

El Cheapo-Mk2-PRO

The "Tube-Sound-DAC" with no tubes inside

Grand sound despite no need to spend a fortune to build

by Barbara E. Gerhold, "TUBECLINIC"

OK - I understand that the final FETishizator V3 already grew grey hair.

AND - it did not match so well with newer balanced output DAC-chips as it was intended for the nowadays obsolete TDA1541.

So, I designed a new Solid-State DAC, which takes into account all of these things.

PLUS - there are new depletion-NMOS transistors, which enable a true triode-like sound without the use of tubes - and no high voltage as well as heaters needed too.

As a first point I need to say, that if anybody had tried to convince me 10 years ago for a HiEnd Solid State DAC-circuit to be as well performing as a triode circuit, I would have laughed out loud! But the times they are a changing.

INTRO

I came across the depletion-NMOSFET (DNMOS), when searching for a simple method to build a fast, exact and stable constant current source (CCS) for my current-sourcing power amp. These parts can be used in static CCS as well as controllable CCS. And well, the path from the controllable CCS to a tube is not wide. I tried the parts by IXYS in my current-sourcing SEA power-amp as a substitute for the existing CCS and they instantly worked by far better than my existing current source.

As a substitute for a pentode, it also sounded and performed really well. But when compared to a triode, the DNMOS showed its huge internal impedance (not to be confused with R_{ds_on} !). So, I experimented to lend them triode-like characteristics. After a while, I found a way. Only drawback was the heat. While they are listed with bigger P_v than most DHT, it is less convenient to get the heat away and needs heavy heat-sinks (plus maybe a fan too), while a glass tube does that all on its own.

Then I also received a small lot of small-signal DNMOS (DN3545 and DN2540 by Supertex Inc.). This was the moment, a fully new design path was started. It ended up in a new generation of current-sourcing resp. current-driven designs: **Cabernet** (current-sourcing SEA-power-amp), **Tequila** (pre-amp), **Chardonnay** (phono-pre), **Barolo** (current-sourcing SEA-headphone-amp) and this **El Cheapo PRO** (DAC output stage). All of them making use of the same genuine technical idea ...

A last thing to all my followers → The name "El Cheapo" came up, when one of the guys calculated the price for this circuit and found out it was only 10% of the **Nitro+** tube thing... "hey, that's a real El

Cheapo" he said and we all laughed. We agreed to keep this copyright pattern as its distinctive name. It is a perfect example for a cheap to build - despite performing second to none - Audio circuit.

If the Audio industry would wake-up and build something apart its badly sounding OPA output circuits, even a SMD version of this fabulous "EI Cheapo PRO" was possible! It does not need exotic parts in first place. I only used MKS caps (5mm WIMA) in the prototype. But however - it is correct too to tell, that I got a really big improvement from a precious NOS MIL Russian PIO and NICHICON Audio Muse Gold el-caps (UKZ series).

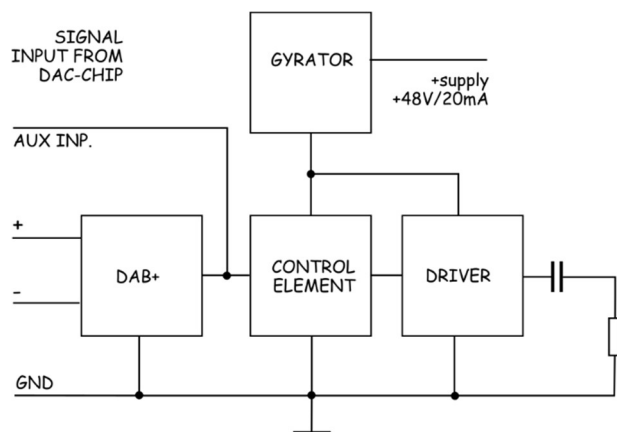
The addition "PRO" in its name derives from the fact, that you only will need this PCB to transform a quite common CD player into a HiEnd disc-player. All needed parts, incl. the DAB+ and the supply section are already on the actual board. Additionally, all points which will need an adjustment of the circuit to any DAC chip from the market are equipped with an adjustment potentiometer to make things easy.

BLOCK-DIAGRAM

As you can see from the sketch, it mainly consists of four blocks:

- The DAB+
- The stabilized NMOS gyrator
- The JFET gain-control element
- The current-controlled NMOS plus DN MOS output driver (it determines output impedance and therefore drive capability).

