Digital Bechtop Power Supply (2)

Part 2: soldering, sawing and drilling

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The construction of the Digital PSU requires extra care and precision. Just like the electronics inside, the mechanical construction and overall finish of the instrument should meet professional requirements.

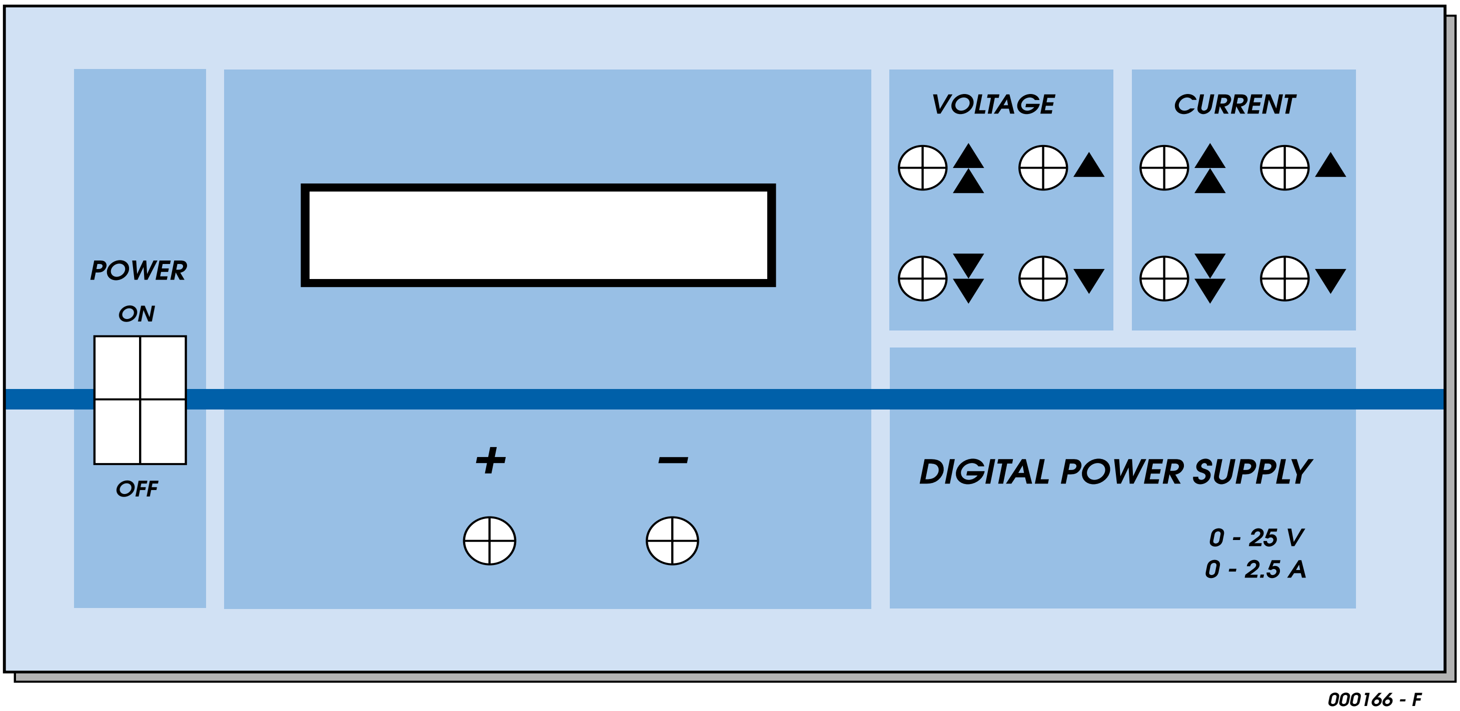


Figure 1. Front panel layout for an elegant final appearance.

As indicated at the outset, there are two versions of the power supply that you can build. However, we have decided not to produce special circuit board and front panel layouts for the smaller power supply and concentrated on the larger 2.5 A unit.

