



SOUND ADVICE

I picked up the Jan. '08 issue of *aX* and wanted to let you know that the article on tweaks ("Of Tweaks, Mods, and Evidence," p. 16) was the most interesting in a long time. Could you ask Bill Waslo what sound cards he would recommend? My computer doesn't have one and I'd like to get one, especially for this purpose.

Joe Wdowiak
flyfishonly1@hotmail.com

Bill Waslo responds:

There have been a number of soundcards that have worked well for this kind of testing. My favorite is called the ESI "Juli@," which is a pro level (but reasonably priced) 24bit/192kHz sampling PCI card. A PCI card like this would only do with a desktop computer, though. There is an advantage to using a portable battery-operated laptop computer instead to do the tests, in that you can avoid any hum-inducing ground loops that might otherwise result from the AC power line grounds.

If you want to use DiffMaker with a laptop computer, I've had good luck with the EMU 0202 USB, a USB2.0 type 24bit/192kHz card, also reasonably priced. Another one that is downright cheap to buy, if you can find it, is the "Soundblaster Audio ZS Notebook," a PC Card (PCM-CIA) device that can sample at 24bit up to 96kHz. I would use the ZS Notebook only at the 96kHz or 24kHz sample rates, however, because the other rates are provided only by using a somewhat signal-degrading form of "sample rate conversion." If you have only USB1.0 on your laptop, consider an M-Audio "Transit USB," which does well at 24bit/48kHz.

The card must, at bare minimum, provide stereo line-level recording inputs (most laptop computers offer only a mono microphone input for recording) and line-level playback outputs. Some built-in sound functions in desktop computers have even worked well (one particularly good one I found is one that used the Analog Devices "SoundMAX" chipset).

Diffmaker itself can be used to do a particularly sensitive test of soundcard quality.

Just play a high quality short WAV file out of the soundcard's line outputs and cable it back into the soundcard's line inputs and re-record it at the same sample rate. That gives you two WAV files of the same thing, one being the original and the other being one that has passed through both the A/D and the D/A conversion of the soundcard. Then use DiffMaker to extract the difference between these two files. Doing this test of a perfect card would leave silence. I haven't found one that leaves a silent difference result yet, but the Juli@ card comes close, leaving a weakly audible bassy sound, probably because of low frequency phase shifts in its AC-coupled analog circuitry.

ARRAY TESTING

In reference to Mr. Fitzmaurice's article, "The CurveArray" in the January 2008 issue of *audioXpress* (p. 8), he did not report any listening observations about the system, except that it has higher sensitivity and has a point source characteristic. However, the point source claim is not completely accurate. The apparent sound image changes with listening position. To confirm this, I constructed a 33" line of closely spaced drivers to see what effects could be heard. The listening tests were made at a 10' distance, somewhat like the distance used for home theater.

As expected, the straight line configuration has a strong output when the listener is opposite the center of the system. The image also appears to be at the center, but as the listening position moves to the left or right, the image appears to follow the listener to the left or right. However, this effect is almost entirely negated by the drastic loss of output at the mid and high frequencies as the listener approaches the ends of the line.

In the convex arrangement where the listener is directly opposite the center, the image again appears to be at the center, but the listening level is reduced. As the listening position moves left or right, the image again tends to follow the listener left or right, but only moderately so. The response sounds very uniform from left to right, even when the

curvature approaches a semicircle.

In the concave orientation, the image again seems to be at the center and is slightly higher in level than the convex orientation. However, the image, surprisingly, is reversed as the listener moves from side to side. When the listener moves to the left, the image appears to move to the extreme right, and so on.

Although the response measurements supplied in the article indicate benefits in the concave arrangement, they do not account for how we hear and the shifting of the sound image with respect to the listening position. Monophonic voice in the center channel will not appear to be at the center unless you are seated exactly in the center. There is also the question about amplitude and phase response of a phantom image reported in my last article on hearing¹.

It would seem that a single driver in the center would be a stable point source that will eliminate the image from shifting and also retain the coherence of the original sound. Accuracy could be preserved and the image would remain in the direction of the driver regardless of the listener position.

Roger Russell
rogerr4@earthlink.net

1. "Sounds and Hearing, Part 1," Roger Russell, *audioXpress*, October 2007, p. 28.

