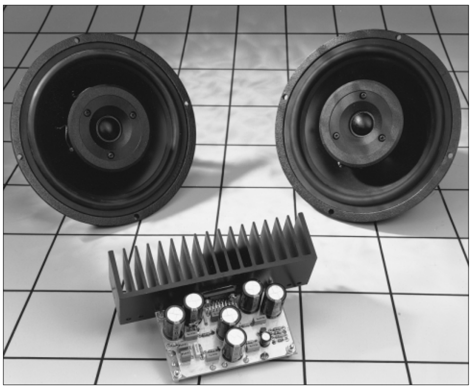
30 W AF AMPLIFIER FOR CARS



Design by T. Giesberts

The power that can be obtained from a standard car radio amplifier operating from a 12 V car battery is 5–6 W, which (for many listeners) is not really enough for satisfactory hi-fi reproduction. It is, of course, possible to boost the 12 V supply with a power inverter, but that is fairly expensive and not always acceptable. Now, a Philips IC enables audio power of about 30 W to be obtained from a 12 V car battery.

Until not so long ago, the Class B output stages of a standard car radio could not deliver more than 2× 5–6 W_{rms} into 4 Ω loudspeakers. More was not possible with a single supply line of 12 V. Most modern car radios use bridge amplifiers to boost the output to 12–16 W. Often, each of the four loudspeakers has its own dedicated amplifier. Many car manufacturers do not like the use of power inverters to raise the on-board voltage out of fear that these can cause (embarrassing or even dangerous) interference with the remainder of the electronic systems in the car (of which there can be many). There is also the problem of heat generation in the output stages, which may necessitate forced cooling.

Class H

Electronics manufacturers have been researching ways and means of obtaining adequate output power without the use of a power inverter, and Philips have come up with the TDA1560Q.

Output amplifiers can be arranged in a number of different configurations, of which most audio enthusiasts only know Class A and Class B. A different one that provides fairly high output power with relatively low dissipation is Class G. In this configuration, use is made of two supply voltages: a fairly low one that is constantly available and a much higher one that becomes available only when the the voltage swing of the output stages can not be sustained by the low supply voltage.

Since in cars only one supply voltage is available, Philips engineers have devised a pseudo Class G configuration in which a number of electrolytic capacitors are charged by the battery voltage. During brief voltage peaks in the output signal, semiconductor switches connect these capacitors in series with the 12 V line so that the supply voltage to the amplifier is temporarily doubled. Since this is a further development of the Class G technique, it is named Class H. The (temporary) 24 V supply to the amplifier enables (theoretically) a power of 80 W to be delivered into 4 Ω or 40 W into 8 Ω.

A simplified diagram of a Class H output amplifier is shown in Fig. 1. It contains two principal circuits: the first is a Class B amplifier, T_1–T_4, which is loaded by R_1, and the second raises the internal

Brief Technical Data

Class H operation	
Low dissipation with music signals	
Extensive protection circuits (output current; temperature; load impedance)	
Supply voltage	12 V nominal
Quiescent current	100 mA
Output power	
(1 kHz sinusoidal, THD = 0.5%)	30 W r.m.s. into 8 Ω
(music signal)	40 W into 8 Ω
THD + noise (1 W into 8 Ω)	<<0.01% (1 kHz)
	<<0.05% (20 Hz to 20 kHz)
THD + noise (20 W into 8 Ω)	<<0.06% (1 kHz)
	<<0.2% (20 Hz to 20 kHz)
Power bandwidth (–3 dB)	5 Hz to 100 kHz

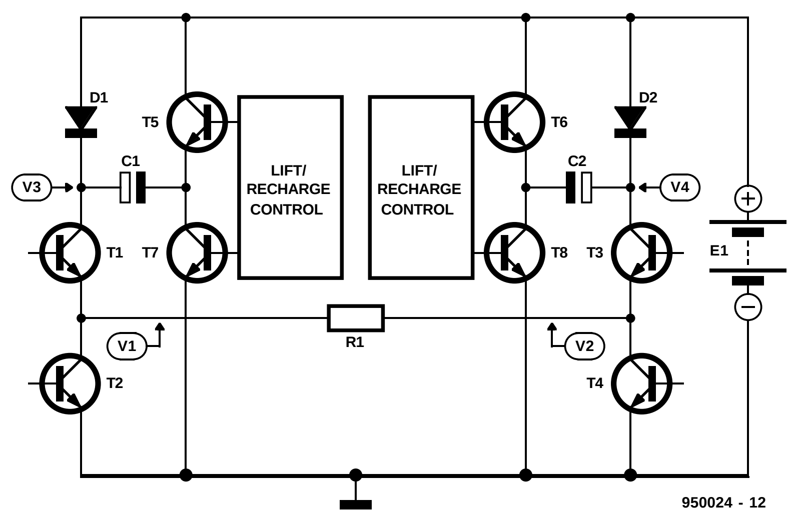


Fig. 1. Diagram of a basic Class H amplifier.

