CORRECTION

I spotted a mistake in equation (VII) in my article "Choosing Cathode Bypass Capacitors" (*aX* 8/08), for which I alone am responsible. There should have been a closing bracket after ra in the denominator. It should be as set out in equation (VIII). Because equation (VIII) is right, no one should be too confused, however.

$$\omega R_k C_k = \sqrt{1 + \frac{R_k(\mu+1)}{2(Ra + ra) + \frac{1}{2} Rk(\mu+1)}}$$

D. Ivan James

MONSTER MONITOR

If you prefer a large screen for your work such as drafting, drawing, circuit schematics or large-scale calculations, you might welcome our David J. Weinberg's resource search for such a satisfactory upgrade from a smaller unit to what he refers to as "a tame monster." Some of us prefer dual monitors as a solution to video real estate which is fairly easy these days since video cards now routinely offer two video outlets. For the more adventurous go to www.multimediamanufacturer.com, or refer to the article in the Sept./Oct. issue of *Multi Media Manufacturer*, to benefit from David's advice.—ETD

DIY FESTIVAL

The organizers of the annual Burning Amplifier Festival are busy gearing up for this year's event to be held October 19 at the Presidio Yacht Club in San Francisco, Calif. The event promises an international group of audio DIYers, great sounds, great equipment, plus plenty of new ideas you can bring to your next project. Go to www.burningamp.com for more information and to register.

MIGHTY MIDGET

In the interesting Mighty Midget article by Peter Millett (May '08, p. 17), the idea of using a single tube to build an entire power amplifier has taken a new direction through the ingenius use of a TV double pentode tube. The way the schematic was developed, the clear and detailed explanations in the text as well as the practical implementation of the amp makes it really attractive and desirable to build. I suppose it has a special attraction to young or even not so young converts to the hobby, and for obvious reasons: simple and easy to build, low cost, and attractive. A huge crowd of entry-level young audio tube hobbyists is hanging around audio discussions groups on the web, and to these people, Pete's Mighty Midget must be music to the soul. Even if very few have direct access to *audioXpress*, there is always somebody in a discussion group to link a thread to an interesting article in the magazine, which has happened already with the Mighty Midget.

This kind of situation begs a question: Why not make the construction of this amplifier a little more accessible to this kind of crowd? A few examples: For some young lad without pertinent experience, the Japanese output transformers used in the amp may represent a nonattainable target; so why not mention a replacement, say, one of Hammond's 125 SE series available from AES even as the secondary reflected impedance is not exactly 7K.

Setting up the driver stage is a tricky task, as Pete mentions. Couldn't it be made less tricky? What about connecting the feedback path straight to the grid of the output tube through a small capacitor or to RC series combination? This way you may be avoiding even the unusual values of R2 and R4 and save some aggravation in the process.

I am well aware of the difference in quality between the two versions, at least in the measurement process, but does it make such a difference in the listening process? Many European radios built in the 50s and 60s used one or the other of the two versions in the AF output stage. You could find a few more similar samples in the article, but this is not the purpose of this letter. To be clear, I am not pleading here for a change in design; in my opinion this project is excellent the way it was conceived and it is understandable that any change or part substitution may alter the end product.

I suggest the author offer alternatives to make the project more attractive and feasible to entry-level hobbyists, even if it is going to sound a bit different from the intended version. In my view this kind of approach would apply to any practical project of this kind. Perhaps a part list including sourcing of the main parts would have also been beneficial.

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Pete Millett responds:

Thanks to Mr. Nisel for his kind words. As is true of most of the projects I publish, the Mighty Midget amp was targeted at those builders who are interested in DIY audio, but aren't willing or able to spend large amounts of money and effort on a project. I think this amplifier would be an excellent first project.

I'm afraid that Mr. Nisel must have missed reading part of the article. A sidebar, "Some Suggestions for Builders," included some practical suggestions, including some suggested transformers that are readily available, unlike some of the parts that I used.

As far as setting up the output stage and setting the values of the resistors in the feedback path, the "tricky" part is really just in the initial design of the amp; once the appropriate values have been determined, you should be able to reproduce it without any experimentation. I did use 1% resistor values, but I don't think there's much difficulty these days in finding 1% resistors, so I don't really see that as much of a problem. I also tested the circuit with a number of different tubes to make sure the performance was not too tied to individual tube characteristics, which vary quite widely.

That said, I have to admit that a 61.9k, 1W resistor, in particular, is a bit of an odd part (even though it is a "standard" value), which I didn't realize when I published the circuit. I probably should have mentioned that a 62k, 5% part would work just fine, and is certainly easier to find. Similarly, 357k could be replaced with a 360k, 5% resistor.

I have published full parts lists with vendor information for projects in the past. I've found doing so can be a bit of a two-edged sword. The problem is that if a particular part specified is out of stock, or discontinued, it really can cause more trouble for an inexperienced builder than if only a "generic" part is specified. For example, for the 0.22µF 400V coupling capacitor: if you search for "0.22µF 400V" part at one of the catalog distributors, you will probably come up with many options, any of which would work fine. But if I were to specify a particular vendor catalog part number, and it happens to be out of stock, what does an inexperienced builder do?

