1. Aims

Aim was to only use 2x commonly available Noval valves for a low power guitar amp, powered from a 12VDC plugpack.

Output stage was chosen to be 12AU7 PP fixed bias to allow a MM1900 20kΩ OPT, or similar low VA mains power transformer that provides >10k PP loading to a 4, 8 or 16 ohm speaker. Triode mode should be relatively ‘clean’, compared to pentode.

The valve for input stages needs to provide both high gain (eg. about 12Vpk signal drive from 50mVpk input = 240x) and phase inversion. A typical pentode first stage only achieves circa 100x gain, so a Jeffrey [1] direct coupled configuration is used for its higher gain and phase inversion.

Suitable common TV era pentode/triode noval valves with a 9AE socket base include 6EA8, 6U8A/ECF82 with 6V 0.45A heater, and PCF80, 9A8, and PCF200 with a 9V 0.3A heater option.

A cheap $11 eBay 150W 12Vdc input switchmode inverter [2] was simply enhanced with diodes/e-caps to provide a 320Vdc B+, and a -60Vdc bias. B+ level can be stepped down by lowering the input 12V using one or more series diodes.

12AU7 heater is powered directly from 12Vdc, and the 6V or 9Vdc heater can be resistor or diode dropped from 12V, or a cheap $6 switchmode buck module can be used to achieve lower loss [3].

Parts were all ‘in stock spares’ due to other projects and restorations. Buying all new parts, and a chassis would likely extend to $75. PCF80 and equivalents are on eBay at $5 each but as a batch of 5x, however these valves are very common TV valves so any radio/ham/boot-sale is likely to have them, and I had 6 spare. Similarly for 12AU7, as this is a very common valve and doesn’t have to be purchased at an audiophoolery price. The MM1900 is $10 at Jaycar. E-caps were about $1.50 each but purchased in a batch.

1.1 Jeffrey input configuration

The input stage pentode uses a cathode bypass of 100uF and 1k to provide a suitably low 1.6Hz corner. The screen voltage is set by 820kΩ + 1MΩ trimpot, and also suitably bypassed.

For the cathodyne with a nominal 320V B+ and 40V minimum anode-cathode voltage, along with a 33+66=100k DC loadline, indicates the max current swing is from 0mA to (320V-40V)/100k = 2.8mApp. For a centre-biased cathodyne, assume idle at 2.8mA/2 = 1.4mA, the cathode voltage is 66kx1.4mA=92V, the anode at 320-(33kx1.4mA)=274V, and Vak=274-92=182V. Vak has swing limits of 320V and 40V (ie. 280Vpp), so a 140Vpk swing away from 182V Vak idle. Triode curves compress towards cutoff and will round off a sine peak, whereas peak of sine will show clipping when approaching saturation.

Measured idle Vkt=96V, falling to 94.5V with 10MΩ meter loading on Vap=83V, for VS2=327V, which indicates the triode idle Vgk~12V.

