STUDIOTIPS

Acoustics Forum

small room acoustics

A few questions about Helmholtz resonators and acoustic mass

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A few questions about Helmholtz resonators and acoustic mass

by **ChrisW** » Tue Apr 13, 2004 9:49 am

Newbie (to this NG) posting.

I've been studying acoustics in my spare time for about 18 months now, and I think I've got a pretty good understanding of the statistically based RT60 calculations (Sabine, Fitzroy, Eyring, Arau etc). Now I'm looking more deeply into the physics of sound. I've got alot of learning to do when it comes to the applied maths and physics, so maybe these questions arise from my general lack of knowledge in these areas, anyway, here goes...

Firstly, am I right in expecting the formula for a perforated Helmholtz resonator to be very similar to the formula for slotted resonator? Kinsler & Frey (third edition) Eqn 10.8 refers to the resonant frequency of a perforated resonator as:

Code: Select all
```
f = c*SQRT(S/t*v)
```

Where:
c = speed of sound
S = hole area
t = end corrected panel thickness
v = cavity volume of one repeat unit

which appears very different from the formula for a slotted resonator:

Code: Select all
```
f = 2160*SQRT(r/((d*D)+(r+w)))
```

Where:
r = slot width in inches
w = slat width in inches
d = effective depth of slot in inches (1.2 x the actual slat hickness)
D = airspace depth (depth of box behind the slots) in inches

Is my expectation right, or are these equations simply algebraical rearragements of each other, if so, what is their common starting point?

Secondly, a spring/mass system is an analogue of a Helmholtz resonator. Therefore (as I understand it), the acoustic mass of the resonator is the mass of air in the neck/hole?

This is my understanding from Kinsler and Frey. However, in their new book "Acoustics Absorbers and Diffusers", Cox and D'Antonio quote a formula (Eqn 6.6, page 167) for calculating the acoustic mass of a Helmholtz resonator as:

Code: Select all
```
m = rho/epsilon*(t+(2*delta*a)+sqrt((8v/omega)*(1+(t/2a))))
```

Where:
rho = density of air
epsilon = panel porosity
t = panel thickness
delta = end correction factor

a = hole radius
v = kinematic viscosity of air
omega = angular frequency

My expectation is that as the distance between the holes rises (I.E. the porosity drops), then the acoustic mass should drop because there are fewer holes per unit area. But since the porosity factor is in the denominator, as it decreases, the acoustic mass rises.

I can only think that this equation must be measuring the mass of the panel between the holes - but in that case, why are the viscosity of and density air required, and why does the hole radius appear in two terms? I must have missed something here, but I don't know what.

Lastly, why are the units of acoustic mass kg/M^-4?

Regards

Chris Whealy
--
The voice of ignorance speaks loud and long,
but the words of the wise are quiet and few.
--
ChrisW

Posts: 153
Joined: Tue Mar 30, 2004 12:42 pm
Location: Brentwood, Essex, UK
Top

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by **Eric.Desart** » Tue Apr 13, 2004 10:17 pm

Hello Chris,

Welcome here.

I have no time to go in-depth now on this thing (later maybe).
If you write formulas can you give also the exact units to distinguish between metric and US units.

Kind regards
Eric
PS: give the link here of your Excel file: can be interesting for others too.
Eric.Desart
Moderator

Posts: 2461
Joined: Tue Feb 10, 2004 4:29 am
Location: Antwerp, Belgium
Top

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by **avare** » Wed Apr 14, 2004 2:23 am

I can not comment on everything that you wrote and questioned. There is an error in the equation for the slot type absorber that is endemic on the web calculators. For an excellent presentation of this read the following thread by Eric. He words it much better than I can.

http://groups.google.ca/groups?q=Everest+Helmholtz+group:alt.sci.physics.acoustics&hl=en&lr=&ie=UTF-8&newwindow=1&group=alt.sci.physics.acoustics&safe=off&selm=403219d5%240%2413249%24ba620e4c%40news.skynet.be&rnum=2

If you look at the corrected version of the slat type formula you will see that it is a direct form of the Helmholtz formula, presented in an easier form for the specific application of slat resonators.

