It all looks so involved...the kit of parts for the 10A 30V Laboratory PSU!

10A 30V Laboratory PSU

Text by Martin Pipe

FEATURES

- Digital voltage meter: 3 digit 0·1V accuracy
- Digital ampere meter: 3 digit 0·01A accuracy
- Output voltage variable from 0 to +30V (Fine adjustment over 1V)
- Variable current limit from 0 to10A
- LED current limit indicator
- Output short circuit protected
- Maximum output ripple 0·5V rms
- Cooling fan for prolonged usage at full power

This extremely flexible laboratory power supply unit (PSU) is capable of sourcing well-regulated DC voltages of up to 30V at currents of up to 8A continuous, 10A peak. As a result, there is a wide range of potential applications for the hobbyist, service department and educational institutions. For example, it is ideal for the testing of prototypes; in addition to the sheer power output available, there is a current-limiting function – ideal for trying out your more delicate circuits. This function, and the robust nature of this unit, makes it an ideal choice for servicing DC equipment (e.g., portable audio and video equipment) and for college workbenches. In addition, this piece of equipment is ideal for the running of CB and amateur radio equipment, and even the charging of batteries; lead-acid packs in 'constant voltage' mode, and Ni-Cd cells in 'constant current' mode.

Applications

- Laboratories and test benches
- Powering mobile radio equipment
- Precision charging of batteries

Circuit Description

1. Control PCB

(Refer to circuit diagram of Figure 1). IC2 & 3 are µA723 voltage/current regulators. IC2 is used to set the output voltage; R6 providing feedback to compensate for the voltage drop across T2, R16, T3 and R31. A fraction of the output voltage determined by R5 and R23 is supplied to IC2 as feedback. IC3 is responsible for current-limiting; its operation is very interesting. A user-set reference voltage (the 'current limit') is derived from the IC3's on-chip reference via RV1/2/3, R18, R27 and R28. This is compared to the voltage developed across R37 to R40 (which are situated between output ground and the reference ground); if it exceeds the user-set reference, then the error voltage produced by IC3 will be sufficient to forward-bias the LED, in doing so it will turn on the current-limiting transistor integral to voltage regulator IC2.

