

# Improved Hybrid HeadPhone Amplifier

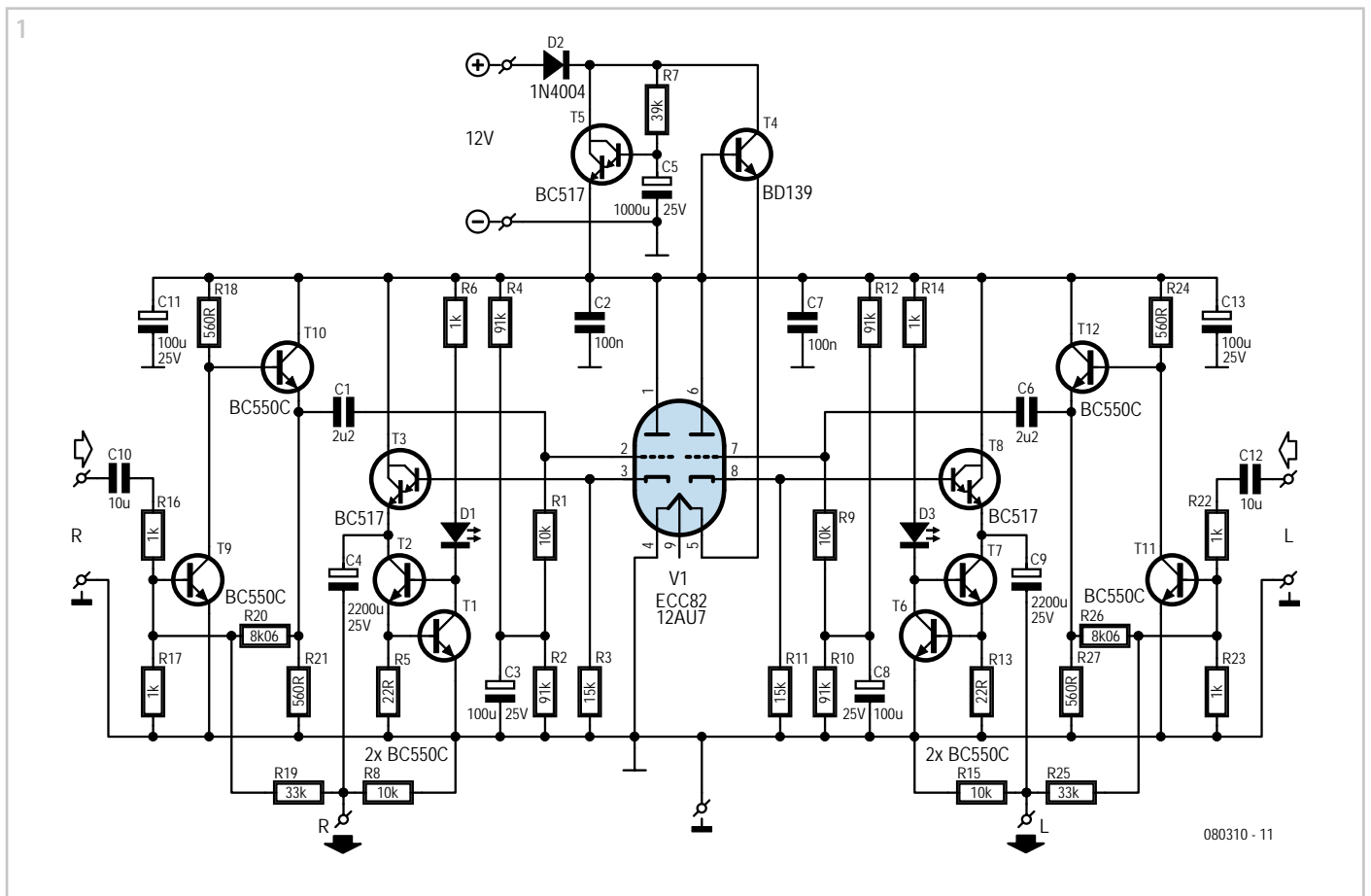
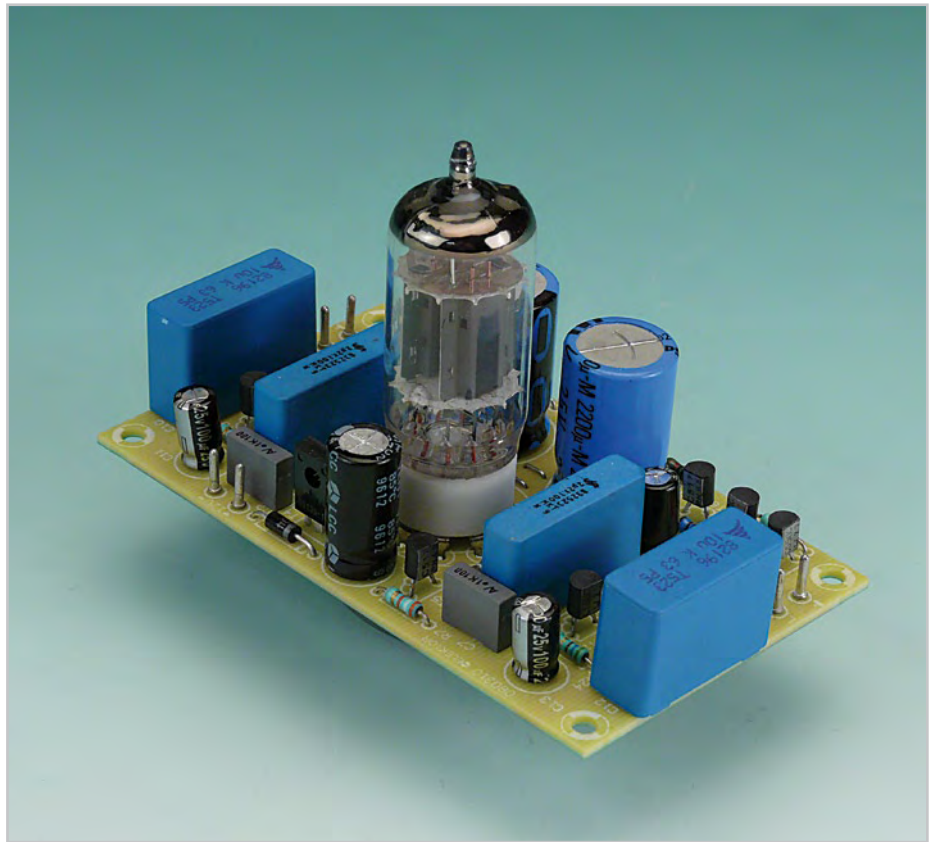