Enjoy!
avare

Posts: 965
Joined: Thu Mar 04, 2004 10:22 pm
Location: Hamilton, Ontario, Canada
Top

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by **Dan Nelson** » Wed Apr 14, 2004 2:49 am
I think you have the formula with the typo in it I believe the correct one is
fo = 2160*sqrt(r/((d*1.2*D)*(r+w)))

owever, in their new book "Acoustics Absorbers and Diffusers", Cox and D'Antonio quote a formula (Eqn 6.6, page 167) for calculating the acoustic mass of a Helmholtz resonator as:

I'm jealous, I'm dying to get that book. You can't get it in the states yet. Yes I'm an acoustics geek.

Dan

edit i see the thread before me points you to the formula
Dan Nelson

Posts: 629
Joined: Sat Jan 31, 2004 2:52 am
Top

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by **ChrisW** » Wed Apr 14, 2004 9:24 am

OK, the correction to the slot resonator formula is noted, and I'll study Eric's reply on alt.sci.physics.acoustics.

Dan, if you want Cox and D'Antonio's book (which I highly recommend - it's excellent), try going straight to the publishers Spon Press. The book is not cheap (£90!!), but its worth every penny.

Try this link - I don't know if they ship to the US though.

https://ecommerce.tandf.co.uk/catalogue ... er=ByTitle

Regards

Chris W
--
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but the words of the wise are quiet and few.
--
ChrisW

Posts: 153
Joined: Tue Mar 30, 2004 12:42 pm
Location: Brentwood, Essex, UK

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by **Eric.Desart** » Wed Apr 14, 2004 11:22 am

I entered (back then) this Slat type Helmholtz message also in this group (my home)
http://forum.studiotips.com/viewtopic.php?t=94

Regards
Eric

PS:
Where:
rho = density of air
epsilon = panel porosity
t = panel thickness
delta = end correction factor
a = hole radius
v = kinematic viscosity of air
omega = angular frequency

Is this metric? Units? How's delta calculated? etc....
When entering a formula do it as in a school book.
Eric.Desart
Moderator

Posts: 2461
Joined: Tue Feb 10, 2004 4:29 am
Location: Antwerp, Belgium
Top

---

by **ChrisW** » Wed Apr 14, 2004 2:12 pm
All formulae quoted from Cox and D'Antonio use MKS units:
Code: Select all

```
m = rho/epsilon*(t+(2*delta*a)+sqrt((8v/omega)*(1+(t/2a))))  (Cox & D'Antonio Eqn 6.6)
```

Where:
rho = density of air (Kgs/m^3)
epsilon = panel porosity (no units)

t = panel thickness (m)
delta = end correction factor (no units)
a = hole radius (m)
v = kinematic viscosity of air (=15 x 10^-6 m^2s^-1)
omega = angular frequency (s^-1)

The porosity is given by:

Code: Select all

```
epsilon = PI()*a^2/D^2 (Cox & D'Antonio Eqn 6.5)
```

Where:
a = hole radius (m)
D = Repeat distance between holes (m)

The end correction factor represented by the placeholder delta is calculated:

Code: Select all

```
delta = 0.8(1 - 1.4*sqrt(epsilon))  (Cox & D'Antonio Eqn 6.7)
```

Where epsilon is the porosity as quoted above.

Also, at Eric's request, here is the link to a spreadsheet I wrote for calculating the basic acoustic properties of a rectilinear room.

http://www.rmmpnet.org/members/ChrisW/index.html

For those people with some spare time on their hands, I would appreciate objective feedback on the useability of this spreadsheet.

Thanks

Chris W
--
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but the words of the wise are quiet and few.
--
ChrisW

Posts: 153
Joined: Tue Mar 30, 2004 12:42 pm
Location: Brentwood, Essex, UK

Top

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by **ChrisW** » Wed Apr 14, 2004 5:51 pm

Oops! Forgot to mention that the equation for the end correction factor (delta) only applies if the porosity is less than 16%. Otherwise a value of delta = 0.85 should be used.