Bill Fitzmaurice responds:

First, a horizontal line array should only be used when you need the sensitivity that an array provides, and placement options won't allow a vertical array. If you can use a point source center channel, that's all well and good. But when the rest of your HT speakers are high-sensitivity, your center channel must be as well. While an Altec A7 or a Fostex or Lowther loaded backhorn center is seldom a viable option, a small line array often will be.

That being said, Roger's observations are correct. With a concave array the audio image will seem to emanate from whichever driver set is closest to on-axis with respect to the listener, so it will shift

to the right when the listener is to the left, and vice versa. In theory this may seem problematic, in practice it isn't.

To understand why, listen to a TV with eyes closed and try to find the audio source. Most mono TVs have the internal speaker on one side of the screen or the other, and it's easily discernible which with eyes closed, as the only information your brain is processing is the audio triangulation provided by your ears. Now open your eyes, watch the TV, and try to pinpoint the audio source again. It will seem to come from the center of the screen, irrespective of the actual location of the speaker. The reason? Your brain gives priority to visual stimuli over audio, and it shifts the perceived sound source from where your ears say it's coming from to where your eyes are telling you it's coming from.

My own HT is probably a worst-case scenario, with my CurveArray located 3' below and 20" to the right of the center of the 42" screen. With my eyes closed, the center channel is clearly sourced nearly 4' from the center of the screen. With my eyes open, the source is dead center. Roger's testing would have had a different result had it been done in conjunction with a visual source rather than audio only.

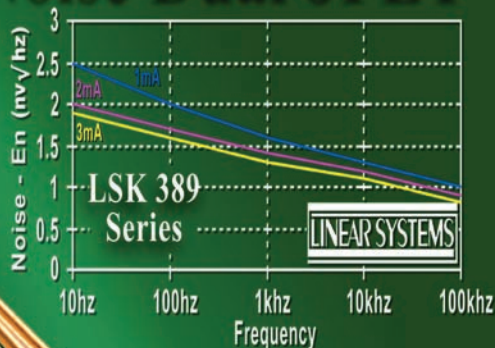
Regarding a convex versus concave array, a concave array suffers far less from comb-filtering and lobed response than convex. Because the imaging superiority of the convex array is rendered moot by our visually dominant brain, the real-world advantage belongs to the concave alignment.

AUDIO LEMMINGS

After reading the exchange between Steve Nugent and Dennis Colin in the January 2008 "Xpress mail" (p. 47), I could only shake my head in amazement. Here it is the end of 2007, and there are so many people out there who still don't get it. I am afraid that the audio community is doomed to live in purgatory for another few millennia before the question of blind testing is resolved. I'll start by saying that I am in the camp of Mr. Colin as far as blind testing goes. I also agree with Mr. Nugent that even with a well-run blind test of one component, you cannot say with certainty how another component will perform unless you also test it as well.

That said, Mr. Nugent is guilty of

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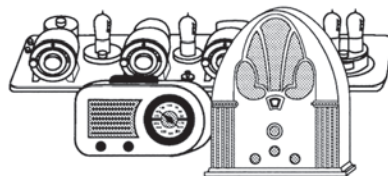
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using psychological pressure on the readers instead of valid testing to convince them that unless you have the best equipment or the best hearing you are relegated to the mass of unwashed who will never be able to participate in audio Nirvana. That is nothing but heaping, steaming, gurgling piles of brown stuff. It is truly a sad state of affairs in this industry that we still have people using scare tactics to try to make a point instead of using reliable testing. His inference that if you don't automatically hear the superiority of this cable or that resistor, you must be deficient is pure bunk.

Mr. Nugent uses the analogy of a Ferrari and a Geo to describe proof of performance of add-on products. The ability to go faster, a measurable result, is the proof. And how is this done? By measuring the velocity of the cars or who gets across the finish line first. The cars are put to a test and the results verified.

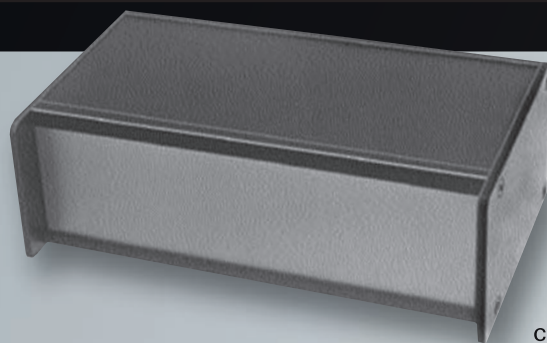
This is not to say that all things that affect your audio experience at any given time are measureable. Listening can be a very emotional experience. In fact, producing a very satisfying emotional ex-

perience has always been the goal of this hobby for me. However, that very fact demands that when determining the effect of any given component, the preconceived notions of what should happen during that experience must be removed. Note that I did not say that the emotions themselves should be removed, only the preconceived notions. The only way to reliably do that is with a blind test, preferably double-blind.