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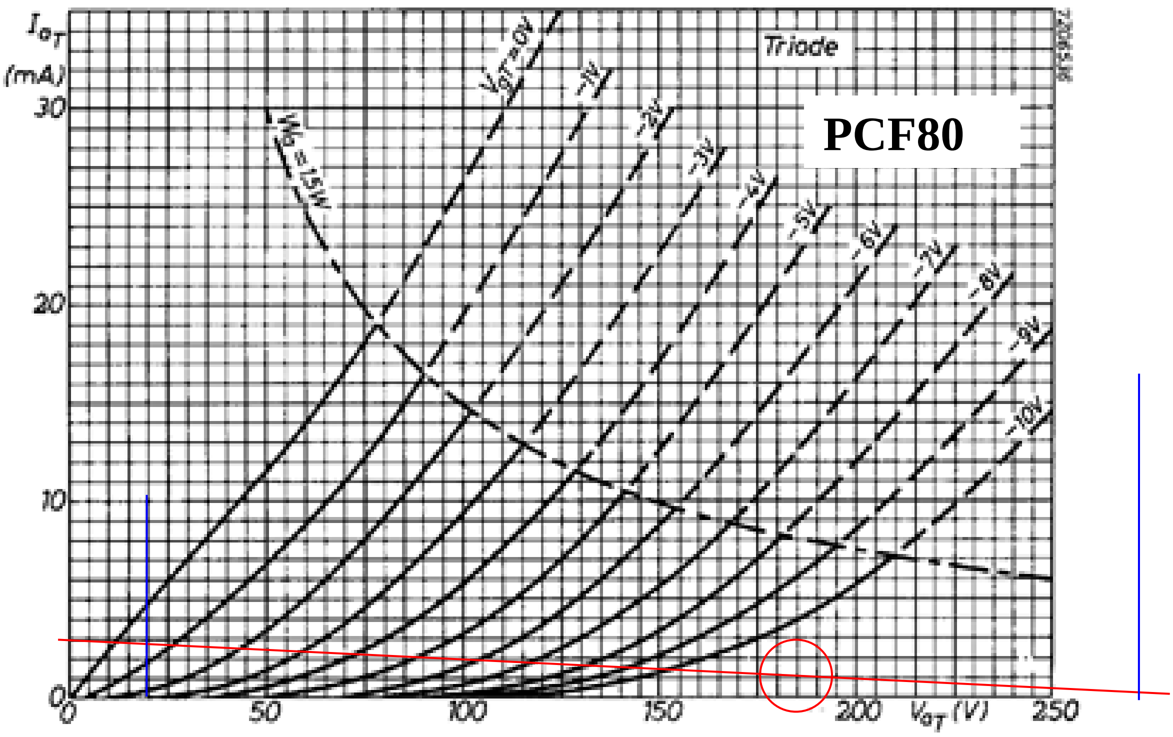
[1] 1947 WW p.247. RDH4 Fig. 12.29B. Briggs amplifiers Ch.9. Hi-Fi News March 1961. Bennett Audio Xpress July 2006.
[2] eBay search on “DC 12V to AC 110V 220V 150W Inverter Boost Transformer Power Adapter”.
[3] eBay search on “XL4015 DC-DC 12V/24V to 5V 5A Buck Converter Power Supply Step Down”.

PI grid stopper used to tame any overdrive.

Pentode input stage with fixed screen voltage, which is relatively high (circa 80V) for this Jeffrey config due to the 66kΩ asymmetric cathodyne resistor. The idle anode current is about (320-80)/220k = 1.1mA. The very high gain of the pentode, due to the almost infinite anode load, means the anode voltage loadline is horizontal, with a lower limit close to 0V and an upper limit bootstrapped to the cathodyne cathode positive excursion limit of nearly 140Vpk. This indicates the pentode anode swing to near 0V, or about 80Vpk is likely to be the limitation on the Jeffrey configuration, however this aspect was not explored further.



