GMT
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Yes, the Theatre 3-PI I mention is a 2-way. I've been using mine for HT for over a year now and as mentioned in another thread, am very happy with it without augmentation with a subwoofer. I don't think it goes down all the way, but with a little bass-boost from the receiver, should satisfy a lot of users. In fact, I think the Theatre 3-PI might even go down lower than most mass marketed powered-subs you find in big-box stores.Wayne, I think your recommendation with the LAB-12 in a BR is interesting in that it represents a great excercise to compare and contrast it with the T18.In terms of box size, the 3.5 ft^3 you suggested for the LAB-12 is slightly larger than the 3 ft^3 of the T18, but for practical comparison, let's call them equal.Where I see the two differ is that the LAB-12 sub relies on high quality and more expensive components (driver and amp) to perform while the T18 shifts performance responsibility to the cabinet.LAB-12 BR = Big driver + High powered amp + simple boxT18 = Small driver + Low powered amp + complex boxIf you're someone with the skills, tools and time to put together a T18 cabinet, you can save over $200 compared to the LAB-12 route. But it's not a simple cabinet to build and time is a scarce resource. For a lot of people, the extra cost of a sub like the LAB-12 BR is well worth it. I bet that if cabinets were sourced to a builder, both options would net out to approx the same amount.Just some numbers I used for the comparison above: T18: $50 driver, $75 amp, wood $60 LAB-12: $150 driver, $250 amp, wood $30Gar.

Subject: Re: Clarification
Posted by Wayne Parham on Wed, 14 Sep 2005 16:36:27 GMT
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I agree with you in some areas. But when you consider the price of your time, then a folded horn is a very expensive cabinet. I know my cabinetmaker charges me a whole lot more for a horn cabinet than even the most expensive drivers. So I think that's an important consideration. For DIY efforts, maybe less so, but still something to think about.And really, down very low, a

basshorn has issues. If the horn isn't huge, it doesn't provide very much horn loading in the bottom octave. It is more like a quarter-wave pipe, if even that. A very small horn used at low frequencies is basically a direct radiator in a fancy box. So driver performance is very important.

Subject: Re: Tuba18 Sub
Posted by Bill Martinelli on Wed, 14 Sep 2005 17:19:24 GMT
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Great job Gar. Simply wonderful! I just now took a minute to look at all the photo's. I'd like to give a listen when I'm in Toronto next.Bill

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Subject: Just because I'm in the mood to argue ...
Posted by GarMan on Wed, 14 Sep 2005 17:37:13 GMT
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Whether a folded horn is considered expensive depends on how you account for the time you spent on it. If you consider your time purely as an investment to build the horn, then yes, it is expensive. For me, I enjoy the process and see it as a pastime, like golfing. The fact that I spent four days building this sub instead of going out to the golf course meant that I actually ended up saving money. How's that for twisted economics.I once justified to my wife that the money I've been spending on audio is cheaper and more innocent that other hobbies. I could be like some husbands who go out drinking and whoring every weekend. Not amused.

Subject: Re: Tuba18 Sub
Posted by GarMan on Wed, 14 Sep 2005 17:40:24 GMT
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No you wouldn't. They're going to my sister's place as soon I can build a chassis to house the plate-amp (which can take anywhere from one week to a year).But you can still drop by next time you're in Toronto. Any chance you'll be crossing the lake in your new toy?Gar.

Subject: Re: Tuba18 Sub
Posted by Bill Martinelli on Wed, 14 Sep 2005 18:37:08 GMT
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Gar,Yes, I'll be taking the boat across the lake next summer for sure. Bill

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Subject: Re: Just because I'm in the mood to argue ...
Posted by Wayne Parham on Wed, 14 Sep 2005 22:21:49 GMT
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Subject: Re: Just because I'm in the mood to argue ...
Posted by Manualblock on Wed, 14 Sep 2005 23:38:23 GMT
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Wayne; I don't think you got your point across.Garman; man you do great work.

Subject: Re: Just because I'm in the mood to argue ...
Posted by Wayne Parham on Thu, 15 Sep 2005 01:27:51 GMT
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Three points, briefly:1. Small basshorns aren't horns. They are too small to be effective at low frequencies.2. The complexity of a folded horn adds to its cost. The cabinet becomes a significant cost factor.3. Gar's golf savings, "twisted economics" and his justification to his wife are all damn funny.

Subject: Re: Just because I'm in the mood to argue ...
Posted by Manualblock on Thu, 15 Sep 2005 11:48:21 GMT
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Item no 1 doesn't seem to be recognised. Your original post pointed that out so I wondered if anyone would have an opinion concerning that issue.Seems like a lot of work if the same performance can be had much more easily.It makes a great woodworking project though.Item 2 is obvious and item three..well he was pretty funny there.

