Subject: Response curves of closed vs. vented systems
Posted by Wayne Parham on Sun, 02 Dec 2001 16:32:53 GMT
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Several graphs are shown below that describe various common tuning methods along with a couple examples of mal-aligned systems. I was asked to do this a few days ago, and with Till's most recent post, it seemed an opportune time to illustrate the response that can be expected from various systems.Each of these graphs were prepared using a woofer motor having the following characteristics:Fts = 30 HzVas = 5 cubic feetQms = 5.0Qes = 0.4Qts = 0.37Re = 6.0 ohmsLe = 1.0 mHXmax = 0.22 inchesEfficiency - 90dB@1W/1MNote that I use the term "optimal" in a way that can be interpreted to mean "critically damped." In other words, when I describe an "optimally tuned cabinet" or one having "optimal size", many would refer to this as being critically damped. There is merit in building systems that are not critically damped for various reasons, and one should not misinterpret the term "not optimal" as excessively derogatory. However, "critically damped" motor cabinets provide the best performance, so the term "optimal" is accurate.Optimal Sealed AlignmentThis is the absolute best frequency response that can be obtained using this woofer in a sealed cabinet. Notice that the -3dB point is approximately 55Hz.Optimal Ported AlignmentThis is the absolute best frequency response that can be obtained using this woofer in a ported cabinet. This is the alignment that can be expected from PiAlign'ed cabinets for woofers having Qts between about 0.3 and 0.5. This is also known as a fourth order Butterworth alignment, or B4 for short. Notice that the -3dB point is approximately 35Hz.Overdamped Sealed AlignmentThe response curve shown above results from placing a woofer in an oversized sealed box. As the cabinet is made larger, the -3dB cutoff point does not drop, and in fact, begins to get marginally higher. But the total energy available "under the curve" grows because there is more usable response at very low frequencies. The trouble is that this is also where the woofer is generating the majority of its distortion. Personally, I would prefer to extend the -3dB point down to the resonant frequency of the woofer, and then allow the entire system to unload so that high distortion generating frequencies below woofer resonance are attenuated. Nevertheless, this is a common alignment with some builders because relatively flat and deep bass response is assured. Overdamped Ported AlignmentHere we see response from placing a woofer in a ported cabinet that is a little larger than optimal and tuned a little lower than optimal. It is typical of PiAlign'ed cabinets for woofers having Qts below 0.3. The response curve is similar to that shown for an overdamped sealed cabinet, and if the system is tuned significantly below woofer resonance, then performance is very much the same. As was the case with overdamped sealed cabinets, care must be taken to ensure that system distortion doesn't rise if the -10dB point is at a low frequency where woofer distortion is high. But typically, because of the quick rolloff slope of ported systems, this is not as much a problem.Third order Quasi-Butterworth (QB3) alignments are commonly generated for systems having woofers with Qts less than 0.3, and these have response curves that look very much like the C4 systems shown below. However, PiAligned cabinets are more likely to be slightly overdamped as shown above, than they are to have QB3 characteristics. PiAlignments tend to "favor" overdamped systems for woofers like these.Underdamped Sealed AlignmentThis is the response curve resulting from placing a woofer in a sealed cabinet that is a little too small. When a woofer is placed in a sealed box, the only thing that can result in an underdamped system is box size being too small, and it will always shift the resonant frequency and -3dB point up.Underdamped Ported Alignment, tuned highThis is the result of placing a woofer in a ported cabinet that is tuned slightly higher than optimal frequency. Unlike a sealed cabinet, two things can cause a ported cabinet to be underdamped - non-optimal tuning frequency or non-optimal box size. This particular alignment is typical of PiAlign'ed cabinet for woofers having Qts greater than 0.5 and relatively small Vas.Underdamped Ported Alignment, tuned lowThe response curve shown above is from placing a woofer in a ported cabinet that is slightly larger than optimal.  This is called a Fourth order Cheyshev (C4) alignment and it is typical of PiAlign'ed cabinet for woofers having Qts greater than 0.5 and relatively large Vas.EBS Stepped Response from ported cabinet with specific peakingThis is an interesting response curve, formed when a ported cabinet is larger than optimal and also tuned lower than optimal - both by a specific amount.  It is a useful alignment for extanding bass response.Grossly Underdamped Sealed AlignmentWhen a woofer is placed in a sealed chamber that is extremely small, the system becomes massively underdamped.  All of the alignments above can be considered to be viable system solutions, but this one is not.  It is merely shown for illustrative purpose.Grossly Underdamped Ported AlignmentWhen a woofer is placed in a ported cabinet that is tuned too high or too low or if the cabinet is too large or too small, the system can become massively underdamped.  Notice that the example of a grossly underdamped sealed cabinet can be caused by only one thing - the chamber being too small - but a ported cabinet can be made underdamped by excessively "going any direction" with its tuning.  As with the grossly underdamped sealed cabinet, this "alignment" is non-viable and is merely shown for illustrative purpose.