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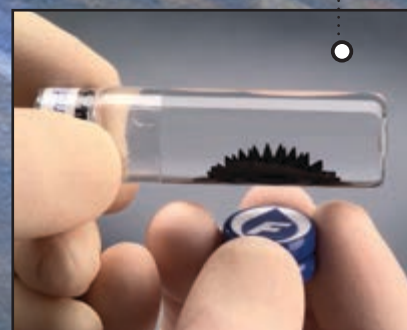
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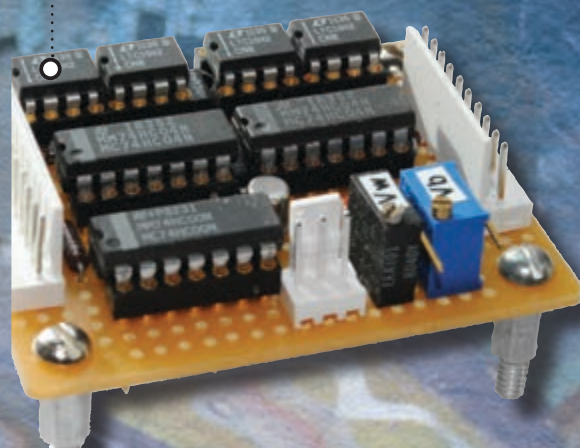
Parallel Push-Pull Amp Project



Ferrofluid's Magnetic Attraction



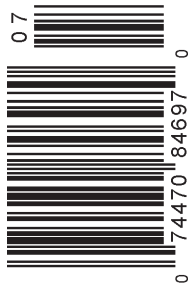
DIY Accurate Bias Meter



Custom Tube Design

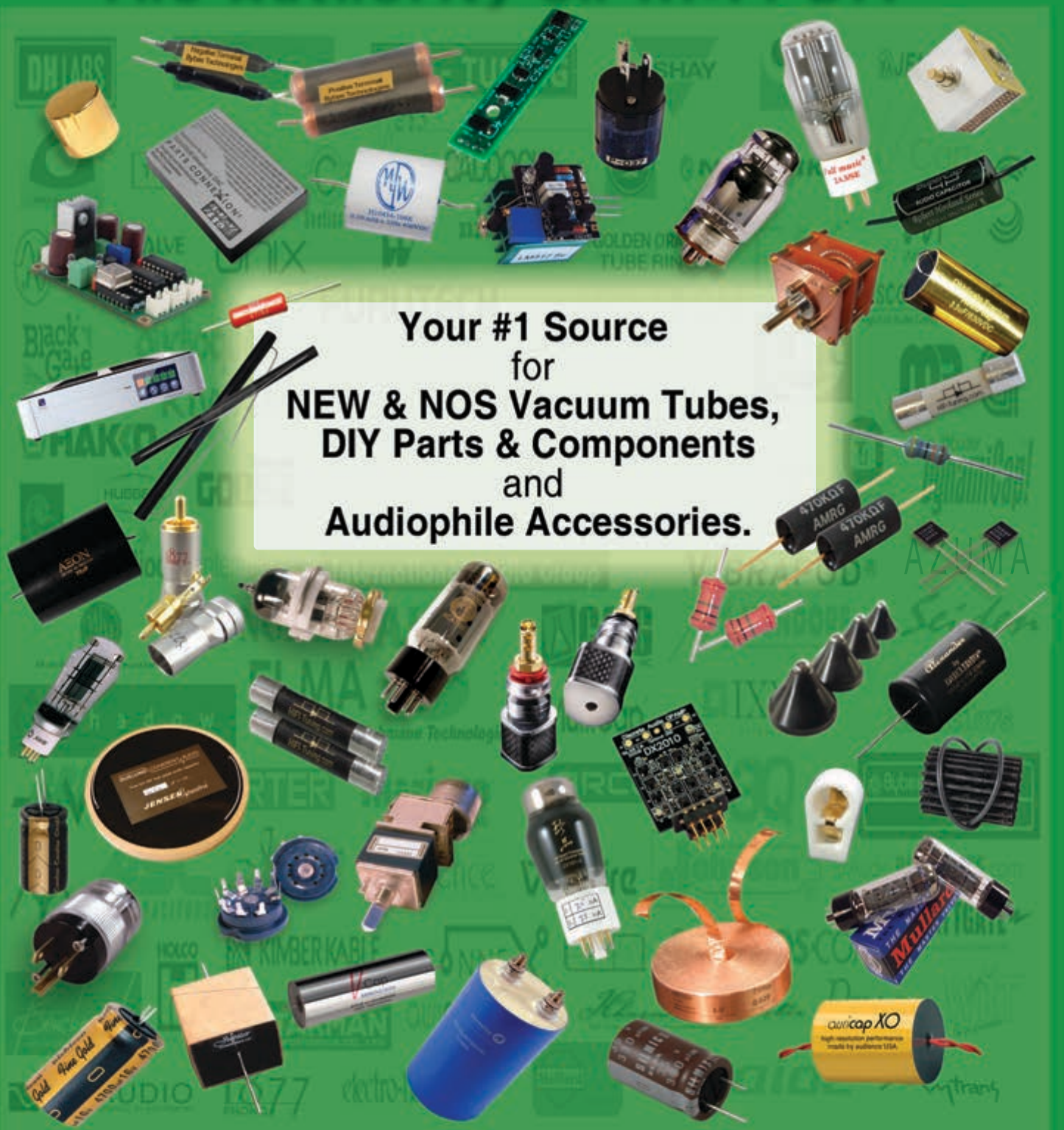
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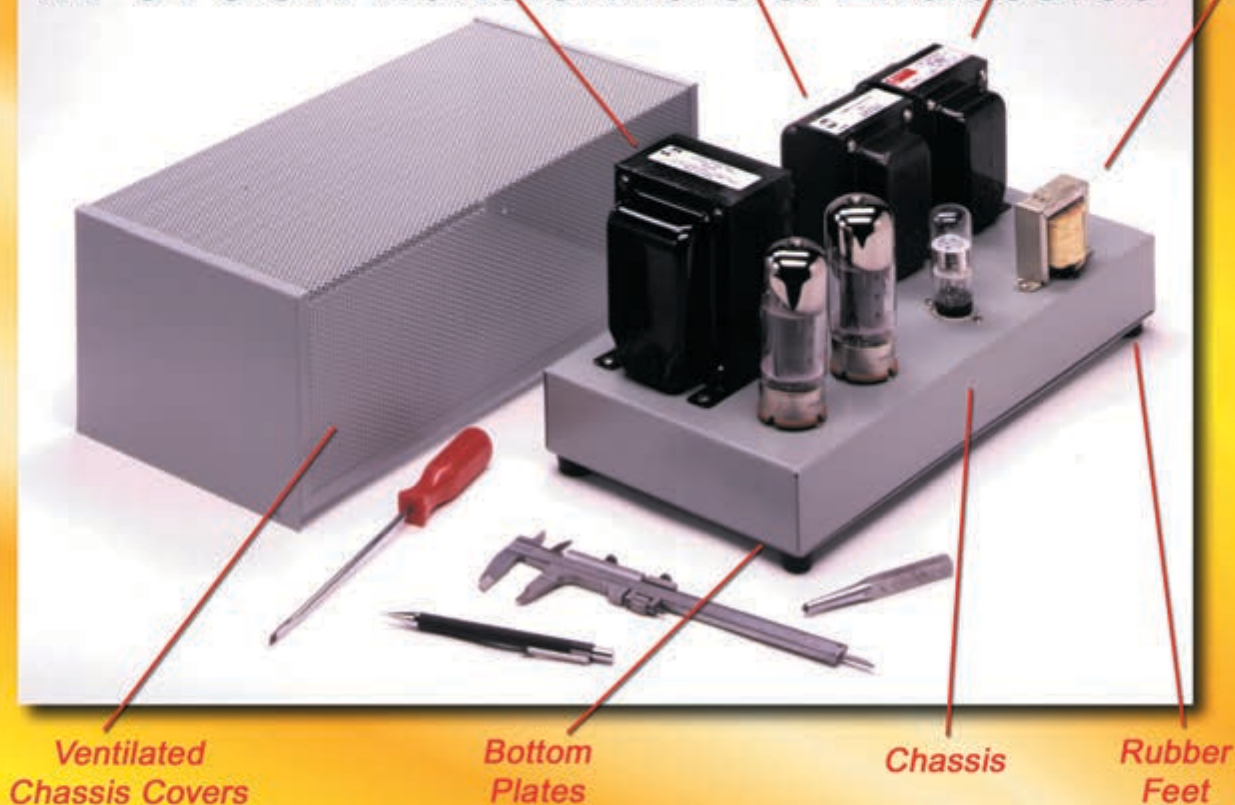
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Our editors and authors deliver you a diversified issue every month. Although each issue of *audioXpress* is different, the formula is constant: one part speakers, one part tubes, and one part solid state. Thus, each issue comprises audio projects, DIY tips, interviews, and more.

Turn to page 12 to learn how Mark Driedger built an efficient bias meter. The design is intended for push-pull tube output stages.

On page 18, Alexander Arion presents his "Strange Beverage Amp," which features an old transmission tube. You can easily follow Arion's lead to build your own.

Want an update on some of the most innovative technologies that were showcased at CES 2012? David Weinberg wraps up his article series with a review of some the most intriguing products (p. 31).

We have two speaker-related columns this month. Mike Klasco and Steve Tatarunis cover the topic of ferrofluid and its use in speaker design on page 8. On page 22, Vance Dickason describes the results of tests he ran on a 12" subwoofer.

We typically feature an interview in each issue. This month, we treat you to two in-depth interviews with audio professionals, as well as a profile of a recent *audioXpress* author, Gregory Charvat (May and June 2012). On page 36 is an interview with Gabe Herman, an audio engineer and Assistant Director of the Music Production Technology program at the Hartt School of Music in Hartford, CT. Richard Honeycutt provides insight into the work of amp designer Kevin Shaw on page 26.

Let us know if there is an engineer, musician, or audio enthusiast you'd like us to interview. We'll be happy to consider your recommendation.

Regards,

C. J. Abate
editor@audioxpress.com

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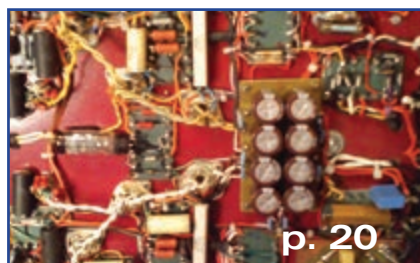
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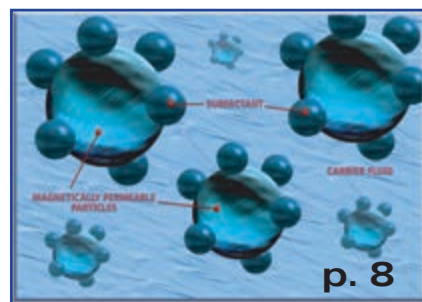


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The Story Behind Ferrofluid

An in-depth look at magnetic fluid



Undoubtedly, you have seen the terms “ferrofluid-cooled,” “liquid-cooled,” or “magnetic suspension” in speaker ads and read the cryptic descriptions of the benefits of ferrofluids in a speaker manufacturer’s literature. In our series, it seems time for a more comprehensive discussion of magnetic fluids in loudspeakers. We will define what ferrofluids are, explain why they are used, and discuss ongoing developments in this unique technology.

THE INVENTION OF FERROFLUID

Ferrofluids are submicron-size magnetic particles suspended in a carrier liquid such as lubricating oil, water, or solvent. They were first created in research for NASA during the mid-1960s (see **Figure 1**).

Ferrofluidics Corp. was founded in 1968 by Dr. Ronald Rosensweig and Dr. Ronald Moskowitz. Both men had worked for the company that was doing the research for NASA. They left with a license from NASA to research the technical and market development merits of magnetic fluid technology.

Magnetic fluid applications have included high-performance bearings and seals, such as those used in computer hard disk drives, optical scanners, and rotating semiconductor process equipment. Ferrofluids have also been used in stepper motors to improve settling times—enabling faster access times—and to properly damp the system for more stable performance.

Due to the presence of the suspended magnetic particles, ferrofluids can be precisely positioned and controlled by the presence of an external magnetic field (see **Photo 1**). The fluid is always attracted to the location of the highest magnetic strength. As we have discussed in previous articles, every loudspeaker has a voice coil suspended in a strong magnetic field (the magnet’s air gap). This is where the ferrofluid resides, typically surrounding both the inner and outer diameter of the voice coil. It fills the space between the coil, the magnet pole piece, and the top plate (see **Figure 2**).

Loudspeaker manufacturers have used ferrofluids mostly for expediency—to increase production yields and reduce customer warranty returns. This is due to ferrofluid’s thermal conductivity, which reduces voice coil burn out and the “magnetostatic force” of the ferrofluid within the magnetic gap, which suppresses voice coil rocking.

Ferrofluids, being magnetically responsive, push back when the coil shifts off center in the gap, acting as a restoring force to maintain concentricity, thereby preventing rubbing and buzzing. This is only partially due to the levitation effect (magnetostatic force) of ferrofluid. Another factor in fewer voice coil scrapes is the reduction in voice coil operating temperature. As the coil heats up, it expands, reducing the already tight clearance between the coil and the magnet. Ferrofluid enables the coil to run cooler, which minimizes coil

expansion and reduces the instance of coil burn out in the field. Even the simple lubrication effect of the fluid reduces the abrasiveness of coil/top-plate collisions. There are other practical benefits, such as ferrofluid’s deterrent to dirt or particles entering the gap. It even inhibits corrosion of the coil and gap. Speakers used for life safety and voice-warning applications almost always use ferrofluids to pass UL tests.

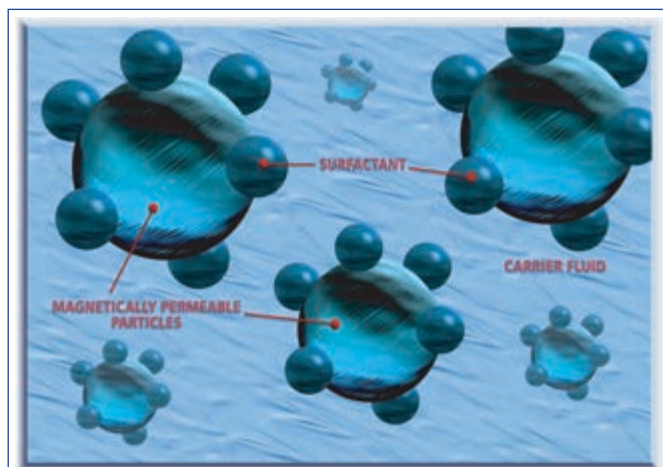


Figure 1: The components of a ferrofluid (Source: Ferrotec Corp.)

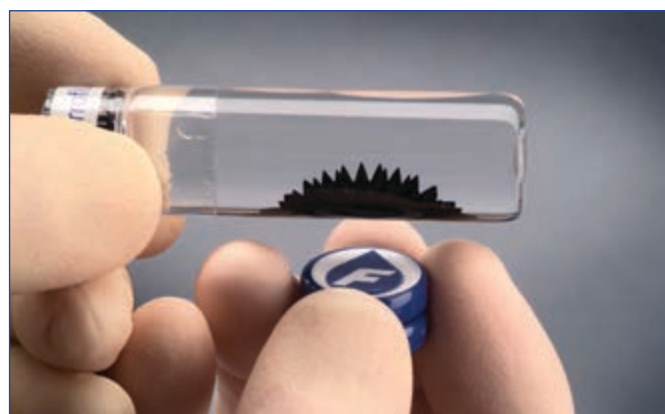


Photo 1: Ferrofluid under the influence of a magnetic field (Source: Ferrotec Corp.)

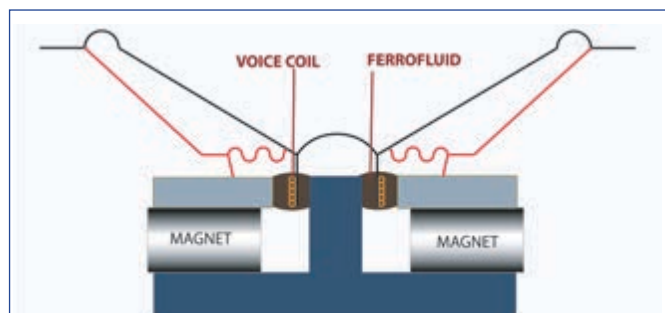


Figure 2: Ferrofluid in a loudspeaker (Source: Ferrotec Corp.)

UNLOCK YOUR AMP'S TOP TONE

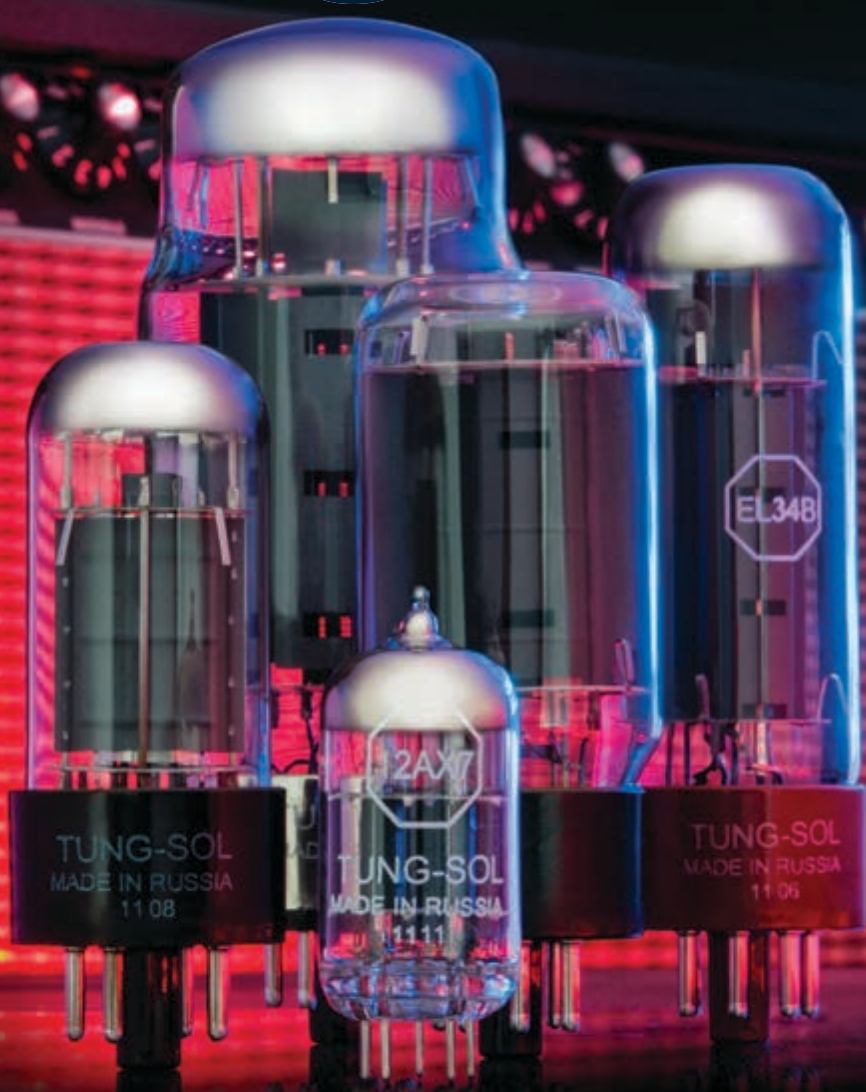
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Speaker manufacturers have had positive results with ferrofluids in tweeters and mid-range drivers for almost 40 years. But, they also wanted a ferrofluid appropriate for mid-bass and woofers. More recently, low-viscosity, high-magnetization strength fluids were developed, which enable the fluid to stay in the magnetic gap even at large excursions without requiring extensive changes to existing woofer designs.

