NITRO

An introduction to a new idea on the design of a superior DAC

By Barbara E. Gerhold "TUBECLINIC"

Well – it took some time between the design of the FETishizator in 2007 and this new project - although it deals with the same theme.
Well – and again, it turned out to become a tube-design.
This is NOT because I do dislike JFETs nowadays, but it was the first task for my new masterpieces - the Russian subminiature tubes!

Sometimes in life, things come together, they coincide - so to say - and if all these parts of the game drive into the same direction, something very special will come into being…

FIRST part was that a Hong Kong friend of mine directed my attention to a newly available DAC module called "DAC-5". It may be purchased from several Hong Kong ebay- dealers for less than 100 U$, ready to use and with all parts; also including a well-built power supply.

SECOND part came along with a Ukraine friend, who introduced me to the Russian subminiature tubes.

THIRD was that another Austrian friend of mine wanted a new CD-player and bought a HiEnd product including a tube output stage. After long listening sessions, he was a bit disappointed with his new player, since it did not keep what it promised: Nevertheless a good 6922 is working in the output stage, its sound tends more into the direction of solid-state.

FOURTH was, that since longer time I had gathered my interest into the direction of designing a stand-alone DAC. This resulted from the fact, that my old Sony CD-player would not accept all CDR, strictly no CDRW, SACD or AudioDVD. It is old but good – I tuned it many years ago using better OP-amps (OP249) then built-in the FETishizator circuit and finally after a further tuning using a 6N16B for the output stage it blossomed out to become a real primadonna.

So why not try this DAC module, back it with a tube output stage as from my old CD-player and look what's going on? However, things in life are not as simple, so I had to research the web about what is state-of-the-art in today's top-of-the-score CD-players and DACs, as well as to find all published articles about the PCM1798. Well, and again I had a big opportunity to fail, because I then would make the mistakes all designers make and I did …

Investigating the web for a proper method of converting the output currents of the DAC-chip I found an in-depth review about one of the most wanted and celebrated DACs in the world, which converts the differential output currents via a transformer to single-ended voltage. Then I found the site of a well-known British transformer maker, who also appoints this kind of application. Additionally there are dozens of schematics and articles about I/U-conversion via OP-amps in lots of different styles.

Therefore, I tried in the first, what I received originally from the HK dealer: There is a differential output stage using three AD871, very good in resolution, but bad in sound – clear but nasty solid state sound - far, far away from vinyl's performance. Changing the OP-amps for some other types and brands gave the same result: Solid-state sound but with some different colorings.

Now I had to try the transformer method: In the meantime, my transformers had come and I disconnected all parts in direct touch with the differential current outputs and pulled the OP-amps. Well I found sound a little bit better, but again this nasty solid-state sound – with a tube-only stage in behind? How is this possible? Is solid-state sound a product of solid-state elements or is there somewhat else? …

… for to make a long researcher's story a bit shorter: I found out that all mentioned methods do the same: They kill even order harmonics … I should have known in before, but the research of the web and studying all these reviews left me brain-washed, anyhow …

Using a digital signal synthesizer program, I strictly numerically distilled a 32-bit/192kHz sine wave of 440Hz with a defined additional portion of 20% of the first harmonic (k2 = 880Hz). After I sampled it down to 16-bit/44,1kHz and burnt it to a CD, I could clearly see on my scope the hunchback on the positive half-wave and the dent on the negative half-wave, when looking at the primary winding of the transformer. A look at the secondary side showed me, that it is was nearly deleted. Also, a balanced transformer builds a differential system. A final measurement with a spectrum analyzer gave me the true value: Only short of 1% of the former 20% left… The transformer treats k2 as if it was a common mode signal!

Counter-test -> I did the same, but added 20% of k3 (second harmonic, 1,32kHz). It stayed as I already proposed; odd order harmonics will not be subtracted, but added. Awful, anyway!

Can you imagine, what this means to the playback of recorded music? All these sophisticated subtleties of recorded live sound –> gone! This is where this nasty solid-state sound derives from: From either a generic differential system or the use of high NFB, which in fact is also nothing else but a differential system.

