Subject: Horn Mouth Diffraction
Posted by M on Thu, 06 Oct 2005 00:59:25 GMT
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Dear all,It is rather well understood that a finite aperture of a horn/wave-guide causes diffraction effects, [1]. However, neither this reference nor another paper [2], which at least tangentially touches on this issue, gives any insight on computation of a mouth shape that would give an optimal (whatever the criteria) diffraction.I am also aware of the work of Jean Michel Le Cleac'h [3], but this appears to be concerned with the entire horn contour, and not only the mouth shape. As such, it appears inapplicable to a situations, where a horn contour is pre-determined, e.g., constant directivity.I would appreciate if anyone, who aware of any theory/papers/software dealing with this issue, could post references.Thank you,M[1] Geddes, E., R.: "Sound Radiation from Acoustic Apertures." JAES., vol. 41, pp. 214-23 (April 1993)[2] Henwood, D.J.: "The Boundary element method and Horn Design, JAES, vol. 41, pp. 485-496 (June 1993)[3] http://ndaviden.club.fr/pavillon/lecleach.htm

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Subject: Re: Horn Mouth Diffraction
Posted by Wayne Parham on Thu, 06 Oct 2005 05:24:40 GMT
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I was going to suggest Geddes, but see you already have the reference. Seems like you have a pretty good handle on the issue.Maybe I've over-simplified the problem, but I've always been of the opinion that an oversized horn is a solution because the mouth is larger than the wavelengths involved. Of course, this is an impossible proposition in many cases, or at least an impractical one. But for home hifi use, where room boundaries can be exploited, you can take advantage of the walls as flare extenders if you can get the mouths close enough. So for LF and MF frequencies where size matters, the expansion from a corner can reduce edge diffraction by effectively extending the flare. And for HF frequencies, the wavelengths are small enough that you can make the horn large enough to reduce edge diffraction.

Subject: Re: Horn Mouth Diffraction
Posted by Martin on Thu, 06 Oct 2005 10:00:45 GMT
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M,I include diffraction around the perimeter of the horn's mouth in both of my latest front and back loaded horn MathCad worksheets. These worksheet are not the ones currently available for downloading form my site. It is a similar calculation that is done by the EDGE program with one exception. When the bottom edge of the horn is in contact with the floor, then it bcomes both a diffraction and a reflection problem. Some typical results can be seen in my advanced back loaded horn design documentation. I am still working on the technique so I expect further

revisions will be coming.Martin
Quarter Wavelength Loudspeaker Design

Subject: Re: Horn Mouth Diffraction
Posted by M on Thu, 06 Oct 2005 20:57:14 GMT
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Dear Wayne,thank you for your time replying.The problem with an oversized horn, as I understand it, is that the frequency of the on axis "hole" moves down. Because it is a phenomenon with harmonics, this results in more of these "holes" in the passband.M

Subject: Re: Horn Mouth Diffraction
Posted by M on Thu, 06 Oct 2005 21:05:53 GMT
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Dear Martin,thank you for your time replying.I am well aware of your "released" MathCad worksheets. I am also familiar with EDGE, but I am unaware of its ability to model other than a flat baffle. If you understand, how to do that, could you please give me a hint?I am wondering if I could be your "guinea pig" for your diffraction solution, either by letting me have the MathCad worksheets or calculate a solution for me, which I would reciprocate by providing you with measurements.If my suggestion is unreasonable, please cheerfully ignore it. As an Intellectual Property practitioner, I understand your ownership concerns; otherwise, please contact me at mefistofelez_at_hotmail_dot_com.Thank you,M

Subject: Re: Horn Mouth Diffraction
Posted by Wayne Parham on Thu, 06 Oct 2005 21:30:04 GMT
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I am not aware of any such phenomenon. Can you post some references?

Subject: Re: Horn Mouth Diffraction
Posted by M on Thu, 06 Oct 2005 23:09:38 GMT
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Dear Wayne,[1] Geddes, E., R.: "Acoustic Waveguide Theory revisited." JAES., vol. 41, pp. 452-461 (June 1993). See Section 3.5. The equation introduced there and its implication are treated in:[2] Geddes, E., R.: "Sound Radiation from Acoustic Apertures." JAES., vol. 41, pp. 214-23 (April 1993). See in particular Section 6; the conclusion in the first paragraph.M