While ferrofluid's use and application for increasing power handling are common knowledge, its advantages in reducing harmonic distortion, intermodulation distortion, and high-power nonlinearity anomalies—such as power compression—are not commonly discussed.

FERROFLUID IMPROVES SOUND QUALITY

So how do ferrofluids optimize and stabilize sound quality? Transient response settling time (the ability of the speaker to stop when the signal stops) is usually improved. The damping is effective since, in the case of ferrofluids, it is applied directly into the motor, rather than “after-the-fact damping treatments” on the cone or suspension. If a speaker has a top-end response peak, ferrofluids will bring this under control with fewer side effects than a passive crossover network solution. Ferrofluids also reduce certain mechanical noises that speakers make in and around the voice coil when the diaphragm moves. The muck or noise floor (self-noise) of the speaker masks the natural inner voices of the music and ferrofluids usually clean this up a bit.

To demonstrate ferrofluid's ability to reduce the speaker's self-noise, a multitone distortion test called spectral contamination is used. Multiple tones are played through the speaker. For the speaker's response, we are not so concerned about the tones themselves, but in what happens between the tones. In **Figure 3** and **Figure 4**, we see spectral contamination measurements of a 1"-dome tweeter. In **Figure 3** (no ferrofluid), the speaker's noise floor is on average 40 dB below the amplitude of the test tones. In **Figure 4** (with ferrofluid), the speak-

er's noise floor is on average 52 dB lower than without ferrofluid. The ferrofluid has effectively increased the dynamic range of the speaker, which will improve the clarity and inner detail of the reproduced sound.

Perhaps the biggest difference is not what you hear, but what you won't hear. Speakers change sound quality as the voice coil heats up, which normally results when music plays for an extended period of time at realistic (or beyond realistic) sound levels. Since ferrofluids avoid much of the power compression effects that would otherwise result under these conditions, the sound characteristic is more stable over time with ferrofluids. What are the unstable effects? We discuss these in more detail later. But briefly, as the coil heats up, the speaker's impedance increases, which shifts the (passive) crossover point.

HEAT BUILDUP & POWER COMPRESSION

The heatsinks in power amplifiers are a familiar sight. Most amplifiers are less than 85% efficient, with the wasted 15-plus% energy resulting in heat. We won't get into amplifier efficiency in any detail, but an amplifier that consumes 100 W will produce about 75 W of audio power and 25 W of heat. But when the 75 W of an audio signal is connected to a speaker, almost all the power results in heat within the speaker, with only a tiny amount of signal actually converted to sound. Only the most sensitive speakers achieve efficiencies of 5%, with most well-damped dome tweeters and medium-density cone paper or poly-cone woofers performing closer to 1 to 2%.

Let's say we had a speaker connected to an amplifier and test it at a 1-W level for impedance and frequency response. Next, the power is

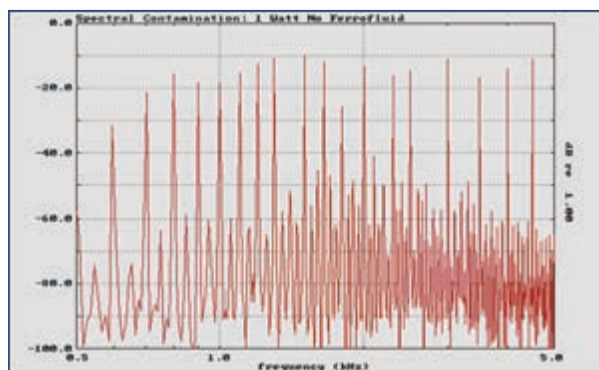


Figure 3: No ferrofluid in the loudspeaker (Source: Ferrotec Corp.)

cranked up and left on. After an hour, the speaker is retested. The impedance will be significantly higher, and the crossover network turnover points will have shifted significantly. It changes the characteristics of the speaker system's crossover and the frequency response, typically with a falloff in the upper range of the woofer. All of these anomalies are caused by voice coil heating. The heat generated by the amplifier power passing through the voice coil is partially transferred to the steel top plate of the speaker's magnetic system, and eventually carried throughout the speaker. Unfortunately, air is not an adequate conductor of this heat. It builds up on the voice coil faster than the air can carry it away. Changes in impedance are not the only problem with hot voice coils, as the heat causes the coil to expand, usually resulting in buzzing from scraping the top plate.

Ferrofluid immerses the voice coil in a thermally conductive fluid and transfers the heat off the coil, reducing reliability problems and changes in performance that occur due to heat buildup. Ferrofluid

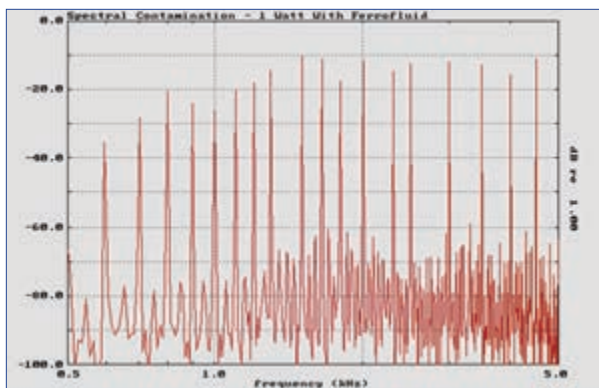


Figure 4: Ferrofluid in the loudspeaker (Source: Ferrotec Corp.)

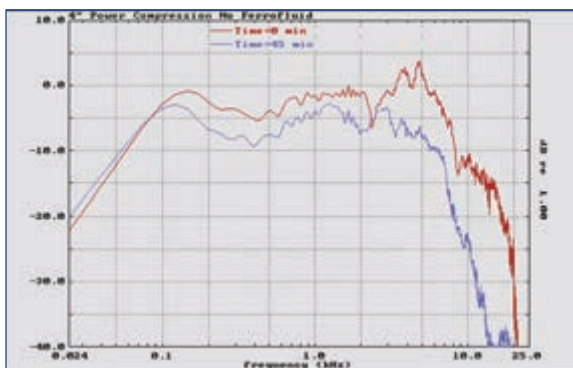


Figure 5: The loudspeaker without ferrofluid (Source: Ferrotec Corp.)

stays in the gap due to its strong magnetic field.

A look at the two response plots shows a 4" autosound (car door) speaker driven at 35 W (see **Figure 5** and **Figure 6**). **Figure 5** is the speaker without ferrofluid. One plot taken immediately. The second was taken 45 minutes later. There is a loss of more than 3 to 8 dB over most of the response range, with a strong loss of output at the top end. **Figure 6** is the 4" full-range treated with ferrofluid, under identical conditions. Note that the loss of output is only 1 to 3 dB, with only a slight shift in top-end response and a noticeably preserved linearity of the compressed response.

While ferrofluids are omniscient in their use in high-frequency drivers—such as compression drivers and tweeters—expanded applications are occurring in full-range drivers for docking stations and other consumer electronic products. The use of ferrofluids in surround-sound satellite woofers and sound-bar speakers is also growing. Moving in the complete opposite platform direction, micro-speakers for mobile devices, hearing aids, and so forth are one of the final loudspeaker frontiers for ferrofluid research and de-

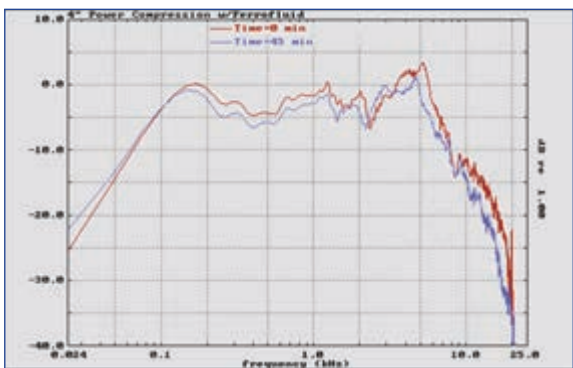


Figure 6: The loudspeaker treated with ferrofluid (Source: Ferrotec Corp.)

velopment. The purpose of ferrofluids for this application is both similar and different to what we've already described. Quite frankly, that application needs its own article.

It is important the optimum viscosity of ferrofluid is selected with attention to the viscosity versus temperature curve and the effect on the efficiency and operating bandwidth of the driver.

When normal operating temperatures are typical, the dampening effects of high-viscosity ferrofluid can be used as an integral design factor. When high-temperature operation is common, the viscosity should be selected so that the pass-band response of the driver is not affected by ferrofluid at normal operating temperature. The decreasing viscosity of ferrofluid counteracts the effect of power compression during high-temperature operation so the frequency response will not be appreciably altered.

Early design efforts to use ferrofluid occasionally went overboard in the use of excessively high-damping characteristics. Ferrofluid was used to control top-end resonance problems, and to limit low-frequency excursion of tweeters. In the 1970s, one Japanese studio monitor, which sold in the U.S. audiophile market, eliminated the crossover network completely and used high-viscosity ferrofluid of a few thousand centipoises (approaching the thickness of molasses). Today, the trend for audio product grade (APG) ferrofluid for new applications will likely be to lower viscosity fluids.

SPACE-AGE TECH

The vast amount of speakers that use ferrofluid do so because the manufacturers want higher-power handling, less production rejects, and less warranty returns. Yet, more and more speaker designers are using ferrofluid because the treated speakers sound cleaner, have less power compression effects, and have more stable characteristics at the crossover point.

Speaker designers have always suspected the more simplistic testing of speakers, such as frequency-response sweeps, does not reveal all that can be heard. One example is the power-compression phenomena—the heating of the voice coil increases the speaker's impedance, which misaligns the crossover network. Another example is the ability of ferrofluid to reduce distortion in a loudspeaker, as we saw in the spectral contamination measurements.

Many space-age technologies are used in our daily lives. Ferrofluid is just another example. Still, the scientists conducting research in the 1960s probably never imagined this technology would find its way into our homes, automobiles, and mobile devices via the billions of loudspeakers that have been successfully manufactured with ferrofluid. *aX*

Editor's note: The authors thank Barry D. Moskowitz (Global GM of the Fluids Business Unit at Ferrotec Corp.) for his help in the preparation of this article.

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An Accurate Bias Meter for Tube Output Stages

Test bias with a DIY meter

Accurately setting the bias level for push-pull output stages is important to maximize amplifier performance and tube life. Most bias meters measure the absolute bias current of each tube (e.g., measuring a target of 60 mA on a 0-to-100-mA meter). While those old Westinghouse meters look good, this method is not very accurate. In contrast, this circuit measures error relative to the target bias current and error relative to a balanced condition in the push-pull pair. The meter is compact, low-cost, simple, and accurate thanks to the use of a window comparator IC (see **Photo 1**).

THE BIAS METER THEORY

A small value sense resistor R_S is connected in series with each output tube (see **Figure 1**). Balance is measured between points A and B. This type of balance meter configuration is fairly common. Bias is measured by averaging the voltages A and B at point C and comparing the result to a DC-

reference voltage, V_R . The reference voltage is set based on I_O , the target bias current per tube, according to $V_R = I_O \times R_S$. To the best of my knowledge, this arrangement for measuring bias is unique.

Push-pull output stages can be configured with bias and balance controls (see **Figure 2a**), or independent bias controls for each tube (see **Figure 2b**). I prefer the arrangement in **Figure 2a**, and this article describes the corresponding meter configuration. In the last section of this article, I describe how to modify the meter to work with independent bias controls. The meter is designed for fixed-bias amplifiers, not those with cathode bias. Cathode-bias amplifiers generally do not have bias adjustments, or if they do, the configuration varies widely, making it hard to recommend a specific bias-meter design.

The sense resistor in the cathode introduces a small amount of negative feedback, theoretically reducing both gain and distortion. In practice, the gain loss is minimal for the values rec-

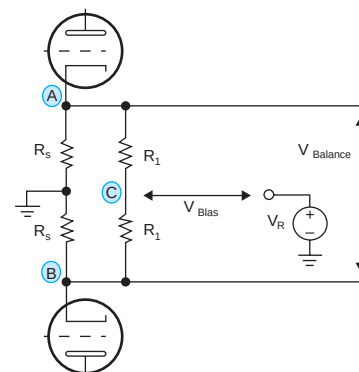


Figure 1: Bias meter concept

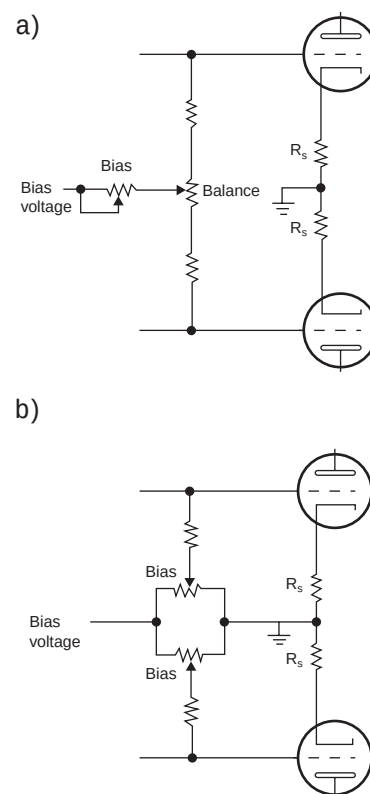


Figure 2a: Bias + balance configuration;
b: Independent bias configuration

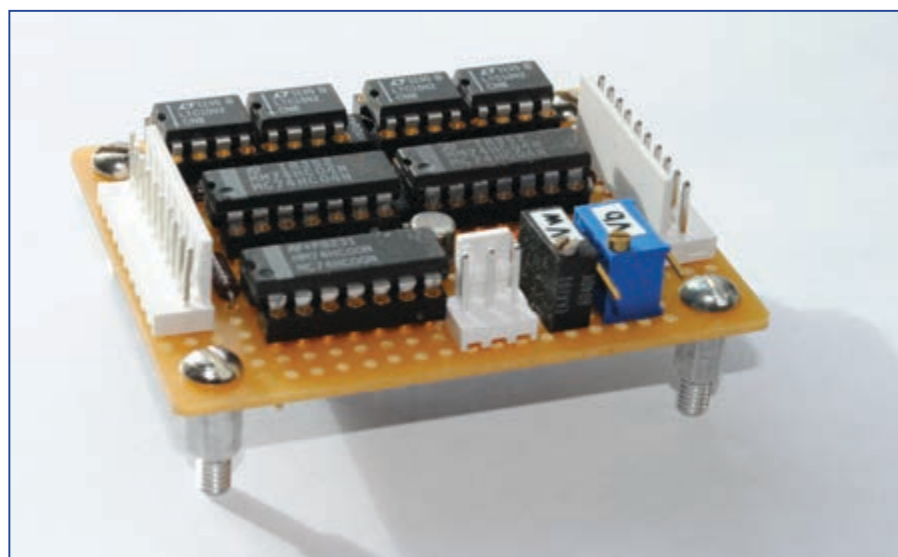


Photo 1: Completed stereo bias meter

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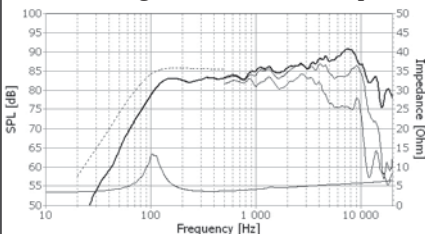
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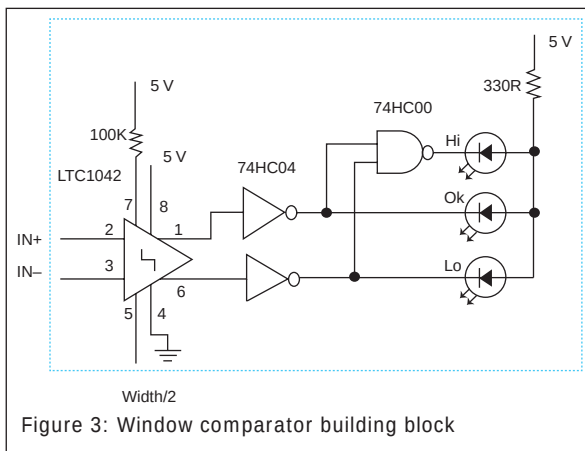


Figure 3: Window comparator building block

ommended. For example, the predicted gain loss for a 10- Ω sense resistor and a triode-connected KT-88 with a 5-k Ω plate-to-plate load, μ of 8 and r_p of 650 Ω is 0.2 dB. If this is a concern, you could shunt the sense resistors with a switch when the meter is not being used. Bypassing with a capacitor is not practical due to the low impedance of the sense resistor. Several well-regarded classic amplifiers leave small sense resistors in the cathode circuit (e.g., Marantz 9, Heathkit W-7M, Luxman LX-33, Radford STA-25R, and Harmon-Kardon Citation II). I don't feel there are any practical negative impacts of doing so. You can think of the sense resistors as being analogous to emitter degeneration resistors in a transistor differential pair.

