Frank Leegstra TS2016: tubes.audio/2a3 amplifier

The goal of this project was to build a Single Ended Amplifier (SET) with a Direct Heated Triode (DHT). These type of amplifiers are known to have a very nice and special sound. Most commonly used tubes are the 300B and 2A3. Most DHTôs have a power output of less than 8 Watt. This sounds silly, but with the right very efficient set of speakers, they can make you deaf.

Design considerations

The project started with a wide internet and literature research, leading to the following initial design considerations:

- Use the 2A3 instead of the 300B, because of its subjective preference on internet forums over the 300B
- Make sure it uses a powerful driver stage with low output impedance
  - To be able to handle possible grid current easily in case of overload
  - To be able to deal with the higher input impedance of the 2A3
  - To be able to handle the relatively small grid bias resistor needed for the 2A3 if an AC coupled design would be chosen
- Make sure the amp can recover from overload situations very quickly
  - Limit the impact of blocking distortion, in case of AC coupling
  - Give the voltage amplifier tube and driver tube a lot of headroom to make sure they do not need to recover from overload situations
- Make sure the voltage amplifier stage and driver stage do not exceed 10% of the DHTôs own THD
- Use either AC or Current Source as filament, because DC does not have many fans
- Use a very clean power supply

Sources used for design considerations:

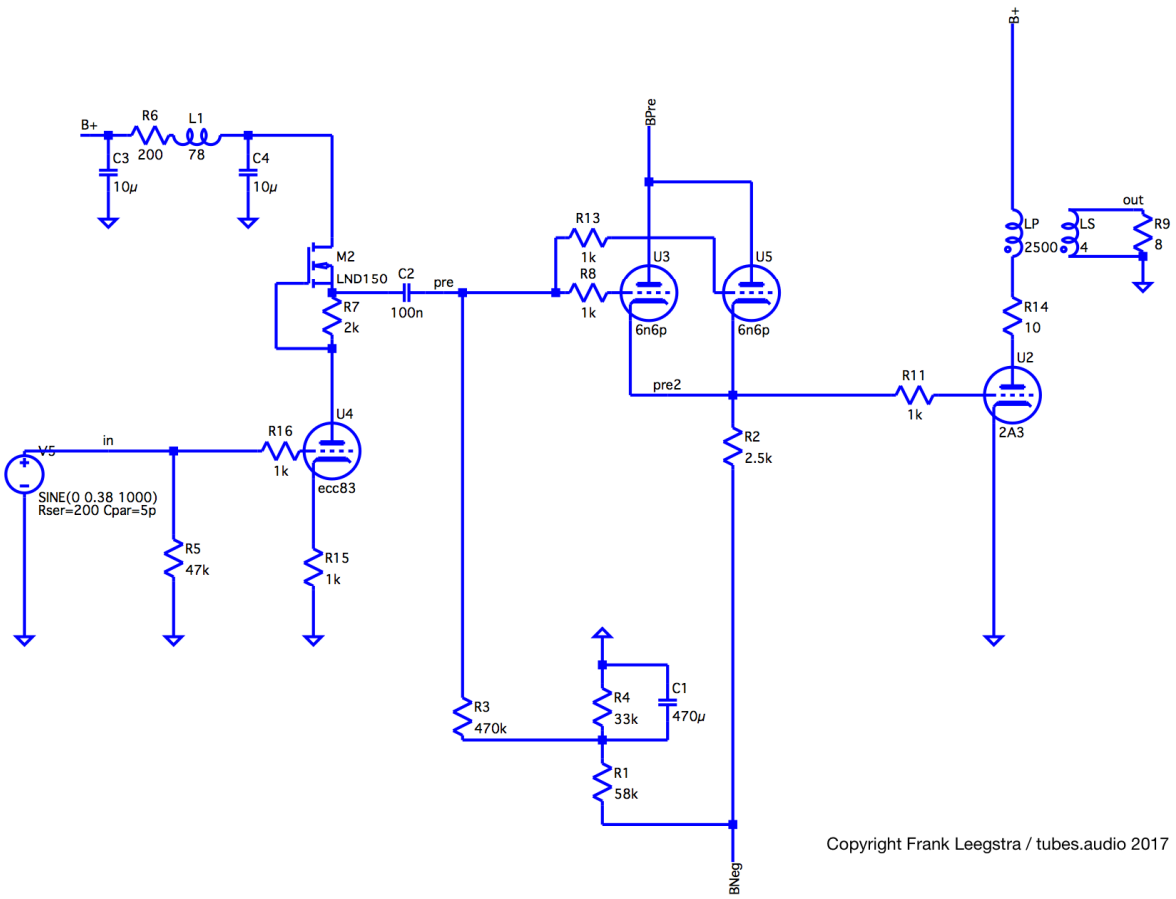
- http://www.6moons.com/audioreviews/yamamoto6/sidebar3.html
- http://www.diyaudio.com/ - various subjective opinions about DHTôs
- http://www.aikenamps.com/index.php/what-is-blocking-distortion
- Meetings at TubeSociety - https://mennovanderveen.nl/

