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PIPE DESIGN

I'm working through a design based on Cornelius Morton's article "A Hegeman Subwoofer," published in the December 2003 edition, and have two questions.

If I wanted to extend the design to six pipes from four, as originally published, should the resonant frequency of the additional pipes be placed at the square root of 2 multiple? This would give a set of frequencies at Fo, 1.4*Fo, 2*Fo, 2.8*Fo, 4*Fo, and 5.6*Fo. Or would it be better to use something different, such as the third root of 2 for a multiple, which would yield a set of frequencies at Fo, 1.26*Fo, 1.59*Fo, 2.00*Fo, 2.52*Fo, 3.17*Fo?

Would it be better to scale the area of the tunnel such that the pipe Qs occur over a narrower range, which might make tuning easier? I realize that this would complicate the construction of the cabinet.

Rob Weinstock
rweinstock@archstoneconsulting.com

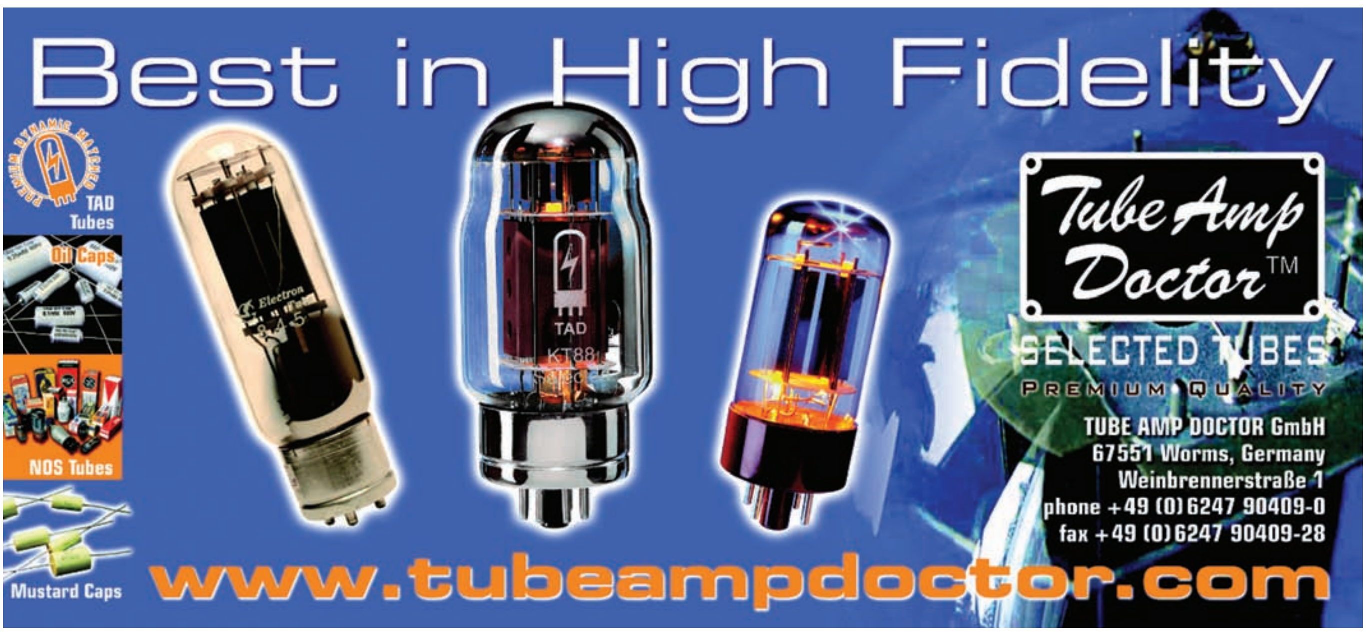
Cornelius Morton responds:

Thanks for your interest. The original Hegeman model ones were a six tube design that was subsequently changed to a four tube configuration to accommodate ease of tuning the Q of the individual tubes. If you examine the typical free-air impedance curve for a subwoofer driver, the area from one octave below Fs to one octave above Fs is the area that requires control to properly damp the value of Q below one.

Considering this range, then, a four tube design requires that the individual Qs be 2.5 to 3, and for a six tube design the Qs should have a value between 4 to 5, the value of Q being inversely proportional to the spacing between the tube frequencies. The Q values required for the six tube design approach the maximum values that are obtained in a tube of this design leaving little room for adjustment; the Hegeman ones did not use lossy material to control the Q values. The required Q value may be decreased slightly by increasing the frequency range that the tubes control, usually at the high end.

