universal power supply

As regular readers will agree, ample space and attention has been devoted to power supplies on Elektor's pages in recent years. They have become one of the designer cuisine's specialities, so to speak. Our September '80 issue, for instance, featured the precision power unit, a very neat, accurate device that can also act as a reference voltage source.
This time Elektor wishes to cater for more universal tastes and has therefore produced a less exclusive, but highly popular power unit: a cheap, straightforward, multi-purpose experimental supply that can be adjusted between 0 and 20 V.

An adjustable power supply can, of course, be designed in a number of ways. To start with, it could be constructed with discrete components only and there are many standard recipes which cater for this. The problem is, however, that a reasonable-size power supply requires quite a few discrete components, so that such circuits end up being highly complicated. Quite unnecessary, in the chip age.
A quick and inexpensive solution, provided the supply only has to deliver fairly low currents, is to use integrated voltage regulators. As soon as higher currents are involved, however, the price of integrated regulators also tends to go up . . . which brings us back to square one.
That is why a compromise must be sought: a reasonable quality power supply without breaking the bank. This particular power supply is a step in the right direction. It combines a few cheap, integrated low-power regulators and several series transistor 'heavies'. The ICs stabilise and control the voltage, without complicating matters, and the transistors provide the required number of amps.
Since the supply voltage of most circuits rarely exceeds 18 . . . 20 V, the upper voltage threshold has been chosen at 20 V. If a higher voltage is required (to test amplifiers, for instance) two power supplies may be connected in series. We'll come back to how that is done later. Besides, a double power supply has considerable advantages, as more and more circuits nowadays need both a positive and a negative voltage. A double version is therefore to be recommended for experimental purposes.
One of this circuit's greatest attributes is that its lower voltage threshold is really and truly 0 V — a commodity which very few other circuits can boast. Because of the large voltage range, provision has been made for both coarse and fine adjustment of the output voltage. Any experimental power supply will, of course, have to be short-circuit proof and this is certainly the case here. However, no arrangement was made for a presettable current limitation, as this would only serve to complicate matters and, in any case, experience has shown that this 'luxury item' is hardly ever used.
The supply can deliver up to 2 A — plenty for most applications. Furthermore, the power supply features a very low ripple voltage due to the IC's high

- output voltage: 0 . . . 20 V coarse and fine adjustment
- output current: 2 A maximum
- short-circuit current: about 2.3 A
- ripple < 1 mV (at full-load)

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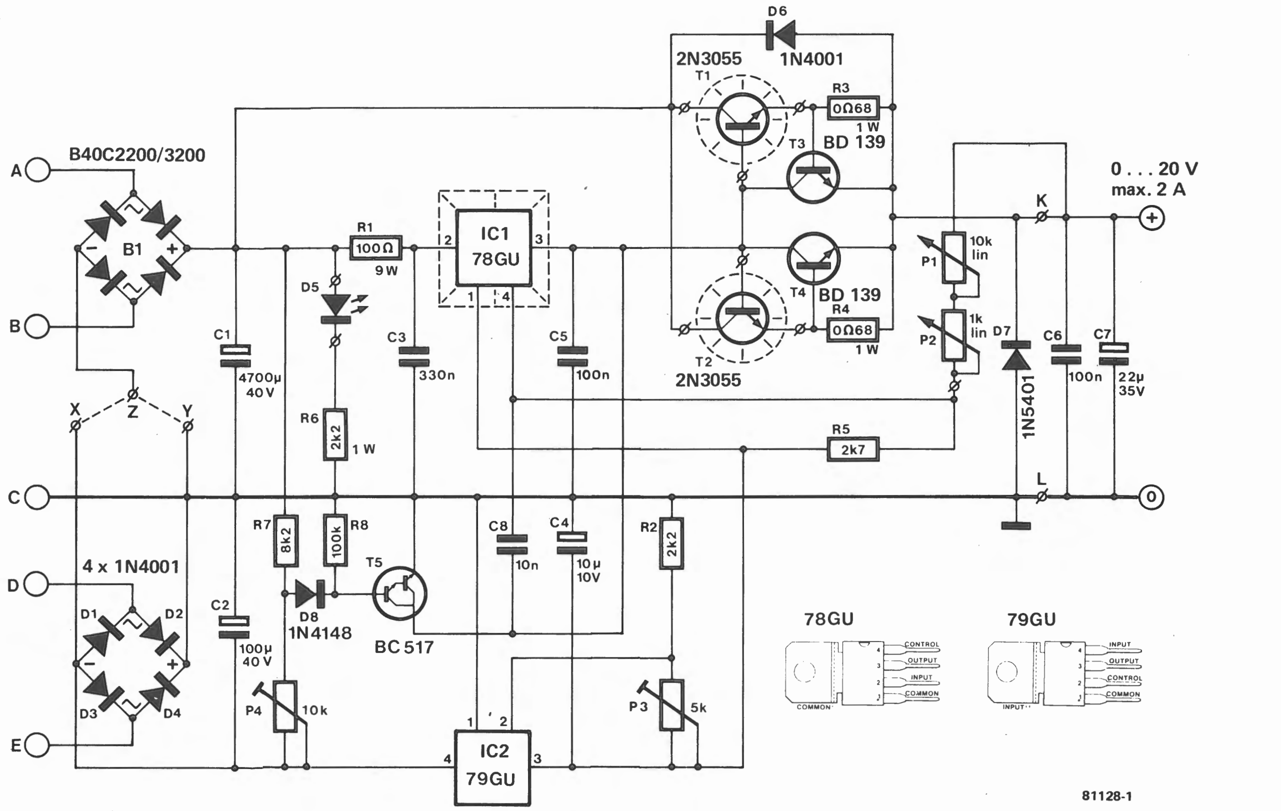

