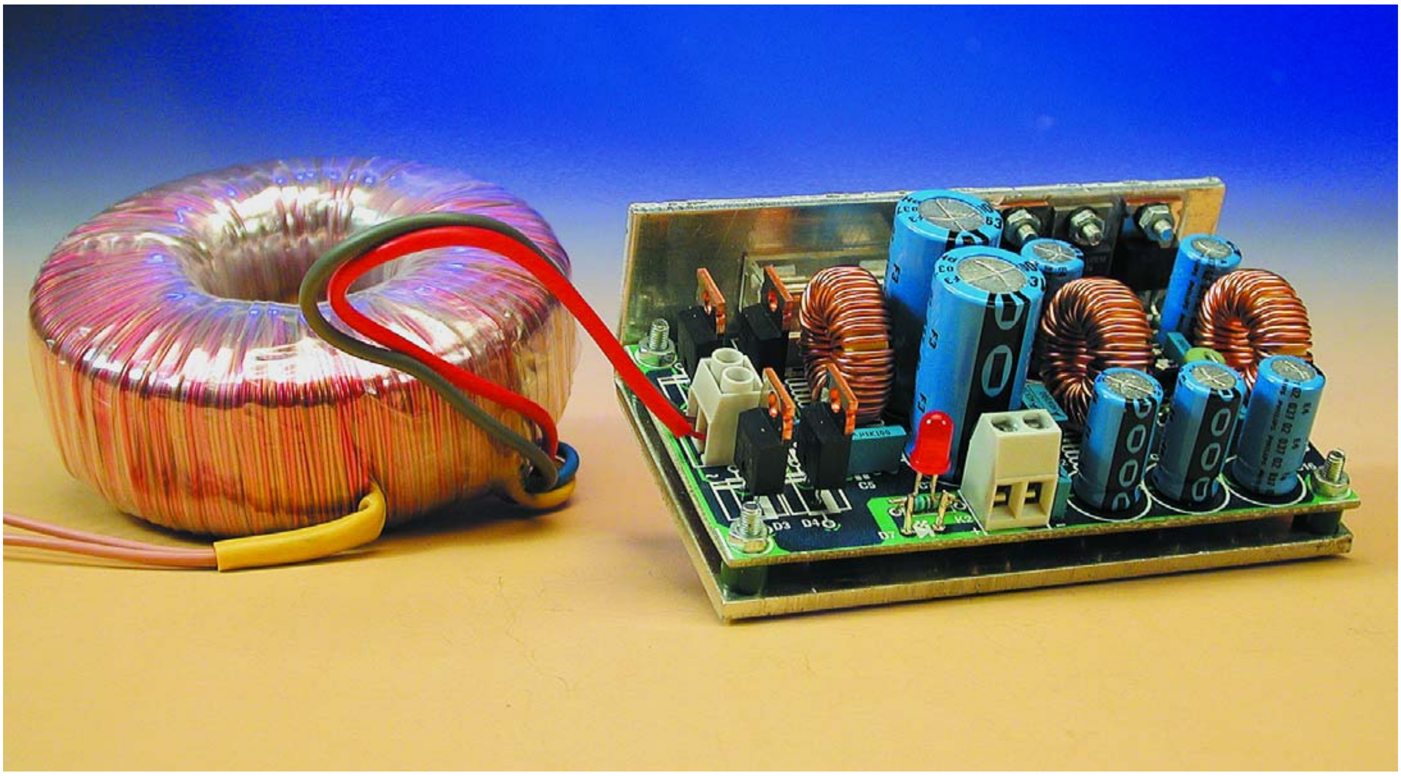
17 V/10 A Switch-Mode Power Supply

For the active multimedia subwoofer

design by T. Giesberts

This compact stabilised power supply was specifically designed to obtain the best performance from the recently described subwoofer that forms part of our Active Loudspeaker System. It produces the ideal supply voltage of exactly 17 V, is capable of sourcing up to 10 A and has an excellent efficiency.



In the article for the active subwoofer we already mentioned that there were two choices for the power supply: the usual combination of a transformer, bridge rectifier and smoothing capacitor, or a stabilised 17 V supply. We promised to publish a design for this in the near future, and here it is.