I will not state that there are no cables that will not make a sonic difference. I will state that I have tested many in double-blind tests and heard no differences. More important, I have run double-blind tests with a manufacturer who makes cables and speakers as well. This person heard no differences with his cables in my system and then blamed it on my speakers. We then repeated the same tests using his own speakers and he again was not able to hear any differences. Could there have been other factors that interfered with the results? Possibly, but the point is that with enough controlled listening tests, a degree of confidence about the results will emerge.

Doing uncontrolled listening only leads to susceptibility to listener bias about what should be heard. And all the classical condemnations of double-blind testing being too fast and producing too much pressure only apply to tests that are poorly run. I have seen tests in which an ABX box was left with a user for over one month in his house to use to test sonic differences of two amplifiers when used in his system. There was no rush and no pressure from other observers to achieve one result or another. Was that a lot of work? Yes, but the results were rock solid and very believable.

Finally, saying that certain parts are sonically superior because so many people are buying them that they are in short supply is truly ludicrous. An analogy would be that jumping over a cliff to your death is a good thing because all the lemmings do it. There are huge numbers of experiences in human history where people go in a particular direction because of peer pressure that may not result in positive results. So let's not be audio lemmings and be forced by peer pressure to believe that you must be able



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to hear differences in certain "golden" components lest you be deemed an inferior clod. Do yourself a favor and prove those conclusions in an unbiased way.

Tom Perazella
Sleepy Hollow, Ill.

SUB DRIVER GOALS

I would like to thank Tom Perazella for his inspiring article, "The Kiss Bass Project" (Sept. '07 *aX*, p. 21). As Mr. Perazella said, the amplifier he used in his project has been discontinued. If you use the substitute he recommends, you will need to change the speaker enclosure size. The physical dimensions of these amplifiers are different. The dimensions of the discontinued amp were 10 3/8" W × 10 7/16" H × 3 1/4" D, with an enclosure cutout of 9" W × 9 1/4" H. The dimensions of the new amplifier are 9 13/16" W × 9 13/16" H × 5" D, with an enclosure cutout of 8 1/2" × 8 1/2".

To keep the idea of using the plate amplifier as the back of the enclosure, you need to reduce the outside width and height from 10 3/4" to 10" and adjust the depth to meet the desired vol-

ume. Remember that the box volume displaced by the new amplifier is different not only because of its overall dimensions but because it has an enclosed back. The Vb of the Kiss Bass enclosure 0.537ft³ is the total box volume of 0.792ft³ less 0.0459ft³ for the driver and 0.209ft³ for the amplifier.

Mr. Perazella made no reference to damping in his article. By damping an enclosure, its size can typically be reduced but usually at a cost of slightly raising the F3. Was this ignored to keep it simple, or to keep the F3 as low as possible? Should adding some stuffing be a consideration?

Also, how was the testing done for the response graph? I assume the results shown include the room response. If Bass Box 6 Pro is used to predict the response for the Tang Band W8-740C driver in a 0.8ft³ enclosure, the results are quite different. This design software predicts an F3 of only 65.3 with a low total system Q (Qtc) of 0.462.

Figure 1 predicts the cone displacement and amplitude response superimposed on the same chart. It confirms that there are indeed adequate output levels of 106dB. I would personally say that the design goals have been surpassed in this regard because I believe anything above 105dB is adequate for even a medium-size room. The right cursor shows the predicted F3 of 65.3Hz. The left cursor highlights that the Tang Band driver is capable of achieving these output levels without exceeding its Xmax of 12.0mm.

I would also like to review Mr. Perazella's goals for this subwoofer project. They were:

- Clean bass
- Predictable performance (not ultimate)
- Use a simple method to achieve results
- Use key driver parameters to tune enclosure
- Simple design (no vents, passive radiators, transmission lines, servos, and so on)
- Small design (I assume Mr. Perazella means 1ft³ or less)
- Designed for small rooms
- Sealed box
- Modest bass requirements (reasonably deep but not very high SPL lev-

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els)

- Cone displacement capable of frequency response and output level
- Fb of 40Hz
- F3 of 40Hz

I respond in this genre because I believe that many hi-fi enthusiasts share similar goals.

