

LINE ARRAYS

Line arrays have been a very popular topic among DIY enthusiasts for the last half-decade or so, partially due to the availability of reasonably priced electrodynamic planar speakers. Mr. Russell's article ("A Unique Stereo Column System," Oct. '05 *aX*) was interesting, covering many of the advantages of line arrays, although he did not touch on the problem of comb filtering, which will limit the fidelity of an array in the high-frequency range. Mr. Russell's array will suffer from this somewhere in the region of 3.2kHz and above (based

on driver spacing of 4.25"). Admittedly, some DIYers report that the problem is not as serious sonically as theory would predict, but still—with that spacing—it will have phase problems in the top two octaves at least.

Today, Dr. Griffin's line array paper (2003) is the leading set of guidelines used by those building line arrays <http://www.audiodycentral.com/resource/pdf/nflawp.pdf>. Also of interest is Paul Taylor's 1964 paper <http://homepage.mac.com/tlinespeakers/TLS/downloads/taylor-line-array.pdf>. Although primarily focused on far-field use of line arrays, this one goes deeper into the math and has some very illustrative graphs of the comb-filtering issue. There is also good coverage of power tapering.

Mr. Russell's patent #4,267,405 is an interesting read. The tweeter array described with 3.1" spacing will comb above 4.4k, meaning it will provide not much more than two octaves before the phase problems associated with combing come into play.

David Dlugos
Victoria BC
Canada

Roger Russell responds:

The information that Mr. Dlugos is looking for is contained in my second article to be published in *audioXpress* sometime this year. This is about an updated system having improved drivers plus information concerning comb filtering, driver spacing, and driver directionality.

Many years ago, I read an article titled "Performance of Series-Parallel Speaker Arrays" by James Novak that was published in *Audio Magazine*, September 1961. It explains the expected losses from driver spacing, and so on. The effect of reduced output

at the higher frequencies has been taken into account in both article designs.

I don't know whether Mr. Dlugos has ever heard a properly designed column, but despite all the misgivings about comb filtering, phase and theoretical predictions, stereo imaging and coherence in music are more accurate than ever. Response is very smooth and extended and is confirmed by both listening and measurement.

Power tapering or response tapering is not necessary for long column designs, and it defeats some of the advantages of the long column, such as increased floor reflections for the mids and highs and reduced power handling at the higher frequencies. Worse than that, it could introduce those dreaded parts used in crossover networks!

NOS COMPONENTS

I've come across a source for new-old-stock of hard-to-find semiconductors. You're probably familiar with the PMD17K100, PMD16K100 power Darlington transistors from Lambda that were used in the Pass A-40 power amp (*TAA* 4/78). I used these as an example, and I can get 300 of each just from one particular lot dated 1990. Price is \$3.50 each in quantities of 100, Lambda metal can parts from a trustworthy source.

I believe that I can get the rest of the transistors (the small signal parts should be much less) in case you want to bring back the Pass A-40 kit. This might be a way to have much more affordable kits. An air-cooled monoblock version in a nice retro chassis would be sleek: http://www.hammondmfg.com/jpeg/1441Grp_B.jpg.

Pete B.

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http://members.aol.com/basconsultants/bas_cons.htm

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Some of my classic speaker-related posts:

http://www.classicspeakerpages.net/dc/dcboard.php?az=show_topic&forum=3&topic_id=5243&mesg_id=5243&page=

http://www.classicspeakerpages.net/dc/dcboard.php?az=show_topic&forum=3&topic_id=5576&mesg_id=5576&page=9

My amplifier-related posts:

<http://www.diyaudio.com/forums/showthread.php?s=8d5fe7f215d9f5330e08752b5d939f87&threadid=48873>

CD MODS

In the February 2003 *aX* ("Upgrade Rotel's 970BX CD Player," p. 26), Charles Hansen outlined a simple and effective mod for the Rotel 970BX CD player. Using his template, I modified my player, albeit with slightly different parts. I have the itch to fiddle a bit more with this player and I would like to bounce a few questions off Mr. Hansen.