Design choices

I have tried quite some different designs using LTSpice and evaluated them based on the design considerations mentioned above. This lead to the following design choices:

- Direct couple the driver stage to the DHT. This solves all the problems related to overload recovery.
- Use a fixed bias for the DHT to limit the impact of overload situations
- Use two 6N6P tubes as cathode follower in parallel as the driver (to have a powerful, low impedance driver). The 6N6P receives some good credits these days and it also was the winning tube in a previous pre-amp contest at the TubeSociety meetings.
- Use ECC83 with a CCS to have a clean voltage amplifier with enough headroom
- Use Rod Coleman's DHT Current Source to power the filaments
- Use VanderVeen-Super-C power supply to have a simple and clean power supply. I made PCB's of this power supply earlier this year.

Schematic



Voltages: B+ = 250VDC, BPre = 150VDC, BNeg = -150V, Bias is set by trimming R1.

Lessons learned during building, experimenting and listening

- **Distortion Pattern**: DHTôs (and tubes in general) are believed to be so nice because of their distortion pattern. They usually have a lot of second order distortion, while the higher order distortions degrade very rapidly. My first believe was also that this was the best way to configure the amplifier. However, after some listening tests and some research of Menno van der Veen we discovered that by configuring the DHT for minimal THD instead of the ócclassicôfalling distortion pattern, the amplifier sounded a lot better to most of the listeners. This was especially the case for sharper and higher phrases in the music, which in my view probably relates to having a lower IMD if the amp is configured for lowest THD.

  I used a precision trimmer to set the current of the CSS used in the anode of the ECC83. With this pod I could easily change the bias setting of the ECC83 and thereby also change its distortion characteristics. Because second harmonics in the ECC83 are able to compensate for second harmonics in the 2A3 i could therefore easily adjust the amp from the ócclassicôTHD setting to the ólowest THDôsetting.