Subject: Re: Horn Mouth Diffraction
Posted by Martin on Thu, 06 Oct 2005 23:31:11 GMT
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M,Looking at the EDGE again I think I was in error. My MathCad worksheets use the same basic math as the EDGE but can handle both rectangular and circular sources and baffles. So modelling a round or rectanguler horn mouth and baffle is easily done. I don't think the EDGE will do those combinations. I used the EDGE as a double check of my algorithm using sample problems.As far as rounded edges on baffles, I do not believe that exact modelling of this is needed. There are two effects from the baffle, the baffle step as the sound radiated transitions from 4 pi to 2 pi and the sound "scattering" at the edge itself. The second effect produces small wiggles in the SPL plot. I do not believe that these small wiggles are as significant as room effects or the baffle step response. Maybe this is because I use full range drivers that are starting to beam at these same frequencies so the impact of the edge sharpness/radius is minimal.Thanks for the offer of help with the horn worksheets. At this time I am pursuing a design and test of my own and have decided to hold onto the worksheets and the test results until I decide what I want to make available.Martin

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Subject: Re: Horn Mouth Diffraction
Posted by M on Fri, 07 Oct 2005 01:40:30 GMT
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Dear Martin,you wrote:"As far as rounded edges on baffles, I do not believe that exact modelling of this is needed. There are two effects from the baffle, the baffle step as the sound radiated transitions from 4 pi to 2 pi and the sound "scattering" at the edge itself. The second effect produces small wiggles in the SPL plot. I do not believe that these small wiggles are as significant as room effects or the baffle step response. Maybe this is because I use full range drivers that are starting to beam at these same frequencies so the impact of the edge sharpness/radius is minimal."This is my understanding, and please correct me, if I am wrong. There are (at least) two consequences associated with the transition from the boundary formed by a horn or a cone driver.A transition from the boundary constrained space to a 2 pi (if mounted on a baffle) or 4 pi (if radiating to free space), which is characterized by impedance mismatch, reflections, and resulting standing waves (ripples).The second is diffraction on the edge of the boundary. Invoking Huygens'principle, the wave emanating from the boundary restricted space will interfere with the wave emanating from the edge of the boundary.I have an idea how to deal with the first one. Whether I am correct is to be seen.   However, I am at loss how to deal with the other one, if I esclude various rules of a thumb. I understand that I am making a heuristic argument here, but it appears to me, that by a "proper" shape of the edge of the boundary, the interference could be minimized. You wrote:"Thanks for the offer of help with the horn worksheets."ROTFLMAO. You are very polite, you know, where my motivation was comming from. You wrote:". . . and have decided to hold onto the worksheets and the test results until I decide what I want to make available."No problem at all, see my previous post. I would like to nominate myself as a beta tester, though. M

Subject: Re: Horn Mouth Diffraction
Posted by M on Fri, 07 Oct 2005 01:54:19 GMT
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Dear Martin,I have completely forgotten to add that the second phenomenon of my message is eloquently described in your "Design of a Front Loaded Exponential Horn" paper, p. 7, last two paragraphs.M

Subject: Re: Horn Mouth Diffraction
Posted by Wayne Parham on Fri, 07 Oct 2005 04:45:26 GMT
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I don't have those papers, but I do have a copy of Geddes 2002 book "Audio Transducers." Chapter 6 is about waveguides and on page 152, he wrote a section called "Treatment of Mouth Diffraction." There are references to the rippling of polar response that occurs when the mouth terminates abruptly, and a wider flare is suggested as a solution.The primary mode of wave propagation in conical tubes is spherical and along the central axis of the tube. An infinite horn has no termination, and so no mouth diffraction. An extended horn with a large mouth tends to approach this as far as I can tell.Maybe what you are talking about are high order modes. Geddes has made that a special focus, and he uses a aborbant foam in his horns to reduce them. While the principle mode of radiation is along the central axis, high order modes also exist that traverse from side to side. He explains that his solution attenuates the high order modes more than the primary mode because they have to bounce through more absorbent material.That's what I have understood from talking with Earl, but beyond that, I should probably allow him to elaborate. Perhaps he'll chime in and discuss it further.

