ATX Power Sup

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PC power supplies can often be bought cheaply at places such as computer fairs. But it isn't that easy to check if such a (second hand) power supply still works properly. This dedicated tester makes that job quick and straightforward.

ply Tester Checks all voltages

New ATX 2.2 specification

This tester was designed for recent ATX power supplies, but it is also ready for use with new power supplies described in version 2.2 of the ATX specification. These have a main connector with 24 pins instead of 20 (75 Watt extra for use by PCI Express cards).

There is a curiosity in the new specification regarding the -5 V connection. According to version 2.2 of the specification it is no longer used and the pin in question (20) is marked as NC (not connected). However, according to the manuals of several motherboards with a new 24-pin connector the –5 V is still present. So keep in mind that when you test a power supply with a 24-pin connector the –5 V output may or may not exist. The –5 V should always be present on a 20-way connector.

The change from 20 to 24-pin connectors is compatible with the older 20-pin connectors, with an extra +3.3 V, +5 V, +12 V and ground added to one end. An older ATX power supply with a 20-pin connector fits in a 24-pin socket and can only be inserted one way, so mistakes aren't possible.

Figure 1. The pin-outs for 20 and 24-pin ATX power connectors.

Apart from the power supply and this tester, you'll only need a mains cable (and socket!). All outputs from the power supply can be tested under load and any deviations from the nominal values are shown on 6 LEDs.

Although the power supply in a PC has little bearing on its overall speed, there are times when it needs to be replaced. This may be because the old power supply has simply given up the ghost, and sometimes the internal fan has become too noisy, or an upgrade of the PC has increased the power requirements above that what the old power supply can deliver. ATX power supplies are available from virtually every computer shop. When you buy a new power supply it is obviously safe to assume it will be in perfect working order. But when you buy a (used) power supply at a computer fair or boot fair you want to be sure that it works *before* you fit it into the case and connect it

to the motherboard. A quick test would be very useful then. The true hobbyists may also want to investigate the exact fault in a broken power supply. But it isn't a straightforward job to test a PC power supply with a multimeter.

The power supply tester described here is a very useful and compact tool. We have to admit that you probably won't need it very often. But once you have acquired one, word will spread amongst your circle of friends and you shouldn't be surprised when you're called to 'quickly' check a PC power supply for them.

What is measured?

Our tester doesn't require a separate power supply, as it takes its power from the PC power supply under test. All you need to do is plug the power supply into the tester and then use a mains lead to connect it to the mains. A rotary switch is then be used to quickly check all the out-
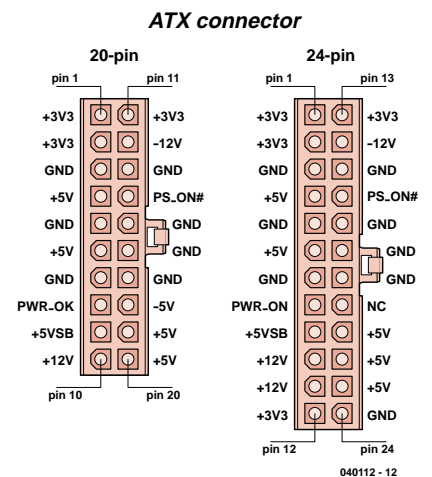
put voltages. The percentage deviation of a selected output is shown on 6 LEDs. Two of these LEDs show whether the deviation is positive or negative and the other four indicate the percentage difference from the required output voltage.

For output voltages that are connected to more than one pin only the first pin is tested. (A power supply generates only a single +5 V supply, even though it is made available on several pins.)

There is a 26-pin header (K2) on the PCB that can be used to test each pin individually. The outputs are connected through 1 kΩ resistors to protect them against short circuits. If you connect an extension lead to this header you can use a multimeter to take measurements from any pin.

