Subject: Re: Throat distortion, air pressure
Posted by Tom Danley on Sat, 03 Apr 2004 19:26:21 GMT
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Hi Tom>> This effect is also seen in a sonic boom, here, on the leading>> edges, the air is compressed over 1atm at supersonic flight. Here,>> because of the same temperature/speed relationship, what finally> >reaches the ground as radiated sound is also a saw tooth (on the> >front edge), over all, the waveshape of a sonic boom is like a> >capitol letter N.>>Throat distortion is pretty much a non-issue in bass horns though,>>one and coil drivers generally cannot produce enough acoustic>>pressure to cause this.>When a direct radiator, I agree that a loudspeaker of this world cannot increase the general air pressure of >the entire atmosphere very much (which I'm pretty sure step response shows, showing sound pressure .when voltage step function is applied).>In a basshorn though (or any horn), cant you think of the piston being a moving 'pump', forcing air >through the throat? Yes, unlike a sealed tire pump etc however, on the throat side of the radiator, the "pressure" is not proportional to displacement but rather the velocity. This results in the curious situation where if one looked at the points of minimum and maximum acoustic pressure, one finds that instant in time is where the radiator displacement is zero (but has greatest velocity). >A smaller throat would be creating more compression at the peaks or crests on a sine >waveform, and so >theres more distortion if air pressure is increased to much due to a small throat (caused >by high SPL). On >the other hand, a larger throat would create less compression at both low and high SPLs >because of less >restriction, so less changing in the temperature/speed relationship (causing volume >changes to be >unequal when pressure is changed), so less changing of waveshape. I dont know if a >basshorn has the ability to increase air pressure much past 1 atmosphere, I guess it must compress to some >degree though. I think I'm getting mixed up with midrange and HF horn throat distortion though...What your saying is exactly true, a compression ratio increases the pressure in the throat and in any given circumstance that automatically increases the non-linearity of the air.What makes this "more complicated" is that at the pressures a VC driver can produce in a Bass horn, the non-linearity of the air is often FAR smaller than the typical driver motor and suspension linearity.Remember, sound at least the way we deal with it is logarithmic.For example, if one were able to fully modulate one atmosphere, the resulting pressure is 194 dB or so.This is loud, the sound has a pressure of 14.7 psi peak to peak.At 174 dB, the physical pressure is 1.47 psi and in a really high powered bass horn like a BT-7 or maybe a LAB Sub, the peak throat SPL should be in the neighborhood of 157 dB or .147 psi peak to peak.By the time one gets down to just plain "loud bass" one finds that 132 dB is about 4 pounds per square foot of pressure.I guess the point is that in a really powerfull bass horn, one might be lucky to find a peak throat pressure of 1/100 atm peak to peak. This is not enough to be a real problem and was what convinced me to pursue the more linear unconventional styles of drivers for bass horns. . does >one need more acoustic pressure to compress the peaks of a very long low frequency wavelength? Nope, pressure is pressure.>Why is >this? Is it because, for example a 600Hz wave vs 20Hz wave. The peak area/region on the 600Hz >wave is >a lot smaller than the peak region on a 20Hz wave, which would be very wide. So at the same >SPL level, >the compression of air atmosphere in the 20Hz wave is more 'spread out' than on the 600Hz >wave, so the >speed/temp relationship is not changed as much on the low frequency wave, so distortion >doesn't occur >until you feed the 20Hz wave a lot more power to get a lot more acoustic power to >compress the air to the >same level? But on the 600Hz wave, compression is now restricted to a smaller >area, so it air pressure is >compressed by a greater amount when played at the same SPL level as the 20Hz >wave.For a simple case horn, one finds (for flat power response) the driver displacement increases by 2 for each octave one goes down, for a direct radiator in a sealed box, the displacement increases by a factor of 4 for each octave (until past Fb where the displacement is constant with decreasing F).Throat pressure is constant (ideal horn) and output pressure (power) are constant.A real horn (which is always smaller) usually has more "issues" making some of this hard to see.Further complicating this is the fact that the actual throat distortion is much more of an issue at the top end of the response , not at all the bottom. Here is why (or at least what I see / think).The thumb rule for throat distortion shows the band width being a very strong factor in the result.The reason is that the wider the bandwidth, the slower the expansion (dictated by the low cutoff) is compared to the much shorter wavelengths of the high cutoff.This means the HF signal has to travel a greater distance (in wavelengths) at the higher pressures associated with the slower expansion. With our levitator sources (narrow beam, 21KHz @ 160+ dB), we saw this real time, one could take the mic and starting at the source and moving away say a foot (about 20 wavelengths), one saw the waveshape go from a sine to a sawtooth.>I would think then, looking at just direct radiators now, if we had a magical direct radiator which could >produce HEAPS of acoustic pressure/SPL, and ignoring distortion caused by the driver itself, the mere >unequal compression and rarefaction of air pressure will cause distortion of the sine waveshape all by or >in itself. Yep.>Getting back to the horn now... I'm trying to understand how the throat size distorts the >waveshape. I >know that it does, but I've managed to confuse myself. Is it because, the throat size itself has >the ability >to change air pressure? It is the only thing I can come up with that seems to make sense. >>Amplitude of >the pressure wave increases at the throat where air pressure is maximum? YesThen air pressure >decreases as you move away from the throat and down the horn? So the a smaller throat increases air >pressure over a larger one, causing more throat distortion/modification of the sine waveshape to a saw >tooth wave.Yes But on a basshorn, weather there is a high compression ratio or a low compression ratio, because of the very large wavelengths of low frequencies, you still need a ton of acoustic output for the crest region of the sine waveform to become compressed enough to distort the waveshape?Yes, another way to look at it is "power density" HF horns cover both a wide bw and are physically very small. For a compression driver to radiate say 1 acoustic Watt, that power (pressure) is concentrated into a very small area.For a bass horn radiating 1 acoustic Watt, the throat is tens to hundreds of times larger and so the power density is proportionally less. Add in the narrower BW and one finds the air non-linearity is not a big deal in bass horns.