AUDIO BASICS

A MONTHLY NEWSLETTER OF AUDIO INFORMATION

VOLUME THIRTEEN NUMBER SEVEN JULY 1994

Audio Basics will be free starting in 1995!

Given the new engineering and design work we are now doing, coupled with increasing administrative obligations as we grow, we simply do not have the time available any more to write *Audio Basics* each month in a timely manner. We do want to and will share our observations regarding the field of audio, but must continue publication on an irregular but as needed basis to eliminate the pressures of continuing short term deadlines.

We need to refresh and raise again some essays from the past to keep up the forum against stupidity and bad value. We will continue to provide a marketplace for trade-up and unique equipment. We want to keep you informed of our developments and new products. We will continue publication of *Audio Basics* without the obligations of a must-do by a given date which we are not realizing as well as we should at this time.

We will continue to publish as long as it is worthwhile to you and us. When your renewal date comes up, we will maintain you on the mailing list if you let us know you're still interested and we have a current address. If you now have more than a year remaining on your subscription, you will receive a refund for your last year(s).

Don't read this as a free lifetime subscription offer, but we will mail to current subscribers as long as it is mutually worthwhile. We reserve the right to be selective as to who we maintain on the *Audio Basics* mailing list.

Thanks for your support and understanding. We will continue to make *Audio Basics* a voice for real value and for true high fidelity in an increasingly greed dominated marketplace of plastic features and fraudulent foo-foo dust.

Some Thoughts Regarding Audio Design

The following are ruminations by my daughter, Vanessa Van Alstine, helping you understand some of the issues she has had to consider in preparing an EE Master's Thesis dealing with determining meaningful audio amplifier objective measurements. I think you will enjoy reading this fresh viewpoint about the problems involved. FVA

After at least 40 years of serious design attention the field of audio engineering is still filled with more questions than answers and no final conclusions in the merits of different circuit and device topologies. In virtually no other field of engineering is there serious attention paid to the designs of the past as being competitive to modern alternatives. The typical ignition computer in automotive systems is both more complex and more reliable than the state of the art defense computers of the 1950s. A $2000 home computer system would have made research universities drool in the 1970s. Carbon graphite composite materials make all kinds of products lighter and stronger than before. A tennis playing friend laughed upon seeing my old wooden tennis racket and said that she could break it in half in well under a dozen serves. Perhaps researchers, scientists, and engineers in fields outside of audio shake their heads in puzzlement at the serious attention given to decades old designs.

Published each month by Frank Van Alstine of Audio by Van Alstine, Inc., 2202 River Hills Drive, Burnsville, Minnesota 55337 USA. Telephone 612 890-3517. Subscription price for 12 monthly issues is $16.00 per year plus $8.00 per year for foreign air mail. Annual back issue sets available from 1982 at $15.00 per year.

So what is the problem with audio? Sure, the mystics are too busy selling green magic markers and $10000 water-filled oxygen-free resonant wood cables to have a clue, but there must be at least a few designers out there who are doing more than styling neat black push buttons lettered in black with black indicator lights. There must be more compelling problems than finding clever ways for VCR clocks to set themselves so that most households don't have a perpetually blinking "12:00." After all, there are scholarly journals dedicated to audio design, for example, the *Journal of the Audio Engineering Society*.

What makes audio different from other fields? I believe part of the difficulty is that audio still involves knowledge of circuits and analog design, while many other electrical engineering problems can use digital solutions. Analog design tends to be more quirky - lab exercises don't always behave the way the manual says they should. Stray capacitances or a tangle of wires can cause a circuit to behave unexpectedly. Digital design, on the other hand, tends to be more polite. It is more of an intellectual exercise, with a lot of the work done on the computer, puzzling over code or analyzing data. Problems in the digital arena can often be solved with perseverance and logic - if you look long and hard enough the error is bound to be lurking somewhere. Problems with analog designs tend to take some intuition to find and solve. Perhaps moving the wire an inch or two may clear up the noise, or decoupling a part better may take care of unwanted oscillations.

The academic training for an electrical engineer tries to cover all of the basic fields, discussing analog and digital circuits, analysis and design techniques. In my own education, I have found there to be more emphasis now on digital circuits instead of analog, and more on analysis than design. Showing someone how to analyze an existing circuit is easier than trying to teach the fine art of clever or innovative design.

