Subject: Electrical filters and Acoustic Filters
Posted by Wayne Parham on Mon, 19 Sep 2005 13:04:19 GMT
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I've received a lot of E-Mails lately about this particular topic. I'm not exactly sure why I'm the one that has been asked to evaluate this, because I'm not directly involved with the debate. But I've used both electrical and acoustic filters, so I am pretty familiar with it. In fact, everyone that has ever designed a speaker has used both, whether they know it or not.The very nature of the loudspeaker itself - just the raw driver - has three filter functions. It has the electrical filter, formed by the voice coil inductance and resistance. That forms a damped first-order filter, all by itself. So without any additional components, you have a coil and a resistor in the circuit. The output circuit of the amplifier often interacts with the voice coil to form an addional filter. Then there is the mechanical filter, formed by the mass and suspenson of the driver. This forms a mass-spring resonator, damped by the resistance to movement. These two interact to form a compex reactive system. So they act like a complex filter, having a resonator and low pass filter combined. Next we have the acoustic filter. This one is even more complex. The size of the radiator sets a wavelength related filter, one that creates collapsing DI and modifies response as a result.   The shape of the cone and its stiffness make a non-linear filter. At low frequencies, the driver acts like a piston but at higher frequencies, the cone flexes like ripples on a pond. And of course the cabinet is another filter chamber, adding to the set of filters in the system.So as you can see, a single driver has a lot of filters built-in, even if there are no additional electrical components. No matter what. When designing loudspeakers, it makes sense to look at the broader picture, and to include these things in your analysis. At least being aware of them is a good first start.When discussing loudspeaker cabinet types, it makes sense to discuss the other featurers, because they are all inter-related. It is probably best to consider driver Qes, for example, when analyzing overall driver suitability and perfrmance in a specific cabinet. But Qes is modified by amplifier output circuitry and by additional components in the circuit.You can talk about a hypothetical voltage source amplifier, one that has high damping factor and no anomalous behavior. That is the normal way to discuss speakers. Or you can consider a specific output impedance, and look at its effects. You can be more general, and talk about a range of values that perform well.But consider this. A constant current source amp is one that acts like it has output resistance. A constant voltage amp is one that acts like it has none, or very little. If you have one loudspeaker manufacturer that finds his speakers work very well with tube amps or constant current sources, he is saying his speakers work best with a touch of series resistance. This increases Qes and tends to increase bass and reduce midrange and treble. If you have another loudspeaker manufacturer that says adding a small value of series resistance acts as a sort of compensation circuit when using solid state amps, then the two manufacturers are saying the exact same thing. These are equivalencies.I hope that helps. There are a lot of good ways to implement loudspeakers. Sometimes it gets confusing, but there are a lot of numbers that add together make 10.

Subject: Re: Electrical filters and Acoustic Filters
Posted by Martin on Mon, 19 Sep 2005 15:38:21 GMT
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Hi Wayne,You wrote :"But consider this. A constant current source amp is one that acts like it has output resistance. A constant voltage amp is one that acts like it has none, or very little. If you have one loudspeaker manufacturer that finds his speakers work very well with tube amps or constant current sources, he is saying his speakers work best with a touch of series resistance. This increases Qes and tends to increase bass and reduce midrange and treble. If you have another loudspeaker manufacturer that says adding a small value of series resistance acts as a sort of compensation circuit when using solid state amps, then the two manufacturers are saying the exact same thing. These are equivalencies."EXACTLY .... almost. In my opinion, the major diference between SS and tube amps is the presence of series resistance that needs to be accounted for when matching a speaker system. I have been beating this idea to death for years with limited success. So your summary above is very good with one exception, again in my opinion. Series resistance does not change the driver's Qes, it has no impact on the drivers T/S parameters at all. At the speaker input terminals, the driver's impedance is unchanged. What the series resistance does is form a voltage divider so that the amount of signal applied by the amp to the speaker terminals is shaped. Bass output is not increased. Midrange and treble are attenuated.What I like about using SS amps is that I get to determine the amount of series resistance to apply in the design. I get the optimum amount by design. Loss of efficiency is less of a concern because I have adequate power. When you read the AA high efficiency forum, you see many inmates swapping tube amps and cables to get a configuration that mates with their speakers and provides the best balanced response. In my opinion, what they are really doing is swapping series resistance. That is a very expensive way of adjusting series resistance. I believe that the other differences between SS and tube amps are a second order effect when compared to series resistance.Martin