>Maybe I've got this all wrong... you've really got me thinking about this, I'm trying to convince myself >to believe that throat distortion in a basshorn is not an issue because it is not there!I can't tell you what to think but I would say as evidence of what I have described is that if air non-linearity were a problem, it would have been when the measurements for the BT-7's were taken.In that case, they were radiating about 180 acoustic Watts each.>I've heard of some people breaking their woofer cones from high compression ratio's even if distortion is >not an issue, its one reason to keep the compression ratio low. What comp ratio did you use on the >labhorn? Have you ever damaged a woofer before because of high comp ratio at high power?You bet, this was a real problem in the early days of the Servodrives, we installed a window in the side of a box and we watched (in some what horror) as we swept the oscillator up and down at high power and watched the cones slowly fold up like some paper flower.We came up with a treatment we dip them in which stopped cone failures and makes them strong enough to stand on.The BT-7 has a radiator area of 266 sq ins and throat of about 80 sq ins and the Lab sub has about the same throat area but uses 2, 12inch radiators so it has a lower compression ratio.The Lab 12 has a highly reinforced cone, huge ridged dust cap and a stiffener underneath that so it is not likely to have much "non-piston" motion in use.>> This distortion is the sum of the VC motor and mechanical system's>> non linearity.>>The "bad" effects of the latter can be minimized by choosing a>> driver with a low Fs which then requires a small Vb to end with>> the right compliance.>> Depending on the sealed volume more means that a more linear>> spring is dominating over the drivers relatively non-linear>> suspension (by comparison) spring.>> Generally, stay away from High Fs driver for bass horns if low>> distortion is a goal.>I remember you telling me before, the idea is to get the reactances to offset each other, leaving the >resistive components to interact with each other. What I am saying, is how can you say a larger Vb >dictates that the suspension of the driver is not as linear as a driver requiring only a smaller Vb?It doesn't say that directly but in practice, one finds the air to be a more linear spring than most driver suspensions and spiders. Also, most stiff drivers tend to be of the low Xmax variety as well>So basically, the idea is to get a load as stiff as the throat, but behind the driver instead using a rear >chamber - to get even loading on each side, so its more linear on each side, resistive only. Did you mean >to say the compliance of the rear chamber Vb should be matched to that of the throat instead and not the >driver suspension? As a matter of interest, the rear Vb which cancels or balances out the capacitive >reactance from the mass reactance of the throat, may not be the volume which provides the best/most even >frequency response, even though it may be the most linear for the driver/lowest distortion combination...In a perfect world and in the case of a 50% efficient system, one would want to make the acoustic resistance on the radiator to be about equal to the sum of the mechanical and electrical losses.This condition results in about half the input power being dissipated as heat and the other half as acoustic power.In practice, with a real horn, one would "tune" to get the best trade off in response /low cutoff and possibly efficiency.>I am pretty sure that in smaller box volumes, the air inside it is stiffer (inductive reactance?) which may >be needed to balance out the capacitive reactance from the throat. Just 'how stiff' do you need it though? >That is hard to know, unless there are formula's around, which there probably are. I think though that to >generalize to say that you must have a small rear volume to make the system linear is a bit of a stretch. It >could even be made too small...which would not be good, because then the reactance's wouldn't balance. >The 'right' rear volume may even be relatively large by comparison...The high pass nature of the load and the spring force controlled driver lf response both govern the horn's output. The spring force is the sum of BOTH the driver suspension compliance in parallel with the enclosure compliance.The air is the more linear of the two so I suggest making its contribution larger and the drivers suspension smaller to still end with the needed total compliance.>How come a driver with lower Fs will end up with smaller rear volume? I would think driver Qts would >play the biggest part here...For two drivers of identical area and mms, the one with the lower Fs has a weaker suspension spring and depends more on a smaller box to get the desired Fb.>By the way, would you mind checking my horn length in my first post? It is in the 3rd diagram down. I >have the horn length measured right down the dead middle of the horn... is this how you would normally >measure it? Have you got any comments on horn/path length? >http://www.audioroundtable.com/HighEfficiencySpeakers/messages/481.htmlI don't know if this is a help but I generally figure that the horn has to end with the same internal volume folded or not when I lay one out. In reality, a bend does add a tiny bit of extra inertia.I had seen your horn in several posts and was thinking of making a suggestion.I try to end up with a minimum of un-used space, looking at the void in the forward end of you box, I can't help wonder if you reduced the thickness dimension a bit (making the horn take up a little bit more space up and down) if that wouldn't use it up.Or, possibly increase the front to back dimension a bit and make the horn a bit longer which also makes it take up more space (and of course go lower).Please do not take my suggestion as being critical, I encourage you to pursue what ever it is you end up with. Horns can be a lot of fun to design and clearly you have the bug.Cheers,Tom Wayne I have a reply started to you too but I have to run, more Saturday chores.