In several of his designs, Hafler used a common resistor for the two push-pull output tubes. This should prove somewhat better at reducing distortion, although it would not support the bias meter described here. It is interesting to note that he chose the specific value of 11.2 Ω in the patent-pending Dynaco Mark III "Biaset" design, specifically because this value provided an optimal reduction in intermodulation distortion.^[1] The Mark III User Manual describes a similar concept of calibrating the sense voltage by comparison to a reference voltage source, in this case, a fresh dry cell battery (1.56 V).^[2]

CIRCUIT ANALYSIS

A Linear Technology LTC1042 window comparator IC is the heart of the meter. A window comparator provides a digital output when the input voltage is between the upper and lower limits of the window, hence the name. The LTC1042 has differential inputs, which can float between ground and the 5-V supply. As shown in **Figure 3**, the

comparator drives three LEDs through logic gates, which indicate if the input is below, within, or above the window. The sensitivity is controlled by the "width/2" input to the comparator. The "OK" LED illuminates when the difference in the inputs is less than $\pm$ width/2. The 100-k Ω resistor between pin 7 and the 5-V supply sets the internal oscillator frequency for the comparator. (It uses a sampled architecture to reduce power consumption.) Since only one of the LEDs is illuminated at a time, you can get away with a single-current limiting resistor rather than one per LED. Two of the basic window comparator circuits are used for each amplifier channel (see **Figure 4**). A TL431 precision voltage reference develops a stable 2.5-V source, which is divided down to provide the reference voltage (set by R4) and the width control voltage (set by R6).

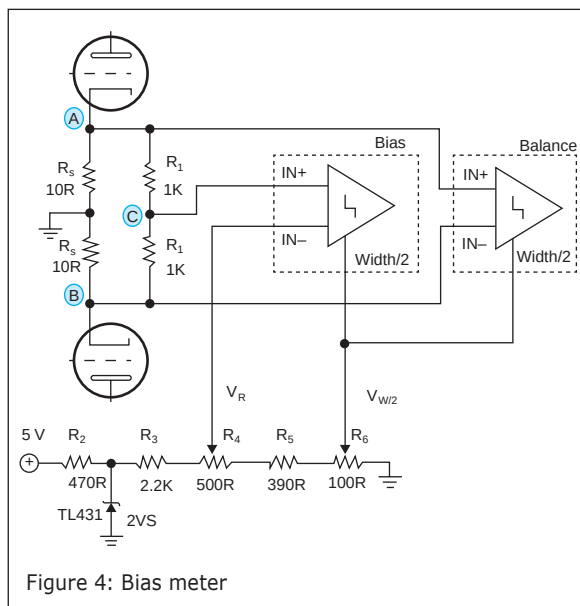


Figure 4: Bias meter

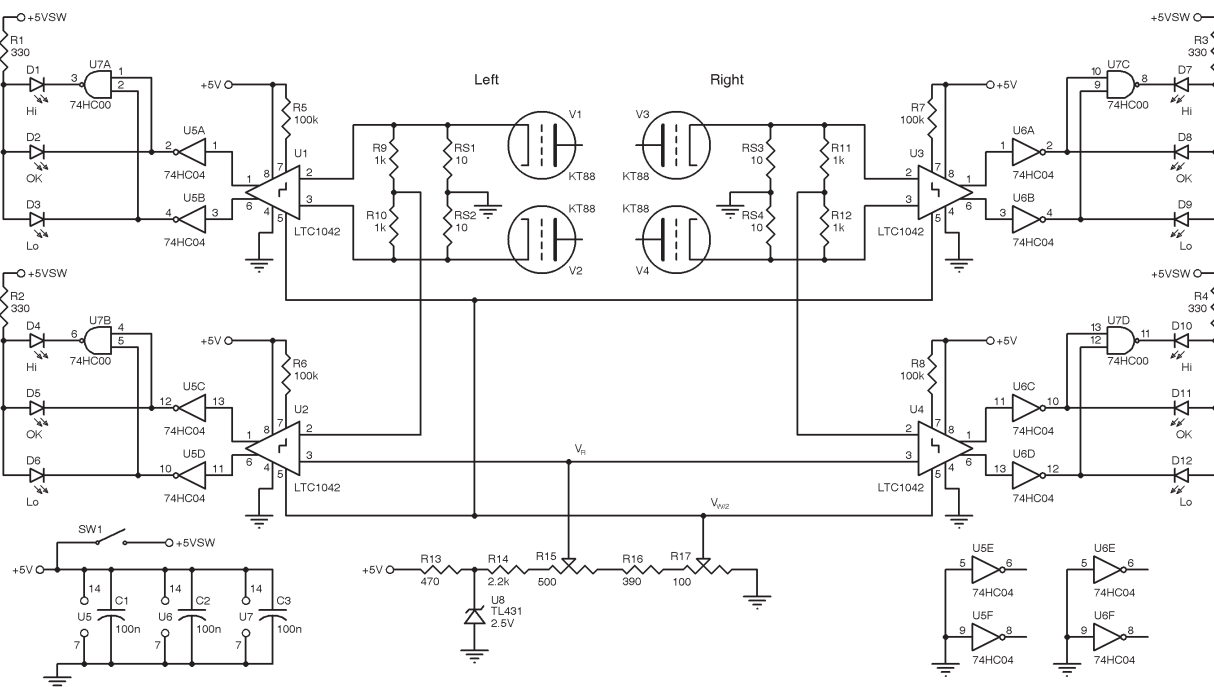


Figure 5: A full schematic for the stereo bias meter

The adjustment range is from roughly 40-to-80-mA target bias current per tube, with a window width of 0 to ± 8 mA. The value of R1 is not critical but each pair should be matched. Their value should be less than 10 k Ω (per the input impedance guidelines in the LTC1042 datasheet) and large compared to the sense resistors.

The sense resistor value is a compromise between sensitivity and overload. I recommend sticking with 10 Ω in most cases. The comparator inputs

will sit at 0.6 V for a typical 60-mA bias current, which is nicely within the 0-to-5-V range of the comparator. The maximum comparator input for no damage is 5.3 V, translating to 530 mA, which is well above what would be experienced in the normal operation or overload conditions. The LTC1042 accuracy is on the order of a couple millivolts, which translates to a few tenths of a milliamp error. Using a 10- Ω sense resistor makes it easy to remember how to set the reference voltage (reference

voltage in mV = bias current in mA $\times$ 10). Dissipation in the sense resistor (DC + worst case AC) is about 0.125 W. I

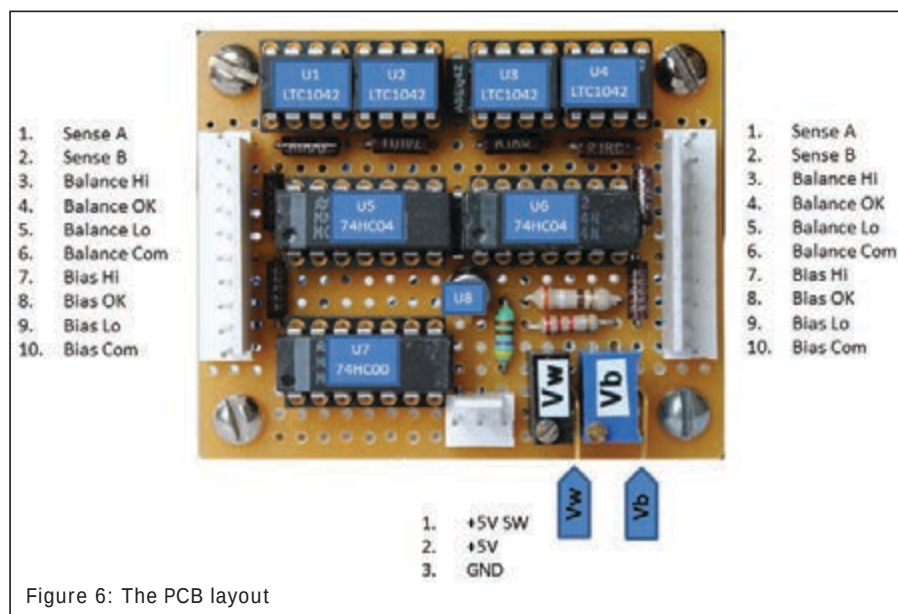


Figure 6: The PCB layout

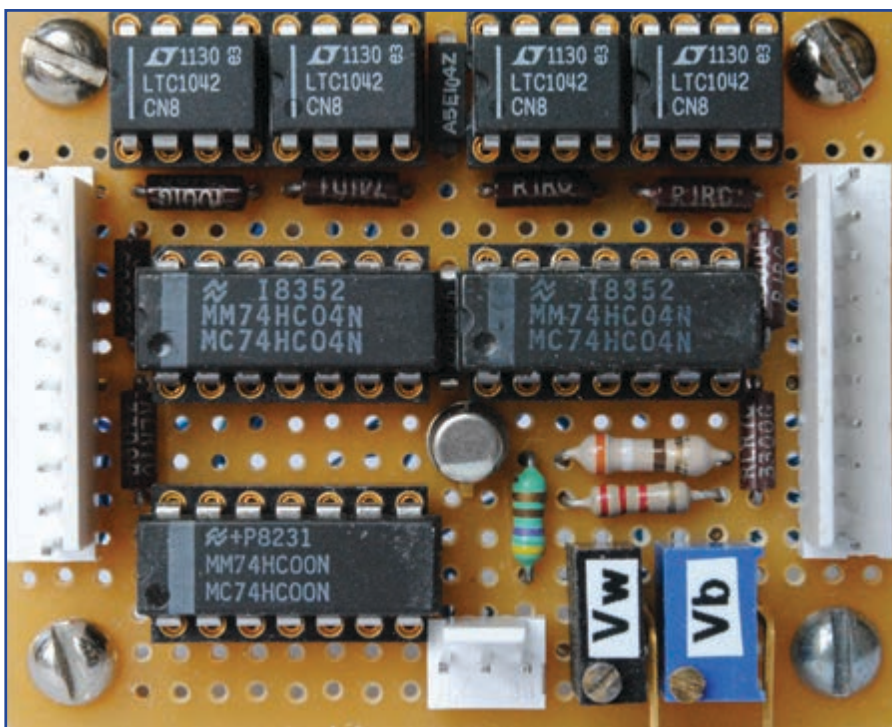


Photo 2: The completed circuit board

recommend using a 0.5-W resistor to provide a safety margin.

I didn't bother with input protection

since the 530-mA limit seems safe and the LTC1042 is inexpensive to replace if it is damaged. If you want to err on the

side of caution, you could put a 1-k Ω resistor in series with each comparator input and clamp the input pin to the 5-V rail with a Schottky diode. This would also protect against the failure scenario in which one of the sense resistors blows.

CONSTRUCTION & USE OF BIAS METER

The meter can be built into the amplifier, or you can use the same principle by bringing points A, B, and the ground to a connector and building the circuit externally.

I built a stereo version of the meter shown in **Figure 5** on a 2" $\times$ 2.5" perfboard with wirewrap construction. If you don't have a lot of wirewrap experience, I would suggest using a larger perfboard and less dense construction. Total cost is roughly \$30. You will need to provide a 5-V supply referenced to ground. To avoid damaging the ICs, you need to apply power to them anytime the amplifier is powered. During normal operation of the amplifier, the LEDs will switch on and off with the audio signal. SW1 enables them to be disabled to avoid coupling noise into the audio circuits. Install the LEDs beside their corresponding adjustment potentiometer.

Adjust R15 to correspond to the desired idle current using a DVM. For example, a 60-mA idle current target corresponds to 600 mV. Adjust R17 for the desired sensitivity. For example, a ± 4 -mA window corresponds to 40 mV at the wiper of R17. Once the reference voltage is set, it will be stable. There is no need to check or adjust it in normal operation.

In operation, adjust the bias and balance potentiometers until the middle LED is illuminated with the amplifier idling (warmed up, with no input).

ADDITIONAL USES

The LTC1042A design (see **Photo 2**) can form the basis of several other useful circuits in a tube amplifier. For example, if you have a design with a DC-balance control in a phase splitter, you can divide down the plate voltages with 100:1 voltage divider (1-M Ω and 10-k Ω resistor) and then use the same basic window comparator block. It can

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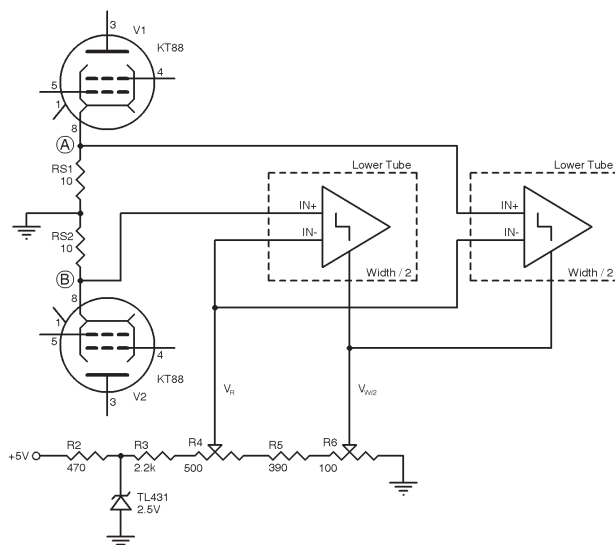


Figure 7: Modified bias meter for use with independent bias controls

also form the basis of an overload detector, sensing an overcurrent situation in the output tubes and shutting down the power supply at an accurate

trip point.

PARALLEL OUTPUT TUBES & BIAS CONTROLS

Many amplifiers have independent bias controls such as shown in **Figure 2b**. In the case of parallel output tubes, this is almost always true. The meter can be modified to work with independent bias controls (see **Figure 7**). Each sense resistor input is compared to the common reference voltage and measures bias on the corresponding tube. There is no balance measurement, per se. The bias is set to be identical on each tube, inherently achieving balance.

For parallel output tubes, simply replicate the comparator circuit for each tube, using a single reference voltage circuit. *ax*

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- [1] D. Hafler, "New Amplifier with KT-88s," Radio-Electronics Magazine, 1958.
- [2] Dynaco, "Instructions for Assembling the Dynakit Mark III," www.curcioaudio.com/mk3_mnl.pdf

RESOURCES

J. Stewart, "Safe Bias and Balance Measurement," *Glass Audio Projects—17 Vacuum Tube Designs*, Audio Amateur Press, 1997.

Turner Audio, www.turneraudio.com.au/Integrated5050.htm.

PARTS & COMPONENTS

Capacitors

- C1–C3 = 100nF decoupling capacitor

Miscellaneous

- SW1 = SPST switch
- U1–U4 = LTC1042 window comparator
- U5, U6 = 74HC04 hex inverter
- U7 = 74HC00 quad NAND gate
- U8 = TL431 precision voltage reference

Resistors

- R1–R4 = 330R, 1/8 W
- R5–R8 = 100 kΩ, 1/8 W
- R9–R12 = 1 kΩ, 1/8 W (matched pairs)
- R13 = 470R, 1/8 W
- R14 = 2 kΩ, 1/8 W
- R15 = 500 R 10-turn trimpot
- R16 = 390 R, 1/8 W
- R17 = 100 R 10-turn trimpot
- RS1–RS4 = 10 R, 0.5 W

Semiconductors

- D1–D12 = LED (Above/Below—Red; OK—Green)



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The Strange Beverage Parallel Push-Pull Amp

Tube experimentation results in a unique amplifier

After a few months of *dolce far niente*, which means a very hot summer holiday followed by a warm autumn, I decided to build a new and strange tube amplifier for a friend of mine (see **Photo 1**). Due to the economic recession, my nice, big laboratory has been reduced to a little room on the third floor of our flat. I have tried to put all my tools, instruments, and parts inside so I can continue building different audio amps for several more years. The space is not big enough, and the neighbors are not so pleased when I test amps at high volumes. But, I shall survive.

EXPERIMENTING WITH DIFFERENT TUBES

My idea for the amp was to introduce some tubes not usually used in audio construction. I observed that many DIYers in *audioXpress* were doing this with amazing results.

During a tour with my friends to some former American military bases near the sea, we found a lot of parts, including tubes, in big, solid wood boxes. The tubes were brand new, in perfect shape!

So, for the first time, I met the 8458 power double tetrode (in the same balloon) and the 5687 double triode. The 5687 is an "old friend," due to a well-written 1997 article written by Eric Barbour for *Vacuum Tube Valley* (VTV) magazine. This double triode is strong enough to attack any power tube, so it could also work in my strange amp. As usual, I began searching through huge collections of old magazines and books. Many of them were bought years ago with the help of *audioXpress*. The information regarding the 8458 was not so plentiful. The tube was built as a transmission power tube and, as with all the

tubes I have used, it should work with both relatively high anode tension and a much lower tension on the screen grid. After consulting many electronic diagrams, I decided it was necessary to build some preliminary designs to ensure the tube could be used successfully in the real project. So, I mounted some different output transformers—built by my friend and collaborator, Tim Giatras, who specializes in handmade, custom transformers, classical (E+I) laminate, and toroidal types—in my big testing chassis. I also mounted some tube bases (magnoval and noval type), and I used a separate source for my power supply needs.

TESTING THE 8458 AS A SINGLE TUBE

For the first step, I tried to see how the 8458 would work as a single tube in a single-ended connection in an economical diagram (see **Figure 1**).

The multiple tensions coming from the external power supply gave me a lot of choices. And, the different primary impedances from output transformers helped me find the best solution. Note that the screen grid (G2), is common for both tubes and is connected to the power source by a 470-Ω/1-W resistor. The two high-cut resistors (1.5 kΩ) are present in both input grids (G1). As the prefinal tube, I used the first half-triode from 6SN7—a well-known octal-based tube—and the amp worked. The most significant performance for this little SE power stage was not bad at all—7 W at 8 Ω for 7.5-V RMS input from 20 Hz to 40 kHz.



Photo 1: "The Strange Beverage"

But I needed more, so the second auxiliary project began.

THE SECOND STEP

The 8458 tube has a common cathode for both tetrodes, so it is easy to bias them in pure Class A, using a proper RC circuit connected to the ground, of course, considering the two tetrodes are equal. They should be because they were Amperex, brand new, in their original boxes! The second circuit I experimented with was a push-pull, more specifically, a parallel push-pull, due to the fact we got the power tubes in one balloon. In the cathodes, the RC circuit were 120-Ω/10-W resistors plus 470 MF/100-V electrolytic capacitors (see **Figure 2**).