Figure 1. The circuit diagram of the power supply. IC1 is the main voltage regulator and IC2 provides a negative bias voltage enabling the output to be adjusted down to 0 V.

'ripple rejection' (70 dB). It will not exceed 1 mV over the full range of output current and voltage.

The circuit diagram

As figure 1 shows, the power supply circuit really isn't that complicated. In all fairness, this is not the complete version. We have omitted the 'front-end', because the transformer(s) and bridge rectifier B1 and D1 . . . D4 may be connected in various ways, according to the ply's purpose. This aspect will be dealt with further on in the article.

The rectified and smoothed transformer voltages appear across C1 and C2. The higher of the two goes, via R1, to the heart of the circuit: IC1, a four-pin 78GU voltage controller in a 'power watt' case. Normally speaking, the common input of the IC should be grounded, giving a minimum output voltage of 5 V. As it would be nice to have the lower voltage threshold at 0 V, however, the common input is connected to a –5 V negative voltage in this circuit. This negative bias voltage is obtained from the second voltage regulator (IC2) and is adjusted with P3.

The output of IC1 is buffered by two emitter followers (T1 and T2) that are connected in parallel to provide a maximum output current of 2 A. The output voltage can be coarsely adjusted with P1 between 0 and 20 V; P2 provides the fine adjustment.

T3 and T4 ensure short-circuit protection. As soon as the output current exceeds 2 A, the voltage across R3 and

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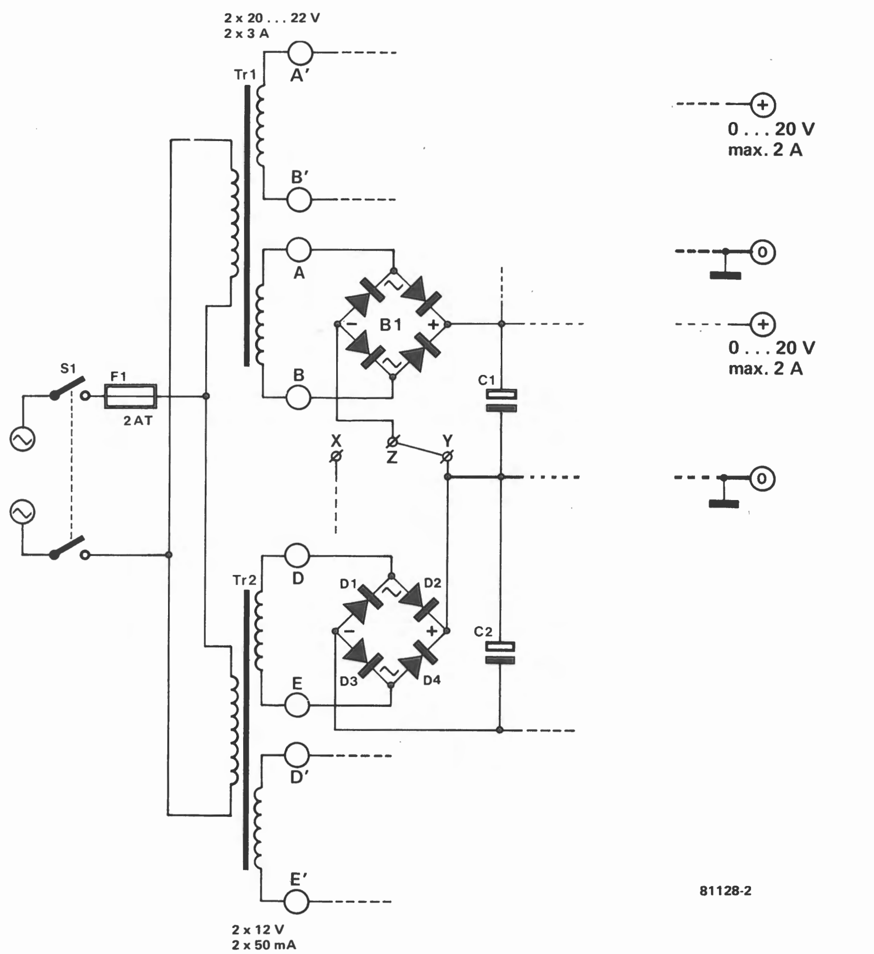