For example, if the driver requires control from 17Hz to 57Hz, the range of tuning could be from 20Hz to 75Hz. But doing this comes at a price. Resonance control is accomplished by inserting controlled resistance into the electromechanical circuit of the driver. When this is extended past the resonance hump, the efficiency of the driver at frequencies beyond the hump is decreased.

Determining the frequency spacing for a six tube design. As an example, I will use the 20 to 75Hz range mentioned before and an Fs (free-air resonance) of 28Hz. Let



$20x^0$ = 20Hz and $20x^5$ = 75Hz. Then x^5 = 75/20 = 3.75 and x = $3.75^{(1/5)}$. Then x = 1.3026. The frequency values of the tubes are, starting with x^0, 20Hz, 26.05Hz, 33.94Hz, 44.2Hz, 57.58Hz, and 75Hz. Typical Qs will be 3.7, which will allow for some adjustment. The value of Fs is very close to the lower edge of my target range, which is 0.8 × 33.94Hz to 1.2 × 33.94Hz. This is easily adjusted by lowering low frequency from 20Hz to 19Hz, which sets the third tube to 32.24Hz and the last tube to 71.25Hz, or x may be re-evaluated using 19 and 75Hz.

Tube area. I have found that setting the total mouth area of the tubes to 80% of the effective cone area of the driver provides good results. The general effective cone area for a 10″ driver is around 60 in^2, which would result in a tube area of 10 in^2 for a six tube design and 15 in^2 for a four tube design.

General. The free-air resonance, Fs, has been used throughout this discussion. As the impedance of the tubes as seen by the driver is a resistance instead of a reactance as seen in most other designs, the resonant value does not change when the driver is mounted in the box, thus Fs is the proper design value. A small increase in damping efficiency may be obtained by adding another divider in the plenum. Use a divider similar to the one in the design but on the opposing wall, from a line just clearing the outer edge of the 58.8 tube up to the top edge of the plenum.

The original corner reflectors were made slightly narrow to increase the tube bandwidth—I found this to be unnecessary as the angled stops are sufficient. Increase the design width from 2.18″ to 3.888″. The tuned tubes also operate as a resistance that is an odd harmonic of the design frequency, phantom tubes.

For example, the 21.5Hz tube acts as a phantom tube at 64.5Hz, and the 30Hz tube shows a phantom tube at 90Hz. Both of these phantom tubes provide an additional bit of damping, dependent upon the Qs at which the parent tubes are set. At even harmonics, primarily the second, the tubes act as though the mouths have been closed, reducing the volume that the driver is working into. The 21.5Hz tube shuts off at 43Hz and the 30Hz tube shuts off at 60Hz. This increases the efficiency of the tubes operating near or at those shutdown frequencies. Because these effects depend on the Qs of the parent tubes, they result in interactions during tuning.