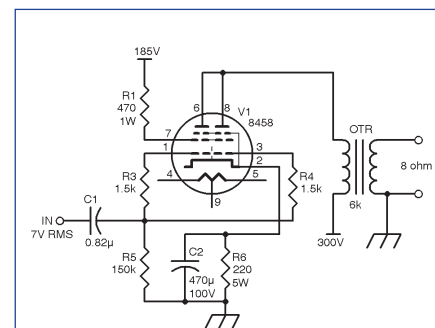
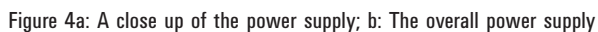


Figure 1: A single tube using a single-ended connection



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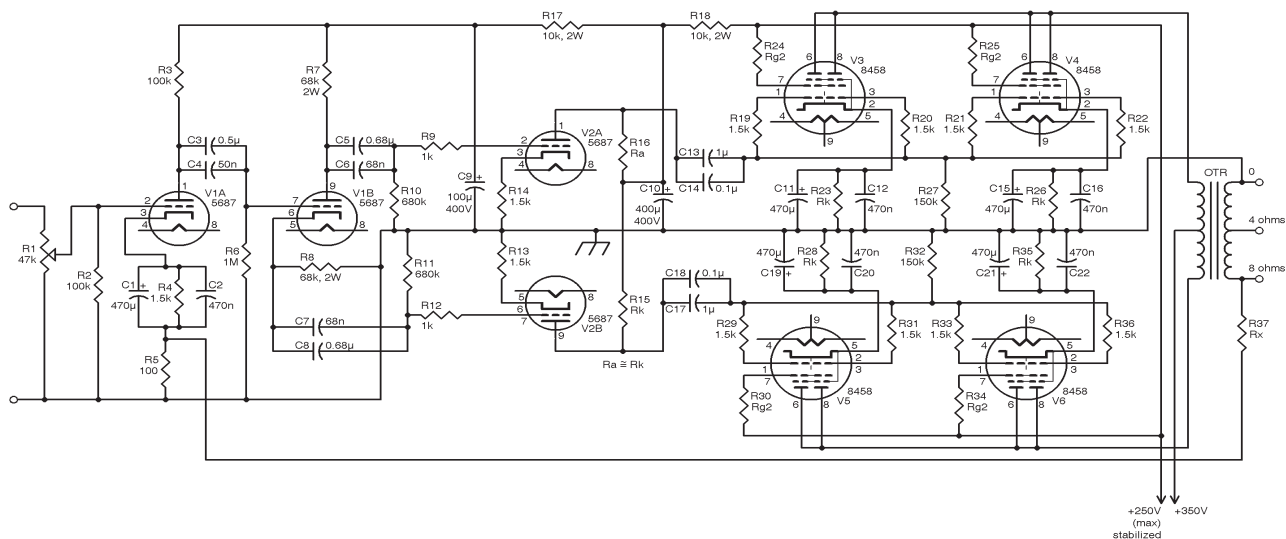


Figure 5: The electronic diagram

22 W/8 Ω , for an amazing frequency band between 16 Hz to 70 kHz $\pm$ 1 dB.

The 5687 had a very clear sound and little distortion. To obtain this performance, I observed the tension for the G2 (screen) had to be stabilized, because it fell when a lot

of power was needed.

THE FINAL DIAGRAM

The power supply required a little work to meet the exact needs of the power amplifier.

First, the big toroidal transformer had to provide the tensions and currents for the anodes, screens, and heaters for both power amplifiers. A special solid-state stabilizer circuit should be built for the screens. The stabilizer for high tensions could be a tube (two to three tubes) or a solid-state one, using FETs or conventional transistors. The least expensive solution was the latter one.

I recalled a time when I was working for Sony in Athens, Greece when some old power transistors from Sony color TV sets were strong enough to do the job. They were the 2SC1413s, and I found them at an inexpensive price. A simple enough circuit—with which I once experimented—worked well, and the power supply was ready (see **Figure 3**).

I connected in parallel the main electrolytic capacitors—two paper-in-oil special American ones, taken from that deserted U.S. military base mentioned earlier. **Figure 4**, shows the final power supply. **Figure 5** shows the final electronic diagram (one channel). So the PPP was the best thing that happened to the 8458 tubes, which were used for the first time in an audio project.

The cathode RC groups were mounted on a PC board 8 × 650 MF/250 V in parallel with 470 NF/250 V, Nipponchemicon +8 Ω × 220 Ω /10 W. In front, I used one 6587 double triode as a prefinal stage (current amplifier) and the phase-splitter was used as a classical cathodyne, with a coupled DC to the next triode. Every little bit of feedback was used, despite that the amp was also working well with "O" feedback. I ordered the output custom transformers and began the last phase, which was the final adjustments and tests. The mounted chassis (see **Photo 2**) shows the point-to-point handmade connection frame. **Figure 6** shows data regard-



Photo 2: An inside, bottom view of the the amplifier

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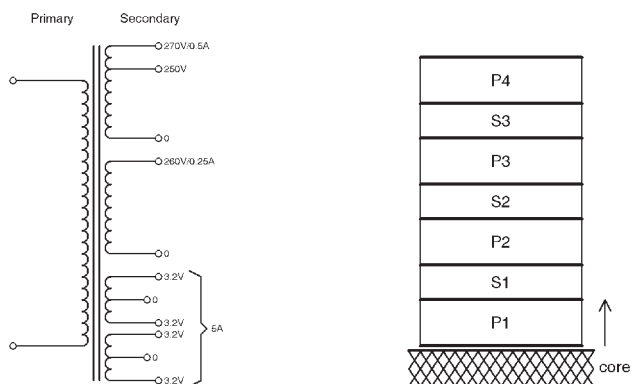


Figure 6: Power and output transformers

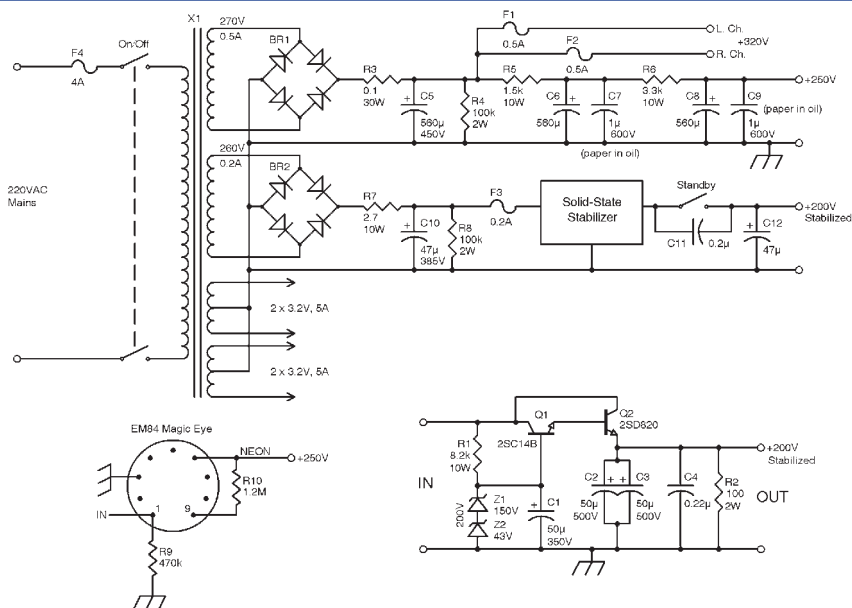


Figure 7: The ultimate power supply

ing the power and output transformers. In **Figure 7** you can see the ultimate power supply, including the solid-state stabilizer. The chassis is made from a 2-mm aluminum stove painted dark red. The frame is a massive black wooden box made from African wenge. All the connectors are on the back of the unit. The cover is beautifully painted black steel, which is grounded on the chassis. I am sure my friend's wife will not have any objections about this new beauty in her house. Did I mention the EM84 magic eye in the center of the chassis?

FINAL CONSTRUCTION

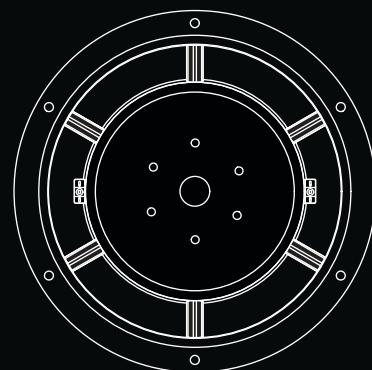
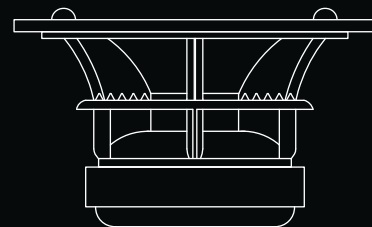
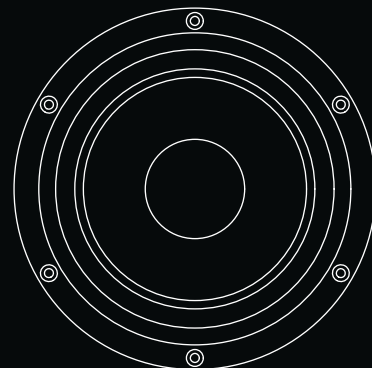
On my Leader testing instruments,

The Strange Beverage Parallel Push-Pull power amp gave some good measurements. For a 0.5-V to 1-kHz input signal, the output clear power on an 8-Ω charge was 48 W with zero feedback. The frequency range was 19 Hz to 58 kHz ± 0 dB, and the THD was less than 0.5% for 20 W, in all the spectrum. The signal-to-noise (S/N) ratio was better than 100 dB, with my ARLab improved version speakers, using my Universal tube pre-amplifier and a Yamaha CD player (also improved) the CD testing had a good image, astonishing linearity, and clarity.

I hope the old 8458 (YLL1240) transmission tube will find its way into other audio tube designs. *aX*

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The SB34SWNRX-75-6 Subwoofer

A 12" subwoofer gets put to the test



Photo 1: The SB34SWNRX-75-6 subwoofer

The new 12" SB34SWNRX-75-6 is a subwoofer version of the 12" SB34NRX75-6, which I examined in *Voice Coil* (March 2008). If you are not familiar with SB Acoustics, SB is an acronym for Sinar Baja, which is a large OEM driver manufacturer located in Indonesia. However, the driver line was conceptualized by David Stephens, a former U.S. representative of DST. Transducer design of all SB drivers is done by former Vifa/Scan-Speak engineers Ulrik Schmidt and Frank Nielsen, the principals of Danesian Audio. Danish Sound Technology, if you are new to the industry, was bought out by Tympany. At its peak, it included the Vifa, Peerless, and Scan-Speak transducer brands.

It has a generous feature set that includes: a cast-aluminum frame, a stiff curvilinear cone, a dust cap made from a proprietary blend of paper fibers, a FEA-designed progressive Conex spider, SBR surround, a 75.6-mm (3") diameter voice coil wound with round copper wire on a nonconducting glass fiber former, and a ferrite motor composed of two 20 mm × 145 mm magnets sandwiched between a shaped T-yoke and front plate (see **Photo 1**). Voice coil lead wires are terminated to gold terminals located on opposite sides of the frame. Cooling is provided by a 55-mm round pole vent, four large 45 mm × 15 mm, and four small 8 mm × 15 mm vents. Located below the spider-mounting shelf, it enables air to flow across the front plate and exposed voice coil.

I began characterizing the SB Acoustics 12" with the LinearX LMS analyzer and VIBox. Both voltage and admittance (current) measurements were generated in free air at 1 V, 3 V, 6 V, 10 V, 20 V, and 25 V. The measured Mmd (an actual physical cone assembly measurement with 50% of the surround and spider removed), provided by SB Acoustics, was used rather than a single 1-V added (delta) mass measurement. It should also be noted that this multivoltage parameter test procedure includes

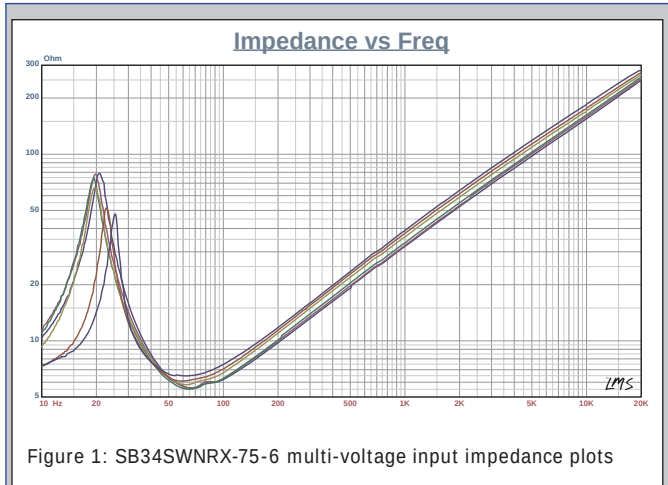


Figure 1: SB34SWNRX-75-6 multi-voltage input impedance plots

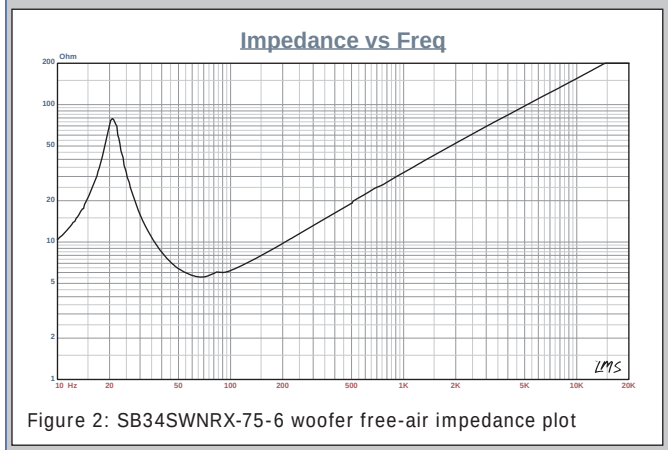


Figure 2: SB34SWNRX-75-6 woofer free-air impedance plot

	TSL model		LTD model		Factory
	sample 1	sample 2	sample 1	sample 2	
Fs	20.6 Hz	18.4 Hz	19.6 Hz	17.7 Hz	19 Hz
Revc	4.35	4.32	4.35	4.32	4.50
Sd	0.0527	0.0527	0.0527	0.0527	0.0508
Qms	6.41	6.07	5.58	5.06	5.0
Qes	0.36	0.34	0.33	0.30	0.34
Qts	0.34	0.32	0.31	0.29	0.32
Vas	151.9 ltr	191.0 ltr	169.2 ltr	209.1 ltr	164 ltr
SPL 2.83 V	87.6 dB	87.4 dB	87.7 dB	87.6 dB	88 dB
Xmax	11.3 mm	11.3 mm	11.3 mm	11.3 mm	11 mm

Table 1: The SB34SWNRX-75-6 subwoofer samples

heating the voice coil between sweeps for progressively longer periods to simulate operating temperatures at that voltage level (raising the temperature to the third time constant). The 12 sine wave sweeps for each woofer were further processed with the voltage curves divided by the current curves to produce impedance curves. (See **Figure 1** for

the impedance curve set.) Phase curves were generated using the LEAP phase calculation routine. Impedance magnitude and phase curves, plus the associated voltage curves, were then copy/pasted into the LEAP 5 software's Guide Curve library. This data was used to calculate parameters using the LEAP 5 LTD transducer model. Because most of the manufacturing data is produced using either a standard transducer model or, in many cases, the LEAP 4 TSL model, I also generated LEAP 4 TSL model parameters using the 1-V free-air and

delta mass curves that can also be compared with the manufacturer's data. See **Figure 2** for the SB29NRX75-6 1-V free-air impedance plot. **Table 1** compares the LEAP 5 LTD and LEAP 4 TSL T/S parameter sets for the SB 12" driver samples submitted by SB Acoustics with the factory data.

From the SB woofer's comparative data in **Table 1**, you can see that all four parameter sets for the two samples were reasonably similar and correlated well with the factory data, with the exception that SB quotes a more conservative Sd.

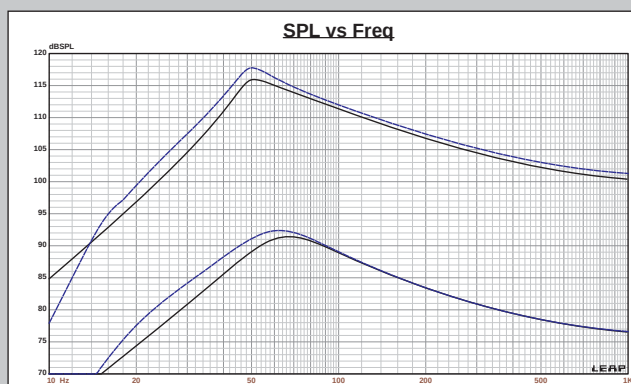


Figure 3: SB34SWNRX-75-6 computer box simulations (black solid = sealed @ 2.83 V; blue dash = vented @ 2.83 V; black solid = sealed @ 54 V; blue dash = vented @ 60 V)

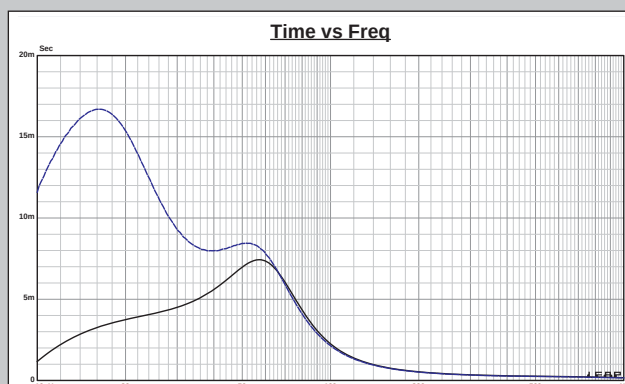


Figure 4: Group delay curves for the 2.83-V curves in Figure 3

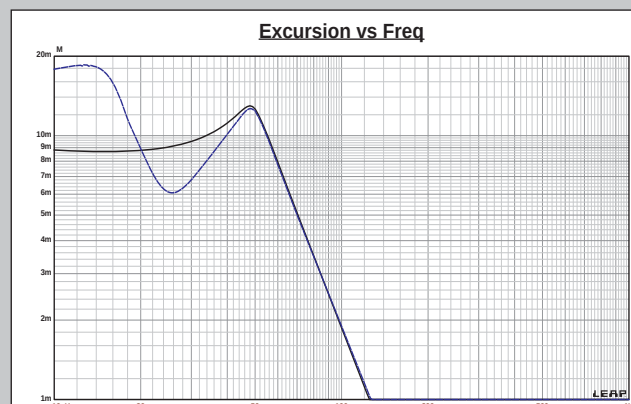


Figure 5: Cone excursion curves for the 54-V and 60-V curves in Figure 3

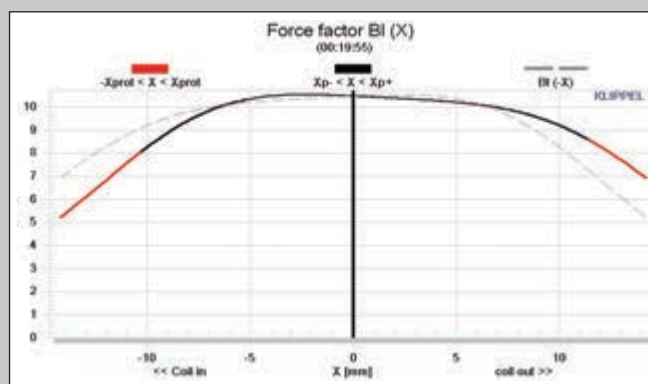


Figure 6: Klippel analyzer BI (X) curve for the SB34SWNRX-75-6

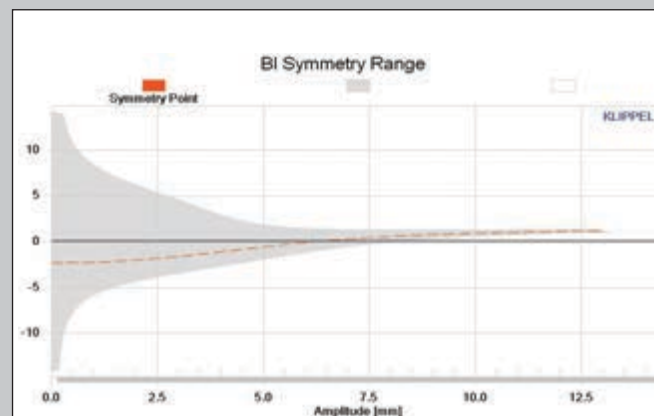


Figure 7: Klippel analyzer BI symmetry range curve for the SB-34SWNRX-75-6

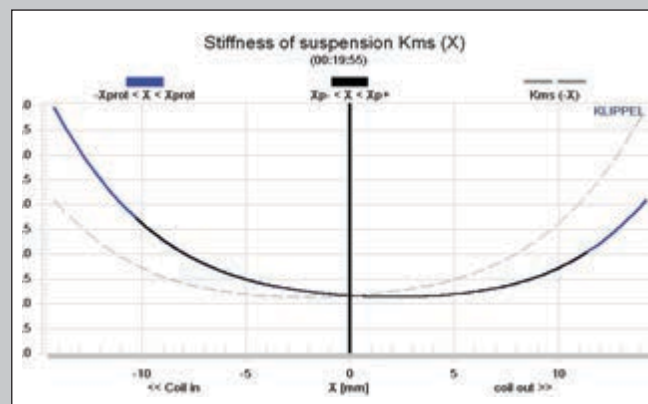


Figure 8: Klippel analyzer mechanical stiffness of suspension Kms (X) curve for the SB34SWNRX-75-6

