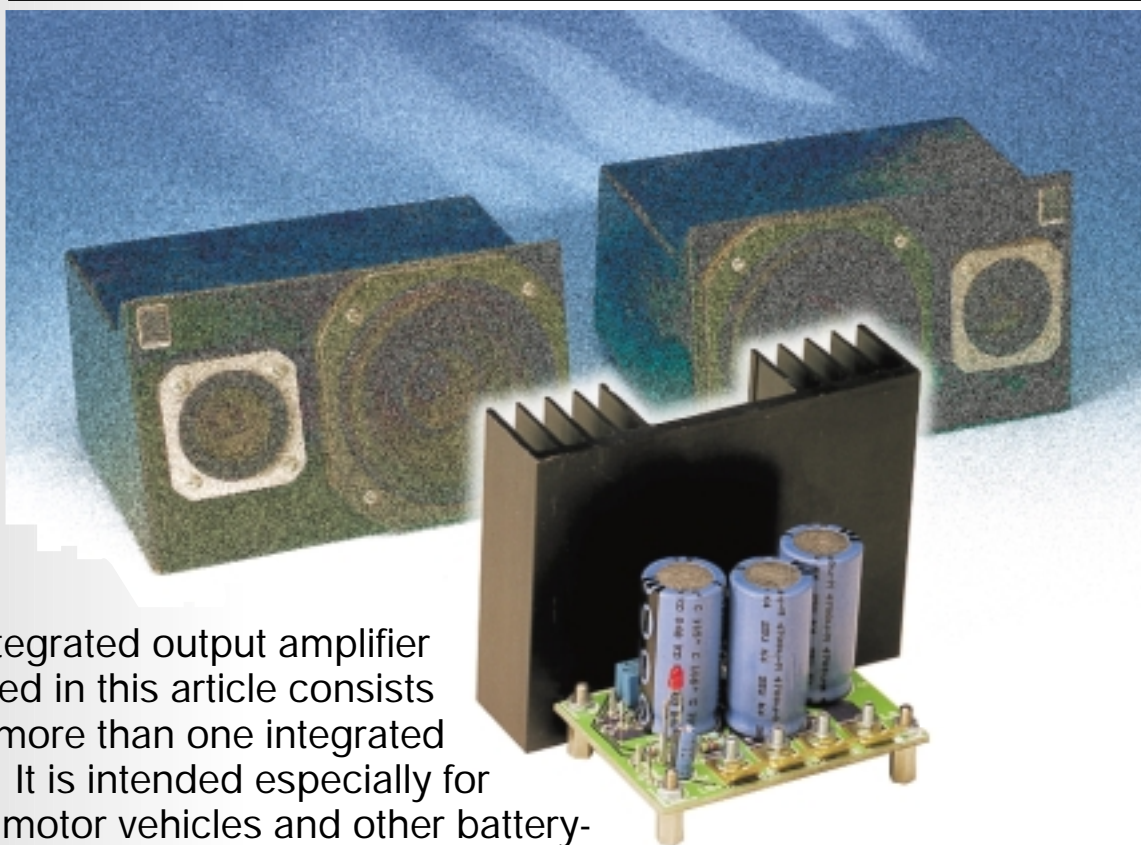


# one-IC audio power amplifier

*designed for in-car use*

## 50+ watts from a 12 V battery



The integrated output amplifier described in this article consists of little more than one integrated circuit. It is intended especially for use in motor vehicles and other battery-operated applications. Although it appears simple and hardly worth looking at, the amplifier can produce an appreciable audio power output.

Amplifiers come in all sorts. Most of the amplifier designs published in this magazine are intended for domestic or studio use. As such, they are usually powered by a 60–150 V supply, which may, moreover, be further divided into two balanced voltages. This makes these amplifiers unsuitable for use in motor vehicles.

Amplifiers that can operate from a 12 V supply are quite different units, designed as they are for low-voltage supplies. If, moreover, they are required to provide a substantial

power output, their design is far from simple.