As noted in the article, the player's output is higher than the standard 2V. What resistor values might you suggest trying at the outputs to attenuate this monster's gain? I'd like my ARC SP6B preamp's gain pot (Alps Black Beauty 100K) to be more usable! As it is, I can use only the first half-dozen clicks, or about to "9 o'clock." With other sources, the pot's usable range goes to "3 o'clock."

I have not bypassed the 100 μ F output 'lytics yet, but I did replace the op amps. I used new quality sockets and fitted them with Burr-Brown's OPA627s. Sounds terrific. Thanks for the hints!

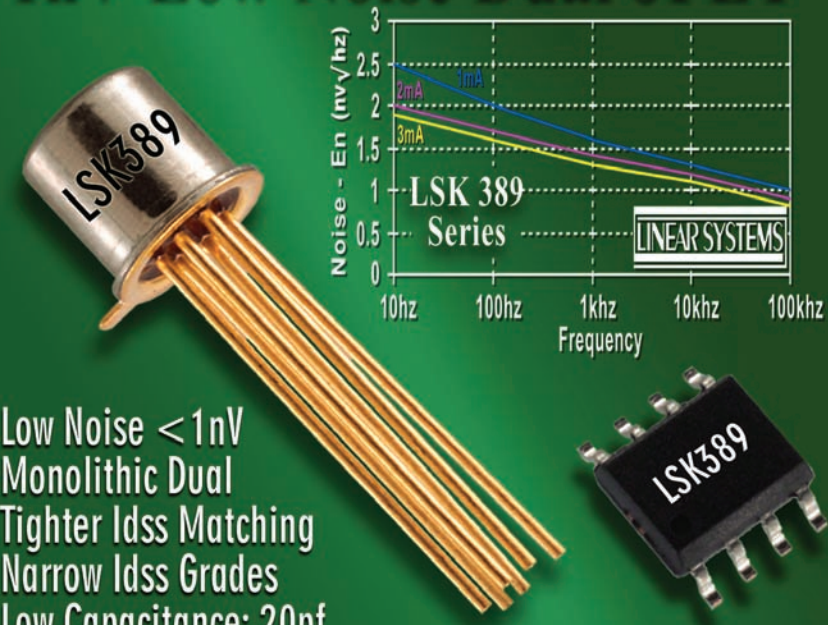
I know that circuits like this usually comprise low-noise metal film resistors, but I've had such fantastic results using both Riken and Kiwame carbon resistors in my amplifier's signal path that I'm tempted to try these out in the CD player. I know it's atypical—and perhaps good reasons exist for this—but I think the player's sound could stand a little "warming up" anyhow. I must say, too, that the new op amps warmed the sound considerably. The player immediately played with a chestier, harmonically richer sound after this surgery.

What do you think of this modern carbon resistor idea? The Rikens, in particular, sound lovely, and although I don't have the equipment or skill to measure such things, they claim to be very quiet with tight tolerances. I've also been itching for a reason to try a couple of

the nearly disappeared Shinkoh tantulums. Might be a good spot.

Also, have you ever messed about with biasing the op amps into class A operation? If so, how'd you implement it and what did you think of the results?

1nV Low Noise Dual JFET



The graph shows Noise - En (nV/hz) on the y-axis (0 to 3) versus Frequency (Hz) on the x-axis (10hz to 100khz). Three curves are plotted for 1mA, 2mA, and 3mA bias currents. The 1mA curve is the lowest, followed by 2mA, then 3mA. All curves show a decrease in noise as frequency increases. The LSK 389 Series is labeled on the graph, and the LINEAR SYSTEMS logo is in the bottom right corner of the graph area.

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Thanks so much for your articles. Like many of those in *audioXpress*, I enjoy them quite a bit.

Mike Genett
Los Angeles

Charles Hansen responds:

Thanks for your kind letter concerning my Rotel 970BX modification article. I'm glad you found the article helpful. Let me try to answer your questions.

1. According to the Philips data sheet, the TDA1305 has a full-scale output (Vfs) of 1.5V RMS into 3k. In order to obtain a 2V RMS Red Book full-scale output from the 970BX, you will need a gain (Av) of 1.333 at your OPA627. Change the feedback resistor (pin 6 to pin 2) from 4k70 to 4k02 and you should have it.
2. Many people think highly of the OPA627.
3. The use of different resistor types is a subjective choice, so I must leave that up to you and other readers. There are two types of carbon resistors—carbon composi-

tion and carbon film. Riken seems to call the latter carbon composite film.