A look at the circuit

An ATX power supply has a total of 6 output voltages, which all have to be tested: +3.3 V, +5 V, +5 V for
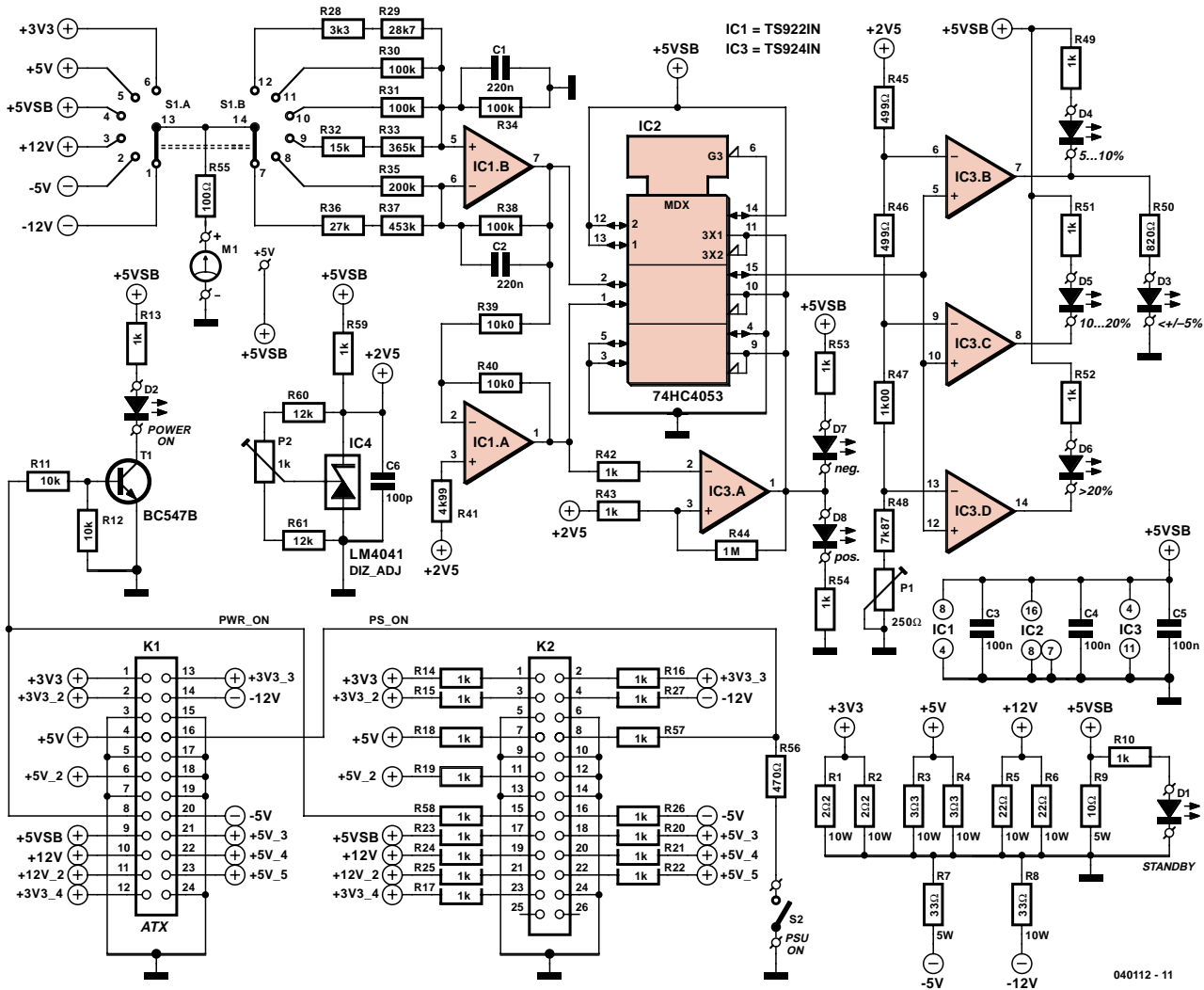
Figure 2. The measurement circuit itself is fairly small. A lot of room is taken up by the power resistors (R1-R9), which load the power supply.

standby, +12 V, –5 V and –12 V. The standby voltage (+5VSB) is always present as long as the mains is connected. This voltage is therefore used as the supply for the tester (**Figure 1**). LED D1 is driven directly from the +5VSB supply and hence indicates that the mains is turned on and that the power supply has at least a working standby voltage.

The power supply is turned on by closing switch S2. This pulls pin PS_ON sufficiently low via R56. According to the specification this pin should be <0.8 V at 1.6 mA. A value of 470 Ω for R56 achieves this. The PWR_ON output, also called PWR_GOOD or PWR_OK, is used by the power supply to show that the most important outputs (+12 V, +5 V and +3.3 V) are within their limits and can supply a nominal current. When this signal is active, D2 lights up. Since this output can only source

200 µA at a minimum voltage of 2.4 V, a buffer stage consisting of R11, R12 and T1 has been added.

Once the mains is turned on (and D1 and D2 are lit), S1 is used to select the voltage that is connected to the input of amplifier IC1b.