In my experience as a graduate student, fledgling engineers spend most of their classroom time learning mathematical and analytic techniques. These ways of assessing systems and processing information are the basic tools for breaking down and understanding electronics. Most classes also have mandatory laboratories to complement the theoretical work with some hands-on experience. Here some of the most meaningful learning occurs. For example, I found out that one of the active filter circuits from the text book didn't work at all, sloppy wiring layouts done by the lab partner were nearly always a bad idea and had to be redone, and the parts that the shop supplied and swore up and down were exact substitutes for the part specified weren't really exact substitutes. The project didn't work at all with the supposedly identical replacement parts. After spending most of the night trying to trace the trouble down I learned to not trust the people handing out parts but instead looked the devices up in the manufacturer's data books to try to find out what they really were. But by and large, more time is spent with calculators and note pads than in the lab wiring up projects. We graduate students are to become engineers, after all, not technicians.

The emphasis on math is necessary. Without being able to model the physical components and understand their behavior the engineer isn't any better than the magic ear or tinkerer. The problem, of course, is that making models of the world is a long, tiresome process filled with lots of errors along the way.

Devices behave the way they behave, and getting a good grip on them and pinning a neat and tidy equation to them is hard. Most things around us behave in strange ways. I'm not even talking about people, but such supposedly orderly bits like electrons - little fellas that are supposed to obey the laws of physics and all that. Well, the easiest models to use, the ones with simple math that don't take forever to compute and don't take up more than a few lines in the book are tidy, convenient, maybe even easy to remember, but probably not entirely accurate.

For many purposes having a decent approximation to what is actually going on is more than good enough. And often an approximation is necessary. You need to have a starting place for teaching. It's better to start off simple and understandable and be reasonably close to get the basic concepts across, then you can make the model more complex (and presumably more accurate) from there. The complexity and accuracy needed really depend on the situation. For example, the charts, maps, navigation instruments and knowledge necessary for paddling line-of-sight about a lake or navigating the ocean are entirely different. And how sophisticated a model we can derive depends upon how well we can observe and measure and think and come up with a way of describing something and representing it using the language of math that matches our best observations. These things tend to change over time. As we start to notice phenomena that don't quite fall in with our original assumptions, we look at the measurements to see if we did them right, and then try to find new, more complex ways to explain what we perceived. This evolution of ideas and concepts is at the heart of good science, and hopefully of good engineering, too.

So, what about engineering and audio? I suspect the descriptions and models needed to deal well with audio questions tend to be more complex and subtle than currently taught in graduate school. There is an enormous amount of material to cover in the courses and a fairly large number of different kinds of tasks and sub-fields in electrical engineering, everything from robotics to power generation, acoustics to integrated circuit design. Audio is quite a small portion of the whole. In general basic courses the device models tend to assume linear operation. This is generally sufficient to give an idea of the inner workings of the field-effect transistor (FET) or bipolar junction transistor (BJT) and to show that parts work as more than just black boxes. Most of the designs covered are simple illustrations of an idea - here's an amplifier, here's a comparator, here's an oscillator - and then it is on to the next chapter. Maybe an instructor or text book mentions that for intricate design there are more complex models of the parts involving non-linear elements, but those will be studied "later." "Later" in this case meaning after taking more math courses to be able to handle computations with non-linearities and then, if offered, taking the class covering some specific subject. The mainstream cover-the-essentials coursework does not delve into some of the complexities particular and peculiar to audio.

It seems a shame that there is such disparity between the engineers and the technicians. There is a noticeable bias among the engineering students against techs: we are to design things, not get our hands dirty working on them. We will be white collar professionals. In only one upper level course in grad school did I have to use a soldering iron. I was the only person in the class who really knew how - we got a brief lecture as to which end to hold so as not to burn our little fingies. Needless to say, my project was the only one free of assembly errors - no bad solder connections, no parts put carelessly in the wrong place. Maybe the other students learned that no matter how good the design, the project still won't work if it isn't buildable, and that quality of workmanship is a large factor in the overall quality of the final piece. Hopefully my classmates will see that "tech" is not a dirty word.

It might even be that the serious tech, working with actual physical manifestations of circuits and not just their paper representations may in some cases have a better idea of how circuits actually behave and what needs to be done to compensate. They may not have the math to explain precisely what they are doing, but they may have a better feel for how to get the circuit to work. A good repair technician could probably tell designers and engineers just what the weak points are in the design - the things that fail with time or heat or maybe never did work just right and how to patch it up. Engineers may be able to get useful information talking to technicians with a lot of background and experience like (to stretch an analogy a bit) pharmaceutical company researchers hope to find clues to potentially life saving new drugs by talking to the medicine men and herbal healers in the rain forest.

The best designers should probably have the math and academic background to be able to analyze circuits and mathematically describe their behavior, be familiar with the types of circuits and how they behave and why, but should also have the practical experience to know when the designs don't work as planned and how to fix them. With aspects of both the technician and engineer, perhaps the designer has the information to start to develop better explanations of what the designs are doing and why and how to build an entirely better amplifier. I suspect there are entirely too few people in audio with the technical training, creativity, and practical experience to really tackle this problem.