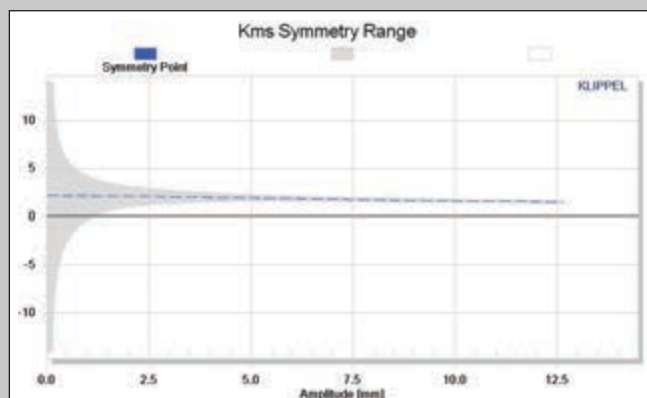


Figure 9: Klippel analyzer Kms symmetry range curve for the SB34SWNRX-75-6

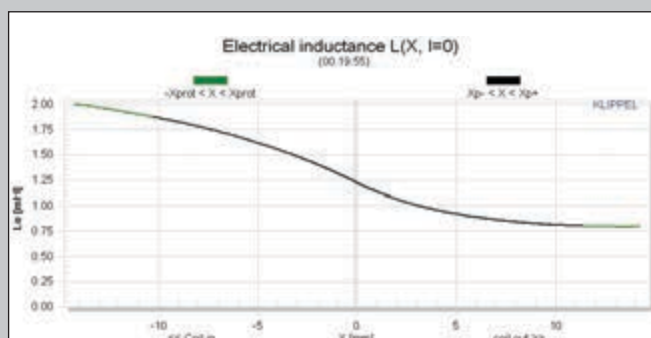


Figure 10: Klippel analyzer $L_e(X)$ curve for the SB34SWNRX-75-6

Following my normal protocol for testing, I used the Sample 1 LEAP 5 LTD parameters and set up two computer box simulations, one in a 1.3-ft³ sealed enclosure with 50% fill material (fiberglass) and a second vented box Quasi Third-Order Butterworth (QB3) alignment in a 1.95-ft³ box with 15% fill material, tuned to 24 Hz. Because of the small enclosure volume and relatively low tuning frequency, it may be more appropriate to come up with a passive radiator solution for this woofer, considering that a 4" diameter port would have to be 26" in length (14" for a 3"-diameter port).

Figure 3 gives the results for the SB34SWNRX-75-6 in the sealed and vented enclosures at 2.83 V and at a voltage level sufficiently high enough to increase cone excursion to $X_{max} + 15\%$ (13 mm for SB34SWNRX). This resulted in a F^3 of 47 Hz with a $Q_{tc} = 0.68$ for the 1.3-ft³ closed box and a -3 dB for the QB3 vented simulation of 43 Hz. Increasing the voltage input to the simulations until the approximate maximum linear cone excursion was reached, $X_{max} + 15\%$ resulted in 116 dB at 54 V for the sealed enclosure simulation and 118 dB with a 60-V input level for the larger vented box. (See **Figure 4** and **Figure 5** for the 2.83-V group delay curves and the 54-V/60-V excursion curves.)

Klippel analysis for the SB 12" woofer (our analyzer is provided courtesy of Klippel GmbH)—which, as usual, was performed by Patrick Turnmire, Red Rock Acoustics—produced the Klippel data graphs given in **Figures 6–10**. Please note, if you do not own a Klippel analyzer and would like this type of data on any transducer, Red Rock Acoustics can provide Klippel analysis of almost any driver. (For information, visit the Red Rock Acoustics website at www.redrockacoustics.com.)

The $BI(X)$ curve for the SB34SWNRX-75-6 shown in **Figure 6** is somewhat asymmetrical with a tilt but has a fairly broad BI plateau, typical of a driver with

substantial X_{max} . The BI symmetry curve in **Figure 7** shows a 2.3-mm BI coil in (rearward) offset at rest that transitions to a near zero offset at the 6.2 mm of excursion, which indicates the voice coil is staying centered in the gap at higher output levels.

Figure 8 and **Figure 9** show the $K_{ms}(X)$ and K_{ms} symmetry curves for the SB subwoofer. These curves show a fairly large forward offset in the compliance of 2.2 mm. Displacement limiting numbers calculated using the woofer criteria for BI, were $X_{BI} @ 70\%$ (BI dropping to 70% of its maximum value) equal to 10.2 mm (less than the physical 11-mm X_{max} for this driver) for the prescribed 20% distortion level (the criterion for subwoofers). For the compliance, $X_C @ 50\%$ C_{ms} minimum was 9.1 mm (also less than the physical X_{max} of this driver), which means that for the SB woofer, the compliance is the

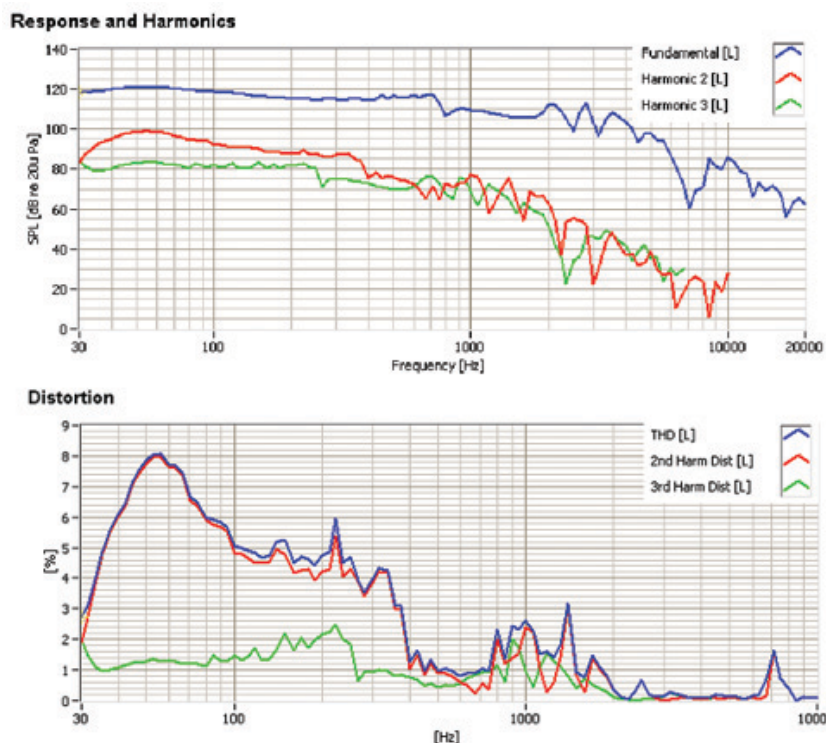


Figure 11: The SB34SWNRX-75-6 SoundCheck distortion plot

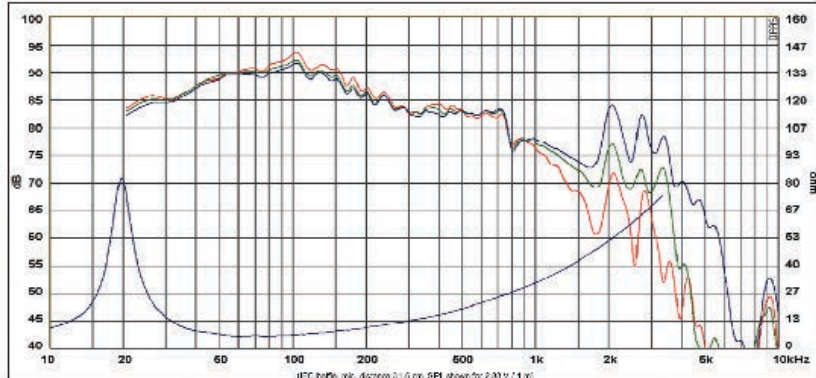


Figure 12: The factory SB29SWNRX-75-6's on-axis frequency response

most limiting factor for getting to the 20% distortion level.

Figure 10 gives the inductance curve $L_e(X)$ for this transducer. Motor inductance will typically increase in the rear direction from the zero rest position and decrease in the forward direction as the voice coil moves out of the gap and has less pole coverage, which is what we see with the SB woofer. The only thing that changes this curve shape and decreases inductance in the rear direction is a shorting ring, which was not incorporated into

this woofer.

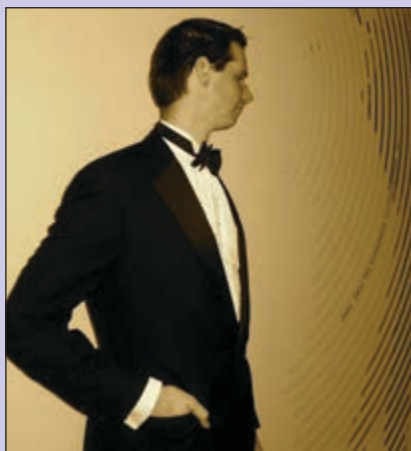
Next, the Listen, Inc. SoundCheck analyzer was used to perform distortion analysis. As usual, I dispensed with time-frequency analysis for subwoofers as the data is not really significant below 100 Hz. For distortion measurements, the voltage level was set with the driver mounted in an enclosure with a 14" x 30" baffle and increased until it produced a 1-m SPL of 94 dB at 16 V (my SPL standard for home audio drivers). The distortion measurement

was then made with the microphone placed nearfield (10 cm) with the woofer mounted in the enclosure. This plot for the 10" SB subwoofer is shown in **Figure 11**. As you can see, this actually includes two plots, the top graph being the standard fundamental SPL curve with the second and third harmonic curves, and the bottom graph the second and third harmonic curves plus the THD curve with an appropriate X-axis scale. Interpreting the subjective value of conventional distortion curves is almost impossible. However, looking at the relationship of the second to third harmonic distortion curves is of value.

The SB34SWNRX75-6 has a tremendous amount of inductance, which attenuates the SPL at a fairly low frequency. Because of this, it was not practical for me to do my usual on- and off-axis SPL measurements. However, **Figure 12** gives the factory frequency response curve of this transducer and indicates a low-pass roll-off of about -3 dB at 150 Hz.

For more information, visit www.sbacoustics.com. [aX](#)

MEMBER PROFILE



Gregory Charvat

Member Name: Dr. Gregory L. Charvat

Location: Westbrook, CT

Education: PhD (2007), MSEE (2003), and BSEE (2002) in Electrical Engineering.

Occupation: Research engineer at Butterfly Network, Inc.

Member Status: Greg has subscribed to *audioXpress* off and on since 2009.

Affiliations: He is a senior member of IEEE, a member of the American Radio Relay League, and a member of the Antique Wireless Association.

Audio Interests: Developing audio power amplifiers and preamplifiers and building these out of military surplus parts creating a late 1950s cold-war electronics appearance.

Most Recent Purchase: A set of 10 matched pair EL34 Electro Harmonix tubes to replace the aging EL34s in his home theater system, which is now 11 years old.

Current Audio Projects: Creating bad audio, restoring antique radios and modifying them to play pre-war jazz music from an iPod. The old music sounds new again when played through an antique radio, as if it were live on the air.

Dream System: Greg has already built his dream system. It was discussed in *audioXpress* (May and June 2012). This dream system is a vacuum tube theater, consisting of five tube power amplifiers, a surround sound tube pre-amplifier, and a two-channel Hi-Fi mode. It has a total of 23 tubes, is housed in a 7' tall rack, and makes use of military surplus switches, knobs, and indicators. In the future, Greg might replace the McIntosh C-24 pre-amplifier with a tube pre-amplifier of his own design.

Excellence in Amp Building

Amp designer shares his industry insight



Shaw Audio is a boutique manufacturer of hollow-state instrument amplifiers and speaker cabinets. Manufactured in the Nashville, TN, area, the line includes five amplifier models and four models of speaker cabinets. I interviewed founder and chief engineer Kevin Shaw to get his perspective on tube amplifier design (see **Photo 1**).

RICHARD HONEYCUTT: The first time I ever met you, you had already been repairing and modifying guitar amps forever. When did you first get started?

KEVIN SHAW: I hadn't been doing it as long as you think when we first met. I was probably 20 years old when we first met. I started playing guitar at about 14, and I probably started tinkering with the gear at about 15 or 16. It really was just tinkering because I knew enough to be very dangerous with some of that gear. But, I really probably got started building guitar effects first and then got brave enough to actually dive into a guitar amp and try to do things.

RICHARD: When you were working on an amp, did you have a particular type of sound that you were going for? Or did you just have a general feel of "I'll know it if I hear it?"

KEVIN: Back in the day, there were not a lot of amps that you got a lot of real good overdrive. Most all the amps were clean. I grew up playing Fender amps, and that's really where I got my start as far as working on amps. We were always trying to make those amps sound more—I



Photo 1: Kevin Shaw of Shaw Audio, a tube amp designer and builder (Source: Shaw Audio)

guess like the British amps: something that would get a lot more usable distortion. That's really what we were doing when we were going into them. We wanted to figure out a way to open them up, get more gain in them, and at some point, we wanted to add channel switching to change between the clean and dirty sounds. But those were the kinds of things I was looking for, listening for. I don't think I had a sound in my head that I necessarily wanted other than something dirtier than what I had.

RICHARD: I know a lot of guys around that time had a particular craving for a Marshall sound or a Mesa Boogie sound, or they just didn't want the clean Fender sound, or even the kind of dirt

that you could get from a late-1950s Bassman head, used as a lead amp. But they had a specific amp model they liked. Even today, there are a lot of amp emulators being sold. Now that you've gotten into the business of building amps, how would you characterize yours in terms of comparison with a Marshall sound or a Mesa Boogie sound?

KEVIN: That's interesting. Really what we do now is kind of hard to put into a category. It's kind of a category all of its own. I've taken bits and pieces of other amps and other sounds that we like and have grown up with, and put them together. There's some Vox flavor in some of my amps. We do a good bit of work with the EF86 pentode tube, which kind of fell by the wayside many, many years ago as a guitar amp tube, and it's had a resurgence in the last few years. My amps—I guess because I grew up on Fenders and they always had such clean, more American-type tone—lean more toward the British flavor, even though I didn't grow up playing British amps. We couldn't afford Marshalls and things like that where I grew up. But the "Marshallly" tones that are in some of my stuff are not necessarily the real high-gain 1980s Marshall sound that got so popular. It's more the earlier, lower gain stuff, like the 18-W amps that Marshall made that have become popular. So there's a lot of that in what I build.

I've also gone even further back. There's a lot of 1940s and 1950s influence in my amps, especially in the way they're constructed. So they really don't sound like a Marshall. They don't sound like a Boogie. They

don't sound like a Vox. But, there are hints of those flavors in the amp. I mean even some of the older Fenders—there's nothing inherently bad about Fenders: it is its sound—the flavor of the earlier 1950s Fenders is in some of my stuff, depending on which model it is.

RICHARD: If you had to identify the part of the amp that's most responsible for its characteristic sound, would you say it's the pre-amp, the phase splitter stage, the power amp, or really a combination of all three?

KEVIN: I think we've got to say it's a combination of everything. And, it goes even further than that because it has so much to do with the player. It really starts at the player's fingers. That's where tone starts. And some people would say it goes even deeper than that. It starts at the player's heart. And just like you've got to have a complete package, you've got to have the right player with the right guitar and the right amp and the right speaker. It's kind of the same way with the amp. I mean all the pieces have got to work together to achieve that tone. I will say this. I have spent quite a bit of time in an area where a lot of people don't spend a lot of time and that's in the phase splitter. In a few of my amps that's where I've made probably some of the biggest changes because I think a lot of what we hear, that we don't like in amps, can be blamed on the phase splitter. I don't know if I have enough evidence on that to hold up in court. But you know the end result is what our ears tell us, and if it doesn't make sense, that's okay. It's got to sound good.

RICHARD: I did some testing one time on a Fender amp, stage-by-stage, trying to find where the clipping was occurring, and what kind of clipping was occurring where. I discovered that under most circumstances, with a standard 1960s-vintage Fender Twin, for example, the most solid-state-sounding, grungy distor-

tion was happening in the phase splitter. And, the stuff happening in the pre-amp tubes, you could see on a 'scope, but you would not necessarily hear it as readily. When they started coming out with hybrid amplifiers, my first question was, "Okay what part are you going to keep 'tube,' and why?" In most cases, it was the power amp that they discarded, using solid-state because it's cheaper to build solid-state power amps. And I really think "cheaper" is reason, not that they thought you could replace tube power amps with solid-state without noticing the difference.