Figure 2. The transformer and bridge rectifier section when a double power supply is built up on two boards.

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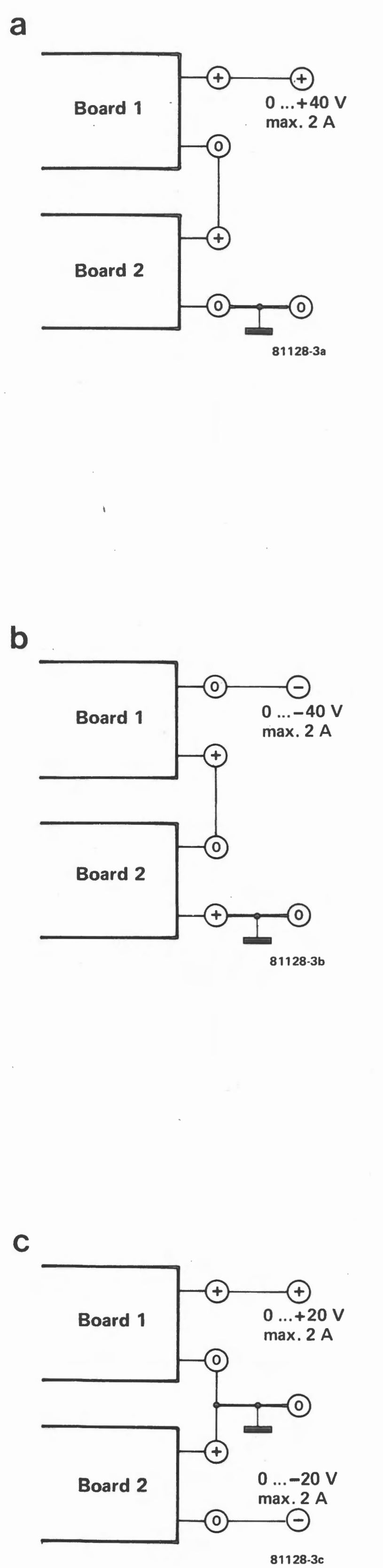

Figure 3. A double power supply is clearly much more universal for experimental supply purposes.

R4 reaches the point where T3 and T4 will start to conduct. This causes the power supply load to be directly connected to the output of IC1. IC1 would now like to deliver its maximum short-circuit current (about 1 A), but is prevented from doing so by R1. R1 usually only has to pass the base drive current to T1 and T2. When there is a short, the voltage across it drops to such an extent that the output current of IC1 is reduced to around 250 mA. In addition, the resistor prevents the thermal overload protection in IC1 from cutting in, as this would produce a square wave at the output.

Obviously, things could go wrong if the negative bias voltage collapses while the main positive supply is still present (immediately after switching off, for instance). For this reason, T5 is added: it shorts the output of IC1 if the negative supply fails.

C6 and C7 serve to 'kill' high frequency components and they also improve the transient response. That is why these capacitors are *not* mounted on the board but directly across the output terminals. D6 and D7 are protection diodes. D6 will bypass IC1, should any irregularity in the load cause current to pass in the wrong direction. D7 prevents IC1 from being blown up, if by chance the output of the power supply is connected to a voltage with the wrong polarity.

LED D5 has the 'cushiest' job of all the diodes: it merely acts as an on/off indicator.