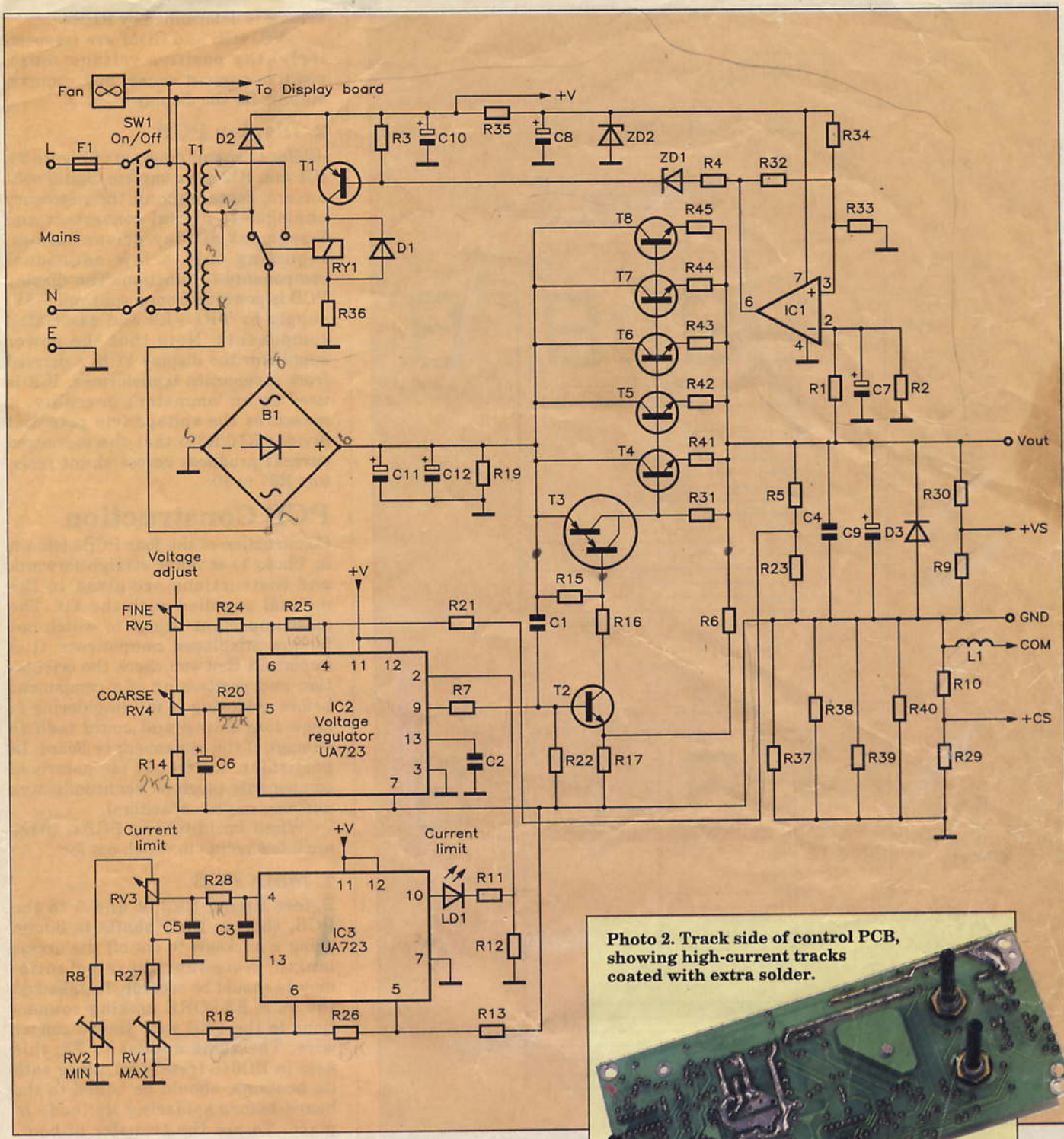


Figure 1. Power supply unit circuit diagram.

Photo 2. Track side of control PCB, showing high-current tracks coated with extra solder.

T2 is the control transistor for T3, a Darlington device, which provides plenty of drive current for the output pass transistors T4 to T8, which are fed with the smoothed DC output from the bridge rectifier and reservoir capacitors. Note that the main power transformer is a very beefy (300VA, 15-0-15V) toroidal type. R41 to R45 are required to allow for the variation in current gain among the transistors; these items are not matched. D3 is present to protect the power supply from any reverse-polarity voltages that may accidentally be applied to its output terminals.

IC1 is a 741 Op-amp configured as a comparator; it switches in the second winding of the toroidal transformer, via T1 and RY1, when the output voltage rises above 12V; this

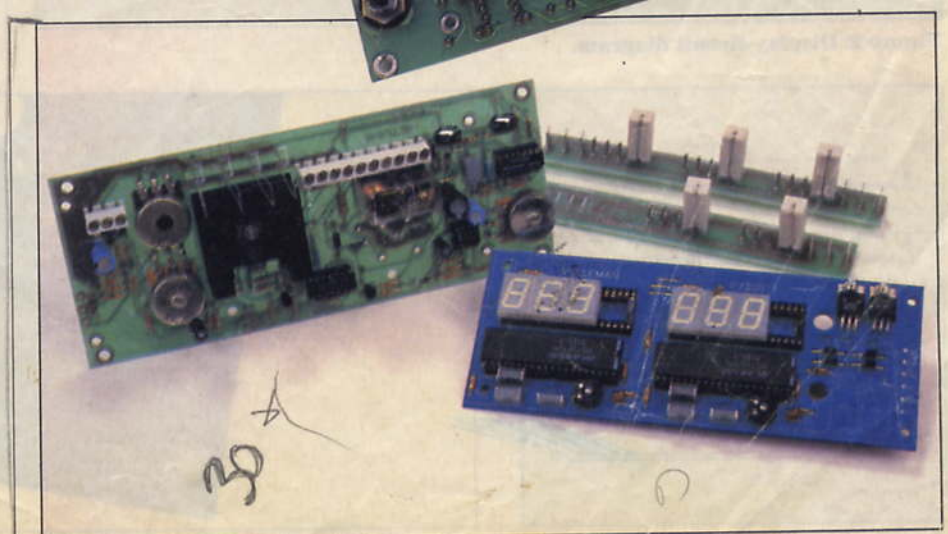


Photo 1. The four assembled PCBs of the Laboratory Power Supply.

