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Posted by [Wayne Parham](#) on Tue, 23 Aug 2022 14:09:36 GMT

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I meant to add some comments about the Helmholtz frequency in each of my responses above, but forgot. It was more important to me to discuss the use of flanking subs and multisubs, and the reasons for needing them. So I became involved in those responses and forgot to come back to box tuning. I'll correct that now.

Your measurement of the Helmholtz frequency looks correct to me. I don't get too focused on box tuning unless someone has adjusted dimensions. And even then, I'm not as focused on the Helmholtz frequency as I am on the possibility of anomalies from internal standing waves. Of course, if the Helmholtz frequency were shifted by a large amount - particularly upward in frequency - there would be adverse effects. So if a person were to forget the duct entirely - leaving just an unvented port hole - or do something else that shifted box tuning up a half octave, that would be bad. It would show up in the response curve as an underdamped hump. But I rarely see that problem.

I designed both the three Pi and four Pi speakers to have a slightly overdamped response curve. They aren't designed for max flat extension. This is partly for size and partly because I like the behavior of a slightly overdamped vented cabinet. It cannot shift anywhere close to having an underdamped hump, even as parameters have thermal shift at maximum power levels.

Such a system has a response curve that looks a little like a sealed cabinet, but with deeper extension from the same sized box. Its overdamping makes it look less like the traditional vented fourth-order curve and more like a sealed second-order. It also becomes very tolerant of parameter shifts. And being vented, it benefits from reduced excursion even with the added energy down low.

This design approach creates a speaker that rolls off gradually and works well with the flanking sub approach. It sounds good without subs - having plenty of useful bass - but it does lack the full depth of a system that includes subs. Sometimes, at shows, I switch off the subs and people don't notice a huge difference. It's not completely lacking in bass. But the system does benefit from subs, for all the reasons I described above.

As an aside, acoustic suspension advocates would argue that the transient response and group delay of a sealed system is better, but those are very dated arguments. To argue that phase shifts from the vent are a disadvantage that sealed cabinets don't suffer overlooks the very real influence of room modes. There is no phase benefit from a sealed cabinet when used indoors, because phase in the modal region is all over the place and different in every location. There again, that's why we use multisubs.

The published impedance curve of the four Pi shows it to be tuned to around 35Hz and the three Pi is tuned to around 25Hz. That's the approximate location of the impedance minima. If I were to look closer at the raw data, I might see that the exact minima is 24Hz for the three Pi and 34Hz for the four Pi. These two speakers might drift to 26Hz and 36Hz from thermal parameter shift or different amounts of damping material. It's fine all the way up to beyond 30Hz on the three Pi and

40Hz on the four Pi. I often even round up to those values when asked. If someone is pushing them hard for prosound or high-power home theater and they want to high-pass the mains, I would suggest those values for the HPF.

The target Helmholtz frequency for the four Pi design was 37.5Hz and the three Pi was 28.5Hz. But like I said, slight shifts downward totally don't bother me and this design approach - being slightly overdamped - allows for slight upward shifts too. As I mentioned earlier, what I am equally concerned with - perhaps even more focused upon - is internal standing waves. These cabinets are large enough they develop standing waves in the lower midrange.

As part of the initial design and testing, I modeled the cabinets with Martin King's spreadsheets and then made physical models to test with, all in an effort to ensure the positions of the midwoofer, port and damping material prevented an antinode being at the port or the driver, where it would create response ripple. After all the modeling, testing and cabinet modifications to dial it in, the internal standing waves were mitigated, and the Helmholtz frequency stood where it is now.

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