GOING GREEN

The CES 2008 went green for the first time by promoting audio products using recyclable or green materials—an indication that the industry is starting to pay attention to the undeniable threat of global warming. It is the responsibility of the audio industry to green up, as other industries already are (e.g., the Green Computing initiative by the computer industry). Designing and manufacturing audio products in a way that minimizes the impact on the environment is a very important step.

Green Audio? The next, much more important step, is how we audiophiles make our contribution. Let's acknowledge that the effort to produce eco-friendly products is a drop in the ocean compared to the environmental impact of *using* these products over time. Many of us enjoy our audio systems, for several hours every day, every week, every month, and that translates into many KWH (KiloWattHours) of electricity needed to operate our audio systems and that's a way bigger threat to the environment than production of audio equipment itself. . .

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This letter continues at www.audioXpress.com.

SOLDERING

I was pleased to see Ed Simon's article ("Soldering: A Tutorial," March '08, p. 42): Soldering is a very important topic that is given far too little attention today. I figured I'd add a few comments about irons, and a few more tips about soldering. I was an assembler and an inspector on mil-spec electrical components many years ago, so I have had a bit of practice—and some experience—with what can go wrong if you don't do it right.

First, I should say that anyone who expects to do any serious soldering should

CONTRIBUTORS

After receiving his technical training in the Air Force in the mid 1960s, **Rick Spencer** ("A Beginner 6BQ5 SE Amp," p. 6) has worked in the air conditioning, heating, and refrigeration systems field ever since. He has built over 30 audio components in the last 41 years and is currently working on at least two amplifiers that will be low in cost but high in sound quality (and they are geared toward the novice who is looking to get started in this wonderful hobby).

A specialist in a practical approach to electronics, **John Laughlin** ("An Automated Level Control," p. 18) has spent 25 years in the electronic industry, and 25 years as a college instructor. He has a first-class radiotelephone license, and is a member of the Brazos Valley Amateur Radio Club. He has written for several publications, including *Popular Electronics, Ham Radio Magazine*, and *QEX*. Besides electronics design, he enjoys making custom billiard cues, sailing, and he has walked across the Grand Canyon three times.

The audio hobby for **Alex Arion** ("A Greek Triad," p. 24) began in the magic '60s in Communist Romania in his grandmother's attic, where, together with two friends, he installed a small "illegal" laboratory. Their first attempt was a beginner's guitar amplifier and a professional guitar pickup. The tubes used included ECC40s and EF40s. The rectifier was a 5µ4, Russian equivalent. They mounted all in a hat box that they found in the attic. After finishing his studies and many years of research, Alex moved to Greece, where he continues to build different tube-based and solid-state amps.

Joseph D'Appolito ("Testing Loudspeakers: Which Measurements Matter, Part 2," p. 28), regular contributor and author of many papers on loudspeaker system design, holds four degrees in electrical and systems engineering, including a Ph.D. Previously, he developed acoustic propagation models and advanced sonar signal processing techniques at an analytical services company. He now runs his own consulting firm specializing in audio, acoustics, and loudspeaker system design. A long-time audio enthusiast, he now designs loudspeaker systems for several small companies in the US and Europe.

Ed Simon ("An Isolation Transformer, Pt. 3") received his B.S.E.E. at Carnegie-Mellon University. He has installed over 500 sound systems at venues including Jacob's Field, Cleveland, Ohio; MCI Center, Washington D.C.; Museum of Modern Art Restaurants, New York; The Coliseum, Nashville, Tenn.; The Forum, Los Angeles; Fisher Cats Stadium, Manchester, N.H.

John Shand ("Jazz Track," p. 54) is a CD reviewer for *Australian HiFi and Home Theatre Technology.*

invest in a real temperature-regulated iron—one that uses an actual sensor and feedback mechanism. Not only will it heat faster and make the job easier, but it will actually make you much *less* likely to damage expensive components and PCBs, and improve your results dramatically. Also, being less fussy, it just makes soldering much more fun. . . .

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This letter continues with Keith Levkoff's insights and soldering tips for both beginners and experts on our website, www.audioXpress.com.

CROSSOVER APPROACHES

I'd like to thank Mr. Koonce for documenting his research and presenting the results of his efforts ("Passive Crossover Linear Phase Speakers," June/July '08). I really liked the special plot format—he developed a satisfyingly high information density, as Edward Tufte would say. The problems with designing a linear phase (transient perfect) multi-speaker system are clearly seen, and I must admit to having gone to the dark side and adopted DSP to implement my crossovers in the digital domain for exactly these reasons.