Contents

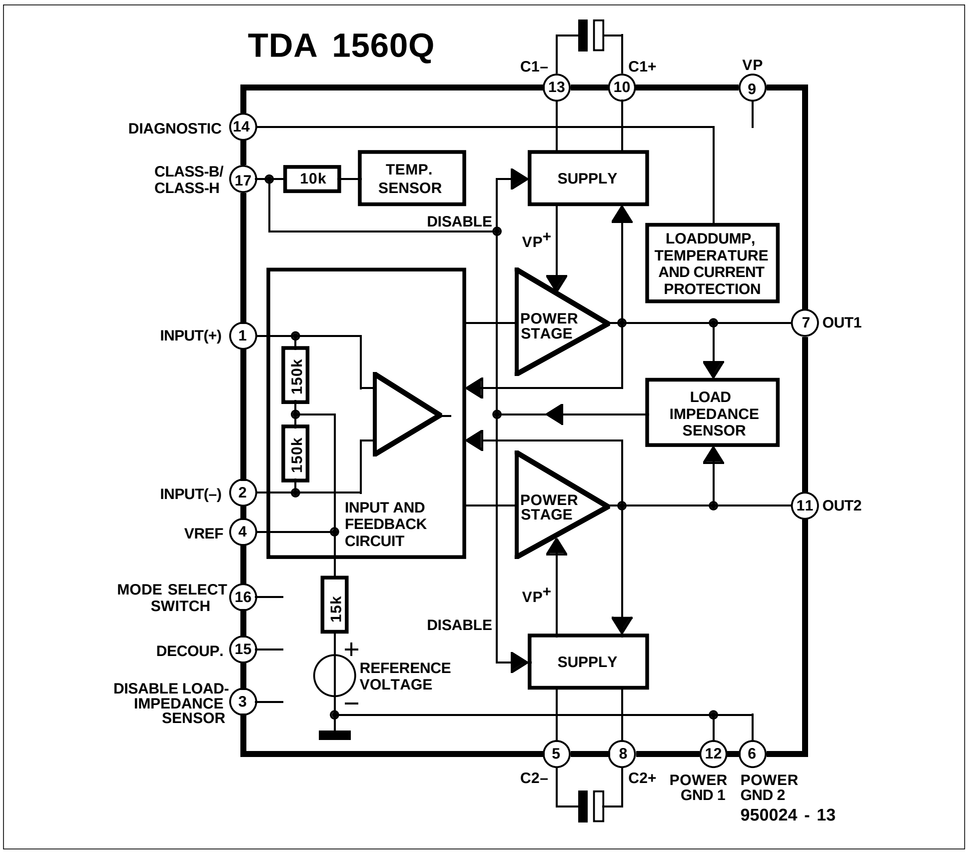


Fig. 2. Block diagram of the TDA1560Q

supply voltage. The second circuit uses two external capacitors, C_1 and C_2, which serve as supply buffers.

Since a music signal consists only for a small part of high level components, the supply voltage needs to be raised for a small part of the time only.

Because the supply voltage is raised for short periods of time only, the average dissipated power will be only slightly higher than that of an amplifier without a voltage-raising circuit, in spite of the fact that the peak output power is appreciably higher.

Capacitors C_1 and C_2 are charged through current sources T_7 and T_8 to a voltage which is nearly equal to the supply voltage, E_1. When either voltage V_1 (or V_2) rises and T_1 (or T_3) approaches the saturation voltage, the lift control circuit detects this. Lift transistors T_5 and T_6 then conduct, so that the charged capacitors are switched between the collector of T_1 (or T_3) and supply voltage E_1. Diodes D_1 and D_2 prevent the capacitors being discharged via the battery. Voltage V_1 (or V_2) can increase to nearly twice the supply voltage. The lift/recharge control circuit ensures that T_5 and T_7, and T_6 and T_8, can not conduct simultaneously.

Inside the TDA1560Q

A block diagram of the TDA1560Q is shown in Fig. 2. A differential input stage in the input and feedback circuit is connected to pins 1 and 2. Because of this stage, the IC is highly insensitive to common-mode interference. The input impedance is 300 kΩ, so that for a good low-frequency response even small input capacitors are sufficient.

The input and feedback circuit contains circuitry that controls the supply circuits and the power stages.

