INTERACTIVE LOUDSPEAKER DESIGN ON THE INTERNET

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SpeakerBuilder

THE LOUDSPEAKER JOURNAL

A BALANCED RESPONSE SPEAKER

BUILD AN ACTIVE CROSSOVER WITH VACUUM TUBES

THE SUPER SIMPLINE: A One Evening Project

Test Driving the PYLE PRO DESIGNER

SPEAKER STANDS FOR SATELLITES

0 74470 84699 4 01

Critics Judge New InfiniCap

(bulletin posted on The Audiophile Network, to one and all)

Note: Mr. Blackburn's credentials as a sober critic are impressive. An engineer for a worldwide company, he is involved in the development and ongoing support of advanced digital imaging and storage systems. His articles have been published by Stereophile (he satirized pseudo-physics in high end audio), The Audiophile Voice (equipment and music reviews), and The Sensible Sound (music reviews). He is a regular contributor to Positive Feedback.

> Msg#:19460 09-11-95 08:46:01 From: Doug Blackburn
>
> I found a great sounding new cap — unbelievable sounding actually. I used to think [a highly regarded multiple section film and foil capacitor*] sounded pretty good, but ***these*** caps are unreal. I tried these caps out in various locations in some of my equipment — power supply bypasses, in the audio signal path, etc. ***Unreal*** sound quality. These make [a highly regarded multiple section film and foil capacitor] sound ***broken!*** I'm ***not kidding!*** The difference is ***very*** large.
>
> These are called InfiniCap. They are from the same people who came up with WonderCaps quite a few years back. These sound ***nothing*** like WonderCaps — far far far better. They aren't cheap, but they don't set new record high prices either.
>
> These caps are well worth the price/performance. I look forward to many months of happy experimenting with these caps in other components.

* The original posting explicitly states this capacitor's name. The above excerpt quotes the first, second, and last paragraphs in their entirety.

"The Audiophile Network is the granddaddy of cyberspace meeting places for audiophiles, and remains the insider's choice for audiophile information. Dataline phone #818-988-0452." — Stereophile, July 1995

New Wonder Solder UltraClear

For years, Wonder Solder has been the standard of the world:

"The best-known silver solder in the high-end audio community is Wonder Solder. Suffice to say, many manufacturers of high-end audio equipment use Wonder Solder." — Gary Galo, The Audio Amateur 3/94

"An audibly superior solder with superb working properties and a pleasure to use. Several audio manufacturers have reported, after listening tests using Wonder Solder, significant sonic improvements over identical components assembled with their favorite solders. Use of Wonder Solder will provide greater transparency without the glare and brightness often associated with silver bearing solders." — Michael Percy, Audio Consultant

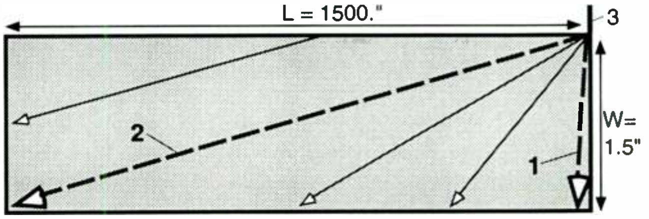
Now there's *new Wonder Solder UltraClear*™

- Stunning Ultra Transparency — Hear the subtle inner detail that brings music to life; even stereo imaging improves! Every single solder joint in your whole playback system passes vital signal information, and contributes to the transparency you hear (or don't hear) from your system. Other solders obscure information at every solder joint. This lost music is rescued by UltraClear.
- Clean Purity — It sounds ultra clean and pure, without the grundgy distortion, smudging, and smearing of other solders.
- Natural Musicality — It lets music sound naturally sweet, liquid, delicate, and warm. Other silver solders put an artificial glaze on music, sounding unnaturally hard, cold, bright, and fatiguing (like pseudo hi-fi, they might seem superficially clear, but their hard clog actually blocks music's subtle natural textures).

You won't believe the sonic difference a solder can make, until you try new Wonder Solder UltraClear. For mere pennies you can solder (or reflow) a whole amp or speaker, and make it sound like one twice as expensive. Available with rosin or water soluble flux core, and in bars for tanks (we'll send rosin as standard sample).

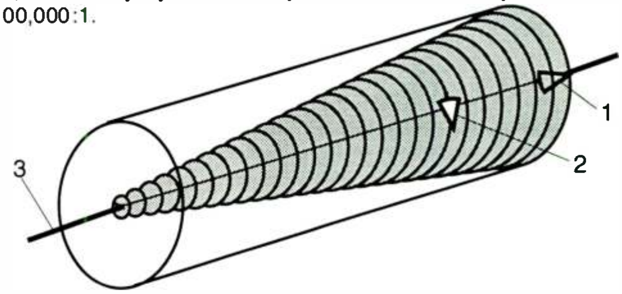
What's Wrong with Your Capacitors?

For any capacitor to work, electric charge must get from the terminal (3) to all parts of the plate. It fans out over your capacitor's plate, following the diagonal paths shown. This creates a bad problem. Path 2 can be 1000 times longer than path 1. So your music doesn't all get through your capacitor at the same time. Some music gets through quickly, via path 1, but some of the same music signal takes 1000 times longer, via path 2. This time smears your music, so it sounds fuzzy, defocussed, and veiled, and perhaps muddy, clogged, honky, or glary.



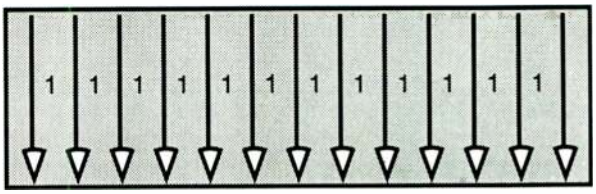
Your capacitors have another problem that's even worse. They roll up signal path 2 into a tight corkscrew coil (below). The inductance of any coil is multiplied by the number of turns squared, and there can be 1000 turns in an audio capacitor. So the inductance of path 2 can be a million times higher than straight path 1, delaying music a million times worse for some paths through the capacitor than for other paths. This capacitor actually smears music by a factor of 1,000,000:1.

Multiple capacitors with 10 sections reduce these problems a bit, but merely by 10. So they still smear music by a factor of 100,000:1.



The New InfiniCap is Different!

Only the new Wonder **InfiniCap**® capacitor cures all these problems. InfiniCap's unique design (patents pend) with metal ends eliminates long, diagonal, corkscrew signal paths like path 2. InfiniCap has an **infinite number of parallel paths**, which are all like path 1, as shown below.



These signal paths are all **short**, so InfiniCap is fast. These paths are all the **same length**, so all of your music signal gets through the capacitor at the same time. These paths don't make coil turns, so they don't have drastically differing inductances.

It's like an infinity of capacitors in parallel – **InfiniCap**! That's why **InfiniCap** sounds:

- transparent, open, and airy — instead of veiled or clogged;
- clean and pure — instead of smeared or dirty;
- clearly focussed, coherent — instead of defocussed or fuzzy;
- fast and delicate — instead of sluggish, hard, or splattered.

InfiniCap gives you all the music at the same time. InfiniCap reveals the subtle inner details, the magic that makes music sound real. Hear the amazing sonic difference yourself.

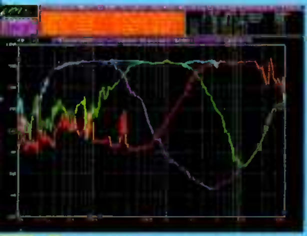
Free sample InfiniCap! Write: *TRT*, 408-b Mason, Vista CA 92084

Reader Service #54

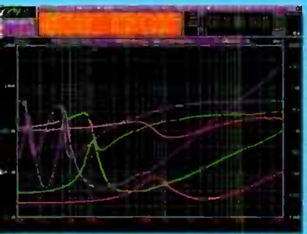
LMS

Loudspeaker Measurement ~~System~~ Solution!

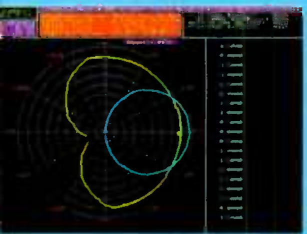
New! Version 3.6



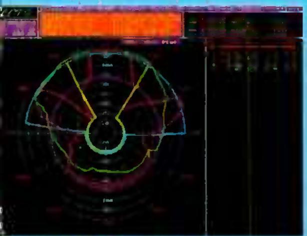
SPL Response



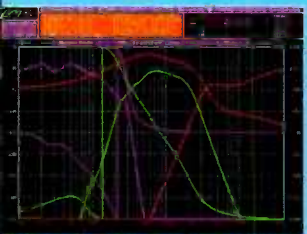
Impedance Curves



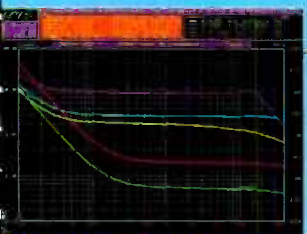
Nyquist Real/Imaginary



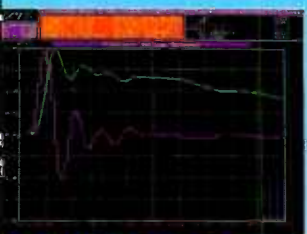
Polar SPL Response



Network Transfer Functions



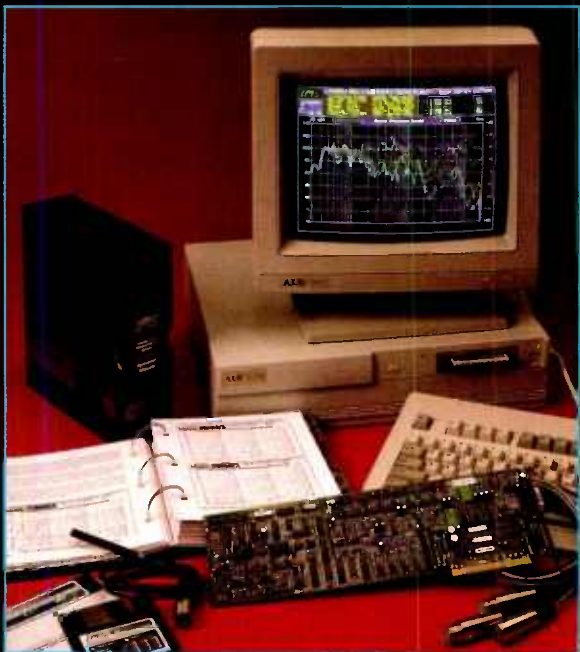
Inductance/Capacitance



Impulse/Step Response

At last, there is a complete and affordable analyzer system that provides quality data suitable for real electro-acoustic engineering purposes. The LMS system provides a vast array of powerful computer based features which are specifically focused on the unique requirements of loudspeaker development and QC production testing.

Whether your application is professional audio, consumer stereo, car stereo, or contract installation, LMS is the perfect tool for development and testing of loudspeaker systems.



No other measurement package today provides as many outstanding features and capabilities at such an incredible price!

System Utilities and Features

The system software provides a host of powerful utilities and processing features which enable the user to perform many complex and tedious tasks easier than ever before. Unlike most other analyzer software which is oriented towards single curve use, LMS handles multiple curve display and operations with a versatile 20 entry library database.

- ✔ Curve library system for multi-curve operations
- ✔ Macro programming of operation for QC testing
- ✔ Standard and user selectable Frequency Ranges
- ✔ Relative and Absolute PASS/FAIL Compare
- ✔ Import and Export Data to ASCII files
- ✔ Speaker Parameter Generation
- ✔ SPL/Z Combo Conversion
- ✔ Nyquist Plot Conversion
- ✔ Polar Plot Conversion
- ✔ Tail Slope Correction
- ✔ Multi Curve Averager
- ✔ RLC Meter

Analyzer System Specifications

- ✔ Full Length IBM PC Slot Card, 8 Bit PC Slot
- ✔ Oscillator: Continuous or Gated Swept Sine Wave
- ✔ Osc Maximum Output: +16dBm (5Vrms)
- ✔ THD: 0.015 , 20Hz-20kHz
- ✔ Frequency Resolution: 200 steps/decade, Log
- ✔ Filters can track Osc frequency by any ratio
- ✔ SPL Measurement Range: 35-125 dB SPL
- ✔ Video graphics support: VGA, EGA, CGA, HGA
- ✔ Calibrated 8mm Electret Mic with Preamp
- ✔ Mic Frequency Range: 10Hz-40kHz
- ✔ Osc Attenuator Range: 60dB in 0.25 dB Steps
- ✔ Osc Frequency Range: 10Hz-100kHz
- ✔ Dual State-Variable Filters: LP/HP/BP/BR
- ✔ System Signal to Noise Ratio: 90dB
- ✔ XLR Interface: Osc out, Bal Input, Mic Input
- ✔ 360 Page Manual with Application Notes

Processing Operations

The LMS software provides a host of powerful post processing features which enable the user to perform complex mathematical operations on curve data quickly and easily.

- ✔ Scaling, Smoothing Curves
- ✔ Minimum Phase Transform
- ✔ Group Delay Transform
- ✔ Addition, Subtraction
- ✔ Multiplication, Division
- ✔ Frequency Div/Mul
- ✔ Invert, Square Root
- ✔ dB to Linear Conversion
- ✔ Inverse FFT

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LINEAR X

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Reader Service #36

About This Issue

Speaker Builder kicks off a new year with an unusual speaker setup (see cover). This dual-baffle design—by computer science professor, engineer, and software developer **Ralph Gonzalez**—is based on his AES presentation in 1991 ("A Dual-Baffle Balanced Reverberant Response," p. 12) and addresses frequency-response irregularities.

Who says you can't improve upon a good thing? Contributing Editor **John Cockroft**'s modification enhances the already excellent sonic quality of his Simpline design and is appropriately entitled "The Super Simpline" (p. 18).

In "Build an Active Crossover Network" (p. 20), Swedish author **Rickard Berglund** examines various crossover designs for different system configurations.

In search of better bass response, **Dan Hildebrand** began a journey that resulted in an attractive, pleasant-sounding subwoofer/satellite system ("Speaker Design and the Internet," p. 26). Along the way, he discovered a surprising electronic resource to assist speaker builders in design and construction projects. The article recounts his adventures and includes a review of the finished speakers, as well as an interview with the woofer's designer.

Robert Wayland's woodworking project ("Wayland's Wood World," p. 38) shows how to make suitable stands for proper speaker placement. Also in this issue, Contributing Editor **Bill Waslo** show us how to read and generate waterfall plots for loudspeaker measurements ("Ask SB," p. 52). And, in the review spotlight, we take a look at some powerful, yet easy to use, speaker design software ("Software Review," p. 44).

Speaker Builder

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The peculiar evil of silencing the expression of an opinion is, that it is robbing the human race; posterity as well as the existing generation; those who dissent from the opinion, still more than those who hold it.
JOHN STUART MILL

Speaker Builder is published eight times a year in the interest of high-quality audio reproduction.

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Editorial

PAPER TRACE

One of my Saturday morning chores is taking our waste paper and plastic to the town dump...oops, I mean the town's recycling center. There was a time when the latter moniker was a euphemism. No longer. Our town's recycling center has become a very efficient and hard-working establishment for recovering and recycling all manner of stuff that we used to just bulldoze under a covering of topsoil. When our main river became too polluted, state laws forced us to search for better alternatives.

Going to the town dump on a Saturday morning has been a fixture in New England life for many years. In some ways our small town dumps were always recycling centers, even before the term became popular. Sometimes you would return home with more treasures than you left with.

Recycling has become a regular, and more organized, feature of our town's center. Books, hard- and softbound, are arranged neatly on shelves (recycled shelves, that is), as well as all sorts of appliances which might be usable with a little fixing up. The "textiles" bin is always overflowing, but a ladies volunteer group from the local churches comes weekly to sort and evaluate the items, bundling up useful items to send to troubled areas of the world where people are without shelter and clothing. Motor oil burns in specially designed furnaces to keep the place warm for the center's workers.

Miraculously enough, what was once a grim, weekly necessity has become a positive experience, with a friendly, festive air about it. Not only so, but the facility earns money to offset local municipal expenses, and thus results in slightly lowered tax bills.

Our company has been recycling all sorts of materials for some time now. We have a special dumpster for corrugated board and bins for aluminum cans, plastics, and bottles. Green trash cans for recyclable paper sit beside almost every desk. The heaviest load in my car each Saturday, however, is a big tote bin full of magazines and catalogs.

For quite a while we have been carefully cutting out the various forms of addresses from duplicate trade mags and catalogs and sending them, along with a letter, to the firms who mail us useless extras. We also promptly send cancellation notices to those magazines we do not find useful.

Most of the time our efforts yield *absolutely no results at all.* The multiple catalogs keep coming. The brochures to various members of the staff continue to pour in. I carry 40 to 50 pounds of such stuff to the center each and every Saturday.

Some of the catalogs are addressed to people who worked in this company as many as ten years ago. The vendor copied the names from the masthead of the magazine, or bought a list from someone who did, and continues to rent it for so much per name.

This excess printed material is very much related to this magazine—indeed to every magazine published in the US. Over the last year we have experienced two increases in the price of paper. This commodity is subject to wide swings in price due to the nature of paper manufacture.

A paper-making machine can have the same length and width as the Queen Elizabeth II. Such monsters cost in excess of a billion dollars and must run 24 hours per day, 365 days every year, to be financially feasible. Adding one machine can lower the price of paper, but the need for new ones must be more than obvious through shortages (and price rises) before any are built.

This waste has its origin mostly in the direct-mail business, whose foundation is list availability. Nearly every American is included on multiple lists. Your driver's license, credit cards, subscriptions to magazines, catalog requests, mail-order purchases, all add your name to a list.

You and I receive so much duplicate mail mostly due to bad list management. Companies who rent their lists—and almost everyone does—do not go to the expense of cleaning them. We often rent lists in which 10% of the addresses are bad. If we return those bad addresses, few if any vendors will bother to correct and clean their lists. Why should they? And refunds for bad addresses are almost never forthcoming. People in the list-rental business apparently consider 10% as normal.

It can help to keep your name and address for each use exactly the same. It also helps to ask publishers or mail-order vendors to correct misspellings. In this way, the conscientious list-rental company can more easily find and eliminate duplicate mailings. The company whose catalog is being missent usually has no way to persuade the list marketer to get the list owner to update these files.

Highly developed software exists to avoid duplicate mailings when a magazine rents multiple lists for a single promotional mailing. The smart and prudent publisher runs a comparison of his own list against rented lists to eliminate duplications. This saves the publisher printing and postage costs. My daily mail shows that many very large corporations do not bother to clean the lists they use.

The United States Postal Service suffers from this problem as much as anyone. They have recently instituted a system-wide recycling program in post offices. But misaddressed mail still annually accounts for billions of pieces, which constitute waste paper.

All this waste costs you and me money. It makes the postal service more costly to operate; it loads the postal system with more mail in all classes; and it raises the price of paper during shortages of capacity.

What you do with duplicate mailings to your home is another matter. If all of us complained loudly enough, the situation might change. If you give the pieces back to the postman, he and your local post office can only recycle them, and no information about their redundancy gets back to the mailer. If you send the labels to the company who mailed the duplicate or unwanted copies to you, it just may do some good.

The economics of direct mail are not difficult to figure out: eliminating duplication is key to improvement. We judge the success of a mailing on the percentage of response. If duplications were eliminated the percentage would be higher, since the list itself would be smaller. Most people do not care to be bothered by junk mail, most of which is mail that is simply not targeted well enough, or is sloppily managed.

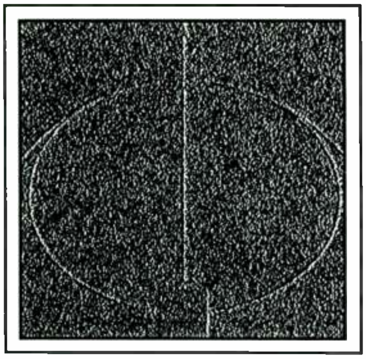
Unfortunately, I have no recipe for a cure to this problem. I am very frustrated when I see another price increase in paper and know in my bones that if half the wasted paper that comes into this office is typical across America, then we are wasting as much as 10% of the massive quantities of paper use every year. If we could fix that problem the price would not need to rise.

In the meantime, find out about the recycling program in your own community. Until we learn how to control the waste, recycling is our only recourse. Of course, recycling is vitally important to our environment in any case. If you have a program in your community, become involved. It might be more rewarding than you thought.—**E.T.D.**

Speaker Builder

THE LOUDSPEAKER JOURNAL

VOLUME 17 NUMBER 1 FEBRUARY 1996



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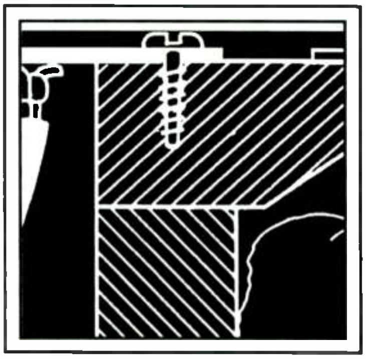

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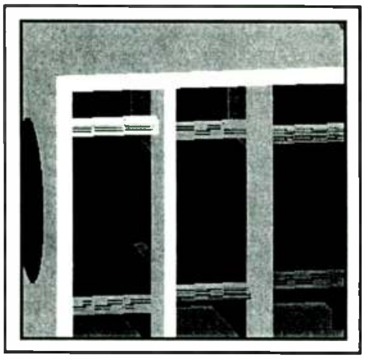

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DEPARTMENTS

Good News

TUBE AMP

The Power 3 Mono Amplifier heads the new line of amplifiers from Sonic Frontiers. The Power 3 offers 6550 power tubes; a damping factor of greater than 50; a power rating of 220W off the 8, 4, and 2Ω taps; single-ended inverting and non-inverting inputs; and a fully balanced design. Extensively tested through a 100 hour burn-in and repeated cycling, the Power 3 is proven reliable. Sonic Frontiers, 2790 Brighton Road, Oakville, ON, L6H 5T4, (905) 829-3838, FAX (905) 829-3033.

Reader service #102

POWER TO GO

Porta Power is a low-cost device that converts DC power (from your cigarette lighter) to AC. It is small enough to fit into your glove compartment and delivers 140W of continuous 115V AC to operate TVs, VCRs, computers, lights, small power tools or kitchen appliances, video games, and so on. Porta Power's safety features include protection against overload, short circuit, reverse polarity, and low battery. Tumbler Technologies, 19201 Phil Lane, Cupertino, CA 95014, voice/FAX (408) 996-8276.

Reader service #108

SOLEN SPEAKER CATALOGS

1996 catalogs are currently available from Solen Inc. Three separate catalogs are offered, specific to the areas of speaker components, crossover and speaker components, and car speaker components. Clear and helpful photos, figures, and tables appear throughout each comprehensive product listing. Solen Inc., 4470 Avenue Thibault, St. Hubert, QC, J3Y 7T9, (514) 656-2759, FAX (514) 443-4949.

Reader service #115

EMINENT DOMAIN

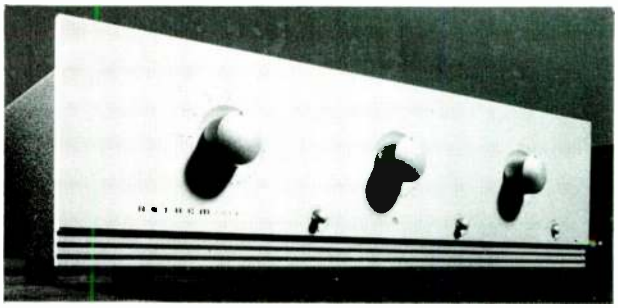
The Domain Theater Two and Domain Soundscape collections include all the speakers needed to recreate the movie experience at home. Theater Two provides a fully configured Dolby Pro Logic or AC-3 array: a pair of Domain D30 two-way, compact left/right speakers, a CTR Stage center-channel model, a pair of Balcony super-compact surround-channel design, and one D1000S active subwoofer. The Soundscape grouping, intended to upgrade existing stereo layouts, is identical except that it does not include the D30 pair. MB Quart Electronics, 25 Walpole Park S., Walpole, MA 02081, (508) 668-8973, FAX (508) 668-8979.

Reader service #114

STEREO POWER AMP

The newly released Aleph 3 stereo power amplifier is rated at 30W per channel into 8Ω. It achieves high measured performance with only two gain stages. Each channel has an input MOSFET transistor that directly drives the output stage, which consists of two parallel power MOSFETs biased by a current source and operated in single-ended Class A. The bias current on the output stage is heavy enough to double the power into 4Ω and still meet rated power below 2Ω. The Aleph 3 sports a heatsink/chassis, from which all external surfaces radiate heat at a temperature of about 50°C. Pass Laboratories, 21555 Limestone Way, Foresthill, CA 95631, (916) 367-3690, FAX (916) 367-2193.

Reader service #107



A SONG OF TUBE ELECTRONICS

Sonic Frontiers introduces the Anthem line of "all-tube" high-end electronic products including a preamplifier, integrated amplifier, amplifier, and CD player. The Anthem Pre 1 is now being offered as an affordable preamplifier featuring both an MC and MM phono stage and adjustable line stage capability. Sonic Frontiers, 2790 Brighton Road, Oakville, ON, L6H 5T4, (905) 829-3838, FAX (905) 829-3033.

Reader service #101

FYI² AUDIOPHILE SWEEPSTAKES

What's the most important component in an audio system?

WIN!

Answer this question using the FYI² QUIZ

Answer these trivia questions below by filling in the blanks. Unscramble the circled letters. They spell out a phrase that answers the sweeps question above. We're giving you one free "OF" to start with. Write your answer on the coupon on this page or on the Reader Service Card attached to the magazine and send it in. Winners will be chosen from entries with correct answers.