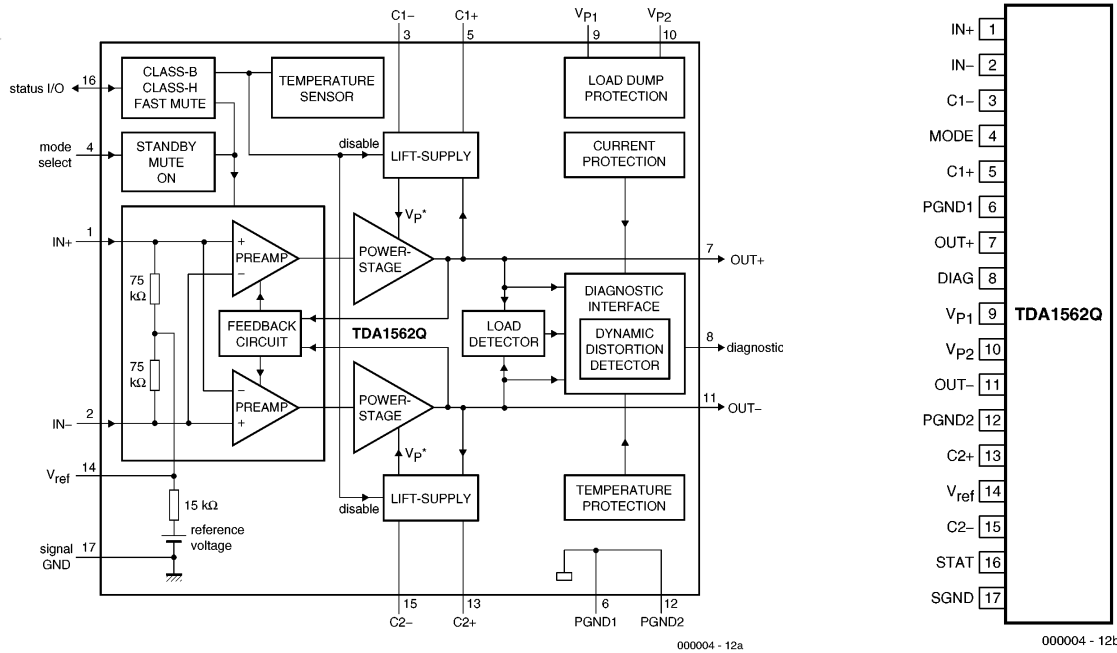
A simple calculation shows that a conventional amplifier operating from 12 V (or maximum 14.4 V when the battery is fully charged) cannot provide a power output of much more than 6 W. Use of a bridge arrangement may push this up to some 20 watts, but that is just about the maximum possible.

Nowadays, many motorists, and more particularly the younger ones, want considerably more power than 6–20 watts. Loudness is their god, but they unfortunately forget that this is an unforgiving god, leading them to early deafness.

Be that as it may, the most obvious way of increasing power output is to raise the supply voltage of 12 V to a higher level by means of a converter. Such a converter, however, is not exactly cheap and is, moreover, a notorious source of noise and interference. In view of the extensive electronic circuits in modern motor vehicles, this latter point is not to be underestimated.

Fortunately for the loudness-hungry, there is an alternative to a converter. Some years ago, Philips introduced a special integrated output amplifier chip, the TDA1560Q, that is able to provide 30 watts into 8 Ω from a 12 V power supply (without the use of a converter). This output power is

Design by T. Giesberts



**Figure 1. Block diagram of the innards of the TDA1562Q. A number of protection networks make the amplifier virtually foolproof.**

obtained by operating the amplifier in Class H (see box elsewhere in this article).

An amplifier based on the Philips device was described in the February 1995 issue of this magazine.

Philips designers have further improved a number of properties of the IC, among which the power output. According to the Philips data sheet, the improved device, the TDA1562Q, can deliver 70 watts into 4 ohms, but that is at the cost of the distortion, which at 10 per cent is rather too high, even for in a car.

The prototype of the design described in this article provides 54 watts into 4 ohms at 1 per cent distortion. Since the number of requisite external components is smaller than in the case of the earlier device, the printed-circuit board is even more compact than that for the February 1995 amplifier.

### THE TDA1562Q

The internal circuitry of the new device is very similar to that of its predecessor. Since, however, not everybody can be assumed to be *au fait* with the February 1995 article, the circuitry is described anew.

The block schematic of the device is shown in **Figure 1**. Particular attention is drawn to the boxes marked 'lift supply', which are necessary in a Class H system (see box).

The IC evaluates the input signal and estimates the consequent drive of the output transistors. When these transistors tend to go into saturation, the supply voltage is raised briefly by switching the capacitors connected to pins 3 and 5, and 13 and 15, in series with the supply voltage.

Apart from the input amplifier and

Class H output amplifier, the device contains several protection circuits. One of these protects the IC against an excessive output current and against short-circuits.