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Jeff Macaulay's excellent single valve ECC82/12AU7 'Hybrid Headphone Amp' (HHA) published in [1] spurred the author to implement some modifications culminating mainly in an additional input preamp. The resulting project was then slightly reworked in the Elektor Audio Labs and the result is shown here, along with a PCB design to Elektor standards.

## Specifications

- Warm up time: min. 30 minutes
- Load impedance: 33  $\Omega$
- Supply voltage: 12.1 VDC
- Current consumption: 235 mA
- Gain (33  $\Omega$  load): 4.5
- Max. output voltage: 730 mV  
(THD = 3%, clipping audible)
- THD + N: 0.13 % (1 mW/1 kHz/B = 80 kHz)
- S/N: 87 dB (ref. 1 mW, B = 22 kHz)
- Bandwidth: 17 Hz – 3.5 MHz (at 1 mW)
- Output impedance: 2  $\Omega$
- DC output voltage: 1 mV (33  $\Omega$  load)  
3 mV (150  $\Omega$  load)



The original HHA was designed for line inputs of the order of 1 V<sub>rms</sub> and an output impedance of about 35 ohms. Unfortunately there do not seem to be hard and fast international standards for headphone output levels or impedances. Higher end headphones such as the AKG type K601 (impedance 125 ohms) and K701 (impedance 62 ohms), coupled a hi-fi preamplifier system like the author's Rega Mira (which supplies only 600 mV<sub>rms</sub> out) resulted in a compromised dynamic range and low loudness performance especially on older CD recordings.

Initial experiments with modifying the BC517 Darlington output of the HHA were rather unsuccessful. The low anode current from the valve requires this specialized gain stage and any efforts to boost the output seems to modify the system from a valve based amplifier into a transistor one and the resulting audio performance was also not encouraging. The main problem with the original HHA is both its strength and weakness, as the unity-gain valve cathode follower does not offer any voltage gain in the first place. The low noise and distortion due to the valve is no doubt offered by its low anode voltage and hence low noise and distortion characteristics.