1.2 PP triode stage

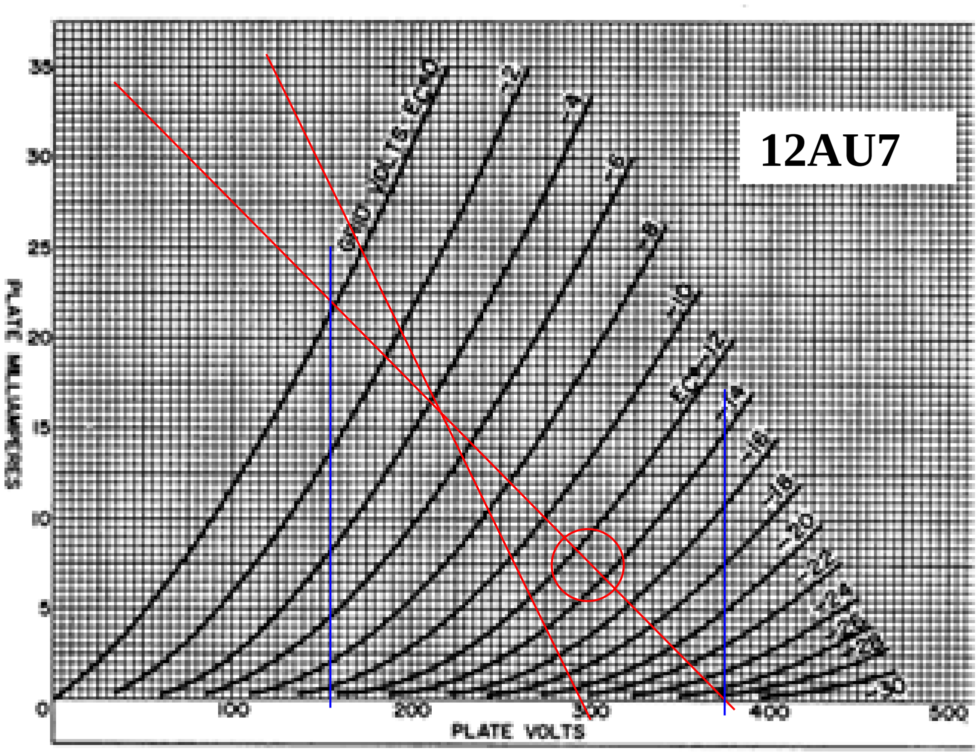
Output transformer is Electus 5W Line Speaker Transformer, stock code MM1900, as 20k PP (2W=CT; 0 & 0.5W primary connections; 8 ohm output).

The push-pull output stage configuration uses fixed bias to minimise power loss. The 20kΩ impedance plate-to-plate OPT presents each pair of tubes with 10k in Class A region, moving to 5k in Class B.

The maximum 12AU7 PP bias current allowed is dependent on the maximum recommended plate dissipation of 2.75W: Ibias(design) = 80% Pd / Vb = 2.75W / 320V = 8.6mA, but set for 6.5mA.

Plate DC voltage will be lower than VS1 by an amount up to ~3V; ie. OPT half resistance of about 105Ω with a peak current of up to about 0.025A. Cathode sense voltage is small.

For a peak plate current of 25mA and 300V supply and 150V min, then output power is about (0.025 x 150V)/2 = 1.8W. Nominal output power of the amplifier would be: $(Ipk)^2$ x Rpp / 8 = 0.025 x 0.025 x 20k / 8 = 1.6W. For this maximum signal condition, the rms OPT current draw is likely about 16mA (64% of peak), and the average VS1 power consumed is about 300x 0.016Arms =4.8W, so the tube plates dissipate 4.8 – 1.6 = 3.2W, or ~ 1.6W each.



10k class A and 5k class B loadlines on idle 300V 7.5mA operating point.

1.3 Feedback

The amp is unconditionally stable with 10dB feedback. A 22kΩ-66pF step network across the pentode anode 220kΩ load has a start frequency of 11kHz and stop frequency of 120kHz, and was included to avoid any minor peaking with capacitive only loads. HF response is flat out to 50kHz, with a +1dB peak at 40kHz.

27mVrms for 1.5W (3.45Vrms) output with 10dB feedback 13k//22k = 8k2.