The control circuitry monitors the input signal and anticipates saturation of the output transistors. As soon as this happens, the supply voltage is raised. Because the input signal is monitored, it is possible to control the lift voltage. To keep the dissipation at a minimum, the supply voltage is raised only to a level where the output will stay below the clipping level.

A current limiter protects the output stages against being short-circuited to ground or to the supply line. In general, whenever the current drawn exceeds a level of 5.5 A, the output and the power stages are switched off. The protection circuit monitors at short intervals whether the short-circuit has been removed. If so, the output stages are reactuated. This arrangement limits the dissipation in the power stages during short-circuits to a minimum.

There is a dual temperature protection. The first switches off the voltage doublers when the temperature of their cases rises above 120 °C. The amplifier can then operate in Class B only. The second protection uses sensors located close to the output and switching transistors. If these sensors measure a temperature higher than 165 °C, the base current of the associated transistor is lowered.

There is also a circuit that monitors the load impedance. After the amplifier has been switched on, the d.c. resistance of the loudspeaker(s) is determined by passing a current through the speaker coil(s) and measuring the consequent voltage drop across it.. Because of the peak current that the power stages can handle, the Class H section is switched off when a 4 Ω loudspeaker is detected. The IC then operates as a Class B amplifier. When the load impedance drops below 0.5 Ω, it is considered a short circuit and the entire IC is disabled. The impedance sensor is very sensitive and may be actuated by spurious pulses (for instance, when a car door gets closed during switch-on: the loudspeakers then act as microphones). The sensor may be disabled by shorting pin 3 to ground.

Finally, the IC contains an internal reference voltage source for the input circuits. This reference is decoupled by a capacitor at pin 4.

Circuit description

The circuit diagram of the 30 W AF amplifier is shown in Fig. 3. The input is connected to the differential input stage (pins 1 and 2) via coupling coupling capacitors C_1 and C_2. Although the –ve input is linked to earth via wire bridge A-B, the arrangement gives good common-mode rejection in spite of the assymetrical input. A true symmetrical input is obtained when wire bridge A-B is omitted from the board. Network R_1-C_3 forms a low-pass filter that suppresses HF interference at the input. The input impedance is determined largely by the value of R_2.

The circuit around darlington T_1 provides a delay at switch-on to suppress switching noise reaching the output stages. This is essential since the impedance measuring sensor (which normally provides the suppression) has been disabled here (pin 3 to ground).

As soon as the supply voltage is on, a potential of 3 V is applied to pin 16 via R_3 and D_1 to place the IC in the mute mode. Initially, since C_{10} is discharged, T_1 remains off. However, the capacitor then gets charged via R_4 and within a few seconds the voltage across it has risen to a level at which T_1 begins to conduct. This results in a voltage of 12 V being applied to pin 16, whereupon the power stages operate normally.

Various facilities are open to the user via pin 14. For instance, it may be used to detect whether one of the protection circuits is working. Normally, this pin is at the level of the supply voltage. If its potential is only half that value, one of the protection circuits is actuated. When the pin is linked to ground via jumper JP_1, the amplifier is muted. When the jumper is connected to +12 V, all protection circuits are disabled. For normal operation, therefore, no jumper should be placed at JP_1.

Capacitors C_{15} and C_{16} buffer the 12 V battery voltage. Capacitors C_{11}-C_{12} and C_{13}-C_{14} are required by the lift/control circuit. Two parallel-connected 4700 µF electrolytic capacitors are used in each case, because these take up less space on the board than a single 10,000 µF component. Networks R_6-C_6 and R_7-C_7 are interference suppressors.

A Boucherot network, R_8-C_8 and R_9-C_9, is provided at each loudspeaker terminal to maintain a ‘normal’ load at high frequencies (at which the loudpeaker impedance rises appreciably owing to its inductive behaviour).

Construction

The construction is limited to populating the printed-circuit board shown in Fig. 4. The IC must protrude slightly from the board so that it can be fitted flush against the heat sink. An insulating washer between IC and heat sink is a must: apply heat conducting paste to both the base of the IC and the heat sink. The insulating washer may have to be cut to size from a mica T03 washer.

Most constructors will use two amplifiers in one enclosure for a compact stereo setup. It is, however, also possible to use four amplifiers in one case: one for each of the two front and rear speakers. Make sure that none of the loudspeaker cables or terminals can touch the chassis, because that does not do the bridge amplifier any good in the long term in spite of the protection circuits.