Mr. Perazella stated that it was three years ago when he was looking for the drivers for this project. The science of driver design has grown somewhat since then. Are there new drivers now available that are better qualified to meet or exceed these goals?

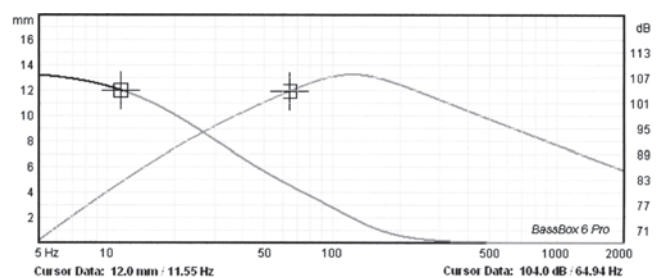


FIGURE 1: Predicted cone displacement and amplitude response.

Figure 2 is a XY Scatter chart, in which each data point represents a unique driver in an “optimum” volume, sealed and undamped enclosure. I have found a chart of this type very helpful in driver selection. The 128 drivers depicted are all available from one distributor and represent models less than 10” in diameter from ten different manufacturers. The chart shows the volume and the predicted F3 for each speaker. The trendline substantiates the generalization that larger enclosures have lower F3s. The data point (0.2, 69) for the Tang Band W8-740C is highlighted. Upon close examination of this chart,

it appears that another driver, also highlighted, could be considered. Drivers from other manufacturers may also be good candidates.

The driver that represents the data point (0.7, 50) is the Dayton

SD215-88 shielded 8” DVC subwoofer, available from Parts Express as part number 295-480. Consider a design with this driver using Mr. Perazella’s design goals, and his “keep it simple” idea to use a plate amplifier for the back of the speaker enclosure. This design will combine the voice coils with parallel wiring. Although this driver has a lower power handling rating than the Tang Band W8-470C, it has a higher SPL rating. The result is a higher SPL at rated power of 108dB for the Dayton versus 105.8 for the Tang Band.

At a regular price of only \$23, this driver becomes even more attractive. There is a catch, however. If you use the recommended box volume of 0.7ft³ to achieve a Qtc of 0.707 and F3 of 50Hz, you find that the Dayton driver is not capable of producing the 108dB without exceeding its Xmax of 6mm. Nonlinear distortion increases when a driver exceeds its Xmax. This is because the magnet system will exert less control over the voice coil when fewer coils are within its gap. This problem is not serious for three reasons.

One, the design goals of this project do not require you to drive the speaker at full power. Two, the mechanical limit of the suspension or the distance traveled before the voice coil former contacts the back plate should be larger than Xmax. Three, the introduction of this type of nonlinear distortion is subtle and not audible unless severe.

Figure 3 shows how far the diaphragm and voice coil of the driver will travel with an input power level of 80W and with 36W. Notice that the plot line rises above the Xmax level below 58Hz with 80W of power and below 26Hz with 36W. Figure 4 predicts the amplitude response and system impedance for the Dayton DVC superimposed on the same chart. It shows four things.

One, at 36W the design meets the output goal for a small room. Two, the design meets the F3 goal of 50Hz. Three, the left cursor shows the output is 12dB down at 26Hz providing enough protection for the driver ensuring Xmax is not exceeded. Four, the right cursor shows the box tuning at about 51Hz. Figure 5 shows the predicted response of the Dayton DVC (black line) and the Kiss Bass (shaded

ARTICLES WANTED

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line).

To help keep things in perspective, for those DIYers who are not restricted to size or simplicity, these drivers can produce even lower F3s if put in larger vented enclosures.

I am currently pursuing drivers from other distributors that will fit the bill. I will follow up with my findings. I would like to thank Tom Perazella once again for his inspiring article.

Tom Finn
Minneapolis, Minn.