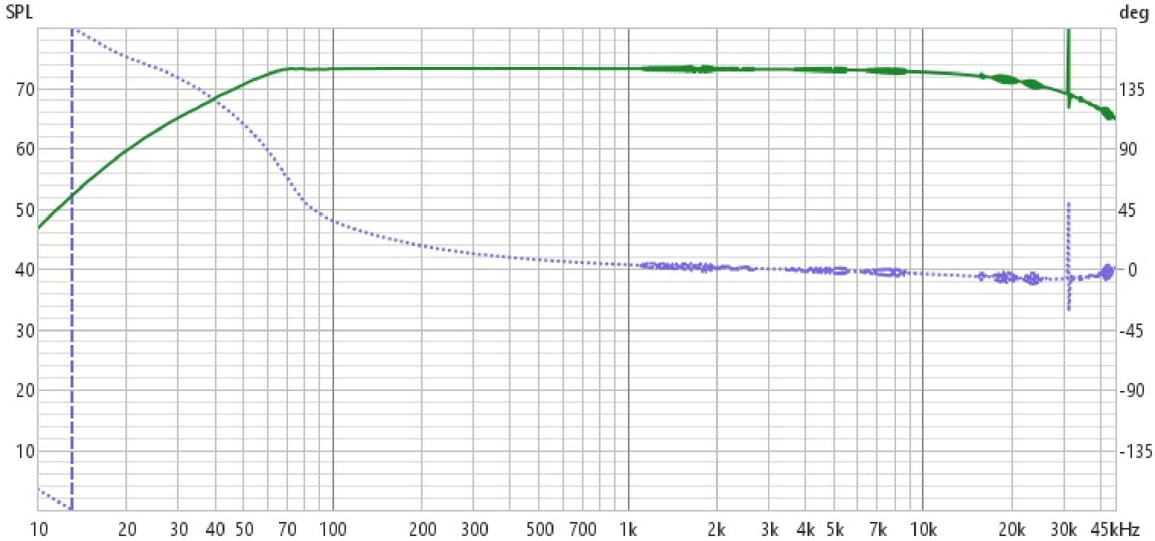
Vol pot included in feedback to provide 8k2 (Vol min) to 18k (Vol max) feedback resistance, so 10dB f/b at min vol, reducing to abt 5dB f/b at max vol for 8Ω speaker load with MM1900. This complexity is not needed (ie. just use say an 18k feedback resistor with no need for ganged pot).

1.4 Tone control

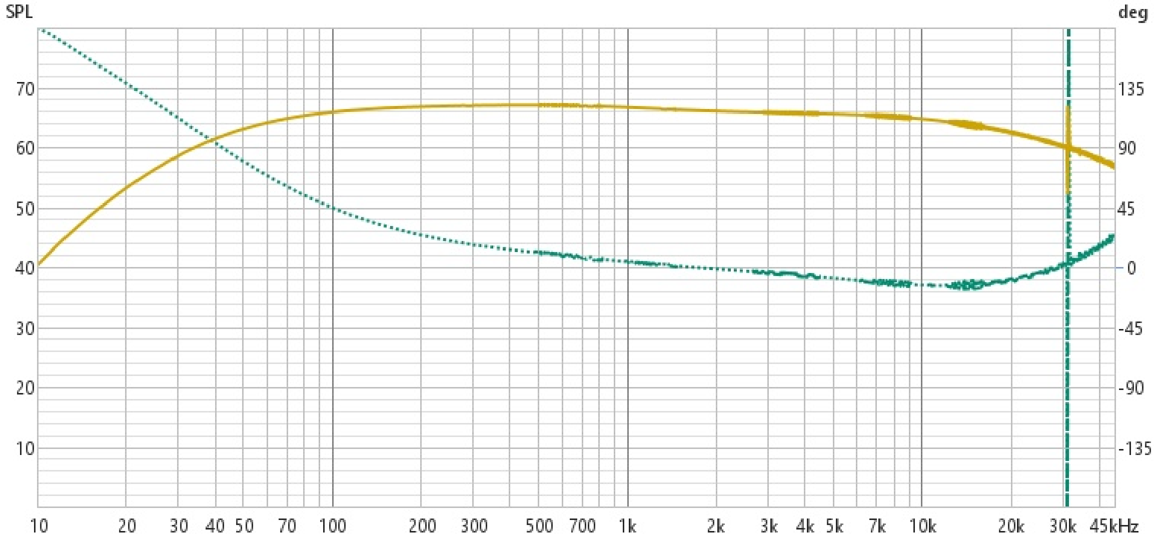
5k pot with switch [see frequency responses later]:

- CCW with switch off disconnects tone shunt RC
- With switch on, signal level drops about -6dB with minor bass roll off below 100Hz, and treble roll off above 10kHz.
- CW pot introduces initial 1kHz corner shelf step down response, increasing to a nominal slope response of -12dB/decade at max pot setting.

