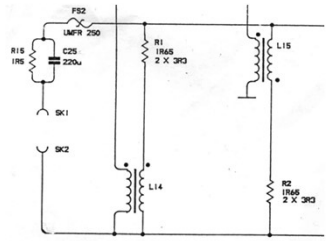
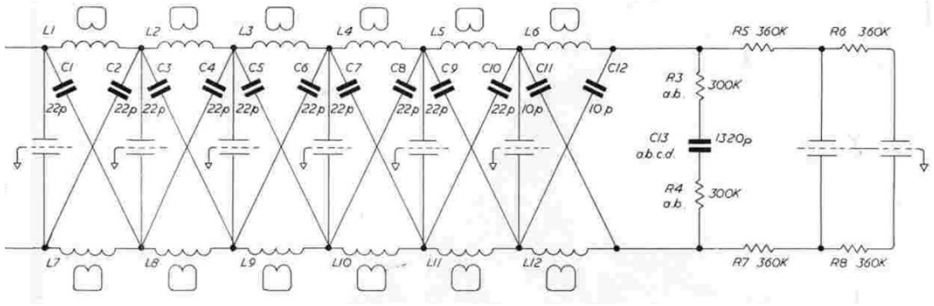
Linear Audio

QUAD ESL 63
transmission line stator drive
(for 989 add two bass panels)





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ESL 63 stator-stator input impedance

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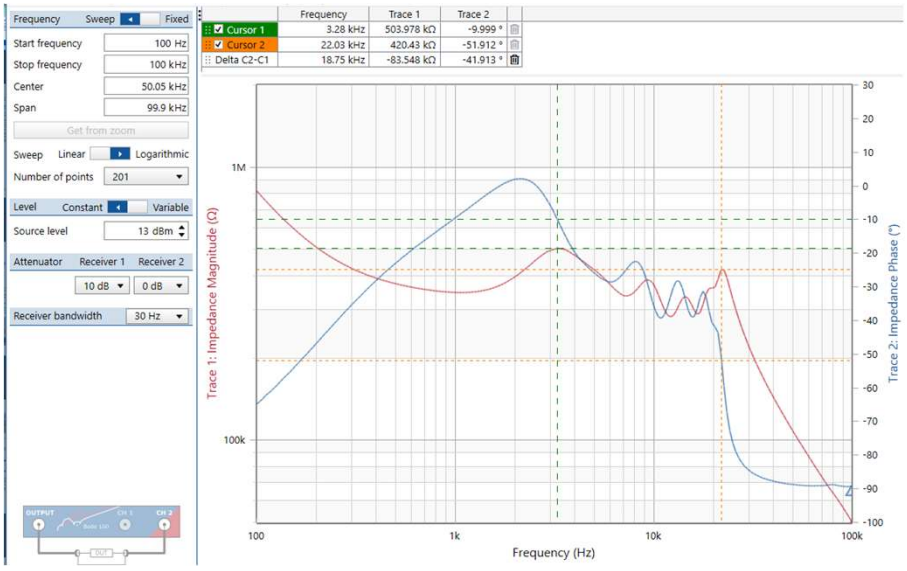

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Amplifier requirements

- Two opposite phase drive voltages up to 5kV pk-pk
- Bridged load signal currents of up to 20mA pk-pk
- Initial all-solid-state design, based on IXYZ 4.5kV FETs and IGBTs
- Abandoned due to very high parasitic capacitances and small SOA

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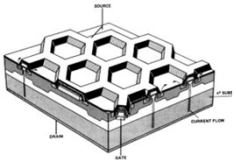
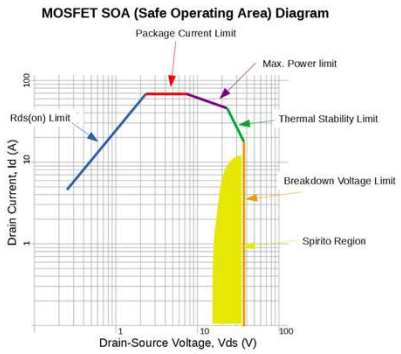
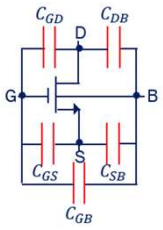
Issues with HV FETs/IGBTs in linear applications

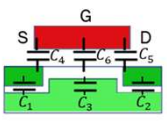
- The Spirito Effect: each cell has the same gate-to-source voltage and the same capacitances but *not* the same gain. A higher gain cell conducts more current, causing a hotspot, leading to secondary breakdown.