For the 2.5 A power supply a metal enclosure 200 mm (width) by 180 mm (depth) by 100 mm (height) and a 24 V 80 VA toroidal transformer are used, with all the parts of the enclosure securely connected to earth. A mains filter must also be fitted, or else the microcontroller may reset in the event of mains interference. The circuit board is fixed to the front panel with bolts, while the base simply carries the toroidal transformer (and possibly also, as shown in the photograph, the mains filter). The heatsink, RS232 connector and next to that the mains cable with strain relief are fitted to the rear panel. Alternatively, a ‘cold condition’ IEC mains inlet with fuse carrier can be fitted. Ideally a mains inlet with built-in filter can be used. The specification of the filter we used was 2L=2.4 mH, Y=2200 pF, X2=0.1 µF and R=1.0 MΩ, and the filter must of course have a suitable maximum load specification.

Next we get our hands dirty with the construction of the enclosure. Preparing the front panel in particular demands a lot of work and high accuracy since it constitutes an advertisement for home-built test equipment.

The unpopulated circuit board can be used as a drilling template for the front panel. **Take care to allow an adequate gap (at least 6 mm) between the mains switch connections and the circuit board!** The rectangular hole for the LCD can be carefully cut out using an electric jigsaw or a fretsaw and the

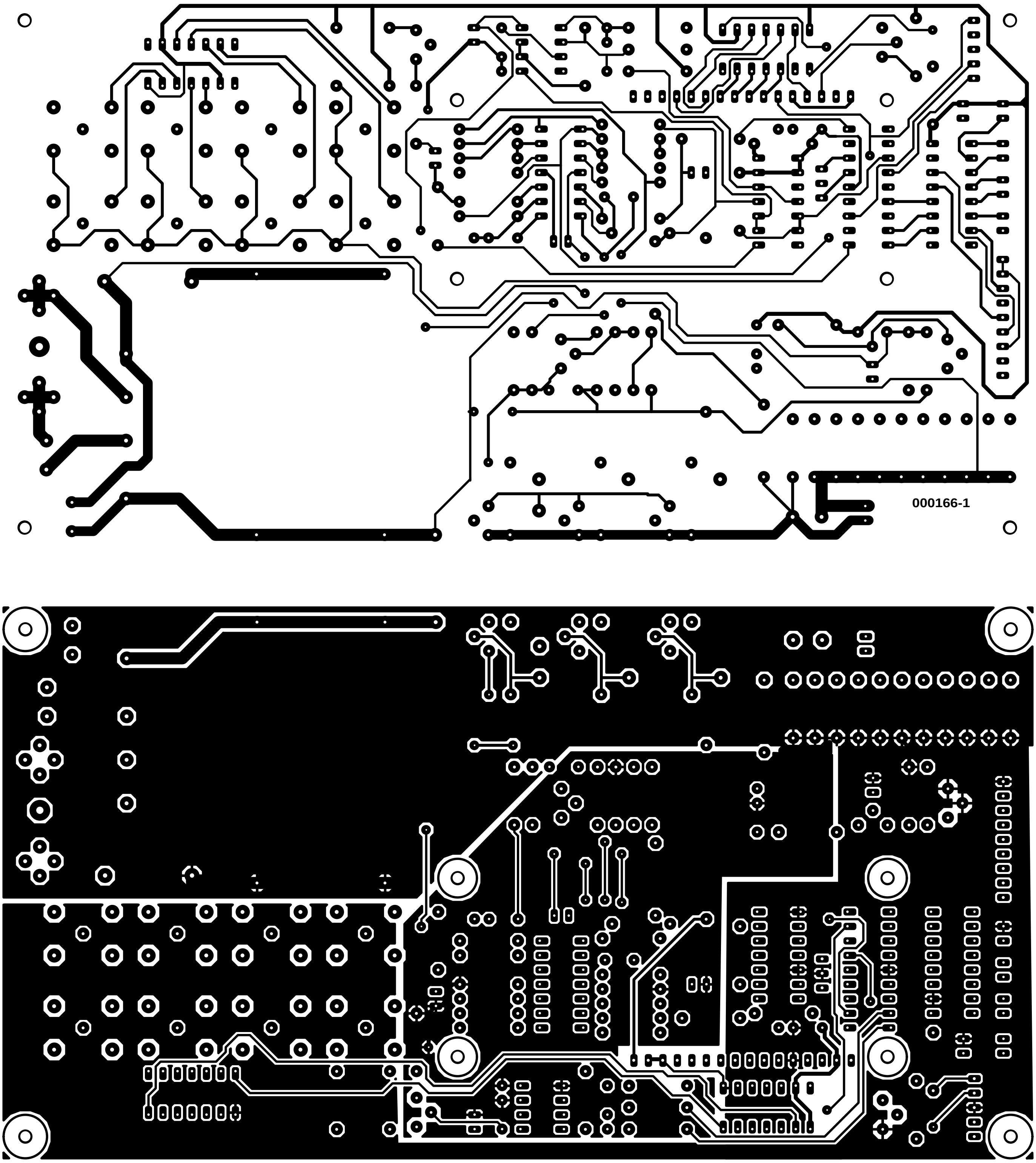


Figure 2a. Layout of the double sided circuit board for the power supply.

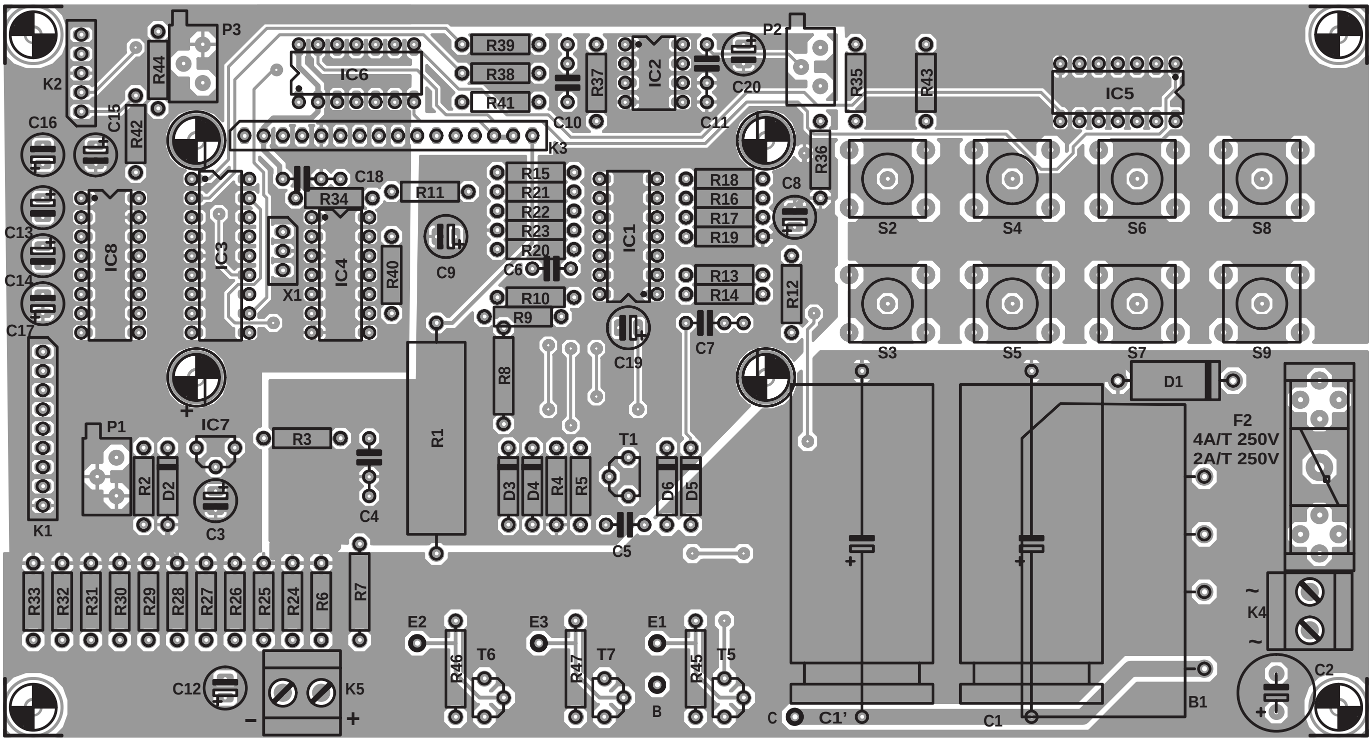


Figure 2b. Component mounting plan of the double sided circuit board for the power supply.