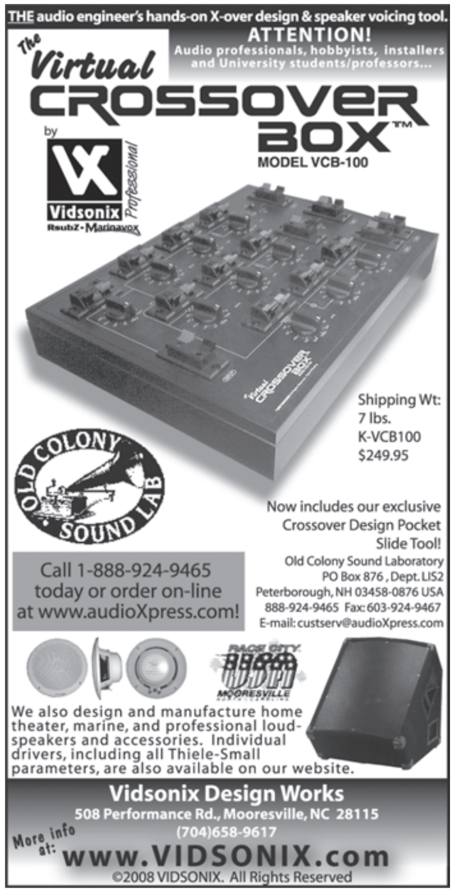
CORRECTION

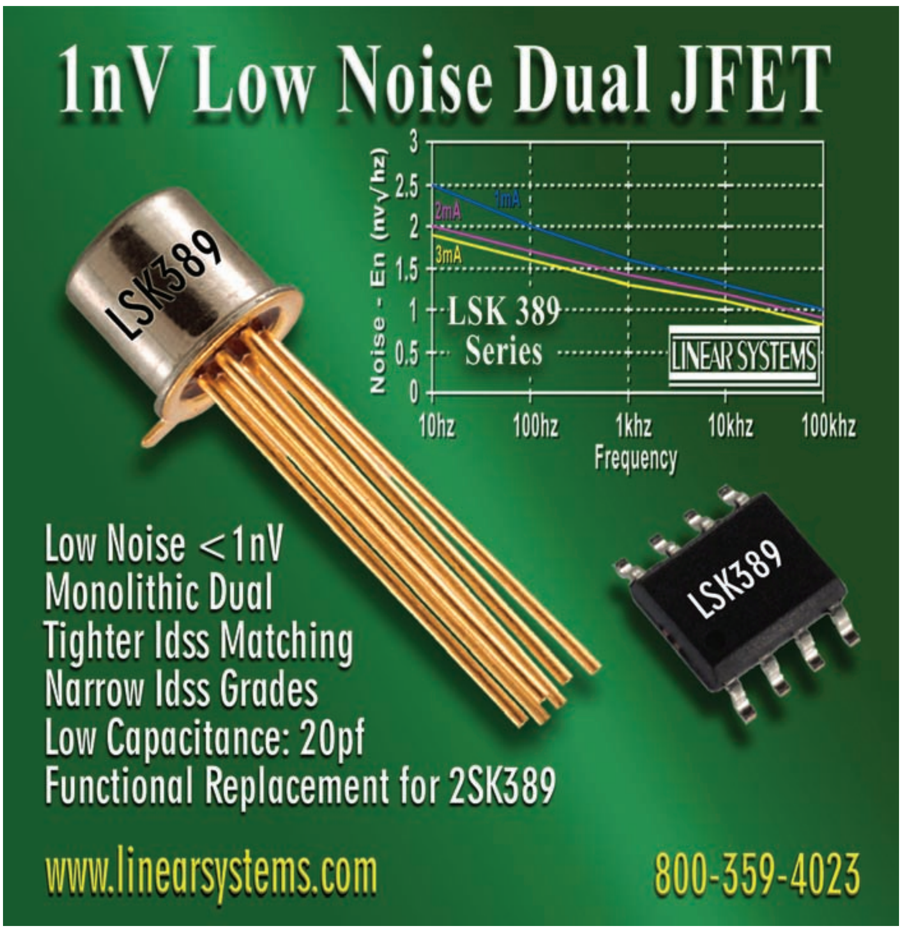
There seems to be an error—probably trivial—in Table 1 of Dennis Colin's article, "Tweaking the Inverse RIAA Network" (August 2007). The correct value for the enhanced RIAA compensation at 20kHz should be -18.979dB, not -18.975dB as illustrated. I checked the math three different ways. All of the other values, save this one, would appear to be correct to 0.001dB.

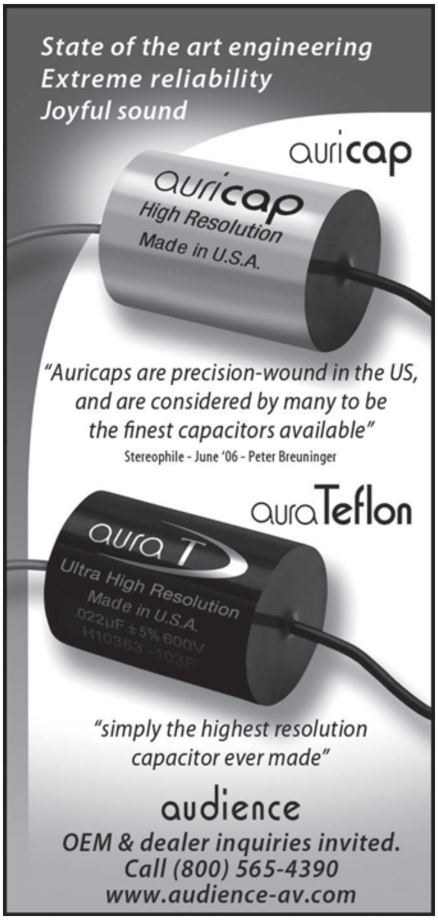
Jack Walton
Short Hills, N.J.