Subject: Re: Just because I'm in the mood to argue ...
Posted by GarMan on Thu, 15 Sep 2005 12:19:42 GMT
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Wayne,On point number one, I don't think it was ever Fitz's intention to use the T18 in freespace. In his posts, he always directs users to face the unit into a corner to take advantage of room boundaries. Is there any difference between this approach and your corner horns?gar

Subject: Re: Just because I'm in the mood to argue ...
Posted by Wayne Parham on Thu, 15 Sep 2005 19:35:50 GMT
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Corner placement of a bass bin is almost always a good thing. The position increases sensitivity by reducing radiation angle. It also tends to make bass response smoother. So that part is good. Without describing the features of a bass bin, one could say that corner loading is almost always a good thing, no matter what type of system it is.Beyond that, corner loading of a truncated horn is something I would consider a requirement. But putting a horn in a corner doesn't lower the flare frequency very much, the real benefit to undersized horns is that it smooths response ripples. At very low frequency, the system is pretty much just a direct radiator and in this mode, the driver's excursion and other specs are more important than the horn part of the cabinet. The passages that make up the horn become useless under the flare frequency.

Subject: Re: Just because I'm in the mood to argue ...
Posted by Wayne Parham on Thu, 15 Sep 2005 19:40:08 GMT
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That's the point. A 50Hz horn is going to produce the most output above 50Hz. No harm in that. If it is small, then corner loading will improve response ripples. But at subwoofer frequencies, it's going to act as a direct radiator. So it would probably be better to use a driver with specs that lended itself for subwoofer use, i.e. more surface area, lower resonance and greater excursion.

Subject: Re: Just because I'm in the mood to argue ...
Posted by Manualblock on Thu, 15 Sep 2005 23:33:16 GMT
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Makes sense to me; thanks.

Subject: Excursion plot
Posted by Wayne Parham on Fri, 16 Sep 2005 05:26:02 GMT
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Here's another way of looking at it. The excursion chart shown below is of a very large basshorn, one that is tuned to operate above 30Hz and that has plenty of mouth area to provide good response without ripples in halfspace, even if only one horn is used. In short, it's a no compromise design. It is also huge, about 40 cubic feet.Notice how overall excursion is reduced by the horn, but also how there are excursion peaks throughout the passband, with the maximum being right at horn cutoff. This particular horn uses drivers that have fairly long throw, so they aren't at their mechanical limits even at the peak. But still, you see the general trend.Now imagine if the horn were made as small as possible. Path area must be made small, so response is now compromised, being a series of deep ripples. Corner loading really helps in this regard. In fact, you probably would consider corner loading a requirement of such a device. Even so, the low frequency cutoff must be made higher, because there just isn't enough room inside the box to support a long path length. That means the excursion peak is shifted up, well into the passband. As you can see, the biggest requirement is that the woofer have good excursion capability. The horn just isn't able to load the driver down low.Don't misunderstand me. I think Gar's horn is probably good down to about 50Hz. When corner loaded, it might be just fine to augment say a single driver speaker or something that needs help below 100Hz. It could extend bass an octave below that. But if its application is to be used under 60Hz, it's being used primarily in the range where it is a direct radiator anyway. So it makes some sense to use a cabinet that is better suited for that frequency range, using the volume to make an alignment that works well to 20Hz. With 3ft3, that suggests a vented box tuned to 20Hz and a driver that can support it.Using a woofer with limited displacement just doesn't make sense in a sub, horn loaded or not. I'd rather have a direct radiator with some surface area and excursion than a physically small basshorn with a smaller driver. It will just plain run out of gas. The one possible exception is ultra-low power systems that won't see more than a watt or two.So my conclusion is this: If you want to make a basshorn sub, make it big or don't make it at all. A midbass horn can be made smaller. Other cabinet styles can be made smaller too. But basshorn subs need size. There's no substitute for cubic inches.

Subject: Re: Excursion plot
Posted by Manualblock on Fri, 16 Sep 2005 12:26:05 GMT
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It's always a learning experience Wayne; these explanations and this style should be translated over to the tube amp site.What about compensating for size with different alignments?

Subject: Re: Excursion plot
Posted by Wayne Parham on Fri, 16 Sep 2005 12:54:58 GMT

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There's a lot of wiggle room one has with different alignments, so a person can sure find good ways to make the system. But for bass, the main thing is displacement. Horn loading can only help if the horn is large, and even then the energy isn't free. The diaphragm still has to move. The moral of the story is to analyze the system and see what you have, making good choices for your intended goals.

Subject: Re: Excursion plot
Posted by Manualblock on Fri, 16 Sep 2005 13:26:34 GMT
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I guess there is just no way around the physical laws of the thing.

Subject: Re: Excursion plot
Posted by Wayne Parham on Fri, 16 Sep 2005 14:44:55 GMT
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Ain't it a shame.