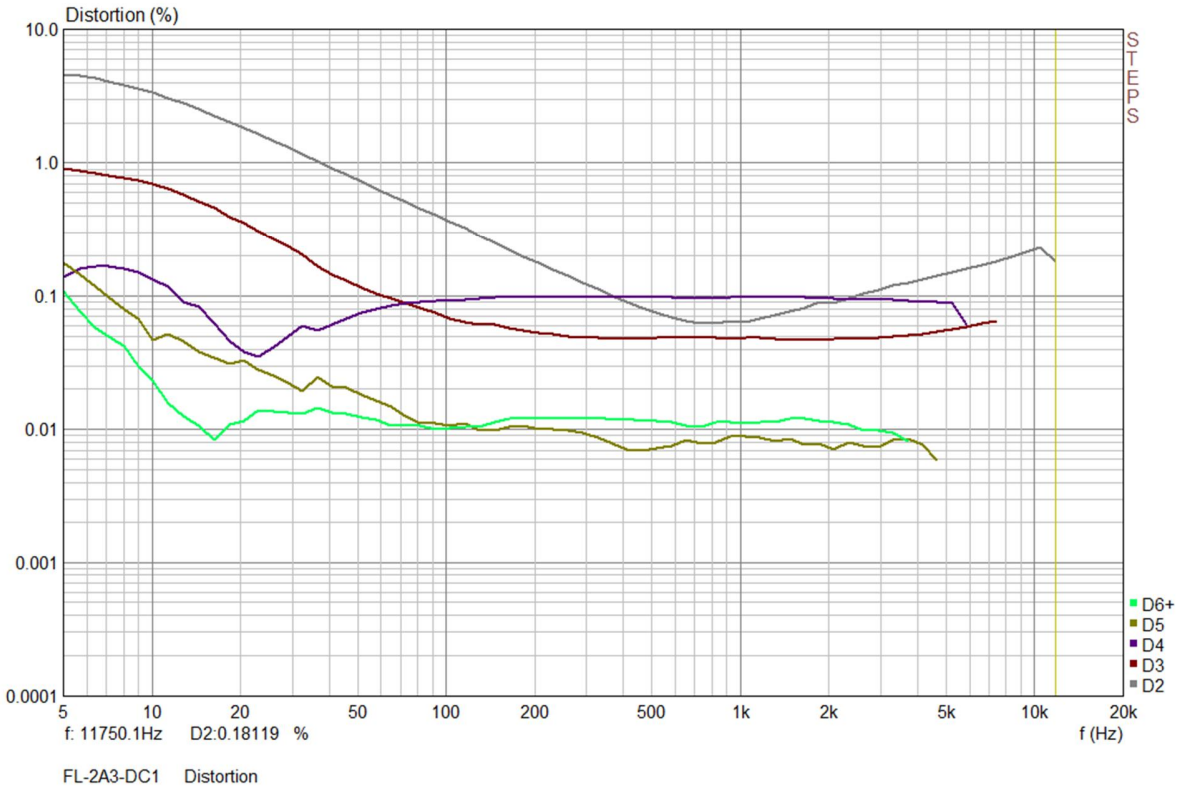
- **Startup problems and protection diodes**: On startup, the cathode follower that provides the fixed bias to the 2A3 has not warmed up yet. This causes the full -150VDC to show up at the grid, while the cathode is at ground level. Serious arcing in the 2A3 is the result. This almost killed a pair of 2A3 tubes and made some very strange noises come out of my speakers. I first came up with the following solution:

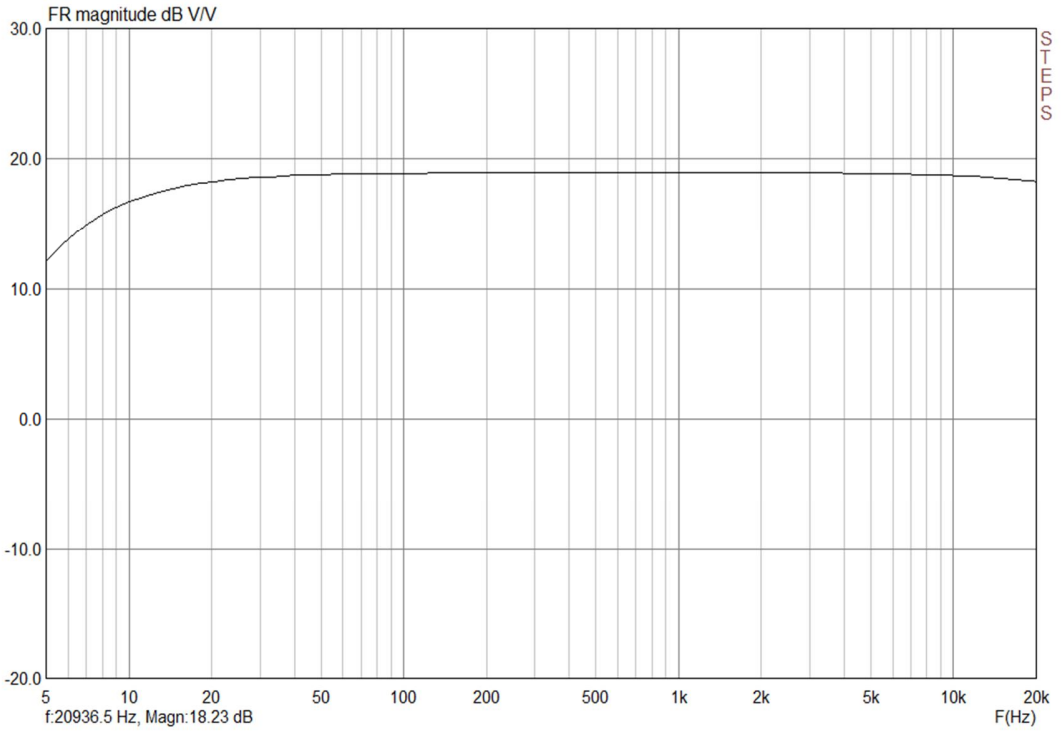
  My initial design already included a regular 1N4007 diode from grid to ground to prevent the 2A3 from going into class A2. I heard some stories (Peter van Willenswaard) about grids that could burn out when grid current flows, so I took this precaution on his advice. To protect for the arcing I replaced this diode with a 100V zener so the potential between grid and cathode would never exceed 100V. This solved my arcing problem.