Carbon composition resistors are quite noisy, but guitar amplifier manufacturers seem to like them for their warmth. They do not have tight tolerances because of the generally accepted temperature coefficient (tempco) of $-1200 \text{ ppm}/^{\circ}\text{C}$. The exact tempco is hard to pin down because it is not only nonlinear but also varies with resistance value. In addition, in the presence of high temperature or humidity and as they age, they change resistance, usually downward as much as -15% .

Carbon film resistors are only slightly more noisy than metal film types. The tightest tolerance is usually 5%, but 1% tolerance is possible over a narrow temperature range for selected resistance and wattage ratings. Long-term resistance drift may still occur due to time and temperature.

Tantalum film resistors seem to have come and gone, as you stated. Nichrome is usually used for metal film resistors.

4. Biasing op amps into Class-A operation is a well-established technique. You can find information in *TAA* 2/90 pages 48-49, *TAA* 1/91 page 48, *TAA* 1/94 page 37, *TAA* 1/96 page 25, and *AE* 3/97 page 39.

JUNK BOX AMPS

Bruce Brown's article on junk box amps was excellent (Dec. '05 *aX*; Larry De-Ruyter co-author). This is valuable to all of us who are working on tube amps and keeping this great culture alive. I have a few questions.

- Can I use a Heath A9 as one of the monoblocks for this project?
- Since I am unable to find another A9, is there another Heath that could serve as donor for the mate?
- Do you have a schematic and bill of materials for the modification to the A9?

Bernie Hyman
NMC Americas

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Bruce Brown responds:

You can use virtually any output transformer designed for a plate-to-plate push-pull amp. Transformers used with 6L6s, 6BQ5s, EL34s, 5881s, 7591s from Heath, Sherwood, Fisher, as well as many others. Any of the A, B, Cs, or W4s will work, and you can find these online most of the time.

You can contact me directly if I can be of further assistance: Tuninfork@aol.com.

I was quite impressed with the amp project in Dec. '05 *aX*, which was contributed by Bruce W. Brown and Larry DeRuyter ("Junk Box Tube Amp Jubilee," p. 24). There is, however, an error in Table 2 (p. 26) which lists tube rectifiers and their ratings. The filament current for the 5V3 is not 3A as listed—it is 3.8A. It is the 5V3A which has the 3A requirement. Also, the stated 1200mA plate current rating should not be confused with the DC output current given under the voltage drop heading, which is correct.

In Table 1 (also p. 26) the heater current for the 6SN7 and 7N7 is .6 amps—not .5A and .8A (respectively) as listed.

Neal A. Haight
Castro Valley, Calif.

Bruce Brown responds:

You are quite correct on the 5V3. I apparently didn't get the A to stay in the revisions. You are also right on the 6SN7 and 7N7 filament currents. Thanks for your sharp eyes.

PEAK AUDIO LEVELS

I thoroughly enjoyed Dennis Colin's article on musical waveform peak power in the November '05 *aX* (p. 48). I would like to see more articles like this. The subject of peak audio levels and crest factor—and what it means for required amplifier power—is something I have been researching for the past year or so. In my case, I built a special meter that can measure average RMS voltage and peak voltages at the same time, outputting each to its own DVM display. The peak detector includes two stages of precision peak-hold circuits so that even the briefest of peaks is held long enough to be displayed accurately. A couple of friends and I demonstrated this at the recent DIY



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speaker gathering in Washington, DC.

My experience was similar to Dennis', with surprisingly large peaks noted on well-recorded CDs with good dynamic range. I took measurements on the following tracks:

1. George Strait—"Ocean Front Property,"—*All My Ex's Live in Texas*—track 1.
2. Rickie Lee Jones—"Flying Cowboys,"—*Ghetto of My Mind*—track 3.
3. "Alison Kraus + Union Station Live,"—*New Favorite*—track 9.
4. Annie Lennox—"Bare,"—*A Thousand Beautiful Things*—track 1.
5. Tracy Chapman—"Crossroads,"—*Crossroads*—track 1.