The end correction value is then used to scale the panel thickness of the Helmholtz resonator as follows:

Code: Select all

```
t' = t + 2 * delta * a
```

Where:

t' = End corrected panel thickness (m)
t = Panel thickness (m)
delta = End correction factor
a = Hole radius (m)

Clarification seems to be an iterative process... :-)

Chris W
--
The voice of ignorance speaks loud and long,
but the words of the wise are quiet and few.
--
ChrisW

Posts: 153
Joined: Tue Mar 30, 2004 12:42 pm
Location: Brentwood, Essex, UK

- Website

Top

by **ChrisW** » Fri Apr 16, 2004 9:25 am

OK, I've mostly been able to answer my own questions about Helmholtz resonators.

I found the answer on Dave Moulton's website where he has a series of lectures on Electroacoustics. His fourth lecture was the one that explained things for me. Here he shows that a damped mass/spring system; a circuit consisting of a coil, resistor and capacitor in series; and a Helmholtz resonator are all analogues of each other.

In providing this comparison between the mechanical, electrical and acoustic domains, not only does explain things from the ground up, but he shows why it is necessary for acoustic mass (which he refers to as inertance) to have units of Kg/m^4.

See http://www.moultonworld.pwp.blueyonder. ... _page.html for more information.

Regards

Chris W
--
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but the words of the wise are quiet and few.
--

STUDIOTIPS

Acoustics Forum

small room acoustics

Flow Resistance of Panel Absorbers

Post and discuss acoustic topics, Studio design, construction, and soundproofing here
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Flow Resistance of Panel Absorbers

by **jonessy** » Fri Feb 27, 2009 11:25 am

Hi all,

Been away for a while. Sorry 'bout that.

I'm trying to model the behavior of solid panel absorbers using a transfer matrix, and could use some help.

For a simple panel<-->air<-->rigid-back construction:

The complex impedance at the panel layer is function of 1) the mass-spring reactance term (imaginary) and 2) the flow resistance term (real).

According to Long* this is:

z = rf + j[omega*m-(rho*c^2/omega*d)]

Where rf is the flow resistance, and all the rest are pretty self explanatory.
I have two questions regarding the approximation of rf:

[1]
For an airtight construction the flow resistance is really high, so one can assume that the rf term approaches infinity.
This in turn means that at least theoretically speaking, at resonance the absorption coefficient is infinity.
Obviously this is not the case in real life.

So if I wanted to model this behavior, would it be safe to normalize the absorption coefficients across the frequency range so at resonance alpha becomes 1 (highest absorption is 1 instead of highest absorption is infinity)?

[2]
Assuming a non-airtight construction, such as an unboxed membrane distanced from a rigid wall, what would be the best way to approximate the flow resistance?
My hunch is that this has something to do with diffraction around the membrane, but I couldn't find any documentation to support this.
Any ideas?

Thanks

Cheers,
Jon.

* Long, M. (2005). *Architectural acoustics.* Amsterdam: Elsevier/Academic Press.

_____
Bert is still my hero.
What d'ya know.
jonessy

Posts: 580
Joined: Wed Jan 04, 2006 3:39 pm
Location: Israel

Top

Re: Flow Resistance of Panel Absorbers

by **Terry Montlick** » Fri Feb 27, 2009 3:07 pm

I think there's something very fishy about Long's inserting the term rf due to resistance from a spring air force **behind** the panel, and implying that this is the same as a flow resistance **through** the panel.

I'll look at this later today and see if I can determine a correct formulation.

Regards,
Terry
Terry Montlick Labs
Tweeters tweaked. Woofers neutered.
Terry Montlick

Posts: 1143
Joined: Mon Apr 12, 2004 9:31 pm
Location: Rhode Island, USA

Top

Re: Flow Resistance of Panel Absorbers

by **jonessy** » Fri Feb 27, 2009 3:31 pm

Thanks Terry, that would be great.

I'm going to re-read the chapter too - now that you've mentioned this, it does seem strange.

Cheers,

Jon.