cuts can then be filed straight. If you are not confident of doing a professional job, you can use a display with a bezel to cover the rough edges. Cutting the hole for the mains switch proceeds similarly. Use a taper drill for a circular mains switch. The holes for the push buttons can be drilled out in stages using various twist drills until they have a diameter 0.5 mm bigger than the buttons, and then filed smooth. Then four more holes are required for the mounting screws, which should be countersunk so that the heads of the 3 mm countersunk screws are perfectly flush with the panel. On the rear side fit nuts to the screws as tightly as possible. Since the nuts should not (and indeed, without damaging the front panel, cannot) be undone again it is a good idea to fix the nuts with superglue. The thread should protrude a few millimetres to ensure that the screws have adequate grip. The fixing holes for the two terminal posts must also be suitably drilled.

If the anodised or brushed front panel is presentable (free of scratches and other faults) it can be annotated using rub-down lettering followed with a few coats of protective spray. Alternatively you can make a front panel using the suggested layout in **Figure 2**. Photocopy the layout onto paper at 1:1 scale and apply a few coats of protective spray. Spray from a distance of at least 40 cm to ensure that the toner does not run. When completely dry apply general-purpose glue to the back of the paper and glue it to a sheet of white self-adhesive labels. Thus we have a robust front panel foil which is easy to work with and which, thanks to the self-adhesive labels, will stick firmly to almost any surface.

The foil should not be attached to the front panel until after the power supply has been fully tested. In order to avoid bubbles when attaching the foil, it should always be smoothed out from the centre to the edge. Finally, go over the foil with a rubber roller or a round pencil. The cutouts and holes can now be carefully cut through using a knife. Work only from the front of the foil making many small cuts, especially when making the holes for the push buttons. An alternative way of making front panel foils using a PC and a printer was described in the July/August 2000 issue of *Elektor Electronics*.

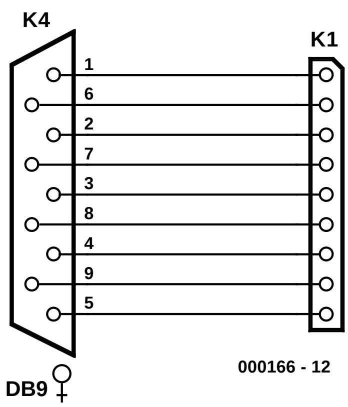


Figure 3. Connections between K1 and the sub-D socket.

Component mounting

After the double-sided printed circuit board has served its purpose as a drilling template, the components can be fitted according to the plan in **Figure 3**. This should proceed without difficulty since there are no surface-mount components, wire links, hairline tracks or tightly spaced solder pads to worry about. The board should be populated in the usual fashion. Before starting to solder,

COMPONENTS LIST
2.5 A version
(1 A version in brackets)

Resistors:
(* Metal film, 1% tolerance)
R1 = 220Ω, 5W
R2 = 330Ω, 0.5W
R3 = 150Ω
R4 = 100kΩ
R5 = 330Ω (1kΩ8)
R6 = 1kΩ, 0.5 W
R7,R18,R23 = 1kΩ *
R8,R17 = 39kΩ *
R9,R10,R13,R14,R40,R41,R43 = 10kΩ
R11,R12 = 47kΩ
R15,R16 = 10kΩ *
R19 = 8kΩ2
R20,R39 = 1kΩ
R21 = 1kΩ * (0Ω)
R22 = 18kΩ * (39kΩ *)
R24-R34 = 1Ω * 0.6W
R35-R38 = 100kΩ *
R42 = 47kΩ
R44 = 3kΩ3
R45,R46,R47 = 0Ω51, 0.5 W (not fitted)
P1 = 10Ω multiturn preset
P2 = 500Ω preset H
P3 = 2kΩ5 preset H