S1 is a 2-pole 6-way rotary switch (it has to be a break-before-make type, otherwise you'll introduce shorts in the outputs). The first switch selects the supply voltage to be tested. The common output of this switch is also connected to a PCB pin (via a 100 Ω resistor for protection). It is possible to connect a small voltmeter module to this pin, so that the absolute value of the selected voltage can be seen. Next to the connection for the meter (M1) is an extra PCB pin with +5 V for the voltmeter module.

The selected voltage makes its way via the common of S1b to one of the potential dividers connected to the inputs of IC1b.

Each resistor combination gives the right amount of attenuation to the chosen voltage such that the output of IC1b will be a nominal 2.5 V at every position of S1. There is no need for a symmetrical power supply to measure negative voltages because IC1b is a rail-to-rail type opamp. With positive voltages IC1b functions as a non-inverting buffer. The two negative supply voltages are inverted and attenuated.

We now take a small jump to the tolerance LEDs in the circuit (D3-D8). According to the ATX specification all voltages should be within ±5%, with the exception of -12 V, which may be ±10%. We have therefore chosen four tolerance ranges that are covered by the LEDs: <5% (green LED D3), 5-10% (yellow LED D4), 10-20% (red LED D5) and >20% (second red LED D6). The range division at 10% was used to give you the choice whether to accept that deviation or

Circuit details

The potential dividers for IC1b have been designed as accurately as possible through the use of resistors from the E96 series. Three of the dividers are made with a (large) E96 and a (small) E12 resistor to get as close to the theoretical value as possible. Since the value of the E12 resistor is much smaller than that of the E96 resistor connected in series, it only has a small effect on the total tolerance. Hence a resistor from the E12 series is suitable here.

Although capacitor C6, which is connected in parallel to reference zener IC4, is not essential according to the data sheet, a little bit of HF decoupling never does any harm with a switched mode power supply.

R41 reduces the effect of the input bias current of opamp IC1a, keeping any error limited mainly to that from the tolerance of resistors R39 and R40.

A small amount of hysteresis is required around IC3a to make it switch cleanly. This does introduce a small error near the zero point as far as a positive or negative deviation concerns ($\pm$0.1%), but this is very small compared to the tolerance levels we're looking at.

For IC3b-d, which are used as comparators, we have intentionally used opamps rather than real comparators because these usually have open-collector outputs. These wouldn't be suitable for this purpose.

The reference voltages (via R45-R48 and P1) for the comparators are 5%, 10% and 20% lower than the main 2.5 V reference (2.375 V, 2.25 V and 2 V respectively). Resistors R45 and R46 in the potential divider should of course have been exactly 500 Ω, but 499 Ω is a difference of only 0.2%, which is much less than the tolerance of the resistors themselves.

not. A difference of more than 20% is not acceptable in any case.

These LEDs are driven by comparators IC3b-d, which have their inverting inputs connected to a potential divider (R45-R48 and P1). This determines the tolerance ranges with respect to the 2.5 V reference voltage. P1 is used to set the reference levels as accurately as possible.

This just leaves the section that joins the output signal from IC1b to the LEDs. This output signal is nominally 2.5 V and may be a bit more or less when it deviates. But the comparator circuit built round IC3b-d can only indicate negative differences. To get round this problem IC1a inverts the output signal from IC1b. This is followed by an analogue switch that can be controlled using a digital signal. This switch is part of IC2 (a triple analogue multiplexer). The output signal from IC1b and the inverted one from IC1a are connected to inputs Y0 and Y1 of an analogue switch (pins 2 and 1 on IC2). The output of IC1a is also connected to opamp IC3a, which acts as a comparator and compares the signal with the 2.5 V reference voltage. The output of IC3a acts as the control signal for the analogue switch. When the deviation is negative (<2.5 V), IC3a switches pin 2 of IC2 to the output (pin 15), which is connected to the comparators. When the deviation is positive (>2.5 V), the inverted signal (pin 1) is connected to pin 15. In this way LEDs D3-D6 always show the deviation com-