_____
Bert is still my hero.
What d'ya know.
jonessy

Posts: 580
Joined: Wed Jan 04, 2006 3:39 pm
Location: Israel

Top

Re: Flow Resistance of Panel Absorbers

by **bert stoltenborg** » Fri Feb 27, 2009 5:29 pm

Quick & dirty (obvious that I don't know exactly what you're talking about):
isn't this comparable with a speaker in a box or vented enclosure?
If you view life with the knowledge that there are no problems, only opportunities, you are a marketing manager.....this is my personal philosophy
bert stoltenborg

Posts: 4456

Joined: Sun Apr 18, 2004 11:03 am
Location: Achterhood, Netherlands

Top

Re: Flow Resistance of Panel Absorbers

by **jonessy** » Fri Feb 27, 2009 7:09 pm

I guess...

Only the driving force is not the electro-mechanical system, and the membrane is rectangular and not conical..

Does this mean that the membrane's flow resistance is equivalent to the mechanical resistance of the driver ?

I'm confused...

_____
Bert is still my hero.
What d'ya know.
jonessy

Posts: 580
Joined: Wed Jan 04, 2006 3:39 pm
Location: Israel

Top

Re: Flow Resistance of Panel Absorbers

by **Terry Montlick** » Fri Feb 27, 2009 7:30 pm

Okay, Jon. Page 273 of Long is pretty fucked up. It looks like ***my*** math at the end of a really bad day.

Here's the **right** way to derive this. Consider the transfer matrix of just the thin panel. Remember that a transfer matrix simply relates pressure and velocity on one side of something to the pressure and velocity on the other side of the same something:

$p_{i+1} = T_{11}*p_i + T_{12}*v_i$
$v_{i+1} = T_{21}*p_i + T_{22}*v_i$

where T is the 2x2 transfer matrix that I can't show neatly in ASCII!

So what is T for an ideal thin panel with mass per unit area M?

We have [Kuttruff p. 43] the simple relation between the pressure on each side of a thin panel:

$p_{i+1} - p_i = M\, dv/dt = j\omega M v$

And for velocity the relation is completely trivial, because motion on one side of the rigid panel is exactly the same as the motion on the other:

$v_{i+1} = v_i = v$

This gives us a transfer matrix with the following elements:

$T_{11} = 1$
$T_{12} = j\omega M$
$T_{21} = 0$
$T_{22} = 1$

How do we add the air layer? From the magic of transfer matrices, we just multiply the transfer matrix of the panel times the transfer matrix of the air layer against a solid wall.

From Cox and D'Antonio, p. 149, we know that the impedance of such an air layer is:

$-jz_0 \cot(k_{air} l)$
where
$k_{air} = \omega/c$
$z_0 = c\rho_0$
l = thickness of the air layer

In transfer matrix form, the impedance gets plugged into T_{12}:

$T_{11} = 1$
$T_{12} = -jz_0 \cot(k_{air} l)$
$T_{21} = 0$

$T_{22} = 1$

So just multiply these two transfer matrices (remember, first row times first column = first element, etc.), and you've got the solution!

Regards,
Terry
Terry Montlick Labs
Tweeters tweaked. Woofers neutered.
Terry Montlick

Posts: 1143
Joined: Mon Apr 12, 2004 9:31 pm
Location: Rhode Island, USA

Top

Re: Flow Resistance of Panel Absorbers

by **jonessy** » Fri Feb 27, 2009 8:27 pm

Thanks Terry for looking into it.

However, there is still no answer for the mysterious resistive component...

Multiplying the two transfer matrices gives a new 2x2 matrix:

T11 = 1
T12 = -jz0cot(ωd/c0)+jωm
T21 = 0
T22 = 1

So from that we derive:

$z = -j\rho 0c0\cot(\omega d/c0) + j\omega m$

Since we know that k(air)=ω/c0 we can rewrite the equation:

$z = j[\omega m - \rho 0c0\cot(kd)]$

Which is the same as eq 7.1 from Long's book (p.273 with the messy math...).

Still, this is only the reactive part of the impedance. Where is the resistive part (or what he calls rf) accounted for ?