1. Gilbert & Sullivan's Captain of the Pinafore is never _ (_) (_) _ at sea.

2. First name of the country singer and Taco Bell spokesman credited with writing Patsy Cline's hit song *Crazy*?

_ _ _ _ _ (_)

3. In an attempt to deal with his alcoholism, composer Sibelius moved to a suburb of this city in Finland

(_) _ _ _ _ _ _ _ _

4. Paul McCartney's first name.

_ _ _ _ (_)

5. Alice's Restaurant was how far from the railroad track?

_ _ _ _ / _ / (_) _ _ _

6. In his later life, what did Beethoven remove from his piano? _ (_) _ (_)

7. Conservative parents of the 60s were outraged by the metaphor for drug indulgence assumed to be represented by this loveable character in a popular folk song. _ (_) _ _

8. Before the "The Grateful Dead," what was the name of Jerry Garcia's band?

_ _ _/_ _ (_) _ (_)(_) _ _

9. Jazz great Dave Brubeck's big pop/jazz 5/4 hit tune:

(_) _ _ _/_ _ _ _

10. *Wayne's World* theme "Bohemian Rhapsody" was performed by

_ (_) _ _ _

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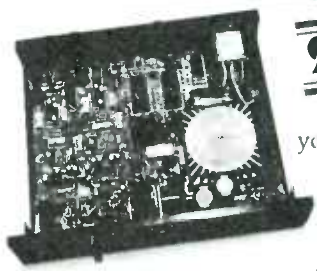

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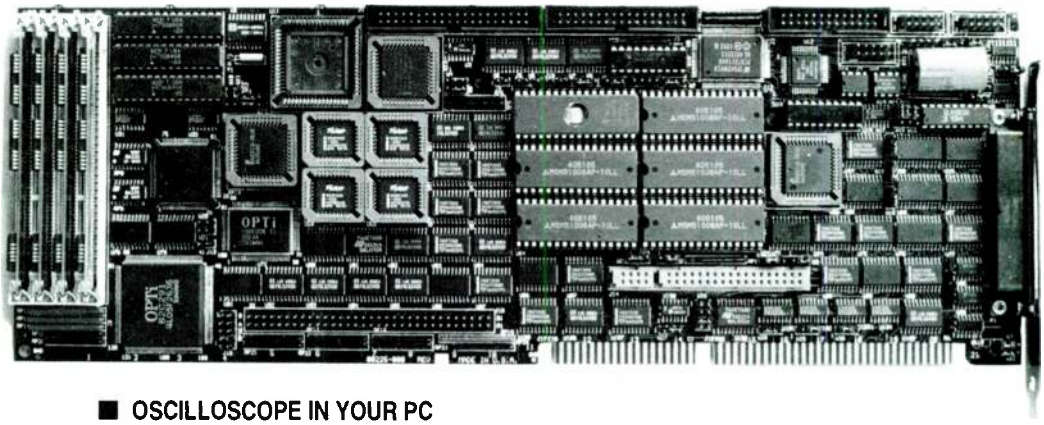

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MCM Electronics is currently offering their latest catalog, number 36. Containing over 2,700 new items, the listing is offered free of charge and includes test equipment, computer products, project accessories, repair parts, and more. Permanent price reductions on semiconductors, video heads, flybacks, motors, and other items appear throughout. MCM Electronics, 650 Congress Park Dr., Centerville, OH, 45457-4072, (800) 543-4330, FAX (513) 434-6959.

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■ CROSSOVER NETWORK

Marchand Electronics Inc. offers a fourth-order constant-voltage crossover design providing low-pass and high-pass outputs with the release of the XM26. The XM26 employs four 12AX7 tubes in each of the two channels, a solid-state regulated power supply, and a heavy-duty toroidal power transformer. Housed in a black heavy-duty steel cabinet with white lettering, the electronic crossover network sports gold-plated RCA connectors for rear input and output, in addition to black aluminum level control knobs and three LED indicators on the front. Marchand Electronics Inc., PO Box 473, Webster, NY, 14580, (716) 872-0980, FAX (716) 872-1960.

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■ 1996 CATALOG

Parts Express announces the release of its 288-page 1996 Catalog featuring semiconductors, CATV and VCR repair parts, test equipment, raw loudspeaker drivers, and audio accessories. Parts Express is a full-line distributor of electronic parts and accessories for the consumer electronics industry and the technical hobbyist. The catalog is free by calling 1-800-338-0531 or writing to Parts Express, 340 E. First St., Dayton, OH 45402-1257.

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A DUAL-BAFFLE BALANCED REVERBERANT RESPONSE

By Ralph E. Gonzalez

PHOTO 1: BR1 prototype in black ash.

This article is based on "A Dual-Baffle Loudspeaker Enclosure for Balanced Reverberant Response," Ralph E. Gonzalez, AES Preprint 3203 (H-2), Oct. 1991.

It is well-known that dynamic loudspeakers are omnidirectional at low frequencies, but not at high frequencies—if you stand behind the speaker you mainly hear bass energy (*Fig. 1*). If such a speaker is designed for flat direct (on-axis anechoic) response, then the in-room reverberant soundfield will contain too much bass as well. In my opinion, this disparity between the direct response—which your ears hear first—and the reverberant response—which accounts for most of the energy reaching your ears—detracts from the sense that the recorded musical performance is taking place in your room.

To alleviate this, some designers place additional high-frequency drivers on the rear of the speaker enclosure. Unfortunately, it is very difficult to do this without introducing midrange frequency-response irregularities. I'll present here an unusual enclosure design that solves this problem.

DIFFRACTION LOSS

In most moving-coil loudspeaker designs, the drivers are mounted on a baffle that constitutes the front of a sealed or vented box. At some frequency f_B, the wavelength is comparable to the dimensions of the baffle. At frequencies below approximately $f_B/4$ (typically 300–500Hz), such systems become nearly omnidirectional as sound energy diffracts around the baffle. At higher frequencies, the enclosure serves as an obstacle to the sound waves and the loudspeaker radiates only into the forward hemisphere.

If the speaker system is not equalized (for example, if a single "ideal" driver is used to cover the entire frequency range), then this diffraction loss at low frequencies will cause the on-axis anechoic response to fall off by 6dB (*Fig. 2a*). Viewing this effect as a 6dB rise as frequency increases, I've also termed it the *response step*.[1] It is evident in the graphs many manufacturers publish in connection with high-quality woofers.

Most knowledgeable speaker designers compensate for the response step by rolling

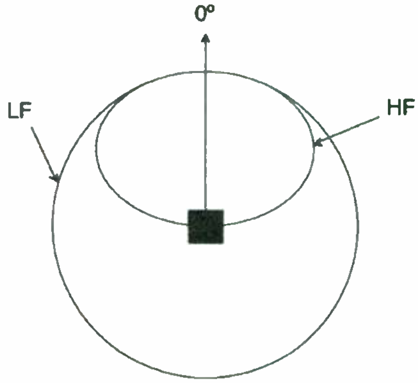

FIGURE 1: Representational drawing of dynamic loudspeaker directivity at low and high frequencies.

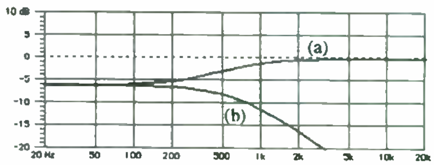

FIGURE 2: Model of forward (a) and rearward (b) frequency responses of ideal driver in 6.75-inch-wide enclosure.

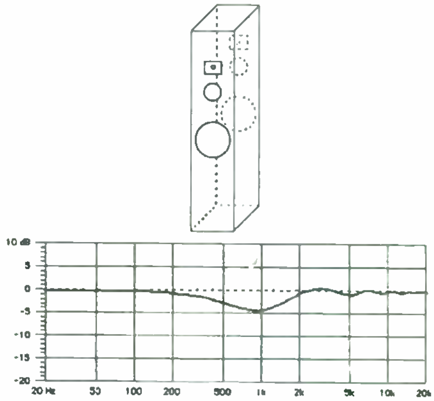

FIGURE 3: Speaker with full-range rear drivers and resulting on-axis frequency response.

off the woofer early in the crossover, resulting in a system with nearly flat axial response. (Note that such a system is of necessity as much as 6dB less sensitive than the manufacturer's sensitivity specification—usually given at 1kHz with benefit of the 6dB response step.) Since the rearward output (*Fig. 2b*) consists solely of frequencies below $f_B/4$, the overall in-room reverberant soundfield contains excessive energy below $f_B/4$.

Incidentally, the smoothness of the response step depends on the baffle shape and the location of the drivers on the baffle. As Harry Olsen demonstrated in his seminal 1950s paper, the worst case is a driver mounted on the center of a disk-shaped baffle.[2] In practice, a rectangular baffle is acceptable, particularly if the drivers are offset or the listener is not on-axis.[3] The computer-predicted frequency-response graphs in this paper are based on the smooth first-order model in *Fig. 2* (resembling that of a spherical enclosure), but the conclusions apply to box-shaped enclosures as well.

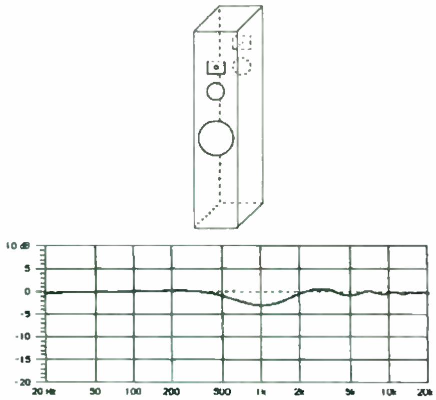

FIGURE 4: Speaker with rear mid- and high-frequency drivers and resulting on-axis frequency response.

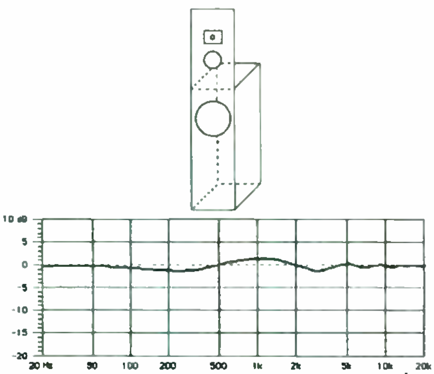

FIGURE 5: Speaker with unenclosed midrange and resulting on-axis frequency response.

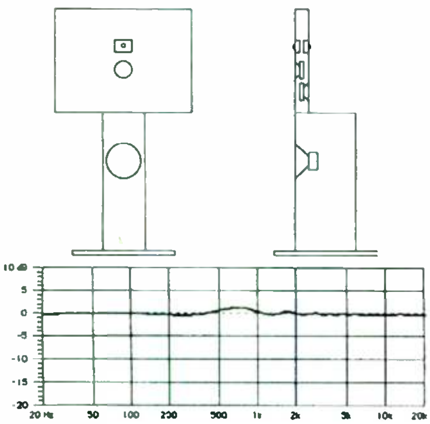

FIGURE 6: BRR speaker and on-axis frequency response assuming 4:1 baffle ratio.

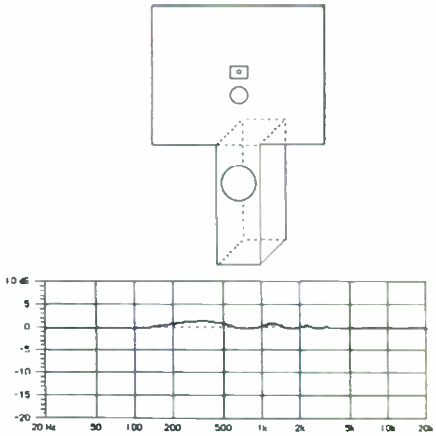

FIGURE 7: BRR speaker with unenclosed midrange and on-axis frequency response.

IMAGING

I distinguish between two types of speaker systems: those which attempt to give the listener an accurate window on the musical performance (such as my minimonitor),[4] and those which try to convince the listener that the performance is taking place in his or her listening room (such as my Delac S10).[5] If executed well, each approach has its merits. This article concentrates on the latter goal.

In a live, unamplified musical performance, the reverberant soundfield mirrors the sound that strikes the listener's ears directly, except for the instruments' intrinsic directionalities and the venue's frequency-dependent sound-absorbing qualities. If the instruments are close-miked, you can reproduce the recorded performance convincingly in the listening room as long as (1) the speakers have directionality similar to those of the instruments they reproduce, and (2) the listening room has acoustical qualities similar to those of the original venue. In practice, the acoustics of your room are difficult to control (unless you're single!), and

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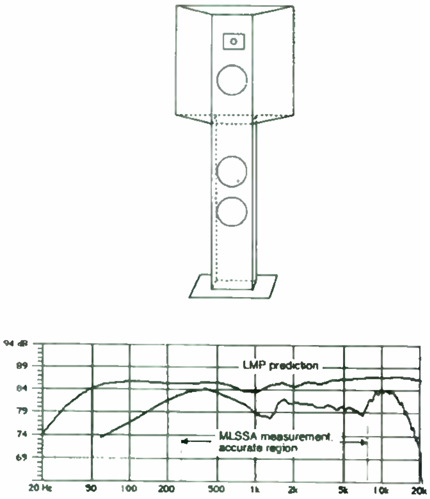

FIGURE 8: BR1 prototype, predicted and measured response.

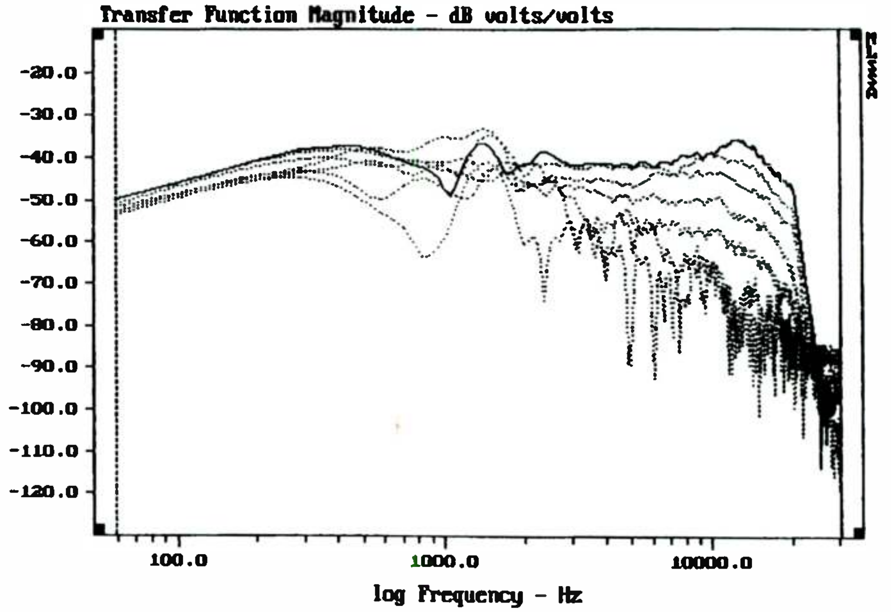

FIGURE 9: BR1 measurements at 0°, 30°, 60°, 90°, 120°, 150°, and 180° in horizontal plane.

the directivity of most loudspeakers is as discussed above.

If you are concerned only with the human voice, then a head-sized, forward-facing speaker is ideal (assuming unequalized, close-miked recordings), but what about violin, piano, snare drum, flute, guitar, or vibes? (After all, no one wants bad vibes!) None of these instruments has a distinct radiation axis, and their dimensions—and diffractive qualities—vary enormously. When a box speaker with a flat axial response is reproducing the music, the frequency balance of the in-room reverberant response is usually very different from that of the original venue. I believe that this makes a "you are there" soundstage very difficult to achieve. A near-omnidirectional speaker would appear to be a much better compromise than a conventional forward-firing one.

What if the recording was made with distant microphones, where the instruments' directional qualities have already voted in the recorded reverberant soundfield? Ideally, the reproduction of such a recording should take place in an anechoic chamber where the recorded ambience will not be compromised. In a normal, partially-reflective room, the speakers should preferably not change the balance of the reverberant energy. Again, this requires near-omnidirectional speakers. (Another alternative is an extremely directional speaker that minimizes room interaction. Unfortunately, it is very difficult to extend this quality much below 500Hz.)

ON-AXIS PROBLEMS

Why, then, do many audiophiles consider omnidirectional speakers inaccurate? Most such designs rely on multiple drivers oriented in all directions. Unfortunately, multiple spatially separated drivers generally combine

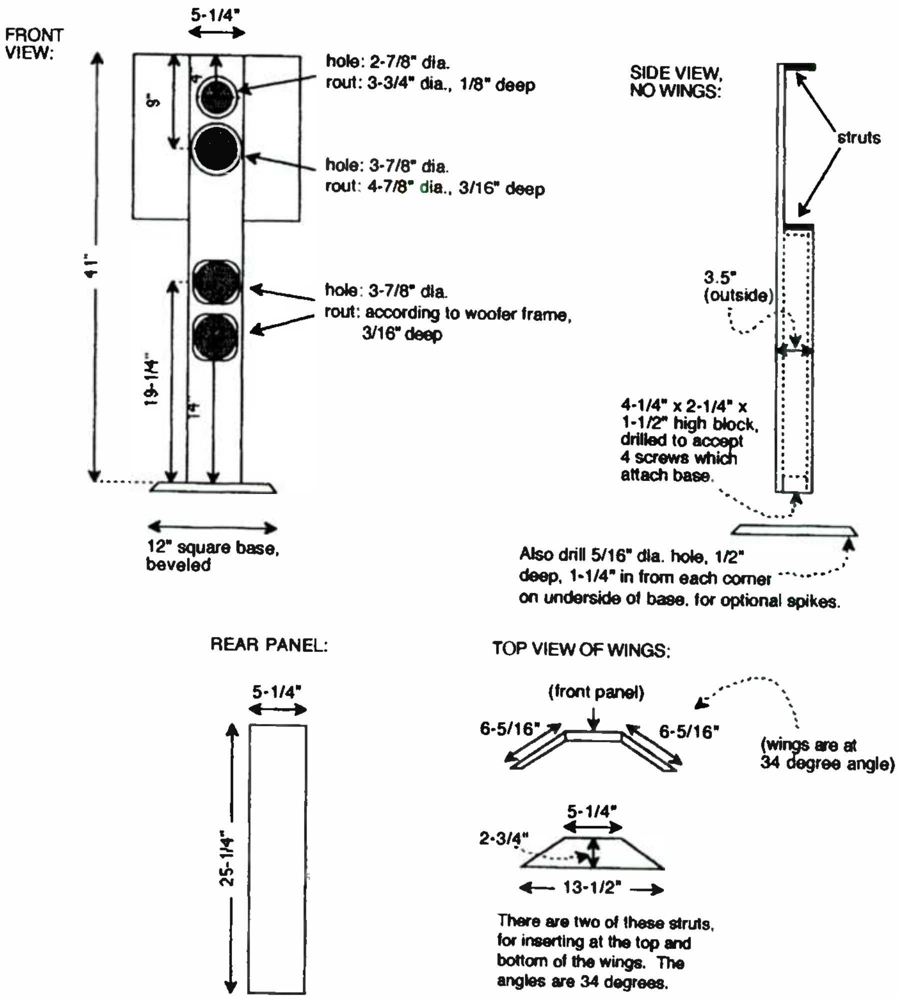

FIGURE 10: BR1 enclosure plans. Front panel and base are ¾" MDF, wings are 5/8", all other pieces are ½". I chose 34° for the angle of the wings because this prevents a gap when using ¾" front panel and 5/8" wings (35° is probably close enough). Note that there is no back to the winged compartment.

to produce severe on-axis anechoic response irregularities.

The simplest case involves a box with identical rear-mounted drivers (*Fig. 3*), the delayed output from which diffracts to the forward axis, compensating the diffraction loss at very low frequencies, but combining destructively with the axial output of the front-mounted drivers at frequencies close to $f_B/4$. For the 6.75-inch-wide enclosure, f_B = 13,500 (in./sec)/6.75 (in.) = 2kHz.

It is important to note that these are results predicted from the idealized first-order model illustrated in *Fig 2*. The enclosure is assumed to be shallow and tall, so the axial contribution of the rear-mounted drivers is delayed by one-half the enclosure width, a "best case" model. With real-world, box-shaped enclosures, the response irregularities are often more pronounced and jagged.

In my Delac S10 design, a rear-mounted bass-midrange driver helps fill in the midrange portion of the reverberant response, while the angled tweeter fires additional high-frequency energy at the ceiling. The result is a highly musical and listenable speaker with holographic imaging, balanced against a slightly uneven midrange whose absolute accuracy cannot match that of fine monitors.

A more common (and less expensive) approach is to add rear-mounted mid- or high-frequency drivers (*Fig. 4*) instead of using a full-range rear complement. To be effective, the response of the rear-mounted drivers must extend down close to the frequency $f_B/4$. In the graph in *Fig. 4*, the rear midrange's high-pass crossover is second order at 333Hz. The on-axis response is still problematic.

Another alternative is using an unenclosed midrange in an open baffle to contribute additional midrange energy to the reverberant response (*Fig. 5*). This has the benefit of requiring no extra drivers (except perhaps a rear tweeter) and of eliminating midrange box colorations. The polarity reversal of the midrange's rear output partially compensates for its delay relative to its forward output, producing a mild peak instead of a dip at 1kHz. However, the overall variation is still about 3dB and is likely to be significantly worse in a real-world design.

THE BRR DESIGN

My BRR (balanced reverberant response) speaker uses two baffles of differing dimensions, one for high-frequency drivers and one for low-frequency. Let f_H be the frequency where the wavelength is comparable to the dimensions of the HF baffle, and let f_L be that where the wavelength is comparable to the dimensions of the LF baffle.

You place front- and rear-mounted drivers on the HF enclosure. To prevent the delayed output of the rear drivers from affecting the axial response, you should restrict their output via the crossover to frequencies an octave or two above $f_H/4$. You place low-frequency drivers on the front of the LF baffle. These should be omnidirectional up to frequencies well above $f_H/4$. You accomplish this by ensuring that f_L is higher than f_H; i.e., the LF baffle has smaller dimensions than the HF baffle. Centering the crossover between $f_H/4$ and $f_L/4$ results in a system that is omnidirectional or bidirectional at all frequencies, yet whose direct axial output is not compromised by its rear output.

The system in *Fig. 6* is similar to that of *Fig. 4*, except that the 27-inch-wide HF baffle for the midrange and tweeter drivers is four times wider than the LF baffle: f_H = 500Hz and f_L = 2kHz. These baffles begin to serve as obstacles to sound at about $f_H/4$ and $f_L/4$, respectively. Thus, at the 333Hz crossover frequency, the woofer is still largely omnidirectional, while the axial output of the rear-mounted midrange is significantly attenuated. The resulting frequency response is significantly smoother. The rear midrange's output on the forward axis peaks at about 400Hz with a level of −19dB.

In *Fig. 7*, the rear midrange is omitted and the front-mounted midrange driver is unenclosed, as in *Fig. 5*. The HF baffle is again four times wider than the LF baffle, so the differences in the graphs in *Figs. 6* and *7* arise solely from the polarity reversal of the midrange's rear output.

If you make the ratio between the widths of the HF and LF baffles greater than 4, then still greater improvements in frequency response result. However, the resulting loudspeaker may become aesthetically unacceptable.

BR1 PROTOTYPE

I built a prototype BRR speaker using an unenclosed midrange and all-SEAS drivers. For aesthetic reasons I settled on a 3:1 baffle-size ratio, with a three-piece angled HF baffle. Even so, it's got a "you either love it or you hate it" appearance (*Photo 1*).

Figure 8 shows the predicted and measured on-axis response. I now believe that the hump in the measured response at 400Hz was due to the specific parameters used in the MLSSA measurement at the time. Some midrange anomalies remain, but ±2dB is probably a fair specification for most of the frequency range.

Measurements at 0°, 30°, 60°, 90°, 120°,

Continued on page 50

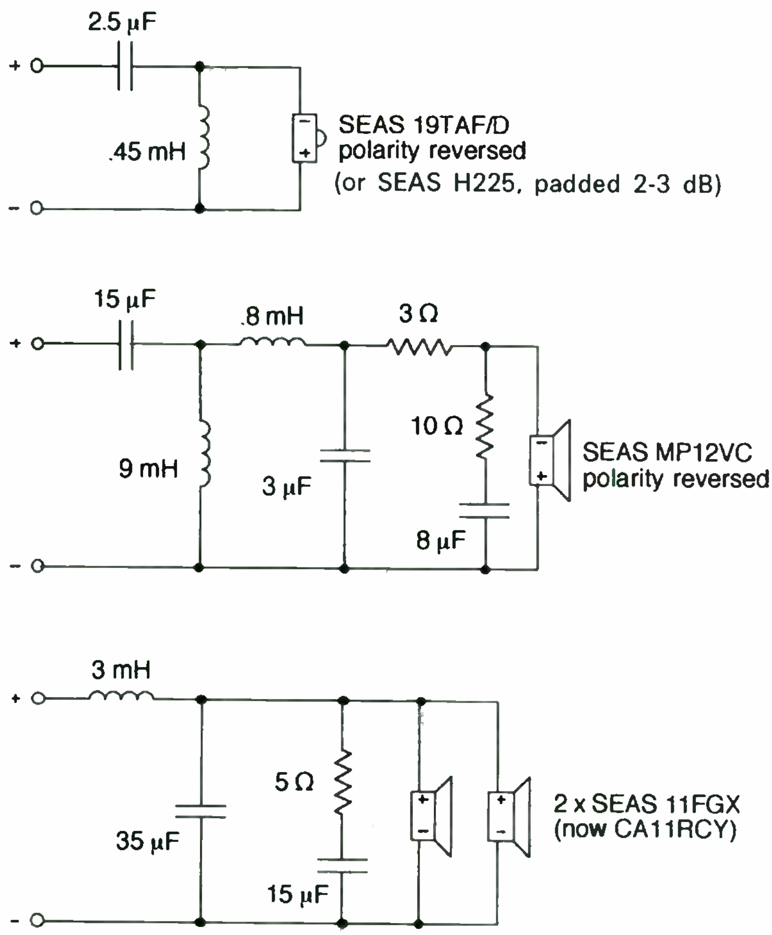

FIGURE 11: BR1 crossover design.

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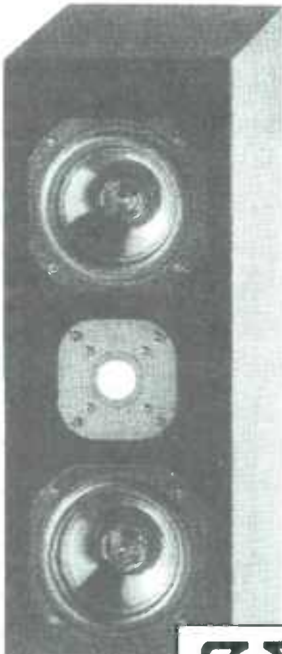

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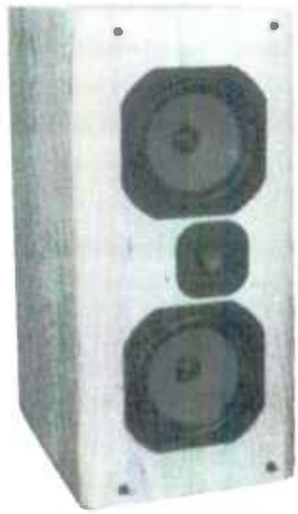

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THE SUPER SIMPLINE

By John Cockroft

Over the years I have probably listened to my Simpline loudspeakers (*SB* 2/93, p. 14) more than any other system. They have a natural, detailed quality that I find endearing. The Super Simpline was not born out of my belief that the Simplines required improvement. I have always been happy with them. My impulsive curiosity and the means at hand to appease it resulted in this new, improved version.