pared to the nominal value. The output of comparator IC3a is also connected to two LEDs, which indicate if the measured voltage is greater or smaller than the nominal value. The yellow LED (D7) is lit when the voltage is lower and the red LED (D8) indicates that the voltage is higher than the reference voltage.
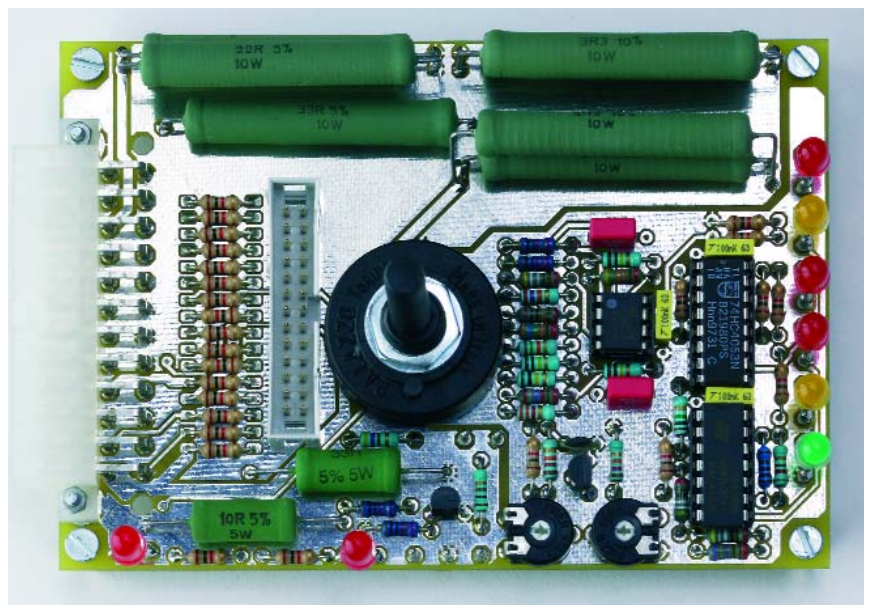
The 2.5 V reference voltage mentioned a few times previously is supplied by an LM4041DIZ-ADJ (IC4) made by National Semiconductor. This voltage can be adjusted to exactly 2.5 V with preset P2.

All outputs from the ATX power supply are provided with a resistive load, where some outputs are loaded more than others. The +3.3 V and

+5 V outputs often require a minimum load for the power supply to operate correctly, and are therefore loaded more heavily. To avoid excessive heat generation we haven't taken the maximum power from the supply, but have limited it to some 45 W (R1 to R9).

Construction

The PCB designed for the tester is shown in **Figure 3**. The dimensions of the PCB have been kept as small as possible and are not based on any particular enclosure. The ATX power supply connector is on the edge of the PCB, so that this can stick out through the side of an enclosure.

COMPONENTS LIST

Resistors:
R1,R2 = 2Ω2 10W
R3,R4 = 3Ω3 10W
R5,R6 = 22Ω 10W
R7 = 33Ω 5W
R8 = 33Ω 10W
R9 = 10Ω 5W
R10,R13-R27,R42,R43,R49,R51-
   R54,R57,R58,R59 = 1kΩ
R11,R12 = 10 kΩ
R28 = 3kΩ3
R29 = 28kΩ7
R30,R31,R34,R38 = 100 kΩ
R32 = 15kΩ
R33 = 365kΩ
R35 = 200kΩ
R36 = 27kΩ
R37 = 453kΩ
R39,R40 = 10kΩ0
R41 = 4kΩ99
R44 = 1MΩ
R45,R46 = 499Ω
R47 = 1kΩ00
R48 = 7kΩ87
R50 = 820Ω
R55 = 100Ω
R56 = 470Ω
R60,R61 = 12kΩ
P1 = 250Ω preset
P2 = 1kΩ preset

Capacitors:
C1,C2 = 220nF
C3...C5 = 100nF
C6 = 100pF

Semiconductors:
D1,D2,D5,D6,D8 = LED, red, low-
   current
D3 = LED, green, low-current
D4,D7 = LED, yellow, low-current
T1 = BC547B
IC1 = TS922IN (ST Microelectronics,
   Farnell # 332-6275)
IC2 = 74HC4053
IC3 = TS924IN (ST Microelectronics,
   Farnell # 332-6299)
IC4 = LM4041DIZ_ADJ (National
   Semiconductor, Farnell # 271-263)

Miscellaneous:
K1 = 24-way angled ATX header, PCB
   mount (Molex 39291248, Farnell #
   413-8508)
K2 = 26-way boxheader (2x13)
S1 = 2 pole 6 position rotary switch,
   PCB mount
S2 = on/off switch, 1 contact
Optionally:
M1 = $3^1/_2$-digit LCD voltmeter module,
   range 0-20 V (e.g., Farnell # 422-
   0146)
Enclosure: e.g., type 1455L1601BK
   (Hammond Manufacturing)