Tom Perazella responds:

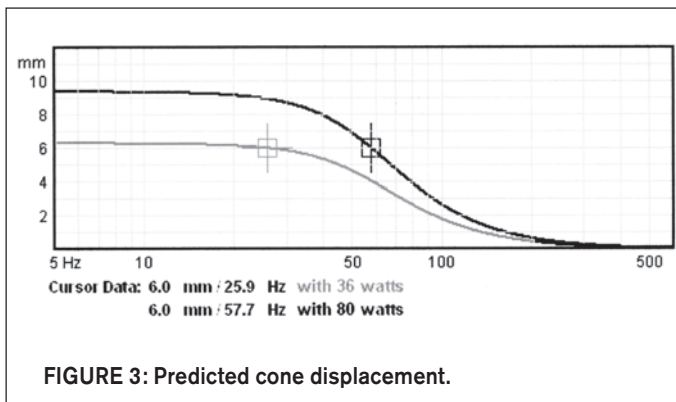
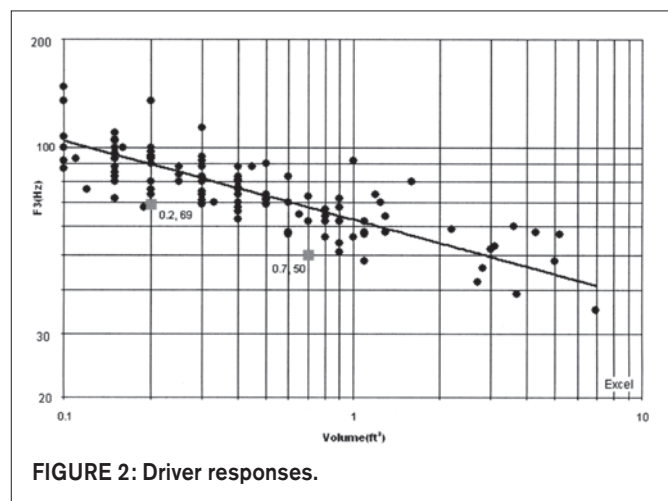
Many thanks to Mr. Finn for the kind words about my article. I have always tried to pick subjects that would provoke an interest in readers and it appears that I have succeeded in this case. I would like to reiterate that the purpose of this work was to show people who may have thought that speaker building was a complicated and

quite simple.

There is no doubt that building full-range speakers can be quite involved. However, subwoofers are good entry-level projects for many reasons including the fact that the long wavelengths involved minimize some of the stick problems that you face in mid-range and high-frequency designs. Simple sub projects can often outperform commercial designs for less money.

Mr. Finn is correct that if you want to retain the design using the subwoofer amplifier as the back wall, you would need to change the dimensions for amps having different dimensions. It is a simple matter to

time-consuming endeavor that in some cases it could be



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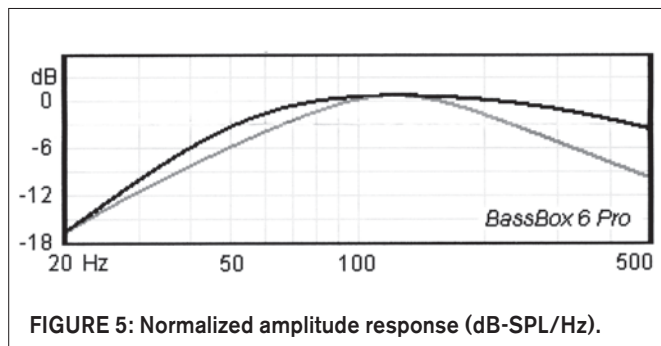
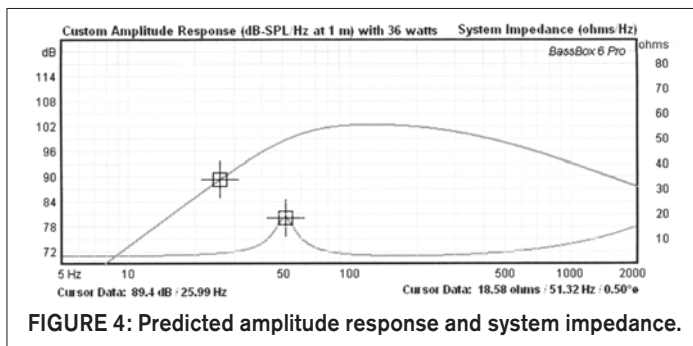
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re-calculate the dimensions to reach the required volume. If the resulting shape is not to your liking, you can forgo the "amplifier is the back wall" method and use a more conventional design that results in a more acceptable configuration. That's the fun of doing it yourself.

The testing was done close miked, with a very small distance from the microphone to the center of the dust cap. In this configuration, room gain is minimized.

When it comes to choice of driver, you are truly blessed by the number of competent drivers available today. My choice of the drivers was determined by what was readily available having high Xmax. One of

the most important characteristics of a good designer is to be a good librarian. Doing the research on what devices are available to meet the project's needs can result in a very satisfying project at a reasonable cost. Mr. Finn is correct that there are other drivers that would be satisfactory in this type of project. Again, making this choice is a large part of the satisfaction of designing a custom component.