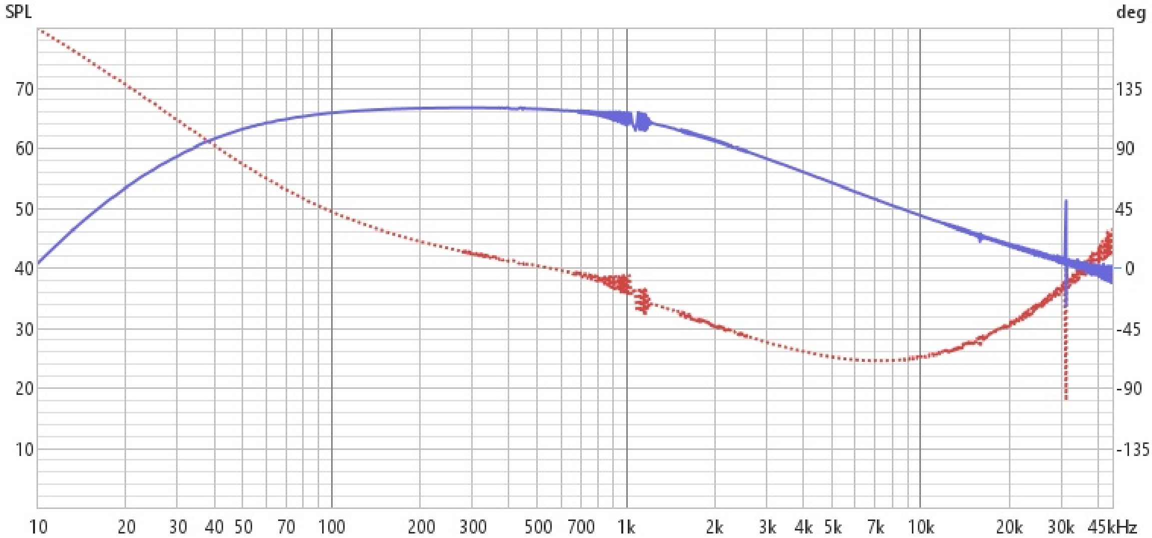
1W frequency response with Tone switched out and Vol at max, so abt. 5dB feedback provides flat and wide response.



1W frequency response with Tone switched in, but CCW pot setting. Gain has fallen abt. 6dB.



1W frequency response with Tone at full CW setting. Treble slope abt. 18dB/decade.



1.5 Output transformer

MM1900 default.

YDH-41, 115+115V to 6.3+6.3V mains 50/60Hz, MPower Rev1.1

- Turns ratio measured as 14.85+14.85:1, so about 7k PP to 8Ω, or 14k PP to 16Ω.
- 8Ω load gave 5dB fb at max Vol
- Soft clipping started at 3.3V into 8Ω (1.4W) with f/b.
- 16Ω load gave 6.8dB fb at max Vol
- With 16Ω load and prior f/b, soft clipping started at 5.1V (1.6W)
- FR at 1W is better with 16Ω (more feedback), and compared to MM1900 with 8R the YDH-41 has similar LF response (50Hz -2dB) but not as extended HF response (-2dB at 15kHz versus 22kHz).

1.6 Power Supplies

A relatively common and small 12V 1.5A regulated plug-pack is sufficient to power the amp, and requires about five initial short hiccups to stabilise as the heaters warm up and the capacitors charge to a nominal idle requirement of 12V at 1A. An 8A regulated plug pack starts the amp immediately.

Both the 320Vdc step-up inverter pcb and the XL4015 step-down converter module include a LED indicator. The 320V inverter pcb comes in two formats – a square format as shown in photo, and a longer but narrower rectangular format, and exhibits a low internal loss of about 2W.