The results are summarized here. All of the tracks were reproduced at the same volume control setting. The voltages were measured at the terminals of the left channel speaker. The power amplifier used was rated at 250W per channel. The

response, and they reflect the contribution from both stereo channels.

There are several interesting things to note from the data. First, the crest factor of the Rickie Lee Jones track is substantially higher than even that of the George Strait track measured by Mr. Colin. Also note that the Jones track is recorded at a lower average level than the others, presumably to make room for the high peaks, which occur on snare drum hits. This is a well-recorded album and does not seem to have artificially boosted highs.

Although a 132W per channel amplifier is required to reproduce the Jones peaks, the average SPL at the listening position is nowhere near loud. In fact, a "realistic" level for this would probably be at least 3dB higher, at 80dB SPL, implying the need for a 264W per channel amplifier to reproduce it without clipping at that level with these speakers. To play the Jones cut at the 90dB listening level Dennis used as an example would require

a 2640W per channel amplifier. Use of more efficient speakers rated at 86dB 1W/m would only cut this number in half.

While it is true that the Jones track has an unusually large dynamic range, this

SPL readings were taken at the listening position with both channels driven.

The speakers are 8Ω three-way Morel-based bookshelf speakers with an efficiency of about 83dB 1W/m. The listening position was about 11' from the speakers. The first number in the watts column is the minimum power rating, per channel, of the power amplifier that would be required to reproduce the peak voltage without clipping. The second number is the actual average power corresponding to the RMS voltage. Both power levels are referred to an 8Ω load.

Obtaining the V RMS and average SPL numbers required some judgment, because they tend to jump around with the program material. In both cases here, it is the number that the meter hovers around during the louder sustained vocal passages over a period of more than one second. I believe this is likely to correlate reasonably well with the perceived loudness of the playback level. The SPL numbers were obtained from a Radio Shack SPL meter set to A weighting and slow

data still suggests that many listeners may be clipping their amplifiers more often than they think. This may especially be the case for those with tube amplifiers who are not using extraordinarily efficient speakers. The amount of clipping, and the way in which amplifiers handle clipping, may account for more of the perceived differences in amplifier sound than we realize.

It would be nice if all amplifiers had accurate and fast clipping indicators. It might be a real eye-opener. In my view, if your amplifier is clipping, you have left the realm of high fidelity.

Once again, many thanks to Dennis for a thought-provoking article.

Robert R. Cordell
Holmdel, N.J.

Dennis Colin responds:

Thank you for your interest in my article. I especially appreciate your work and the results you published here, which rein-

Artist	Vpeak	V RMS	avg SPL	max watts	avg watts	crest factor
Strait	43	4.1	82	116	2.1	21
Jones	46	2.1	77	132	0.6	27
Kraus	30	4.1	80	56	2.1	17
Lennox	54	12.5	90	182	19.5	13
Chapman	41	4.7	83	105	2.8	19

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force the need to allow sufficient amplifier headroom.

I like popular music, including hard-driving rock, but I'm frustrated with the lack of well-recorded (i.e., noncompressed, etc.) material in this genre. I realize this compression (and attenuation of natural deep bass) is perpetrated upon us in the interest of the industry's "loudness wars" (sales are proportional to dB SPL/dollar). Rickie Lee Jones is an exceptional testament to the importance (to perceived loudness) of maintaining the source's dynamic range, even of the short duration (but high amplitude) peaks.

I agree with your belief that the amount and nature of amplifier clipping account for much (if not most?) of perceived amp differences.

My "Mad Katy" tube amp, a 125W per channel, has fast and accurate clipping LEDs, sensitive enough to show a single cycle of overdriven 20kHz. In a fast A/B test using Sennheiser HD 450 phones to compare the amp's input/output signals (amp loaded by a reactive speaker simulator), no difference could be heard until the amp was overdriven about 3-5dB on fast peaks. But just listening normally (through speakers and without referencing to the input), more than 10dB overdrive was often needed (depending upon source) to notice a difference. This amp clips very smoothly with no recovery transient problems. But many amps, tube and SS, produce nasty overdrive waveforms; these would be expected to produce noticeable degradation with even slight overdrive levels.