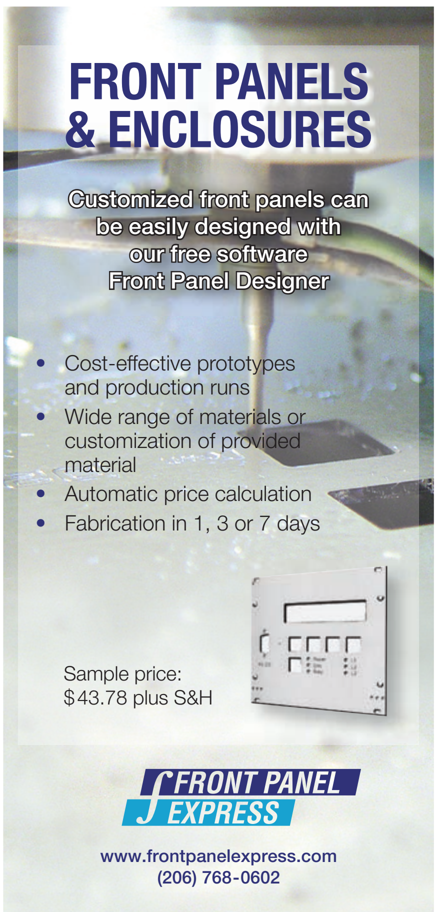
Dennis Colin responds:

Mr. Walton, you are correct. While no one could hear 0.004dB, especially at 20kHz, I sincerely welcome the pointing out of any mathematical error. Plus, I needed the hand calculator exercise (using rectangular to polar conversions on my TI-30Xa calculator). My corrected result is 18.9786513512dB for enhanced RIAA equalization at 20kHz, re 1kHz. Using a 10-digit calculator, but storing









12 digits, I obtained the last two digits by subtracting 18.978 and then multiplying by 1000. So there's my result to one tenth of a nano-dB.

Thanks for your interest. By the way, you can view the completed Groove Master phono preamp on my website (colinelectronics.com).

SPEAKER SETBACK

I have wondered about speaker setback and its relative location in 3D space ever since I built a three-way system and separated the mid-tweeter assembly from the bass. I mounted my final D'Appolito MTM configuration in a very small, rigid box (the mids had an enclosed back), and the bass was a 90 liter acoustic suspension, also very rigid with internal hardwood/softwood rods bracing across all walls, with Butterworth three-way active crossovers.

I installed the bass units into the front wall, tight to each corner and on a fireplace mantel, the bass driver center about 55″ off the floor. The front faces of the bass units were about 8″ away from the wall, to use the "Allison effect." The MTM boxes were at ear height, mounted on a 1″ steel pipe spiked to the floor and braced to the sides with a gate-like arm to allow them to be moved away for other family reasons such as cleaning or enjoying a fire. The front-to-back location was defined with a rigid rod that locked to the mantel and the speaker.

By carefully listening to many disks to determine the spacing between the bass and MTM, I finally settled on 49″ away from the front wall, 42″ from the sides, with the bass to MTM distance about 55″ on the diagonal. I measured the output of each driver and balanced them with their crossovers, from several locations, and checked the phase at each crossover notch. I spaced the two mids according to the frequency at crossover, and, apart from a slight "hooded" quality from the mids (Phillips 2″ dome midrange), it has been the best system I have heard in my listening room, and certainly as good as any commercial system I've heard in friends' homes.

The amplification included homemade MOSFETs 36W/A with Darlington power supplies and Plitron toroids in a separate chassis, 6 amps/4 power supplies for the MTMs, and a hefty Nad 200W/channel for the bass. These were built before the advent of commercial subwoofers being added to music systems, when surround sound was analog!

I carefully analyzed the resulting sound using many music sources, with many critical listeners, and at no time did we sense that there were disconnects or anomalies. I reasoned that in live music, with several performers, the original sounds emanated from diverse locations, yet in a simple system they all are projected from one place.

One obvious artifact was heard in the original design when the front panel of the MTM box was at least twice as large: a blurring of the treble. I reduced it somewhat with carpet felt rings around the tweeter, but after I used the small, narrow front baffle, and adjusted the center distances according to the D'Appolito calculation, that disappeared.

I sadly built into the amps a fatal flaw—no fuses—and when our local power company dropped the neutral line onto a hot line, the spike blew out the power supplies, allowing the rails to see 120V AC, and poof, the voice coils on one channel were toast. I obtained replacement mids from one of your contributors (many thanks, Darcy), and I'm gradually re-designing the power supplies and amps.

David Mayfield
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DIY AMP

Looking at the amp (it looks like my winter audio project) presented by Joseph Norwood Still ("A $450 Triode/Ultralinear Integrated Stereo Amp," Sept. '08), I had three questions:

The first is with the schematic. The version shown is the UL—that's clear from the circuit description. The wire colors for the UL windings are not indicated on the output transformers. I'm sure they are included with the transformer docs, but it would be nice to have them in front of me as I build this amp.