I had received four Dayton 275-060 tweeters, which were on sale from Parts Express. I ordered them because they seemed to be a good bargain, and I probably could eventually use them. (They were, and I did.) I was curious about their performance.

The tweeters appeared to be a take-off of the Audax TW 75 series of tweeters, which I had used for years. I assumed that the general impedance curve might be similar. The Dayton tweeters had an R_E about 1.2Ω higher than Audax units, which I took into account in determining the high-pass and attenuator-network filter for the Super Simpline.

PRELUDE TO A PROJECT

The shape of the Dayton tweeter faceplate allowed me to easily mount it as an extension to the Simpline's baffle. I then hooked everything together with wire, crocodile clips, and banana jacks.

I decided to use the Dayton as a super tweeter to augment the Simpline with its contour filter rather than replace the filter and design a conventional crossover. I believed that approach would degrade the already excellent sound and sonic balance of the Simpline and would cause complications. This is inconsistent with the philosophy that birthed the Simpline in the first place.

I spent an evening manipulating components and finally arrived at a surprisingly pleasant sound. I spent many more evenings reassuring myself of the validity of that surprise and pleasure. My reassurance was so complete that I believe others who have built and listened to Simplines might also be pleased. I hope I am right.

This project's best feature is how easily and inexpensively it can be achieved. Other than the Dayton tweeters, which Parts Express sells for $6.50 each, you simply need some hook-up wire (I used 16-gauge zip cord, but you could also use #18); a 1.5μF capacitor; a 5 or 10W, 3Ω resistor; and two #6 × ½″ panhead sheet-metal screws for each tweeter.

I mounted the tweeter on the baffle of the Simpline, with the tweeter facing upward (*Fig. 1*). One end of the tweeter faceplate overlaps the front of the baffle (the edge facing the listener) by about 5/8″ (leave a bit of space between the inboard tweeter input terminal and the front edge of the baffle after soldering the connecting wire to the terminal, to avoid pressure on the terminal). For consistency's sake, I placed the positive (red) terminal in the outboard position facing away from the baffle (*Fig. 2*).

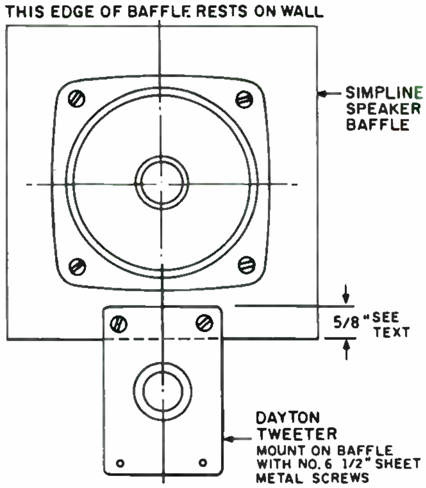

FIGURE 1: Location details for the retrofit Dayton tweeter.

CONSTRUCTION

While holding the tweeter in position (centered on the front edge of the baffle), trace the inside of the tweeter mounting holes to mark the screw locations. Indent the locations with a center punch or a small nail and drill holes about halfway through the baffle with a 1/16″ drill bit. You can wrap a bit of tape around the bit, at the proper place, to indicate the drill depth.

It is easier to solder the wires to the tweeter terminals before screwing the tweeters in place. Mark both ends of at least one wire with the proper polarity so the hookup is in the proper order (*Fig. 3*).

Perhaps before you wire, you should decide where to put the high-pass and attenuation filter. Most builders will prefer the inside of the lower end of the enclosure, which is fine. If you are building a new Simpline from scratch, you could run the wires inside, by drilling a hole a couple of inches below the tweeter and poking the wires down through the stuffing in the same manner as the original wires. I leave these mechanics to you.

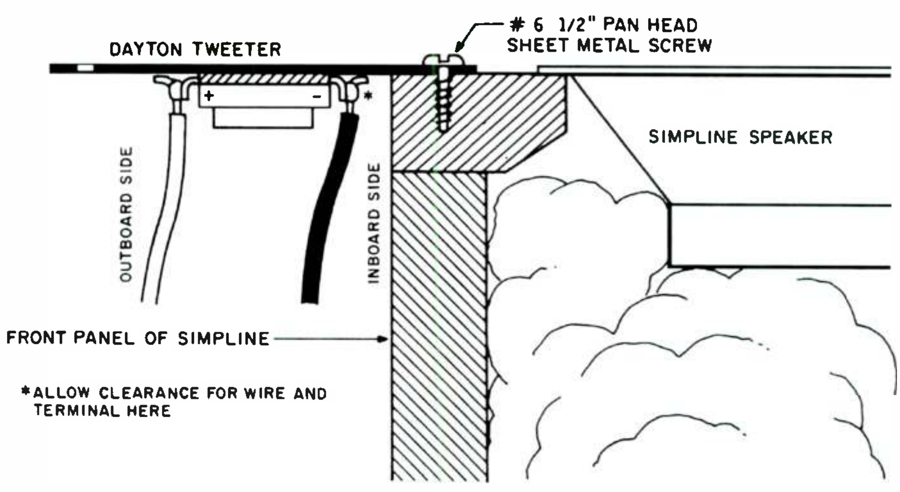

FIGURE 2: Additional details of Dayton tweeter mounting on Simpline speaker baffle.

TABLE 1

SUPER SIMPLINE PARTS LIST

Required to turn a pair of Simplines into a pair of Super Simplines:

2 ea	Dayton ½″ Mylar® dome tweeters #275-060 @ $6.50
2 ea	1.5µF Solen metallized polypropylene capacitors #027-528 @ $2.15
2 ea	3Ω 10W wire-wound resistors @ $.39
Misc.	Wire, solder, DAP Kwik Seal (or RTV)

You can purchase everything above, except the miscellaneous stuff, from Parts Express. Minimum order is $20. The above costs $18.08, so order an extra component to avoid the service charge.

The easiest way to assemble the filter is on a piece of cardboard, using RTV or caulking material, such as DAP Kwik Seal. Then mount the cardboard on the enclosure with the same material. In case you need to remove the filter, simply slide a knife blade between the cardboard and the enclosure. Attaching is just as simple.

Connect the positive (red) tweeter terminal wire to one end of the resistor, and the other end of the resistor to one end of the capacitor. The other end of the capacitor connects to the positive input terminal of the Simpline. The negative terminal wire goes to the negative terminal (*Fig. 3*).

BOUNCING 'ROUND THE ROOM

The tweeter appears to be in an excellent position for integrating into the sound of the Simpline. When you lean the Super Simpline against the wall in the prescribed manner (*Fig. 4*), the tweeter sound reflects off both the wall behind the enclosure and the ceiling, at the same angles as the main

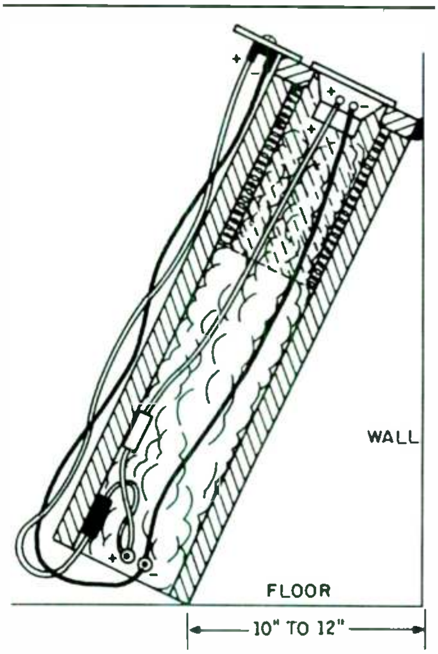

FIGURE 4: The Super Simpline.

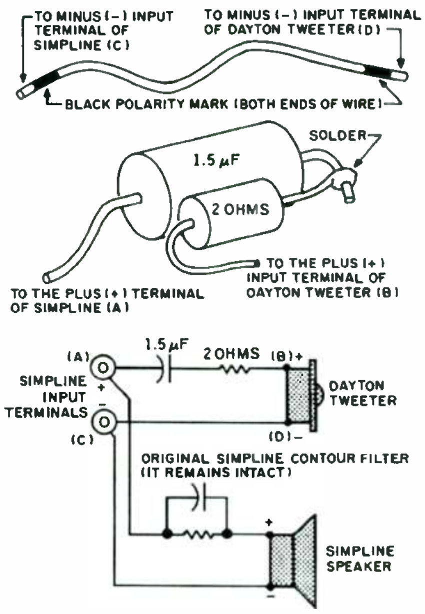

FIGURE 3: Pictorial and schematic views of the Super Simpline tweeter contour filter.

speaker, but a bit farther from the wall and slightly higher up. The on-axis (from the viewpoint of the tweeter, not the listener) sound from the tweeter reflects from the wall and from the ceiling, prior to entering the listening area. The fringe off-axis sound bounces only once (off the wall on the inboard side of the tweeter and off the ceiling on the outboard side).

These sonic actions allow me to increase the power response of the tweeter while avoiding the uncomfortable feeling of being hosed down by high-level tweeters. The reflections to the sides are not early reflections. The Super Simpline's sound is easy to listen to for long periods of time.

I continue to think about the looks of the Simpline. I haven't yet developed a substitute format that retains all of the sonic qualities of the leaning version. The addition of the super tweeter confirms my belief that the Simplines simply need to lean against the wall to do their job in an upright fashion.

SO, HOW'S IT SOUND?

The moment of truth was at hand. As I played the music, the sound caressed my ears. The Simplines and Super Simplines will enjoy the best of electronics that you can offer them, and, in appreciation, will repay you to your heart's delight.

POSTSCRIPT

A few days after writing this article, I received a copy of *Stereophile*'s new Test CD 3. It seemed natural to test it on the Super Simplines.

The channel identification and tone tracks showed that all was well, so I proceeded. All of this CD's music tracks are superb, reinforcing my belief that the Super Simpline thrives on the very best input material. I'm acutely aware, and a little embarrassed, that I'm using a pair of $35 speaker systems to critically judge (favorably) a test CD that appears, in all respects, to have been made on the finest equipment. The results are definitive in all respects (except for the very low bass). The Super Simplines did quite well down to the 50Hz warble tones, below which they needed to relax a bit and rest.

As I listened to this CD, my mind, unusually in the throes of a bit of inflated ego (I suppose), waffles between two beliefs: one, that the Test CD 3 is showing off my Super Simplines; and, two, that the Super Simps are showing off the Test CD 3. Whichever it is, the two items are a delightful duo. I always found it a bit sad when a cut ended.

The tutorial tracks are almost as much fun as the musical cuts. The chromatic scales on cut 16 were a revelation to me. Now I know why the Super Simps sound so smooth—because they are. Listening to the music on track 9 really made me a very proud (and a very astounded) Papa indeed. I recommend that anyone building the Super Simplines obtain a copy of this CD, which presents the Super Simp in its kindest and most impressive light so far. Thanks for a job well done, Mr. Atkinson.

My equipment included a Carver DTL-200MK2 (with the Digital Time Lens turned off) CD player, connected to a box containing a Radio Shack 100kΩ stereo volume control. I hooked directly into my Adcom GFA-535 power amplifier, then to the Simplines via 14-gauge stranded copper wire.

Note: If you plan to reread the original Simpline article, it contains some typographical mistakes (I guess the printer's devil did 'em). The corrected text was published in the letter column of the succeeding issue (*SB* 3/93, p. 65).

SOURCE

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BUILD AN ACTIVE CROSSOVER NETWORK

By Rickard Berglund

Active crossover networks include active high- and low-pass filter sections, used between the preamplifier and power amplifier. They offer many advantages: lower IM distortion, better amplifier/speaker coupling for woofers, a damping-factor adjustment for each loudspeaker element, easier control over driver sensitivity differences, and the possible use of cheaper tube amplifiers (e.g., if you have one amplifier that sounds good in the bass and another that sounds good only in the treble, you can add this to the amplifiers).

POWER SUPPLY

Figure 1 shows the power supply, which uses 6CW5/EL86 as a pass element. This tube gives four times more current for a given voltage drop than 6BQ5/EL84. It can also handle more heat-to-cathode voltage and costs less. *Table 1* shows the parts list.

The positive regulator has a conventional design; the negative regulator uses screen-grid drive for the pass tube. The load regulator for a zero to 50mA change is 2V for the positive regulator and 4V for the negative regulator.

The power-supply rejection ratio is 33dB for the positive and 30dB for the negative at 25mA load, while the line regulation is 27dB for the positive and 30dB for the negative 25mA load. Both the PSRR and the line regulation are load dependent and measure 6dB higher with no load than with a 50mA load.

You can also use this power supply for equalizers and tube op amps.

FILTER SECTIONS

The filter sections use a unity gain amplifier

TABLE 1

POWER SUPPLY PARTS LIST

PART	DESCRIPTION
C101	680nF
C102, 103	220µF, 300V
C104	2,200µF, 63V*
D101, 102	51V Zener, 0.4W
D103–105	100V 1W Zener
D106–109	600V, 1A**
D110–113	200V, 2A**
F101–102	2A slow blow
F103–104	80mA
F105–106	500mA slow blow
F107	2A slow blow
T101	2 × 170V 100mA
	6.3V, 0.8A
	6.3V, 1.4A
R101	12k
R102	56k
R103	33k
R104, 105	22k
R106, 107	1.2kΩ
R108–110	100Ω
R111–112	100kΩ
R113	100Ω
V101, 104	6CW5/EL86
V102, 103	6EJ7/EF184 or 6JC6A

*1,000µF 100V if you use eight or ten 9JW8 tubes
**use fast-recovery diodes

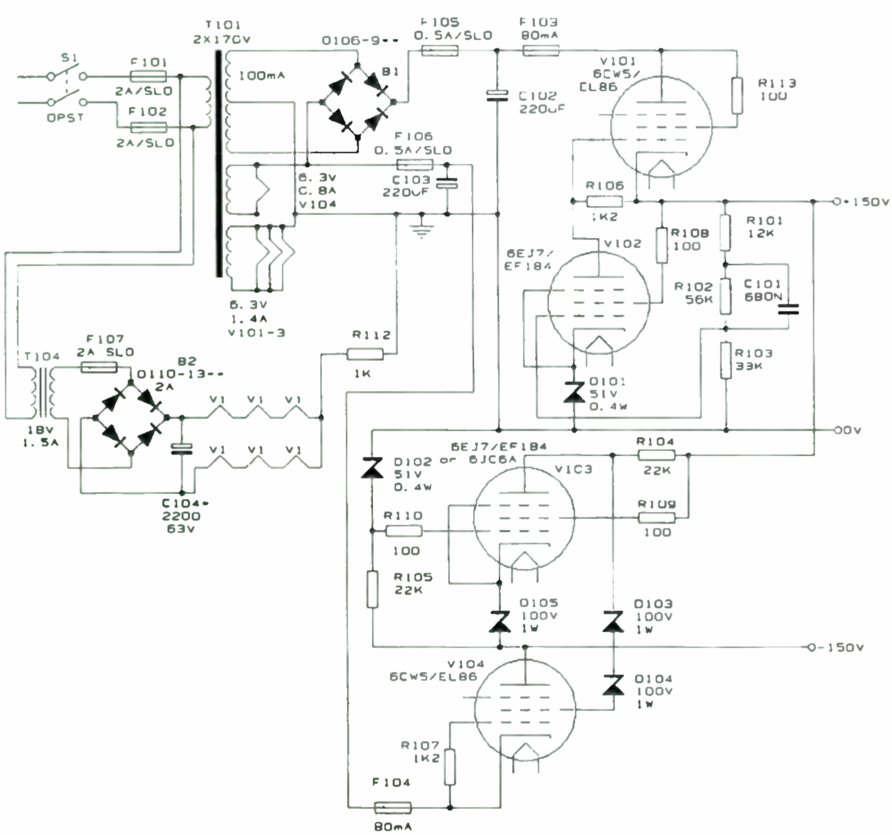

FIGURE 1: Power supply.

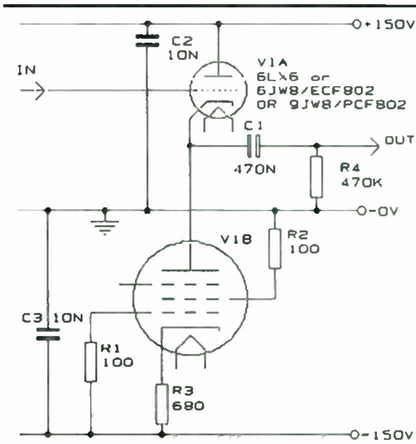

FIGURE 2: Unity gain stage.

TABLE 2

GAIN STAGE PARTS LIST

C1	470n 160V PP
C2, 3	10n 200V PP or ceramic
R1, 2	100Ω
R3	680Ω
R4	470k
V1	6LX8, 6JW8/ECF802, or 9JW8/PCF802

TABLE 3

THE FOURTH SECONDARY WINDING

NO. OF TUBES	6LX8	6JW8	9JW8
4	18V 0.9A	19V 0.9A	28V 0.6A
6	28V 0.9A	29V 0.9A	42V 0.6A
8	37V 0.9A	39V 0.9A	55V 0.6A
10	46V 0.9A	48V 0.9A	69V 0.6A

TABLE 4

SECOND-ORDER BUTTERWORTH AND FOURTH-ORDER LINKWITZ-RILEY

Frequency	C1	C2	C3, C4
80Hz	85n	42.5n	42.5n
240Hz	28n	14n	14n
500Hz	13.6n	6.8n	6.8n
1kHz	6.8n	3.4n	3.4n
3kHz	2.2n	1.1n	1.1n
5kHz	1.36n	0.68n	0.68n

(*Fig. 2*). Tube choices include the 6LX8, 6JW8 or 9JW8—which are basically the same tubes, but with different heater voltages of 6, 6.3, and 9V, respectively (*Table 3*). The heaters are connected in series, and all tubes must be the same type. You can use a transformer with higher voltage than in *Table 2*, but then you must connect a resistor in series with the filaments.

The triode section of this tube has a transconductance of 3.5 millisiemens (mS), which gives an output impedance of 280Ω. The mu factor is 70, so the gain is 0.986. The pentode section works as a current generator yielding approximately 3.5mA.

Figures 3–7 show different types of filters, all calculated to achieve a crossover frequency of 1kHz. If you prefer another

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TABLE 5

SECOND-ORDER BESSEL CROSSOVER

Frequency	C1	C2	C3, C4
80Hz	55n	41n	42.5n
240Hz	18.3n	13.8n	14.2n
500Hz	8.8n	6.6n	6.8n
1kHz	4.4n	3.3n	3.4n
3kHz	1.5n	1.1n	1.1n
5kHz	0.88n	0.66n	0.68n

TABLE 6

THIRD-ORDER BUTTERWORTH CROSSOVER

Frequency	C1	C2	C3	C4, C5, C6
80Hz	212n	84n	12.2n	41n
240Hz	71n	28n	4.1n	13.8n
500Hz	34n	13.4n	1.95n	6.6n
1kHz	17n	6.7n	975p	3.3n
3kHz	5.7n	2.2n	325p	1.1n
5kHz	3.4n	1.34n	195p	660p

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Another brand of metallized polypropylene capacitors ? Well, not exactly ... At Orca we have been thinking for a while about how to make polypro caps more affordable for a larger number of speaker builders, people who use caps only for speaker passive X-over network. We thought that it would be tremendous if we could offer a line of polypro caps that would be so affordable that people would have no reason to use cheap mylar, as they would be able to get for not much more money a much much better cap. As you know, even extremely powerful solid state amps (we are talking KW here) can barely produce rail voltage higher than 60 V. So it is safe to assume that a 100 VDC cap would be a pretty robust cap to use in a passive loudspeaker network. So to be really safe, we decided to make all the AXON cap of our FINE CAP basic line 250 VDC. Now that's about where the compromises start and stop. On the other hand for example, you may or may not know that when a cap value is said to be 10.0 µF with 5% precision, it means that the manufacturer of caps sets its winding machine to 9.7 µF and then produces this series with 2% tolerance (not very difficult with numeric controlled winding machines). The result: the manufacturer saves more than 3% in material, the precision is respected, but chances are all your caps will measure on the low side ! Orca made the special arrangement that all the AXON caps were to be wound with 5% precision with the target value set at exactly the nominal value. That means now, as most of you do, and rightly so, expect, that you should find a much greater proportion of caps very close to exactly 10.0 µF, if not 10.0 µF exactly! As for the rest, we could display here all sorts of figures and graphs that would only makes sense to 1% of our customers, but what for ? We can simply tell you this is the first polypro cap at a price closing on mylar caps. It is made by the same company that makes all our high voltage and very high voltage SCR caps, as well as our film and foil caps. Some of the best loudspeaker manufacturers have already made that easy choice. Now see for yourself and ... let your ears make the call.

Value µF	Diameter mm	Length mm	SRP US$	Value µF	Diameter mm	Length mm	SRP US$
1.0	11	21	1.23	12.0	25	33	3.56
1.5	12	22	1.44	15.0	25	38	4.18
1.8	13	22	1.49	20.0	29	38	5.16
2.2	15	22	1.58	24.0	29	43	5.98
2.7	14	25	1.67	30.0	32	43	7.30
3.0	15	25	1.73	33.0	32	48	7.74
3.3	16	25	1.78	41.0	35	48	9.32
3.9	16	25	1.83	50.0	37	53	10.96
4.7	18	27	1.96	51.0	37	53	11.16
5.6	18	30	2.10	56.0	39	53	12.00
6.0	19	30	2.20	62.0	39	53	12.98
6.8	20	30	2.33	75.0	43	58	15.12
8.0	20	33	2.91	82.0	45	58	16.28
8.2	21	33	2.97	91.0	47	58	17.50
9.1	22	33	3.08	100.0	49	58	18.76
10.0	23	33	3.23	120.0	51	63	21.98
11.0	24	33	3.38	130.0	54	63	23.38

BLACK HOLE

High efficiency dampening products from ORCA

A better speaker damping material...

If you've been building speakers for some time, you know how much guesswork goes with speaker damping and stuffing. The choices seem endless: fiberglass, wool, Dacron, flat foam, convoluted foam, felt, tar, plus various "magic" compounds that you're invited to brush or pour into your new cabinets. Everyone has their own recipe, and who knows if it's a recipe for disaster? Or what effects the vapors emitted by these chemicals might have on the glues that bond your woofer surround to its cone and chassis? In this era of costly, space-age drivers and computer-assisted design, we think such risks are totally unacceptable. So we went to work to find the ideal solution.

The problems are fairly well-known: a driver transforms electrical energy into mechanical energy. This mechanical energy is transformed into acoustical energy which is radiated to the outside of the cabinet - the useful front wave - and to the inside - the sometimes-useful back wave. Unfortunately, it is also transmitted though the frame of the driver to the cabinet itself, which acts as a very large "cone" of very small excursion. This means that the spurious resonances and vibrations of the cabinet have to be controlled in a predictable and reproduceable way. That's how we came to BLACK HOLE 5 and the BLACK HOLE PAD.

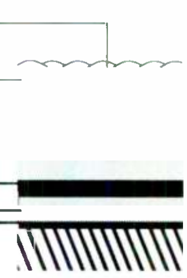
First, THE PAD. It's a thin (1/16 inch) black flexible viscoelastic damping material (filled vinyl copolymer) with maximum performance between 50 and 100 degrees F (we hope that that covers the temperature range of your listening room) and excellent flame resistance - it meets UL94 V-O. Thanks to its outstanding damping characteristics, THE PAD will dramatically reduce the vibration energy stored in the walls to which it is applied.

Easy to cut and apply, THE PAD has a pressure-sensitive adhesive back: simply peel off the release paper and press hard onto a clean surface. You can use THE PAD on just about anything you suspect of vibrating: driver frames, thin panels like car doors, and, of course, the walls of your speaker cabinets. And it can be used to recess a driver without using a router: just laminate enough layers to match the thickness of the driver frame and apply to the front baffle. Finally, it is the ideal material for "constrained layer" wall construction, where two panels are laminated on each side of a damping material for optimum transmission loss. Because THE PAD has a fine grain leather finish, you can wrap an entire cabinet exterior and give it an attractive appearance at the same time!

For applications which require **maximum damping, isolation and absorption,** we've developed BLACK HOLE 5. One and 3/8" thick, BLACK HOLE 5 is a high-loss laminate that provides optimum acoustical damping performance. It consists of five layers:

Thin diamond-pattern embossing, densified with a polyurethane film surface. This unique surface layer dramatically improves the performance of the whole acoustical system, especially the lower mid-range and mid-bass frequencies where simple acoustical foam loses its effectiveness.

One-inch deep polyester urethane foam, structurally optimized for acoustical damping. Highly effective at "soaking" maximum sound energy with minimum thickness.



Barrier septum, 1/8 inch thick. Made of limp flexible vinyl copolymer loaded with non-lead inorganic fillers, it is a "dead wall" that isolates the vibrations in the walls of your cabinet from the vibrations created inside the enclosure.

Polyester urethane flexible open-cell foam, 1/4 inch thick. Thanks to special vibration-isolation characteristics, it decouples the vibrating structure (the wall) from the rest of the damping system, thus optimizing performance.

High-loss vibration damping material, same as The Pad. It is strongly bonded to the cabinet wall with pressure sensitive adhesive.

These layers are laminated using an adhesive-free mechanical and thermal process, thus optimizing performance and eliminating the risk of solvent fume damage. BLACK HOLE 5 can be used in any enclosure, as well as for acoustical panels to improve the characteristics of your listening room. *YOU PROVIDE THE MUSIC; BLACK HOLE FIVE WILL TAKE CARE OF THE NOISE!*

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AΞON Cables — *New from ORCA!*

AX-ON (Greek axon, axis): that part of a nerve cell through which impulses travel away from the cell body. AXON 8 speaker cable combines outstanding design features with component quality usually associated with the most expensive cable. With eight AXON 1 solid-core conductors and utilizing mylar/ polypropylene construction, AXON 8 offers outstanding performance for amp-speaker connections and perfectionist internal speaker wiring. Our superb AXON 1 AWG 20 solid core conductor is also available separately. Oxygen-free and 99.997% pure, it is ideal for most internal wiring applications.