Two versions

As we mentioned before, the transformers and bridge rectifiers have various possibilities, as the circuit can be built as either a single or a double power supply.

Double power supply: 2 x 0 . . . 20 V/2 A

If two individual presettable voltages are to be available, the 'raw' supply section will have to be constructed as shown in figure 2. Transformer Tr1 provides the main supply and a (small) transformer Tr2 provides the supply for IC2. Obviously, the double version will require two printed circuit boards, which are both constructed in the same manner and both include the Z-Y link. The points marked with an accent (A', etc.) belong to the second board.

Two separate supply voltages naturally allow for all sorts of combinations. This is illustrated in figure 3.

Single power supply 0 . . . 20 V/2 A

As figure 4 shows, a single power supply involves fewer components and less work. Only one transformer is now required (although it must have a double winding) and D1 . . . D4 may be omitted. In this case the Z-X link needs to be made.

Connecting B1 in the manner drawn in figure 4 provides IC1 with a positive voltage and IC2 with a negative voltage. In spite of the fact that the voltages are not equally loaded, the supply transformer will be under a symmetrical load.

Construction and setting-up

Figure 5 shows the printed circuit board for the power supply. A number of components are not mounted on the board: the supply transformer(s), the power transistors T1 and T2, the two potentiometers and C6 and C7.

T1 and T2 are mounted together on a heat sink with mica insulation. The heat sink must have 1.7°C/W thermal resistance, or less. These are available with pre-drilled holes (for 2 x TO3). The wiring from the transistors to the circuit

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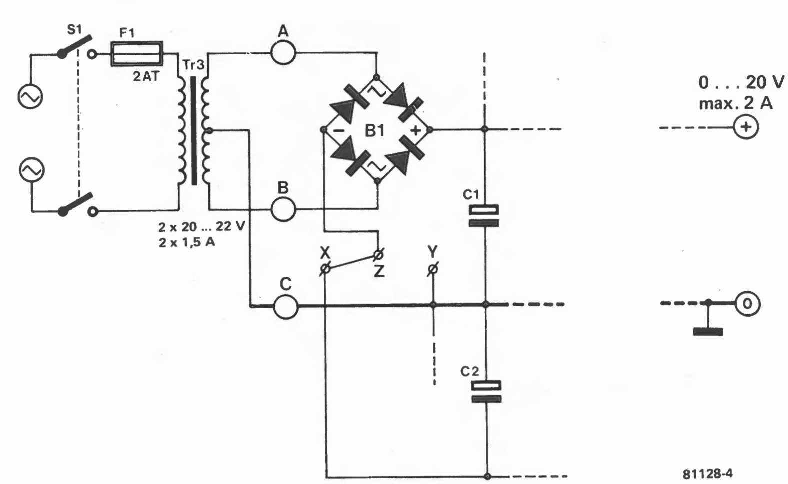

Figure 4. An ordinary single power supply only requires one transformer.