PCB, order code **040112-1**, see
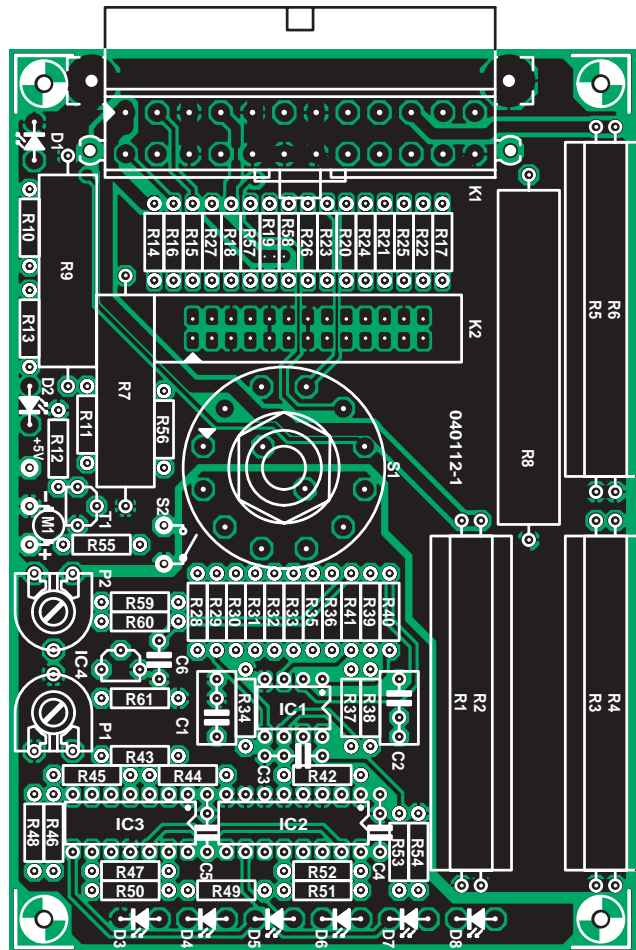   Readers Services page

Figure 3. There is room on the PCB for all components. The power resistors are mounted on top of each other.

This makes it much easier to insert the connector from an ATX power supply.

There are no 'special' parts on the PCB. As long as you take care with the polarity and values of all components, and solder neatly, you shouldn't have any problems with the construction.

All the power resistors are also mounted on the PCB. Due to the heat these generate they should be mounted at least 2 or 3 mm above the PCB, otherwise the PCB will give off smells. (The resistors will do that in the beginning anyway). Resistors R1, R3 and R5 are mounted another 2 to 3 mm above R2, R4 and R6. This method of construction leaves enough air around the power resistors for ventilation.

Before you mount the board into an enclosure or drill any holes, you should make a careful note of the distance between the rotary switch and the ATX power supply header. The wiring for the LEDs and the on/off switch can be made with thin stranded wire.

Since this circuit generates a fair amount of heat, it is advisable to use a metal enclosure with sufficient (possibly even forced) cooling. A miniature 5 V fan will be essential if you use a small enclosure. This can be connected to the +5 V pin for the voltmeter module. Make sure that you have enough ventilation holes in the enclosure.

To give the tester a professional look, and make it easier to use, we have produced a front panel, which is shown at a reduced size in **Figure 5**.