The first question many readers will ask is why we have used a stabilised power supply in this instance, which we normally don't do for power amplifiers. The main reason for this is that the TDA7374B power amplifier IC can only operate at a relatively low supply voltage. The best performance and maximum power output of this integrated power amplifier are obtained at a supply voltage of 17 V. This is a fairly unusual voltage, which would be difficult to achieve using standard components. The closest you could come to this is with a 12 V transformer, but with rectification the voltage drop across the diodes reduces the maximum voltage to about 15 to 15.5 V. When compared to a supply voltage of 17 V this reduces the maximum power output by a considerable amount, and that would be a pity. There is really only one solution when you want to obtain the maximum power output from the TDA7374B: a stabilised supply providing exactly 17 V.

The next point to consider is how such a stabilised supply should be implemented. A 'classic' linear design requires a heavy-duty regulator, which has an unavoidable voltage drop across it. And at a maximum current of 6 A this should be kept into consideration. This gives it two clear disadvantages. Firstly, the voltage drop gives the supply a low efficiency. Secondly, all losses will of course be converted into heat, leaving the regulator to dissipate a lot of power, which therefore requires a substantial heatsink. Not an ideal solution really.

If you require a reasonable efficient design that has to supply large currents (as we do here), that leaves only one realistic choice: a switch-mode supply. After ample considerations we decided to use an old favourite: the LT1074 made by Linear Technology.

Step-down regulator

The LT1074 is an integrated step-down switching regulator, which can source a healthy 5 A and furthermore requires very few external components. This IC has previously been used in the 'In-car SMPSU', published in the June 2001 issue.

Advantages of the LT1074 are its reliability, response time, as well as its built in protection against overloads and short circuits. The fact that it is a step-down regulator has the advantage that a mains transformer with any secondary voltage between 18 V and 30 V can be used to provide the 17 V output.

One problem is that the LT1074 can 'only' supply 5 A, whereas we need at least 6 A at full power. We have solved this by cleverly connecting two virtually identical LT1074 circuits in parallel, which is described next.

Powerful pair

A quick glance at the circuit in **Figure 1** shows without a doubt that there are indeed two LT1074's and that there are far fewer external components than expected. Of the two ICs, IC1 functions as a 'master regulator', whereas IC2 only springs into action when the output current rises above 5 A.

