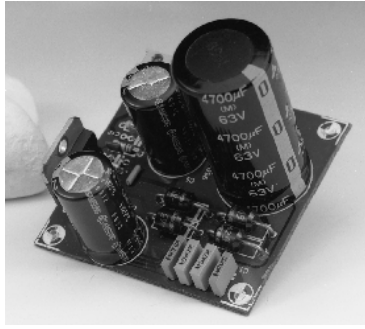


DC-DC converter

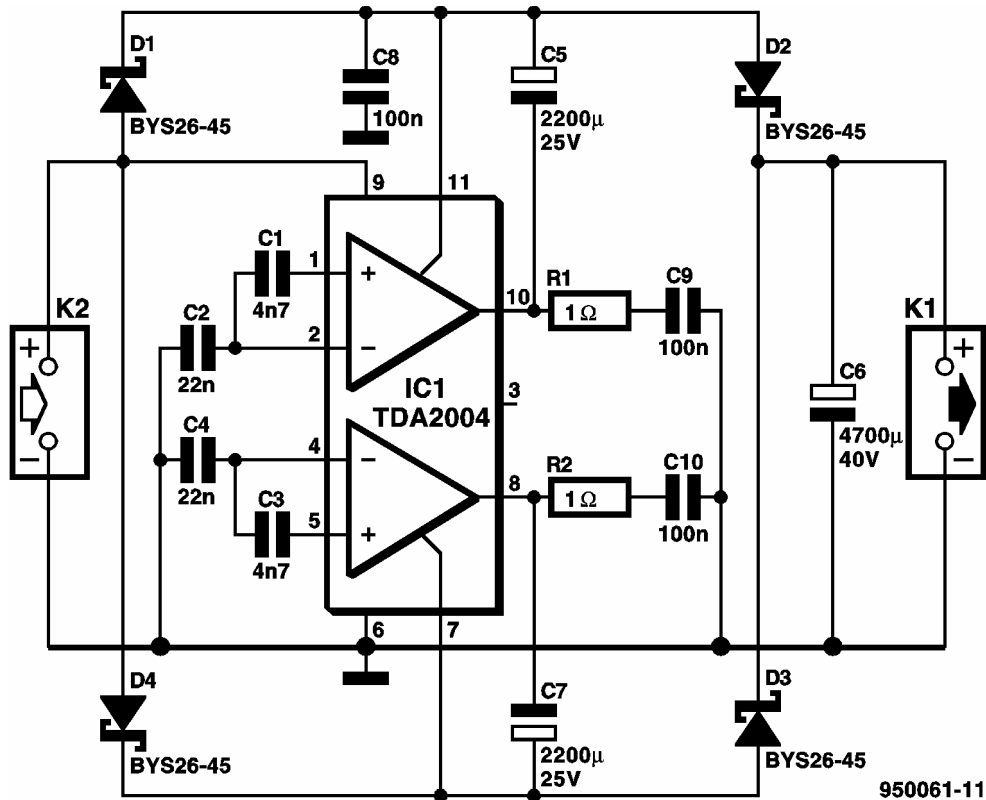
Design by W. Zeiller



There are often occasions when a higher direct voltage is required than an available battery can provide. In many such cases, the circuit described can offer the solution. It can raise 6 V to 12 V or 12 V to 24 V.

There are several special ICs on the market for use in d.c. to d.c. converters. The present circuit, however, uses a standard device: a stereo a.f. amplifier from SGS Thomson, which is arranged rather differently from its usual application.

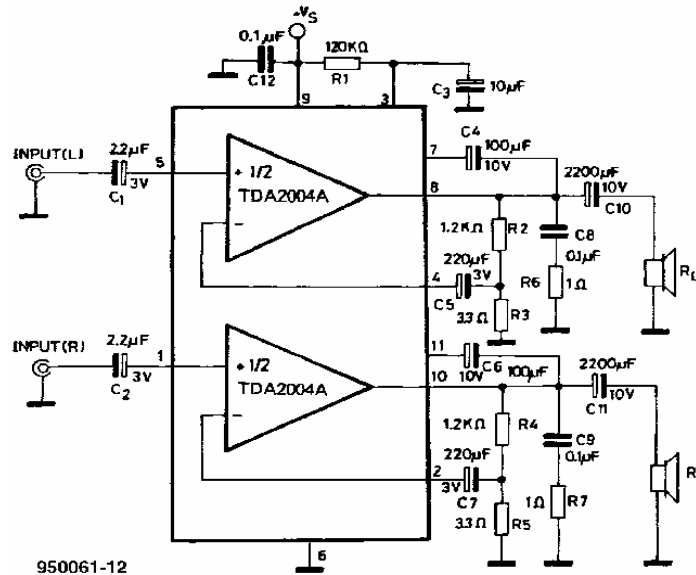
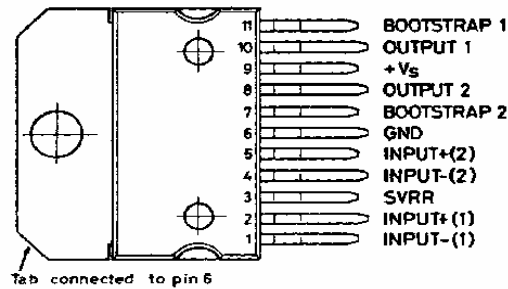
Fig. 1. Circuit diagram of the step-up d.c. to d.c. converter.