Second, I'm curious about why you wouldn't want to include a switch to configure triode/UL mode for a listening comparison. Is the answer risk due to an open screen grid?

Third, I don't see any wiring challenges to wiring in a single chassis, but if there is a need to isolate, you could easily fashion a pair of dividers. It would make the unit much easier to transport and reduce the number of connectors.

Jim Albanowski
Princeton, N.J.

Joseph Norwood Still responds:
You can construct the amplifier on a single aluminum (17 × 10 × 3) chassis, which is available from Mouser (800-346-6873), PN 546-1444-32. Detailed wiring and color-coding instructions are provided with the transformer. Be sure to ground the black wire and the black and white striped wire to the chassis. To ensure no oscillations occur, four separate switchers would be required for UL and triode stability. This complicates construction and can also lead to burnout of the 6 550s. *aX*

CONTRIBUTORS

Paul J. Stamler ("Tri-Way Low Voltage Supply, Pt. 1," p. 8) is a recording engineer/producer, musician, and technical writer; he also hosts a radio program, "No Time to Tarry Here," featuring traditional folk music and related stuff. He has delighted in 78s since he was a boy, when they were still being made.

Atto Rinaldo ("Remote-Controlled Ten-Input Line Preamp," p. 18) is an active retiree after 32 years at IBM, where he experienced various job responsibilities in the US and other parts of the world. He received a radio techniques diploma 45 years ago. Vacuum tubes were the technology used at that time, and he has loved them since. Transistors were just born; he had never heard about integrated circuits. Joining IBM in the late '60s, he has seen vacuum tube computers phasing out just about that time. When transistors and ICs took over, he said to himself that one day he would play with tubes again. He did.

Karin Preeda ("A Chip-Driven SE Monoblock," p. 24) is the chief test engineer for Celestica Thailand. His interests include building tube audio equipment, and playing bass or lead guitar in a band.

Gary Galo (Review: Benchmark DAC1 USB, p. 26) is Audio Engineer at The Crane School of Music, SUNY Potsdam, where he also teaches courses in music literature. A contributor to AAC since 1982, he has authored over 230 articles and reviews on audio technology, music, and recordings. He has been the Sound Recording Reviews Editor of the *ARSC Journal* (Association for Recorded Sound Collections) since 1995, was co-chair of the ARSC Technical Committee from 1996 to 2004, and has given numerous presentations at ARSC conferences (www.arsc-audio.org). Mr. Galo is also a frequent book reviewer for *Notes: Quarterly Journal of the Music Library Association*, has written for the *Newsletter of the Wilhelm Furtwängler Society of America*, and is the author of the "Loudspeaker" entry in *The Encyclopedia of Recorded Sound in the United States*, 1st edition.

Chuck Hansen (Measurements for the Benchmark DAC1 USB, p. 32) is an electrical engineer and holds five patents in his field of engineering. He began building vacuum-tube audio equipment in college. He plays jazz guitar and enjoys modifying guitar amplifiers and effects to reduce noise and distortion, as well as building and restoring audio test equipment. He enjoys sailing and has over 150 magazine articles to his credit.

Jan Didden (Show Reports, p. 39) built his first OTL amp with 807 tubes 35 years ago. He has built speakers, preamps, and tape recorders, but is most interested in power amps, especially using error correction as discussed by Hawksford. Many of his projects have been published by *audioXpress*. Now retired from a career with the Netherlands Airforce and NATO, he tries to complete all those half-finished projects accumulated for lack of time. He now also has the time to travel to interesting audio events and interview audio luminaries. His projects are documented on his Linear Audio website.

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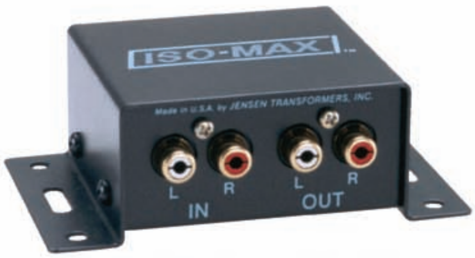

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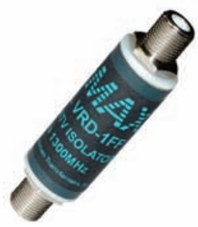

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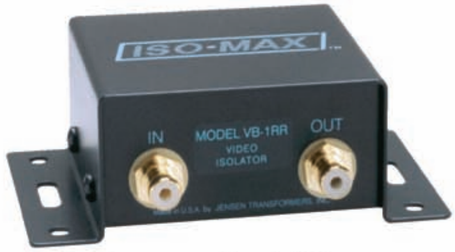

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