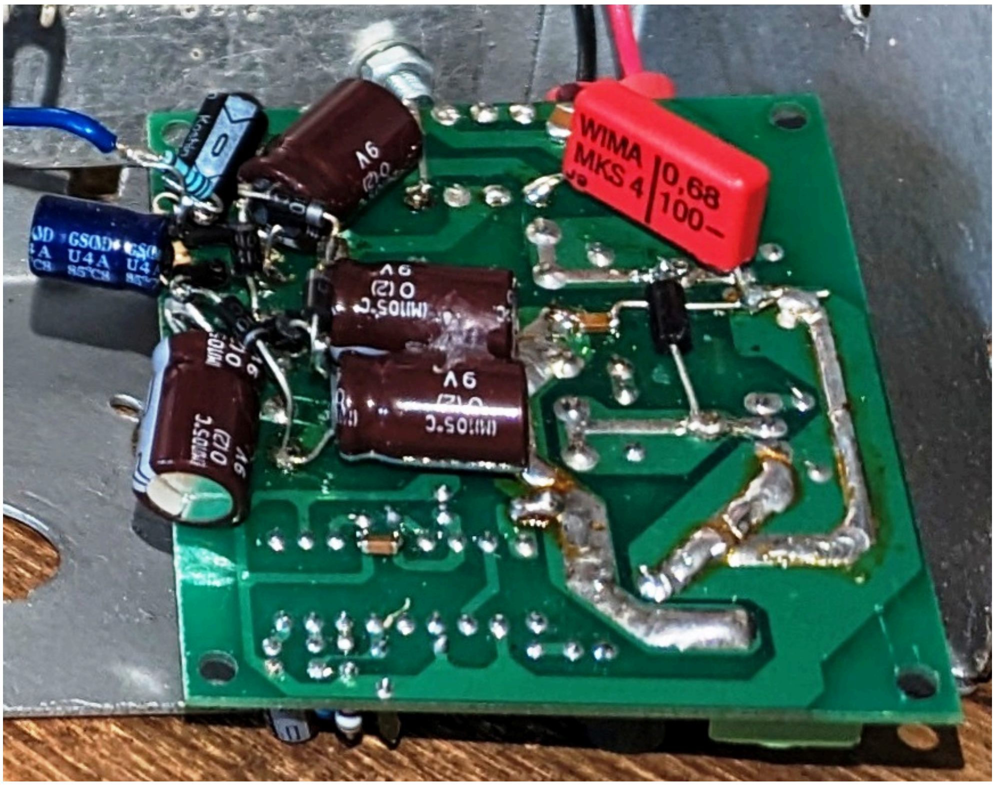
Heaters connect in parallel to the 12Vdc rail, and draw about 0.3+0.45 = 0.75A or less (if the XL4015 dc/dc is used), so about 8 to 9W.

Idle currents:
V1A: ~ 1.2mA V1B: ~ 1.4mA VS2: 1.2+1.4 = 2.6mA
VS1: 2x 6.5mA + 2.6mA = 15.6mA Loading ~ 320V x 0.016A = 5.1W
Total current draw from plugpack was about 1A at 12V, so 12W loading.