KEVIN: Yeah, it was interesting that one man who really bucked the system on that was Leo Fender. When he did Music Man, he kept the tube power amp. He believed that was really where the sound was, which I thought was interesting coming from a guy who was really not a player. He built amps for years and years that were inherently clean. I mean, except for the smaller Fenders you could really push hard, Fender's a clean sound. And yet, he comes out with an amp that's a hybrid, and kept the [tube] power section, which was really strange. Cranked up, the power amp distortion is a very desirable part of the sound, if mated with the right speakers. I don't know whether anybody's doing that today or not—building a hybrid and keeping the [tube] power amp, because it's not cost-effective. You might as well go ahead and build the whole tube amp.

RICHARD: How much effect does the power-supply stiffness have?

KEVIN: Some of this may be just opinion, but I base a lot of what I say and what I learn on information I get from actual real-world players who come in and tell me what they think of my amp or another company's amp, or whatever. What I keep hearing is the power supply has more to do with the way the amp "feels" than the way it sounds. In our business,

the way the amp—and I consider the amp as much an instrument as the guitar itself—feels has a lot to do with how the player will react with it, and I do amps both ways. I have some amps whose power supplies are solid-state, and I have discovered that in a true Class A amp, most of the time, the vacuum rectifier is a waste because the amp has plenty of feel and natural "sag" so that you don't really need it. But, it depends on the player. There are guys who come in, and you can talk to them for five minutes and tell this is a guy who will like a really tight amp so you go with an amp with a solid-state power supply. Then again there are guys you can tell want something that's got a lot of sag to it and a lot of feel. So it's more of a feel thing than a sound thing, to my ears anyway.

RICHARD: I probably have learned more about amps over the years from cheap ones than from good ones. You can see a tremendous difference, for example, if you compare an old Silvertone Twin Twelve versus an old Silvertone model 1430; whereas, if you compare a Fender Twin versus a Fender Bassman, there are differences, but it's not anywhere near as dramatic. The Twin Twelve used a voltage doubler power supply, which of course had no stiffness at all. If you turned that thing halfway up, it had a really sweet distortion. It was the kind of distortion you could use on Ventures music, but you would not want to do grunge-band music with the 1430, if you could stand the hum, because that was its big problem. Those 1430s used a pentode pre-amp, which as you say disappeared for a while. I didn't know it was coming back. That's interesting.

What can you say about differences in tubes? I know some of the manufacturers will market half-a-dozen different kinds of 12AX7s, which they will

claim are high-gain, or clean, or dirty, or whatever.

KEVIN: Well, tubes can be a problem. We're limited as amp manufacturers now. It's not practical to be an amp manufacturer and depend on old-stock tubes. Even though there's a lot of stuff still available, you can't depend on that and produce multiple amps. So what we have to work with is what's being produced today. I don't know if my numbers are correct, but I think there are only about three or four actual tube factories in the world. Most of the companies are going to these manufacturers and stamping their names on the tubes, so a lot of what you get is really coming out of the same factories. I haven't been over there and witnessed it myself, but from what I've been told by people who are more deeply involved in that part of the industry is even though they're coming out of the same factory, you can say, "we want this tube made, and we want it made with this particular level of metals and stuff." So, there are different levels of quality coming out of the same factory, depending on the materials they use, the processes, and the way the tube is designed. Because, nowadays, you can pick out 10 12AX7s and they'll all look different inside—the way the plates are done, and everything. All that affects the sound. So, there is a lot of difference in tubes.

I do think we're fortunate that we have some pretty good tubes being manufactured that are reasonably priced, and we've got a lot of companies doing a lot of post-production testing on tubes. So we're not dependent on everything as it comes straight from the factory. You have companies that are doing power-tube matching, and screening pre-amp tubes for different levels

of gain, different levels of noise, and different levels of microphonics. Sometimes you might pay a couple of bucks extra for a tube to get that selection. So I think when companies are touting a certain tube as higher gain or whatever, all they're doing is buying boatloads of tubes and running them through certain processes, and they're picking out the ones that come out better. You can look at a tube and the way it's manufactured, and there's going to be quite a bit of variance as to what comes out of the factory, so that's kind of what we deal with there. It's very difficult, in my opinion as a builder, to test different types of tubes and go, "Okay, we're going to do this, this, and this, and run it through this test, and listen to this, and decide immediately that this is the tube we want for this amp." It's just not that easy. I find that I have to use a particular brand of tube over a period of time, and look at the results I'm getting. Am I consistently getting

the same tone out of this amp with this brand of tube? Is it consistently getting me what I'm looking for, is it hit-or-miss, or is that one just not working out? That's how I settle into the tubes I use: it's more how they perform over a period of time, not, "Okay, I'm going to buy one of everybody's tubes, do some kind of tests, and decide, this is the one." There's not that much consistency. I still have tubes that fail within the short warranty period provided by most suppliers, and you have to send them back and get them replaced. We're still very dependent on the tubes and how they're manufactured.

RICHARD: With pre-amp tubes, phase splitters, tremolo circuits, reverbs, and so forth, you're pretty much set on 12AX7S or 7025s. There is no standardization in output tubes. There are the EL series, the 6550s, a few 5881s, and 6L6s. I had a friend who wanted me to help him find an amp with 6V6s recently. What's your experience with differences in the sound of different varieties of output tubes?

KEVIN: The 6V6s are my favorite, and what I spend most of my time building around—I've probably got four. I do the least amount of my work with 6L6s. I don't know whether it's because I don't care for their tone or because I grew up playing Fenders, and I just wanted to go in a different direction. What really kind of put us on the map—and it's a really small map if we're on it, because we're a small company—is the EL84. It has gained a tremendous amount of popularity in the last few years because of the 18-W Marshall hype that's out there.

When I was learning more about tube amps, I got into collecting amps. In the late



Photo 2: Shaw Audio Tonerod SE instrument amplifier (Source: Shaw Audio)



Photo 3: Shaw Audio Tonerod SE chassis. Note the large output transformer at left for the Class A 6550 output tube (Source: Shaw Audio)

1980s and early 1990s, it was always cheaper amps—things you pick up at yard sales and flea markets, you know, things you could afford—and I noticed that every time I got a small practice amp of some sort, it was built around an EL84. It just always sounded good. There was always something about it that I liked. And when the 18-W Marshall thing started getting really popular, I found that tube really worked well in the low wattage territory. So that one's really good.

I love the EL34, because it's the big brother to the 84, and it gives you that same British vibe, but with good tight bottom and a little more headroom and everything. The 6V6s are very sweet. I've been doing a lot of amps in the 15-W range with a pair of 6V6s running Class A. Right now, we're working on a 30 W with a quad of 6V6s running Class A, and all octal pre-amp tubes. So we've gone way back! And it's just stunning. The note definition and clarity is amazing. So those are three of my favorites. I've done some work with 6550s. I have a single-ended Class A amp that can use a pair of 6V6s that are parallel, single-ended. But you can also pull both of those out and plug a 6550 into either socket, and run it by itself (see **Photo 2** and **Photo 3**). It's a wonderful-sounding amp! I've done a few push-pull 6550 amps. They're good—that's a tighter, cleaner tube, real rugged. But probably the 6V6, EL34, and EL84 are my bread and butter—they're my favorites.

RICHARD: How would you describe your primary customers?

KEVIN: It falls probably in two categories. It's either the very young player in his early 20s who's just realized there is such a thing as tone and is looking to buy his first good gear, not just go to the music store and buy what's on sale for \$399. They're looking to buy a good-quality amp, and they're looking for their sound. I see a lot of those guys, and I also see a lot of guys

in their 40s and older who have the money to buy boutique equipment and high-end guitars. They're really after the tone, and they don't want just one. They want this amp for this tone and that amp for that tone. I do quite a bit of work with them. I guess that's the two main categories. We really like working with the young players. They've proven to be quite loyal, too. They come back for their second amp, and they come back for repair work or modification work, or they come back for custom pedalboard work, because they're just beginning to get into the business full-time as players. That's been a big part of our market.

RICHARD: This is an off-the-wall question. A friend recently asked me to look at a Red Bear amp, built in Russia but marketed for a while by Gibson. The sound reminded me of an early Marshall Combo amp like they used to build for guys playing

in small lounges. Do you have any feel for whether we're likely to start seeing amps from new manufacturers in the former Eastern bloc countries?

KEVIN: Really, I don't know. There's such a resurgence of tube gear being made. I had a fellow who has his fingers on the pulse of the industry tell me that at any one time there are about 185 tube amp builders. I'm assuming he's counting the big ones: Marshall, Boogie, Fender, and so forth. But once you name off those top three, four, or five that leaves a whole lot of boutique builders and small companies. And there's a lot of tube stuff being made in China and Russia, so I don't see why there wouldn't be more production of amps there.

RICHARD: Well, Kevin, thanks for your time. This has been very interesting, and I'm sure it will be for our readers. We certainly wish the best for your company. *aX*



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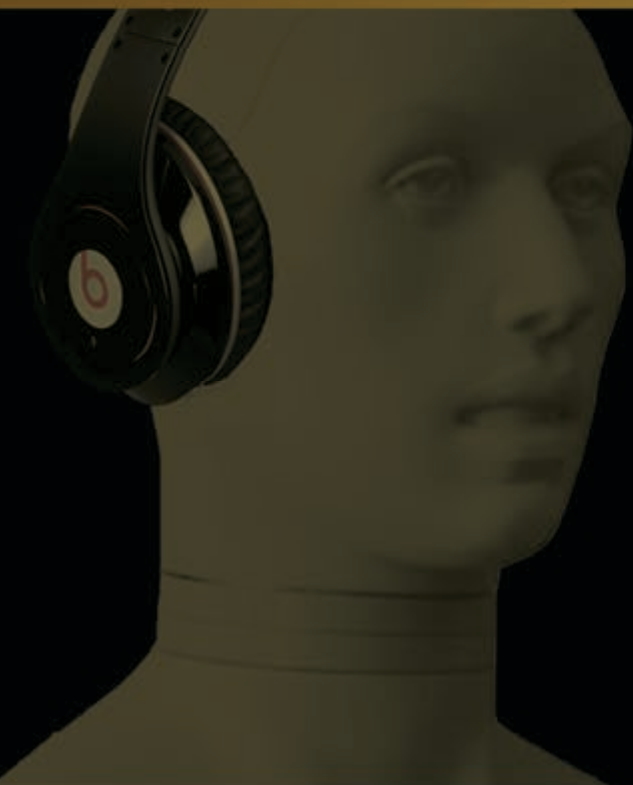


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CES 2012, Plus (Part 2)

Essential Bits of Technology

CES serves as a launch pad for new devices

Part one of this report, which ran in the June issue, covered my take on the audio and video exhibits at the January 2012 consumer technology events in Las Vegas, NV. This article provides my spectral sampling of the other represented technologies that have become intrinsic in our lives.

CONSUMER TECHNOLOGY

While video and audio devices are adequately represented at CES, other consumer electronics have become ubiquitous in our lives and the major focus of exhibits and events.

Other World Computing (www.owcomputing.com) highlighted the Newer Technology (www.newertech.com) Power2U UL/CUL-listed AC/USB wall outlet (a duplex AC wall outlet with two USB-charging connectors; \$28 at OWC). "Power and/or fully charge your iOS [and] other USB-equipped mobile devices without a bulky adapter." OWC also sells solid-state drives (SSDs) for Windows or Mac systems. However, several experts informed me that any system needs some very low-level parameters to be tweaked to take full advantage of the SSD's claimed performance improvements, and some systems aren't capable of enabling those adjustments. You need to do your homework.

The **HomeGrid Forum** (www.homegridforum.org; a non-profit trade group) demonstrated **G.hn** multi-vendor interoperability. G.hn is part of a family of open standards developed by ITU-T (G.9960—physical layer and architecture; G.99 61—data link layer) that enable compliant network devices to transmit data, including high-definition video, over various types of wiring (coax, phone wires, Ethernet, and powerlines) throughout your house.

The **HomePlug Powerline Alliance**

(www.homeplug.org) is an industry-led initiative with 65 member companies that creates specifications, plus marketing and certification programs, to encourage worldwide adoption of powerline networking. It announced support for the IEEE 1905.1 hybrid networking draft standard (<http://grouper.ieee.org/groups/1905/1>) that is intended to integrate a variety of home networking standards including IEEE 802.11 (Wi-Fi), IEEE 802.3 (Ethernet), IEEE 1901 (powerline), and MoCa (coaxial cables). This will enable compliant products to work seamlessly with existing products, and simplify network setup by providing common procedures for adding devices, establishing secure links, and managing the network.

Line2 (www.line2.com) adds a phone line to the iPhone, the iPad, and Android-based devices (\$10/month, after seven-day free trial), enabling the user to make calls over Wi-Fi or 3-G data connections—unlimited North America calling, and unlimited U.S. texting, plus visual voicemail. With some limitations, you can select a new number or transfer an existing one.

Make your own music with **Keith McMillen's QuNeo 3-D Multi-touch Pad Controller** (www.keithmcmillen.com/quneo/overview; \$250 srp), an iPad-size device with 27 pads, sliders, and rotary sensors that are pressure, velocity, and location sensitive. (Operational descriptions are from the website.) The 17 switches also respond to how hard they are pressed. Each of the 16 square pads reacts with 127 levels of velocity response, XY location, and continuous pressure. Each of the two rotary sensors measures angle, pressure, and radial distance. The nine touch-sensitive sliders can be mapped to fader and effects controls. LEDs within each slider can be level meters or markers of where they were

last touched. The spread between two fingers on a slider can set stereo locations or filter resonances. Tapping a slider can mute or toggle any track or function. They smartly sized it to match the iPad, enabling use of iPad holders and cases. An accessory MIDI expander (\$40 srp) is available to connect the QuNeo to external hardware via a five-pin MIDI DIN connector. The device was created for music makers, but I wonder if it could also be used with a PC/Mac and audio mixing/mastering software, providing a more tactile control panel for those functions. The QuNeo was developed with funding through Kickstarter (www.kickstarter.com), a "funding platform for creative projects."

Yet more devices to be connected: **iDevices'** (www.iddevicesinc.com) **iGrill** Bluetooth meat thermometer (\$80 srp; www.iGrillInc.com)—wirelessly monitor the roast in the oven or on the grill, even from your exercise bike, where you can also monitor your fitness progress with the **iBike** (www.ibikesports.com) **POWERHOUSE** fitness computer system (\$270 srp) that includes a weatherproof iPhone case with sensor electronics.

PixelOptics's **EmPower!** (www.lifeactivated.com) are electronic-focusing glasses that change prescription just below lens-center at the touch of the temple arm or in automatic mode when the wearer looks down or straight ahead. Cost is estimated at "25–30% premium over top-of-the-line progressive lenses."

The **Olloclip** (www.olloclip.com; \$70; "ollo" means "eye" in Galician) is a clip-on lens attachment for the iPhone 4 and 4s that adds fisheye, macro, and wide-angle image capture to its camera.

The **Tamaggo** (www.tamaggo.com; less than \$200) is 14-megapixel 360-Imager with a built-in panamorph

technology that can one-click-capture 360° high-resolution, navigable photos.

Vidyo (www.vidyo.com) has developed personal telepresence products that enable relatively simple teleconferencing on PCs, iOS/Android tablets/smartphones, and other devices, using the Internet for communications without requiring a central teleconferencing service provider.

Interactive Voice (ivee) brings you the voice-activated alarm clock (www.helloivee.com; the Flex—\$60, and the Digit—\$50) that understands more than 30 voice commands, including setting and responding to the alarm. No more blindly reaching for the sleep button. They claim its voice recognition “can understand anyone, without prior training.”

Leonar3do (www.leonar3do.com) is an integrated hardware/software kit comprising an install DVD, virtual-reality goggles, motion sensors, and the “bird” (a custom-designed input and control device) that claims to provide “the easiest way to create and visualize

virtual 3-D objects in real space while sitting at your desktop.” It is available in home, professional, and education editions.

Victorinox Swiss Army (www.victorinox.com) has 64-GB, 128-GB, 256-GB, and 1-TB SSD versions of its pocket tools. Each version comes with two bodies: one is “flight-friendly” while the other includes traditional Swiss Army knife implements (blade, scissors, and nail file/screwdriver combo). The SSD module has a single connector that fits into USB 2/3 and eSATA 2/3 connectors and “handles automatic backup and synchronization issues in un-hacked AES 256 security (combination hardware and software).”

There were more than 25 market-specific TechZones, covering product categories including broadband services, safe driving, and sustainable technologies.

The Eureka Park TechZone showcased 94 start-up companies and entrepreneurs. This tech zone was a partnership with the National Science Foun-

dation (www.nsf.gov), Startup America Partnership (www.startupamericapartnership.org), CNET (www.cnet.com), and UK Trade & Investment (www.ukti.gov.uk). This zone was “designed to benefit budding entrepreneurs, fledgling start-ups, home-grown innovation, and small companies looking to gain footing in the consumer electronics industry.” This is part of CEA’s **Innovation Movement** (www.innovation-movement.com), which was formed “to bring together an engaged community not just of industry professionals and entrepreneurs but of all citizens who believe innovation is critical to American global leadership and economic growth. This grassroots campaign mobilizes Americans in support of public policies—such as international trade, skilled immigration, deficit reduction, and broadband deployment—that encourage and advance American business and shore up our economy for future generations. ... Innovation isn’t just about technology or even business—it also includes the policies that lawmakers choose to enact, which either help the spirit of innovation thrive or stifle new ideas before they can reach full potential.”

Startup Debut (www.startupdebut.com) was a “media party where innovative startups [displayed] new products for media, analysts, bloggers, and investors.”

Scott Paul Technologies (www.scottpaultech.com) has come up with low-cost simple, flexible stick-on “handles” for cellphone and iPad-size devices. They also can be used to stick the device on any surface, including a car’s dashboard.

ElderGadget (www.eldergadget.com), founded by Elle Gindl, is a “technology review and news site geared toward the dynamic boomer, [that] features reviews and explanations of” the latest tech devices.

The Aging Technology Alliance (www.agetek.org) [from their press release] is a non-profit group that “represents companies and organizations dedicated to promoting the awareness, benefits, and value of products and services for our aging society.” The AgeTek pavilion featured four companies including GrandCare Systems,

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Presto Services, and VitalLink. The press release also listed five other member companies exhibiting at CES.

Cambridge Consultants (www.cambridgeconsultants.com), which had a booth in the Digital Health pavilion, released a report that points to the integration of "digital goods with personalized predictive and prescriptive value to consumers-as-patients." This fusion of technology with personal healthcare could facilitate individuals more effectively managing their own health, customizing their care to their lifestyle, potentially reducing visits to medical facilities, and reducing patient costs.

The Federal Communications Commission (www.fcc.gov) provided information about "cramming charges" [which is] "the practice of placing charges on your telephone bill for unauthorized products or services." Cramming charges can show up on landline, wireless, and VoIP bills. An estimated 15–20 million households receive cramming charges each year. FCC investigations show that approximately 0.1% of consumers used the third-party products for which they were billed. Monthly individual-vendor cramming charges range from \$2–\$20. "Charges sometimes appear as service fees, service charge, other fees, voice mail, mail server, calling plan, or membership, and might be cramming if they were unauthorized or the cost was misrepresented." Read your phone bill carefully.