Calibration and operation

There are two presets on the PCB that can be used to set the tester up accurately, although the circuit works perfectly well when they are set to their mid-position. For those of you who want to set the tester up as accurately as possible we'll explain the calibration procedure.
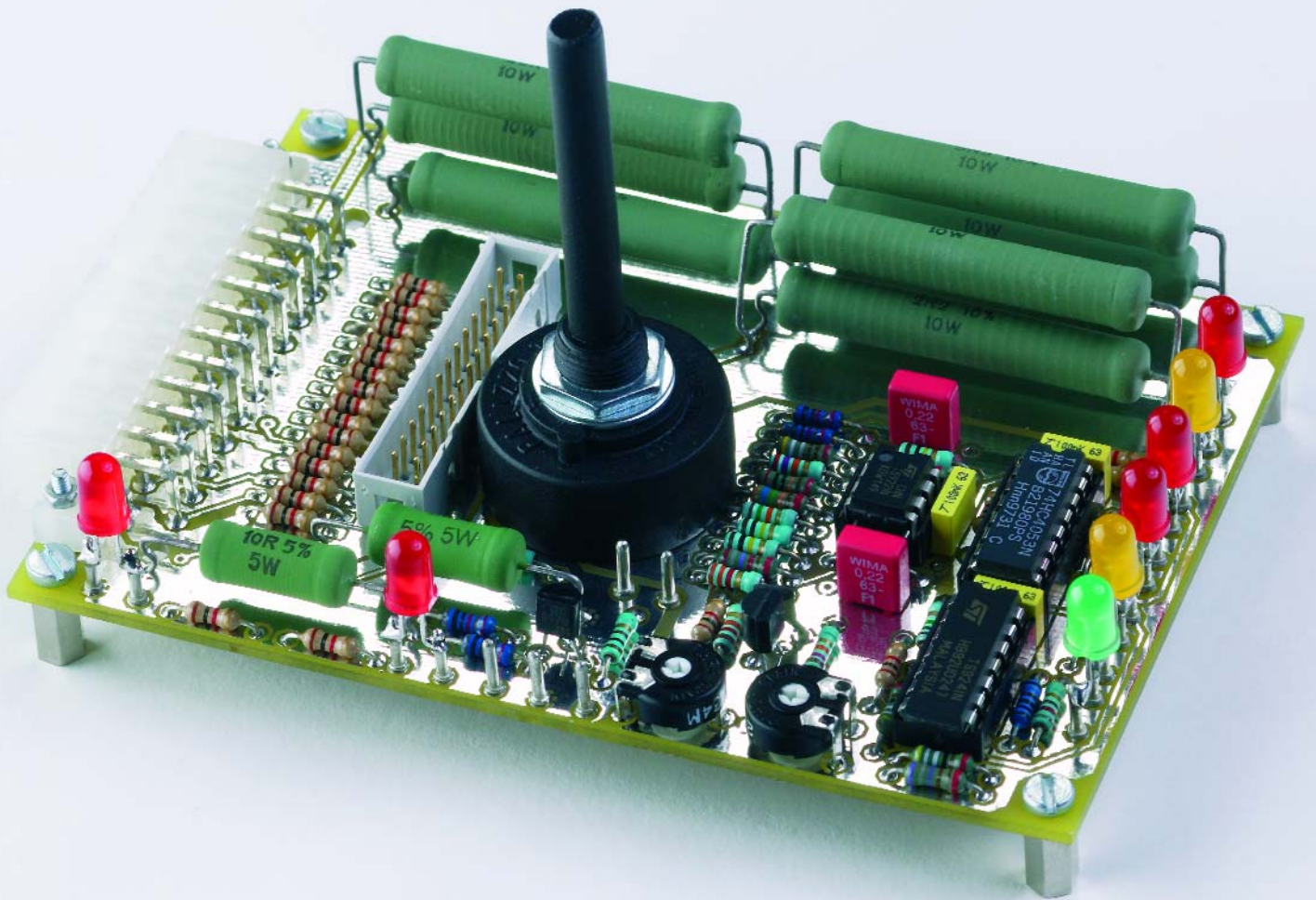
Figure 4. The completed PCB. When the tester is mounted in an enclosure you should make sure that there is plenty of ventilation for the power resistors.