However, the problems with lobing in multi-way speakers remain, and the discussion of coaxial speakers was very interesting and timely for me. From the plots for the coaxial speaker, Fig. 7 in particular, the magnitude and phase responses are very similar to those of the modified two-way in Fig. 5. Could Mr. Koonce confirm whether he used an actual coaxial driver for the real driver plots in Fig. 7 or whether he simulated a coaxial driver using the responses of the woofer and tweeter shown in Fig. 3 by simply setting the vertical offset to 0?

The reason I ask is that, as Mr. Koonce states, you need to ensure that the acoustic origins are in the same point in 3D space, otherwise there will always be some angle where there is a phase difference between the two drivers at the crossover point and lobing will occur. In fact, in a coaxial speaker, having one driver in front of the other acoustically is worse than a vertical or horizontal offset because it will cause lobing in both vertical and horizontal responses. I have been pondering the experiment to test whether coaxial drivers can make their acoustic origins coincident. I'm not sure that they can, and I also don't think that adding delay will compensate either, because different angles require different delays.

Another factor I have been considering is how frequency plays into this. It would seem that high frequencies, with their shorter wavelengths, would be more susceptible to a particular offset. To illustrate; a 30mm offset represents a 94° phase shift at 3kHz, but only 9° at 300Hz. This seems to imply that the lobing should be reduced with a lower crossover frequency.

A couple of final questions: It wasn't clear in the text, but I'm assuming that you used the acoustic phase responses of the speaker drivers as well as the zobel networks in the models. I haven't simulated any speaker-crossover systems, but I would expect that the zobel network would affect the speaker acoustic phase response as well.

Did you use an electronic circuit simulator to model the crossovers-speaker system or did you just crunch the math in a spreadsheet? Before I set out on my own math crusade, I'd be interested in hearing your opinions on the best environment in which to work.

Thanks again for a great article.

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G.R. Koonce responds:

I want to thank Iain McNeill for the kind comments on my article concerning linear-phase speakers. All "real" two-driver-response systems used the two responses shown in Fig. 3 and all "real" three-driver-response systems used the three responses shown in Fig. 10. Thus, the coaxial driver results shown in Fig. 7 are for the real driver response plots of Fig. 3 with the vertical offset set to zero. I apologize for not making these points clear in the article.

You can build coaxial drivers with an optimum alignment of their acoustic origins. This is accomplished by building the tweeter behind, or inside, the woofer motor and firing right through the woofer center.

However, just because the tweeter motor is located behind the woofer's cone does not ensure proper acoustic origin alignment. I have measured some that were terrible in this regard. I also worry about Doppler distortion with coaxial drivers that use the woofer cone as a horn for the tweeter. The car coaxial drivers with the tweeter mounted in front of the woofer cone generally have not tested well for acoustic origin alignment.

Adding true time delay to the tweeter is effectively the same as moving the tweeter backward horizontally. With a coaxial driver the correct time delay to align the two acoustic origins will be correct for all vertical and horizontal angles. The ability to use time delay is a major advantage of using a digital crossover implementation. It allows building a phase-linear system without having to "step" the front panel. However, even with time delay, only the coaxial driver will avoid lobing problems. A multi-driver system will still have linear phase over only a limited vertical angle (assuming a vertical array of drivers). As developed in the article, the use of a symmetrical (D'Appolito) array greatly improves performance, but not to the extent possible with a properly aligned coaxial driver.

It is true that the effect of acoustic origin offset becomes worse with increasing frequency; i.e., with shorter wavelengths. Thus generally with a three-way system the lower (woofer to midrange) crossover causes fewer problems than the upper (midrange to tweeter) crossover. With a two-way system, whether things become better with a lower crossover frequency depends on the drivers involved and should not be taken as a general rule-of-thumb. When going for a linear- or minimum-phase system, the driver-response overlap requirements may not allow much liberty in crossover frequency selection.

My approach to modeling is as follows. A modeling program I wrote takes in the driver's on-axis acoustic response (magnitude and phase) and input impedance (magnitude and phase). The program is also fed the physical placement of the drivers including the acoustic origin positions. The crossover is added as components, and the program computes the response of each crossover section loaded by its driver and zobel, if used. Thus, the zobel will affect the voltage (magnitude and phase) feeding a driver.

The directivity of the driver (change in its response with angle off its own axis) is modeled by the program. If desired, the effect of diffraction spreading loss is also modeled on each driver's acoustic response. Finally, the acoustic response for each driver gets a phase shift correction for the path to where the system response is summed. This is all done at each frequency that is to be plotted. Thus, the approach is a lot of number crunching done in a program written just for that purpose.

Many systems were breadboarded in my test baffle to verify that the modeling does a good job of predicting the response. This approach is surely not the only way to solve the passive crossover design problem, but is one that works for me because it fits what I can measure about the drivers I intend to use. You could use a similar modeling approach with an active crossover and multiple amplifiers with the simplification that the driver's input impedance would not need to be considered. Voltage-sensitivity differences between drivers would also be handled by amplifier gain correction rather than by padding networks in the crossover. aX