HEADPHONE AMPLIFIER

Design by T. Giesberts

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Although many audiophiles still believe discrete components are best, the relentless progress of integrated circuits can not be stopped: these devices get better and better. Even top-quality commercial equipment is now loaded with ICs and no one can doubt their quality and reliability. In many modern CD players, preamplifiers and digital-to-analogue converters (DACs) there is hardly a transistor to be found. Only the design of power amplifiers often still relies on discrete devices. The present amplifier is based on an IC: a surface mount device (SMD) Type TDA1308T from Philips Components.

The IC was developed specifically for use as a headphone driver: the enthusiastic claims of the manufacturer as to its qualities appear to be rather less exaggerated than is often the case (see opposite page: Performance). A signal-to-noise ratio of 110 dB and a distortion factor of <0.009% (with a 5 kΩ load) are undeniably good.

The IC can be used to good effect in CD players, DCC players, keyboards, laser disc systems, multimedia amplifiers, and more. It draws a quiescent current of only 3 mA and can work from supplies of 3–7 V. The latter makes it suitable for use in either battery-powered circuits or in standard mains-operated equipment. Its dynamic range is good, its bandwidth is 5.5 MHz and its slew rate is 5 V µs^{-1}.

The (simplified) internal design of the IC is shown in Fig. 1. The differential input stage uses MOSFETs, M_1, M_2, is provided with current mirrors and is powered by a current source, J_1. The input stage is followed by two operational amplifiers, A_1 and A_2, that drive output stages M_3 and M_6, which are also MOSFETs. The advantage of MOSFETs is that the necessary input bias current is very small: typically 10 pA; moreover, the swing of the amplifier with high impedance loads is nearly equal to the supply voltage.

The inverting and non-inverting inputs of the op amps have an excellent common mode suppression that ranges from the negative supply voltage to 1.5 V under the positive supply voltage. The IC can be fed from single as well as bipolar supplies. The closed-loop gain can be set with two external resistors.

The outputs are short-circuit-proof and totally free of switching noise. The hum suppression is 90 dB.

Circuit description

The circuit diagram is given in Fig. 2. Values of components are generally those recommended by the manufacturer. Power is derived from a single, standard mains adaptor, which should output at least 9 V. The adaptor output is smoothed by C_8 and regulated by IC_2. Diode D_1 protects the circuit against wrong polarity.

The input impedance is determined largely by R_2 (R_6). The value of 3.9 kΩ presents no problems to any preamplifier. The amplification factor is set by the ratio R_2:R_3 (R_6:R_7). As is seen, the factor here is unity, so that the name 'amplifier' is, strictly, a misnomer; 'driver' would have been more appropriate. There is no need for amplification, because the usual line level of 1 V (nominal) is more than enough to drive any headphone. However, a standard line output can not provide sufficient current for driving low-impedance headphones. The present amplifier remedies this.

Resistors R_9 and R_{10}, and capacitor C_5, set the IC for operation from half the supply voltage. Capacitor C_6 provides additional decoupling of the amplifier. Since the supply is asymmetrical, input capacitors C_1 and C_2 (C_3, C_4) are essential. Some audiophiles will raise their eyebrows at this, but in this application no adverse effects of these capacitors have been detected. Resistors R_1 and R_4 (R_5, R_8) make sure that these capacitors are charged even when the input and output are open.

Construction

The design has been kept as compact as feasible as can be seen from the drawings of the printed-circuit board in Fig. 4. In spite of the small dimensions, the construction is no more testing than most, at least not as far as the standard components are concerned. Soldering the surface-mount IC into place (not at the component side of the board, but at the track side as is usual with SMDs) is a tedious job. But, with patience and a small soldering iron with a fine tip, even relatively inexperienced constructors should be able to make a good job of it. Lightly tin the pads on the board and the pins of the IC and place the device in position. Take great care with the positioning of the IC: it is so small that mistakes are easily made. The side of the device where pins 1–4 are located is marked by a chamfered edge on the case. If you can not see this properly, use a magnifying glass. The chamfered edge should point in the direction of R_2 and R_3. Since it is very small, pressing