In many other fields, the same concern for the accuracy of the active device model may not be necessary. The types of circuits involved may behave better, performing as the engineer expects them to. Audio, using active devices in a linear amplification mode ends up requiring much more subtle design than fields that can use the same devices as switches, where the non-linearities tend to not be critical compared to the final design goal. Take, for example, computers.

Data manipulation in the computer is digital. 1s and 0s. On or off. Text, graphics, sound, everything becomes a matter of having the appropriate pattern of data bits. Programs and instructions to the computer get filtered from some programming language through assemblers into information on shuffling bits about in the right way - it all becomes a big logic problem.

The things inside the computer that are doing the logic functions and controlling the bits shuffling about are transistors being used as switches. Depending on the input to the transistor and the function it's performing, at the output you have either the transistor turned off and not conducting or turned on all the way. You get out either no voltage or as much as the transistor will put out, and these levels are interpreted as the 1s and 0s. You really want to avoid the active linear region of the device and instead turn it on or off. Put a couple of transistors together and get a simple logical function. Have hundreds of thousands of them and you get a microprocessor. The integrated circuits of a computer are assemblages of thousands and hundreds of thousands of transistor connections with some resistances and capacitances. The same things could conceivably be made of discrete components, but the size, cost and complexity would be awful, like the early vacuum tube computers the size of a house that did less than the average pocket calculator does now.

The model of the transistor needed to do all this is relatively simple. You just have to know enough about the physical element to be able to turn it high or low at will to get those 1s and 0s, and to keep it from overheating or melting or doing something bad. Designers of the actual integrated circuits have a challenging job, trying to design tiny bits of silicon to act like thousands of transistors and do the functions desired. However, the people working and designing with computers don't have to design the chips or think terribly hard about the physics going on inside their sleek desktop box. They are able to assume the nasty physical models have been solved, if they even think about transistor models at all. Electrical engineering for computer scientists is kind of like chemistry for poets. A fairly simple explanation of how things work is sufficient for their needs in both cases.

Not just computer fields, but many active areas of electronics research now are trying to solve questions a few steps away from basic questions of how does this particular device work. In many fields transistors can be fairly safely thought of and used as switches without significant problems. Digital audio, signal processing, communications, image processing, system theory, and so on are more the realm of the programmer now and not the people worrying about where the electron went. The field of audio engineering as a whole seems to be moving in that direction. Many of the papers in the *Journal of the Audio Engineering Society* in the past few years concerned digital signal processing and communications. Very few were published on circuit topology or device physics.

The problem is, I don't think that we are done yet in describing how the physical devices work. In an audio amplifier, we are still using parts that act in some pretty complex and nonlinear ways and we need to keep close track of where all the electrons go. The simple descriptions don't seem to be sufficient to give us enough information to do a really good job.

My microelectronic circuits text book has about 50 pages covering output stages and power amplifiers. It covers everything from the different types of output stages to biasing a circuit to making an amplifier with a BJT, op amp, or IC. Fairly straightforward explanation with the necessary schematics, equations and diagrams and that's it. It's a thick book with a lot of basic circuits and subjects to cover. I haven't built and tested any of the amplifiers outlined in the text, but I think I don't want to. Why not? I rather suspect the amps would sound fairly atrocious. Why? That's where it gets hard.

Describing exactly what a circuit is doing is incredibly complex. The easy equations, simple to compute and memorize, are probably not a good enough description of what the circuit is actually doing. We need to get a better accounting from the electrons as to where they go and what they do while there. The human ear is a very sensitive and complex organ. It is quite possible that we are able to hear differences between circuits that are behaving quite differently and we have just not been clever enough yet to come up with measurements, explanations and mathematics subtle and complex enough to entirely account for our perceptions. But if we want to know what we are doing and why one design works better than another we will need to give it a try.

To think that we can get an audio playback system to work exactly right even if we assume that every piece of equipment and component we encounter along the way works perfectly is pretty amazing. When we consider that none of the things we encounter - from a needle moving in a plastic groove or beam of light reflecting light from a series of pits in piece of metal embedded in plastic to the transistor to the speaker cone to the human ear - works in a nice, simple, easy to understand and calculate manner, but instead has quirks of behavior, responding differently at one sound pressure level than another, or one frequency over another, or one voltage level instead of another, the problem becomes mind boggling. Without understanding how each device actually works, there is no way to compensate for its peculiarities and make the entire system behave as desired. If each part is well understood, flaws and all, maybe we can overcome the strange aspects and work around the imperfections.