Power IC Type TDA2004

The IC used in the converter is a Type TDA2004 integrated Class B stereo power amplifier, developed primarily for use in motor vehicles. Operating from a 12 V battery, it can deliver an output power of 2x10 W. It needs few external components, can provide a current of up to 3.5 A, and can work into loads as low as 1.6 Ohm. The IC is housed in an 11-pin Multiwatt case that does not need to be isolated from a heat sink (if used). It is known for its robustness and is provided with a host of protection facilities, which make it proof against short-circuits, inductive loads, too high temperatures, and so on. The diagram shows the pinout as well as a typical application circuit: a complete amplifier for car radios, which can deliver 2x10 W into 2 Ohm.

Pinout

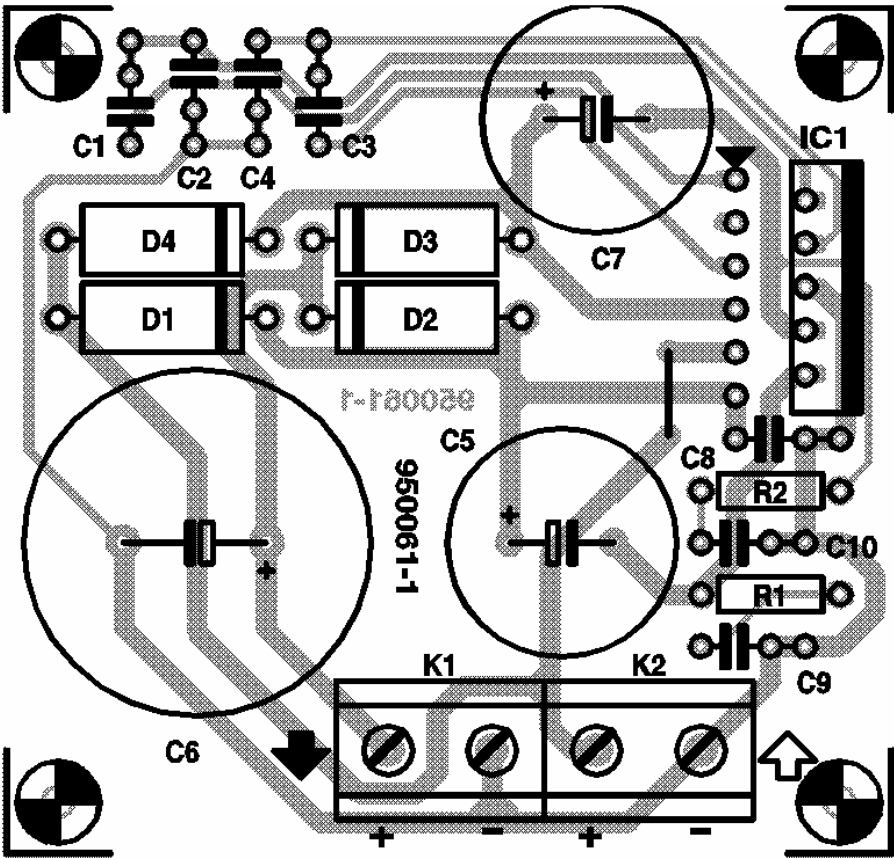


The more important parameters are:

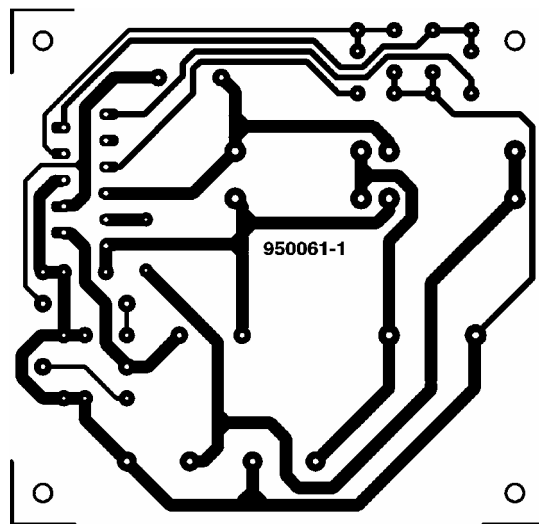
Peak supply voltage:	18 V	Quiescent current:	typically 65 mA, peak 120 mA (for $U_b = 13.2\text{--}14.4\text{ V}$)
Power output:	2x6.5 W into 4 Ohm; 2x10 W into 2 Ohm (for $U_b = 14.4\text{ V}$)	Distortion:	typically 0.2%, peak 1% (for $U_b = 14.4\text{ V}$ and $R_L = 4\text{ Ohm}$)
Bandwidth (-3 dB):	35 Hz to 15 kHz ($R_L = 4\text{ Ohm}$)	Peak output current:	3.5 A
power dissipation:	30 W		