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Subject: Re: Electrical filters and Acoustic Filters
Posted by Wayne Parham on Mon, 19 Sep 2005 17:33:13 GMT
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Agreed. The driver itself isn't altered using series resistance, but the circuit Q is modified. Adding series resistance has the same effect as if the driver were altered in a way that increases Qes, just as if the voice coil had greater internal resistance. I probably could have written that differently but the point I wanted to make was that the speaker circuit's electrical Q changes, damping changes, the frequency dependent voltage division changes and there is a shift in the response curve as a result.

Subject: Re: Electrical filters and Acoustic Filters
Posted by roncla on Mon, 19 Sep 2005 21:38:15 GMT
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Series resistance does not change the driver's Qes, it has no impact on the drivers T/S parameters at all. At the speaker input terminals, the driver's impedance is unchanged. What the series resistance does is form a voltage divider so that the amount of signal applied by the amp to the speaker terminals is shaped. Bass output is not increased. Midrange and treble are attenuated.Totally agree. I had assumed (we know what that means) that it would affect the Qes, but in reality it dosent. I still like as little in the signal path as possible, but still am running a zoble and 2 ohms series R on my old horns. I believe you have to tune the amp/speaker to personal taste/room conditions though.ron

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Subject: Re: Electrical filters and Acoustic Filters
Posted by roncla on Mon, 19 Sep 2005 22:12:21 GMT
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Sorry 1 ohm series resistance, i tried 2 ohms and the lower end got boomy.ron

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Subject: Re: Electrical filters and Acoustic Filters
Posted by Martin on Mon, 19 Sep 2005 22:32:54 GMT
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Everything you say is true. It is just the perspective which one looks at the problem that is different. I like thinking of the problem as voltage division without any change to the driver properties because it lets me visualize the next level of complexity.For example, say I have a speaker that needs 2 ohms of series resistance and a baffle step correction of 6 ohms of resistance in parallel with a 2.5 mH inductor. What is the diferences between having a 2 ohm resistor in series with the baffle step circuit in series with the driver or the other way combining the 2 ohm resistor with the 6 ohm parallel resistor to form a new baffle step circuit. This is a real world problem. Thinking of adjustments to the Qes does not help you get a feel for the results. Thinking about voltage division as a function of frequency provides the insight needed to visualize what is going on with this more complex circuit.I like thinking of the series resistor in terms of voltage division so that I understand what is going on with the speaker.

Subject: Re: Electrical filters and Acoustic Filters
Posted by Martin on Mon, 19 Sep 2005 22:34:17 GMT
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I agree I don't like to add components into the signal path either .... unless it sounds better.

Subject: Re: Electrical filters and Acoustic Filters
Posted by akhilesh on Tue, 20 Sep 2005 02:57:15 GMT
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Martin wrote:"I believe that the other differences between SS and tube amps are a second order effect when compared to series resistance."Well, weshould not underestimate the effects of even order distortion and frequency curve deviations. We will need empirical data to verify whether it is indded an order of magnitude less. All I can say is that if the distortion is sufficiently high, it will have a significant effect, as will frequency curve aberration (even more so). But of course, I agree with Wayne's post & yours, in general. -akhilesh

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Subject: Re: Electrical filters and Acoustic Filters
Posted by Wayne Parham on Tue, 20 Sep 2005 12:12:53 GMT
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I think people will first grasp the concept of a voltage divider as an attenuator. Then they'll begin to see how reactive components can attenuate signals of different frequency and modify the response curve. But the last thing to consider is how resonators store energy and release it back into the system, so that's why an explanation of damping is so important in addition to the voltage divider concept.Q is a measure of damping. An underdamped resonant system will peak highly, increasing movement at that frequency. Sure, it is still a voltage division that's fundamentally in play, but since the cone is in mechanical resonance, increasing series resistance can make the system underdamped, which then modifies system Q.I think it is important to have this discussion, to illuminate the issues for any of those that don't fully understand them.