Cheers,

Jon.

_____
Bert is still my hero.
What d'ya know.
jonessy

Posts: 580
Joined: Wed Jan 04, 2006 3:39 pm
Location: Israel

Top

Re: Flow Resistance of Panel Absorbers

by **Terry Montlick** » Fri Feb 27, 2009 9:05 pm

jonessy wrote:...
Since we know that k(air)=ω/c0 we can rewrite the equation:

$z = j[\omega m - \rho 0c0\cot(kd)]$

Which is the same as eq 7.1 from Long's book (p.273 with the messy math...).

Still, this is only the reactive part of the impedance. Where is the resistive part (or what he calls rf) accounted for ?

He added a general rf resistance term and called it flow resistance of the panel. But panels (either sealed or infinite) don't have flow resistance unless they are perforated! [And perforated panels aren't talked about until the next section, with different math] So rf appears to be a catch-all resistance term. It would more typically be due to the resistance of a porous absorber placed **behind** the panel. You can of course add this as another layer to the transfer matrix.

Regards,
Terry
Terry Montlick Labs
Tweeters tweaked. Woofers neutered.
Terry Montlick

Posts: 1143
Joined: Mon Apr 12, 2004 9:31 pm
Location: Rhode Island, USA

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Re: Flow Resistance of Panel Absorbers

by **jonessy** » Fri Feb 27, 2009 9:21 pm

*Terry wrote:*He added a general rf resistance term and called it flow resistance of the panel. But panels don't have flow resistance unless they are perforated!

Exactly my point. Well to be more accurate, panels don't have airflow through them, so they should have a flow resistance of infinity, no?

Long further elaborates:

*Marshall Long, p.273 wrote:*If the panel is impervious to flow, the flow resistance is infinite and the absorption is theoretically infinite at resonance. Above and below resonance the absorption coefficient falls off.

So far so good. Sort of. I can live with infinity, and that's where my question originated from (can I normalize infinity at resonance to alpha = 1).

But wait, just as things start to make (a little) sense, he writes:

*Marshall Long, p.274 wrote:*In this model the sharpness of the peak is determined by the amount of flow resistance provided by the panel.

What freaking *amount* of flow resistance ???

You (he) just wrote that for a solid panel the flow resistance is infinity. What gives?

I looked up nearly every acoustic text I have, Kutruff, Bies & Hansen, Kinsler & Frey, et al. Nobody goes near this stuff.

I didn't check Morse & Ingard, though. That book scares the shit out of me.

Help (!)

Cheers,

Jon.

_____
Bert is still my hero.
What d'ya know.
jonessy

Posts: 580
Joined: Wed Jan 04, 2006 3:39 pm
Location: Israel

Top

Re: Flow Resistance of Panel Absorbers

by **Terry Montlick** » Fri Feb 27, 2009 9:30 pm

*jonessy wrote:*What freaking flow resistance ???

Exactly.

He sticks in a term that doesn't really belong, doesn't define it, talks around it (badly) for a bit, and just ends up confusing the reader, which is you!!

Regards,
Terry
Terry Montlick Labs
Tweeters tweaked. Woofers neutered.
Terry Montlick

Posts: 1143
Joined: Mon Apr 12, 2004 9:31 pm
Location: Rhode Island, USA

Top

Re: Flow Resistance of Panel Absorbers

by **Eric.Desart** » Sat Feb 28, 2009 6:33 am

A bit off-topic
Higini has made a model to predict the behavior of panel absorbers (he's a PhD)
As I understood it's published in one of his Spanish books about acoustics. (Never bought it since I don't speak the language). I don't know this model.
Maybe you can email him.
It's a very nice, warm and humble man with an enormous knowledge.
He's one of Spain's top acousticians.

Maybe you can email him. (He speaks some, but not good English)
I once had some extensive email contact with him.