Outer insulation: UL approved TPE
Cable geometry: non interleaved spiral
Individual conductor insulation: 105 degree Celsius, UL approved PVC
Cable equivalent gauge: total - AWG 11, 2 conductors - AWG 17, 4 conductors - AWG 14
Individual conductors: solid core AWG 20 copper, long-grain and ultra-soft, free of all contaminants and oxygen.
Cable core: crushed polypropylene
Inner envelope: mylar film

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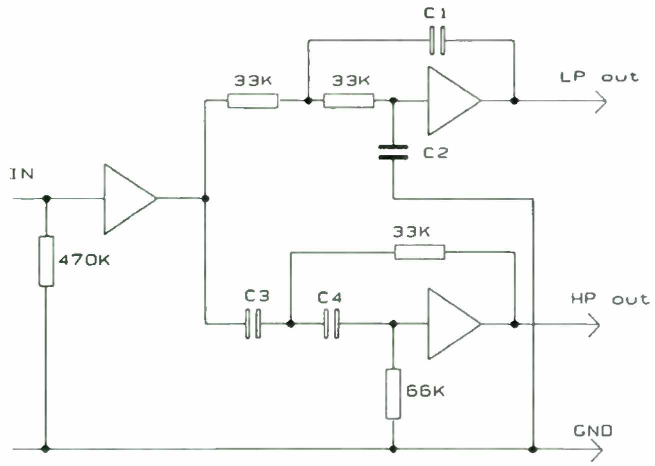

FIGURE 3: Second-order Butterworth crossover.

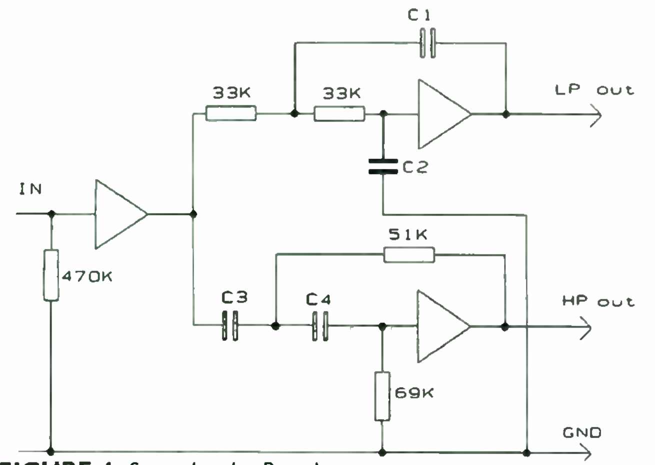

FIGURE 4: Second-order Bessel crossover.

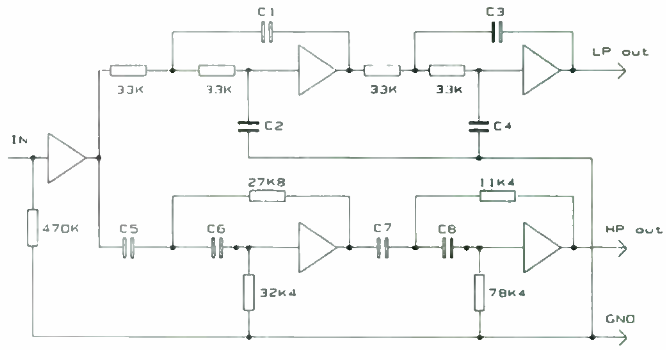

FIGURE 6: Fourth-order Butterworth crossover.

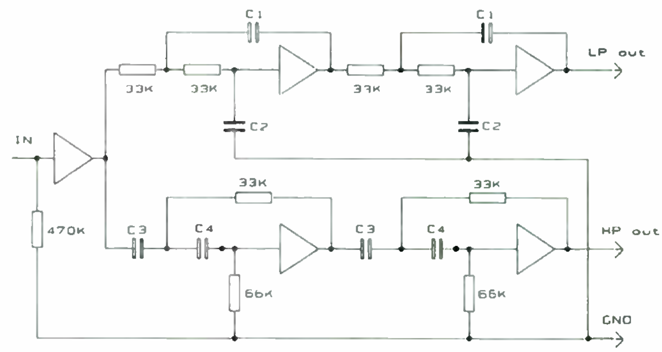

FIGURE 7: Fourth-order Linkwitz-Riley crossover.

from page 21

frequency, you must change the capacitor values so they are inversely proportional to the frequencies (e.g., for a 300Hz crossover, you must multiply the capacitor value times 3.33; for a 5kHz crossover, multiply the capacitor value times 0.2). *Tables 4–7* contain the capacitor values for the various crossover points.

The filters used show a unity gain stage as input. If your preamp already has a low impedance output, such as a cathode follower, you don't need the input buffer. You must always have a 470kΩ resistor from input to ground. If you use a single bass speaker in a stereo system, build your crossover as shown in *Fig. 8*.

TABLE 7

FOURTH-ORDER BUTTERWORTH CROSSOVER

Frequency	C1	C2	C3	C4	C5, C6, C7, C8
80Hz	65n	55.6n	158n	23n	66n
240Hz	1.7n	18.5n	52.5n	7.7n	22n
500Hz	10.4n	8.9n	25.2n	3.7n	10.6n
1kHz	5.2n	4.45n	12.6n	1.84n	5.3n
3kHz	1.73n	1.5n	4.2n	610p	1.8n
5kHz	1n	890p	2.5n	370p	1.06n

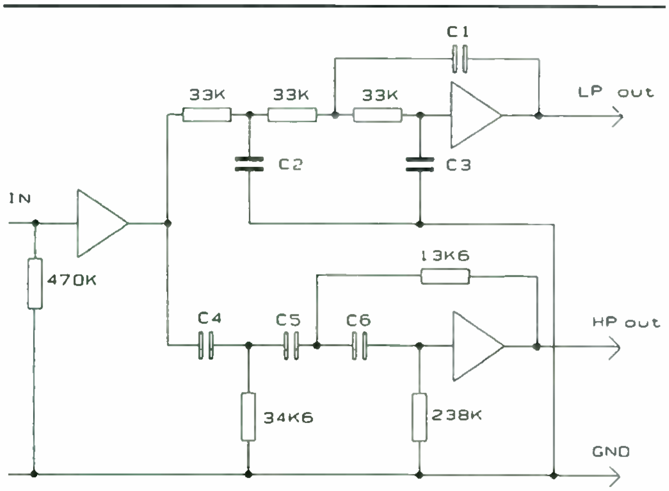

FIGURE 5: Third-order Butterworth crossover.

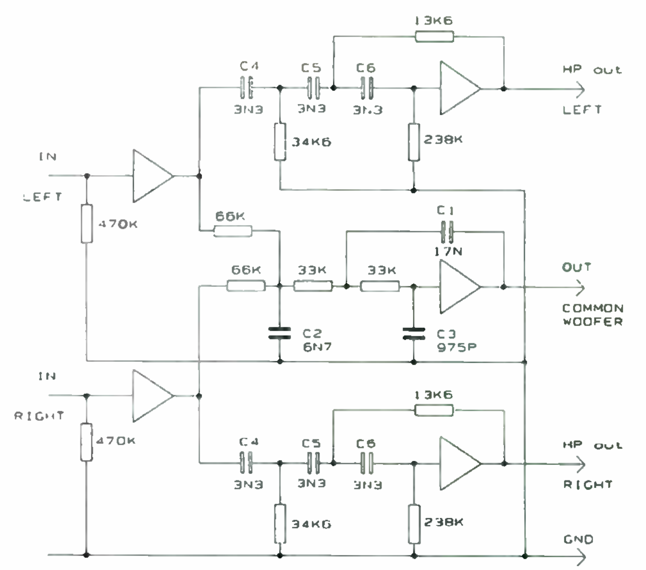

FIGURE 8: Third-order Butterworth crossover for a common woofer system.

SPEAKER DESIGN AND THE INTERNET

By Dan Hildebrand

Over a year ago I encountered a high-quality sound system that motivated me to upgrade my own uninspiring "rack." Since my background was in operating systems and computer hardware, my analog electronics skills were ancient history, but buying equipment "off the shelf" did not appeal to me. I prefer the do-it-yourself (DIY) approach, so I began reading everything in sight to refresh my atrophied analog skills.

THE SEARCH

My goal was to build a set of speakers that would deliver the impressive extended bass response and spacious detail of high-end audio systems. While prepared to spend considerable time building this system, I needed to accept fiscal realities and stick to a budget as well. I began to search the literature for ideas on building a high-end, yet still reasonably cost-effective, home system (*Photo 1*).

The Internet provided access to messages posted by participants in the audio-related newsgroups (such as rec.audio.tech and rec.audio.high-end). After six months of "lurking" (reading the discussions without contributing much), I was finally ready to begin construction. Coincidentally, some people within the rec.audio groups were starting an electronic mailing list for "discussions pertaining to the reproduction of deep bass." Perfect timing! Ultimately, the acquaintances and friendships I made through the Internet proved invaluable to the successful completion of this project (see Internet Audio Resources sidebar).

Several mailing-list members (headed by Douglas Purl) decided to pool our purchasing power and place a volume order for NHT1259s from A&S Speakers. Subsequently, A&S sold over a hundred of these woofers to the mailing-list members. The success of this effort (perhaps an Internet first) demonstrates a good use of the system to coordinate the interests and purchasing power of a large group of geographically distributed, but like-minded, people.

ABOUT THE AUTHOR

Dan Hildebrand is a senior R&D staff member at QNX Software Systems, Ltd., doing POSIX microkernel OS development work. Although a software developer today, through these speakers and recent work on tube amps, he has rediscovered his hobbyist roots and an enthusiasm for analog electronics.

PHOTO 1: The author's subwoofer/satellite system.

BUILDING A SUBWOOFER

The NHT1259 woofer, which was very favorably reviewed in *Stereophile*[1], has a 12″ polypropylene cone, butyl-rubber surround, heavy cast-aluminum frame, and a 59 oz magnet (hence the "1259" designation). It has many high-quality characteristics, such as a bumped backplate to prevent the voice coil from striking against the structure during full excursion. This woofer weighs 10 lbs and is manufactured for NHT by Tonegen. (See the NHT1259 sidebar for more details.)

While magazines and books contained good material on the design of crossovers, they lacked detailed information on cabinet construction. Again, while browsing the Internet newsgroups, I found a reference to the North Creek Music Systems' *Cabinet Handbook*[2], which I ordered for a small fee. I highly recommend this booklet, which shows there's a lot more to speaker-cabinet building than just good carpentry skills.

CABINET CONSTRUCTION

I used 1″ MDF for the exterior cabinet walls and ¾″ Baltic birch (13 ply, no voids) for the interior braces. I chose the birch plywood for the braces because it is *much* stiffer than either MDF or hardwood and is also void-free. MDF worked for the exterior panels because of its high internal damping characteristics, uniform density, and machinability (not because of its stiffness).

The birch braces run vertically in the cabinet, with the front baffle supported against the first brace by four 1-inch-diameter maple dowels a couple inches in from each corner (*Fig. 1*). Another four dowels hold this first brace against the next one, which is finally braced against the back wall. Each of the birch braces has a 7″ circular hole cut in the center. Since the back panel is the largest unsupported component of the cabinet, I fastened a "rib" made from a 2-inch-wide strip of birch to the back panel to reduce panel flexing.

Following a North Creek guideline, I spaced the vertical braces one-third and five-eighths of the distance from back to front (measured from the center of each panel, not from the interior or exterior edges). This spacing distributes standing wave modes between the subpanels to ensure that no one resonant mode is dominant.[3]

I constructed the box with butt joints by drilling 1/8″ pilot holes for screws every 4″ along the glue joint. I used corner clamps to hold the panels at 90° angles while drilling and gluing the panels (with a liberal coating of carpenter's wood glue). I used two-inch, Robertson-head (square-head) decking screws, instead of the more common Phillips-head drywall screws[4], because they more easily accept torque from a screw gun.

Decking screws have a coarse thread that stops ¾″ below the head of the screw, allowing the threads cutting into the second piece of wood to pull the first piece tightly into contact. In fact, they pull themselves into the MDF so well that I didn't need to countersink the screw heads at all—the screw literally pulled its head beneath the surface of the MDF. Because of the large number of screws to be applied (over 2 lbs), a screw gun is not an option!

Using a screw every 4″ makes the joint

self-clamping, removing the need for numerous large clamps. This technique allows you to set and screw one joint and immediately move on to the next without waiting for the glue to set. The joints are so well-clamped by the screws that there's no doubt of them being air-tight, which is very important given the acoustic-suspension nature of the NHT1259 design and the powerful pressure waves it generates. Since I planned to router the edges of the cabinet later, I removed the screws after the joints were set and filled the holes with plastic wood.

During assembly, and especially during insertion of the dowels between the vertical braces, I tapped on the cabinet to hear its resonant frequency increase with the addition of each brace. The final cabinet is very stiff. Although no individual piece of the cabinet was overly heavy, the finished subwoofers weigh 100 lbs each.

CABINET DAMPING

Very stiff cabinets exhibit panel resonances high enough in frequency that damping becomes very effective. The NCMS booklet suggests coating the interior walls (but not the braces) with "glop" to deaden them. Glop is a mixture of a nontoxic, soft-setting glue and large-crystal sand (1 part glue, 1.5–2 parts sand). Before mixing the glop, bake the sand in an oven until powder-dry to sterilize it.

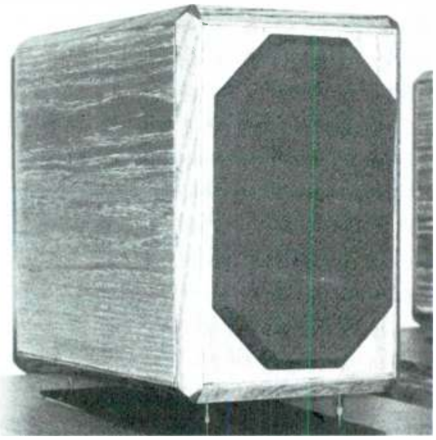

PHOTO 2: The system features an octagonal grille design.

North Creek recommends a glue derived from Aileen's "Super Tacky" glue that has a greatly reduced drying time. Tacky glues are commonly available in craft stores and look much like white wood glue and dry clear, but remain pliable when dry (which takes about 24 hours). This nontoxic glue will not produce vapors harmful to the adhesives that hold the driver and its suspension together.

Mix and blend the glop thoroughly, com-

INTERNET AUDIO RESOURCES

In addition to the rec.audio newsgroups, if you have E-mail access to the Internet, you can participate in the bass and DIY speaker mailing list by sending an E-mail message to:

majordomo@lunch.engr.sgi.com

The subject of the message isn't critical, but the message content should be:

subscribe bass-digest

end

From this point on, you should receive E-mail messages that contain the discussions of the bass mailing list. Typical traffic is one or two lengthy E-mails per day.

Also, if you have access to a "World Wide Web" browser, such as Mosaic or Netscape, you can access on-line pictures of the satellites and subwoofers described in this article by connecting to:

http://www.qnx.com/~danh/

A number of other Internet audio resources are also reachable through this "web page."

pletely coating each grain of sand. You'll know the mixture is ready when your arm is about to fall off: the mixture becomes *very* stiff and heavy.

Apply a ¼-inch-thick layer of glop with a trowel or with your hands (the glue washes off easily) on the center, unsupported area of each panel. The layer will "dry" to approximately 1/8″ thickness, adding more damping to the panels without adding much weight. Harwood suggests covering approximately 50% of the panel area, concentrating on the unsupported center.[5] The downside of this glop is its lengthy drying time of 24 hours (unless you use NCMS's glue), which limits the length of time you can work on the cabinets each day.

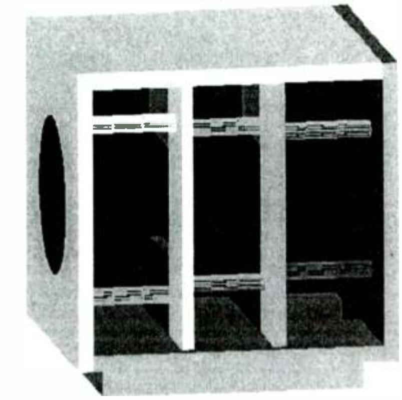

FIGURE 1: View of the NHT1259 cabinet with the right-side cabinet wall removed.

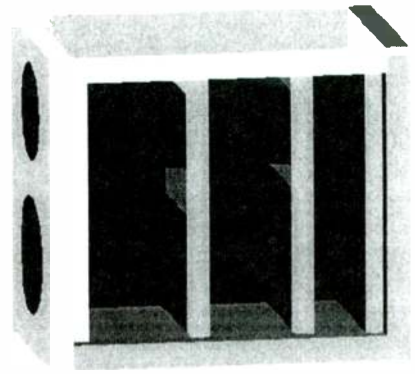

FIGURE 2: Side view of the satellite cabinet with the right-side panel removed.

FRONT AND BACK PANELS

The NCMS booklet also recommends using "tacky" glue to construct laminated front and back cabinet panels, MDF on the outside, Baltic birch on the inside. The two panels with dissimilar resonant characteristics, joined with a pliable adhesive, result in a very stiff, acoustically dead panel. I elected to use only a single, 1″ thickness of MDF for

NHT1259

A discussion with Bill Bush, chief engineer for the IJI Specialty Audio Group (NHT/AR) and designer of the NHT1259 bass driver.

Q: Why build an acoustic-suspension subwoofer when most designers seem to be going with vented enclosures, noted for their higher efficiency and extended bass?

A: Although drivers for acoustic-suspension enclosures are more difficult to manufacture, test, and ship than drivers for vented boxes, we believed that the technical advantages of an acoustic-suspension driver were needed to meet our performance goals for the NHT 3.3. For subwoofer applications, an acoustic-suspension design has a number of advantages:

1. A vented box has a fourth-order rolloff below resonance, while an acoustic-suspension design, being a second-order system, continues to sustain more bass output below the resonant point. So even though the response may be dropping off, the acoustic-suspension system still generates output where the vented box has already rolled off.

2. The driver in an acoustic-suspension box remains "loaded" below resonance and is unlikely to hit its excursion limits. In a vented-box design, the driver is "unloaded" below resonance and likely to hit its excursion limits. A vented-box design requires a subsonic filter to control this effect if you're going to drive it with high levels of low bass.

Q: Why was the very high X_{MAX} figure of 13mm a design goal in the NHT1259?

A: With a small X_{MAX} and high output levels, the voice coil would be more likely to be driven out of the magnetic gap, which leaves the speaker cone traveling under its own inertia rather than under the control of the amplifier. With a large X_{MAX} design, the voice coil always remains within the magnetic gap, under the control of the amplifier. The result is "tighter," more controlled bass and less distortion.

Q: In the NHT 3.3 speaker system, the NHT1259 driver is unconventionally "aimed" along the wall rather than into the listening room, while the remainder of the drivers in the cabinet are aimed into the listening room. Why this unusual "corner loading" approach?

A: People often will set up a pair of speakers in their listening room for good imaging, but then find that the distances from the back and side walls cause a level and phase mismatch between the bass and midrange. To control this problem, you should place the NHT 3.3s 3–9″ from the back wall so the acoustical loading experienced by the NHT1259 driver when emitting upper bass is a known constant. The designed crossover within the NHT 3.3 then smoothly blends the midrange and bass drivers with this controlled phase and amplitude room response. You can then vary the spacing between the NHT 3.3s to achieve good imaging without needing to readjust for room response. This largely removes tonal balance as a setup variable.

Q: For speaker builders who might be making a conventional subwoofer or full-range pair of speakers with this driver, how would you compensate for locating the drivers facing into the listening room instead of along the wall?

A: For NHT1259-based designs, especially biamped systems with an active, adjustable crossover, builders have a lot more flexibility when calibrating the crossover between the midrange and bass. They can use the active crossover to calibrate for the room effects for which the corner-loaded placement of the NHT 3.3 would otherwise have compensated. The calibration sequence would be to:

1. Position the speakers for best imaging.

2. Adjust the phase of the bass crossover to match the phase of the midrange at the crossover frequency by playing a test tone through the sound system at the crossover frequency and adjusting the phase of the bass crossover until maximum output level is heard (or measured). Maximum output occurs when the midrange and bass drivers are correctly in phase.

3. Adjust the relative output levels to equalize the tweeter, midrange, and bass. If level adjustments introduce a phase error, you may need to go back to step two and readjust the phase.

Q: What crossover frequency would you recommend when using the NHT1259 in a subwoofer application?

A: To keep a single subwoofer's location hidden, choose a crossover frequency below 100Hz. However, with a pair of NHT1259s, hiding the location isn't a problem. As a result, you can actually go up to 400 or 500Hz before the cone starts to distort. Unfortunately, that frequency is in the middle of a male vocalist's range, so it may not be the best choice.

Generally, with a pair of NHT1259s, I'd set the crossover frequency to below 200Hz, which, coincidentally, tends to be the "half-power" point for a lot of music. So for a biamped system, you can use equally powerful amps to drive the "above 200Hz" satellites and the "below 200Hz" subwoofers.

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the subwoofers, but used the laminated approach with the satellites.

The NHT1259 woofer is shipped with a black plastic ring to protect the cone and the butyl-rubber suspension. This ring serves as an ideal template for cutting the woofer mounting hole. After completing this cut, I dropped the woofer into the hole and marked the edge, to which I would router a 3/8″ recess, allowing the woofer to be mounted flush with the front panel. Even working freehand with the router to cut up to this line, I was able to easily machine the MDF to a nice edge. A router circle guide makes this operation even more precise.

I used industrial-looking black ¼″ × 1.5″ Allen-head bolts (sometimes called socket-head bolts), along with T-nuts mounted into the back side of the front baffle, to mount the woofer. A Norsorex gasket from A&S sealed the woofer into the front baffle.

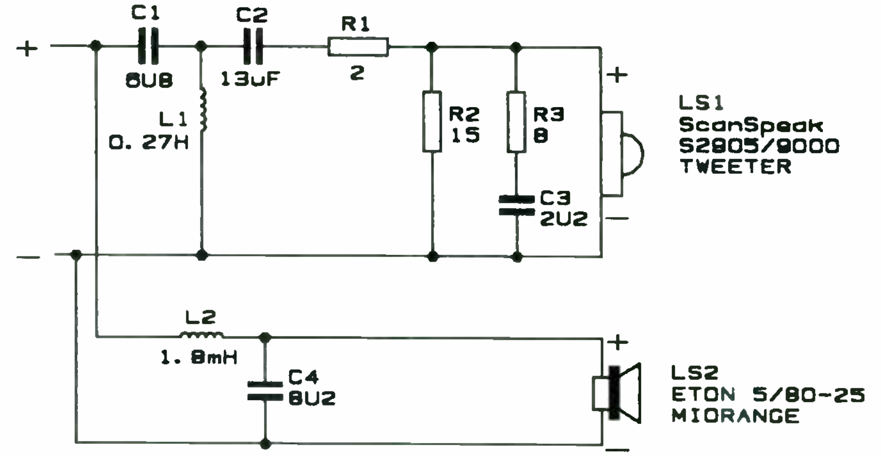


FIGURE 3: Tweeter and midrange crossover schematics.

ACCESS PANEL

To facilitate access to the interior of the cabinet without removing the woofer, I cut a 5″ × 3″ hole in the bottom of the cabinet just behind the bottom skirt. I covered the hole with an 8″ × 5″ piece of 1″ MDF, applied a ring of closed-cell weather stripping, and attached it over the opening with decking screws. Since this cover is only 1″ thick, and the bottom skirt on the cabinet is 2″ high, the panel hides nicely behind the skirt. The skirt also shields a set of casters for moving the heavy cabinets. The cabinet's weight and the small diameter of the casters (1.5″) combine to approximate a spiked stand.

This hatch is handy for popping the snugly fit woofer out of the recessed front baffle and for adjusting the stuffing without having to remove the woofer. I stuffed 2 lbs of polyester into each cabinet, using the dowel braces to hold the stuffing in place.

PAIR OF SATELLITES

With the subwoofer project complete, and my knowledge of speaker building increasing, it was time to tackle the satellites. I selected high-quality drivers with broad, well-behaved response curves. With such drivers, you can use a relatively simple

to page 34

Reader Service #1 →

SUBJECTIVE AND ANALYTICAL LISTENING TESTS

By Dave Dal Farra

When Dan first approached me through E-mail to solicit advice and measurement assistance for these DIY speakers, I thought, "Please, not another flying-saucer chaser." Budding loudspeaker builders often confuse cabinet-making savvy with real audio design. Who wants his design to be voted "Loudspeaker of the Year" by "Furniture to Go"? I was pleased to find my fears unfounded (although the cabinets are beauties).

The physical design is sound: the cabinets are the proverbial "bricked loo." Dan also realized that without access to test tools, designing a decent crossover is a hit-and-miss affair. Crossovers are typically the "Achilles heel" of DIY speaker projects. After weighing his options, he solicited the help of A&S, which, as the objective measurements will show, provided a commendable design.

IMPRESSIONS

I made a direct listening comparison with the drivers in my best DIY design: the Scan-Speak 18W/8543 7″ poly mid-woofer and the Vifa D25-AG-35-06 aluminum dome tweeter.

The talker-placement track, "Mapping the Sound Stage," on the *Stereophile* test CD2 confirmed my initial impressions of top-notch imaging. Placement is stable, the sense of depth excellent, and the perception of height is commendable for such a physically small design. I've never heard the sense of studio size and the relative locations of the musicians on the Flaming Lips' "UFO Story" (from the *Telepathic Surgery* CD) so accurately portrayed.

With the obligatory, hi-fi, geek discs out of the way, it was time to listen to music. This speaker immediately involves you in the music, as opposed to leaving you drooling and poo-pooing with audioholic blather at the expense of listening to the tunes. Musicality was very good, and as enjoyable as it was accurate. I was impressed.

It was also evident early on that the ScanSpeak tweeter is a clear subjective winner. Not a one-trick pony, Dan's loudspeaker system is enjoyable with everything from chamber music to hard-core punk. Detail retrieval is far better than with the Vifa, yet without harshness, stridency, or glare.