I would like to clarify the discussion of Xmax by Mr. Finn. First, Xmax is not simply determined by the magnetic structure of the driver, but also the changes in compliance versus travel of the suspension. The two characteristics used to determine Xmax

are Xmag, the behavior of the magnetic structure, and Xsus, the behavior of the suspension. **Figure 6** is a datasheet for a 15" dual voice coil Dayton driver that I use in a larger system. You can see the values for Xmag, Xsus, and Xmax. If the linear ranges of either the magnetic structure or the suspension are exceeded, Xmax will be limited. I have seen drivers that were limited by either Xmag or Xsus.

It is not just the voice coil former striking the back plate that can cause a limit to acceptable performance caused by the suspension, although if that does happen you will certainly have a very sudden and audible problem with the output. Even when ex-

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The Sound Strobe™ was designed by Dennis Colin, currently working as an Analog Circuit Design Consultant for microwave radios and a frequent contributor to *audioXpress* magazine.

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ceeding Xsus limits, you are not necessarily going to strike the back plate, although the distortion will rise dramatically from suspension nonlinearities.

With regard to the audibility of the distortion mentioned by Mr. Finn in point three, I partially agree. Certainly a small amount of distortion caused by mild excursions beyond Xmax are less noticeable at lower frequencies. However, looking at the graphs, it is clear that once you get beyond the Xmag or Xsus points for this particular driver, the departure from linearity progress at much faster rates, translating to a very fast rise in high levels of distortion that will be audible. The linearity change in this driver, although fast, is slower than other drivers I have seen, especially those with under hung voice coils. In a nutshell, the performance of the driver goes south very quickly when Xmax is exceeded.

Over the years, I have become an Xmax junkie. It used to be that Xmax was at a premium, especially when amplifier power was low and the requirements for reasonable output levels demanded that a short voice coil in a short magnetic gap be used to provide high sensitivity. Now, driver designers routinely substitute sensitivity for higher linear excursion because of the avail-

ability of plentiful low-cost clean amplifier power.

In this particular design, although the 8" Dayton driver mentioned will provide an acceptable level of output before exceeding Xmax, the Tang Band driver will provide double the Xmax for only \$15 more based on its sale price. The Dayton driver will also run out of linear excursion before the amplifier runs out of power, not a good match. Considering the cost of the amplifier, wood, and sundries, the driver cost increase is insignificant for double the displacement.

When I think about speaker designs and linear displacement, I always remember the statement by Luigi Chinetti, who drove for and managed Ferrari USA, that went something like this: "The only substitute for cubic inches is rectangular money." To try to get extra performance from a driver with limited volume displacement requires some of the techniques such as servos that were not explored here because of cost considerations and complexity. Even when those extra steps are taken, there is only so much additional linear output that you can achieve when Xmax is limited. Given one driver with "X" amount of Xmax versus another in the same cost neighborhood with "2X" Xmax, all else being equal, I'll take the



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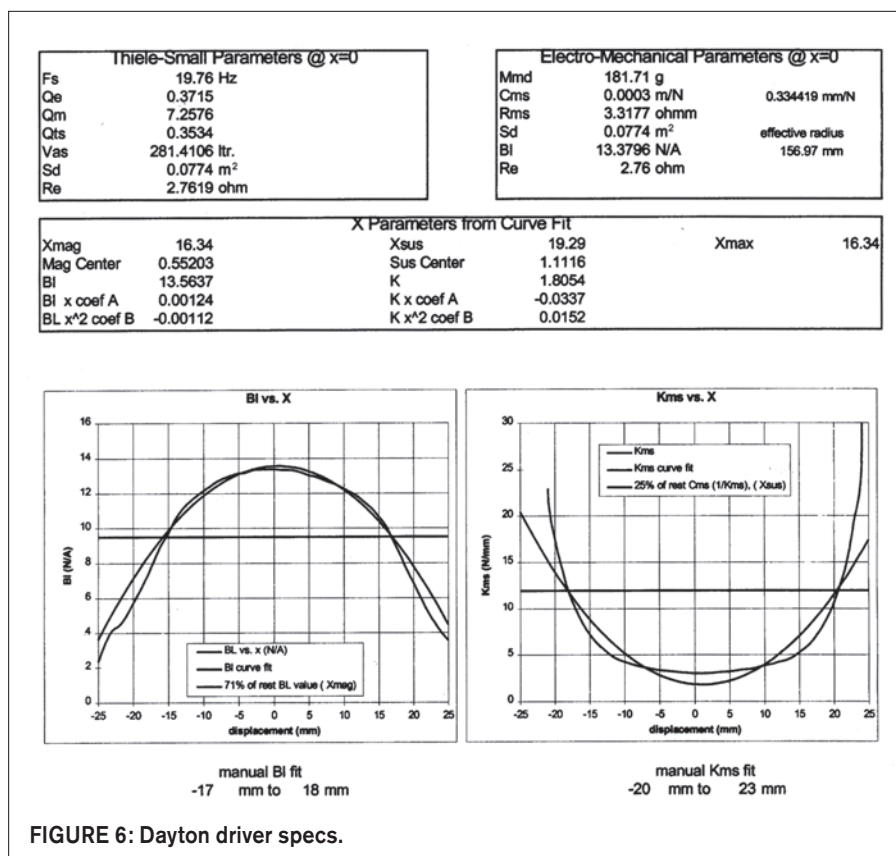