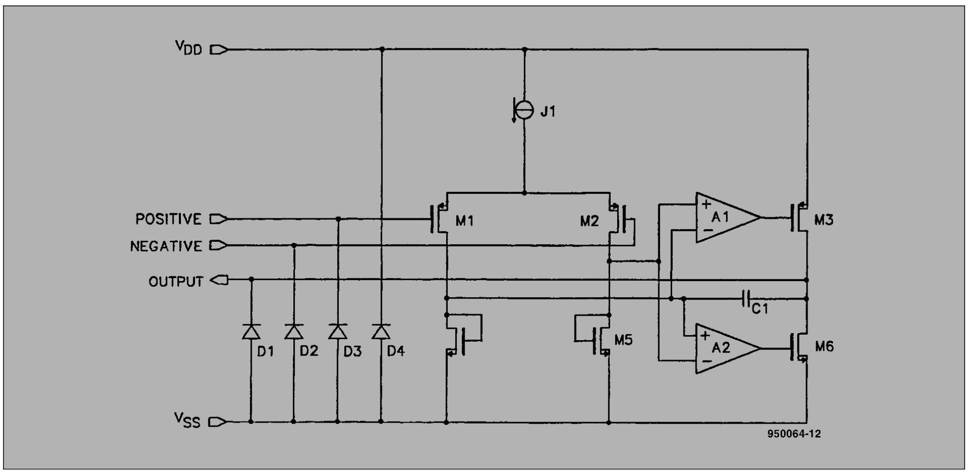

Fig. 1. Diagram of internal circuitry of the TDA1308T.

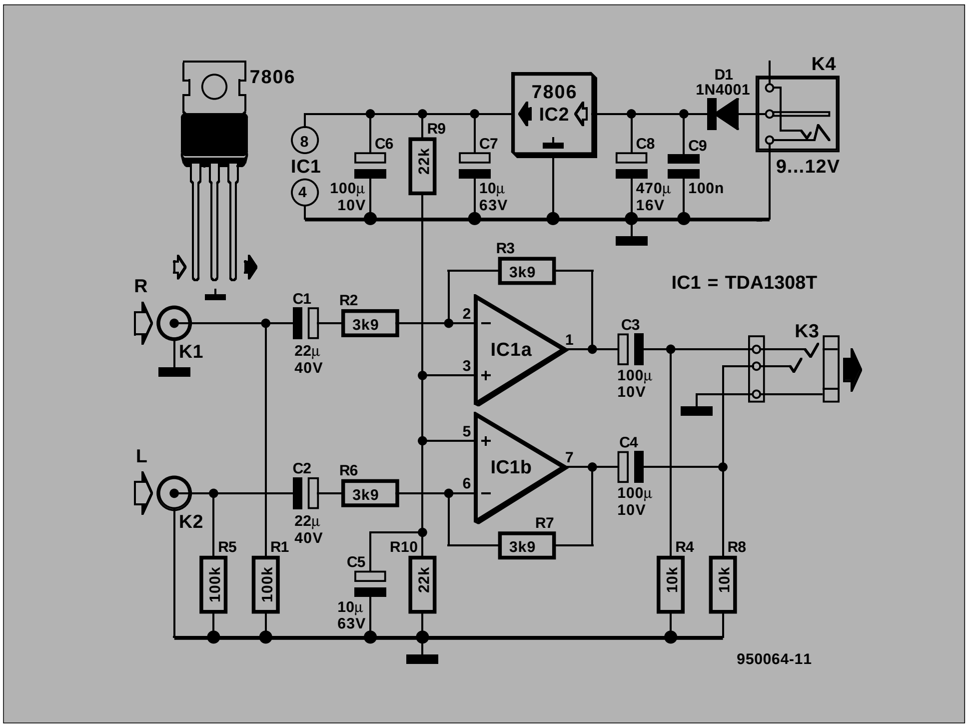

Fig. 2. Circuit diagram of the headphone amplifier.

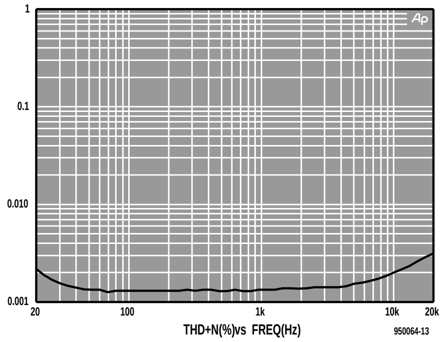

Fig. 3. The THD + N characteristic for 1 V input and a load of 600 Ω.

worse channel separation, but this can not really be attributed to the amplifier.

The maximum output voltage is 2 V r.m.s. across 560 Ω and 1.5 V r.m.s. across 32 Ω.

with a fingernail will do. Gently solder one of the pins into place and make sure that everything is as it should be. If so, carefully solder the other pins on to the board.

The top of the finished board is shown in the photograph in Fig. 5. Note that the various connectors are soldered directly to the board: two phono plugs for inputs K_1 and K_2; an adaptor socket for K_4 and a 6.3 mm stereo jack for K_3. These connectors are, of course, required only if the amplifier is to be used as a stand-alone unit. If the amplifier is built into an equipment, the connectors can all be replaced by soldering pins from where the various connections are made. The signal lines should be in screened cable. Moreover, a mains adaptor will normally not be required, since power can invariably be derived from the main equipment: the amplifier draws only a very small current. If the voltage in he main equipment is too high, it can be dropped by a series resistor and zener diode (9 V or 12 V).