Subject: Re: Electrical filters and Acoustic Filters
Posted by Wayne Parham on Tue, 20 Sep 2005 12:17:35 GMT
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The boomy sound is the result of an increase in system Q. The speaker became underdamped. The driver's Qes obviously didn't change, but the speaker circuit Qes did.

Subject: Re: Electrical filters and Acoustic Filters
Posted by akhilesh on Tue, 20 Sep 2005 19:34:20 GMT
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Wayne,ANother way to put it.A lot of single driverbuilders think EQ is a bad word, and don;t realize thereis EQ everywhere: the driver, the box, the room, all EQs. SO adding EQ to get a flat frequency curve (or as close to flat as you can) is not a bad thing at all. Anyone who thinks different is buying a pack of Equine dung.Oh wait...maybe I should have said...are being fooled. -akhilesh

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Subject: Re: Electrical filters and Acoustic Filters
Posted by akhilesh on Tue, 20 Sep 2005 19:35:03 GMT
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Well said Martin. -akhilesh

Subject: Pipes, tapered pipes and Helmholtz resonators
Posted by Wayne Parham on Thu, 22 Sep 2005 17:55:43 GMT
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We've had some discussions here about bass-reflex, tuned pipes, tapered pipes and horns, specifically about their similarities and differences. So I've taken a moment to put together a list of references from authors other than those that normally contribute here.Acoustics and Vibration Animations, list of articles and demonstration by Dr. Daniel RussellAcoustic High-Pass, Low-Pass, and Band-Stop Filters, Daniel Russell discusses propogation of sound through ducts, transmission lines and acoustic filter chambersSuperposition of Waves, shows the interaction of standing wavesRadiation from a Baffled Piston, shows the effects of frequency on directivityEvanescent Modes in Waveguides, shows higher order modes in ducts driven above and below their cutoff frequencyMass-Spring Systems with Damping, shows how system damping affects resonance amplitude, which in turn affects responseThe Forced Harmonic Oscillator, shows systems driven below resonance, at resonance and above resonanceCoupled Oscillators, shows two mass-spring systems, like the mechanical resonance of a loudspeaker and the acoustic resonance of the cabinetThe Dynamic Vibration Absorber, shows how two tunes systems can be optimized for working together. Think speaker and box.Vibrational Modes of a Circular Membrane, shows cone flex breakup modesHyperPhysics - Resonance, several links on the subjectHyperPhysics - Air Column Resonance, online calculator of open pipe, closed pipe and tapered pipe resonant modesHyperPhysics - Cavity Resonant Frequency, online calculator of Helmholtz resonant frequencyResonance, standing waves, & Eigentones, discussion of resonance and QAir Column Acoustics, a description of wave propogation in pipes and conical sectionsMusical Acoustics - Some Introductory Pages, several links about matters acoustic from the University of New South WalesPipes and Harmonics, University of New South Wales, compares closed cylinder pipes, open cylinder pipes and closed conical pipesHelmholtz Resonance, University of New South Wales, describes Helmholtz resonanceSound Waves and Music, several online lessons from the Physics ClassromResonance and Standing Waves, Physics ClassroomStanding Waves and Resonance, describes standing waves in mechanical, electrical and acoustic transmission linesResonata, a groovy applet

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Subject: Re: Pipes, tapered pipes and Helmholtz resonators
Posted by GM on Thu, 22 Sep 2005 22:42:50 GMT
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Greets!Thanks for the effort! Here's my fave animations for BR driver/vent interaction:GM
BR explained

Subject: Re: Pipes, tapered pipes and Helmholtz resonators
Posted by akhilesh on Fri, 23 Sep 2005 02:30:01 GMT
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Great links, both of you!-akhilesh