The temperature protection circuit works in two steps. When the first threshold temperature is exceeded, the device switches from Class H to Class B operation. There is then no question of increased supply voltage. When the second threshold temperature is

exceeded, the drive to the output transistors is reduced.

There is also a protection circuit against overvoltage and one against too low load impedances. When the load impedance drops below a predetermined critical level, operation is switched from Class H to Class B. A load impedance smaller than 0.5 Ω is seen as a short-circuit, which causes the device to be switched off altogether.

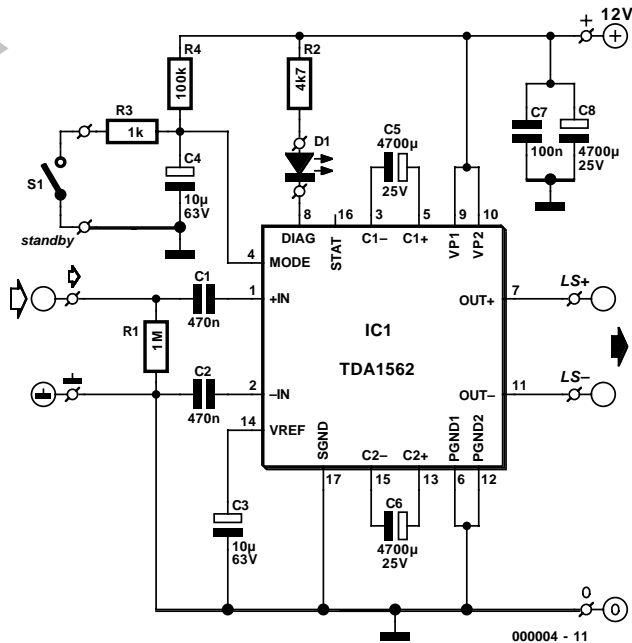
## Brief technical data

### Properties

- High power output through Class-H operation
- Low power dissipation during reproduction of music signals
- Proof against short-circuits
- Protection against excessive temperatures
- Standby switch
- No power-on or power-off clicks
- Visible error indication

### Measurement results (at $U_b = 14.4 V$ )

Supply voltage	8–18 V
Sensitivity	760 mV r.m.s.
Input impedance	70 kΩ
Power output	54 W r.m.s. into 4 Ω ( $f = 1 kHz$ ; $THD + N = 1%$ )
Harmonic distortion (THD + N)	at 1 W into 4 Ω: 0.046% (1 kHz) 0.29% (20 kHz) at 35 W into 4 Ω: 0.12% (1 kHz) 0.7% (20 kHz)
Signal-to-noise ratio (with 1 W into 4 Ω)	88 dBA
Power bandwidth	7.5 Hz – 185 kHz (at 25 W into 4 Ω)
Quiescent current	about 135 mA ('on')



**Figure 2.** The circuit of the amplifier is conspicuous by its simplicity. Diode D1 is an error indicator.

## CIRCUIT DESCRIPTION

The circuit diagram in **Figure 2** emphasizes how few external components are needed to construct a complete output amplifier (in fact, fewer than half the number in the February 1995 amplifier). For instance, the new device does not need compensation networks to enhance the stability. Also, because of the absence of switch-on phenomena, there is no need for a switch-on delay network.

There is, of course, still a need for supply line decoupling capacitors.

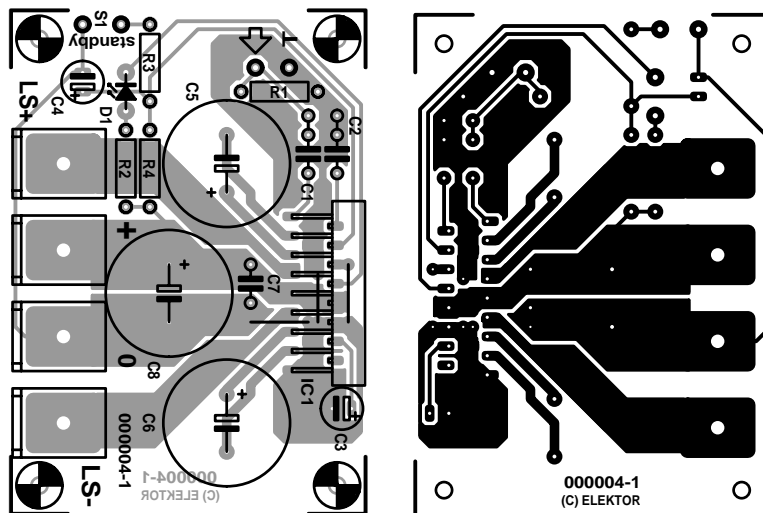
Capacitors C5 and C6 are required for Class-H operation, about which more in the box.