Before you think that Dan has paid for my testimony, let me state that I found some shortcomings. The upright bass in "More Speluti Please" (Harry James, *King James Version*, Sheffield Labs) showed signs of muddiness, despite tuning the Eton in-box to a very low Q_{TS}. IM distortion can produce such a perception, but measurements failed to confirm this. The effect, in any event, is minor, and more noticeable in direct comparison with the ScanSpeak midwoofer.

I also noticed a small upper midrange accentuation, especially on Dave Brubeck's "Take 5" (Sony, SBM) and the Beasts of Bourbon's "If You Find Your Way to Heaven" (*From the Belly of the Beasts*, Red Eye records). The rise in the crossover range or the peaks at 5kHz (*Figs. A–E*) are the main suspects. The crossover "elves" need a bit of overtime.

With the severely overdamped, sealed alignment, don't expect "Cars-That-Go-Boom" bass. Many small speakers fool the listener into a perception of deep bass by boosting midbass (e.g., the LS3/5A). Being the honest lad that he is, Dan kept things flat. Given the intended pairing with the NHT1259-based subwoofers, the trade-off is a good one that allows the use of a gentler high-pass crossover slope to the satellites.

One listener commented that the system sounded a bit bright. While a 13kHz bump (see objective measurements) may be at play, I suspect that this impression is an effect of the overdamped and restricted bass and will largely disappear when the subwoofers fill in the bottom end.

If you're a fan of imaging and detail retrieval, this is a great DIY design. As with any system there are some qualifiers, but all things considered, this is the best-sounding DIY loudspeaker project built by a nonaudio professional that I've ever heard. It is leagues above most commercial designs I've auditioned at anywhere near the price.

With some minor crossover tweaking, this would be a very sweet system. The fact that someone relatively new to the DIY game put it together without the use of test tools is a great compliment to Dan's work.

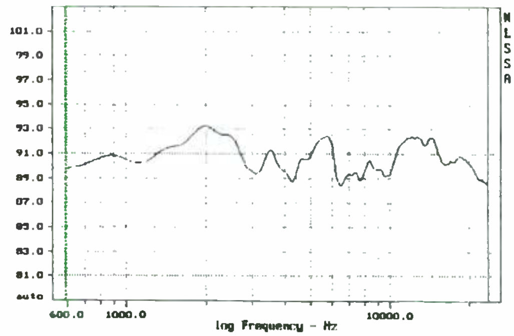


FIGURE C: On-axis in-room response showing 2kHz crossover peak.

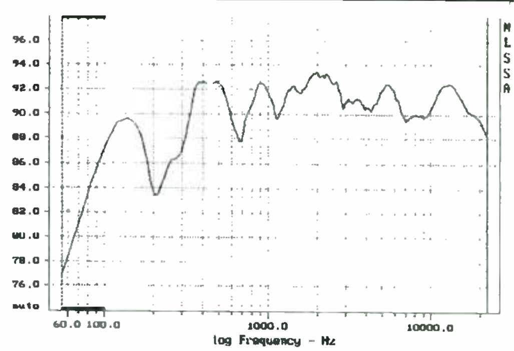


FIGURE D: 200Hz floor notch demonstrated with in-room response.

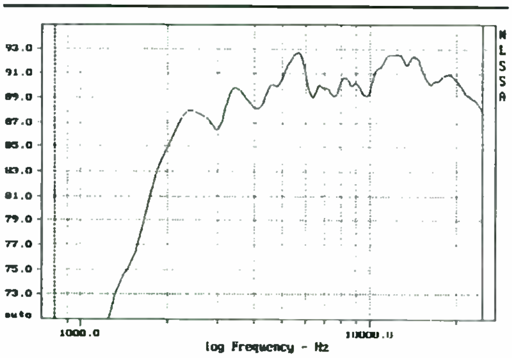


FIGURE A: D2905/9000 tweeter with crossover in-room.

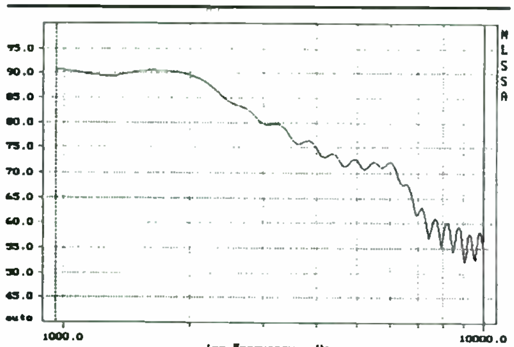


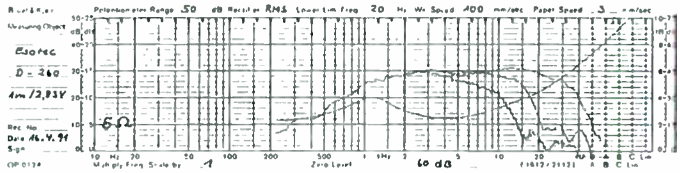
FIGURE B: Eton midrange with crossover, in-room response.

ESOTEC *Speakers by Dynaudio*

The Dynaudio Esotec loudspeakers represent a breakthrough in transducer technology with each stage of development aimed at creating ideal performance for a loudspeaker. The Esotec D-260 high frequency transducer is a culmination of thousands of hours of research and hundreds of thousands of dollars in tooling and dedicated instrumentation. The finished product was required to have the same precision tolerances as the now legendary ESOTAR series, but at a moderate finished cost. The end result is a tweeter with clear and accurate resolution, yet without a trace of sharpness even at highest output levels. Continuing this standard are three new cone transducers: the 15W75 midwoofer, utilizing a 5 inch cone and a 3 inch voice coil; the 17WLQ, a 6.5 inch woofer with a 3 inch coil, which can be used in either sealed or vented enclosures; and the latest development, the 20W75, an 8 inch woofer that also has a 3 inch voice coil and can develop very low bass (below 35 Hz) in moderate vented enclosures. All woofers feature cast frames, magnesium silicate impregnated polypropylene cones, butyl rubber surrounds, vented pole pieces, and laser cut precision spiders. These precision technologies incorporated into the ESOTEC drive units produce extremely smooth frequency response with the control and attack that is possible only with large voice coil design.

ESOTEC D-260 $115.00

The D-260 is a 1" damped soft dome tweeter with a transmission line rear chamber. This new design gives this tweeter a very musical sound, clear and accurate. This driver will not compress, at loud volume it still reproduces a crystal clear sound.

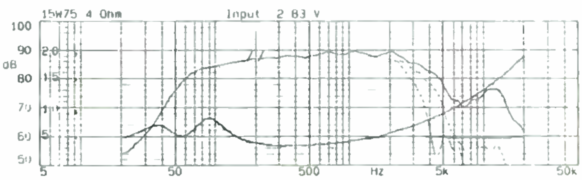


Theile-Small Parameters:

Q, mechanical	Q_{ms}	0.83	eff. cone area	S_D	7.7 cm2	**Voice coil:**		
Q, electrical	Q_{es}	1.14	moving mass	M_{ms}	0.51 g	diameter	d	28 mm
Q, total	Q_{ts}	0.48	lin. excursion (p-p)	X_{max}	0.3 mm	length	h	2.8 mm
Resonance, free air	fs	1000 Hz	max. excursion (p-p)		3.2 mm	layers	n	2
force factor	BxL	3.9 Tm	**Power handling:**			inductance (10 KHz)	L_e	0.063 mH
Equivalent volume	Vas	-	nominal (long term)	IEC	130 W	nom. impedance	Z_{vc}	8 Ω
			transient	10ms	1,000 W	DC resistance	R_e	5.2 Ω

ESOTEC 15W75 $116.00

The 15W75 5" woofer with a 3" voice coil is a very fast midbass driver. The sound reproduction from this driver is very smooth and accurate. We have used this driver in 2-ways, MTM designs, autosound and as a midrange. The results were exceptional.

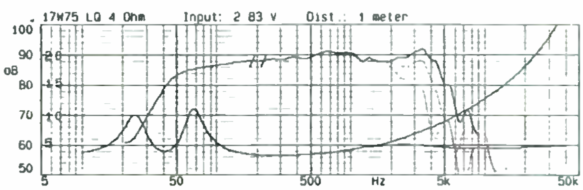


Theile-Small Parameters: 4Ω / 8Ω

Q, mechanical	Q_{ms}	1.7	eff. cone area	S_D	87 cm2	**Voice coil:**		
Q, electrical	Q_{es}	0.6	moving mass	M_{ms}	12 g	diameter	d	75 mm
Q, total	Q_{ts}	0.4	lin. excursion (p-p)	X_{max}	5.5 mm	length	h	10.5 / 10 mm
Resonance, free air	fs	55 Hz	max. excursion (p-p)		15 mm	layers	n	2
force factor	BxL	4.7 / 6.0 Tm	**Power handling:**			inductance (10 KHz)	L_e	0.15 / 0.19 mH
Equivalent volume	Vas	7.5 l	nominal (long term)	IEC	130 W	nom. impedance	Z_{vc}	4 / 8 Ω
			transient	10ms	1,000 W	DC resistance	R_e	3.0 / 4.9 Ω

ESOTEC 17WLQ $120.00

This driver should be in stock by Sept. so we don't have personal experience with it yet. It looks as if it should get down to 43Hz in .6ft^3 and 70Hz in a .4ft^3 sealed enclosure. If this driver is anything like its brothers, it will be worth waiting for.

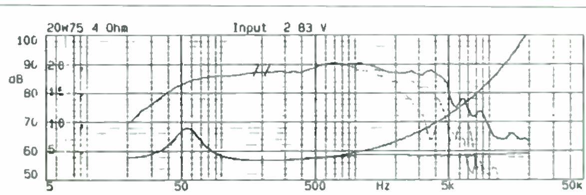


Theile-Small Parameters: 4Ω / 8Ω

Q, mechanical	Q_{ms}	1.8	eff. cone area	S_D	120 cm2	**Voice coil:**		
Q, electrical	Q_{es}	0.5	moving mass	M_{ms}	15 g	diameter	d	75 mm
Q, total	Q_{ts}	0.4	lin. excursion (p-p)	X_{max}	6.5 / 5.5 mm	length	h	11.5 / 10.5 mm
Resonance, free air	fs	40Hz	max. excursion (p-p)		17 mm	layers	n	2
force factor	BxL	5.0 / 6.0 Tm	**Power handling:**			inductance (10 KHz)	L_e	0.15 / 0.19 mH
Equivalent volume	Vas	22 l	nominal (long term)	IEC	130W	nom. impedance	Z_{vc}	4 / 8 Ω
			transient	10ms	1,000W	DC resistance	R_e	3.0 / 4.9 Ω

ESOTEC 20W75 $133.00

The 20W75 has en extremely smooth roll off for an 8" woofer. This driver works well sealed or vented, with low F_3's in moderate sized boxes. The 4ohm driver has an f3 of 32Hz in a 1.8ft3 vented enclosure. Grills are available for autosound.



Theile-Small Parameters: 4Ω / 8Ω

Q, mechanical	Q_{ms}	1.5 / 1.8	eff. cone area	S_D	180 cm2	**Voice coil:**		
Q, electrical	Q_{es}	0.5 / 0.7	moving mass	M_{ms}	20 g	diameter	d	75 mm
Q, total	Q_{ts}	0.4 / 0.5	lin. excursion (p-p)	X_{max}	8.6 / 9.2 mm	length	h	13.6 / 14.2 mm
Resonance, free air	fs	30 Hz	max. excursion (p-p)		15 mm	layers	n	2
force factor	BxL	4.8 / 5.0 Tm	**Power handling:**			inductance (10 KHz)	L_e	0.2 / 0.3 mH
Equivalent volume	Vas	64 / 65 l	nominal (long term)	IEC	130W	nom. impedance	Z_{vc}	4 / 8 Ω
			transient	10ms	1,000W	DC resistance	R_e	3.15 / 5.0 Ω

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from page 30
crossover of high-quality components to smoothly blend them. In keeping with this philosophy of simplicity, I elected to implement an acoustic-suspension design rather than a vented box.

One advantage of this design is a lower relative sensitivity to driver parameter tolerance errors. Also, it exhibits a second-order transfer function—as opposed to the fourth-order of a vented box, which would be much more sensitive to component and cabinet tolerance errors.[6,7] The acoustic-suspension approach is also suitable for a beginner with limited test equipment and ability to tune the final product.

Although a vented box would be capable of deeper base response and more efficiency with a given driver, the NHT1259 subwoofers ensured that I would have more than sufficient bass. I also would not lack power to drive the speakers to sufficient volume, since I was planning to biamp the speakers.

SATELLITE DRIVER SELECTION

A number of people on the Internet recommended the ScanSpeak D2905/9000 fabric dome tweeter, which has a surprisingly low resonance frequency (800Hz, or 600Hz for the newer D2905/9300 model) and a smooth, well-behaved response curve. I also chose the Eton 5-80/25 midrange driver, which has a surprisingly smooth, extended response curve, making it suitable for pairing with the tweeter with only a second-order crossover. It also doesn't exhibit as much of the 5–6kHz break-up mode as many other Kevlar® midranges.

The end result is that these two drivers blend into a smooth overall response without requiring excessive crossover tweaking to "tame" the drivers in the stopband of their respective filters. After constructing these satellites, I discovered that the Focus Audio Signature Series Model 78 speakers also use the ScanSpeak/Eton combination, so I was not alone in pairing these drivers.

In the interest of better imaging, I designed the cabinets with a minimal front baffle, pushing the edge diffraction frequency up. The resulting cabinets are 8″ wide, 13″ high, and 15″ deep, with an internal volume of 0.45 ft^3 (approximately 12 liters). Since the Eton did not need to deliver bass below 100Hz, I anticipated that it would provide a detailed midrange response due to reduced IM distortion.

I constructed the satellite cabinets (*Fig.* 2) according to the NCMS booklet suggestions, which resulted in cabinets that weigh 40 lbs each (very heavy for such a small box). With their thick walls and stiff bracing, they respond to knuckle raps with the impression

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It is also the most positive testament I can make regarding the present state of our hobby.

Associated equipment included: SOTA Sapphire turntable with platter and spring upgrades, Syrinx PU2 Gold tone arm, Stanton 881 MKIIS stylus, Acurus P10 phono preamp, homebrew passive preamp, heavily modified Bryston 2B amplifier, and a POOGE'd Magnavox CDB482 CD player.

OBJECTIVE VERIFICATION

1. The tweeter and high-pass filter exhibit a well-behaved response with a passband sensitivity of 90dB SPL/2.83V/1m (*Fig. A*). The filter slope is sufficient to prevent excursion-limited power handling from being an issue. The wide 2dB peak centered on 13kHz may be partially responsible for the great sense of detail retrieval noticed in the listening tests. The nulls spaced just over 1kHz apart are an artifact of diffraction. The corner radius on the cabinet is too small to be very effective, since the nulls are deeper at the lower frequencies where the wavelength-to-radius ratio is larger.

It is possible the medium-high-Q peak between 5 and 6kHz contributed to the occasional mild accentuation on several passages, particularly on some horns and vocals. Some diffraction control may reduce the effect but, as waterfall plots (not shown) revealed, won't eliminate it (the peak was high enough in Q to be driver related).

2. The quasi-anechoic response of the Eton 5-80 woofer and its low-pass filter reveal a passband sensitivity of 90dB/2.83V/1m, equivalent to that of the tweeter and its high-pass filter (*Fig. B*). Note the complete lack of rolloff rate between 4.5kHz and 6kHz, probably a resonant artifact of the Kevlar/honeycomb structure used in the cone's construction. The woofer output in that region is 13dB below that of the tweeter response and should be effectively masked.

Waterfall plots (not shown) confirmed that the 5kHz resonance was not high-Q. To the Eton's credit, the frequency response is much better behaved than typical Kevlar drivers. The –3dB point corresponding with the crossover frequency is about 2.3kHz.

3. The quasi-anechoic system response betrays a crossover problem in the form of a wide 3dB peak centered at 2kHz (*Fig. C*). It requires more concern with phase in the crossover design. You can reduce the peak by lowering the low-pass frequency slightly, but probably at the expense of some off-axis nulling. Even so, tweaking is recommended.

4. Notice the infamous "floor notch" near 200Hz in the 1/3-octave smoothed in-room frequency response (*Fig. D*). The path-length difference between floor reflection and direct sound results in the deep null. The over-damped alignment generated by the much-larger-than-required box results in a premature response rolloff starting above 100Hz. The lean low-end of the satellites forces the NHT1259s into duty up to 100Hz. With the Eton 5-80 used as it is here, locate the NHT1259 in close proximity and use it more like a woofer than a subwoofer.

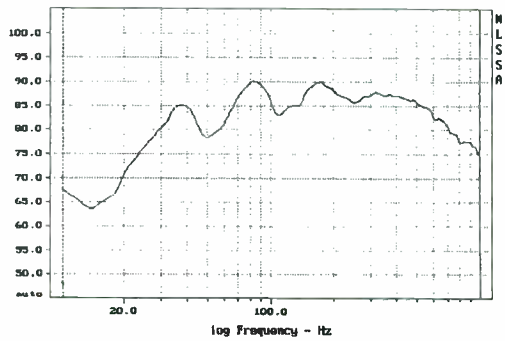

FIGURE E: NHT1259 in-room response away from corner.

5. I measured the NHT1259 in-box, mid-room response; *Fig. E* shows the 1/3-octave smoothed response. System resonance appears to be a couple of hertz above that predicted by Thiele/Small. Response below 70Hz is on average shelved 5dB below the response level shown above 70Hz, but placement was midroom.

It appears NHT's advice to locate the enclosure close to room boundaries is exactly right. Response extends to 500Hz, but further measurements (not shown) illustrate that the crossover should be kept below 300Hz, as the off-axis response above 400Hz becomes noticeably ragged.

Associated equipment included: MLSSA 9.0, B&K 4133 microphone, B&K power supply "mike preamp" (0dB gain), a Symetrix 202 mike preamp, Sony STR-D990 amp (calibrated out in the frequency measurements), and a B&K 124dB pistonphone for calibration of the mike.

Dave Dal Farra is an audio and acoustics designer at Bell Northern Research in Ottawa, Canada.

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3	KW-3 Kit	Improved Preamp PS	99.00	19.95	Borbely TAA1/87
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41	MWR14BK1F5	#14 Hookup Wire 1-1/2 Ft.	1.95	.50	Black
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1	MWR2477-20.0	Neglex 2477 Speaker Cable	53.80	26.95	20 ft, black
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1	MWR2534BK-10.0	Neglex 2534 Interconnect	14.90	7.95	10 ft, black
1	MWR2534BL-32.0	Neglex 2534 Interconnect	47.68	23.95	32 ft, blue
1	MWR518-49.0	Accu-Flow Speaker Cable	73.01	36.95	49 ft, clear
53	PCBX-3 PCB	40W MOSFET Amp 1 ch.	26.00	4.95	Chater TAA2/88
69	PCBX-3A PCB	40W MOSFET Amp PS	14.00	2.95	Chater TAA2/88
39	PCBX-4A PCB	75W Car Amp 1 ch.	23.20	4.95	Vikan TAA4/88
51	PCBX-4B PCB	75W Car Amp PS	17.00	2.95	Vikan TAA4/88
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of a solid oak cube. I anticipated that the stiff, dead cabinets—coupled with the small surface area of the front baffles—and high-quality drivers would result in excellent imaging, and I was not disappointed.

I consulted Brian Smith at A&S about the details of the design, and utilized its $25 service to implement a LEAP-designed crossover. One advantage of this crossover was that A&S was able in designing it to use data measured from in-stock crossover components and drivers of the same production run to tune the LEAP-simulated crossover.

Deriving the design from the measured components was important for the design to match the actual performance of the speakers. I intended to use this crossover design as a starting point, and further refine the design as I acquired additional experience and measurement equipment.

The midrange crossover is a straightforward second-order filter (*Fig. 3*), while the tweeter crossover implements a third-order filter with some impedance smoothing (the 2.2µF capacitor and 8Ω resistor) and level matching (the 2Ω and 15Ω resistors). Again, the generous overlap of the driver-response curves enables the use of this simple crossover. In effect, spending money on better drivers reduced the complexity and parts count for the crossover, allowing mc to use fewer, higher-quality components. I used Solen film capacitors and 14-gauge, air-core inductors in the crossover.

CROSSOVER CONSTRUCTION

I assembled each of the tweeter and midrange crossovers on separate 4½-inch-round pieces of pegboard (the physically large 14-gauge air-core inductors required separate crossover boards). I chose this 4½″ diameter so I could insert the crossover boards through the midrange driver's mounting hole. I used cable ties and a hot-glue gun to mount the crossover components onto the pegboard.

Mounting the pegboards into this cabinet is much like building a ship inside a bottle, with the tweeter crossover mounted on the vertical brace behind the tweeter and the midrange crossover mounted on the second brace, farther behind the midrange driver and its large magnet. I stuffed a half-pound of long-hair wool into each cabinet. By using an oscilloscope to view the EMF generated in the coil of one crossover, while driving the other crossover, I determined there was no significant cross-coupling of signals between the inductors.[8]

FINISHING THE CABINETS

I used contact cement to glue 1/8″ red-oak plywood to the MDF boxes of both the satellites and the subwoofers. The red-oak plywood costs less than veneer and is much easier to cut and glue. I used a router on the edges of the cabinets to accept 5/8″-square oak strips, which I then carefully cut and glued into place. As an alternative to using

REFERENCES

1. *Stereophile*, Feb. 94.
2. *Cabinet Handbook*, North Creek Music Systems, Sept. 1992.
3. Tappan, "Loudspeaker Enclosure Walls," JAES, July 1962.
4. R. Spear and A. Thornhill, "Speaker Enclosure Screws," *SB* (2/94), p. 42.
5. H.D. Harwood, "Some Factors in Loudspeaker Quality," *Wireless World*, 82, No. 1485 (1976), p. 45.
6. V. Dickason, *The Loudspeaker Design Cookbook*, 3rd ed. (Marshall Jones Co., 1987), p. 17. [Fifth edition (Audio Amateur Press) is available from Old Colony Sound Lab, PO Box 243, Peterborough, NH 03458, (603) 924-6371, FAX (603) 924-9467.]
7. D.B. Keele, "Sensitivity of Thiele's Vented Loudspeaker Enclosure Alignments to Parameter Variations," JAES, May 1973.
8. M. Sanfilipo, "Inductor Coil Crosstalk," *SB* (7/94), p. 14.
9. S. & K.B. Rasmussen, "On Loudspeaker Cabinet Diffraction," JAES, Vol. 42, No. 3, March 1994.
10. B. Wayland, "Wayland's Wood World," *SB* (8/94), p. 47.

expensive web clamps on the oak strips, I successfully used a pair of loading straps with built-in winch mechanisms (less than $10 at most automotive stores).

With a 7/8″ router bit, I formed a 45° bevel on the oak strip edges. I've discovered that rather than using a piloted bit, it's much more effective to use an unpiloted bit and a router guide that bolts onto the router deck (about $10 from Black and Decker). This ensures that you won't "burn" the cabinet as the bit slides along. The solid-oak, beveled edges produce a nice effect at the corners of the cabinet where all the bevels come to a point. These edges also approximate the reduction in diffraction effects that a rounded corner provides[9] and are more aesthetically pleasing.

I originally intended to stain the cabinets black to match my other A/V cabinets, but after appreciating the raw-oak cabinets for a few weeks, I decided to apply a Danish oil finish. I first applied the Danish oil to the cabinets and then rubbed off the oil after 30 minutes. I wet-sanded additional coats of oil into the finish, rubbing the surface dry after each session. The final result was a perfectly smooth, low-gloss finish that enhanced the wood grain.

GRILLES

Published results in the hi-fi press show that grilles can produce response distortion. However, I decided to add grilles to achieve a high SAF (spousal approval factor) with this design. Rather than use the "picture frame" technique demonstrated by Bob Wayland in his woodworking column[10], I chose an octagonal design: a "round" octagon for the subwoofer and an elliptical octagon for the satellites, giving the speakers a common "visual theme." This resulted in grilles that are vaguely reminiscent of B&W 801s (*Photo 2*).

I outlined the octagons on a 5/8″ sheet of particleboard and used a jig saw to cut them out "approximately." I then used a sanding disk mounted on a table saw to precisely trim the octagons, a router to fashion a 45° bevel on the outer edge, and a rounded-over bit for the inner edge of the grille.

By stacking the two grilles and drilling pilot holes through them and into the cabinets, I was able to mount the "mushrooms" identically on both grilles, making them interchangeable. I then sprayed flat-black paint on the frames and stretched the speaker cloth, stapling it to the innermost edge of the grille. With less than an hour invested per pair, the end result was quite professional-looking.

I mounted threaded spikes (Big Toe Jrs from NCMS) into the bottoms of the satellites, which I placed onto 3/16″ flat-black metal plates resting on blue-tack padding on top of each subwoofer. By threading the front spikes farther out than the back ones, I was able to properly "aim" the satellites to project at ear height for seated listeners. While the spikes offer a "mechanical ground," the blue-tack pad provides

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SOURCES

A&S Speakers
4075 Sprig Drive, Concord, CA 94520
(510) 685-5252

North Creek Music Systems
Main St., PO Box 1120, Old Forge, NY 13420
(315) 369-2500

ACKNOWLEDGMENTS

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Wayland's Wood World

SATELLITE SPEAKER STANDS

By Bob Wayland

How frustrating it is to finally get your whole system together, sit down in your favorite listening chair, put on your best demo piece, and then find it just doesn't sound right. Often, the devil is in the detail of where you place the speakers. There are many opinions as to where and how to locate the speakers to get the sound you want. For the high-frequency satellite speakers, most authors agree on two criteria: first, that the enclosures should be at head level when you're seated; second, that the satellite speakers need to be off the floor and away from the wall or any other obstacle that might cause diffraction effects. This article outlines some recommendations for accomplishing these goals and offers some ideas for stands you can build in an evening or two. My next column will be devoted to stands for the larger two- and three-way systems and subwoofers.

READY MADE

In looking for satellite-speaker stands, you can find usable items in hardware stores, especially the super stores such as Home Base, Home Depot, or Builders Square. One example is a wall-mounted bracket with one or two swivel joints fastening it to another plate that attaches to the speaker. I don't especially like them for placing speakers because of the poor sounds that result, but

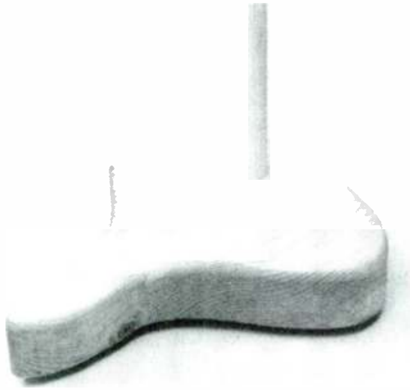

PHOTO 1: The base of a satellite speaker stand.