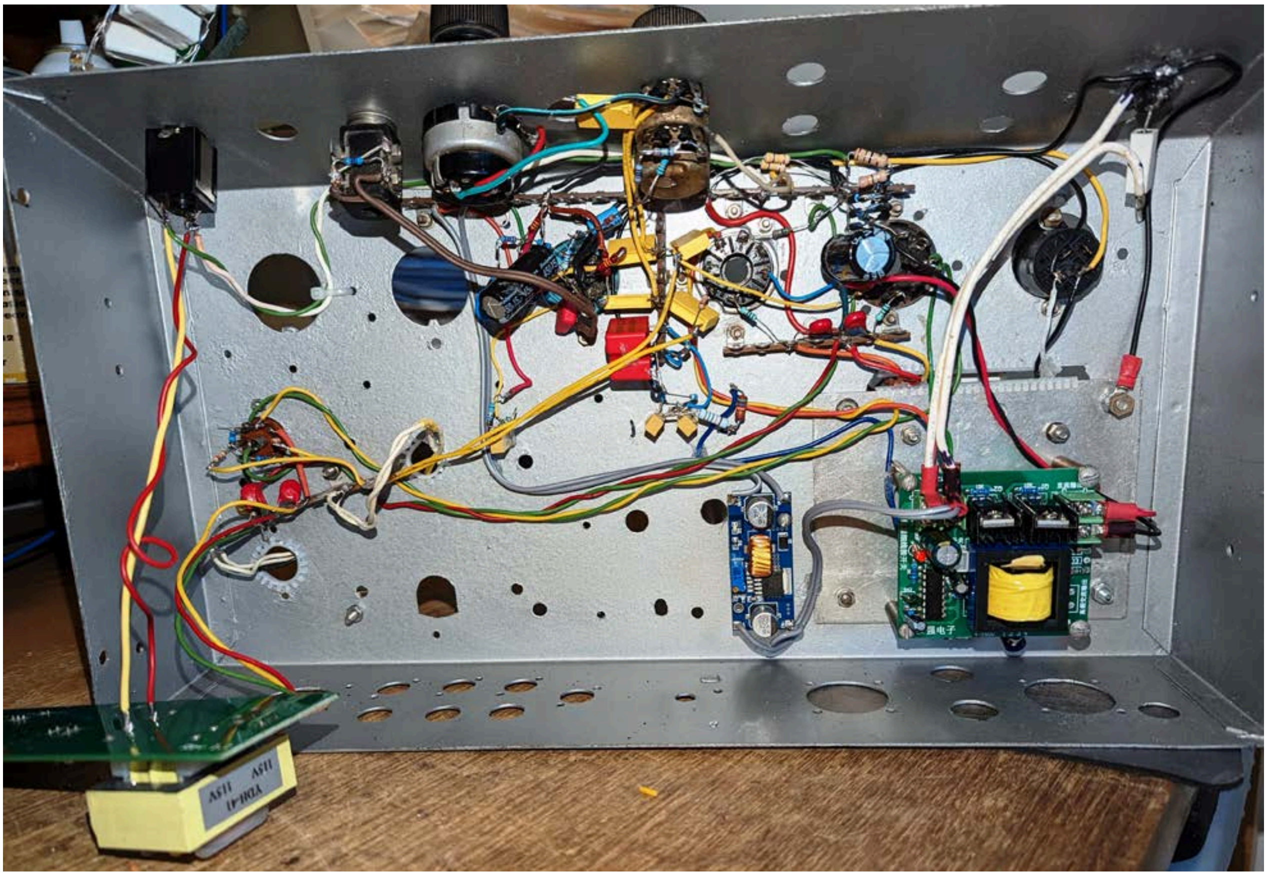
The additional parts added to the 150W inverter pcb assembly were fitted to the rear of the pcb in a way that minimised circuit loop area for switching currents. As the assembly was also used for a 15W amplifier, the pcb was modified for lower trace resistance and smt caps were added.