The value of input capacitors C1 and C2 is relatively low, thanks to the high input impedance of the IC.

Switched RC network R4-C4 at the 'mode select' input (pin 4) serves to switch the IC to 'mute' or 'standby'. When the supply voltage is switched on, the IC is first switched automatically to the 'mute' mode and to 'on' only after a short delay. The time constant R4-C4 is a few tenths of a second and this delay between the two states is sufficient to obviate disturbing (and annoying) switch-on phenomena.

Switch S1 enables the amplifier to be switched to 'standby' when the use of the amplifier is not needed

**Figure 3.** The compact printed-circuit board for the amplifier is available through the Readers' services (towards the end of this issue).



for a period of time. When that time has elapsed, the amplifier is quickly reverted to normal operation. The current drain in the standby mode is virtually negligible at only 200  $\mu$ A.

Resistor R3 prevents a short-circuit current ensuing when S1 is being closed at the instant C4 is being discharged.

## ERROR INDICATION

The diagnostic output (pin 8) of the TDA1562Q is one of the few facets of the device that is completely new. As shown in the diagram, it can now be used to drive a visible error indicator, D1, directly. During normal operation the diode should be out. Its lighting may be caused by one of four possible causes.

1. The amplifier is being overdriven. The internal circuit responsible for the indication is the 'Dynamic Distortion Detector' (see **Figure 1**). In practice, this will be the case when the distortion rises above 1.6 per cent at 1 kHz. The diode is, therefore, a kind of clipping indicator.
2. There is a short-circuit between the outputs or between one of the outputs and the supply line. In the first case, the outputs are disabled, whereupon the protection network ascertains at short intervals of time whether the short-circuit has been removed. The DIAG output is then disabled for 30  $\mu$ s at 20 ms intervals. In the case of a short-circuit between one of the outputs to the supply line, the DIAG output remains active.
3. The internal sensor measures a temperature of 145  $^{\circ}$ C, whereupon the

## COMPONENTS LIST

### Resistors:

R1 = 1M $\Omega$   
R2 = 4k $\Omega$   
R3 = 1k $\Omega$   
R4 = 100k $\Omega$

### Capacitors:

C1, C2 = 470nF  
C3, C4 = 10 $\mu$ F 63V radial  
C5, C6, C8 = 4700 $\mu$ F 25V radial  
(18mm max. dia., raster 7.5 mm)  
C7 = 100nF, raster 5 mm

### Semiconductors:

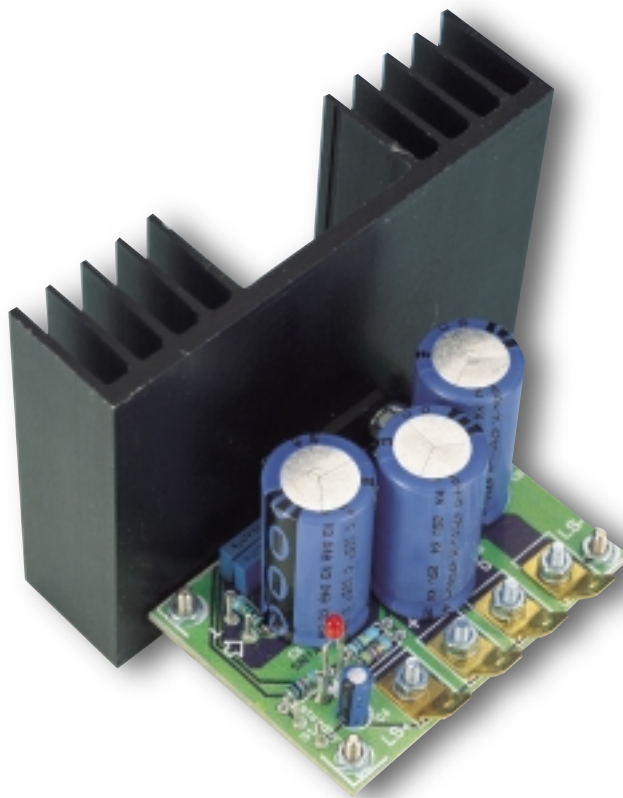
D1 = high-efficiency-LED  
IC1 = TDA1562Q (Philips)

### Miscellaneous:

S1 = single-pole on/off switch  
Four spade connectors, PCB mount  
Heatsink for IC1 ( $R_{th} < 2.5$  K/W)  
PCB, order code 000004-1 (see Readers Services pages)

**Figure 4.** There cannot be many 50 W output amplifiers that are this small.

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relevant protection circuit is enabled.