The circuit diagram of the present converter is given in Fig. 1. The available direct voltage is applied to plug K2. The doubled direct voltage is available at socket K1. Whereas one of the prime requirements of an audio design is total freedom of any tendency to oscillate, in the present application this does not matter at all. The two amplifiers contained in the IC are arranged as a multivibrator, which provides a rectangular voltage at a frequency of about 5 kHz. The frequency and duty factor are determined by the values of C1–C4. Operation is straightforward: when the output of one of the amplifiers, say, pin 10, is low, capacitor C5 is charged to virtually the level of the supply voltage via D1. When the multivibrator changes state, pin 10 goes high, which results in the output voltage (i.e., nearly supply voltage level) of the amplifier being added to the potential across C5. This raised voltage is used to charge C6 via D2. This means that the potential across C6 is a pulsating direct voltage with a peak value of very nearly double the supply voltage. Of course, every time pin 10 goes low, the potential drops sharply. The second multivibrator acts in the same way, but in 'antiphase' as it were. This means that when pin 10 goes low, pin 8 goes high. Therefore, when the potential across C5 begins to drop, C7 is being charged to almost double the supply voltage. Since the potential across C7 is also used to charge C6 (via D3), the voltage across C6 is thus nicely 'ironed out'. The aim of the circuit has been reached: the potential across C6 is constantly at a level of double the supply voltage (or very nearly so) and no longer shows a pulsating character. There is, of course, some voltage loss in diodes D1–D4, and also owing to the saturation voltage of the output transistors in IC1, but these combined losses do not amount to much. Networks R1–C9 and R2–C10 are Boucherot networks that are indispensable for maintaining stability in a.f. amplifiers.

Fig. 2. Printed-circuit board for the d.c. to d.c. converter.



Track layout



Construction

The converter is intended to be built on the printed-circuit board shown in Fig.2, which is, unfortunately, not available ready made. The construction of the board is straightforward. Note, however, that, although Schottky diodes are specified for D1–D4, standard 5 A types may also be used. These will, however, lead to a greater difference between double the input and output. If, therefore, the output should be as nearly as possible double the input, Schottky diodes must be used. Depending on the output current, the temperature of IC1 may rise quite appreciably. This is natural, because when the output voltage is 24 V and the output current is 1 A, the power output is well above 20 W. Even assuming an efficiency of 80%, which is, of course, very good, the IC dissipates at least 4 W. It can not handle this without a heat sink (rated at 5 K/W). If the fixing hole of the IC is carefully drilled out from 3.7 mm to 4 mm, the device can be fastened with a brass M4 bolt, which conducts heat much better than the usual iron M3 bolt and is, moreover, insensitive to magnetic influences. The introductory photograph shows the completed prototype board. The choice of enclosure will depend to a very large extent on the envisaged application. There is no restriction on any type, as long as the cooling of the IC is not jeopardized. Note that if the temperature of the IC rises unduly, its protection circuits become active with the result that the voltage plummets. It is, of course, also possible in some applications to build the converter into an existing appliance. Some results measured on the prototype operating from a 12 V battery are as follows. With load currents not exceeding 200 mA, the output voltage remained very close to the theoretical value of 24 V: actual 23.5 V. When the current increased, the output voltage dropped slowly: to 22.3 V at 1 A and to 20.7 V at 1.4 A. The latter figures are about the maximum, because output power is then 29 W. The efficiency of the converter remained in all case above 80%: with an output current of 1 A, it was 85.5%. With 12 V input, the quiescent current of the prototype was about 130 mA. With a dry or small rechargeable battery, this needs to be taken into account; with a car battery it is not worth mentioning.

Parts list

Resistors: R1, R2 = 1 Ohm

Capacitors: C2, C4 = 22 nF C5, C7 = 2200 μ F, 25 V, radial C6 = 4700 μ F, 40 V, radial
C8, C9, C10 = 100 nF C1, C3 = 4.7 nF

Semiconductors: D1–D4 = BYS26-45 (Schottky)

Integrated circuits: IC1 = TDA2004 (SGS Thomson)

Miscellaneous: K1, K2 = 2-way terminal block, 7.5 mm pitch Heat sink 5 K/W (e.g. SK106)