Capacitors:
C1 = 10,000µF 50V (4,700µF 35V), axial
C2 = 470µF 50V, radial
C3,C13,C14,C15,C16,C17 = 10µF 25V, radial
C4,C7,C11 = 100nF, ceramic, 5mm lead pitch
C5 = 10nF, ceramic, 5mm lead pitch
C6 = 1nF, ceramic, 2.5mm lead pitch
C8,C9 = 10µF, tantalum bead
C10 = 4nF7, FKS-2
C12 = 4µF7 63V, MKS-4

Semiconductors:
D1 = P600D (1N4007)
D2 = zener diode 12V 1.3W
D3,D4,D5,D6 = 1N4148
B1 = B80C5000 (B80C1500)
T1 = BC557B
T2,T3,T4 = TIP142 (1 only)
T5,T6,T7 = BC547B (not fitted)
IC1 = LT1491
IC2 = TLC272
IC3 = PIC16F84A-04P, programmed, order code **000166-42**
IC4 = 4066
IC5, IC6 = 74HC164
IC7 = 78L05
IC8 = MAX232

Miscellaneous:
F1 = Fuse, 2A, time lag
F2 = Fuse, 4A, time lag (2A, time lag)
S1-S8 = pushbutton, C&K 3FTL6 + 1S09 22.5, or general-purpose 10×10×20mm, lead pitch 5mm
TR1 = mains transformer, toroid, 24V, 80VA, e.g. UI 39/1721 V, 2571 mA
X1 = ceramic resonator, 4MHz, 3 pins
LCD module 16×1, with backlight
Fuse holder, PCB mount
Fuse holder, chassis mount, (alternatively IEC mains appliance socket with integral fuse)
Two wander sockets (red, black)
FI1 = mains filter, 2A (not fitted)
K1 = 9-way SIL pinheader, with 9-way sub-D socket (female), chassis mount
K2 = 5-way pinheader
K4,K5 = 2-way PCB terminal block, lead pitch 5mm
14-way IC socket with turned pins
18- way IC socket with turned pins
12 solder pins
Heatsink, size 180×75×48 mm, spec 0.6 K/W (100×50×31mm, spec 2.4 K/W)
Enclosure (w×d×h) 200×180×100 mm, e.g. Telet type LC950
Mains switch, mains cord
PCB, order code **000166-1**

make sure that the push buttons stand a good 10 mm higher than the electrolytic capacitors. A few components are soldered to the rear of the board: the bridge rectifier (for reasons of space), the trim potentiometers, the connectors, the solder tags for the transistors and the fuse (so that it can be changed easily). The circuit board connector for the banana sockets is mounted on the component side. The components under the display, such as C19, must, where possible, be mounted flat.

If you know that you will never want to reprogram the microcontroller on the board, you can of course dispense with the programming connector K2. High-quality sockets should be used, at least for the two expensive ICs, IC1 and IC3. R1, R2 and R6 can get hot and should be fitted raised slightly above the board. Ensure that any solder flux is removed from the area around IC1, IC2 and IC4 after soldering, to avoid the effect of parasitic resistance.

After checking all the soldered connections the display can be suitably fixed using long bolts. The electrical connections are made using bare wire. Now the whole assembly can be fixed to the front panel, and the transformer and PC interface wired up as shown in **Figure 4**.

The power transistors are fitted with an insulating mica washer and fixed to the heatsink, the module being connected to the main circuit board using three 10 cm long 0.75 mm^2 wires.

Initial operation

Once everything has been assembled and wired together, you will not want to wait a month for the description of the software and operation of the unit; you will want to try your power supply out immediately. With IC1 and the microcontroller not fitted, the mains can be switched on for the first test. As long as no smoke signals are emitted, the unit can be left switched on.

Between pins 4 and 11 of IC1 a voltage of 27 V (for the 1 A power supply) or 32 V (for the 2.5 A power supply) should be measured. There should be a voltage of 12 V across Zener diode D2 and a voltage of 5.1 V between pins 5 and 14 of the microcontroller. If all is well, turn off the power supply and fit the remaining ICs. Turn P2 fully to the left. When the unit is turned on again the display should read:

00.0V 0.00A

When a push button is pressed (or held down) the display should switch to 'set mode' and show the values as they are adjusted either in milliamps or millivolts. To adjust the offset voltage, turn P2 gradually to the right, checking whether the display changes. When the display stops changing, you have gone too far and you should back the potentiometer off a little.