We now have a look at the standard com-

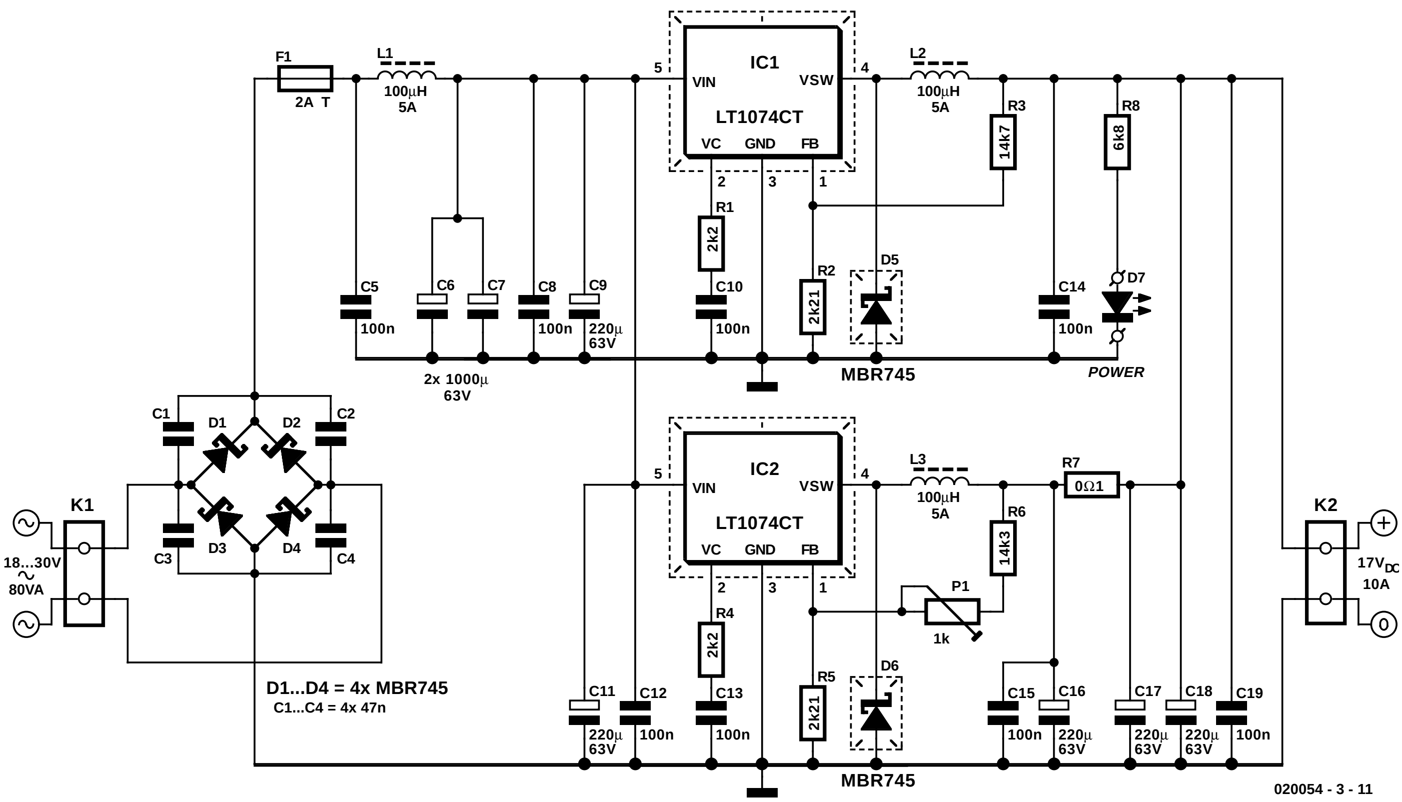


Figure 1. The 'beating hart' of the power supply is a pair of LT1074's.

ponents surrounding the ICs, initially limiting ourselves to the 'master regulator' (IC1), since this is used in a standard configuration.

The transformer voltage from K1 is first rectified using a discrete bridge rectifier (D1-D4). Capacitors C1-C4 have been added to suppress rectifier transients and other noise. The input voltage is then decoupled by L1 and C5/C8/C9, which also prevent switching pulses from the LT1074 finding their way back into the mains.

The output voltage is determined by resistor network R2/R3, where the voltage at pin 1 is compared to the internal reference voltage of 2.21 V. Since we've used a value of 2.21 kΩ for R2 (not coincidentally), you don't even need a calculator to determine that the theoretical output voltage is 16.91 V in this case. R3 has intentionally been connected to a point after inductor L2. Before L2 is a pulse width modulated signal, which has an average that corresponds to the output voltage, but which would throw the reference circuitry into utter confusion.

The R1/C10 network is required for frequency compensation in the LT1047. D5 functions as a freewheeling diode for inductor L2. The smoothing capacitors at the input and output (C6/C7 and C16/C17/C18) have intentionally been connected in parallel in order to reduce the size of the current pulses in individual capacitors. This gives them a longer life and also causes a reduction in the total ESR (equivalent series resistance) and parasitic inductance. With an eye on keeping the ESR as low as possible, a voltage rating of 63 V has been chosen for the electrolytic capacitors.

Now for the second LT1074 (IC2). This has actually been connected in parallel with the first and functions as a sort of 'emergency' supply; it will only start to contribute a current to the output when a heavy load causes the output voltage of IC1 to drop slightly. Two measures were taken to implement this. The first is the addition of series resistor R7 to the output. And secondly, the output voltage of IC2 can be varied using P1. The adjustment of this preset is very simple. With no load connected to the power supply, it should be turned clockwise to just *before* the point where the output voltage at K2 increases. The output voltage of IC2 is then just a fraction below that of IC1, leaving it in an almost dormant state until such time that the first becomes stressed, which is exactly what was intended.

Bridge rectifier and transformer

To keep the efficiency of the supply as high as possible we've used the same Schottky