More information is at www.fcc.gov/guides/cramming-unauthorized-misleading-or-deceptive-charges-placed-your-telephone-bill and at www.fcc.gov/encyclopedia/cramming-tip-sheet-consumers.

OTHER SESSIONS & EVENTS

If trying to stop by more than 3,100 exhibitors wasn't enough to keep you busy, CEA held keynote speeches and "SuperSessions," plus 32 conference tracks. MP3 recordings of the eight keynotes, seven supersessions, and the other 229 sessions and presentations are available as downloads from www.mobiltape.com/conference/2012-International-CES.

While not part of the show, the CEA

has established 10 technology and standards committees/subcommittees (www.ce.org/standards) on topics including: audio; video; portable, handheld, and in-vehicle devices; wireless power; home networks; and residential systems. These CEA groups develop standards in accordance with American National Standards Institute (ANSI) guidelines and submit them to receive approval as ANSI standards.

The Institute of Electrical and Electronics Engineer's (IEEE) 30th annual **International Conference on Consumer Electronics** (www.icce.org)—organized by the IEEE Consumer Electronics Society (<http://ewh.ieee.org/soc/ces/>)—brought "the latest R&D ideas and next-generation consumer electronics technologies from around the world" [in the form of] keynotes, technology tutorials, and 350+ technical presentations. ... Topics included smart grid, home healthcare, HDTV, PVR, mobile broadband, handheld and wearable computers, spectrum usage, digital media, security, and

rights management, privacy, and social impacts."

STORAGE VISIONS CONFERENCE & EXHIBITS

Thomas Coughlin (Coughlin Associates; www.tomcoughlin.com) is founder and organizer of the Storage Visions conference. Coughlin is author of *Digital Storage in Consumer Electronics: The Essential Guide* (ISBN 978-0-7506-8465-1; approximately 300-page paperback; \$60 from www.newnespress.com), which "presents best practices for selecting, integrating, and using storage devices to achieve higher performance, greater reliability, and lower cost."

The theme of **Storage Visions 2012** (www.storagevisions.com) was "Heavy Storage for Thin Clients," exploring "the convergent needs of digital storage to support cloud content distribution and sharing, user-generated content capture and use, [plus] professional media and entertainment applications." The conference emphasized entertainment content, recognizing the rapidly growing



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video-file sizes due to increasing image resolution, and the exploding increase in user-generated content. Coughlin reported that “video over the Internet consumes more than 60% of North American Internet bandwidth,” citing Netflix, Amazon Prime, and YouTube as three major content sources.

The Entertainment Storage Alliance (www.entertainmentstorage.org) was formed in 2005 to provide a forum on storage requirements for creation, distribution, and reception/playback of entertainment content.

While the concepts and strategies presented were not new to me, from several panel members and company representatives I learned that apparently the ideas of file-based workflow, networked data-center storage, and archiving are still new to most of the entertainment industry.

The 2012 Storage Visions's four keynotes and 10 sessions delivered approximately 60 presentations dealing with growing file sizes and storage requirements, remote or local storage, protection from data loss and theft, archiving, plus content access anywhere on all types of consumer devices. I was disappointed that with the concern about archiving, no one from the Library of Congress National Audio/Visual Conservation Center (responsible for preserving and archiving the U.S.'s audio/video history) was present or on the panel.

- Coughlin summarized storage trends including: disk drive (HDD) shortages due to Asian earthquake and flood damage, reduced flash-memory prices due to excess capacity, increasingly faster storage buses (Thunderbolt, SATA-10 USM, USB 3.0), cloud storage use by consumers and video professionals, plus higher video resolution and frame rates.
- Bob Herzan (Rorke Data; www.rorke.com) outlined a process Rorke uses to design, select, and install a workflow and storage system that meets clients' needs. They survey the client to learn about existing operating systems, applications, collaborative activities, file formats, scalability, support capability (including system/network

administrative staff and expertise), required redundancy, archiving, encryption, portability, interfaces for data input/output, and so forth. Assuming video at 30 fps and film at 24 fps, professional image data rates can range from 25 Mbps (approximately 13 GB/hour; approximately 75 hours/TB) to 9,000 Mbps (4 K film—4096 × 3112; more than 4,000 GB/hour; 15 minutes/TB). Rorke has determined that a serious problem is the natural degradation of storage performance due to file fragmentation over time, plus randomization occurring from copying and rendering.

- Michelle Munson (Aspera; www.asperasoft.com) spoke about “Transforming Cloud Storage Systems for Digital Media”—network and I/O bottlenecks and various business models (capital outlay versus pay-for-use). I asked about the risks of data loss, cloud storage companies going out of business with or without warning (potentially causing loss of customers' data, which has already happened), plus data privacy and security. The panel did not have definitive answers, except to thoroughly investigate the cloud service, and possibly to use more than one service for redundant storage.
- Tom Leyden (Amplidata; www.amplidata.com) is involved in “building a 45-year live video archive” of the Montreux Jazz Festival, comprising more than 5,000 hours of video, more than 5,000 hours of high-quality audio, 3,000 concert descriptions, plus press releases, photos, and so forth. They are using a dual-archive system: an offline secure tape archive as well as an online disk archive that can enable streaming and for mastering DVDs and Blu-ray discs plus HDTV broadcasts. Considerations for the online archive were power consumption, high availability, low latency, security (especially on a multi-tenant computer storage system), and long life cycle. The system uses Amplistor (www.amplistor.com) 1 PB

(Petabyte = 1,000 TB = 1 million MB) disk storage, and can be expanded.

- David Duncan (Imation; www.imation.com) raised the issue of “Finding and Protecting What We Have,” pointing to the increasing problems caused by companies allowing employees to use their consumer mobile devices on the enterprise network; “66% of respondents to an Information Week Analytics 2011 end-user-device management survey allowed employee access to e-mail and storage over employee-owned devices, [creating] significant problems for compliance and data security.” A KC Research and Jupiter 2011 report stated that “85% of mobile devices are unprotected.” A Ponemon Institute national study of data-loss identified missing devices as causing more than 40% of the security breaches. Duncan pointed out that abstinence (“do not use personal devices”) does not work, and that there are procedures and hardware/software that can substantially reduce the problem. “Design for human behavior: the simpler, the more automatic, and the more transparent your removable and mobile device security solution is to your users ... the better.”

Allan J. Schollnick (V.P. Sales, Backlot Imaging; past chairman, SMPTE Hollywood section) suggested putting digital data on film [as has been done for Dolby Digital and Sony's SDDS digital soundtracks for more than 15 years; but using all available film area] would likely provide long-term data storage that could be more reliable than disk storage and require less maintenance.

An exhibitor at Storage Visions, the **Storage Networking Industry Association's** (SNIA; www.snia.org) **Solid State Storage Initiative** (SSSI; www.snia.org/forums/sssi) was formed to foster broad use of solid-state storage. SSSI exhibited samples of SSDs from Fusion-io, Micron, Smart Modular, Toshiba, and Violin Memory. Micron manufactures all of its SSDs

components. Most companies purchase at least some of their SSD components; some get their NANDs from Micron. See www.snia.org/forums/sssi/knowledge/standards for an explanation of solid-state storage standards and www.snia.org/pts for information on the SSD Performance Test Specification that defines performance tests and methodologies.

SNIA's SSSI issued the white paper: "Understanding SSD Performance Using the SNIA SSS Performance Test Specification: How to Use the PTS Results to Evaluate & Compare SSD Performance" (2012) downloadable from www.snia.org/forums/sssi/pts, which discussed factors affecting SSD test results, including device-level factors, system-level factors, and architectural factors.

A representative from SNIA told me consumers cannot trust that SSD-manufacturers' specs, advertising, or even third-party testing, will accurately reflect in-use SSD performance. For example, it is known that Apple researches and tweaks low-level buffering, interface, and other SSD-related parameters (far below the Preference Pane level) to optimize system performance with the specific SSD installed, even if that SSD's raw test results aren't as impressive as those of other SSDs.

One SSD exhibitor was **Pure Silicon** (www.puresi.com).

Ferrotec's **ferrofluid** has been used in loudspeakers since 1972, when Bob Berkowitz selected it to fill the voice coil gap in an Acoustic Research tweeter, according to Ferrotec's brochure, "A Brief History of Audio-Grade Ferrofluids." The brochure also shows test results of a ferrofluid type D01 sample, received from Eminence Speakers that had originally been tested in 1975 by Epicure (which manufactured EPI speakers) and retested by Ferrotec in 2008, with performance essentially unchanged after 33 years. In addition to ferrofluid's thermal transfer, gap centering, lubrication, motion damping, and gap-sealing capabilities, it can be used (in a water- or solvent-based solution) to make magnetic-domain patterns visible, such as on hard disk platters or magnetic tape.

HiWave (short for "human interface

waveforms," www.hiwave.com, formerly NXT) offers balanced-mode radiators (speakers with flat diaphragms instead of traditional speaker cones), audio exciters (turns a surface into a speaker; e.g., a laptop screen can also be its stereo speakers), and haptic display solutions (providing tactile response functionality for devices such as smartphones and tablet PCs). HiWave has been able to integrate the audio and haptic functions into single modules, enabling more cost-efficient combination of haptic sensing and audio output in a panel with fewer components.

Alex L. Goldfayn has written ***Evangelist Marketing: What Apple, Amazon, and Netflix Understand About Their Customers (That Your Company Probably Doesn't)*** (www.evangelistmktg.com, \$16 at www.amazon.com), in which he (from the Amazon webpage) "argues that technology companies succeed in spite of their marketing, not because of it." He says "if consumer tech makers ceased all marketing activity today, they would not see a significant decline in sales."

At Digital Experience, **Toshiba** demonstrated its **FlashAir SDHC memory cards** with embedded wireless LAN functionality, enabling users to wirelessly upload and download files. Toshiba also displayed 32-GB and 64-GB USB flash drives that are compliant with USB 3.0 standards.

OVERALL IMPRESSIONS

Consumers are choosing to be increasingly connected, leading manufacturers to expand Internet and inter-device connectivity of products including smartphones, fashion-centric wearable technology, HDTVs, whole-house surround audio systems, appliances, home system monitoring and control, and cars.

i-Devices, their competitors, accessories, and apps have become a major presence at CES. Security and privacy continue to be problems, especially because most consumers aren't aware, or don't care, until their identity is stolen or private data is distributed beyond their control (and often to their embarrassment). There was a noticeable increase in Chinese-branded products. 3-D was present but not the center of

attention.

The show floor was crowded. CEA issued early estimates of 153,000 attendees (including more than 5,000 press and analysts), 34,000 of whom were from overseas.

CEA claims that 20,000 new products were launched at this year's CES, including "ultrabooks, OLED TVs, Android 4.0 tablets, next-generation smartphones, and 3-D printers" (from a CES press release). That averages to approximately 6.5 new products (models?) per exhibitor. It might be interesting in a year to read a report identifying which ones became successful.

CEA's expansion in the number of start-ups and entrepreneurial exhibits is consistent with CEO Gary Shapiro's philosophy that innovation is critical for economic success and needs to be more strongly encouraged and supported.

It is impossible to cover all the products and events of interest during that eight-day period, but it is fun to try. I'll try again next year. *ax*

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SHANNON BECKER: Where do you live?

GABE HERMAN: I live in West Hartford, CT.

SHANNON: How did you become interested in music?

GABE: I owe my interest in music to my parents. They are passionate lovers of all kinds of music, and they were always playing records and tapes in the house and in the car when I was growing up. The music in our house was like wallpaper. When I was in high school, my friends loved coming to my house because there was always Chicago blues records blaring over the din of my Dad's woodshop. My parents had a killer record collection. Now that I look back on it, I think it would've been amazing if I didn't have an interest in music.

SHANNON: Are there any instruments you currently play?

GABE: Yes. I'm primarily a guitarist, but I have also recently picked up the banjo and lap steel guitar.

SHANNON: You have engineered and produced numerous musical groups. How did you get started?

GABE: I first started engineering and producing sort of by accident when I was in school studying sound design at the Savannah College of Art and Design. At the time, I was coming off a career as a professional musician and wanted to widen my skill-set by studying sound design and audio post production. To make ends meet, I was teaching guitar lessons and playing shows at night. But, I was also trying to establish myself as an audio post engineer so I wouldn't have to depend so



Photo 1: Gabe Herman pictured inside his recording studio (Photo courtesy of Anthony Crisafulli)

much on my music to support myself.

By learning the technical side of recording, I learned how to work a studio, and how to work with musicians. It wasn't long before I was getting requests from my musician friends to help them record their music. Pretty soon, I was doing as much audio post work as I was music recording. Jackpot.

I got a call one day from this really incredible guitarist, Richard Leo Johnson, whom I had just met. He said he was looking for someone to mix his latest record (The Legend of Vernon McAlister) for Cuneiform Records. He asked if I would be interested in giving it a shot. He had composed all the music by overdubbing nontraditional performances from an old National Aeolian resonator guitar. He'd hack at the strings with a cello bow, or wrap rubber bands around the neck and hit the strings to get overtones. It was the perfect project for me because it required using all of the creative synthesis skills I had learned as a sound design student concurrently with my musical chops. I was in heaven! By the end of the project, I had come to this catharsis that sound design and music are inseparable for me and that

I wanted to pursue every opportunity I could to work with a variety of traditional and nontraditional projects. It was an amazing experience for which I will forever be grateful.

SHANNON: Do you have a favorite genre and, if so, why is it your favorite?

GABE: I find it really hard to answer that question because there are so many different genres out there and I have songs that I love in almost all of them. When I think about what these songs all have in common, I come up with some over-arching themes. My favorite music has great songwriting; both lyrically and musically. Orchestration is important to me as well. I'm fascinated with combinations of instruments and the way artists choose to combine sounds to help get the emotional point (or counterpoint) across. I'm especially drawn to music that combines elements from different genres and cultures.

SHANNON: You have worked with several professional musicians. Is there one artist or project that stands out?

GABE: One that I'm particularly proud of is a record due to be released fairly soon on 482 Records. It's called "State of Emergency," and it's the first solo feature record by bassist Nat Reeves. Nat is an amazing jazz musician and has played on so many commercial albums with legends including John Scofield, Pharoah Sanders, Kenny Garrett, Jackie McLean, Sonny Stitt, Eric Alexander, Joe Farnsworth, and so many others, yet he's never had a record of his own.

Nat is a colleague at The Hartt School, where he teaches bass at the Jackie McLean Institute of Jazz, and we have grown close working there together. As I was first getting to know him, I was amazed that he hadn't done a record for himself. I asked if he wanted to make a record with me and he said, "Yes!" I secured some funds, and he got some musicians to play with him: Rick Germanson (piano), Johnathan Barber (drums) and Josh Brunau (trumpet). The week we were scheduled to go in the studio was the week of that terrible snowstorm we had in January 2011. There were, I think, originally four or five more musicians who were supposed to drop in for the session, but the storm had everybody locked down for at least a week. Nat, Josh, JB, Rick, and I had come down a day earlier to set up and rehearse a bit, so we got snowed into the studio. We were staying in a hotel right next door, but we had to walk backwards to get to the studio because the snow was blinding. Once we were inside, there was this amazing sense of calm that came over everything. No one's phone rang, there was no traffic, no distractions of any kind. Nat and the gang settled in right away and played their asses off. It was one of those magical sessions where everything just fell into place. A couple of months later when we sat down to mix the CD, I was surprised at how much of that great vibe came through the recording.

I also think it was the first and only record I ever mixed without using compression of any kind. I only had to use just a smidgen of EQ. The rest was just a couple of subtle fader moves. We just got the tracks back from mastering at Systems 2 and now I can't wait for the CD to come out! Should be any day now. We're already making plans to do another record later this summer with Steve Davis, Shaun Montiero, and Eric McPherson.

SHANNON: When did you open your own recording space at JamSpot, in Somerville, MA, and what kind of audio equipment do you have there?

GABE: When I started recording music at JamSpot in 2005, I had a very modest setup. I was using a 24-channel, 8-bus Mackie console with a DigiDesign002 converter and some basic microphones (Shure sm57s and such). It was the coolest place to have a starter-studio because JamSpot was (and still is) a rehearsal facility in Boston that offers a clean and well-maintained space to play by the hour.

When I started working there, something like 3,000 or 4,000 musicians were rehearsing there every year. I got started by hanging my shingle out to any band that needed a demo. Because the turnover in the rooms was so high, I was forced to do three or four song demos in four hours or less to work within each band's budget. I got really good at setting up fast as each session had to be set up from scratch. It took me a little while, but eventually, I learned how to get the room to sound decent enough. As business picked up, I was able to reinvest in gear as needed and eventually upgraded to a 24-channel Toft ATB console and expanded my mic cabinet and outboard gear collection until the little room I was working in was at physical capacity. I mean, this room was *small*. By the time I left, I could maybe fit three or four people in there in addition to myself and that was a tight fit. I'd have to take constant breaks to open the door for air, just to keep from suffocating. But that little room taught me great lessons: It taught me how to work fast, and to take constant breaks.

I actually moved out of JamSpot in 2010 and relocated all of my recording equipment to my basement in West Hartford, CT, where I have a home studio. I'm still using my Toft ATB console, but I have upgraded my system to the ProTools 9 software platform, and I am using an RME UFX system with an additional 16 channels of Apogee converters.

Mostly, I mix and do audio post work for film and TV there. When it comes to recording, I do most of my large-format tracking and mix work at the Powerstation New England and then take the tracks back to my home studio to mix and do

overdubs. This is ideal as the Powerstation NE is an exact replica of the Studio A room at Avatar Studios in NYC. You can't ask for a better room to track in and it's the best upgrade imaginable for the work I do.

Working in smaller rooms is fine and fun for some projects, but it's impossible to compare that experience with working in a large room with A-level gear. Artificial reverbs are great and have their place, but I'd much rather get a great sounding room sound the old-fashioned, natural way when I'm recording.

The Powerstation NE has a 72-channel Neve Legend VR console, ProTools HD 3 recording system, tons of outboard effects (including stereo EMT plate reverbs), Lexicon 480L, vintage UA 1176, LA-3, and LA-2A compressors, Five Pultec EQs, Schoeps pre-amps, Millenia pre-amps, and a whole plethora of other erroneous and wonderful outboard effects units. (You'd have to shake a stick for a very long time to get them all.) The mic cabinet is world class and features original vintage Neumann U47 pair, four FetU47s, AKG C12, and rarer C24 (stereo capsule version of the C12), RCA77 and RCA44 ribbon mics, U67s, KM84s, and I'm only mentioning just a few. I'm spoiled rotten when I work at the Powerstation.

