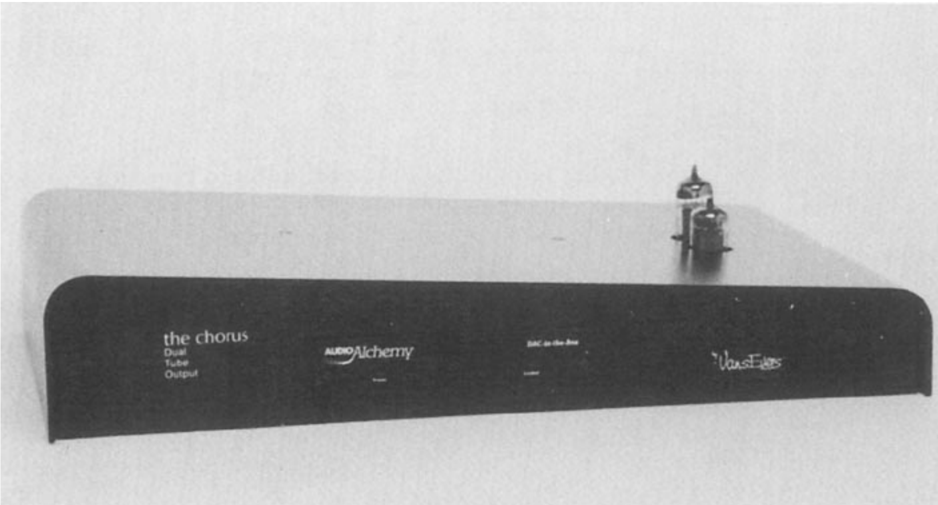
THE CHORUS

A multivocal tube output stage for your "DAC In The Box"



by Mike Vans Evers

The Chorus is a vacuum-tube output stage conceived as part of a project to upgrade the Audio Alchemy DAC-in-the-box (DITB). There are nearly 15,000 units of this famed budget king DAC in existence which makes it an attractive candidate for a modification.

The sound of the DITB is extraordinary considering its price. Hundreds of hours of development time were spent making the most of the inherent resolution of the DITB and sonic flexibility of the Chorus output stage. I have been working on this project with Don Hillebrand of Wavetrace Technologies. Don worked with Stan Warren on the solid state mods while yours truly handled the tubes. The photo shows a complete Chorus/DITB as available through Wavetrace Technologies.

Wavetrace Technologies (Don Hillebrand) has been doing mods to Audio Alchemy products like the DDE for about two years. Modifying new equipment usually voids the warranty. When Don modifies Audio Alchemy products the warranty remains in effect — a good reason to let Don do the mods, and what I recommend also.

I consider this project to be unique in that special techniques for adjusting the tonality of the final product are employed in the design and a few are available for adjustment by the end user. Most designs address only a few of the areas affecting tonality. This design takes a slightly different approach to the Audio Energy Paths (AEP) that exist in audio equipment. These energy paths are both electrical and mechanical. As I see it, these energy paths have natural groupings: #1 Signal Path, #2 Power Supplies, and #3 Structural Resonances.

In this article, I will share the circuit for the Chorus output stage. It is ideally suited for the DITB but it can also be adapted to a multitude of purposes where a unity gain buffer is required. I will also discuss a few other aspects of the design that deal with AEPs and affect tonality.

A few definitions are necessary in order to follow the text:

Audio Energy Path (AEP): All mechanical or electrical energy entering or leaving a device used for recording or reproducing music does so along a conduit or path. These paths can be electrical (through wire, bus bars, etc.), or mechanical (transferred through the chassis, feet, etc.).

Transient Impedance: Music is a series of repetitive transient energy variations. The resulting frequency dependent variations in current are audibly affected not only by standard yardsticks (resistance, capacitance, inductance), but by some other quality. I am going to call this quality, which affects tonality but not frequency response, "transient impedance." If you don't like my term, make up your own. One example firmly establishes the existence of this elusive quality, at least in my mind: production models *do not* sound like the prototype did!

Listening Skill: Some differences in any two like items, of musical nature or not, won't be discernible except to experienced listeners (tasters, drivers, players, etc.). Hearing a difference but not realizing its significance usually translates into *not* hearing a difference. Learning how to recognize differences in two components is a function of training, experience, and desire. Listening skills can be limited by bias. Those people who "know" without experience may never learn.