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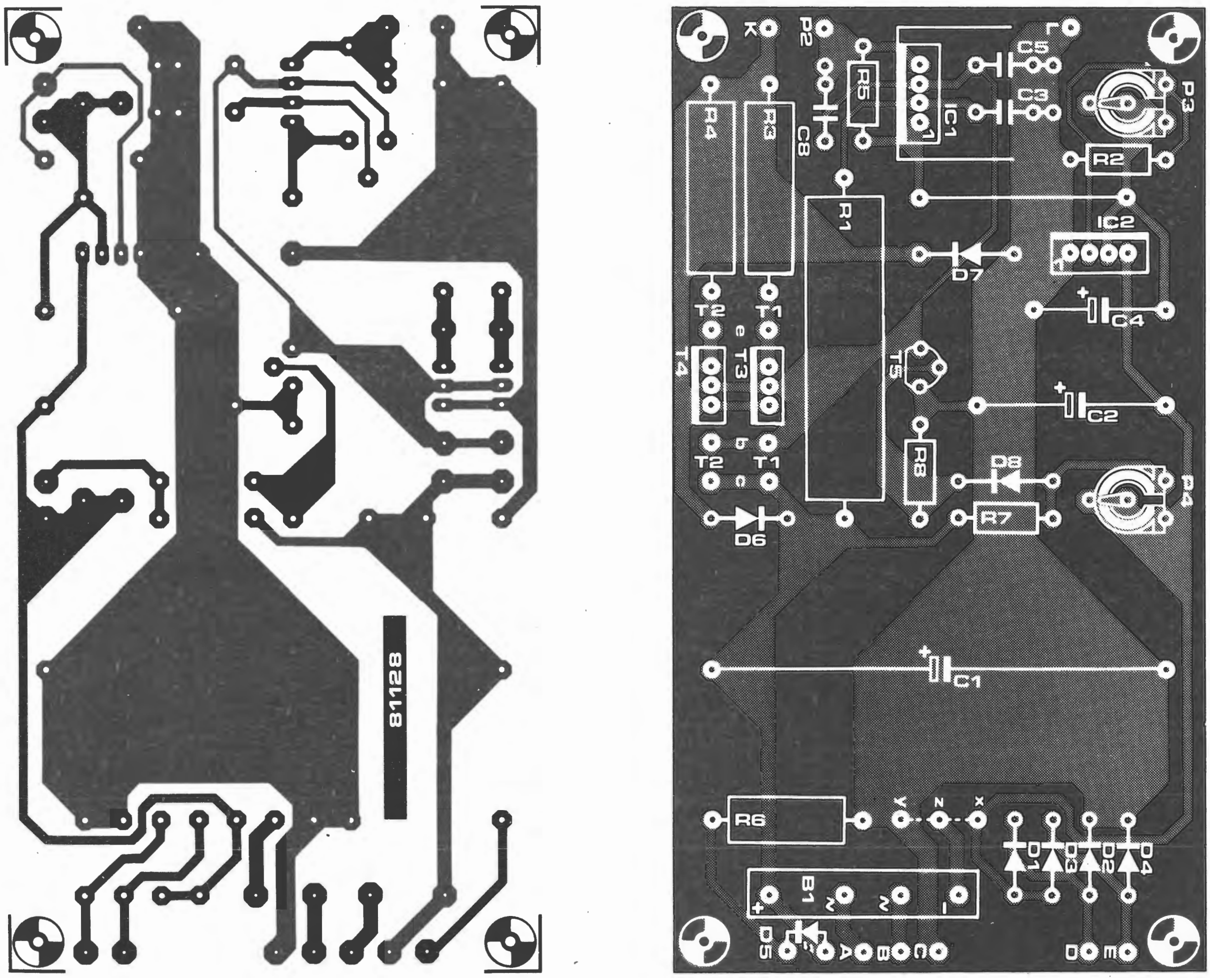

Figure 5. The printed circuit board and component overlay of the universal power supply.

Parts list

Resistors:
R1 = 100 Ω/9 W
R2 = 2k2
R3,R4 = 0.68 Ω/1 W
R5 = 2k7
R6 = 2k2/1 W
R7 = 8k2
R8 = 100 k

Capacitors:
C1 = 4700 μ/40 V
C2 = 100 μ/40 V
C3 = 330 n
C4 = 10 μ/10 V
C5,C6 = 100 n
C7 = 22 μ/35 V
C8 = 10 n

Semiconductors:
IC1 = 78 GU
IC2 = 79 GU
T1,T2 = 2N3055
T3,T4 = BD 139
T5 = BC 517
D1 . . . D4,D6 = 1N4001
D5 = LED
D7 = 1N5401
D8 = 1N4148

Miscellaneous:
P1 = 10 k, linear
P2 = 1 k, linear
P3 = 5 k preset
P4 = 10 k preset
S1 = mains switch
F1 = 2 A fuse, slo blo
B1 = B40 C2200/3200 (40 V/2 A bridge rectifier)
Tr1 = 2 x 20 . . . 22 V/2 x 3 A transformer (figure 2)
Tr2 = 2 x 12 V/2 x 50 mA transformer (figure 2)
Tr3 = 2 x 20 . . . 22 V/2 x 1.5 A transformer (figure 4)

board should be as short as possible and preferably of equal length. The base and collector connections to T1 and T2 all require their own leads to the board.

IC1 must also be provided with a heat sink, albeit a very small one. Please note: the power supply case may *not* be connected to the circuit's '0'. It should only be connected to mains 'earth'.

All that remains now is to calibrate the circuit. This can be done quite easily with a good quality multimeter. Let's deal with it step by step:

- Turn P3 and P4 to 0 Ω (fully anti-clockwise).
- Switch on (mains switch S1) and set P1 and P2 to minimum resistance.
- Turn up P4 until 0 V is measured at the R7-P4-D8 junction.
- Now turn P3 until exactly 0 V is measured at the output of the power supply.
- P1 and P2 can now be used to adjust the output voltage between 0 and 20 V.

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