Alternatively, connect a PC to the interface and start up HyperTerminal with the following interface settings

9600, 8, N, 1, hardware handshake

Now adjust the trimmer so that the value represented by the first five digits after the **D** is as small as possible, but not zero. A value of 2 is ideal, since the unit will then continue to operate correctly even if the value should change slightly as a result of ageing, mechan-

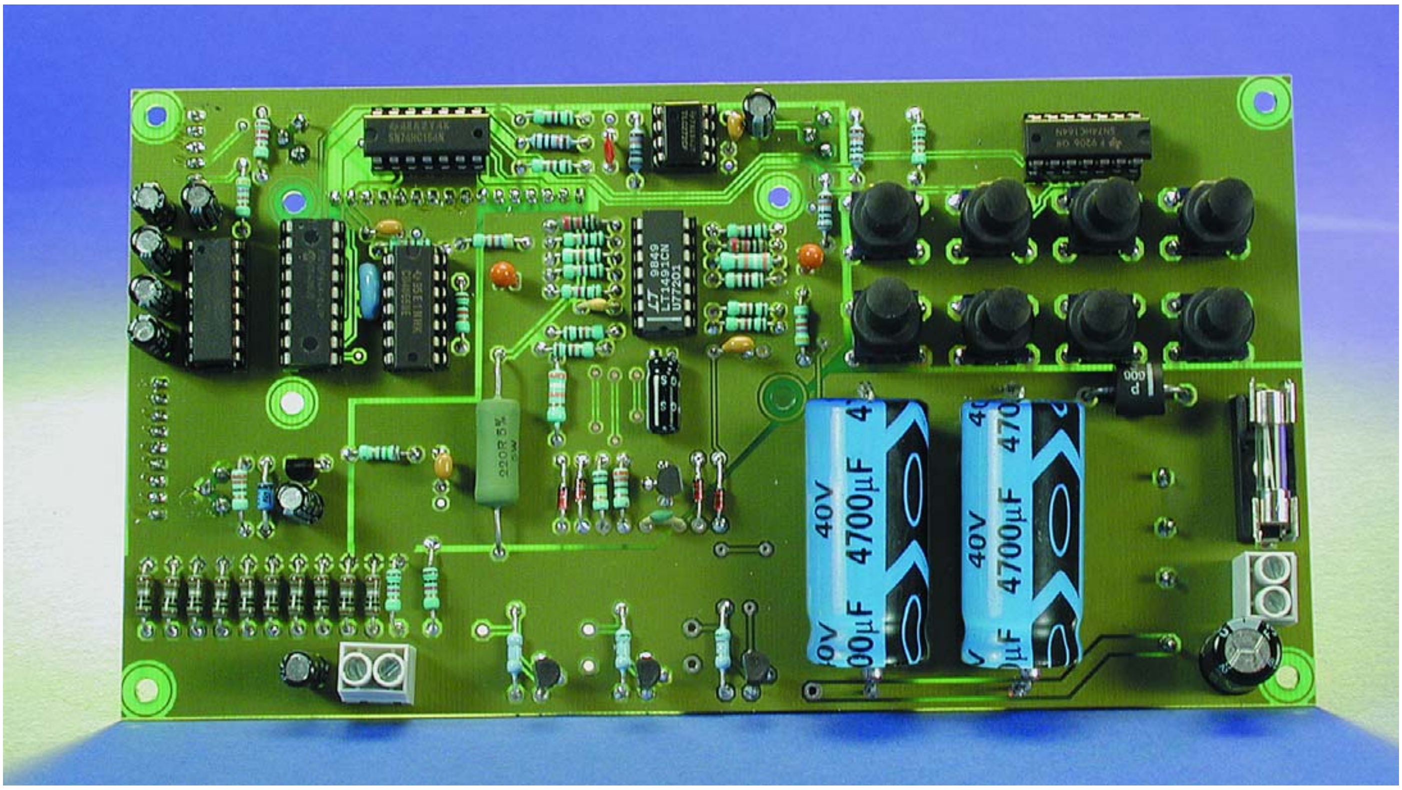
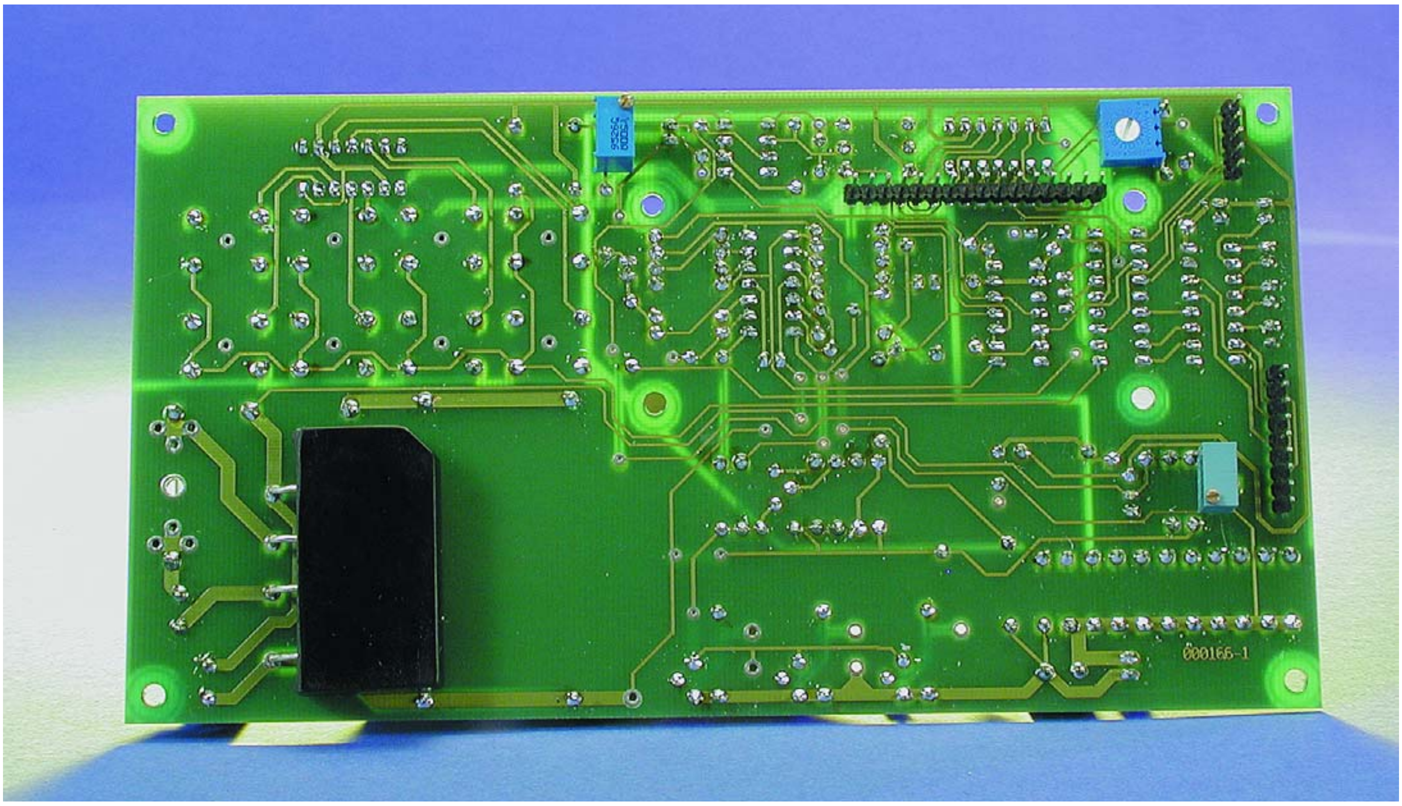


Figure 4. The main circuit board.



ical shock or temperature drift.

After this adjustment the output voltage should be measured with the voltage setting at 0.00 V. It should be 30 mV (±15 mV). Next set the voltage to 19.0 V and adjust P1 for an actual output voltage of 19.03 V. The output current adjustment and its displayed values will then automatically be correct. If the values are awry, or the above values cannot be achieved, the first thing to check is that all the components are correctly fitted and that there is no solder residue between the tracks.

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