FIGURE 6: Dayton driver specs.

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CONTRIBUTORS

Edward T. Dell, Jr. (Editorial—"Magazines: A Primer," p. 6) is editor/publisher of *audioXpress*, *Voice Coil*, and *Multi Media Manufacturer* magazines.

Bruce Brown ("Updating A Classic Pilot Amp," p. 8) is a registered pharmacist who works in the medical research area for a major pharmaceutical company. He has been experimenting with electronics for over 35 years, remaining actively interested in electronics, building kits, and "home brew" audio. Online auctions have stimulated new interests. He has just recently become interested in restoring vintage audio equipment and writing articles to assist other hobbyists. His wife, Kristin, has been invaluable help with editing his ramblings. He currently uses many restored and homebuilt audio amplifiers and welcomes communication about vintage equipment and restorations. He can be reached at Tuninfork@aol.com.

Ethan Winer ("Everything You Wanted to Know About SPL Meters," p. 14) has been a professional musician, composer, circuit designer, recording engineer, audio instructor, computer programmer, technical writer, and consultant since the 1960s. He was a contributing editor for *PC Magazine* for many years and has written more than 70 feature articles. Ethan now designs acoustic treatment products and runs RealTraps, in New Milford, Conn. Contact him at www.realtraps.com.

Bjørn Kolbrek ("Horn Theory: An Introduction, Part 2," p. 20) is an electronics engineer in Norway, and works as an R&D engineer for Scana Mar-El designing remote control systems for ships. His hobbies include building horn loudspeakers, amplifiers, and amateur radio gear. For the last four and a half years, he has studied horn loudspeaker technology—both theoretical—and practical—with Thomas Dunker.

Jan Didden ("aX Visits Burning Amp '07," p. 30) lives in the Netherlands and is a longtime contributor to Audio Amateur publications.

Ed Simon ("The Secret Art of Breadboarding," p. 34) received his B.S.E.E. at Carnegie-Mellon University. He has installed over 500 sound systems at venues including Jacob's Field, Cleveland, Ohio; MCI Center, Washington D.C.; Museum of Modern Art Restaurants, New York; The Coliseum, Nashville, Tenn.; The Forum, Los Angeles; Fisher Cats Stadium, Manchester, N.H.

higher Xmax driver every day.

It was very rewarding to read the excellent response from Mr. Finn and I am looking forward to the results of his searches for other high-quality drivers. This level of competence and dedication to the hobby bodes well for its future. Again, thanks to Mr. Finn and happy building.

SERVO PROJECT

I read with interest the DVC Servo Subwoofer article by Daniel Ferguson (Nov. '03 and Sept. '04). The article tweaked my interest, as I had been working along similar lines using 10" DVC subwoofers for audio systems for my two "student sons," who have limited space and, of necessity, limited power (dorm rooms). However, I had shelved the project due to lack of inexpensive bookshelf speakers of adequate quality (they're very picky with regard to music quality!).

Now the time has come to revisit the project and I want to thank Daniel Ferguson for doing the bulk of the work for me. However, I have a couple of questions regarding the servo subwoofer filter schematic (Fig. 3, Sept. '04) and the differentiator.