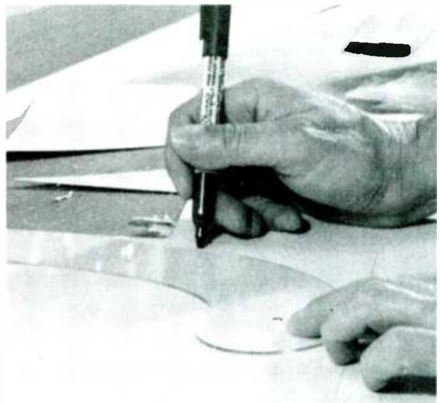

PHOTO 2: Drawing the pattern for the base of the stand.

you might find them useful for mounting the side or back speakers in a surround-sound rear-channel placement.

You can also use old—or new—floor lamps. There are so many different styles that you can easily match any decor. The secret is to remove the socket and use the upright support on the lamp base to secure a small platform for the satellite speaker. The channel for the power cord then provides access for your speaker wire. One of your key considerations, of course, should be the stability of the stand. Most good-quality lamps have weighted bases; you might have to add some weight to the base of an older or cheaper one.

PIPE STANDS

You can make a simple stand from pipe or electrical conduit, but before going into construction details, here are a few general guidelines. You may recall from high school geometry that three noncollinear points determine a plane. You need at least three legs for a stand, but stability increases as you add more legs, especially in odd numbers, i.e., five is more stable than four, or, for that matter, three. The obvious problem is, how do you ensure that the five legs will rest firmly at that special place on your possibly not-so-level listening-room floor? (Sometimes when trying to find the best height and loca-

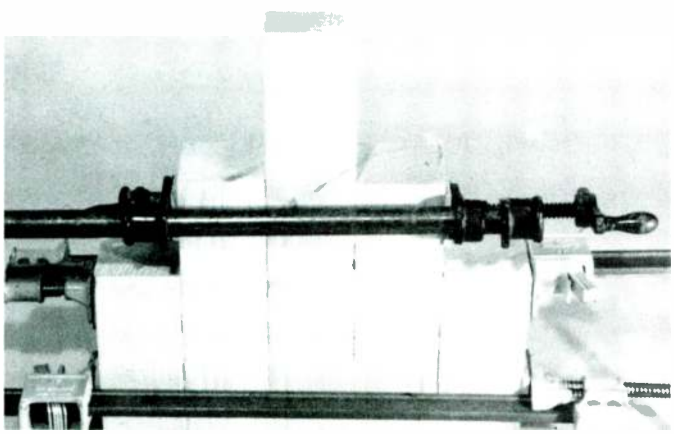

PHOTO 3: The stock is cut to lengths that ensure coverage of the pattern. For this base, I set the two clamps closest to the viewer; then I placed the whole assembly on end and set the middle clamp to ensure adequate clamping pressure.

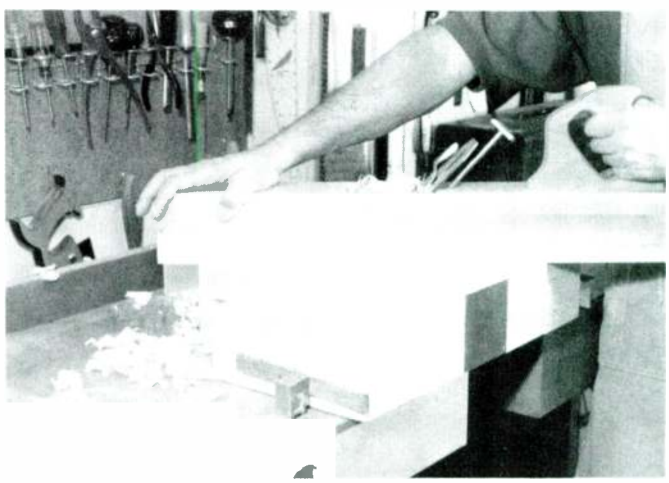

PHOTO 4: The surface of the base being smoothed with a jointer plane.

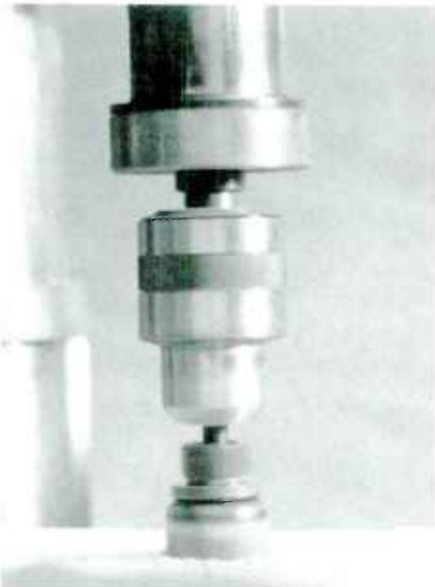

PHOTO 5: Drilling the support-rod hole using a hole saw.

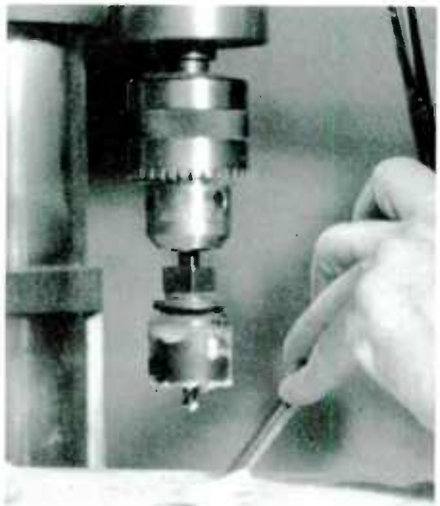

PHOTO 6: Cleaning out the support-rod hole with a straight chisel.

PHOTO 7: A specially designed Japanese chisel for cleaning out holes. Note the small hammer that is made for use with Japanese chisels. One face is flat and the other is slightly rounded.

tion for a satellite speaker, I use a camera tripod with the enclosure temporarily attached to the head.)

If you use only one small area, e.g., the base of the stand (as with the lamp stands), the problem goes away. The question now becomes, "Where is the center of gravity?" As with the Leaning Tower of Pisa, be sure that the center of gravity of the stand and speaker together lies within the footprint of the base.

One of the easiest stands to make is a small disk platform for the speaker to sit on, with legs to support it. The main problem is the method of attaching the legs. Most good plumbing stores have flanges into which you can screw standard pipes, and you can find, in lamp and plumbing stores, brass and enamel-coated sections of pipe. Three-eighths or half-inch pipe works well for speaker stands.

To get the angle you want for the legs, simply cut a wedge of the desired angle and mount it between the flange and the disk. You can run the speaker wire up one of the legs. Instead of pipe, you can use ready-made wooden table legs and the screw-in attachment brackets designed for them. Some brackets allow for mounting the legs either vertically or at a slight angle. Depending upon your decor, this can either provide a nice addition or become an ungainly monster.

ELECTRICAL-CONDUIT ART

Another possibility is to bend electrical conduit into a pleasing shape, attach the speaker to it, and paint it any color you desire. If you are handy at conduit bending, this offers almost endless possibilities. Half-inch conduit normally provides adequate support. For the base, an old floor-lamp base will do, or you can make your own as described below.

A shape that both pleases aesthetically and ensures that the center of gravity is correct, is a question mark. You attach the enclosure to the top end of the question mark. When adjusting the final form, make sure to stretch out the question mark so that the enclosure is in line above the point where the conduit attaches to the base. Of course, there is room for variation here by changing the shape of the base and where the conduit is attached to it. Just keep in mind the center-of-gravity idea.

One way of attaching the speaker to the top of the form is to use a photographic ball head, the type used to hold cameras in various positions on a tripod. Most photographic supply houses have them, starting at about $15. By putting a threaded insert into the back of the enclosure (see "Screws and other Fasteners," *SB* 8/95, p. 42), you can attach the ball head directly to the enclosure. This arrangement has the advantage of letting you quickly change the direction in which the enclosure is pointed.

PHOTO 8: Using the pattern to trace the shape on the base.

PHOTO 9: Tracing the opposite side of the pattern onto the base.

HOME-MADE WOODEN STANDS

When you make your own stands of wood,

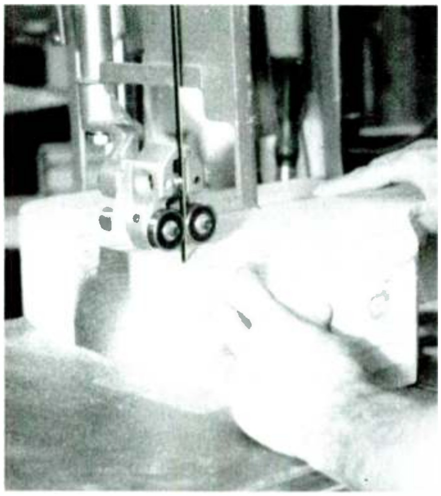

PHOTO 10: Cutting the base out on a bandsaw.

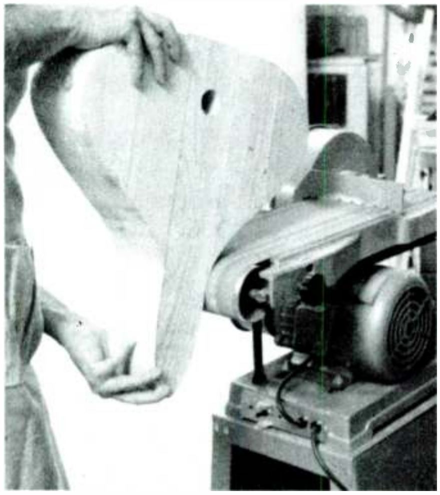

PHOTO 11: Removing the irregularities from the cutting operation shown in Photo 10.

PHOTO 12: Using a router with a roundover bit to smooth the edge of the base.

you have great freedom to select both style and function. Rather than give you a particular design, I will describe how to make a stand in general. It is your choice of the details that will make the stand your own.

Because organic forms appeal to me, the one I describe below has smoothly flowing lines. If your tastes tend toward other styles, just modify my design accordingly. The base is where the style is most obvious, so I'll start there. The speaker sits on a platform extending out from a support pole. To ensure stability, the base should be rather heavy and large enough so that the speaker does not extend beyond the edge of the base (*Photo 1*).

Note that the symmetrical pattern provides good stability both laterally and front-to-back. Make the base from 4″ × 4″ material to guarantee a heavy, steadfast anchor. As a first step, make a pattern for the base. If you prefer smoothly flowing lines, a set of ships' curves is very useful (*Photo 2*). You can find ideas for other designs in furniture catalogs.

The base material I use is fir, in this case a 4″ × 4″ post. You can use other woods such as redwood or cedar, but if you want more exotic woods, you may have to glue up some stock to get sufficient thickness. Most post stock has a poor surface for gluing, so you will need to saw or plane off the rough areas, being careful to keep consistent dimensions. Once you have good stock, cut it to lengths that will cover the pattern and glue them up (*Photo 3*, and see *SB* 2/94, p. 46). Be careful to match the grains at the joints to give the appearance of a solid piece of wood.

The top and bottom surfaces of the base should be flat before you start the shaping process. Because of the size involved, it is usually impossible to use a planer; however, a jointer plane is made for tasks like this (*Photo 4*).

The upright support can be anything from pipe to electrical conduit (see above) to wooden post or pole. My favorite is clothes-hanger rod. This wooden dowel is straight and nominally 1.25″ in diameter, stiff enough to support the heavier satellite speakers. Depending upon your design, locate the position of the hole for the support rod (for our example base, it is toward the back, as shown in *Photo 1*).

Drill out a hole that will make a firm pressure fit (*Photo 5*). If you are using a hole saw, it may be necessary to clean the hole out a number of times (*Photo 6*). A handy Japanese chisel with a hook on the end can simplify this task (*Photo 7*). The hole depth should be about 80 to 90% of the thickness of the base.

The next step is to shape the base. Make a pattern of the shape you desire, use masking tape to anchor the pattern to the base, and then trace the shape onto the base as shown in *Photo 8*. Reverse the pattern to trace the other side (*Photo 9*). Now cut out the base to the patterned shape. *Photo 10* shows a bandsaw being used, but you can also use a jig or saber saw for this operation.

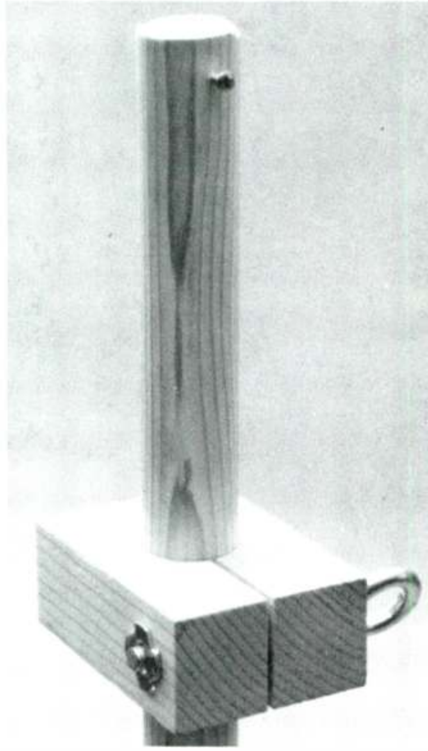

PHOTO 13: The adjustable support platform for the speaker system.

You can modify the base to make a pleasing final design. In my example, I added a simple rounded-over edge. Again, use your imagination to develop new designs of your own. If you use a router to help shape the base, it is important to remove all irregularities introduced by the sawing operation. The easy way is to use a stationary belt sander, as shown in *Photo 11*, or a hand belt sander or a drum sander on your drill press. What you do now depends upon how ambitious you are.

In my example, I have kept it simple. Just use a router with a roundover bit of ¾″ radius to make a smooth edge, as shown in *Photo 12*. Using chisels, spokeshaves, and so on, you can make the shape of the base as complex as you wish.

Now insert the support rod into the hole in the base. If you have done it right, the fit should be snug. Drive it home. If it's loose, use a bit of glue.

SECURING THE SPEAKER

Next, you need to mount the satellite speak-

PHOTO 14: The complete satellite speaker stand.

er to the support rod in such a way that you can adjust the height of the speaker. One method is to make a movable platform that you can clamp tightly into position anywhere along the support rod. To do this, cut a piece of 2″ × 4″ stock about 8″ long and drill a hole the size of the rod toward one end. Then, with a blade having at least a 3/16″ kerf, make a cut from the end nearest the hole to the center of the hole. Put an eye hook (with washer) through a hole drilled perpendicular to the cut into a T-nut anchored on the other side (*Photo 13*).

By tightening the eye hook, you can secure the clamp anywhere along the rod, holding the satellite speaker snugly (*Photo 14*). If you want the speaker always at the same height, omit the clamping mechanism and hold the platform in place with a dowel that passes through it into the support pole.

You can make stands as simple or as complex as needed to meet your requirements. The main thing is to let your imagination run free. Then be very sure of your design and your craftsmanship.

Software Review

PYLE PRO DESIGNER V 1.0

By Craig E.L. Stark and Craig L. Stark

Pyle Pro Designer v1.0. Pyle Industries, Inc., 501 Center St., PO Box 620, Huntington, IN, 46750. Suggested retail: $199. Requirements: IBM PC compatible, DOS 3.3 or later, VGA monitor, hard drive (1MB). Optional: Microsoft compatible mouse, Epson 9- or 24-pin printer, HP Laserjet or Deskjet. Tested platform: 33MHz 486, 20MB RAM, running DOS 6.22, Windows 3.1, and OS/2 v3.0.

Pyle Pro Designer v1.0 (hereafter, PPD) is a PC-based software package designed to let you predict the bass response of a driver in an enclosure. With a suggested price of $199—at least twice the cost of such competitors as BoxModel and BassBox 5.0—it bills itself as "the most comprehensive, yet user-friendly, speaker-enclosure-design software available today." Unfortunately, while the program does have a number of powerful features and is certainly easy to use, its omissions and shortcomings make it impossible to endorse that claim.

INSTALLATION

I found installing PPD simple, and the supplied automatic installation program created the appropriate directories and copied the needed files onto my hard drive. The program ran flawlessly, and I could never make it misbehave under DOS, Windows 3.1, or OS/2 Warp.

The only difficulty arose during installation, while I was setting up my default configuration (e.g., printer type, conventional units, etc.). The program asked me to enter a value for the default number of "steps," without any explanation of what a "step" was. Thumbing through the manual gave me a reasonable idea, though the explanation was nowhere near the "Quick Start" or "Installation" sections. As I'll discuss later, PPD's "step" is a most interesting feature—one I have not seen in other programs. Pyle would do well to make its presence more prominent.

USE AND INTERFACE

Once the software is up and running, you're presented with PPD's main screen (*Fig. 1*). Across the top is a standard menu bar, accessible either with the mouse or by pressing the first letter of the yellow-highlighted item. PPD lets you work with up to four designs at a time, and a box at the upper right gives a brief synopsis of each, showing the driver make and model, enclosure type, and the volume and tuning of the box. Directly above this box are four buttons, used to indicate the currently active design.

Below the summary box is the plotting region where the predicted frequency-response graphs are displayed. The frequency range is fixed from 10–500Hz on the x-axis. The y-axis has a range of 50dB, which can begin at 60, 70, or 80dB SPL. In the

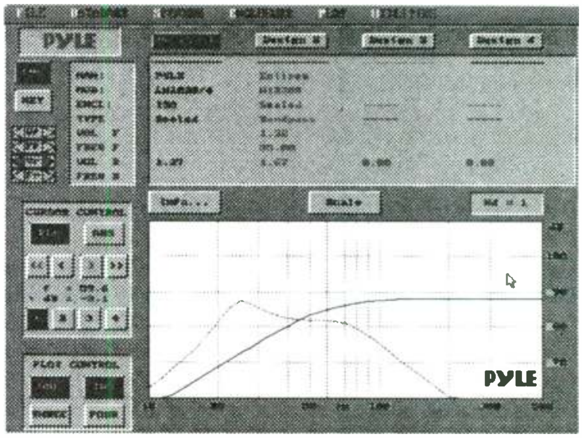

FIGURE 1: Pyle Pro Designer's main screen.

upper-left corner is a pair of buttons for switching between English and metric units, and several other buttons that modify the enclosure parameters. Below this is a box that reports the exact frequency and SPL of a point on the graph, either in absolute SPL or in SPL relative to a desired calibration point. Finally, a group of buttons in the lower-left corner control which of the current designs is to be plotted.

Pyle is perfectly justified in asserting that PPD is very easy to use, especially with a mouse. Generating or modifying a design could hardly be simpler. For example, you can change from a sealed design to a triple-chamber, Isobarik vented-bandpass design (whose parameters the computer calculates automatically for a maximally flat system) and plot the predicted frequency response in a grand total of four mouse clicks. Six more clicks and you've picked out a box shape, and PPD has calculated the required dimensions. Four more clicks and you have a printout of a drawing of the design from one of four views. If the design has a sloped baffle, PPD will even generate a cutting guide that shows you the angles of all the needed cuts and miters.

One of the benefits of computer-aided-design (CAD) packages in general is their ability to explore the design and easily perform "what-if" experiments. PPD is no exception. For example, simply by pressing a button on the screen, you can alter the box volume or vent tuning frequency (if applicable). The tuning frequency is always modified by 1.0Hz, and the box volume is modified by 0.1ft^3 if using English units, or by 0.99 liters (clearly a minor bug) if using metric units.

After any modification, the program alerts you that the current plot is not up to date by changing the color in the design-synopsis area from black to red. Simply clicking on the plotting region refreshes the plot for the active design. If you modify more than one design at a time, you must replot each individually by activating it and clicking in the plot region, or by pressing P and the design number.

ENGLISH OR METRIC?

You can switch between English and metric unit conventions by pressing the appropriate button in the upper-left corner of the screen. Note, however, that this setting is a global one, so all your units must use measurements of the same type. Further, you can change this only at the top level in the program. So, if you're entering driver parameters and happen to be in the wrong mode, you must back out of all your edits, change the convention, and reenter the data. I often found it easier to break out the calculator when this happened, and I wished that I could make the switch at any time.

It would also be nice if the program alerted you to the possibility of being in the wrong mode. For example, I entered the V_{AS} of a driver as 150 liters when I was in English mode. The resulting 4,248ft^3 is clearly implausible. It would be helpful if the program could spot such mistakes or at least clearly state the units when you are entering the data.

Despite these minor criticisms, I feel that PPD's interface is very good overall. Perhaps the best you can say about an interface is that it is not noticeable. When using the mouse, I rarely noticed PPD's. However, keyboard-only users should be aware that while much of the ease of use transfers, there are several areas where it falls short. For example, while many dialog boxes allow you to type in a number (e.g., driver and box-parameter entry), you can enter some numeric responses only by pressing buttons. Entering the number of drivers used is one such instance where a menu appears with choices ranging from 1-4. Mouse users simply click on the appropriate number, but keyboard users, instead of simply typing the number, must hit

the up and down arrows until the correct value is highlighted.

FEATURES

PPD nicely mates its ease of use with several quite powerful features. It allows you to work on as many as four designs simultaneously. The designs are completely independent (unlike those of BassBox 5.0), so you can vary the driver and the enclosure for each. PPD also lets you easily control which designs are plotted and lets you remove an individual plot from the overlay—again, an improvement on BassBox 5.0.

PPD will model the response of drivers in a wide array of enclosure types and will even calculate box parameters for a maximally flat response in each. Like other CAD programs, PPD models the response of simple sealed and vented enclosures. It goes further, however, modeling not only standard sealed and tri-chamber sealed bandpass enclosures, but also vented and tri-chamber vented ones. Moreover, it provides Isobarik configurations of each, giving you a total of 16 possible enclosure types.

While you could model any of these in other programs (e.g., BassBox 5.0 or BoxModel + BPBoxModel), PPD calculates maximally flat alignments and lets you easily design boxes for all of them—something the competition does not do. Notably absent from this list, however—while present in many other packages—is the ability to work with passive-radiator designs.

For each design, PPD will calculate the parameters for up to four drivers (four pairs of drivers in the Isobarik case) per chamber. If you set the number of drivers before specifying the enclosure type, PPD will use that information to calculate the appropriate box volume and response. It will even use the information when generating enclosure dimensions, by subtracting the volume of all the drivers from the chamber volume. However, if you change the number of drivers *after* choosing an enclosure type, you must respecify the enclosure type to get PPD to recalculate the box parameters and response.

MULTIPLE-DRIVER CONSIDERATIONS

It should be noted that PPD does not consider the electrical effects of having multiple drivers in a single system. For example, according to PPD, putting two drivers in an enclosure yields a net gain of 3dB, and a pair of drivers in an Isobarik configuration gives a change of –3dB. In the first condition, you gain 3dB by having two drivers operating in phase and driven from the same signal. In the Isobarik configuration, you lose 3dB by effectively doubling the cone mass.

In practice, however, these drivers are rarely driven by separate amps, and they are connected either in series or in parallel. Normally, you would predict a net gain of 0dB if the drivers are connected in series, or 6dB if connected in parallel. In the Isobarik configuration, paralleling the drivers is standard practice, so there is no net loss of efficiency: the 3dB loss from cone mass is offset by a 3dB gain by halving the impedance. So, when using PPD to design systems with multiple drivers per section, you must be aware that the predicted absolute SPL will probably be inaccurate.

Once you have settled on an enclosure design, PPD has a nice utility that lets you calculate port length. By default, it shows lengths for ports from 2″ to 6″ in diameter, and gives a recommendation based on the widest port whose length is less than the cabinet depth (if known) or 18″, whichever is shorter. If this information is inadequate, PPD lets you manually enter a port diameter and number of ports (1–4), and it then calculates the required length.

As mentioned above, PPD calculates box dimensions and even generates box drawings and cutting guides. It limits your choice of overall shape to rectangles and wedges, but these should be satisfactory for most applications. While more exotic shapes—such as octagons and truncated pyramids—have sonic advantages (and can be designed in some packages such as Bass Box), to construct them successfully requires a level of woodworking skill such that those willing to tackle them can probably produce their own cutting guides.

Given a material thickness (1/4-1″ in standard sizes), PPD can automatically generate box dimensions or let you override the choices and specify other dimensions. Here, the program shows its autosound heritage by consistently making wedge-shaped boxes short and wide, as opposed to thin and tall, and by orienting volume dividers along the wrong axis. If, as in this case, the computer-generated (or manually-entered) box is inappropriate, you can adjust any dimension in 1/8″ increments while monitoring the resulting volume until you've achieved a desirable box design. For major changes, 1/8″ increments can become tedious, and, unfortunately, PPD has no way for you to enter a size directly while modifying a design; nor does the program make provision for keyboard users to enter these adjustments.

TAKING STEPS

Once you have set a basic volume and tuning for a given design, you can activate the Enclosure-Steps function, which displays what the frequency response would be if you changed the volume or tuning (front or rear) by X percent in Y steps. Values (chosen in the configuration section) can be three, five, or seven steps of 5, 10, or 20%. For example, if you've configured the program to run three steps of 10% and then run Steps on the tuning frequency, the program will produce a multicolored plot of the current response and what it would become if the tuning frequency changed by 10% in either direction.

This information can be useful in showing to what extent the design tolerates construction errors, or in quickly estimating how much benefit varying a certain parameter is likely to produce. The Steps function lets you easily answer such questions as, "If I err and make the box the wrong volume, how bad will it be?" and "How much of a benefit am I likely to get by changing the box volume?"

My only complaint with the Steps function is that its implementation doesn't extend to letting you vary more than one parameter at a time. If it could show you the results of changing tuning and volume simultaneously, you could see instantly what any reasonable vented alignment would produce. Then "what if" testing would be a thing of the past!

MAJOR PROBLEMS

You might hope that $199 would buy a program without the relatively minor shortcomings I've mentioned so far, but these should not seriously deter potential customers if the program were otherwise satisfactory. However, I think the following problems and omissions are severe enough that I cannot recommend PPD for the serious home builder.