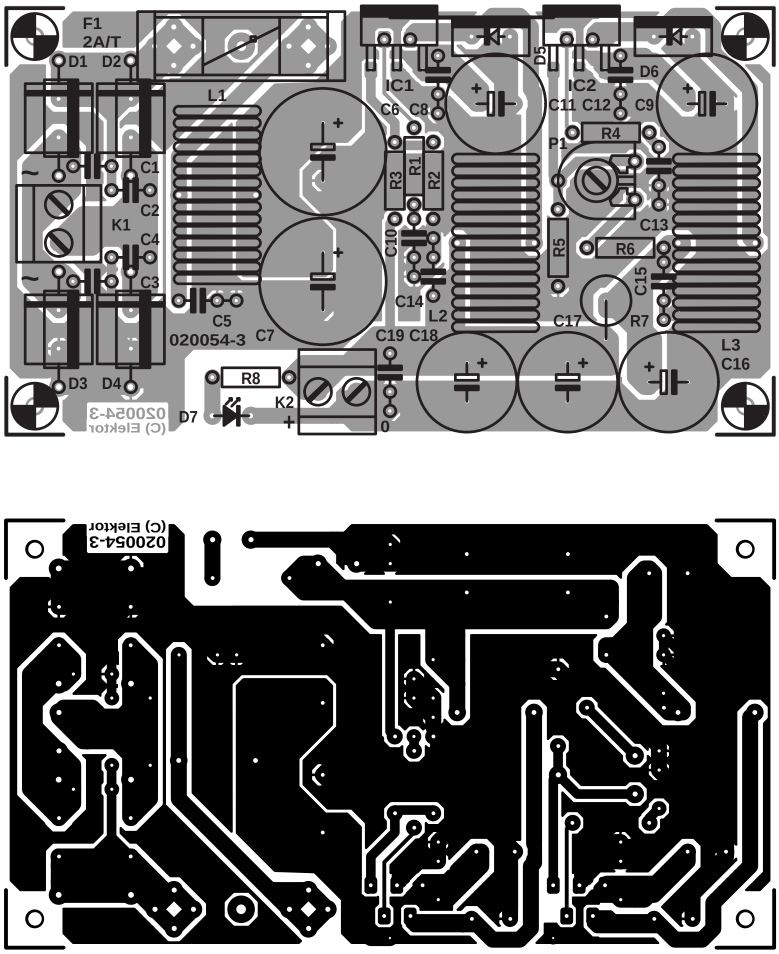


Figure 2. For a power supply that delivers a peak current of 10 A, the PCB turned out surprisingly small.

diodes for D1-D4 in the bridge rectifier as are used for D5 and D6 (the MBR745). These have a very low forward voltage drop, even at high currents, whereas this could easily rise up to 1.5 V for ordinary diodes.

COMPONENTS LIST

Resistors:
R1,R4 = 2kΩ2
R2,R5 = 2kΩ21
R3 = 14kΩ7
R6 = 14kΩ3
R7 = 0Ω1 5W
R8 = 6kΩ8
P1 = 1kΩ preset

Inductors:
L1,L2,L3 = 100µH 5A, e.g., SFT12-50 (TDK)

Capacitors:
C1-C4 = 47nF
C5,C8,C10,C12-C15,C19 = 100nF MKT (metallised film)
C6,C7 = 1000µF 63V radial
C9,C11,C16,C17,C18 = 220µF 63V radial

Semiconductors:
D1-D6 = MBR745 (Schottky diode, 7.5A 45V piv)
D7 = LED, high-efficiency
IC1,IC2 = LT1074CT (Linear Technology)

Miscellaneous:
K1,K2 = 2-way CB terminal block, lead pitch 5mm
F1 = fuse, 2A/T (time lag), with PCB mount holder
PCB, order code **020054-3** (see Readers Services page)

There are still better Schottky diodes, such as the 20TQ045 made by IRF (also 45 V max.), which have an even lower forward voltage drop; these may obviously also be used. With an input voltage of 30 V and using MBR745 diodes, the efficiency was measured to be better than 85%. The quiescent current of the circuit is about 23 mA.

Keeping in mind the efficiency of the power amplifier and supply, we recommend that an 80 VA mains transformer is connected to K1. If you intend to use two subwoofer PCBs, you could use a single 160 VA toroidal transformer to supply two power supply boards (toroidal transformers usually come with two isolated secondaries). The same idea can also be used for the two satellites, which work very well with a rectified and smoothed supply. In this way there are several power supplies that are electrically isolated, thereby avoiding earth loops.