SHANNON: If you could add or change any audio equipment what would it be?

GABE: When I'm working at the Powerstation, there's not a lot more to ask for. I do have a yearning to move all of their equipment to my basement though. One thing I am looking for right now for my basement is an outboard reverb processor, probably a Bricasti M7.

SHANNON: Tell us about your website, www.audiogabriel.com, and how it came to be.

GABE: My website started as a home-built i-website to advertise my services while working in Boston. As I continued, I learned a lot about how to build and maintain content with other applications and have upgraded my site to include a DIY section with articles documenting some builds I had done for myself and my students as well as some philosophical documents for clients and other interested

parties.

I do a lot of research in my downtime. As I learned more about how to build websites and spent more time researching other companies' websites that were doing something similar to me, I realized that my favorites had more than just content relating to who the company was and what they had done. I was drawn to the sites that had as much to say about their clients as they did about themselves. This made total sense to me because a producer is only as successful as their clients. I really believe in the projects I work on, so why wouldn't I do everything I could to promote the artists at the same time? I'm constantly trying to promote the work my clients are doing because I feel that their success as artists defines mine as a producer/engineer. I think this also is an act of good faith that shows I'm not going to disappear as a support system after the project is over.

The other sites I really enjoyed had extra sections devoted to projects that were noncommercial. I learn a lot from the websites of engineers I admire who share their thoughts and ideas, and I wanted to create a place where I could share the things that I had learned too.

Two years ago, I decided to try to write the most comprehensive DIY article on the web about how to convert a speaker into a kick-drum microphone, and had so much fun doing it that I have plans to expand this site to include more DIY projects, with a new article on a custom-built Talk-Back mic interrupt switch made from a piano damper pedal due to come in the next few months.

SHANNON: When did you start teaching and how did you find your way to The Hartt School?

GABE: I started teaching music when I was still in school at Savannah College of Art and Design (SCAD), and that was a really important facet of my life at that time. It was my second time in college. (I had already been a jazz guitar performance major at the University of North Carolina at Wilmington.) So, I was pretty comfortable handling the pressures of being a student. I was regularly asked by faculty at SCAD to help other students with course material and projects outside class. After I gradu-

ated, one of my professors recognized my unique formal training in both music and sound design and encouraged me to apply for an adjunct teaching position at The Hartt School in the Music Production and Technology department. While this position didn't pay much, it provided enough financial cushion for me to make the move and try my skills as a college professor.

When I arrived at Hartt, the level of talent and musicianship the students possessed inspired me, and I was able to connect with the Hartt community instantly. I had such a good experience my first year of teaching that I was offered to teach more classes, including courses in the Music Management department. In 2009, I moved to the position of assistant director of the program, and I'm now one of two full-time faculty members in the MPT department, and I continue to teach adjunct classes in Music Management.

SHANNON: In 2006, you helped design the template for what would later become the audio production department at Boston University's Center for Digital Imaging Arts. How did you get involved with this project?

GABE: After starting to teach at Hartt, I realized teaching was something that I was good at and loved to do. It was keeping me sharp and engaged with issues, and it was feeding my intellectual needs. I wanted to branch out and try teaching at other institutions.

Janine Cowen originally contacted me because she was looking for instructors to help her put together a new audio program for Boston University's Center for Digital Imaging Arts. I was hired as the program's assistant director and we started putting together curriculum. It was a fun challenge, as it allowed me to really dig in and do some research on what skills should be taught and how best to translate those skills to the professional working world. It was a really unique and exhilarating opportunity to get this program off the ground. After the second year, we were able to expand our facilities and construct a Walters-Storyk designed recording facility. I continued to teach there until 2009, when I left to pursue teaching full-time at Hartt. The program is still kicking today.

SHANNON: What about teaching do you find to be the most rewarding and the most challenging?

GABE: There are so many different rewarding aspects to teaching. One of the things I enjoy the most is the long-lasting relationships I have developed with my students, post-graduation. I have so many students who have gone on to do such great things, and I love hearing about their adventures, trials, and successes. It's also an amazing rush to be there when a student has an "ah-ha" moment. It inspires me to keep learning.

I consider myself to be one of the luckiest people on earth to be able to wake up every day and work at doing something I love. Even still, there are times when teaching audio can be challenging. It's a practice that demands an open mind, a lot of patience and sometimes you have to be willing to watch students struggle. As a teacher, I find the biggest challenge is sometimes stepping back from a situation and allowing students to make mistakes. When you're studying audio, it's sometimes true that the best way to learn something is to fail at it the first time around. The questions that come after failure are the best teaching moments.

SHANNON: Do you have any advice for audioXpress readers who are considering audio technology improvements to their own systems?

GABE: Think big, then small, then big again. Anyone who gets serious about audio, at some point, eventually realizes their personal audio system is never complete and is a constantly evolving work in progress.

While it's never a bad time to improve any part of your system, before you start getting serious about throwing money around, it's best to just take a minute, check in on what your ideal audio system is, and ask: "How much does what I'm about to do get me closer to that goal right now?" For example, one of the questions I get asked fairly often is what kind of speakers to buy. I start by explaining that the answer is always complicated and has to do with what you can afford and, more importantly, how well the listening environment is acoustically treated. The greatest,

most expensive speakers in the world will underperform if placed incorrectly or in the wrong space. If your ambition is to work on a pair of really expensive monitors, then you may want to first consider all the other components in your system and how they might limit the performance of the speakers. It might make more sense to hold off on buying a pair of speakers until you also can afford the acoustic treatment, or even the cost of hiring an acoustician to help design the construction and layout of your space so you get the most out of them.

Another thing I would recommend, when considering an upgrade in equipment, is to keep a scientific mind but base the majority of your opinions on your subjective experience. There are a lot of ways for audio equipment to be impressive on paper, (cost is one of them) but what will really excite you is how much fun that equipment is to use, and how well you react to the way it sounds. This should be evaluated beyond first impressions. If possible, before making a purchase, see if the vendor will allow you a test drive. If you're still jazzed after a week of living with a component, you're probably onto something.

SHANNON: What projects are you currently working on? Are you planning any other projects for the near future?

GABE: Right now, I'm finishing up a comedy album for BSeenMedia Records featuring comedians Myq Kaplan and Micah Sherman called "Please Be Seated." It's a collection of silly songs they wrote that we recorded at my home studio, along with some live location recordings I did of their show at The Comedy Studio in Cambridge, MA, last year. In a couple of weeks, I'm going to be starting post-audio production for a new TV series for the Outdoor Network that follows the adventures of a modern mountain man, who insists on living like the pioneers did in the early 1800s.

SHANNON: A lot has changed in audio technology during the past few decades. What changes do you consider positive? Any negative?

GABE: There are a lot of changes, and I think that there is no denying that they have been incredibly valuable for our industry in terms of evolution and growth. Of

course, the biggest shift has been the move from analog recording technology to digital formats. I think the benefits of digital are really amazing and have come a long way over the last 10 years. There has never been a more easy time for engineers and musicians to use audio technology in the way they compose ideas. It has allowed an unprecedented growth in the development of new talent and revolutionized the way records are made.

If there was one trend in our industry that I think has been a bit counterproductive, it's been the overall obsession that surrounds the concept of "tube" and "vintage" mics and processors. There are a lot of manufacturers that are developing new products as having that "vintage" or "tube" sound. I love the way vintage microphones sound, and I love vintage outboard gear, but I think it's silly that manufacturers spend a large chunk of their time and effort making everything new sound "old." The truth is that the best old stuff is wildly erratic, to say the least, in terms of consistency of performance. You can sample two vintage U47 tube mics and each one of them can sound great, but they won't sound the same. If you mass produce a clone of one of them in China, you're only just proliferating the sound of one of those mics and, in doing so, will miss the magic of finding that "special one" that has "the sound" for "a voice." We are living in an age where manufacturing is as cheap as ever and computer design and modeling is so good that virtually anything is possible. While I understand the vintage clone has its place in the market, I wish that more companies would spend their resources developing new ideas instead of trying to reinvent the wheel.

SHANNON: Where do you see audio technology headed 10 or 20 years from now?

GABE: Right now, I think we're listening to digital audio in a very limited fashion. When CDs were introduced in the early 1990s, they were a monumental achievement over cassette tapes. What's interesting to me is that we have barely managed to move forward in the way we listen to digital music, and we're still only just barely scratching the surface of the potential for the medium. The Redbook standard 44.1 kHz/16-bit



Photo 2: Gabe Herman behind the mixing board. (Photo courtesy of Anthony Crisafulli)

resolution of a CD is still our standard uncompressed listening format, even though we have been capable of recording, mixing, mastering, and delivering music at much higher resolutions for quite some time now.

There have been some attempts to release music material in HD such as SACD and DVD-A, but these never made it on the commercial market as viable playback formats. At the same time, HD video has progressed at a very fast pace. We now consume HD picture as a standard, and the industry has had no problem introducing new technologies such as Blue-ray, HD LCD, plasma TVs and even to some extent stereoscopic 3-D transmissions. Yet, here we are still trying to figure out how to make our MP3s sound as good as our CDs.

I think as media outlets continually upgrade the infrastructure for delivering HD media content to our televisions, music distribution will follow suit. There are now a myriad of entertainment systems designed to connect directly to HD cable boxes, wirelessly to computers, and handheld music playing devices and are capable (or very close to being capable) of supporting sample rates of 88.2 kHz/24 bit and higher. We used to call them stereo systems with auxillary media input, but now we call them "home theater systems." It's only a matter of time before HD audio will be integrated as a standard in media transmissions for home consumption, and computers will start living ubiquitously inside our televisions. This would set the perfect stage for a single-supply source for all of our media: music, TV, movies, and video games. [aX](#)

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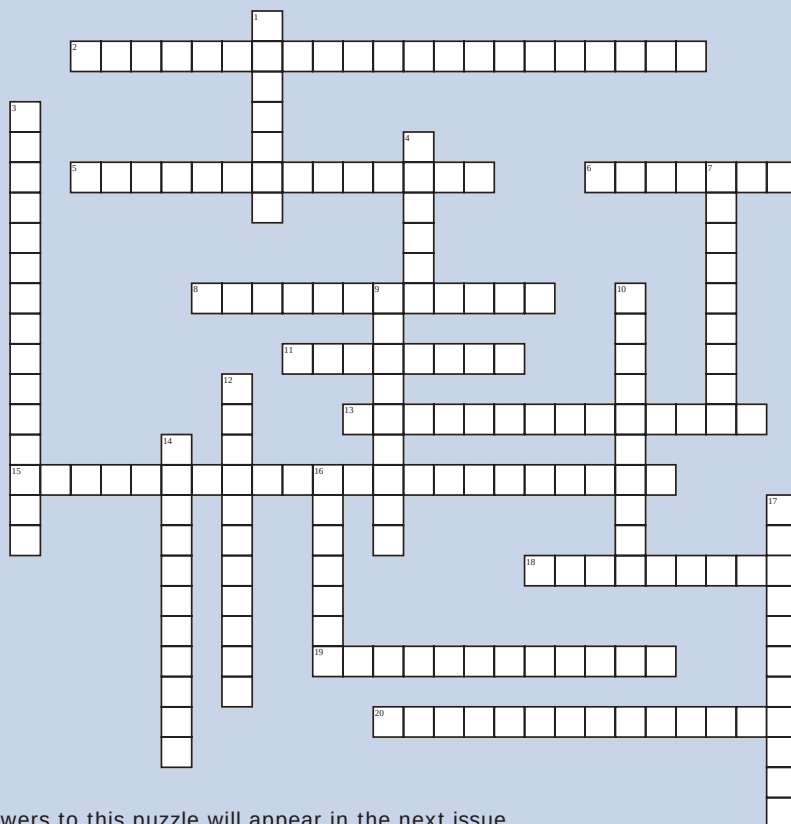
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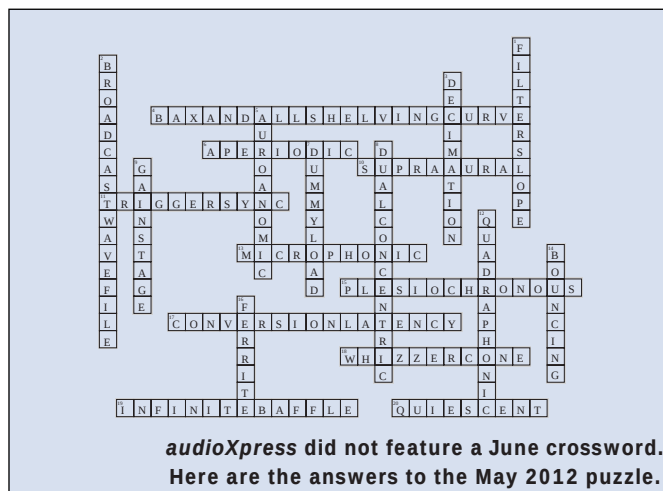
Editor's Note: Answers to this puzzle will appear in the next issue.

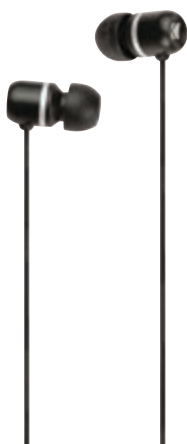
ACROSS

2. The German company that developed MP3 technology and now licenses the patent rights to the audio compression technology for a "digital encoding process" [two words]
5. A measure of the intermodulation performance of an RF device [two words]
6. The output bias for this type of amplifier is set so that current flows in a specific output device appreciably more than a half cycle but less than the entire cycle [two words]
8. A type of small "twist and lock" RF connector often used with co-axial cables and antennas in wireless systems [two words]
11. A variable resistor
15. This theorem states that, when an analog signal is converted to a digital signal, it must be sampled at a frequency that is at least twice the highest audio frequency present in the analog signal [three words]
18. A type of distortion most commonly seen in complementary or "push-pull," Class B amplifier stages
19. An instrument that measures small electrical currents by means of deflecting magnetic coils
20. Describes a device that radiates or receives energy more efficiently from a single direction than from all other directions
9. A rare-earth metal element that can be made into magnets
10. The difference in output when the measurand value is first approached with increasing and then with decreasing values
12. The ratio of the peak value to the RMS value [two words]
14. The process in IT that requires near exact timing coordination to successfully transmit information such as video or audio data
16. A dynamic effect in which the phase relationship between the fundamental and overtone components of a sound is continually changing
17. A research engineer who revolutionized telecommunications by inventing systems that eliminated feedback distortion in telephone calls [two words]

DOWN

1. An audio processor that extracts the basic component of one audio signal and superimposes this element onto another signal
3. Resistance that changes with stress
4. One half of a byte
7. A high-frequency component of certain vocal sounds that can cause problems while recording





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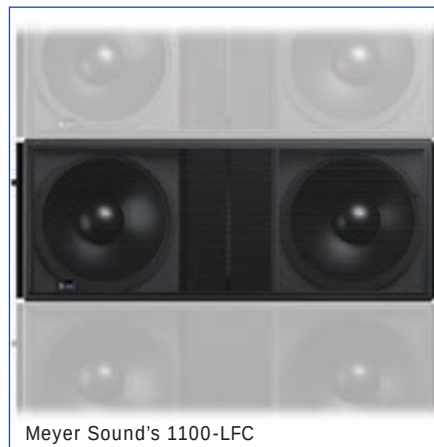


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Alexander Arion ("The Strange Beverage Parallel Push-Pull Amp," p. 18) has an MS in electronics from the Polytechnical Institute Bucarest-Romania. He is a former service manager for Sony and was an electronics university professor in Athens, Greece, now retired. Until 2007, Alexander was also the owner of ArcoSound, a company that conducts audio research and builds prototypes. He has written for many magazines including *Sound*, *Technical Choice*, *Hi-Tech*, *Sound & Image* (Greece), and *audioXpress*. He also admits that he is still in love with the "tube audio technology" from 1960!

Vance Dickason ("The SB34SWNRX-75-6 Subwoofer," p. 22) has been working as a professional in the loudspeaker industry since 1974. He is the author of *Loudspeaker Design Cookbook*—which is now in its 7th edition and published in English, French, German, Dutch, Italian, Spanish, and Portuguese—and *The Loudspeaker Recipes*. Vance is currently the editor of *Voice Coil: The Periodical for the Loudspeaker Industry*, which is published monthly. Although he has been involved with publishing throughout his career, including receiving an AES Citation Award for his ongoing contribution to audio education, he still has a "day job" as an engineering consultant to a number of loudspeaker manufacturers. This currently includes Samsung, The AVC Group (Niles and Sunfire), Artison, and Emotiva.

Mark Driedger ("An Accurate Bias Meter for Tube Output Stages," p. 12) was born in Canada in 1963 and has been experimenting with tube audio since 1980. He has an MSc in electrical engineering from the University of Waterloo, and he has worked in the telecom industry for 25 years in various technical, business, and executive roles. Mark is currently vice president for a division of Tektronix and lives in Dallas, TX. His other passions are his wife and two children, woodworking, and the guitar.

Dr. Richard Honeycutt ("A Hollow-State Interview with Kevin Shaw," p. 26) has been an audio enthusiast, musician, recording engineer, broadcast radio engineer (First Class Commercial licensee since 1969), radio announcer, electronics repairman, tube guitar amplifier designer, speaker system designer, pro-sound/video designer, and college electronics teacher. He is now a consultant in acoustics and electroacoustics. He earned a PhD in Electroacoustics from the Union Institute, and lives in Lexington, NC, with his wife Betty Jane, near his daughter Alyson, her husband, and two of Richard's three grandchildren.

Mike Klasco ("The Story Behind Ferrofluid," p. 8) is the president of Menlo Scientific Ltd., a consulting firm for the loudspeaker industry, located in Richmond, CA. He is the organizer of the Loudspeaker University seminars for speaker engineers. Mike contributes monthly to *audioXpress*. He specializes in materials and fabrication techniques to enhance speaker performance.

Steve Tatarunis ("The Story Behind Ferrofluid," p. 8) is a senior engineer at Menlo Scientific and a 30-year veteran of the loudspeaker industry. He runs Menlo's Boston-area test lab, where he tests speakers, microphones, headsets, and other audio devices for Menlo's clients.

David J. Weinberg ("CES 2012, Plus (Part 2): Essential Bits of Technology," p. 31) is an engineering consultant and technology journalist on audio, video, and film technology. He provides audio and home theater engineering consultation and professional location digital audio recording services to companies, radio stations, and individuals. He brings to his work an MSEE, a First Class Radio telephone license, and five decades of continued study and active involvement in the audio, video, and computer industries. He is chair of the Audio Engineering Society's DC section, and a manager in the Society of Motion Picture and Television Engineers's DC section.

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