AEP #1: The Signal Path
The Chorus Tube Output Stage

"Voicing" a product often takes a manufacturer as much or more time than does its basic engineering. The Chorus is a unique output stage with many "voices" designed to be user-friendly. There are two sockets for twin triodes on the Chorus and they are wired so that one section of each tube is in each channel. You can plug around 70 different tube types from a wide variety of manufacturers into the Chorus and explore an amazing number of combinations. Each combination produces its own voice, the sound being dependent on the type and manufacturer of the tubes in play.

Because of an additional design feature, the position of the two tubes is important. Swap the position of the tubes front-to-back and you have yet another voice. So if you have three tubes on hand, instead of only three combinations, you get six! I recommend that you use both sockets, but the "purist" can choose to use only one tube. If you count in the two possibilities per single tube, a collection of three tubes gives you 12 different voices. Rather than insisting on a "one size rarely fits all" sound, this unity gain output buffer has many possibilities.

No strange biasing schemes are used for this unusual cathode follower, just an ordinary self-bias resistor. This output stage is composed of two dual-triodes, with a halfsection of each tube in each channel. The two dual triodes used can be identical or completely dissimilar, e.g., a Telefunken smooth plate 12AX7 and a Chinese 12BH7.

My current favorite tubes include 12AT7s, 12AU7s, and 12AX7s and 5965, 6414, or 12BH7s. In my system, I use a lower current tube, often a Gold Dragon 12AX7, in the back position and a higher current tube in the front position. Tubes made in China are often brighter, relatively speaking, than tubes made in other countries. As a general rule, 12AU7s have more weight in the bottom end than 12AT7s and 12AX7s. If the harmonic balance of a system is lightweight, I'll usually start with a higher current tube in the back position, say a 12AU7, and use a 12AX7/AT7 in the front position. For overly detailed systems, try to avoid using tubes from China and use higher current types (5965, 6414, 12AU7, 12BH7, etc.), especially in the front position.

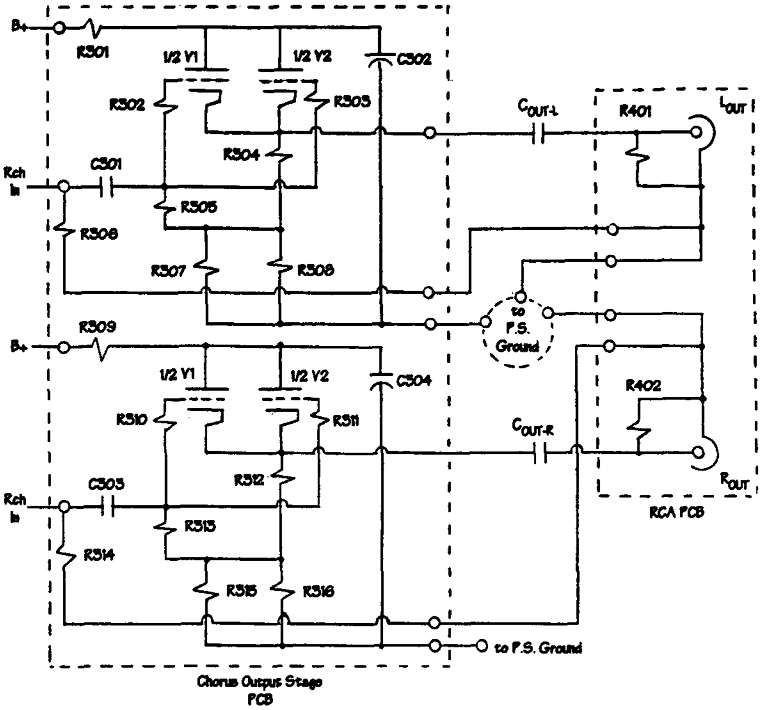
Some suitable tubes for use in the Chorus

Common types	Not so common types
12AT7 / ECC81	12AV7/5965
6201, 6679, 7728	12FV7
	6211
12AU7(A) / ECC82	6414
E82CC, ECC802/S,	6829/E180CC
5814, 5963, 6067,	12AD7
6189, 6680, 7318,	12AZ7
7730	12BZ7
	12DF7
12AX7(A) / ECC83	12DM7
5721, 5751, 6057,	12DT7
6681, 7025, 7729	12FQ7
12AY7/6072	plus many more
12BH7/6913	

