Speaker Response Measurement

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This document describes a method for measuring the frequency response of a closed-box or ported bass speaker in the frequency range where the electromechanical theory is valid. The method can be used to characterize existing speakers, or to test new designs. At the expense of making some assumptions, it allows the measurement to be made without an anechoic chamber. I think it is accurate enough to guide a DIY speaker project, even if a professional audio engineer would probably prefer a more traditional technique.

Overview of method

The method uses a cheap condenser microphone element and Windows software to measure the near-field response of the speaker driver. The near-field method is fairly accurate at low frequencies where the cone is operating as an ideal piston, when used with closed-box speakers. However, the driver response curve is obviously not representative of the response of ported systems.

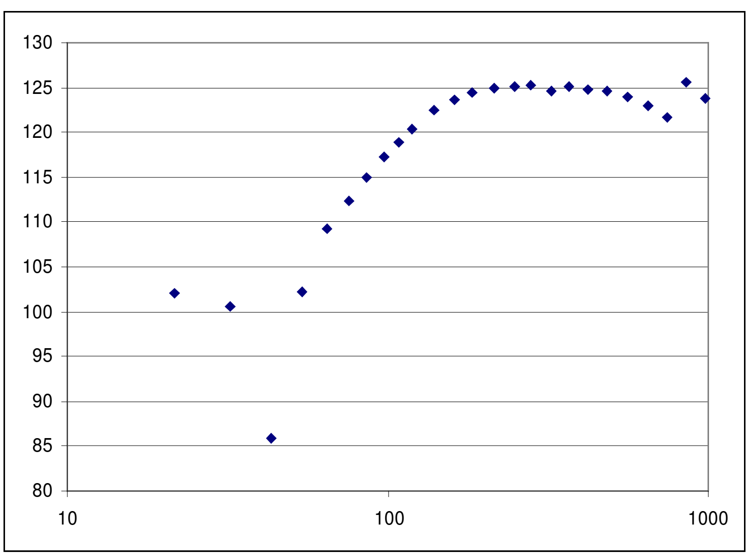
My method makes a single assumption about the behavior of ported speakers, namely that the coupling between the driver and port agrees with basic theory described at my web page. Thus the overall system response at any given frequency f can be computed from the driver near-field response using the formula:

SPL = SPLdriver + 20*Log(1+1/(f^2/fport^2-1)))

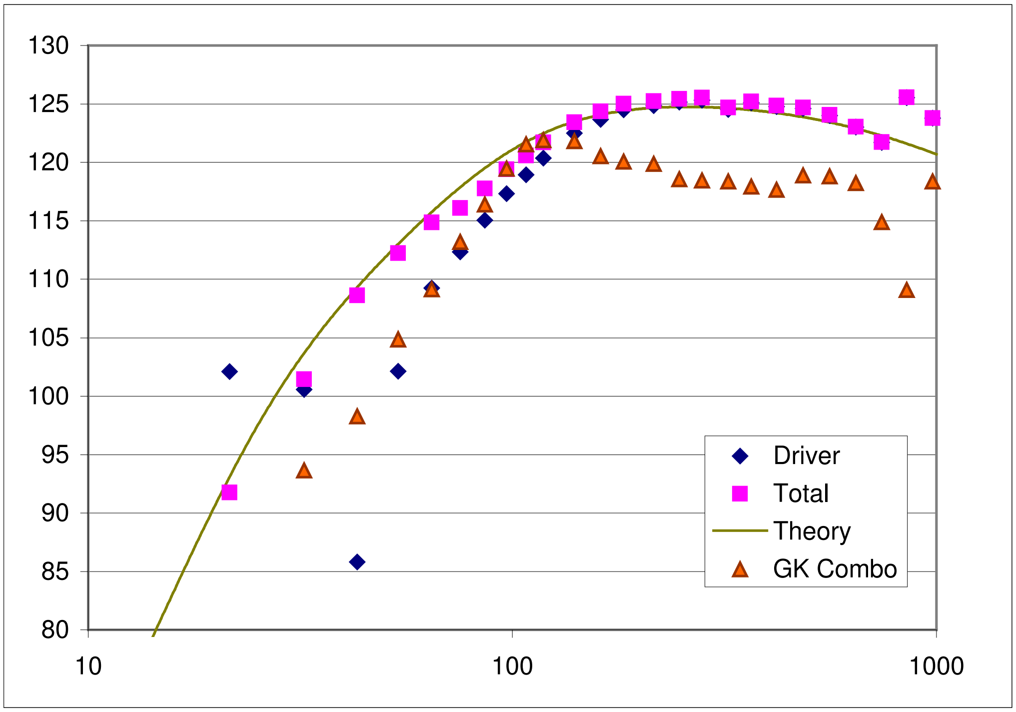
Here, fport is the port tuning frequency. Since the near-field response curve shows a pronounced "dip" at the port tuning, it is easy to estimate this frequency.

Measurement technique

I used my FreeSA spectrum analyzer program (personalpages.tds.net/~fdeck/bass) and a Kobitone EM2200C microphone element (Mouser electronics p/n 256-EM2200C), connected directly to the microphone input of my PC sound card with no additional bias supply. The sound card provides the bias. I ran the output of the sound card to a reasonably flat amplifier, then into my speaker. I hung the microphone directly in front of the driver cone. In a multi-driver system, you should hang the mike in front of a cone that is furthest from the port. With FreeSA, I measured the following driver response curve:



What's worth noting is that there is a pronounced "dip" around 45 Hz. This is the port resonant frequency. Thus, you don't need to know the port or box dimensions to find this value, and it is a good way to test if you got the port correct on a DIY design. I put the response data into a spreadsheet and used the above correction formula. The resulting curve is sensitive to exact values of the port resonance, and it might be ill-behaved around the exact resonant frequency. I adjusted the number up and down in 0.1 Hz increments until the curve looked reasonably smooth across the resonance. Here are the results:



The dB scale is referenced to an arbitrary level. This is purely a relative response curve. "Driver" is the original measured curve. "Total" is the corrected curve. "Theory" is the predicted curve for this particular speaker design taken from the UniBox program. The agreement between the measured and theoretical curves is excellent. It gives me confidence that I can report the frequency response of my homemade speaker, despite not having an anechoic chamber and commercial measuring equipment.

The "GK Combo" curve is the 12" speaker in my GK combo amp, run at exactly the same amp gain as the other speaker. Indeed, I used the power amp in the GK combo to run all of these measurements. The GK uses a sealed box, so the near-field measurement is the true response curve without correction. Here is where it gets interesting.

Setting aside the question of whether my speaker is any good, the agreement between theory and measurement suggests that I can trust the theoretical computation of absolute sensitivity (i.e., SPL at 2.83 V and 1 meter). Therefore, I can treat my speaker as a "standard" for measuring the absolute sensitivity of other 12" speakers, so long as the test conditions are identical. I could put an absolute sensitivity scale on the above graph if I wanted to, which would tell me the absolute sensitivity of the speaker in my GK combo.

I would caution against publishing such an absolute sensitivity graph without specifying the test conditions. After all, we are asking speaker makers to tell us the conditions under which they test their speakers, and we should play fair too. However, I think it would be harmless for bassists to share these curves with other bassists, for the purpose of understanding how our gear works, and to learn what makes good speakers sound good.