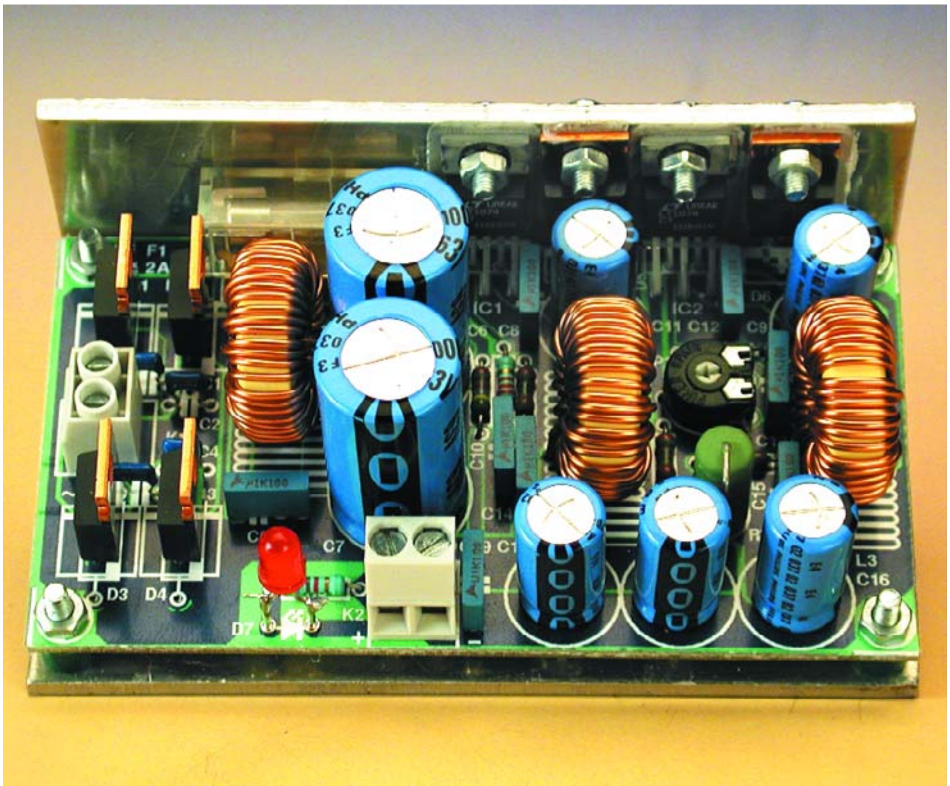


Figure 3. The PCB can be provided fairly easily with a homemade heatsink.

Construction

A very compact PCB has been designed for this circuit, which is shown in **Figure 2**. Populating this PCB shouldn't cause any problems as long as you keep to the usual sequence when soldering the components: the smallest come first, followed by progressively larger ones. Make sure that you don't forget the wire link that runs along the edge of the board behind the pins of IC1, D5 and IC2!

The three inductors, L1 to L3, are ordinary triac suppression chokes that are widely available. The inductance of 100 µH is not critical, but they should be rated for currents of at least 5 A.

The two regulators and their catch diodes have been placed near the edge of the PCB, making it easy to fit them to a heatsink. Its thermal resistance should be around 5 K/W and isolating washers should be used throughout. A small amount of thermal paste improves the thermal conductivity.

It is important that no mechanical strain is introduced to the leads of IC1, IC2, D5 and D6 when they are mounted to the heatsink (this could eventually cause the solder joints to fail). It is for this reason that the pads for D5 and D6 have been placed a bit further from the edge of the PCB; this introduces a small kink in the leads of the diodes, which reduces the strain on them.

Instead of a standard heatsink it is also possible to use a piece of aluminium with a thickness of about 3 mm, which is bent into an L-shape. The photo in **Figure 3** shows what we mean. The capacity of such a homemade heatsink appeared to be more than sufficient in practice, whilst it also made for a nice compact and robust module. The PCB is mounted to the heatsink using four nuts and bolts with stand-offs. These stand-offs have to be the plastic variety, since metal ones could cause shorts between the heatsink and the solder pads of D1 and D3 on the PCB. A bonus of this arrangement is that it can also provide some electrical shielding when the aluminium is connected via a solder tag and short length of wire to the ground of the circuit (the 'zero' connection of K2).

There are a few more practical points regarding the construction. There is space on the PCB to mount a set of normal axial diodes for D1-D4 in an R-6 package, such as the FR606. The efficiency of the circuit is reduced however, and the diodes become fairly warm. In order to prevent the inductors from vibrating and causing noises they should be glued to the PCB using an epoxy adhesive. LED D7 shows when the supply output is present and also functions as an on/off indicator; this LED should therefore be mounted in such a way that it remains visible once the circuit has been encased.

And as a final point we should mention the fuse: the rating of F1 may appear to be a bit low at first, but this value has been chosen to take account of the average power consumption of a subwoofer amplifier. The output current of 10 A should therefore be considered a maximum value and not a continuous current. Just to make things clear: the circuit is certainly capable of supplying a continuous 10 A, but the heatsink (and fuse rating) will have to be upgraded. The current circuit design is perfectly suited for a subwoofer supply.

When connecting the mains transformer to K1 it is advisable to include a mains fuse on the primary side. The exact rating will depend on the type of transformer used, but it will probably be around 200 mA(T).

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