CORRECTION

Many readers have notified us of an error in the September issue. In Graham Dicker's article, "Odds & Evens Revisited," the schematic information in Figures 6 and 7 was incorrect. We regret the error. The corrected figures appear here, and are also posted in PDF format on our website, **www.audioXpress.com**. Simply click on "audioXpress," "articles and addenda," and then the "Odds & Evens Revisited" file.—Eds.

Corrected Figures

FIGURE 6: Variant of emulator schematic.

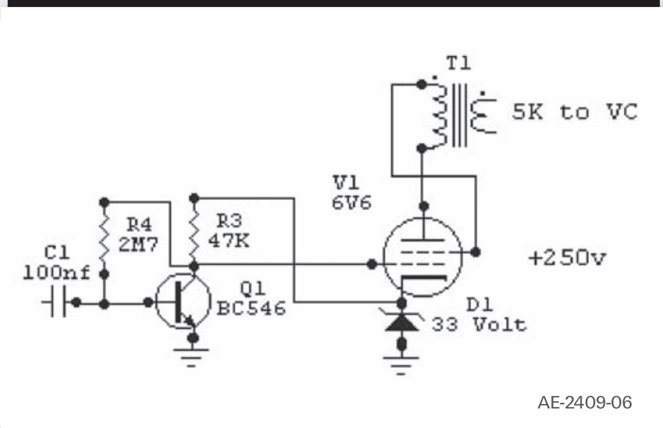
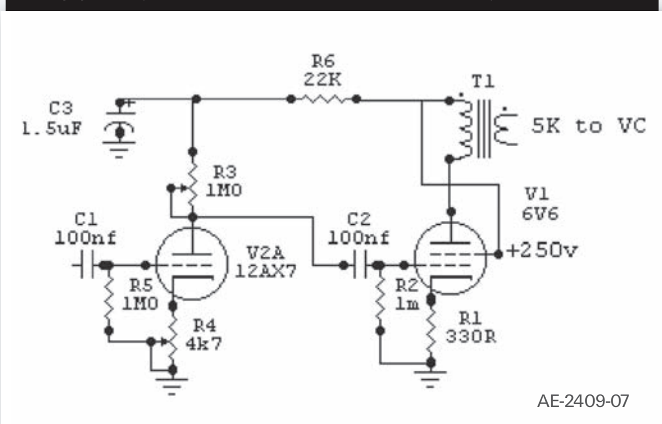


FIGURE 7: All-tube emulator schematic.



VIBRANT WORLD OF SOLID-STATE

By now it's clear that integrated circuits (ICs) are the dominant resources in the field of entertainment electronics; e.g., video and audio. Thanks to these remarkable devices, you can achieve amazing performance with a handful of small chips instead of vast quantities of discrete components. Electronic signal-processing tasks are now performed in audio and video ICs that would take many cubic feet of space if done with discrete transistors, resistors, and so on, which would consume large amounts of power.

Any hobbyist can nurse stunning performance from both audio op amps and the much more complex video ICs simply by making sure that his/her power supplies are carefully implemented and don't become a pathway for load-induced noise to propagate between the ICs. Many projects in *audioXpress* rely on the intervention of the hobbyist to add the quality components needed—but which are often ignored in production—to produce sparkling performance not normally experienced from consumer electronics.

Additionally, experiments with mechanical damping of integrated circuits have yielded agreeable improvements in performance. That introduces the specter of not-so-solid-state, which deserves an explanation, so I acquired and studied some background literature. Here are some useful findings.

A Resource. The mechanical properties of ICs are well documented. The most informative book I bought to study the subject is *Microelectronic Materials* by C.R.M. Grovenor, a particularly detailed text in the Graduate Student Series in Materials Science and Engineering, Institute of Physics Publishing. Many other fine sources surely exist and will convey much the same information.

IC Architecture. There are some similarities between our familiar printed-circuit boards and the tiny architecture of ICs. Both rely on strips of conducting metal on an insulating substrate. The IC is also populated with many transistors, a smattering of resistors, and an infrequent capacitor.

All these features are laid down one after another in layers on a dielectric substrate, usually silicon or other oxide. The formation of conductors, transistor junctions, and so on, is done using masks to control where the features are placed as the various layers of exotic materials are built up. Sometimes the layers are modified by selective removal to arrive at the desired physical configurations.

Metallurgical Realities. A common way of applying the tiny quantities of conductor, semiconductor, and dielectric materials is by depositing vaporized alloys. These extremely hot deposits shrink when cooled by the layers below them, locking in stresses in the materials. Sometimes an interposing alloy is put down to help two layers bond to each other more securely.

The tiny dimensions of the conductors formed this way (one or a few microns wide, fractions of a micron thick) make them vulnerable to the electrical and mechanical effects of grain boundaries in the cooled metals. There arise other vulnerabilities, which you can find in the literature. The metallurgical problems overcome during IC manufacture are daunting, but many clever techniques are applied during production to result in high yields.

Thanks to the minute size of the conductors and their intimate contact with the layers below, it is quite easy to extract heat from them and remove it to the outside world. Knowing this, designers force conductors to sustain current densities vastly greater than our PC foil traces can withstand.

One of the resources used in modern IC design is the "silicon compiler," a software resource that lays out IC design features from libraries of pre-solved architecture. This can be risky business where audio and video quality is concerned, because most such compilers are used for computer-based applications in which digital data is much harder to corrupt, and significant jitter has no effect on results. For computers, feature size and low power consumption are prime objectives, neither of which are of much use to audio- and videophiles, who ultimately want to hear and see the data transformed into pristine analog sound or pictures.