Perhaps the most egregious problem is in the main title bar's File-Save command. Contrary to convention and common sense, this command does not save your current design. Rather, it saves only the current program settings (e.g., printer type). This might be merely annoying were there some other command that *did* save your current design(s). In fact, however, there is simply no way to save your work to disk! Once you quit the program, all your work is lost. If you're working on a design intermittently, you must either leave PPD running or print out the information and reenter it later.

Printouts are easily lost, and being unable to save and retrieve a design from disk makes it difficult to imagine using PPD on a regular basis for anything more than quick-and-dirty experimentation. Surely one of the points of using computers for almost any task is to be able to store, retrieve, and manipulate data easily. Any program that makes me reenter my data each time I use it is not one that will remain on my hard drive for long.

IMPEDANCE OVERLOOKED

Number two on my major hit list is the lack of any attention to impedance. PPD makes no attempt whatsoever to model the impedance of the system. While the effect of an enclosure probably will not change the impedance at a woofer's crossover point, it is quite possible that it will do so at a midrange's lower crossover point. This makes crossover design a process of guessing and hoping, rather than one of calculating and knowing. Even for woofers, the impedance minimum is a useful value, and you need the location and magnitude of the peaks to evaluate the execution of the alignment.

Further, since you can derive the phase of the impedance from its magnitude (assuming a minimum-phase system, typical of raw drivers), an impedance plot can tell you how capacitive and inductive a load the driver will present to the amplifier. Impedance response is not difficult to calculate, and it stands out as a glaring omission in PPD.

Similarly, while PPD can facilitate woofer enclosure design, it makes no attempt to model the displacement-limited power output of a system. Designing a system with a 3dB down point of about 20Hz is not all that difficult. Designing one with such a 3dB down point *and* capable of producing over 100dB across its range is more difficult. Simply knowing the frequency response tells only half the story. Without knowing how much SPL you can actually achieve before hitting the driver's limits is the other half, and PPD ignores this completely.

UNRESPONSIVE

Next on my list is the total lack of consideration of driver-response nonlinearities. PPD assumes the driver behaves exactly according to a Thiele/Small model, so it makes no allowance for resonances or other response abnormalities. If a driver passband has dips and peaks in its response, failing to account for them will result in nonoptimal performance. For example, according to PPD, the response of a woofer for which I'm currently designing a bandpass enclosure would be the bumpy graph shown in Design 2 of *Fig. 1*.

In fact, and according to Bass Box 5.0's prediction, the response flattens out at the top of the peak and is quite smooth out to 70Hz, where it smoothly rolls off. The reason for the difference is a broad peak of several decibels that PPD's model does not account for. Were I to ignore this nonlinearity and use PPD's calculations, I would end up with a very different box and with suboptimal performance. Some way is needed to enter response variations, either via a simple table (as with Bass Box) or through a series of arbitrary filters (as with CALSOD).

INSENSITIVE

Along the same lines, PPD makes no provision for entering driver sensitivity. Although derived from the T/S parameters, it is often an incorrect estimate for the efficiency in the passband. As noted above, PPD fails to accurately calculate system efficiency for multidriver formats. You might circumvent this problem if efficiency were a modifiable variable, so you could trust the SPL graphs. Unfortunately, this is not the case in PPD.

Still on the subject of parameters, you should note that PPD avoids enclosure Qs. While you might not expect it to break the box-loss parameter Q_L down to the degree that you find in LEAP or BoxModel, this parameter should at least be present! Assuming a standard value of 7 is a fine starting point under most conditions, but it is so critical to proper alignment of vented systems that it should be present and open to modification.

Similarly, with sealed enclosures, PPD makes no reference to Q_{TS}. Since sealed-enclosure design often begins by specifying a desired Q_{TS} so the system has certain frequency- and transient-response characteristics, it's inexcusable that there is no way to enter a desired Q_{TS} or report it for a given design. PPD does report (several menus down) the asymptotic dB/octave rolloff of the system, but this is hardly a direct substitute.

DRIVER-DATA DEFICIENCIES

Finally, PPD does a very poor job of storing and retrieving driver data. The program seemingly comes with data on every Pyle driver made, but contains no data for any non-Pyle drivers. While this clearly reflects an understandable manufacturer's bias, the software is intended for a wide enough audience that it should include other popular drivers. You can add non-Pyle drivers to the program, but it will not recommend an enclosure type for user-added drivers unless you yourself do the recommending, which makes the recommendation otiose.

A more serious problem is that PPD does not store the driver data in one large file (or a well-indexed series of files). Instead, it stores this data in 5KB "databases" that can hold only 20 drivers each. It takes 15 of these just to hold the Pyle drivers supplied with the program, and because of the DOS eight-character limitation on filenames, even these 15 have cryptic names. For example, to retrieve one of the Pyle Reference Series 20, 40, or 70 4Ω subwoofers, you must remember that it is in the "PYLE-LW4.PDT" database before you can use it in a design. Since the data is not stored in text files, you can't even compile a paper index of the driver database. A year from now, who will remember if he entered a particular driver's parameters into the database, much less what file it's stored in?

CONCLUSION

Pyle Pro Designer 1.0 is fast, easy to use, and has several advanced features, including the ability to work on as many as four designs simultaneously, with each using different drivers and different enclosure types. It not only models but recommends parameter values and generates drawings for enclosures that range in complexity from simple sealed designs to complex triple-chambered vented bandpass designs.

However, by failing to include such basic tools as the ability to model impedance, displacement-limited power output, response abnormalities, or even to save your work, Pyle Pro Designer 1.0 does not live up to its billing as "Powerful enough for daily use by professional designers and installers, and intuitive enough for the hobbyist or consumer." Still, v1.0 of any piece of software rarely reflects the internal engine's true potential, and since many of these features could easily be added, I look forward to v2 with great anticipation.

Dual-Baffle Design

from page 16

150°, and 180° (*Fig. 9*) indicate a balanced response in almost all directions in the horizontal plane, up to about 3kHz. You could extend this quality to a higher frequency by using a rear-firing tweeter.

I won't say much about the sound, except that everyone who has heard the system has been impressed, making comments such as "it sounds like a high-end speaker."

Figure 10 shows the design, which I offer without detailed construction advice. (I simply handed this illustration to a local cabinetmaker!) I noticed that the "wings" were fairly resonant. Several coats of Acoustic Magic helped deaden these panels, though I imagine other resonance-control techniques (e.g., bitumen pads) would work as well. The woofer cavity is stuffed with long-fiber wool. The 4.5″ woofers require about 6dB electronic boost at 50Hz to correct their overdamped nature. You may instead make the cabinet a little deeper and vent the woofers, or use a separate subwoofer, crossing over at around 100Hz.

The three-way crossover (*Fig. 11*) is a nonstandard second-order design. I glued the midrange and tweeter components onto the shelf at the bottom rear of the HF enclosure, and the woofer components onto a removable panel on the rear of the woofer enclosure.

CONCLUSION

It is possible to construct a loudspeaker with near-omnidirectional response without compromising the on-axis frequency response. You accomplish this by using two baffles of differing dimensions, so that within their respective frequency ranges the low-frequency driver's baffle is acoustically small and the high-frequency driver's is large. You may then use rear-mounted drivers to correct the high-frequency balance of the reverberant response without interfering with the direct-axial frequency response.

The large high-frequency baffle flies in the face of the popular conception that its area should be minimized to reduce diffraction effects, and takes the opposite approach to that in designs by B&W, Vandersteen, and others. Contrary to popular opinion, small HF baffles don't reduce diffraction, but simply move it to a higher frequency. A better solution is to use a large baffle so diffraction irregularities occur at a frequency below the frequency band of the HF drivers—an added benefit of the BRR design.

The challenge of this technique is in coming up with a practical, aesthetically acceptable realization. Also, the narrow dimensions of the LF baffle suggest the need for an array of small drivers, or a separate subwoofer to obtain greater bass extension and power handling. I encourage other speaker hobbyists to experiment with techniques and new applications of the BRR idea.

REFERENCES

1. R.E. Gonzalez, "An Introduction to Frequency Response and LMP," (*SB* 1/87-3/87).

2. H.F. Olson, "Direct Radiator Loudspeaker Enclosures," (*Audio Engineering*, Nov. 1951).

3. R. Kral, "Diffraction, the True Story," (*SB* 1/80).

4. R.E. Gonzalez, "A Revised 2-way Minimonitor," (*SB* 3/94).

5. R.E. Gonzalez, "The Delac S10," (*SB* 2/92).

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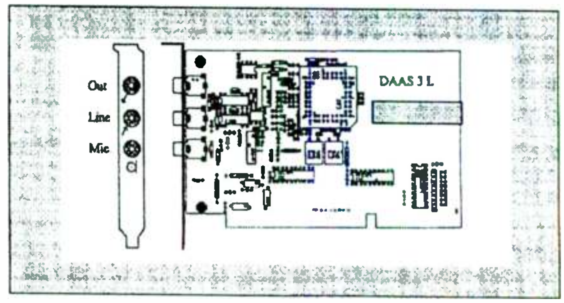
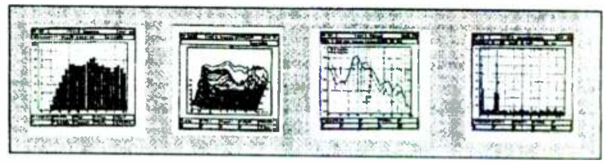




Measurement Functions and Features:

- Electrical/acoustical frequency curve
- Electrical/acoustical phase curve
- Sound level measurement
- Distortion (spectrum)
- Distortion curve
- Intermodulation distortion
- Impedance measurement
- Group delay
- Impulse response
- Spring response
- Waterfall diagram
- Waterfall spectrum can be calculated from free field frequency response
- Spectrum analyzer
- Oscilloscope
- Thiele/Small parameters
- Capacitance/Inductance measurements
- Zoomable phase
- Sample rate changes can be made from menus
- Energy Time Curves (ETC)
- Wobbled sine wave measurement
- TIM distortion
- Smoothing
- Bar charts
- Windowing, with various window functions
- Mouse control

Technical Data:

- Measurement system: Impulse/PN
- Signal generation/evaluation: 16 bit D/A A/D
- Measurement signals (stimuli): Sinus, burst, pink noise, MLS, white noise, PN, chirp
- Input/Output: 1 x line out, 1 x line in, 1 x mic
- Sample rates: 48kHz high, 6kHz low
- Sample length: Max 16384 points
- FFT length: 512-4095 points
- Dynamic resolution: 16 bit
- Frequency range: 15-20000Hz High, 5-2000Hz Low
- Frequency resolution: Max 0.5Hz
- Amplitude error: <0.2dB

System Requirements:

- AT 386 or better
- EGA or VGA
- DOS 5.0 or higher
- 2Mb RAM
- 4Mb hard drive free space
- Runs under Windows 3.1, and OS/2 2.1 in DOS windows

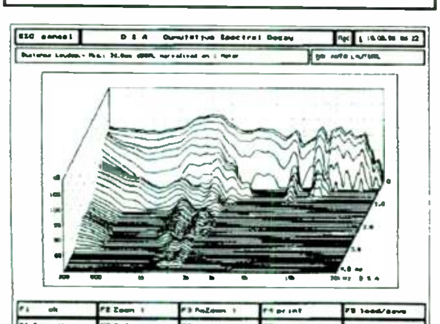
ALSO RECOMMENDED BUT NOT REQUIRED:

RCM Akustik PRE100 Mic Preamp

8.375"x4"x1.375" aluminum case, powered by 3 x 9V batteries. **$295.00**

RCM Akustik MIC300 High End Test Mic

The MIC300 is a calibrated, omnidirectional condenser microphone specifically developed for sound ranging. Freq resp: 20-20kHz. Sensitivity with field idling at 1kHz: 6 + 1.5dB mV/Pa. Electrical impedance: 500Ω. Nominal load impedance: ≥2000W. Signal-to-noise ratio: 64dB. Max sound pressure for 0.5% distortion factor at 1kΩ: 120dB. Phantom power: 10-48V. Feed current: 5.5mA. Calibration strip chart included. Black wood case with blue insert. Mic is 7-1/2" long, matte black with "RCM Akustik MIC300 [serial number]" engraved in gold. Very handsome, extremely accurate in any use. **$595.00**



DSA II—
Digital System Analyzer II **$7995.00**

Also from ADM Engineering, DSA II is the big brother–the REALLY big brother–to DAAS3L. It is made up of a converter PCB, associated software, front end hardware housed in a handsome 17.5"x10.25"x1.75" rack-mount chassis, and complete 91-page illustrated manual. Fully supported from the USA. Further information available on request.

Measurement Functions and Features:

- Signal conditioning and measuring by 16-bit D/A and A/D converters
- Measurement of transfer function and impedance response with variable frequency resolution
- Calculation of phase response from transfer function and impedance with automatic correction of signal propagation time
- Calculation of group delay time from the transfer function
- Calculation of step response and waterfalls of acoustical transfer systems
- Distortion measurement with variable frequencies, distortion curves
- Distortion measurement with external signals (external generator or CD)
- Intermodulation and difference-frequency distortion measurements with variable frequencies
- Transient intermodulation (TIM/DIM) measurements and noise + distortion margin
- Max freq resolution approx 0.5Hz
- Exports into speaker CAD programs
- Much, much, much more!

System Requirements:

- IBM AT 386/486 or compatible, 486DX recommended. *NOT* PC/XT, PC/AT 286 or compatible
- In conjunction with 80386: 80387 math coprocessor
- EGA/VGA/SVGA graphics card
- Windows 3.1x, PC/MS-DOS version 5+, or OS/2 Warp with special drivers
- Microsoft mouse or truly compatible (not essential but easier to work with)
- One hard drive, min 2Mb RAM, 4Mb free space
- One floppy drive

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Ask SB

By Bill Waslo
Contributing Editor

THE WATERFALL PLOT

The Waterfall plot in Liberty Audiosuite or IMP is more properly known as the "Cumulative Spectral Decay" (CSD) plot. This plot technique is generally credited to Fincham and Bernam (of KEF), who used it to detect resonances and internal box reflections in loudspeakers.

A waterfall is a presentation of both frequency-domain and time-domain data on a single graph (*Fig. 1*). Time-domain data is voltage or pressure as a function of time, usually in the form of a measured impulse response (origination from a pulse or MLS measurement), which covers all time. The frequency-domain version is the decomposition of the time-domain impulse response into periodic cosine waveforms via Fourier analysis.

In any combined time-frequency analysis, there are inherent resolution limitations due to the related (reciprocal) relationship of time (seconds) and frequency (per second). You cannot, for instance, talk about a frequency at a point in time—it is rather meaningless to discuss a periodic wave unless (at the very least) you consider the time length of that period. Hence, you cannot say a frequency component starts or stops at a specific time. But you can analyze a band of frequencies in terms of its energy within a given time segment.

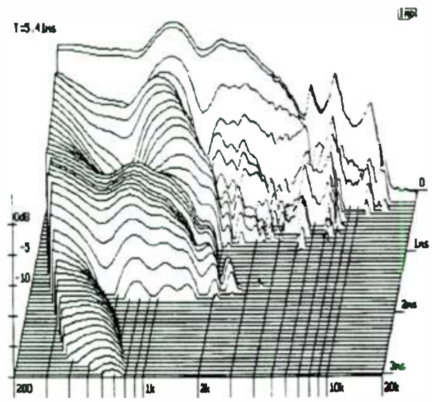


FIGURE 1: Sample Waterfall plot using IMP.

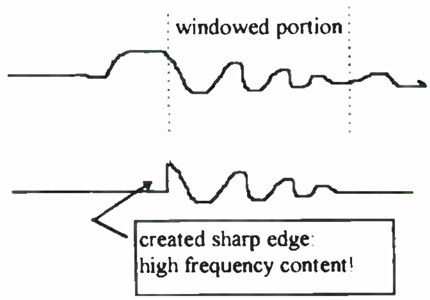


FIGURE 2: Windowing a time signal.

One relatively obvious way to do this is to select (or "window") only a portion of a time signal and perform a Fourier analysis over that section, as if the time signal were zero elsewhere (*Fig. 2*). This does generate some problems in that suddenly chopping a nonzero section of a signal to zero at the edges of the window can erroneously create extraneous frequency components. Using tapered windows on both edges of the time segment, or on only one, can help to reduce (but not eliminate) this effect.

If the time length of the segment is constant, but its position in the time continuum varies as one axis of the plot, and the resulting spectrum of the Fourier analysis is shown versus the remaining axes, the resulting plot is known as the Short-Term Fourier Spectrogram (*Fig. 3*). This plot attempts to show "frequency response versus time." It has the disadvantage that it can contain no valid information for frequencies below 1/(time segment length); therefore, to get data down to 500Hz, the segment length must be at least 2ms long.

If, however, an echo occurs from a real-world measurement at 3ms after the beginning of the impulse response, the time segment can sweep over only 1ms if the echo characteristic is not included; this would not give much of a span for the time axis. If you analyze shorter time spans, you can make a frequency-versus-time plot for a longer length of time, but can show data only for very high frequencies and at poor resolution.

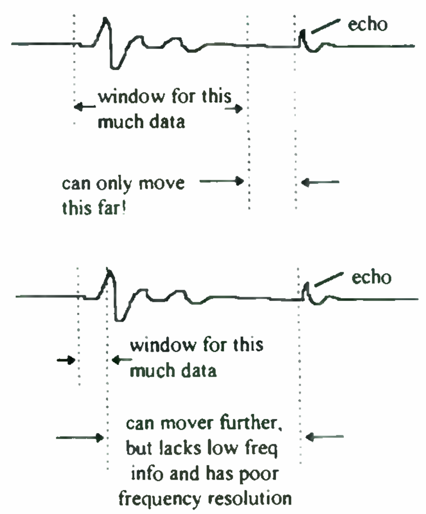


FIGURE 3: Sample short-term Fourier spectrogram.

On the other hand, a CSD or LAUD waterfall plot results (*Fig. 4*) if you include the entire active time trace for the initial transformation, then hold the position of the later edge of the window fixed relative to the beginning point of the impulse response, and vary only the earlier edge. Because the length of each time segment is shortened with each successive step in the "time sweep," the lowest resolvable frequency increases (loses resolution) at later points in the plot. The first traces of the plot can display frequencies down to the anechoic limit; successive curves are valid to approximately 1/(windowed time span). IMP and Audiosuite do not plot data below the LF resolution cutoff, resulting in an easily identified drop edge on the later traces of the plot. Some other packages plot such below-resolution LF data anyway, although it is not meaningful and can lead to incorrect conclusions based on information which simply isn't there.

The CSD waterfall does *not* show frequency response versus time! It shows the (approximate) frequency-content contribution to a total response that occurs after the (relative) time shown in the time axis. At t = 0 on the CSD plot, the entire frequency response is drawn, as the total response

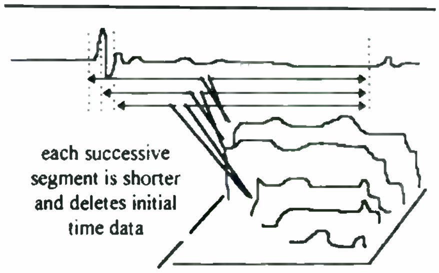


FIGURE 4: Creating a waterfall plot.

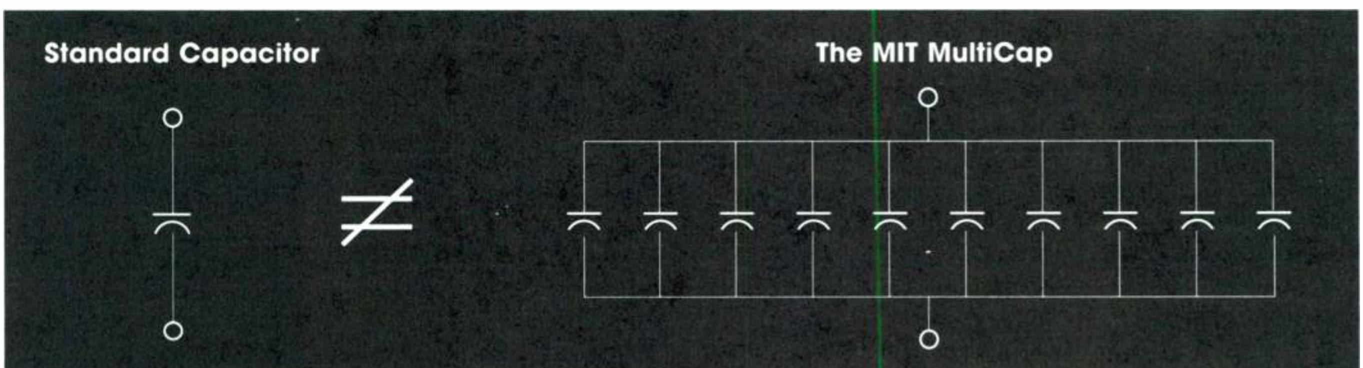
occurs after this time. At t = 1ms, the CSD plot shows the contribution to the frequency response that occurs after, but not before, 1ms, and so on.

But remember the caution stated above: frequencies cannot start at a precise time! CSDs often show the user's technique more than the speaker's quality! Also note that if the time segment selected for the waterfall plot includes an echo pulse, the frequency contribution of the echo will be present in the plot for *all* times *before* the echo occurs.

The most common use of CSD waterfalls is to detect and display resonant behavior in speaker cones, boxes, or horns. A resonance will show up as a long decaying ridge along the time axis, due to the "ringing" of the resonance over time. The data shown is *very susceptible* to measurement and display conditions.

The inherent windowing operation is hacking into the most active part of the impulse response, the result of which changes depending on the window shape, the step size used for the waterfall-graphing routine, the display scales, the low-frequency (even below resolution) content and phase, and so on. Each curve trace alone does not portray much useful information. Rather, the entire plot, the ridges, shelves, and valleys of the overall surface are revealing—in a way that is definitely qualitative, but only slightly quantitative.

If, for whatever reason, you want to find the waterfall curve value at a point in time and at a specified frequency and read off a decibel value for this, you need only recreate the window-edge condition for the waterfall plot and perform the corresponding FFT. For example, assume you have made a waterfall plot normally by setting the time markers so that marker #1 is just before the activity in the time impulse response, and marker #2 is just before the first significant reflection. You want to read off a value at the waterfall plot's "1.4ms" trace, and at 3.3kHz. Merely go back to the time-domain plot (by pressing F1), move marker #1 to a position 1.4ms to the right of its current position, go to the transform menu, and select "FFT." The resulting curve corresponds to the 1.4ms trace of the waterfall plot, and you can use the frequency-domain markers to read off any values of interest.



SB *Mailbox*

SAFETY FIRST

With regard to *SB* 7/95, p. 34, Photo 5, the user of the circular saw is in a dangerous position. Under no circumstances should the operator's right hand be adjacent to or behind the saw.

In my work as a forensic engineer, I frequently am involved with tool accidents. I am currently working on one in which the operator was positioned as shown in Photo 5, except that the saw was 6″ further into the cut. The saw bound in its kerf, and in kicking back, it ran diagonally backwards, severing the operator's right hand. Even the guide shown in the photo, on which the operator's hand rests, will not restrain a saw.

The correct position is to the side of the tool, with one hand in the handle and the other on the front rest. Two-handed operation is a requirement. All circular saws kick back. Never stand behind one, and never lean over one to complete a cut. If you cannot do the cut from the side, use another tool, like a handsaw or sabre saw, to make a preliminary cut, and use the circular saw to make a safe trim cut afterwards. I suggest that beginners retract the saw blade and do a dry run, figuring out where the saw would go if it were to bind and kick back. Then make sure that you and your hands are not where it might go.

Wear eye protection, stay alert, use two hands, and by all means avoid being over or behind the saw.

Les Winter
New York, NY 10003

CROSSOVER QUESTIONS

I found the information in Bruno Carlsson's article "Driver-Offset-Related Phase Shifts in Crossover Design" (*SB* 1/95, p. 26) very enlightening, but I am left with several questions.

Let me state my progress thus far: I am currently developing a two-way system utilizing a Vifa P17WJ-00-08 6.5″ woofer and a Dynaudio D-260 1″ tweeter. It was convenient that Mr. Carlsson had recent experience with the D-260. I plan to use an asymmetrical Linkwitz-Riley crossover (second-order LP; fourth-order HP), and it is in this area that my questions arise.

Using a slight modification of the method outlined in Carlsson's article, I have estimated the driver offset to be 1.117″. As I plan to flush-mount each driver, I made the ZDP estimate from the front of the faceplate, rather than the rear. Thus, I added the thickness of the D-260 faceplate (0.158″) to the measured 0.1″ ZDP distance in the article, and made an approximate measurement of 1.375″ for the ZDP distance of the P17WJ woofer. This corresponds to a phase shift of 59.6° at my proposed crossover frequency of 2kHz.

Now, to my main point: In the article (p. 32), in reference to the second-/fourth-order Linkwitz-Riley crossover combination, Carlsson states that "When the normal connection is used, the phase angle between sections is 90° (−90° for the LP and +180° for the HP), and since Linkwitz-Riley filters are −6dB at crossover, they require a 0° phase angle for a flat response." I follow this until the 0° comment, but how does the fact that filters are −6dB at crossover necessitate a 0° phase angle between sections in order to achieve a flat response?

The article then states that "We must add 90° of phase shift, and, as the figure shows, the minimum error occurs around 90°." Does this mean adding 90° of phase shift to the tweeter? If so—and if this means using the all-pass network in Part 2 of the article—this would result in a 180° difference between filter sections and would then require a reverse tweeter connection to achieve 0°. It appears to me that a total of −270° shift is required.

I feel I may have missed the point here. I do not see how the proposed addition of 90° of shift leads the author to refer back to figure 17 and the apparent minimum error at 90°. It seems that the inherent second-/fourth-order filter combination error of 90° is the very error for which this filter topology is

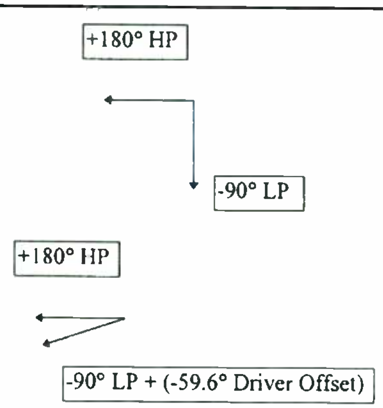


FIGURE 1: Adding filter and driver-offset phase shifts.

the least sensitive. I need help to clear up this misunderstanding.