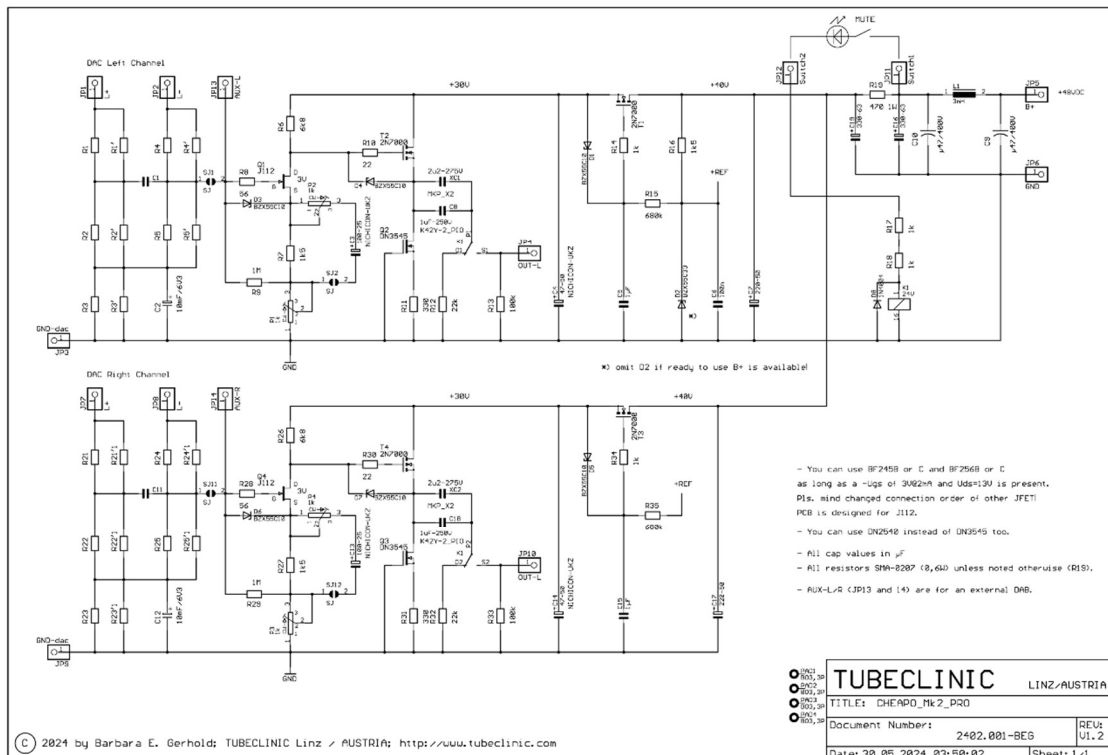
The DAB+ and the control element are coupled via DC to avoid any influence of a cap. Control element and output driver are coupled via DC too. Both stages are supplied by a gyrator, because this is a simple simulation of a choke in the end. And that's the simplest way to keep crosstalk as low as possible while defeating hum and noise to its best figures.



The load is decoupled from the driver via capacitors in a common way. An additional place for the gem of a NOS MIL RuPIO (0,47 - 1 μ F) is reserved at the PCB.



THE FULL SCHEMATIC



THE SUPPLY

I took a SMPS supply (+48VDC) for the new SST generation and it is intended to use this integrated means here too. Due to SMPS technology there will be no hum - as far as you don't introduce it via bad GND connections.

A single ring choke and cap (a so-called PI-filter or -trap) is situated at the DC-input to keep the whole circuit dean of HF noise. If you don't want to supply via SMPS, simply omit this filter.

Behind the filter there are the main storage el.caps in again a PI-filter arrangement (this time a resistive version). Here also the output (Muting) relay is connected. Well - if you again don't want or need it, simply omit it too.

Then comes a stabilized gyrator per channel. I already told you above about its purposes. Additionally, it serves as a switch-on and -off delay to avoid cracks if the output is actually not muted.

The supply voltage is now +30V (depends on the Zener voltage of Zener diode D2 → 33V@5mA typically) and it is free of H+N.

THE DAB+

This description only covers the left channel. The right channel is exactly the same. The DAB+ section is suited for V_{out} as well as I_{out} DAC-chips:

- In the case of a V_{out} DAC-chip you install resistors R1, R2, R3, R4, R5 and C1, C2.
- In the case of a I_{out} DAC-chip you install resistors R1, R2 and R4, R5 and C1. Substitute R3 by a wire bridge to GND, omit C2.
- The values of the resistors and caps can be found by the EXCEL spread-sheet from my web-site. The values for the calculation can be found at the datasheets of the several DAC-chips.
- The resistors Rx' are intended to get an improved approach to the wanted values. You don't need to use them if you can find a value in the $\leq 5\%$ (better $\leq 3\%$) range.
- Foil-cap C1 should be a version with as little losses as possible. I always use STYROFLEX™ types for best results.

THE SIGNAL CIRCUIT

Coming from the DAB+ the signal passes a Solder-Jumper (SJ1/SJ11). Here you can connect and disconnect the DAB+ from the signal circuit. This is necessary, because there is an AUX-input too for use with an outboard DAB or the obsolete R2R-DAC-chip TDA1541. In the case of the TDA you will need an additional coupling cap too.