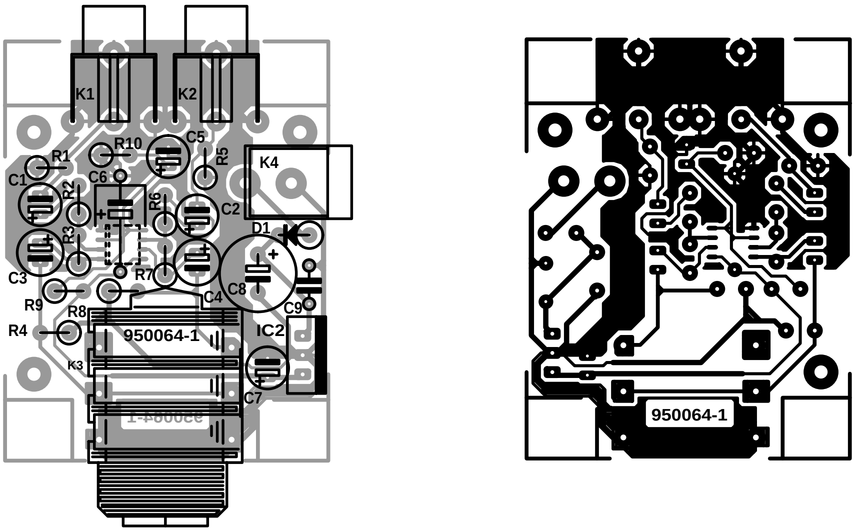

Fig. 4. Printed-circuit board for the headphone amplifier.

Performance

The performance of the Philips chip is typified by the distortion characteristic in Fig. 3. This shows that the THD + N is, as claimed, low: with a 1 kHz input signal at a level of 1 V and an output load of 600 Ω, the measured value was about 0.0015%. With a load of 32 Ω (Walkman-type headphones), it rose to 0.028%, which is still impressive for such a simple IC.

The channel separation measured at K_3 hovered around 90 dB with a 600 Ω load ad 70 dB with a 32 Ω load (frequency range 20 Hz to 20 kHz). These values depend largely on the internal wiring of the headphones: a common earth wire leads to

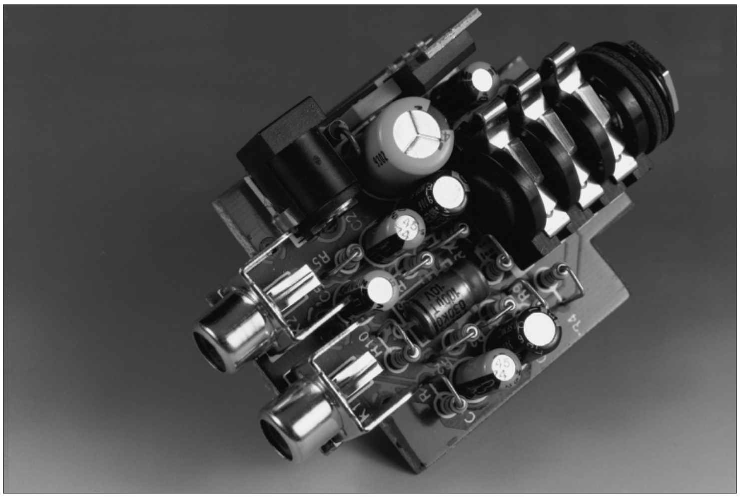

Fig. 5. The completed prototype headphone amplifier board.

Parts list

Resistors:
R_1, R_5 = 100 kΩ
R_2, R_3, R_6, R_7 = 3.9 kΩ
R_4, R_8 = 10 kΩ
R_9, R_{10} = 22 kΩ

Capacitors:
C_1, C_2 = 22 µF, 40 V, radial
C_3, C_4 = 100 µF, 10 V, radial
C_5, C_7 = 10 µF, 63 V, radial
C_6 = 100 µF, 10 V
C_8 = 470 µF, 16 V, radial
C_9 = 100 nF, pitch 5 mm

Semiconductors:
D_1 = 1N4001

Integrated circuits:
IC_1 = TDA1308T (SMD)
IC_2 = 7806

Miscellaneous:
K_1, K_2 = audio socket for PCB mounting
K_3 = 6.3 mm stereo jack for PCB mounting
K_4 = Inlet for mains adaptor (for PCB mounting)
Enclosure (optional): 65×50×30 mm (e.g., Bopla E406 from Phoenix Mecano Ltd, 6–7 Faraday Road, Aylesbury HP19 3RY, Great Britain. Telephone +44 (0)1296 398855)
PCB Order no. 950064 (see p. 70)

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