The problem of reconciling this information is further compounded by the driver-offset-induced phase shift that is present. Are these filter and driver-offset-induced effects additive? In my case, this would result in a +180° for the HP, and a −149.6° for the LP—leaving a difference of 30.4° (*Fig. 1*).

If I were to add a shift of −149.6° to the tweeter and use the reverse connection, this would apparently achieve a 0° difference between the HP and LP. My concern is that the author has deliberately separated the phase errors of filter asymmetry and driver offset for the very reason that they must be addressed on an individual basis.

Patrick Narron
Fremont, CA 94539

Bruno Carlsson responds:

First, let me thank the readers of Speaker Builder *who took the trouble to read my article on Driver Offset-Related Phase Shifts In Crossover Design. I would also like to direct a special thank you to Mr. David Long of Dalton, Georgia, who was kind enough to send me a copy of an exchange of letters between Ralph Gonzalez and Joe D'Appolito in the Mailbox section of* Speaker Builder

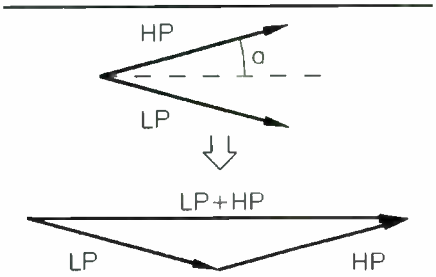


FIGURE 2: Adding filter vectors.

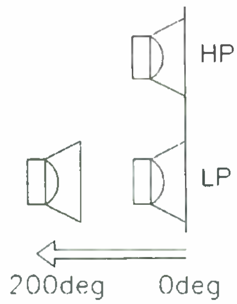


FIGURE 3: Illustrating driver-offset phase shift from 0° to 200°.

4/89. I strongly urge everybody who read my article to also read Mr. D'Appolito's answer to Mr. Gonzalez's questions about Zero Delay Planes.

Turning to Mr. Narron's letter, let me begin with the first question regarding the requirement of a 0° phase angle in the Linkwitz-Riley filters. If we say that a filter is −6dB at the crossover frequency, we are in effect saying that the amplitude at that frequency is 0.5 times the amplitude in the passband of the filter. To carry out a conversion between dB and linear amplitude, you can use the following formula:

$V = 10^{(dB/20)}$, where V is the linear amplitude and dB is the amplitude in dB with *sign.*

To visualize the addition of the outputs from the Low Pass (LP) and the High Pass (HP) filter sections, we use vectors. I have shown in Fig. 2 *how the two vectors add. Graphically, one might say that you put the two vectors "head to tail," and then you draw a third vector from the tail to the head of the combined vectors. Mathematically, you would write:*

$LP+HP = LP \times \cos(a) + HP \times \cos(a)$, where LP and HP are linear amplitudes, calculated as above.

In the case of the Linkwitz-Riley filter, we are adding two vectors, each 0.5 long. To get a flat response, the addition must yield a vector that is 1.0 long. This is possible only if the two vectors are pointed in the same direction. This is equivalent to saying that the angle "a" is 0°.

If we had been using Butterworth filters, which are −3dB at crossover, each filter vector would have been 0.707 long. To get a flat response, the angle "a" would have had to be 45° (you can try this yourself in the formula above). This is why an angle of 90° (two times the angle "a") between the LP and the HP filter sections is necessary for a flat response when using Butterworth filters.

Next, let me address Mr. Narron's second question. After rereading my article, it is now obvious to me that I was less than clear in explaining what "adding phase shift" referred to in the various figures. Where I wrote that "We must add 90° of phase shift...," I should have written, "The addition of 90° of driver-offset-related phase shift to the woofer is necessary...." I believe that this would have prevented any misunderstandings from arising.

I have tried to illustrate (Fig. 3) *what is represented by the 0° to 200° phase shift shown on the x-axis in Figs. 2 through 34 in my article. When the angle is 0°, we have two identical drivers mounted in the same plane, one receiving the LP signal and the other the HP signal. We then move the driver receiving the LP signal back, so that the path to the listener (microphone) gets longer. If we use a crossover frequency of 1kHz, we stop every 0.375 inches (every 10°) to take a reading until we reach 7.5 inches (200°).*

In the case of the second-order/fourth-order Linkwitz-Riley combination, the nonsymmetrical slope of the two filters results in a 90° phase angle between the LP and the

HP filter. What we need is a 0° phase angle. The missing 90° is filled in by the offset-related phase shift from the woofer, using one error to cancel another. Thus, the filter shows the lowest error when 90° of driver-offset-related phase shift is added.

To get back to Mr. Narron's letter, his figure is perfectly correct, as the driver-offset-related phase shift is added to the phase shift introduced by the crossover filter. In this case, it would mean that he would indeed have a phase angle of 30.4° between his LP and HP outputs. He is also correct in stating that reversing the tweeter and adding a negative phase shift of 149.6° would result in a flat response at the crossover frequency.

Alternatively, he could obtain the same result by adding a negative phase shift of 30.4° to the woofer and not reversing the tweeter. Just keep in mind that while these two different solutions are equivalent for steady-state signals at the crossover frequency, the maximum error over the entire frequency range may be different. In addition, it is likely that the group delay will differ for the two solutions.

TABLE 1

JFET MODELS

```
* Library of Japanese Junction Field-Effect Transistor (JFET) Models
* Copyright 1994 by MicroSim Corporation
* Neither this library nor any part may be copied without the express
* written consent of MicroSim Corporation.
* $Revision:   1.0  $
* $Author:   ANW   $
* $Date:   01 Oct 1993 14:16:02   $
* The parameters in this model library were derived from the data sheets for
* each part.  Each part was characterized using the Parts option.
*$
.model J2sj74    PJF(Beta=92.12m Rs=7.748 Rd=7.748 Betatce=-.5 Lambda=4.464m
+                 Vto=-.5428 Vtotc=-2.5m Cgd=85.67p M=.3246 Pb=.3905 Fc=.5
+                 Cgs=78.27p Isr=129.8p Nr=2 Is=12.98p N=1 Xti=3 Alpha=10u Vk=100
+                 Kf=26.64E-18 Af=1)
*$
.model J2sj103   PJF(Beta=2.197m Rs=76.76 Rd=76.76 Betatce=-.5 Lambda=735.3u
+                 Vto=-2.037 Vtotc=-2.5m Cgd=18.95p M=.5045 Pb=.3905 Fc=.5
+                 Cgs=17.02p Isr=38.48f Nr=2 Is=3.848f N=1 Xti=3 Alpha=10u Vk=100
+                 Kf=1E-18 Af=1)
*$
.model J2sk246   NJF(Beta=1.07m Rs=56.76 Rd=56.76 Betatce=-.5 Lambda=2.8m
+                 Vto=-2.638 Vtotc=-2.5m Cgd=10.38p M=.4373 Pb=.3905 Fc=.5
+                 Cgs=6.043p Isr=112.8p Nr=2 Is=11.28p N=1 Xti=3 Alpha=10u Vk=100
+                 Kf=1E-18 Af=1)
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INFORMATION, PLEASE

Applause to reader Steve Pleasant (*SB* 6/95). I think he is right on the point. You should encourage your writers to incorporate the right amount of information for their articles. Each project should explain why the authors made their decisions (e.g., objective of the project, drive-selection criteria, crossover design, and box alignment), how they carried out the project, what kind of performance the final product had (SPL, impedance, resonance), and how the final product sounded. Otherwise, the article simply will not mean much to the readers. I suggest that you should use some of the speaker review articles in *Stereophile* magazine as a reference.

I liked the article by Perry Sink on the modification of the Pioneer A11EC80-02F in the same issue. The total harmonic distortion chart tells me the engineering part of that driver. I believe this kind of information is crucial to the selection of woofers and should be provided by those authors who are well equipped.

Bing Yang
Houston, TX 77095

MISSING JAPANESE JFETS

The listing accompanying Walt Jung's letter in *SB* Mailbox (*SB* 7/95, p. 48) was inadvertently abbreviated to exclude the information for the J2sj103 and J2sk246 models. The complete information about the models is in *Table 1*. —Eds.

Speaker Design & the Internet

from page 37

mechanical isolation. Clearly, the two are at cross-purposes. Further listening tests will determine whether or not I keep the blue tack under the metal plates.

MEASUREMENT AND LISTENING TESTS

As the builder of these speakers, I have subjective, naturally biased, impressions. Nonetheless, the satellites and subwoofers more than lived up to my expectations. The bass is smooth and detailed down to below 30Hz without the thump or boom of an imperfectly aligned vented-box cabinet design. With my hand resting on the cabinet while the volume was turned up, I sensed virtually no vibration in the cabinet walls. Pipe organ music reproduced on the two subwoofers resulted in an impressive sense of "space" that was absent when I listened to the same piece on a single-subwoofer system.

Similarly, the satellites deliver a sense of detail and spacious imaging that puts a silly grin on my face every time. Rather than ramble on about how they sound, I'll let the brutally honest Dave Dal Farra describe them in the sidebar "Subjective and Analytical Listening Tests." At a total cost of approximately $1,000 US for the satellites and subwoofers, this project has more than delivered on the promise of high-quality sound without incurring "high-end" expenses.

WHAT'S NEXT?

With the speakers complete, my next project is to build a hybrid active/passive crossover for biamping. I intend to use a passive high-pass filter to drive a tweaked Dynaco ST70 tube amp for the satellites, and an active low-pass filter to drive a brute solid-state amp for the NHT1259 subwoofers. The active low-pass will also provide sufficient flexibility to phase-match it with the satellites in the crossover region.

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Hafler 9505 Transnova amp, 250W/channel stereo, 750 mono; Audio Research SP-6E preamp; Grommes 24PG EL84 integrated amp; pair Heath WAP2 preamps; Fisher FM80R tuner; assorted Heath test equipment; tube amp trades? Robert, phone/FAX (707) 967-9854.

EV microphones: 644, $71; DO54, $82; Integrex Dolby-B decoder, new, $50; SSS EQ1 12-band equalizer, kit with extra parts, $45; collectible hi-fi books, send SASE for list or I can fax. Andy Keller, 1455 Twinsisters, Longmont, CO 80501, (303) 772-4801.

Metallized polypropylene caps, 100V DC, copper axial leads, three values: 20µF, $3 each; 10µF, $2 each: 5µF, $1.50 each; radial lead cube style, 10µF, 160V DC, $2 each. Will select 1% matched pairs in small quantities. I'll pay shipping. Joe, (800) 669-7430, 9-5 EST.

Infinity Emims, $65 each; pair Sequerra T-1 ribbon tweeter, $600; beautiful oak Infinity/Genesis type 7.5′ ribbon baffle, $900. Douglas S. Robinson, 21842 Hillandale Dr., Elkhom, NE 68022, home (402) 289-0886, work (402) 779-2531 from 8–5.

CLASSIFIED INFORMATION

Four types of Classified Advertising are available in *Speaker Builder*:

FOR SALE: For readers to sell personal equipment or supplies.

WANTED: Help readers find equipment or services.

TRADE: For any business or private party selling equipment, supplies or services for profit.

CLUBS: Aid readers in starting a club or finding new members. Specific guidelines apply to *Club* advertising. Please write to the Ad Department for terms. Don't forget, include a #10 self-addressed stamped envelope.

PRICING

All advertising is $1.50 per word, $10 minimum per insertion. Deduct 5% for a 8x contract. Please indicate number of insertions. Payment MUST accompany ad. *No billing for word classified advertising.*

AD COPY

A word is any collection of letters or numbers with a space on either side. *No abbreviations*; please spell out all words. Count words, not letters. Ad copy should be clearly typed or printed. Illegible ads will be discarded.

SUBSCRIBERS

Receive *free For Sale* and *Wanted* ads, 50 word maximum, each additional word $.20, $10 minimum. For *Club* ads, follow instructions at the bottom of the Clubs listings. Please submit only one ad per category per issue.

Please include your name, address, and telephone number. If TRADE please indicate number of insertions on the ad. All free ads are run only once, and then discarded. ***Ad questions, copy and copy changes cannot and will not be answered on the phone.*** All correspondence must be in writing addressed to:

Speaker Builder
Classified Department
PO Box 494
Peterborough, NH 03458-0494

Hobbyist cleans house. Woofers: Audio Concepts DV12s, Peerless CC1727s, Eminence 10536s; midranges: RS 3″ cat. 40-1289A; tweeters: Vifa D26s & D25s, all perfect, none soldered, full specifications; complete systems: Focal Aria 7s in black (7K011DBLs/T120Tis), Vifa 6.5″ two-way in oak (P17WJs/D25s); Aria 7 MDF enclosures. No reasonable offer refused. Michael, (412) 283-2964 (Pittsburgh, PA area).

Nitty Gritty 2.5, $200 Canadian funds; SEAS PR17 coax, new, $75 Canadian; BBE 402 sonic maximizer, $150; Paradigm Titans, $150. Stan, (604) 376-1487.

Audio Concepts Sapphire IIti plus AC stands, two years old, $790. Mike, (612) 861-1152.

Pairs of classic coaxial Studio Reference monitors: modern oak towers using classic coaxial and triaxial 12″ drivers from Altec, EV, Tannoy, University, etc., 39 x 15 x 12, heavily braced, 1″ baffles, solid oak corners, 2″ bases, black grilles, $600 to $1,200; pair complete enclosures with connectors, port tube, 55 lbs, double boxed, $500. Craig, (314) 579-0088.

Pair Martin Logan Sequel ESL, $1,200; Hafler amps 5, XL280, SE240, $400 each; Denon PMA1520 integrated amps, $500 each; Marchand amp modules: PM22, PM2, PS10; Dynaudio D28AF tweeters, $25 each. Ken Moseley, (415) 661-5411 (CA).

Audio Research LS-3 preamp, *Stereophile* Class A, black, $1,100; Dyna ST-70, $175; three Pioneer SM-100 solid-state stereo power amps, 75W/channel, variable damping and input sensitivity, $175 each; Carver PM1.5 600W/channel power amp, balanced, $550; two Carver 1201 600W/channel amps; Phase Linear 700C power amp. David, (914) 688-5024.

Tri-amped three-piece system, TL loading. Satellites: D'Appolito configuration towers, Audax, Dynaudio drivers (*Speaker Builder* 1/88, pp. 58–9); subwoofer: 12″ PLI in 12′ TL (*Speaker Builder* cover speaker, 4/87); matte walnut Formica, smoked glass tops, DeCoursey 18dB/octave active crossover, subwoofer summing. $600 firm. Cushing, (603) 226-3821.

Boston Acoustics 10.0 10″ car subwoofer driver (was $250), $100; large, special LP record collection (stereos, monos, classical, opera), sell all/part, contact for list; pair Dynaudio D76AF 3″ dome midranges, $150; Dyna FM-5, $50; interesting trades? Jerry Feldstein, PO Box 580163, Bronx, NY 10458, (718) 364-3485, 7–10 p.m. eves., no machine.

Fried Studio Vs with the unique MARS circuit that reproduces a fuller stereo image down to a true 26Hz. This transmission line sound is beautifully clear and full. I spent considerable time "voicing" the internal damping to get it perfect. These new speakers have been fully upgraded with $600 worth of drivers and crossovers. I even used custom, hand-wound chokes that Wilson is trying to get in sufficient quantity for their use because they sound better than what they can currently get. The cabinets are very attractive and extra solid with veneer on the inside as well as outside. Fried is selling the non-upgrade, but more recent cosmetic version for $3,600. I am asking $1,900. Gordon, (510) 889-0193 or days (510) 423-2907.

ACI Titan subwoofers, $650 each, $1,100/pair; Spectral SDR-1000 SII IR remote CD player/preamp, $2,400 (was $8,500); pair Spectral DMA-80M, $2,800 (was $6,000); Spectral DMC-5A, $700 (was $1,700); Threshold T-100, $1,750; pair Eminent Technology FT-8 speakers, new '95, $875; pair Audax PR170X0, new '95, $88; offers. Steve, (203) 397-3888.

Ad Index

ReVox A-77, ¼-track, transport and playback work fine but won't record, $350. Kurt Lyons, (313) 884-8941, 7–9 EST.

Pair Advance MH-30B speakers (quality Mimus 7 "clones" using four element crossover and dome tweeters), require replacement woofers, $22; pair Vifa D19TD-5 8Ω tweeters, $12; pair Philips AD0163 T8 tweeters, $14; Nakamichi 550 portable cassette deck, $125. Greg Nawrocki, 21 Indiana St., Kitchener, ON N2H 2A4 Canada, (519) 745-1579.

WANTED

JBL 375, 2440, 2482, etc. 2″ exit drivers, cheap or blown; HL89, HL90, 2390, 2395, or 2397 horns; 2327 adaptors; Marantz 240, 250, 400, 500, or 516 power amps, repairable OK. Maury, (360) 887-3640, nights PST.

Single Fisher 55A (uses 6550s), any condition but trannies must be OK; tube amps, amps can be dead but transformers must be good; NOS transformers; tube books and related paraphernalia and parts. Robert, phone/FAX (707) 967-9854.

Service manual for Pioneer TVX-9500. Andy Keller, 1455 Twinsisters, Longmont, CO 80501, (303) 772-4801.

One Optimization amp; single Partridge transformer; Altec 1505B horns, 288, 515; JBL 2397/2328. Willie, (416) 251-3007 (Toronto, Canada).

Altec 1566, 1567 mixer; 436, 438 compressor amp; RCA MI9449 15's; UREI, White, Pultec, dbx, Langevin, Fairchild EQ or compressor. Kent Elliott, phone/FAX (913) 677-1824 (KS).

JBL 2235 subwoofers; Focal 10K515T, SK013L, SK413s, T90ti, T120ti pairs; Hafler XL280 or XL600 power amps. Dan, (206) 874-8441 or (206) 803-6410 (message).

Old microphones, tape machines, audio professional gear, radio equipment, etc. Jim, (313) 783-9223.

Electro Voice X8, X36, SP8C, and T35; JBL K151, 2402H and 2405H, any condition; Pioneer Spec 1, Spec 4, D23, and SF-850; Cerwin-Vega 1800I, 3000I, 189JE, and 188EB, any condition. Carlos, (718) 465-6053.

CLASSIFIED DUE DATES

Issue #	Due By
2	Feb. 23
3	April 3
4	May 24
5	July 5
6	Aug. 28
7	Oct. 2
8	Nov. 8

SPEAKER BUILDER CLASSIFIED ORDER FORM

TRADE— for any business or private party, selling equipment, supplies, or services *FOR PROFIT.* **FOR SALE**— to sell ***personal*** equipment or supplies. **WANTED**— to find ***personal*** equipment, supplies, or services. **CLUBS**— to help readers start and maintain club membership.

PRICE: All ads are $1.50 per word. Deduct 5% for an 8X contract. $10 minimum per insertion. **Payment must accompany ad.**

FREE ADS: Subscribers receive free **For Sale** and **Wanted** ads up to 50 words. Over 50 words $.20 per word, $10 minimum. Name, address and phone number must be included with ads. For **Club** ads, follow instructions at the bottom of the Clubs listings.

SUBMITTING COPY: A word is any collection of letters or numbers with a space on either side. Copy must be clearly typed or printed. ***Illegible ads will be discarded.*** Submit copy by mail, fax, or data transfer (ASCII, WordPerfect 5.0 or 5.1, Word for Windows, Word for DOS, Windows Write, or Word Star 3.3- 5.5 formats).

QUESTIONS? Write or fax us at the address below.

❑ For Sale ❑ Wanted ❑ Trade, No. of insertions_____

USE BLOCK LETTERS IF PRINTING. NO ABBREVIATIONS.

1	2	3	4	5
6	7	8	9	10
11	12	13	14	15
16	17	18	19	20
21	22	23	24	25
26	27	28	29	30
31	32	33	34	35
36	37	38	39	40
41	42	43	44	45
46	47	48	49	50

Please charge to my: ❑ DISCOVER ❑ MASTERCARD ❑ VISA

CARD NUMBER EXP. DATE

❑ CHECK/MONEY ORDER ENCLOSED

Subscription Account Number: A❑❑❑❑❑❑❑

NAME

COMPANY

STREET & NO.

CITY STATE ZIP

PHONE

AAP, Inc. — Classified Dept.
PO Box 494, Peterborough, NH 03458
FAX 603-924-6230

ALL ADS SUBJECT TO RUN AT DISCRETION OF PUBLISHER / AD DIRECTOR

CLUBS

If you are interested in joining a club or forming one in your area, contact the following:

ARIZONA

Arizona Audiophile Society
PO Box 13058, Scottsdale, AZ 85267
Paul Christos, (602) 971-3979

CALIFORNIA

Tube Audio Enthusiasts
65 Washington St. #137
Santa Clara, CA 95050
John Atwood, FAX (408) 985-2006

Greater South Bay Audiophile Society
Larry Fisher, (310) 599-6579;
Dave Clark, (310) 427-4207

San Diego Audio Artisans
Dennis, (619) 297-3352 eves.
FAX: (619) 296-0927

Los Angeles Loudspeaker Designers Group
Geoffrey, (213) 965-0449;
Eduard, (310) 395-5196

West Valley Audio Society
Woodland Hills, CA
Barry Kohan, (818) 225-1341

Bay Area Audiophile Society
Dennis Davis, (415) 381-4228

Westside Speaker Builders
Cupertino, CA
Phil Terzian, (408) 446-1336
FAX (408) 446-4527

COLORADO

Colorado Audio Society
1941 S. Grant St.
Denver, CO 80210
(303) 733-1613

CONNECTICUT

James Addison
171 Hartford Rd., A-7
New Britain, CT 06053

Connecticut Audio Society
PO Box 116, E. Berlin, CT 06023
Charles King, (860) 665-2881

FLORIDA

Gulf Coast Audiophile Society
5746 S. Lockwood Ridge Rd.
Sarasota, FL 34231
John R. Chait, (813) 925-1070

GEORGIA

Atlanta Audio Society, Inc.
4266 Roswell Rd. N.E., K-4
Atlanta, GA 30342-3738
Chuck Bruce, (404) 876-5659
John Morrison, (404) 491-1553

ILLINOIS

Chicago Audio Society
PO Box 313, Barrington, IL 60011
Brian Walsh, (708) 382-8433,
E-mail sysop@nybble.com

Prairie State Audio Construction Society
20 Wildwood Tr., Cary, IL 60013
Tom, (708) 248-3377 days,
(708) 516-0170 eves.

MASSACHUSETTS

The Boston Audio Society
PO Box 211, Boston, MA 02126-0002
E. Brad Meyer, phone/FAX (617) 259-9684,
E-mail 72365.75@compuserve.com

MICHIGAN

Southeastern Michigan Woofer and Tweeter Marching Society
PO Box 721464, Berkley, MI 48072-0464
(810) 544-8453,
E-mail aa259@detroit.freenet.org

MINNESOTA

Audio Society of Minnesota
PO Box 32293, Fridley, MN 55432
(612) 825-6806

MISSOURI

Greater Osage Thermionic Warming Group
7454 E. Fox Trot Lane
Rogersville, MO 65742
James Guillebeau, (417) 889-3355

NEVADA (Las Vegas)

Las Vegas Audiophile Society
Las Vegas
Tarcisio Valente, (702) 435-7451

NEW JERSEY

New Jersey Audio Society
209 Second St., Middlesex, NJ 08846
Frank J. Alles, (908) 424-0463
Valerie Kurlychek, (908) 206-0924

NEW YORK

The Audio Syndrome
Nassau and Suffolk counties
Roy Harris, (516) 489-9576

Catskill and Adirondack Audio Society
PO Box 144, Hannacroix, NY 12087
(518) 756-9894

Daniel Phinney
29 Brian Dr., Rochester, NY 14624
(716) 594-8118, 5-9 p.m. EST

Long Island/Westchester County
Publio Morera, (516) 868-8863

Western New York Audio Society
PO Box 312, N. Tonawanda, NY 14150
Denny Fritz

The Gotham City Audio Society
c/o David Schwartz, President
375 11th Street
Brooklyn, New York 11215
(718) 788-0917

NORTH CAROLINA

Piedmont Audio Society
1004 Olive Chapel Rd., Apex, NC 27502
Kevin Carter, (919) 387-0911

TENNESSEE

Memphis Area Audio Society
8182 Wind Valley Cove
Memphis, TN 38125
J.J. McBride, (901) 756-6831

TEXAS (Sweetwater)

Rick, (915) 676-7360

UTAH (Salt Lake City)

Wasatch Audio
Edward Aho, (801) 364-4204

WASHINGTON

Pacificnorthwest Audio Society
Box 435, Mercer Island, WA 98040
Ed Yang, (206) 232-6466;
Gill Loring, (206) 937-4705

Vintage Audio Listeners and Valve Enthusiasts
1127 NW Brite Star Ln., Poulsbo, WA 98370
(206) 697-1936

ARGENTINA

Buenos Aires Audio Club
Rincón 476
1081 Buenos Aires
Willy Pastrana, (011) 54-943-0007

Figaro
Esparta 1680 5000 Res.
Olivos Cordoba
Esteban Bikic, (011) 54-51-684251

BELGIUM

Lowther Club
Avenue Plissart, 16
1040 Brussels
Victor Meurisse, FAX (011) 32-2-736-7394

CANADA

Montreal Speaker Builder Club
4701 Jeanne Mance, Montreal,
PQ, H2V 4J5 Canada
Andrew McCrae, (514) 281-7954

CHILE

Christian Bargsted
Los Gomeros 1542, Vitacura, Santiago
(011) 562-538-0638

GERMANY

ESL Builders Group
Gunter Roehricht
Bühlerstr.21, 71034 Böblingen, Germany

INDONESIA

Tube Audio Enthusiasts
Ignatius Chen
FAX (011) 62-21-3868074,
(011) 62-22-213277

NETHERLANDS

Audio Vereniging Midden Nederland
B. Doppenberg
Brinkersweg 16, 8071 GT Nunspeet
(011) 31-3412-57848

SOUTH AFRICA

Hi-Fi Club of Cape Town
PO Box 18262, Wynberg 7824, South Africa
Chris Clarke, FAX (011) 27-21-7618862,
E-mail chrisc@iaccess.8a

UNITED KINGDOM

London Live DIY Hi-Fi Circle
Brian Stenning, (011) 44-181-748-7489

If your club is not represented or if you are interested in starting up a club, simply send the information (club name, contact person, address, and phone/FAX number) to:

Audio Amateur Publications, Inc.
Clubs
PO Box 494
Peterborough, NH 03458
FAX (603) 924-9467