- High gate charge/discharge currents cause distortion.







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Way out

- Over to the dark side - compactron 6HS5 beam triode tubes!
- +/- 2.2kV design instead of +4.4kV to limit high voltage in box
- Current output into capacitive load for 1st order open loop roll off
- Rely on stable NFB for lowish Zout
- Monoblocs to limit cable length (capacitance)
- Software safety provisions

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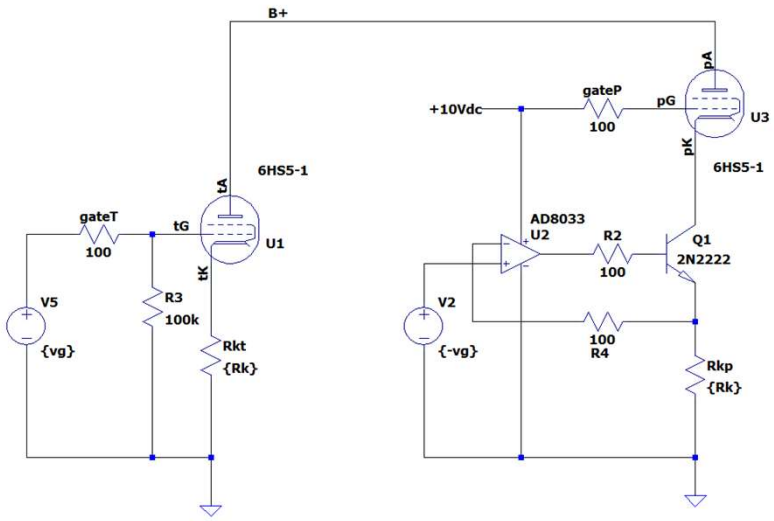
Triode/Beam Triode Common Cathode versus Common Grid/transconductance drive



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Common Grid drive turns a triode into a pentode

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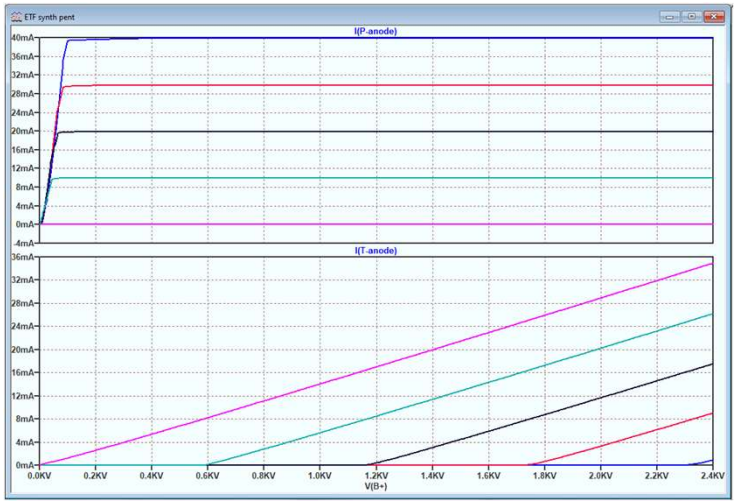

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Basic output stage

- Modulated current source

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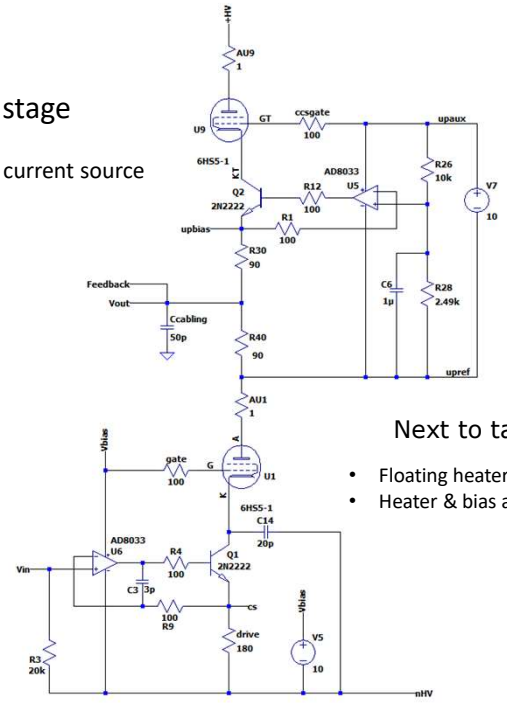