Subject: Not so fast there, excursion breath...
Posted by Bill Fitzmaurice on Fri, 16 Sep 2005 20:08:51 GMT
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This is the T18 with 100 watts in. Xmax isn't exceeded above 25 Hz, and for that matter not below it either, as the power requirements of home theatre program material are not linear, but fall rapidly below 30 Hz, while those of music program drop like a stone below 50 Hz. Not that I'd recommend anyone actually put 100 watts into a T18. With 90dB sensitivity at 30Hz corner loaded, and better than 100dB sensitivity at 50Hz, you just don't need to. But you can.

Subject: Re: Not so fast there, excursion breath...
Posted by Wayne Parham on Sat, 17 Sep 2005 07:32:24 GMT
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No offense there Bill, I'm sure the small T18 does a good job above 50Hz. But as your graph shows, excurson rises rapidly under 50Hz. So what that means is that the box is essentially a direct radiator below 50Hz. My point is there are better ways to optimize a system for operation below 50Hz than a 3ft3 horn.The best 3 cubic foot subwoofer implementation, in my opinion, is to use the entire cabinet volume to provide an alignment that's optimized for the low frequency range, not 50Hz and up. One can then use a driver with greater displacement too, one with more radiating surface area and greater excursion capability.With a horn cabinet, much of the box is used to provide space for the flare, and the rear chamber is then necessarily pretty small. That's what is doing the work here under 50Hz - The sealed box of the rear chamber. So the alignment is not optimized for subwoofer operation, at least not under 50Hz.

Subject: Re: Not so fast there, excursion breath...
Posted by Bill Fitzmaurice on Sat, 17 Sep 2005 14:43:45 GMT
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It is a direct radiator below 40 Hz, to be precise. That's not a matter of contention. It doesn't matter. What matters is that you have a 3.3 cu ft box capable of 90dB/watt SPL at 30Hz at a total build cost of less than $100. That and that alone was the design goal, and having achieved it I'm well satisfied. So are the vast majority of the builders of this cab who were able to build it, and buy an amp to drive it, for no more than the driver cost alone of most direct radiators capable of 90dB/30 Hz sensitivity in 3.3 cu ft. The fact that it totally blows away direct radiators where it is operating in horn mode is frosting on the cake.

Subject: Re: Not so fast there, excursion breath...
Posted by Wayne Parham on Sat, 17 Sep 2005 15:07:05 GMT
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No one questions that the little horn is operating as a horn from 50Hz up, provided it is used with boundary reinforcement. What is at issue is whether or not the three cubic feet is best used for horn path, or whether it would be better used to gain extension by providing box volume to create an alignment better suited for the bottom octave. If you want response from 50Hz to 200Hz, that's one thing but if you want 20Hz to 100Hz, that's another. By omitting the horn and using all space for the box, you are able to gain more power down low where it is needed for a sub.

Subject: Re: Not so fast there, excursion breath...
Posted by Bill Fitzmaurice on Sat, 17 Sep 2005 16:12:28 GMT
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Show me another 3.3 cu ft sub that will do 90dB/watt at 30Hz and, more important if you're going to use it to listen to music, 100dB/watt at 40Hz. Then tell me what it costs. If it's less than $100 I'll buy one. BTW, the T18 does what it does using a $35 driver with these measured specs:fs 30HzQes .26Qms 12.0Qts .26Vas 0.7 cu ftSPL 85.9xMax 16mmSd 220 sq in

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Subject: Re: Not so fast there, excursion breath...
Posted by Wayne Parham on Sat, 17 Sep 2005 16:55:35 GMT
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My suggestion was to use a LAB12 in box that size tuned to 22Hz. It generates at least 15dB more output in the bottom octave from 25Hz to 50Hz than a speaker with the specs you've listed in any size sealed box.

Subject: Are you guys still at this?
Posted by GarMan on Mon, 19 Sep 2005 15:01:13 GMT
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Wow. Came back from the weekend and can't believe there's more posts. Kind of cool though as this is my first "skinny thread".But all this bantering is distracting from the purpose of my original post which is: LOOK AT MY PRETTY SUB.If you must know, I did a sweep on the sub last night with the 4th order lowpass on the plateamp set at 40Hz and this is how it sound in room BY EAR from top to bottom:- slowly starts to roll in at 80Hz- pretty flat between 60-50Hz- peaks up at 40Hz- drop at 30Hz, but still strong- quickly rolls down below 30Hz

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Subject: Re: Are you guys still at this?
Posted by Wayne Parham on Mon, 19 Sep 2005 17:24:13 GMT
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Sorry 'bout that Gar. No offense was meant to you or to Bill. Your speakers are awesome, and that horn looks great. I'll bet it sounds great too.You know, there isn't a lot of material under 50Hz anyway, so having something strong above 50Hz is great and can sound thunderous. I only

get underneath it and provide significant output takes something tuned pretty low.A horn shifts to being a direct radiator below its passband, and since the rear chamber is a rather small sealed box, it has a hard time generating a lot of energy under that point. That's why I wanted to provide

made sense to me but in this case I would have preferred a subwoofer with lower cutoff, that's all.
