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Subject: Electrical, mechanical and pneumatic properties

Posted by [Wayne Parham](#) on Sat, 13 Sep 2003 05:25:00 GMT

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In a sealed box, Q and resonance are set by only one thing outside the woofer itself, and that is cabinet size. But in a bass-reflex system, you have both the Helmholtz frequency and the cabinet size as variables. This means you have the option of making a low Q system in a relatively small box. System Q is a measure of damping, and it describes the response curve. Being overdamped will give a high cutoff and a slowly falling response curve, as frequency goes down. Being underdamped will give a peak, and this peak represents augmentation from rather uncontrolled movement. This is a region that will "ring," and in fact, that is why a sound is generated by a bottle when blowing across the neck. Resonant ringing is the process that creates sounds from an object when it is excited in some way, such as by striking a drum or bell, pushing a pendulum or swing, or blowing across a bottle neck or flute. In a loudspeaker, there are a few things that act as filters, which means they can be tuned to ring or to damp. The amount of ringing or damping is described by the term "Q." Values of Q range from just above zero to just below infinity, although most (Qes, Qms and Qts) values are between 0.15 and 20.0. High Q describes a tendency to ring and is easily excited; Low Q describes a damped condition which is more controlled. A similar condition is found in reverse - Resonating dampers are things that tend to draw energy from a system, and when used, a high Q resonator draws more energy over a narrow frequency range, whereas low Q resonators draw less energy over a wider range. So there are a handful of filters in a loudspeaker system, and it's the appropriate balance that we're looking for. The speaker cone is a mass/spring system, so it acts like the spring and shock on a car. The weight of the diaphragm and moving assembly sets the mass, the stiffness of the surround and spider act like a spring and the resistance of the surround and spider act like the shock absorber. These properties are purely mechanical. We also have the characteristics of the cabinet. A sealed cabinet acts like a cushion, much like a shock absorber does. It modifies the mechanical properties of the speaker driver by changing its resonant frequency and Q. It acts as though it changes the speaker's mechanical suspension by modifying the spring's stiffness and resistance. But a bass-reflex cabinet also adds another resonator to the system - the Helmholtz resonator - so the bass-reflex system has two. One resonator is the mass/spring system of the cone and the second is the Helmholtz resonator of the box. And horns and transmission lines have similar cone loading properties as direct radiating speakers with the addition of having additional multiple standing-wave resonances spaced within their passbands. Each of these types of systems interacts and modifies driver characteristics according to its configuration, tuning and dimensions. Then there are the electrical characteristics. The motor is accelerated and decelerated when forward or back-EMF is applied. This causes a mechanical effect to be created by an electrical property, fundamentally setting a large part of overall system Q. If the motor is very strong, it can accelerate a large mass and overcome a large stiffness and/or resistance. The acceleration can be from stop to start, from movement in one direction to movement in another direction, or from movement in one direction to another speed in the same direction. So the point is that "acceleration" also includes the ability to "decelerate." The motor not only sets the cone in motion, but also stops the cone or changes its speed. The speaker's motor is installed in a circuit that partially determines the characteristics of the electrical system. Motor strength is a function of magnet strength, voice coil current, and the amount of coupling between the magnetic fields of the voice coil and of the drive magnet. And the drive circuit is an integral part of the motor system, since it determines voice coil current capacity. Acceleration and deceleration require current sourcing and sinking by the amplifier and through any components in the line. So the amplifier,

resistance of the connection wires, and any passive components in the circuit form a part of the electrical characteristics of the system. The point of all this is that we have a handful of things that act to damp the system. We have the mechanical properties of the driver, itself. We have the pneumatic properties of the air and the interaction between the box and driver. We have the electrical properties of the voice coil and amplifier. Motor damping is most effective when impedance is low, because that's when current flow is highest, and power is transferred to do work. The speaker motor can damp the system most when current capacity is high, which means impedance is low, both in the loudspeaker and the amplifier. So you can see that some mechanical or pneumatic properties that damp the speaker might raise impedance, such as when the system is in certain resonance modes. Where impedance is low, the motor is able to damp the system provided voice coil current and magnetic flux are strong enough. And so the balance of these properties is what we strive to optimize when we design our speakers for best performance.

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