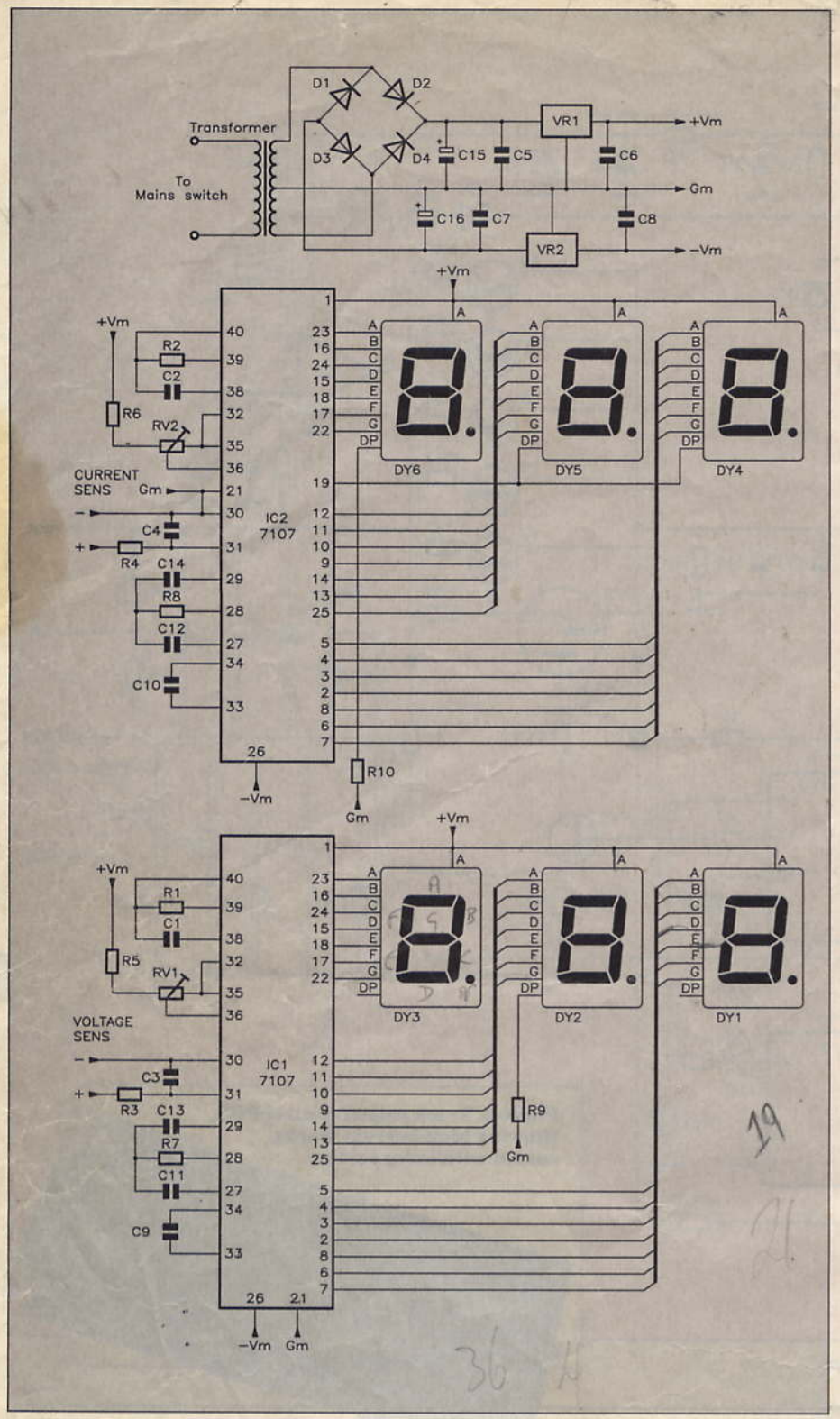


Figure 2. Display circuit diagram.

voltage is determined by R1/R2.

+VS, +CS and COM are (respectively) the positive voltage sense, positive current sense, and common outputs for the display PCB.

2. Display PCB

(Refer to circuit diagram of Figure 2). IC1 and IC2 are complete digital voltmeters, containing all the necessary analogue-to-digital converters and 7-segment display driver/buffers, requiring only a few additional components to function. The display PCB is powered from a split rail (–5V) supply by VR1/VR2 and associated components. Note that the power supply for the display PCB is derived from a separate transformer. IC2 is used as an 'ammeter'; in reality, it measures the voltage (via potential divider R10/R29) that the measured current produces across shunt resistors R37 to 40.

PCB Construction

Construction of the four PCBs (shown in Photo 1) is fairly straightforward, and instructions are given in the manual supplied with the kit. The most important things to watch out for are misplaced components; it is important that you check the orientation and positioning of a component before soldering it in; desoldering is time-consuming and could lead to damage of the component or board. In particular, watch out for polarised components (such as semiconductors and electrolytic capacitors).