Parts list

Resistors:

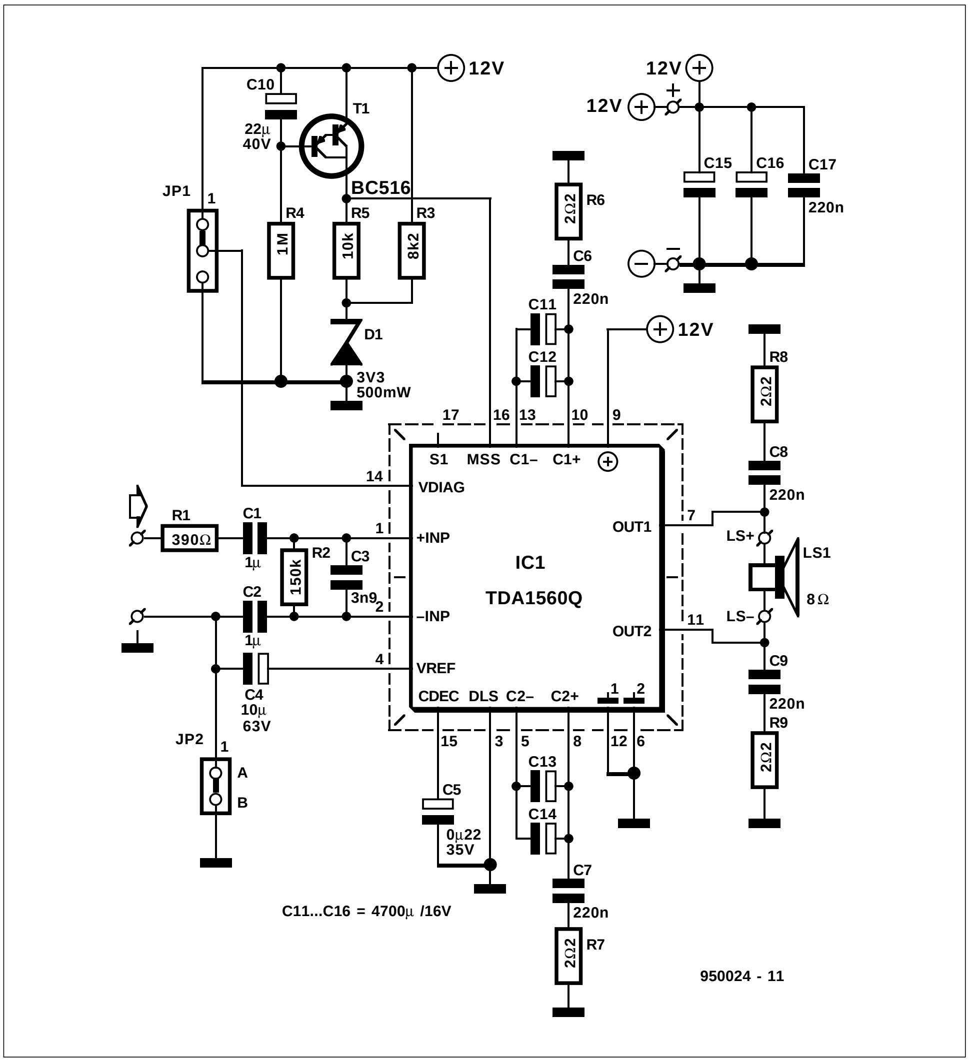


Fig. 3. Circuit diagram of the 30 W AF amplifier for cars.

Contents

R_1 = 390 Ω
R_2 = 150 kΩ
R_3 = 8.2 kΩ
R_4 = 1 MΩ
R_5 = 10 kΩ
R_6–R_9 = 2.2 Ω

Capacitors:
C_1, C_2 = 1 µF, pitch 5 mm
C_3 = 3.9 nF
C_4 = 10 µF, 63 V, radial
C_5 = 220 nF, 35 V, tantalum
C_6–C_9, C_{17} = 220 nF
C_{10} = 22 µF, 40 V, radial
C_{11}–C_{16} = 4700 µF, 16 V, radial

Semiconductors:
D_1 = zener, 3.3 V, 500 mW
T_1 = BC516

Integrated circuits:
IC_1 = TDA1560Q

Miscellaneous:
Heat sink for IC_1; R_{th} << 2.5 K W^{-1}
PCB Order No. 950024-1

[950024]