Subject: Re: Horn Mouth Diffraction
Posted by Martin on Fri, 07 Oct 2005 10:23:04 GMT
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Hi M,"This is my understanding, and please correct me, if I am wrong. There are (at least) two consequences associated with the transition from the boundary formed by a horn or a cone driver.A transition from the boundary constrained space to a 2 pi (if mounted on a baffle) or 4 pi (if radiating to free space), which is characterized by impedance mismatch, reflections, and resulting standing waves (ripples)."Yes I think we are saying the same things. A couple of minor additional points. First, you don't need a baffle to have a baffle step. The physical size of the driver or the mouth of a front loaded horn like the Oris will also produce a baffle step. The source diameter is in effect a baffle. So when I simulate something like an Oris horn or the mouth of a back loaded horn which is "framed" by an enclosure structure I still calculate a baffle step response.Second, I don't think the ripples are a result of standing waves. I believe they occur at frequencies for which the path lengths from all of the edge sources produce reinforcement (arrive in phase) or cancellation (arrive out of phase) of the summed response from the individual pressures from each source. If a standing wave response occured, I would expect these ripples to be more like sharp tall peaks and deep narrow nulls. "The second is diffraction on the edge of the boundary. Invoking Huygens'principle, the wave emanating from the boundary restricted space will interfere with the wave emanating from the edge of the boundary."Yes."I have an idea how to deal with the first one. Whether I am correct is to be seen. However, I am at loss how to deal with the other one, if I esclude various rules of a thumb. I understand that I am making a heuristic argument here, but it appears to me, that by a "proper" shape of the edge of the boundary, the interference could be minimized."What I should have stated clearly before is that my thoughts are primarily for full range drivers and in particular my collection of Lowther drivers. For a tweeter or small horn my thinking would be different, if I had done any thinking at all. At the frequencies where ripples contributed by the edge of a baffle, as seen in the EDGE program, the driver is becoming very directional. For larger horn mouths the directivity is even more pronounced. I am not sure that the ripple produced by different edge conditions, sharp or rounded, is the biggest problem to be solved. I guess I would consider edge treatments as a tweak and something to be experimented with on the completed speaker and probably not something I would include in the initial design calculations. Adding a radius porbably would not hurt the response but I would not highlight it as a feature in the design of the enclosure. As you may have already guessed, I don't have a calculation for a rounded edge on a baffle .... yet.Martin

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Subject: Re: Horn Mouth Diffraction
Posted by M on Tue, 11 Oct 2005 12:44:41 GMT
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Dear Martin,you wrote:"Second, I don't think the ripples are a result of standing waves. I believe they occur at frequencies for which the path lengths from all of the edge sources produce reinforcement (arrive in phase) or cancellation (arrive out of phase) of the summed response from the individual pressures from each source. If a standing wave response occured, I would expect these ripples to be more like sharp tall peaks and deep narrow nulls."Excellent observation in the last sentence. Let me think about it and see if I can desing an experiment that would confirm this.I do trully hope that you will find a way to make your invaluable spread-sheets available without them being missused, although, sadly I have no idea how you could do that. ;-(But then again, I am not as smart as you are.;-)M

Subject: Re: Horn Mouth Diffraction
Posted by Martin on Tue, 11 Oct 2005 15:37:47 GMT
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M,"I do trully hope that you will find a way to make your invaluable spread-sheets available without them being missused, although, sadly I have no idea how you could do that. ;-(" I have been struggling with this problem for a while, I would like to make more stuff available. The feedback, continued discussion, and new design ideas that result accelerate me towards the next round of upgrades. Having people using the worksheets and commenting is extremely efficient."But then again, I am not as smart as you are.;-)"You only see the stuff I get almost right, nobody sees the stuff I screw up. This produces an illusion that I might have more answers then questions.Martin

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Subject: Re: Horn Mouth Diffraction
Posted by roncla on Wed, 12 Oct 2005 01:32:48 GMT
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The more i learn the more i realize i do not know.ron

Subject: Re: Horn Mouth Diffraction
Posted by M on Wed, 12 Oct 2005 11:32:42 GMT
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Dear Martin,you wrote: "I have been struggling with this problem for a while, I would like to make more stuff available."Yes, from my discussion from some people I understood that you were almost ready to give up on shariong your work. I, for one am exremaly pleased to sense this new attitude.M

Subject: Re: Horn Mouth Diffraction
Posted by Earl Geddes on Sun, 30 Oct 2005 23:35:05 GMT
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As the author of one of those papers, you should have asked me. I'm easily reachable. I did not read any of the other replys so I may say the same things and I may say something different.To my knowledge no one but me has ever considered mouth diffraction in a theoretical sense. That was what my earler papers were about. There are two aspects to consider here. One relates to the cross-sectional shape - the shape normal to the wave propagation - and the other the shape in a plane of the wave propagation. The later one determines the amount of diffraction, while the cross-sectional shape has an influence on the axial and polar aspects.Let me first say that NO diffraction is best, so its best to first worry about the in-plane shape. Here the answer is simple, radius the junction of the waveguide with the baffle as large as possible. This will minimize the diffraction and if done correctly will make it small enough that the other shape question is mute.But it is often the case that one cannot radius the edge enough to yield no diffraction and the cross-sectional shape enters into the problem in a subtle way. A circular shape turns out not to be ideal since on axis the diffraction effects all add up in phase to yield a "hole" on axis at some frequency. This can be clearly seen in the Summas polar response. An elliptical section minimizes this hole, smearing it in frequency. But an ellipse has other problems like non-axi-symmetric polar response. Woofers usually have axi-symmetric polar responses. In the Summas, I don't recommend listening on-axis so this hole is not a big problem.Beyond the circle and the ellipse, every other shape has basically these same characteristics.But don't forget the Golden Rule here. NO diffraction is best, and no shape can compensate for a poorly diffracting waveguide mouth.Hope this helps.