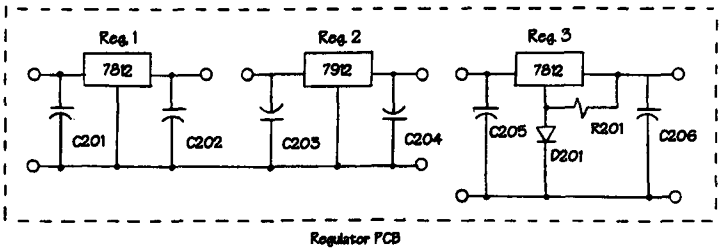
Solid State Circuit Mods

Warning: These mods should not be attempted by the marginally competent because putting a finger too close to the pins of the static-sensitive DAC will very often blow it up, a surefire way to void the warranty. How do I know that DACs are vulnerable? I've fried a couple myself.

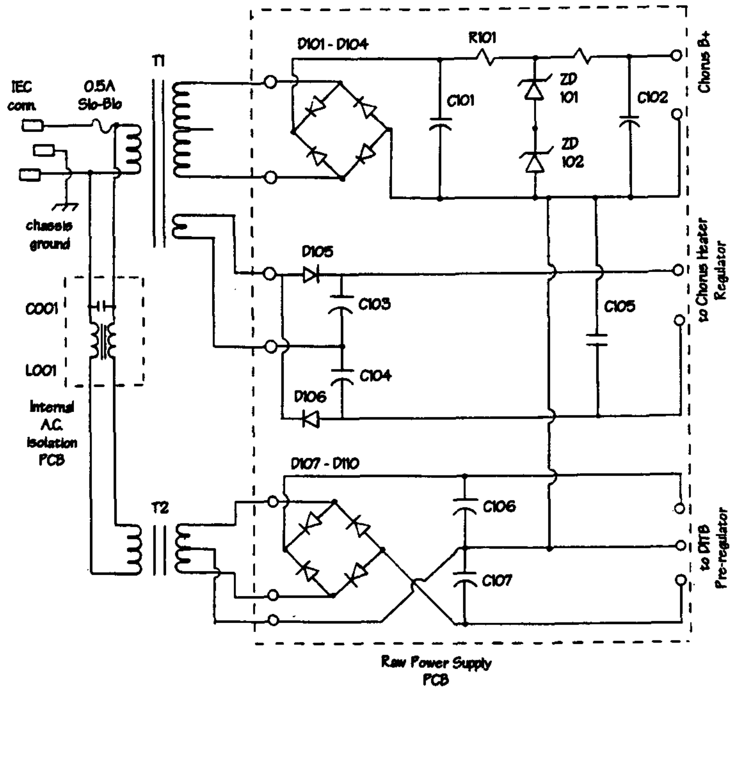
The DITB has separate +/- 5 Volt rails for the respective all-digital and D/A sections, a strength in the design. The stock "wall wart" DC supply was replaced by a beefier transformer, soft-recovery diodes, bigger filter caps, and preregulators. This allows the DAC +/- 5V rails to be increased to +/- 8V, which in turn increases headroom.



R306, 314	39.2K	RN60C Dale
R307, 308, 315, 316	47K	1W MO
R401, 402	1M	RN60C Dale
C201, 203, 205	100uF/25V Rubycon TWSS	
C202, 204, 206	1,000uF/16V Panasonic SU	
C301, 303	0.1uF/400V Wima FKP-1	
C302, 304	150uF/400V Sprague 81D	
Cout L, R	30uF/400V PP Solen	
D201	1N4001	



R201	10K	1/2W MF
R301, 309	1.8K	1W MO
R302, 303, 310, 311	182Ω	RN60C Dale
R304, 312	1.37K	RN60C Dale
R305, 313	1M	RN60C Dale



D101-110	SRP 100K General Instrument
ZD101	1N5375A
ZD102	1N5388A
C101	68uF/450V Nichicon CE
C102	220uF/400V Panasonic TSHA
C103-104	3300uF/16V Panasonic SU
C105	0.1uF/250VAC Allied CF-MH
C106-107	4700uF/25V Mallory SKR
C001	0.1uF/250VAC Allied CF-MH
L001	3.3mH/2A Tamura CMF-8033
T1	250VCT/6.3 Allied 6K1VF
T2	25.2 VCT Radio Shack

These mods help remove much of the roughness and veiling present in the sound of the stock DITB, not to mention improving the bass. Removing the output IC (second order filter/buffer) and replacing it with a single pole passive filter/tube output stage removes what is left of the digital/solid state characteristic of the sound, and completes the modification.