Interruption: Strain Gauge Technology. The structural engineering profession has long been equipped with strain gauges. These small, thin resistive devices bond tightly to load-bearing structures, which deform when stressed. The calibrated strain gauge resistance changes when deformed, easily measured with a Wheatstone bridge, and allows the analyst to compute the strain, and therefore the stress, in the instrumented structure. If memory serves, strain gauges were originated at the Baldwin Locomotive Works in the early 1900s.

The IC as Strain Gauge? When the conductors of an IC are forced to carry AC signals at high current density and are rapidly heated and cooled, they mechanically excite everything around them, because metals change dimensions when heated. The entire IC thus buzzes at signal frequencies, as then do nearby ICs. The resulting strain in neighboring conductors induces sympathetic resistance changes, so even more circuits are victimized by their unavoidable strain-gauge behavior. Every audio op amp I have experimented with has sounded better when equipped with a discrete output buffer, which means the op amps would then consume no more than their idle current.

The Package You See, Feel, and Hear. The packaging compound molded around the IC die—its lead frame (legs) and the wires connecting the two—is required to stiffen and damp the resulting monolithic package, as well as carry away heat and protect the IC within from the ravages of the atmosphere. We are offered plastic resins and ceramics as packaging materials. Stories abound about the sonic superiority of ceramic, but the people manufacturing our electronic instruments don't usually opt for ceramic due to the added cost.

Get the Lead Out. Having little or no choice in packaging material, the next best thing has been to bond a thin layer of lead foil to the top of the ICs to damp mechanical vibration. Still not solid, but better than before.

I tried one or two layers on each side of the op amps, but found that as long as the total amount of foil is the same, it doesn't matter whether it is on one or both sides. It matters how well it adheres to the IC, though.

Detecting the Improvements. Reactions to audio IC damping differ between listeners. It takes practice to learn what to listen for. Video, on the other hand, offers immediately recognizable changes when related ICs are damped. Edge sharpness, color purity, nuance, and small details are noticeable improvements any viewer can distinguish with ease. There is no "golden eyes" equivalent to the "golden ears" argument. Put another way, eyeglasses succeed vastly better than hearing aids.

Are We Alone? The question sometimes arises whether IC manufacturers ever receive feedback from users. Here is one instance: Over ten years ago I was at a holiday gathering in Arizona, and was introduced to a young engineer who was designing a new op amp for his employer. The fellow displayed infinite patience while he heard me rattle off a liturgy of op amp ills you just read about here. A surprise came a few months later when the mail contained specimens of the new op amp, which are still happily at work in my preamp. This op amp is still in production.

audioXpress contributor Michael Danbury recently noted that many enduring op-amp part numbers are being redesigned so they can be packaged in the ever-tinier surface-mount shapes, and large performance improvements are being implemented with little or no fanfare. Mike discovered one such instance of this in the Texas Instruments versions of the NE 5532 and 5534, which sound remarkably better than their originals. A pair of those found a home in my CD player.

Conclusion. Historically, the uses of earlier op amps and other IC designs were so varied and unpredictable that their manufacturers simply made them as fast as they could. Now there are more specific ICs aimed at target applications. This usually brings with it more competition, which is good for the user if he is a careful shopper. Good things are still yet to come in the vibrant world of ICs.

Darcy Staggs
Orange, Calif.

CONTROL UNIT

In the April 2003 issue of *aX*, Joseph Norwood Still has an article on a stereo control based on the 12B4. I built this unit and it is the best-sounding unit I've ever heard! In your October 2004 issue he appears again with another great stereo control introducing his view on a bass enhancement control circuit. My question is: Can this bass control circuit be used in the 12B4-based control unit or could the second control unit be modified to use the 12B4 instead of the 5687? The idea is to have the best of both worlds in one or the other.

Larry Epperson
Severna Park, Md.

Joseph Norwood Still responds:

I'm gratified that you had such great success with your control unit, and the outstanding sound is attributable to the excellent linearity and low mu of the 12B4s. I assume your control unit includes a phono amplifier. If it does, you can elect to install the bass circuit in the last stage of the phono amp, if you are only interested in modifying the sound when playing records. I found the bass adequate when in the FM or CD mode. If you concur, then I recommend the following: Connect a 10µF capacitor to plate and a 39kΩ resistor to the grid of the last stage of the phono section and insert a double pole switch between the resistor and capacitor to engage or disengage the circuit.

If you do not have a phono section or you would like to add bass to the CD and FM modes, then add the resistor, capacitor, and double pole switch between the plate and grid of the 12B4. To maintain the required gain of the 12B4 when adding the bass circuit, bypass the 12B4 cathode resistor with a 100µF electrolytic capacitor. This changes the gain of the 12B4 from 2.5 to 5.0. I noticed when doing distortion tests that no difference in distortion is evident with the cathode bypassed or unbypassed.

Of course, differences are evidenced in the noise measurements. Using a mini-switch instead of a variable pot is less cumbersome and aesthetically pleasing. Adding to the value of the 39kΩ resistor decreases the amount of bass enhancement. A 6dB level is sufficient and recommended maximum for a truly hi-fi sound.

Again, I'm glad you like your control unit. You obviously have a great deal of experience with electronic projects to obtain such a successful outcome.

FREE CDS

I have restored two CDs (58 tracks) of popular music I recorded on ¼″ reel-to-reel tape in the 1950s. I'll send free copies, including postage, to the first 100 requesters. You can download the playlist (Adobe pdf file) from **www.tdl-tech.com.** On the home page click "What's New" and then go to the entry for 2 August 2005.

Ron Tipton
TDL Technology, Inc.
Las Cruces, N. Mex.

Check out these web-exclusive articles at **www.audioXpress.com:** Techniques to Maximize Tube Life, by David Gillespie, Excel Circuit Simulation, by Pierre Touzelet, and Is DVD-Opera Ready for Prime Time? by Jesse W. Knight.