It is the same mistake all designers make: As if I wrote in my article about "Speakers and SET", balanced or differential systems delete even order harmonics! Well and the more precisely a differential system works, the closer to theory this subtraction will be![1]

OK - what to do?

- Use only one of the current outputs and send it directly to the tube output stage via resistive I/U-conversion? -> *Good tube sound but bad resolution and bad noise floor induced by straying RF components.*
- Load both outputs the same way, but will only use one? -> *Same as above, but with improved resolution.*

[1] You may download this article from this website. You may also download three mp3 of my test signals (10"). Then you have to convert them to <wave> format and afterwards you can burn them to a CD. The mp3 is a bit less in quality, but you may use it well if you wanted to relocate my findings. Have an ear on the several colorings of the mp3 – all three show the same basic tone of 440Hz and the same -3dB volume. Also keep an eye on the scope, if the output looks like the input you walk right …

- Add a filter? -> *Bad imaging, any way the filter is designed, but the noise floor is reduced.*
- Add a ground choke? -> *Better than the filter, but all other issues not merely altered.*

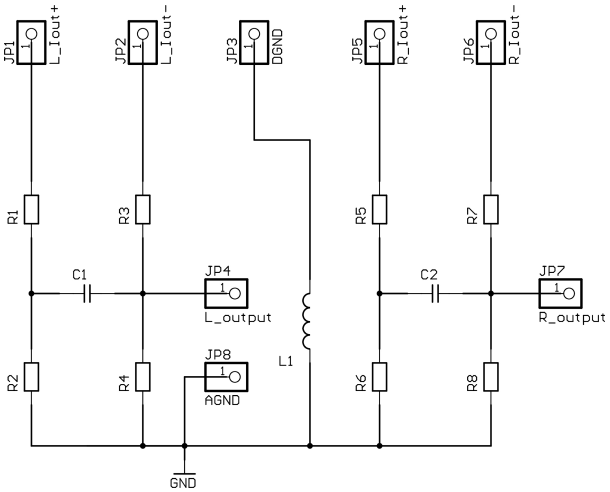
Curtain up - the solution

During my academic studies, I learnt about a BALUN: This is an element, which all wireless amateurs know well, but use for another instance.

However, from its definition a "balun" is nothing else but an element, which converts a **BAL**anced system to an **UN**balanced one.

I gave this solution a distinctive name, so I shall call it **DAB** within the continuing articles, as an abbreviation of "*Digital Audio Balun*".

Here is the schematic:



You can see that it is a mix-up of some portion of everything mentioned above: Both output currents are converted to voltage by two small value resistors in series while the straying HF dirt is kept outside the Audio input by a choke (ferrite bead) and only one signal current output – the inverted one - is used.

The real important thing is the cap across both paths in the bridge configuration: It "links" both differential signal currents, so the switches from each current output have to change the charge of this cap every time their time-slice ratio changes. You may understand it as some form of an integrator. Because only one side is used, no even order harmonics will be deleted or subtracted from the originally recorded signal. All harmonics are treated the same way. This is the best way to hand it over to the following single ended tube stage. It is quite simple and it does not cost a fortune like balanced transformers while the sound is two classes better minimum - very pure and sweet tube sound and very close to the vinyl LP. The choke keeps the digital ground (DGND) and the Audio ground (AGND) apart in respect of RF noise.

To make the "Real-McCoy" complete, I also designed PCBs, for to make the building of this project as easy as possible. If you were a pro in tube design, I would recommend building it on a new, untreated piece of PCB-material, using the copper foil as AGND (ground plane). Pls. see all continuing articles about the <AudioPart> and the <SupplyUnit> of this project.

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To come ahead of a normally instantly asked question -> Yes, this configuration is also useable for differential voltage output DAC-chips. There is only one exception: If the differential amp-stage is already on the chip, there is no way to help with – you might only mill or chisel it from the silicon chip … ;-)