Next to tackle:

- Floating heater & bias for top tube;
- Heater & bias at -2.2kV for bottom tube

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Isolated heater & bias voltages

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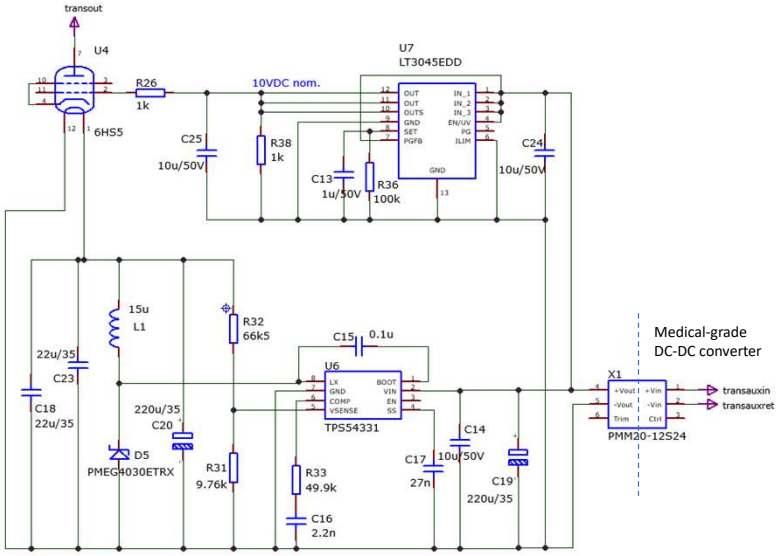

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Heater soft-start

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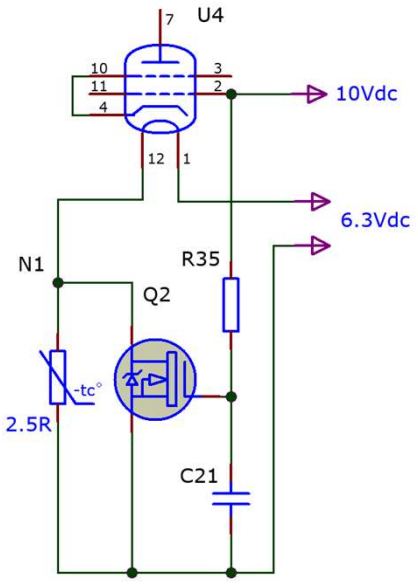

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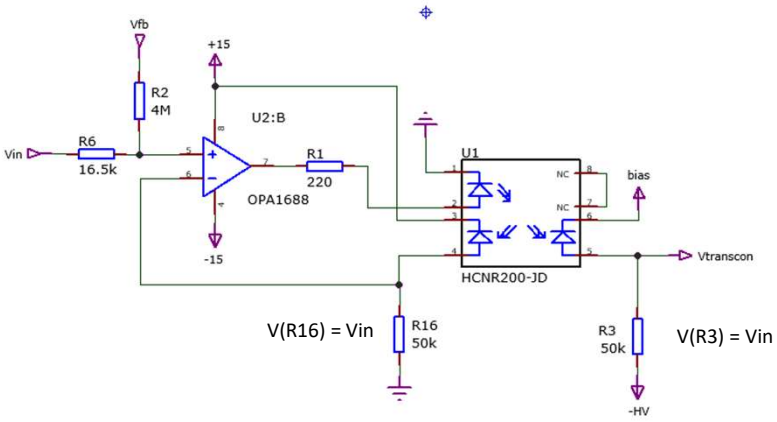
Next to tackle:

- Bringing the signal to -2.2kV reference

Linear isolated optocoupler HCNR200/TIL300



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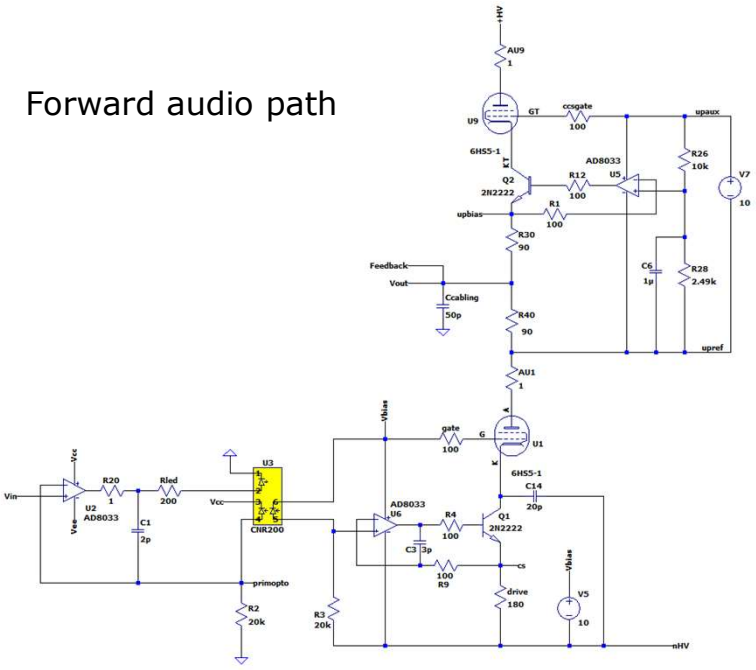
Forward audio path



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Output impedance (simulated, matches measured)

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Distortion at the stators – direct drive

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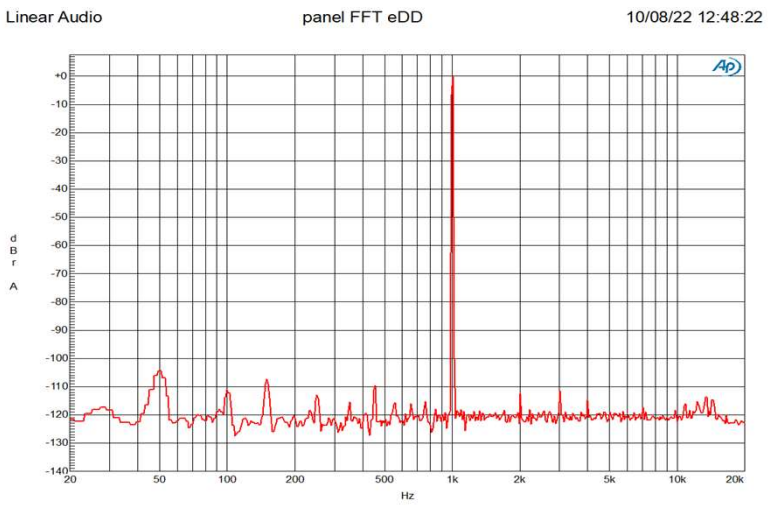

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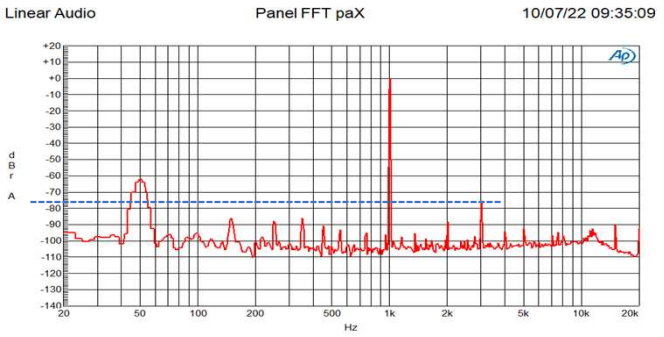

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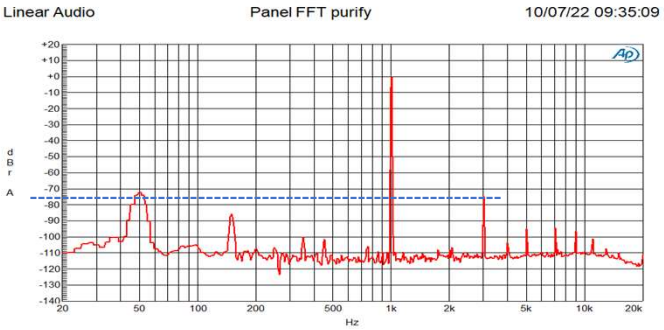
Distortion at the stators – paX & Purifi



Quiz: why are both the Purifi and the paX limited to -76dB THD at the stators when both are MUCH better on an electrodynamic speaker?