Perhaps the math is hard and the equations look nasty. But hopefully we can learn enough to find out what is really going on inside an amplifier and explain why tubes have one sound and transistors another. Perhaps we can learn enough about the devices and what they are really doing to come up with different or better ways of using them that will let us design better circuits than ever before. Maybe we can finally come up with some really good answers and move on, not needing to keep hashing over the same designs of the past half century because we have finally made our breakthrough. The evolution in technology may be abrupt or it could come slowly and steadily as we learn a little more and piece together a more complex, but hopefully more accurate, picture of what the circuits are really doing.

Used Equipment

Fet-Valve Preamplifier in our AVA chassis with phono and line circuits in brand new condition. This is a first – a satisfaction guarantee return (it sounded *too clear* for the elderly owner, he could hear bells and castanets and drums so much better than on his old aging vacuum tube equipment that it startled him). We cannot please everyone. Anyway, his loss can be your gain. We can offer this unit at $795 (orig $995) with our new 2 year warranty (+$10 shipping in the USA).

Hughes AK-100 Surround Sound Processor with AVA Audio Circuits. We installed our circuits in this new customer supplied unit this summer and then he discovered it would not work well with his expensive add-on D-to-A converter (the signal voltage output from the D-to-A unit was far too high – why didn't he try it first?), so we have it to resell. We need $375 for this unit (+$10 shipping in the USA), which is in near new condition and in perfect working order with our 6 mo. parts and labor warranty. Here is a great way to get high fidelity surround sound without need for any additional speakers, wiring, or amplifiers.

Ωmega II 260 Power Amplifier in an outstanding Dyna 400 chassis with a custom black faceplate. This is a really clean unit with excellent thermal capacity and has all of our best circuits including a toroid power transformer so that it is much lighter and quieter than a normal Dyna chassis. I built it up special as a demo unit because the chassis was in too good a condition to waste and because we were temporarily out of stock on our own chassis metal (slow delivery on a reorder from our sheet metal shop - back ordered on aluminum staked-in 6-32 nuts of all things). Anyway it has served its purpose here now that we have new metal in good supply again so it is available to you at $695 (+ $15 shipping in the USA) instead of $895 and it includes our new two year warranty too.

Ωmega II 440hc Power Amplifier in new AVA chassis. This is a pre-production unit built from the finished sheet metal used only as an in-house demo here. It is identical to current new production except that it has a bare aluminum back panel. We had to get it up and running to verify all performance parameters before the anodizing shop had time to do the back panel artwork. The front, top, bottom, and heatsinks are completely finished, just the back metal plate the jacks are mounted on is aluminum color instead of black. This difference is not visible from the front. There is one bonus with this unit – the power transformer is even heftier than standard production (a degree of overkill we did not want to put in production and charge you for). The normal price of an Ωmega II 440hc is $1295. We will sell this one for $1095 with a new two year warranty (+ $15 shipping in the USA).

Ωmega II 170 Power Amplifier in a good Dyna St-120 chassis complete with our new toroid power transformer and all new internal circuits. We got a good deal on a few more Dyna St-120 chassis so you can get our best sounding solid state amp design (and 85 real watts per channel) at just $545 + $15 USA shipping with a two year parts and labor warranty on our circuits.

Ωmega II Pat-4 Preamplifier. The best AVA solid state circuits installed in a very good used Dyna Pat-4 chassis. You get precision volume and balance controls, useful tone controls, phono and five line level inputs, and great musicality. You pay only for the factory rebuild, $345.00. The chassis is thrown in at no extra charge. Hurry, we only have two. Two year warranty on our circuits. Shipping is $10.00 in the continental USA.

Super Pas Three Preamplifier. Brand new AVA circuits installed in good used Pas-3 chassis. You pay $395 for the complete Super Pas Three circuit set installed (including five new tubes) and we will throw in the nice used Pas chassis we just took in trade for only $50 extra. You get a two year warranty on our circuits and you get brand new factory performance. Includes new stepped precision volume and balance controls, selector switch rewired to provide phono and five line level inputs, and clean and tidy original Dyna appearance. Add $10 for shipping in the continental USA.

Super 70i Vacuum Tube Amplifier with new AVA jack set, and all new signal tubes. This is as nice as a small vacuum tube amplifier gets and is a great match for speakers such as our B&W DM640i with AVA upgraded crossovers. We have several good chassis and can offer this package with our new insides for $595.00 plus $15 shipping in the continental USA. These units have a two year parts and labor warranty on our circuits, six months on the chassis and mechanical bits, and 30 days on the tubes. Add $100 for the AVA power transformer and solid state rectifier installed too.

The Radio Shack CD-3400 CD player raved about in *Stereophile*. New shape with box and packing material, $100 + $5 shipping in the USA. We used it for evaluation. If you need a portable, here's the answer.

Frank and Darlene Van Alstine