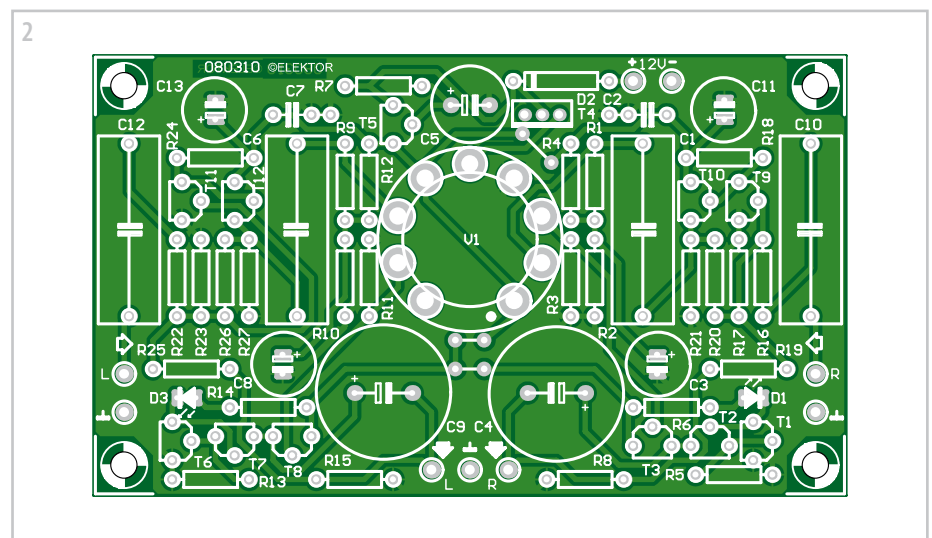
Referring to the circuit diagram in **Figure 1 a**

the **Specifications** listed here were obtained with feedback in place. Without feedback, the outputs carry no direct voltage. The negative feedback feature was found quite useful such as with the AKG K701 to further boost performance, but this is a rather subjective feature you might like to experiment with for yourself. Capacitor C1 (C6) gives the circuit a reasonable specification for its low-frequency roll-off.

In the prototype of the amplifier, the ECC82/12AU7 required about 15 minutes of warming

from the project webpage. You'll notice that the solder side of the board has large copper fill areas to maximise the ground plane surface, which helps to keep noise and all sorts of interference down to a minimum. The valve socket has a rather spacious footprint as well as large holes to allow sockets from different suppliers to be used.

(080310-1)



### Measurement data

#### Voltages measured w.r.t. circuit ground

T1/T6 base	0.7 V
T2/T7 base	1.4 V
T3/T8 base	3.8 V
T3/T8 Emitter	2.8 V
ECC82 grid	4 V
T10/T12 Emitter	6.2 V
T9/T11Base	0.67 V
ECC82 anodes	10 V
ECC82 pin 5	9.4 V
D2 (across device)	0.8 V
T5 VCE	1.3 V
R6/R14 (across device)	6.85 V

### Component List

#### Resistors

R1,R8,R9,R15 = 10kΩ  
 R2,R4,R10,R12 = 91kΩ (E96: 90kΩ9)  
 R3,R11 = 15kΩ  
 R5,R13 = 22Ω  
 R6,R14,R16,R17,R22,R23 = 1kΩ  
 R7 = 39kΩ  
 R18,R21,R24,R27 = 560Ω  
 R19,R25 = 33kΩ  
 R20,R26 = 8kΩ06

#### Capacitors

C1,C6 = 2μF2 100V, lead pitch 22.5mm (WxL = 10 x 26 mm abs. max.)  
 C10,C12 = 10μF 63V, lead pitch 22.5mm (WxL = 10 x 26 mm abs. max.)  
 C2,C7 = 100nF, MKT, lead pitch 5mm or 7.5mm  
 C3,C8,C11,C13 = 100μF 25V, lead pitch 2.5mm, diam.

8.5 mm max.  
 C4,C9 = 2200μF 25V, lead pitch 7.5mm, diam. 18mm max.  
 C5 = 1000 μF 25V, lead pitch 5mm, diam. 10 mm max.

#### Semiconductors

D1,D3 = red LED  
 D2 = 1N4004  
 T1,T2,T6,T7,T9,T10,T11,T12 = BC550C  
 T3,T5,T8 = BC517  
 T4 = BD139

#### Miscellaneous

V1 = ECC82 or 12AU7  
 9-pin ('Noval') PCB mount socket, e.g. Conrad Electronics # 120529  
 PCB, # 080310-1 from www.thepcbshop.com

stereo amp is shown, as opposed to a mono-block for the original HHA. The hunt for a suitable input voltage amplifier to slightly boost the voltage gain resulted in the use of a dual BC550C inverting shunt feedback amplifier with a voltage gain of about 8. Being an inverting amplifier it conveniently allows some negative feedback (about 3%) to be introduced using 33 kΩ resistor R19 (R25). The feedback causes a direct voltage of a few millivolts at the amplifier outputs, and

up before normal operation was obtained. This is due to the relatively low heater voltage of about 9.4 V from the BD139 series pass element. The functions of T5/C5 and T4 are explained in some depth in the original article.

The single-sided circuit board design shown in **Figure 2** allows a stereo amplifier to be built. The copper track layout for making your own PCB can be downloaded free of charge

### Reference

[1] Hybrid Headphone Amp, Elektor July & August 2006; www.elektor.com/050347

### Downloads & Products

#### PCB design

No. 080310-1 (.pdf) at www.elektor.com/080310