  However, after some intensive listening tests I decided to take out the zener as well as the 1N4007. I was more involved with the music when the diode was gone. I am listening to the amp for a couple of weeks now and the 2A3 is still alive. No grids burned yet. I probably have to experiment a bit more before I decide whether the diode should go back or not. For now I just use a switch to power up the amp in two stages.

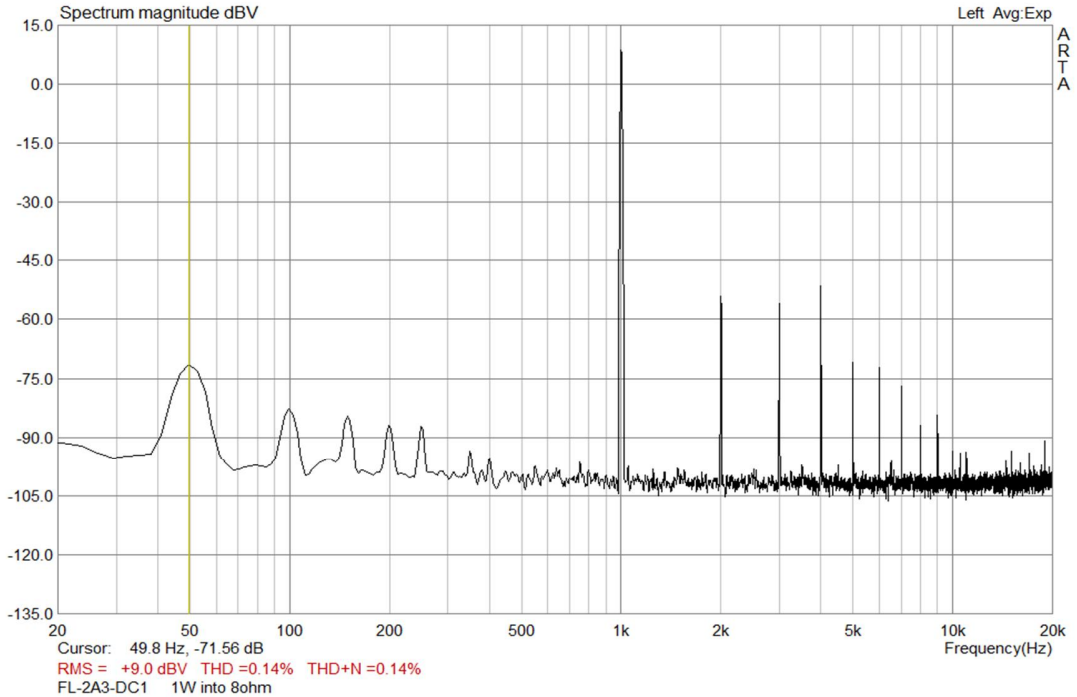
Specs and measurements

Description:	tubes.audio/2a3 Single Ended (Class A), Direct Coupled 2A3 Power Amplifier
Tubes used:	Hytron 2A3, Generic 6N6P, Siemens ECC83
THD @ 1 Watt into 8 ohms:	0.18% (or ~ 0.55% in ćlassicô distortion mode)
Output power:	Approx. 3 Watt
Output transformers:	Audio Note Trans-152 (measures 3.2KOhm)





FL-2A3-DC1 Frequency response



FL-2A3-DC1 1W into 8ohm