- The IC is in the power-up state. When it is switched to the 'on' state, the diode goes out. If, however, the output impedance is not to specification during power-up, the diode remains lit.

### A COMPACT BOARD

The amplifier is best built on the single-sided printed-circuit board shown in **Figure 3** (available through our Readers' services – see towards end of this issue). As mentioned earlier, the board is small for an output amplifier. In fact, most of its surface is taken up by the four car-type (spade) connectors via which the power supply and the loudspeakers are connected to the amplifier.

The small size of the board also creates a few difficulties. If, for instance, the electrolytic capacitors are mounted first, the fitting of the IC becomes pretty difficult. It is, therefore, advisable to start with fitting the IC onto the heat sink (using plenty of heat conducting paste).

Also, ensure that after the board has been placed in a suitable enclosure, its solder (track) side remains readily accessible. After the board and heat sink have been secured in the case, solder the pins of the IC to the board.

**Figure 4** shows a photograph of the completed prototype as built up in our design lab.

Make sure that when the board is fitted in the case, the loudspeaker terminals are not (and cannot be) short-circuited to earth. Although the IC is protected against much abuse and misuse, it is always better not to tempt providence.

In most cases, two amplifier modules will be fitted in one enclosure: one for the left-hand channel and the other for the right-hand channel.

Constructors who find 2×54 watts insufficient may consider driving the front and rear speakers in the vehicle by separate amplifiers. This would take the total number of modules required to eight, and these deliver some 400 watts of audio power into the vehicle. A case of minding the windows!

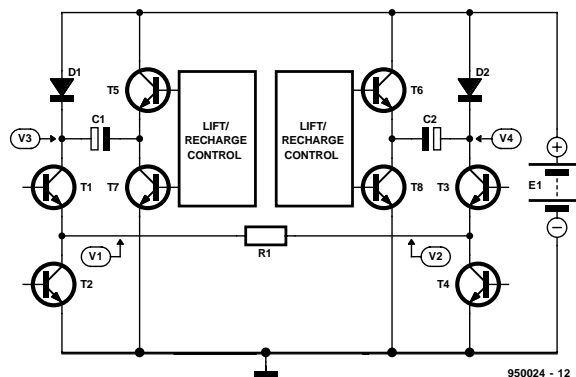
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Text (Dutch original): S. van Rooij

## Class-H operation

A Class H amplifier is somewhat akin to a Class G amplifier, which is a power amplifier in which two Class B amplifiers with different supply voltages are combined. Small-amplitude signals are boosted by the one with the lower supply voltage, resulting in much higher average efficiency for speech and music. When signals exceed the low-voltage supply amplitude, the amplifier that operates from the higher supply voltage takes over, while the first one is switched off.

In a Class H amplifier the supply voltage is varied by an efficient Class S amplifier or the arrangement in the present design so that it remains just above the minimum value required to prevent saturation. This configuration also achieves a much higher average efficiency for speech and music signals. (A Class S amplifier is a pulse-width-modulated audio amplifier in which the active elements are switched by a control frequency several times higher than the signal frequency being amplified. This type of amplifier has an efficiency of some 90 per cent).



In the present amplifier, Class H operation is achieved by the use of two switched capacitors, C1 and C2. These are charged to the battery voltage and switched into series with the 12 V supply line during brief drive peaks.

In the diagram, transistors T1–T4 are part of the 'normal' amplifier, while T5–T8 and C1 and C2 are added for Class H operation. At small-signal amplitudes, T7 and T8 are on and C1 and C2 are charged to the battery voltage via diodes D1 and D2. When the signal amplitude tends to drive T1 or T3 into saturation, the internal sensor (lift/recharge control) detects this and causes T7 and T8 to be cut off and T5 and T6 to be switched on. When that happens C1 and C2 are in series with the supply line; diodes D1 and D2 prevent their being discharged into the battery.

When the input signal amplitude drops, the capacitors are linked to earth again by T7 and T8, whereupon their charge is topped up.