Arau Acustica Higini Arau Puchades
Travessera De Dalt,118-3º-1, Barcelona, 08024
t: 932845016 f: 932850895
http://www.arauacustica.com
info -at- arauacustica.com

He's the one who designed the Arau Puchades RT formula
Higini Arau Puchades "An improved reverberation formula," H. Arau-Puchades, Acustica 65, 163-180 (1988)

divinely-inspired
Eric.Desart
Moderator

Posts: 2461
Joined: Tue Feb 10, 2004 4:29 am
Location: Antwerp, Belgium

Top

Re: Flow Resistance of Panel Absorbers

by **jonessy** » Sat Feb 28, 2009 2:18 pm

Eric -

Thanks for the tip. I'll contact him, maybe he has some answers.

Terry -

I think I'm making some progress.

I modeled our solution to the transfer matrix and it seems incorrect. Alpha values always turn out to be 0, in all frequencies.

This kinda makes sense because systems naturally resonate at zero reactance, so if we don't have energy dissipated due to resistance - we are left with 0 losses.

This lead me to re-think about the rf-term that now seems crucial for the solution.

From p.166 in Cox & D'Antonio:

*Cox & D'Antonio wrote:*Consider a simple absorber formed by a cavity with a covering sheet. The sheet could either be perforated to form a Helmholtz design, **or solid but flexible to form a membrane absorber**.
It could even be a flexible perforated membrane, which is a combination of the two.
In the first two cases, the impedance of the cavity given in Equation 5.25 will **simply be altered by the addition of mass (jωm) and resistance (rm) terms**. These are the acoustic mass and resistance respectively, arising due to the perforated sheet **or membrane**. The surface impedance of the resonant system is:

$z1 = rm + j[\omega m - \rho c * \cot(kd)]$

This matches the Long solution, which is the same of ours, only with the mysterious resistance term.

I still don't get it.

Is this the acoustic resistance of the panel *itself* ? And if yes, then how on earth do I go about calculating it ?

Any thoughts ?

Cheers,

Jon

_____
Bert is still my hero.
What d'ya know.
jonessy

Posts: 580
Joined: Wed Jan 04, 2006 3:39 pm
Location: Israel

Top

Re: Flow Resistance of Panel Absorbers

by **krasmuzik** » Sat Feb 28, 2009 2:35 pm

*Terry Montlick wrote:*Okay, Jon. Page 273 of Long is pretty fucked up. It looks like ***my*** math at the end of a really bad day.

Here's the **right** way to derive this. Consider the transfer matrix of just the thin panel. Remember that a transfer matrix simply relates pressure and velocity on one side of something to the pressure and velocity on the other side of the same something:

$p_{i+1} = T11 * p_i + T12 * v_i$
$v_{i+1} = T21 * p_i + T22 * v_i$

where T is the 2x2 transfer matrix that I can't show neatly in ASCII!

So what is T for an ideal thin panel with mass per unit area M?

Terry

Salford uses the Transmission matrix T=[A B ; C D] which is the input as function of outputs because then the chain multiply is a blackbox T for the entire system. More commonly used in RF theory but applicable to acoustic duct/transformer/layer networks because it is easy to create the matrix chain by transmission chains of series/parallel impedance in two port form rather than going back to the equations - let matlab do all the hard work of chained matrix multiplies.

a random .edu link - wish my class notes were as fancy as this!

http://www.ittc.ku.edu/~jstiles/723/han ... ackage.pdf

in the acoustic impedance analogue p is V and U is I.
Last edited by krasmuzik on Sat Feb 28, 2009 2:50 pm, edited 2 times in total.
Kevin R. Shank
krasmuzik

Posts: 165
Joined: Tue Feb 10, 2004 1:49 am
Location: Newport, VA

Top

Re: Flow Resistance of Panel Absorbers

by **krasmuzik** » Sat Feb 28, 2009 2:47 pm

jonessy wrote:
Is this the acoustic resistance of the panel *itself* ? And if yes, then how on earth do I go about calculating it ?

Any thoughts ?