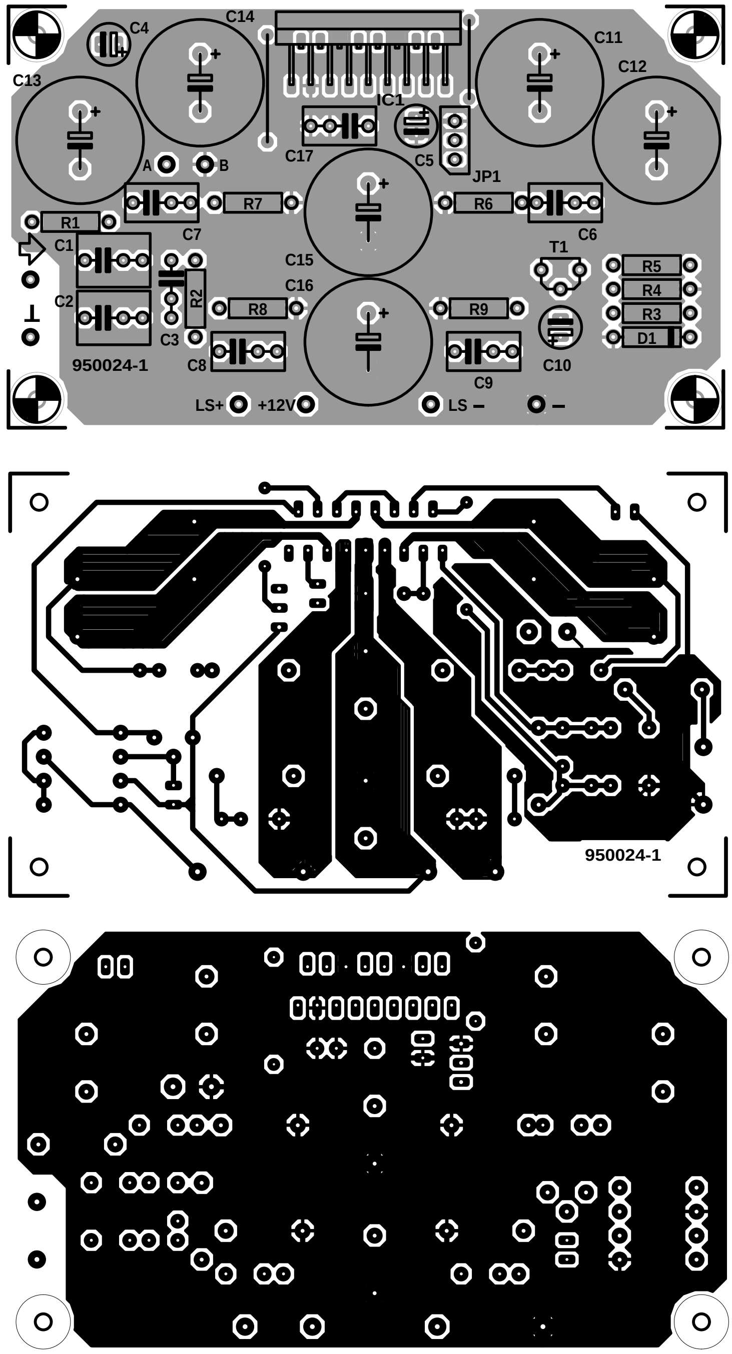


Fig. 4. Printed circuit board for the 30 W AF amplifier for cars.

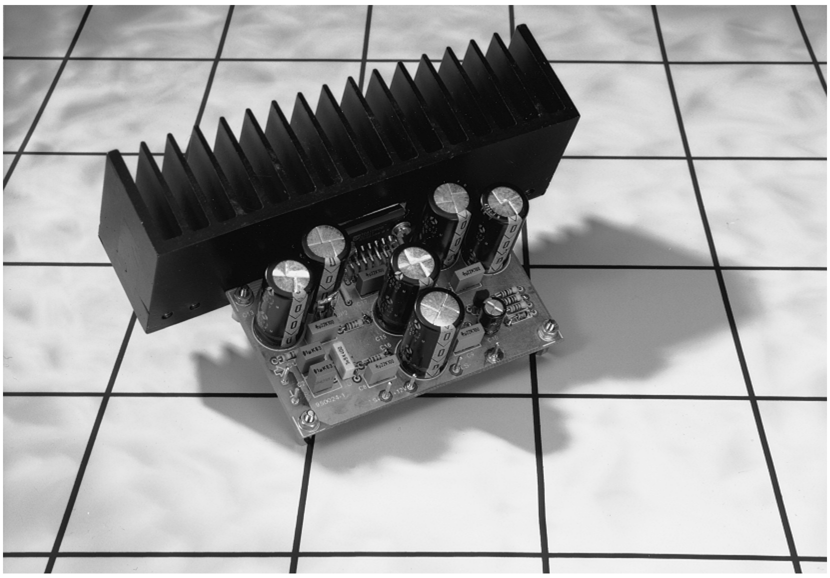


Fig.5. The completed (prototype) 30 W AF amplifier for cars.