The only amplification stage is the input stage, using a J112. This one will give improved performance (compared to a BF245 or a BF256) due to its less internal impedance and its increased transconductance. While you also could use other JFET, this one is my favorite and it's mostly responsible for the triode sound of the circuit. Test JFET for app. $-U_{gs} = 3V @ I_d = 2mA$ and pair them for matched specs and performance. Please mind a possibly altered connection order for other types than J112!

Because most DAC-chips will show a DC component at their outputs, the stage is designed to take that into account. Pot P1 (P3) is able to elevate the gate to a max. value of +2V.

The JFET is installed like you would do that with any triode → called "*common cathode*". Pot P2 (P4) gives the facility to adjust the needed amplification factor of the stage. If you again don't need or want that, simply open SJ2 (SJ12) or omit P2 (P4) and C3 (C13).

Then the signal is taken from the drain of Q1 (Q4) and coupled DC-wise to the grid of T2 (T4). This is a standard NMOS. You can use 2N7000 or any other small signal NMOS ($>40V/100mA$). Please mind a possibly altered connection order for other types than 2N7000!

The NMOS T2 (T4) is loaded by a CCS (Q2/Q3) and R11 (R21) determines the value of its constant current. The shown value (330Ω) will adjust app. 5mA (min load = $>2.5k\Omega @20Hz$) This CCS is very stable and the principal reason for the excellent sound performance of this circuit. At the output you see a place for a $2,2\mu F/275V$ MKP-X2 and the $1\mu F$ RuPIO in parallel. Then comes the output relay, but this one is not always needed ... you know ...

THE ADJUSTMENT PROCEDURE

- Check all your installations visually for possible faults and shorts from soldering. You should check all solder joints by use of a magnifying glass too.
- Disconnect SJ1 (SJ11). Connect your DMM in " Ω " mode, $\perp$ to GND and test $\oplus$ from I+, I- for both channels. All 4 must read the same value and show the added values of what you installed.

- Connect the supply voltage 48VDC to JP5 (+) and JP6 (-). Connect the DMM in "DC volts" mode, $\perp$ to GND and $\oplus$ to R19. Check for app. +48V at the input side and +40V at the gyrator input (drain T1/T3).
- Now connect $\oplus$ to the cathode of D1 and check for app. +33V. Do the same at the source of T1/T3 and check for app. +30V.
- Check at drain of Q1 (Q4) for app. +15V roughly and anode of D4 (D7) for app. +13V roughly too.
- Now connect the inputs (I+, I-) of the DAB+ to the outputs of your DAC-chip. Test the DC-elevation at the output of the DAB and compare it to the calculations you made.
- Connect the DMM in parallel to R9 (R29) and close the SJ1 (SJ11). Now adjust P1 (P3) in a way that the shown voltage becomes 0V. Wait some minutes and test again. Adjust once again if necessary. Do that really diligently!
- Use a test CD to adjust the amplification factor ($\rightarrow$ volume) at P2 (P4) to your desired value. If you have none, download the 440Hz -6dB sine-tone from my website and burn it to a CD. It will help you to adjust both channels to the same value. You can find more test signals at my website at the chapter $\rightarrow$ TEST SIGNALS.
- Connect $\perp$ to GND. Finally check the voltages $\oplus$ at the drain of Q1 ($\rightarrow$ app. +15,5V), Anode of D4 ($\rightarrow$ app. +13,5V) and source of Q2 ($\rightarrow$ app. +1,7V). Do the same for the right channel too.
- Let the circuit work for at least 24hrs and recheck all points. Readjust if necessary. Repeat until you have an absolute stable circuit.

THE CHOICE OF COMPONENTS

Caps are MKP-X2 (275VAC) by TENTA and/or MKS by WIMA as well as 2 additional NOS MIL RuPIOs (pls. refer to the schematic $\rightarrow$ output).

El.Caps are NICHICON Muse AUDIO GOLD, type UKZ. Only in the supply I used standard NICHICON, type VY.

Resistors are standard metal film 1%, type SMA-0207 or -0414.

NMOS are by IR and **DNMOS** are by IXYS and/or by Supertex.

Diodes and **Z-diodes** are from several brands. Pls. refer to the schematic.

OUTRO

Now I can hear the reviewers say, "hey - that's nothing new. It's all like the NITRO+, except the control element and the output drivers are built from Solid State parts!"

"Correct", is my answer, "but why do you want to change a winning team?"

If you have further questions or advices on improvements that you feel should be published here, please contact me via eMail. As you know - all information about the printable, full-size schematic

and the PCB is again situated in a binder enclosed to this website. I still have some ready to buy PCBs in stock and you can get one for € 11.00 plus shipping cost. Simply mail me.