1. For the HP Sallen & Keys filter sections (Op amp B of Fig. 3), from the data given in the article ($R1 = 17.2k\Omega$ and $R2 = 70k\Omega$) the calculated turn-over frequency is 20.8Hz. The F_s for the 12" Dayton DVC woofer used is 20.7Hz. Is this a design point to tame the woofer resonance? Happenstance? Or were these values arrived at empirically?

2. If you model the response of the same HP filter, the characteristic response has a slight hump at the turn-over point. I am of the opinion that a Bessel (linear phase) response might be a better design. Has Daniel Ferguson any comments on this?

*Ian Freeman
Fremont, Calif.*

Daniel Ferguson responds:

Thanks for taking the time to read my article on the DVC servo subwoofer. I'm planning to retire in the next few months and plan to revisit this project in an attempt to make the design more theoretically correct. Anyway, on to your questions.

Regarding the relationship between the filter corner frequency and the woofer's free-air resonance frequency, there isn't any. Furthermore, there is no connection between the filter bandpass shape and the driver/box combination. The filter merely provides the reference response shape that you want the servo to reproduce.

The box in the article was intentionally undersized to produce a strong resonance peak for the purpose of demonstrating the error correction capability of the servo—how well it could change its uncorrected response shape to conform to the filter's shape. In fact, it is theoretically much better to start any servo design with the best open-loop response possible so that the servo must "work" the least amount possible. In this case, the box should have been much larger to get closer to a closed-box Q of 0.7. Then, the system should be more stable and capable of greater dynamic output with less amplifier power.

Concerning the actual trimpot settings, they were as close as I could get these single-turn pots to make the filter have a corner frequency of 20.0Hz with a Q of 0.707. The shape was verified by my relatively expensive RTA to be accurate to within $\pm\frac{1}{2}$ dB. But again, the choice for the filter shape is somewhat arbitrary. You could easily choose to not be that ambitious and set the corner frequency at 25 or 30Hz and make the system more stable.

As to whether to choose a Bessel response over a Butterworth response for a closed-box woofer system, I think that's a matter of individual preference. One of the attributes of the servo is that you can make the reference shape anything you wish. So if you prefer a Bessel response to a Butterworth, you're free to set the pots for a Q that will approximate that.

The only thing that occurs to me is that the debate over which of these two is better is based on open-loop characteristics of loudspeaker dynamics, and I'm not sure it applies in a servo environment. All I think you would get from a non-flat tuning is more response droop at the low-end. Having said that, it would cause the servo to work less and therefore increase system stability.

I hope all this sheds some light on the system tuning. *aX*

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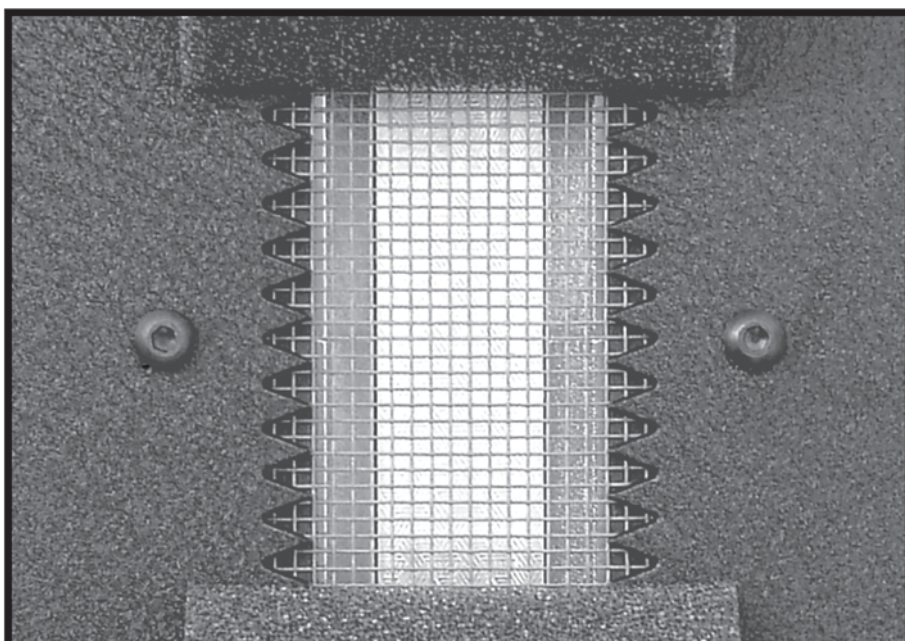
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