Directions for modifying the DITB for use with the Chorus output stage

Caution #1: If these directions don't make sense, let someone else do it.

Caution #2: If YOU do this, you will void the warranty. If Don at Wavetrace does it, the warranty stays in effect.

1. Wear a GROUNDED anti-static wrist strap!!! Use only grounded tip soldering irons/stations!

2. Remove the PCB, holding it only by the edges. Hold the back of the Toslink connector to provide strain relief while unscrewing the machine screw holding the backplate on to it. Set the backplate aside.

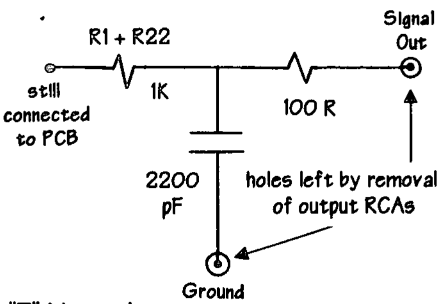
3. Desolder and remove the RCAs and the power connector.

4. Remove the OP-275 output IC. Cut its pins off right at the body of the IC; leave the pins sticking out of the PCB. Don't let the pins touch each other or anything else.

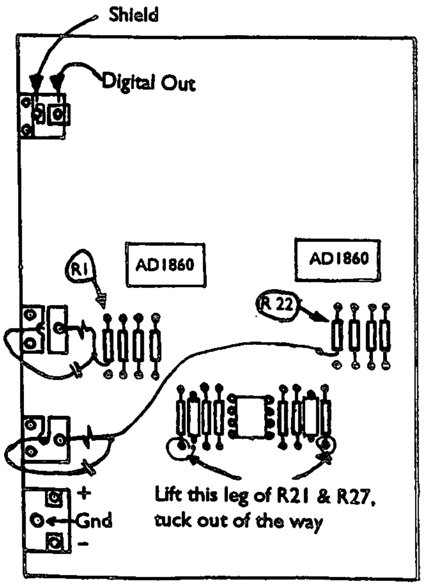
5. Isolate the audio output PCB pads because they are used to anchor the output wiring. Lifting one side of resistors R21 and R37 will do the trick (see diagram).

6. Install "T" network components and new output wiring into PCB holes left when output RCAs were removed (see diagram).

7. Lift the legs of resistors R1 and R22 that are farthest away from the AD1860s. Connect to rest of "T" network (see diagram). The right channel 1K resistor should be connected to its respective 100 ohm resistor with a length of bus wire with the same



"T" Network



PC Board Diagram

diameter as a resistor lead. Insulate the bus wire with something (tape, tubing, etc.).

8. Install RG-187 75 ohm coax into PCB holes left from removing the RCA connector (see diagram).

9. Install power supply wiring. To use large diameter wires that won't fit into the holes vacated by the old connectors, wrap a leftover resistor lead or piece of bus wire around the end of the wire, solder it, and stick that through the hole.

10. Enlarge backplate holes where necessary to clear wiring. Reattach backplate holding Toslink connector when replacing its machine screw.

11. Reassemble. Remember to hold the PCB only by its edges.

12. Connect wiring. Enjoy.

AEP #2: Power supplies

When engineering texts model electronic circuits such as tube or transistor single stage amplifiers, current sources, etc., they treat power supplies as if they were perfect. Man has yet to create the perfect anything, let alone the perfect power supply. In the design of the Chorus power supply, as in the audio circuitry, the foibles of the components comprising the circuit were taken into account. Thus:

1. There is a minimum of the same value/series/manufacturer of filter capacitors on any one voltage rail. This was done to keep any one sonic signature from predominating.

2. Wide use of a. non-magnetic, low temperature coefficient, metal film resistor (Dale). These units were selected for stability and neutral sound, falling between the snappy sonics of the Holco and the extra warmth of the Vishay.

3. Tube output stage coupling capacitors (in and out) were selected for neutrality and, here again, units of different manufacture were mixed.

4. Circuit board traces are kept to minimum lengths. Component groups are connected by hard wiring. This helps reduce the amount of "edge" in the sound.

Plus, all B+ supplies are regulated at least once. The Chorus' high voltage B+ is shunt regulated, enhancing dynamics. The DITB +/- voltage rails are pre-regulated before entering the chassis.