When building the PCBs, there are a few points to watch out for:

1. Main PCB

Before fitting RV3, 4 and 5 to the PCB, shorten their shafts to 30mm using a hacksaw to cut off the excess length. Note that these potentiometers should be securely installed on the PCB BEFORE making connections to the PCB with tinned copper wire. The same applies to T3; this item (a BD646 transistor), along with its heatsink, should be bolted to the board before soldering its leads in place. To aid the transfer of heat, heatsinking compound (not supplied in the kit) should be smeared onto the tab of the transistor before mounting it. Note that all three ICs on this

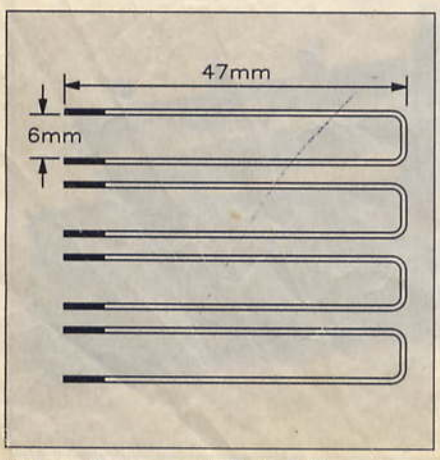


Figure 3. Forming R37 to R40.

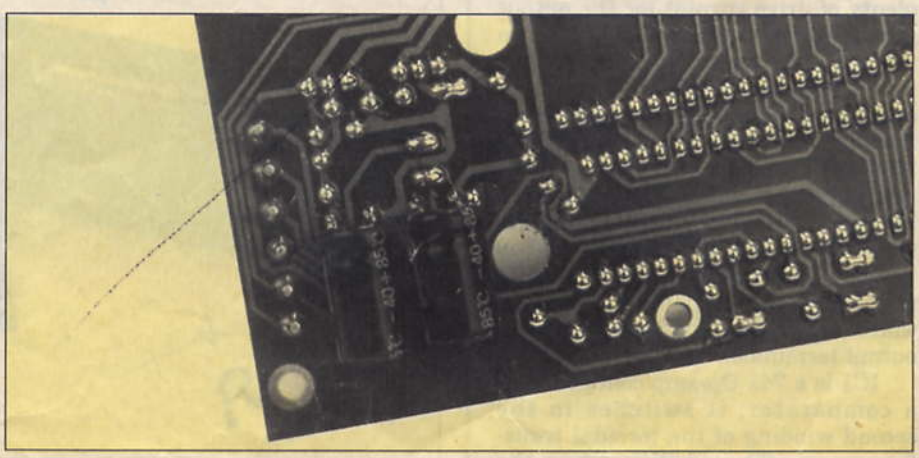


Photo 3. C15 and C16, shown fitted on solder side of PCB.

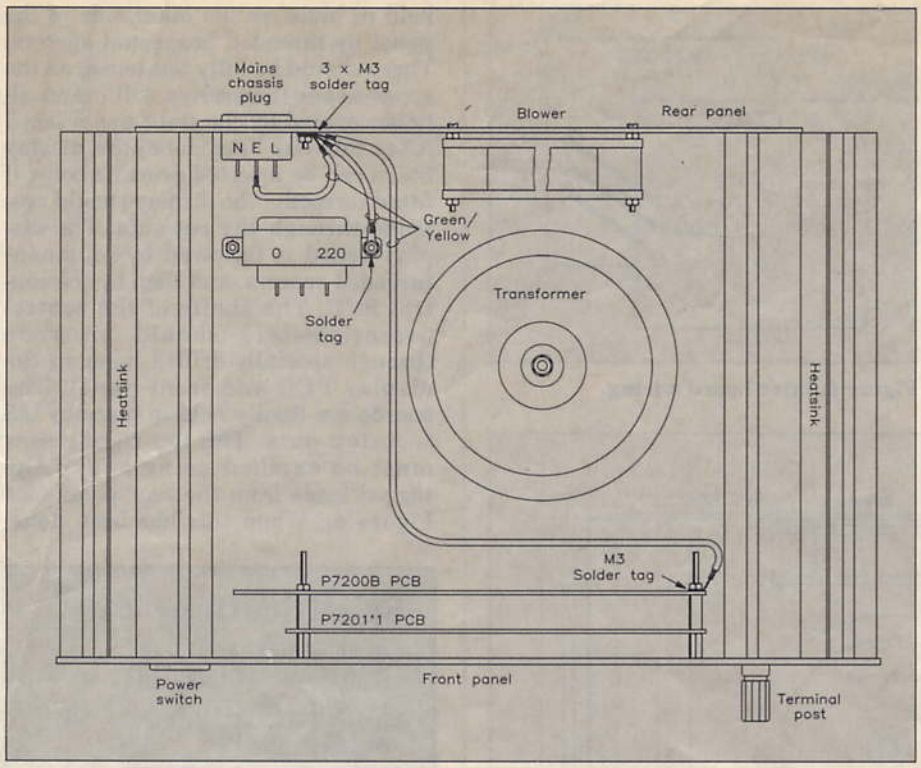


Figure 4. Earthing arrangements.