1.7 Still to do perhaps:

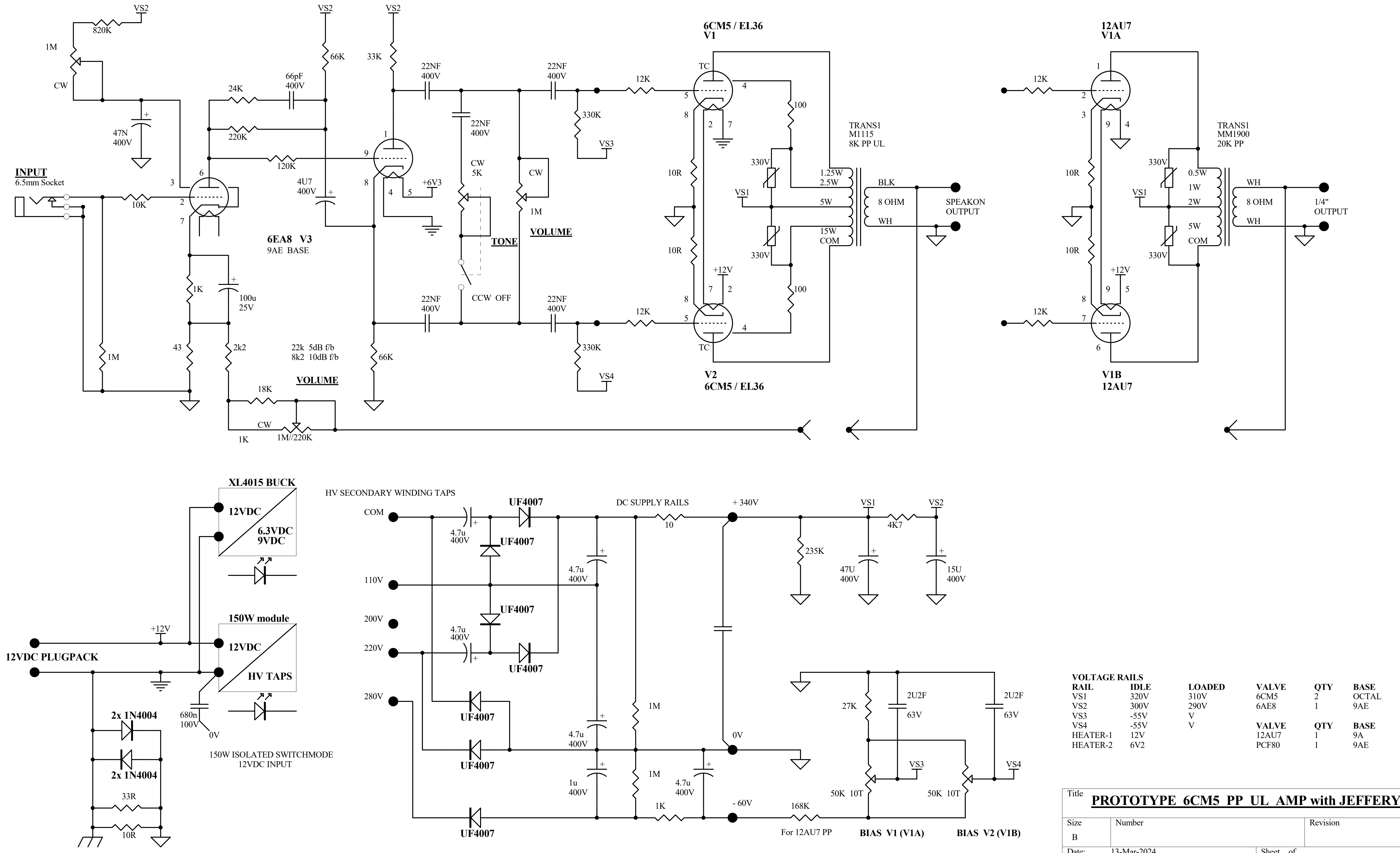
- Switchmode switching frequency identification and influence for plugpack, 150W inverter, and XL4015 step-down. Likely not a concern for simple bedroom amp.
- Tweaking Jeffrey pentode anode voltage for max signal swing.
- Include series 1N540x diodes to drop 12Vdc to 150W inverter module to lower VS1 to say 300V (to meet 12AU7 max design limit).
- Increase in 12AU7 idle current and performance, and just using input 12Vdc for negative bias of output stage (ie. no need for separate bias supply, and connecting 12Vdc pos to chassis neg, but forces 12AU7 bias to be hotter).
- Other alternatives to 12AU7, such as 3-valve options that use readily available TV pentodes with low heater current like 6AU6, including the pentode/triode valves like PCF80 or 6U8/ECF82 or 6AW8, where the two extra triodes could act as effects like tremelo oscillator.



Rear view of 150W inverter pcb with added rectifier and filter parts.



A spare chassis was used for the prototype. The photo shows the mains transformer patched in for output transformer. Chassis also includes an alternative 6CM5 PP UL output stage for 14W output through a M1115 output transformer.



VOLTAGE RAILS

RAIL	IDLE	LOADED	VALVE	QTY	BASE
VS1	320V	310V	6CM5	2	OCTAL
VS2	300V	290V	6AE8	1	9AE
VS3	-55V	V			
VS4	-55V	V	**VALVE**	**QTY**	**BASE**
HEATER-1	12V		12AU7	1	9A
HEATER-2	6V2		PCF80	1	9AE

Title: **PROTOTYPE 6CM5 PP UL AMP with JEFFERY**

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