Cheers,

Jon

An ideal panel does not exist - think about the damped modal analysis of plates for thin panels. Bit more complicated than room modes...don't forget to include the radiation load of the plate on top of your modal analysis.
Kevin R. Shank
krasmuzik

Posts: 165
Joined: Tue Feb 10, 2004 1:49 am
Location: Newport, VA

Top

Re: Flow Resistance of Panel Absorbers

by **Terry Montlick** » Sat Feb 28, 2009 3:46 pm

krasmuzik wrote:
jonessy wrote:
Is this the acoustic resistance of the panel *itself* ? And if yes, then how on earth do I go about calculating it ?

Any thoughts ?

Cheers,

Jon

An ideal panel does not exist - think about the damped modal analysis of plates for thin panels. Bit more complicated than room modes...don't forget to include the radiation load of the plate on top of your modal analysis.

Correct. And neither does an ideal layer of air, with no frictional losses.

Regards,
Terry
Terry Montlick Labs
Tweeters tweaked. Woofers neutered.
Terry Montlick

Posts: 1143
Joined: Mon Apr 12, 2004 9:31 pm
Location: Rhode Island, USA

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Re: Flow Resistance of Panel Absorbers

by **jonessy** » Sat Feb 28, 2009 3:50 pm

I think I lost you guys here...

_____
Bert is still my hero.
What d'ya know.
jonessy

Posts: 580
Joined: Wed Jan 04, 2006 3:39 pm
Location: Israel

Top

Re: Flow Resistance of Panel Absorbers

by **Terry Montlick** » Sat Feb 28, 2009 3:52 pm

*krasmuzik wrote:*Terry

Salford uses the Transmission matrix T=[A B ; C D] which is the input as function of outputs because then the chain multiply is a blackbox T for the entire system. More commonly used in RF theory but applicable to acoustic duct/transformer/layer networks because it is easy to create the matrix chain by transmission chains of series/parallel impedance in two port form rather than going back to the equations - let matlab do all the hard work of chained matrix multiplies.

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http://www.ittc.ku.edu/~jstiles/723/han ... ackage.pdf

in the acoustic impedance analogue p is V and U is I.

Kevin,

This looks suspiciously like a transfer matrix. I don't understand the difference.

- Terry
Terry Montlick Labs
Tweeters tweaked. Woofers neutered.
Terry Montlick

Posts: 1143
Joined: Mon Apr 12, 2004 9:31 pm
Location: Rhode Island, USA

Top

Re: Flow Resistance of Panel Absorbers

by **krasmuzik** » Sat Feb 28, 2009 4:04 pm

*Terry Montlick wrote:*Kevin,

This looks suspiciously like a transfer matrix. I don't understand the difference.

- Terry

chaining upstream vs. downstream or backwards vs. forwards or in vs. out...

Don't remember what version Cox used in his book so just noting the conventions we used at Salford. There are after all many different circuit analogues and many different two-port modeling conventions (not counting these two different ways of T matrixes) - and that don't count CGS vs. MKS units to make it even more confusing
Kevin R. Shank
krasmuzik

Posts: 165
Joined: Tue Feb 10, 2004 1:49 am
Location: Newport, VA

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Re: Flow Resistance of Panel Absorbers

by **bert stoltenborg** » Sat Feb 28, 2009 4:28 pm

Is this flow resistance something like the acoustical impedance you have with speaker membranes?
If you view life with the knowledge that there are no problems, only opportunities, you are a marketing manager.....this is my personal philosophy
bert stoltenborg

Posts: 4456
Joined: Sun Apr 18, 2004 11:03 am
Location: Achterhood, Netherlands

Top

Re: Flow Resistance of Panel Absorbers

by **Terry Montlick** » Sat Feb 28, 2009 4:32 pm

*jonessy wrote:*I think I lost you guys here...

Let me see if I can find a more detailed (non-ideal) 2-port (just air pressure and particle velocity) thin panel model for you which has vibrational loss in it, Jon. Detailed enough so that I can see how some loss gets generated, but not so detailed that I can't understand it.

BTW, if you add any porous absorber (modeled with Delany/Bazley, etc.), you will of course add loss from the resistive flow.

Regards,
Terry
Terry Montlick Labs
Tweeters tweaked. Woofers neutered.
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