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Speaker switching

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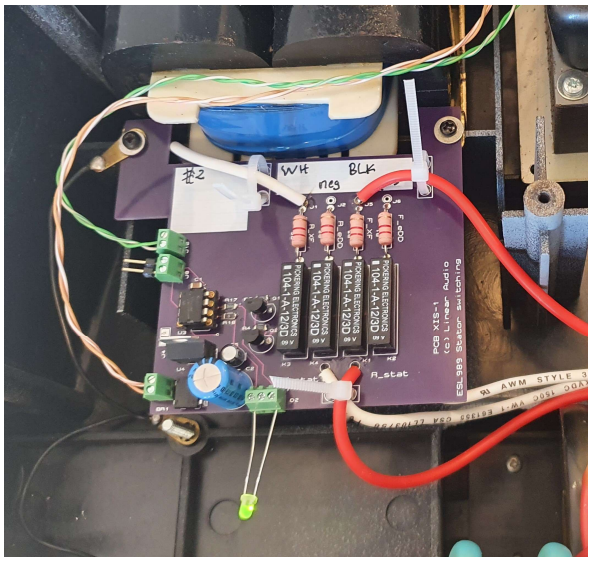
- Stator switching step-up output vs. direct drive output
- A/B direct and step-up drive comparison



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Stator drive response matching

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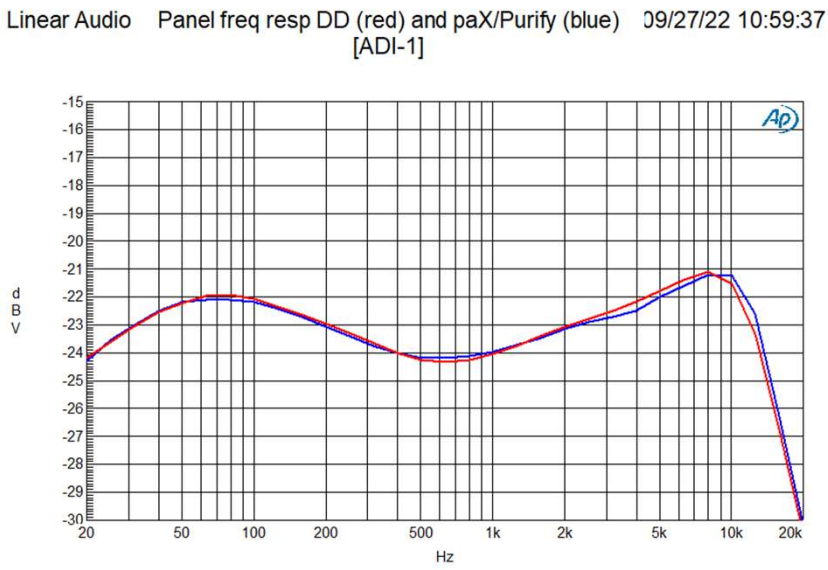

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System components

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Source:
Volumio Primo streamer
Wireless, USB, USBstick,
HD/SSD, TIDAL

Dirac Live! room correction:
miniDSP Flex Digital
2-input 4-output DSP

DAC & EQ:
RME ADI-2 Pro Fs R
'studio-in-a-box', used as
Dual Stereo DAC w/ EQ

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DAC/EQ setup

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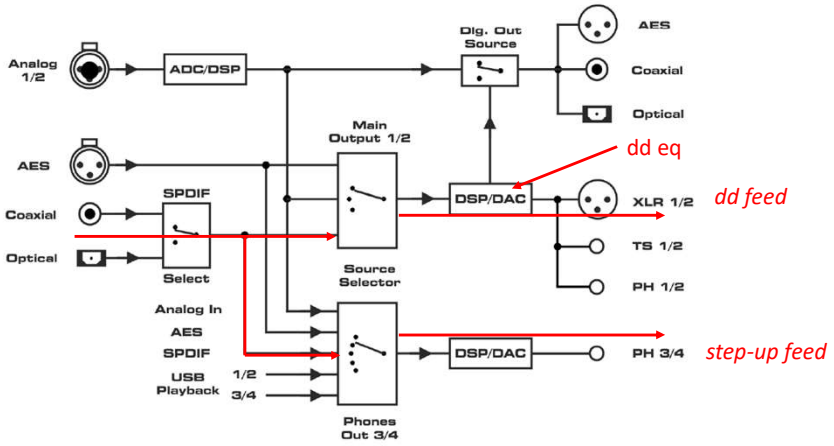
- RME ADI-2 Pro FS R in AD/DA mode used as dual DAC
  - Level matching
  - Response EQ on direct drive



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