Connect a multimeter between R43 (from the lead nearest P1) and ground. Adjust P2 to give a reading of exactly 2.50 V. Then connect the multimeter between R48 (from the lead nearest the mounting hole) and ground. The voltage at that point should then be adjusted with P1 to give a reading of 2.00 V. And that's it! The use of the tester is very straightforward. First connect the supply connector (either the 20-pin or the newer 24-pin) from the ATX power supply under test. A 20-way plug is connected to the 'bottom' of the connector on the PCB, i.e. from pin 1 onwards. It won't fit any other way due to the shape of the plug and socket. The power supply should then be connected to the mains, and the mains turned on. The standby LED should now light up. If that isn't the case then the power supply has a serious fault and is best discarded. Turn the power supply on by closing S2. After a short delay LED D2 comes on if the power supply passed its self-test. You then use the rotary switch to select the voltages one by one and read from the LEDs how good the tolerance is. When you're finished you turn of the power supply again with S2. Remember that you shouldn't leave the tester on unnecessarily for long periods, because the power resistors generate a fair amount of heat.
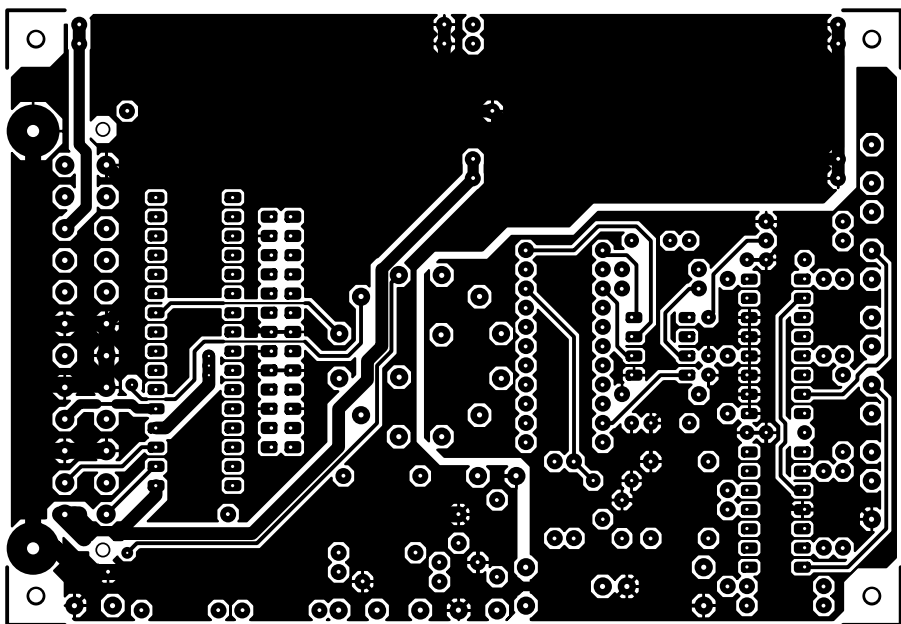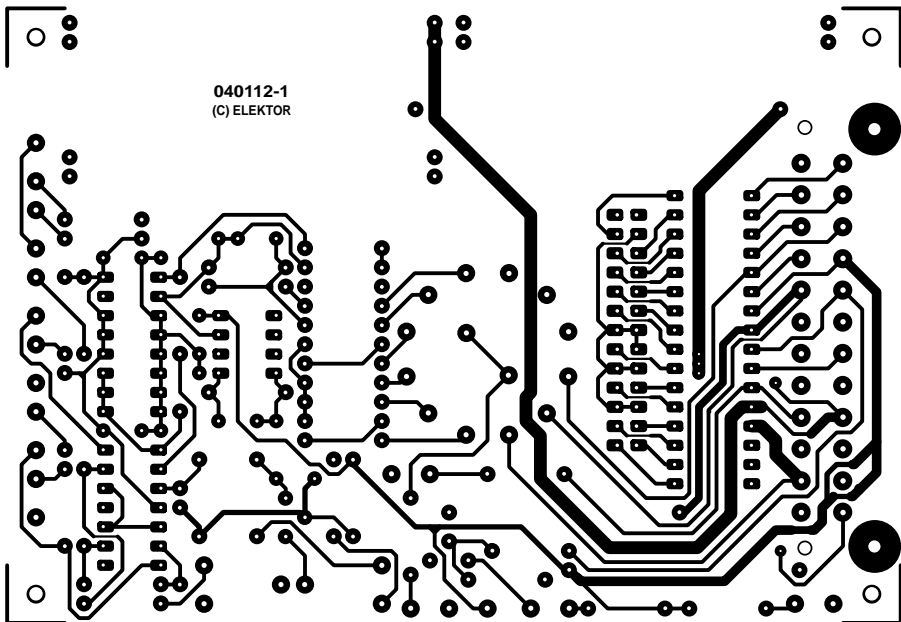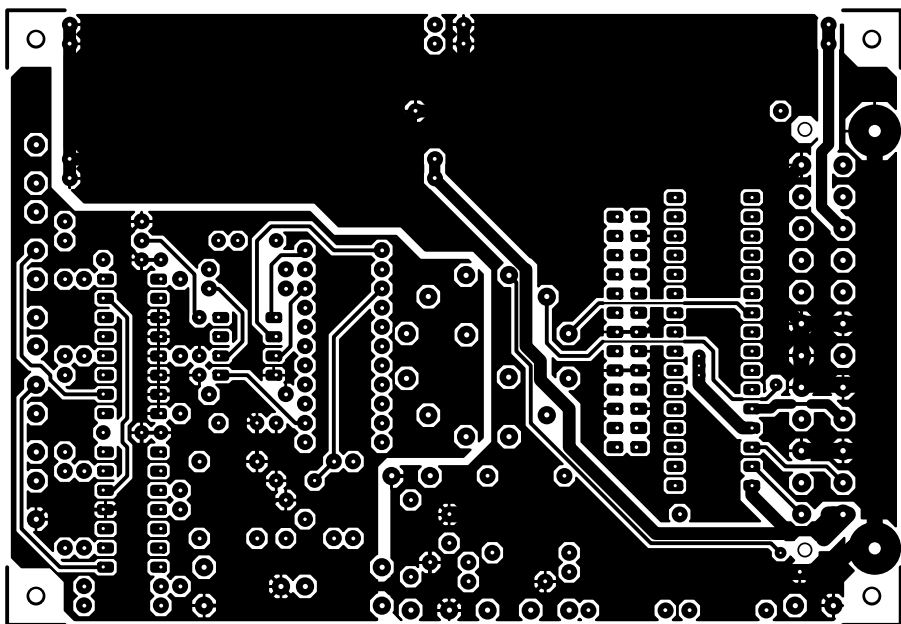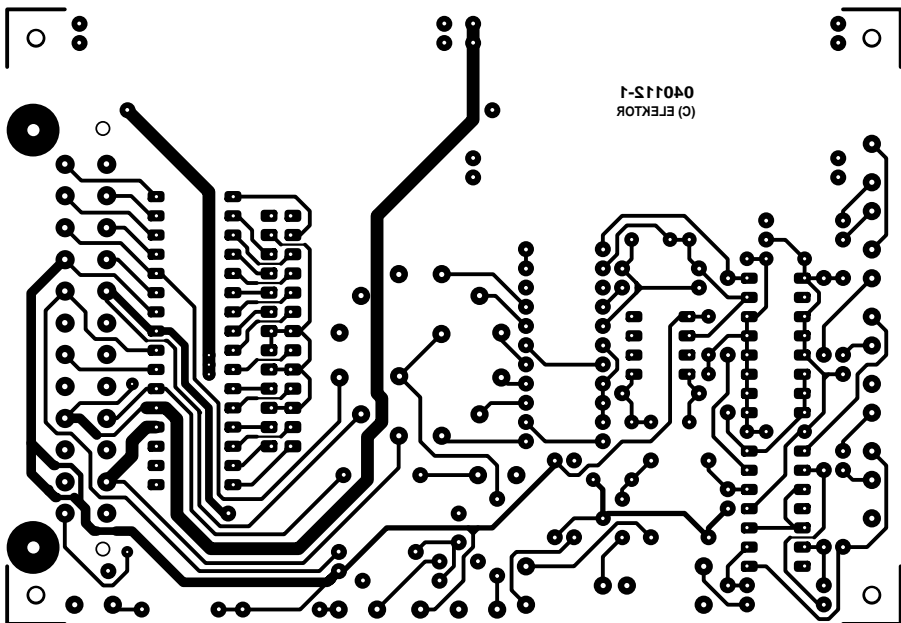
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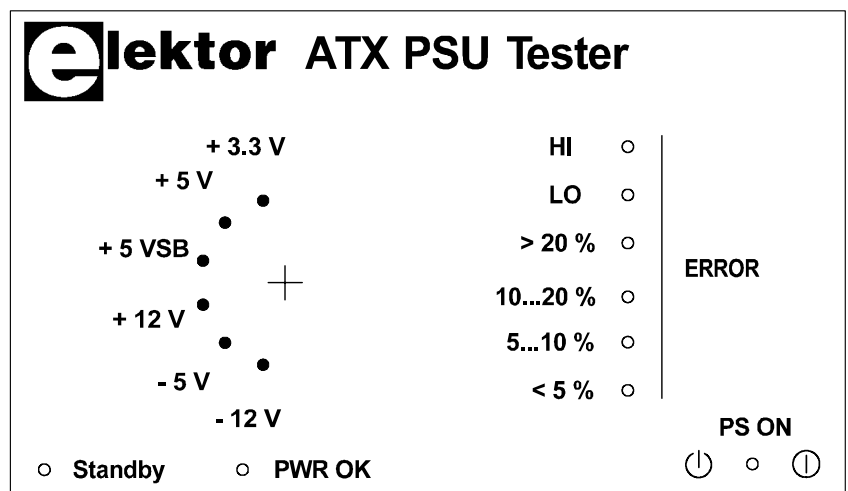
Figure 5. The front panel gives a nice finish to the project and is available as a PDF document.
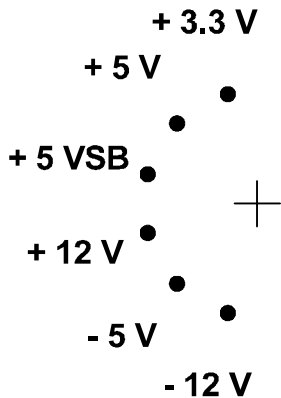
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(C) ELEKTOR

non reflected

(C) ELEKTOR
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reflected

elektor ATX PSU Tester

+ 3.3 V
+ 5 V
+ 5 VSB
+ 12 V
- 5 V
- 12 V

HI ○
LO ○
> 20 % ○
10...20 % ○
5...10 % ○
< 5 % ○

ERROR

○ Standby ○ PWR OK

PS ON
⏻ ○ |

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