A low impedance regulated heater supply was found to be only a first step. This is usually the limit of sophistication applied to heater circuits because the role of the heater is generally considered to be, well, . . . simply to "get hot." Evidently, there is more going on with heater supplies than one would think.

On a whim, an experimental transient impedance altering circuit was series connected before the 12V regulator circuit. It made a very noticeable difference in the harmonic balance of the sound of the Chorus. The listening skill necessary to hear the sonic differences is on a par with the ability to hear the sonic differences between tubes. At this point, the components used in the heater supply were upgraded. This made for another improvement in the sound of the Chorus and further underscored the need to treat the heater circuit with respect. (A proprietary production version of the initial compensation network comes with the full kits and completed units offered by Wavetrace Technologies.)

I am not alone in believing that the power cord is a major contributor to the "sound" of a product. The power entering equipment from the wall is not just 60 Hz. One hundred and twenty times a second, a burst of power is passed by the power cord as the rectifiers in the power supply become forward biased. This burst of energy has frequency components that extend throughout the audio spectrum. In order to allow for substitution of power cords, an I.E.C. receptacle is standard on the Chorus chassis.

AEP #3: Resonance Structure

This section is about microphonics (vibration induced, narrow frequency band signal colorations) and how to creatively take advantage of them. This will not necessarily be an easy road because the whole issue is so contentious these days. There are far too many who would rather trumpet the instances when a technique isn't significant rather than discovering where and when it is of value.

Microphonics are not exclusive to tube electronics. All systems are microphonic, only the degree and character varies. Harmonic imbalance can often be traced to a "lumpy" distribution of system resonances. This is analogous to standing wave problems in listening rooms. The best listening rooms have evenly distributed modes of resonances (standing waves).

Over the last few years, magazine articles containing snippets of information about changing the resonant nature (and therefore the sound) of everything from capacitors to op-amps have become more and more commonplace. Resonance control devices are hitting the market in ever increasing numbers. In many instances, these devices are designed to eliminate resonances. Control, not elimination, is the key. Other designers, Michael Green for one, share the concept that wholesale resonance dampening is not necessarily a good thing.

Resonances are physical phenomena that have been exploited acoustically for thousands of years. The VPI brick was one of the first audiophile resonance modification devices. Cones, pucks, dots, bricks, and blocks can be found in a large percentage of modern audiophile systems.

The resonance structure of a piece of electronics is affected by the materials that are used in its construction, and by those materials that are in contact with the device. Changing either the materials it is sitting on, or those that are sitting on it, changes the equipment's sound.

A chance discovery manifests itself in an optional 3" circular hole cut in the Chorus' chassis directly over the DITB chassis. A friend blew my mind, and his, by placing a geologic core sample (a cylindrical piece of rock) on top of the DITB chassis back when I was working on the prototype. The sonic difference was like the difference between an 18" bass drum and a 24" one. This first experience led to weeks of experimenting with all sorts of materials, from blocks of lead, wood, and stone, to small plates of fiberglass, Teflon, aluminum and other metals. Some changes were more pronounced than others but one thing became clear: this was not to be ignored. Many were the days when friends would come over to investigate the pile of materials atop the DITB chassis, and to debate which combinations sounded better.

I call these bits and pieces of different material "Transmutation Blocks" in honor of Audio Alchemy. These T-Blocks can be made from commonly available materials, such as oak, mahogany, poplar, copper, aluminum, ceramic tile, fender washers — whatever fits in the opening. They are a do-it-youself item.

Wood blocks have a dual effect. They will dampen some segments of upper harmonics, but augment other harmonics — usually in the lower to middle midrange. Metal and fiberglass discs augment various treble harmonics, depending on the composition, size, and thickness of the disc. Heavy materials, such as blocks of lead, granite, and marble affect bass harmonics. The higher the mass of the block, the lower the harmonics that will be affected.

Many people will feel that the Transmutation Blocks are too farfetched. Those wanting to wring that last nuance out of the music will insist on them.

Conclusion

I hope that people will find other uses for the Chorus output buffer. It makes for adaptable equipment that won't be obsoleted when you change other components in your system. When combined with the DITB, it is wonderful (my opinion is, of course, biased). That the heater supply is more important than previously thought should stir up some experimentation and comments. Saying that placing wood blocks and metal discs on top of the DITB can change its sound will make some doubt my sanity and everything else I've ever said. However, all these techniques work towards making better sound.

For more information on the products mentioned in this article, including boards, kits, and complete units contact:

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