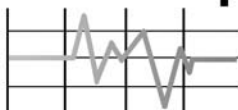
Thanks very much, Robert, for sharing your collaborative research.

BATTERY REPLACEMENT

I started reading with interest the article by Charles Hansen called "Rescuing Fluke's Top Digital Meter Cheaply," (April '05 *aX*, p. 36). About five years ago I went to the Dayton Hamvention with a Fluke 8050 or 8060 on my shopping list. I found an 8050 for \$75 (as I recall). Its batteries were also dead. I hoped to pick up some pointers on improving or repairing my 8050.

As I started reading the article, I realized that all he was doing was replacing the batteries. I recalled that I had ordered some battery packs from Digi-

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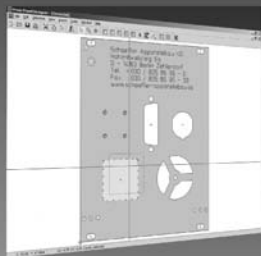
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key that had dropped into the factory holders. I was able to unearth a record of that purchase, and found that I had ordered two P163-F021-ND battery packs from Digi-key. My memory says they totaled about \$35 or \$40, but I do not have the figure in front of me, and it has been several years.

I was actually disappointed that the whole article was about the battery replacement, something which I had done in about an hour (not counting the time waiting for the batteries to come), and with no more fuss than opening the case, measuring the batteries, ordering them, soldering on the four wires, and reassembling the meter. I don't recall how much work it took to trace down a source for the correct size of battery, but I am sure it was less than Mr. Hansen spent retrofitting his meter.

Anyone else having an 8050 may put the batteries in using either method. I recall that I studied the circuitry and found that it should have worked fine off AC power if you replace the batteries with 2.4V to 2.8V zener diodes. However, the batteries are sometimes very helpful, because measurements are then free of both a ground connection and any AC hum from the transformer and power supply.

I have found the meter very helpful. It is very satisfying (and quick) to send a 1kHz tone through equipment under test, adjust the level for test conditions, and press the "RELATIVE" button and watch the meter show you 0dB. Finding the -3dB points is just a matter of going up or down until it says +3dB or -3dB, and recording the frequency. The portable version (8060, I believe) made it even easier, because it included an audio frequency counter. I miss that feature, but the 8060 stayed with my former employer.

*Ted Miller
Elkhart, IN*

NOISE METER

I read with interest Charles Hansen's article on the Solid State Noise Meter Amp (Jan. '05 *aX*) and have some comments. You seem to be under the impression that a low input impedance is desirable. While the noise is lower with no source attached, low input impedance degrades the s/n with any source.

For example, with a 600Ω source and 600Ω input resistance, the noise level is degraded 3dB over theoretical minimum. The input impedance should be at least 100kΩ.

Also, I question the use of the AD745 with its 3nV/root Hz noise. You can do 14dB better with a transistor front end. In general, low voltage noise sources have low impedance, so current noise is not an issue.

You use additional compensation because the 745 has a minimum stable gain of 5, yet in the circuit it has a gain of over 5.

I assume you use two ICs to get the bandwidth. A three-transistor circuit would provide the bandwidth with more simplicity (single power supply, though you would need some large electrolytics).

I wonder why the noise is higher with the AC adapter?

*David Hadaway
dbsys@att.biz*

USHER REVIEW

I recently read a review on the Usher CP8871 written by Mr. Moriyasu in Feb. '04 *aX* (p. 54). I had a few questions for him about his findings regarding the crossover design/shortcomings of this particular model. Basically, are the design and quality issues correctable without needing to build separate outboard crossovers?

*David E. Hawk
david.hawk@sbcglobal.net*

James Moriyasu responds:

Yes, because the cabinets are relatively large and roomy, it would be easy to remove the crossover boards and make the necessary modifications without needing to build outboard crossovers.

The main issue would be the interaction of the inductors. Because there were three of them, the first two could have their poles oriented at 90° to each other. However, the third must be separated by some 10–12" or more to reduce coupling. Of course, the farther the better, and you could mount individual inductors on separate boards and move them as far away from each other as possible. *aX*