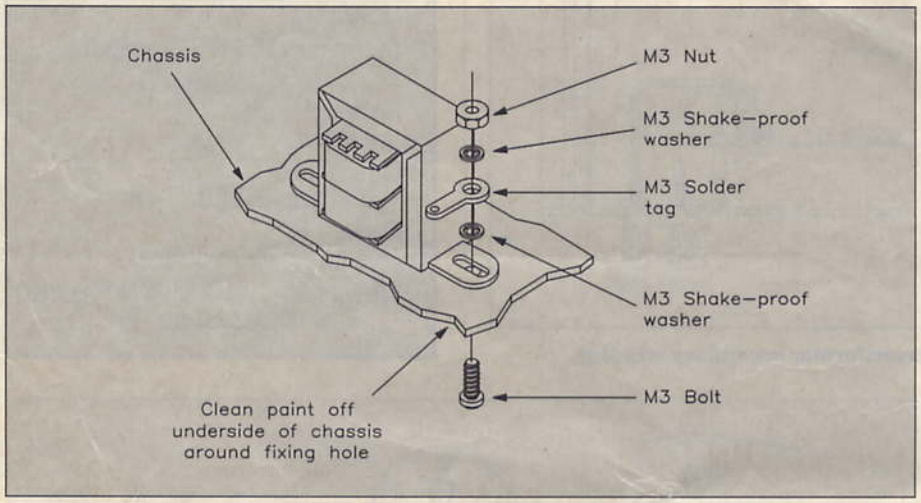


Figure 5. Display transformer

board are socketed. R37 to R40, the shunt resistors, are made from nichrome resistance wire supplied in the kit. Each is formed from a 10cm length of the wire, as shown in Figure 3. The next point to bear in mind is that the current limit indicator needs to be installed on the TRACK side of the board, so that the LED's tip protrudes 30mm above the board's surface. Note that the two-pole screw connectors J1 to J5 (used to connect the transformer's secondary windings to the PCB) clip together (start with J1) before fitting and soldering in place. After soldering the relay in place, coat the already plated tracks with more solder (see Photo 2), so that they can cope with the potentially high currents expected.

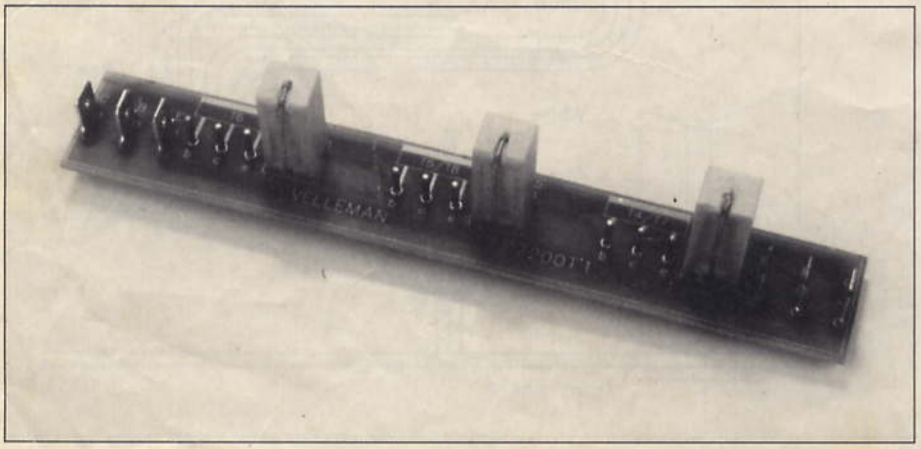


Photo 4. Emitter resistors, fitted vertically to one of the pass transistor PCBs

2. Display PCB

Note that IC1 and IC2 are socketed. In addition, the 7-segment displays are also fitted in sockets – ensure correct polarity when finally fitting these in place. VR1 and VR2 should be bolted into place before soldering them to the PCB. Two electrolytic capacitors (C15 and C16) must be fitted to the SOLDER side of the board, paying special attention to polarity – see Photo 3.

3. Regulator Transistor PCBs

Two boards, which fit in the side-mounted heatsinks of the power supply, hold the connections to the TIP3055 transistors (T4 to T8) and their emitter resistors. The two supplied PCBs are identical; however, one should be made to accommodate the connections to two transistors only. On this board, the space marked 'T6', and the adjacent holes for 'Lucar' terminals (1/4in. blade terminals), should be left unpopulated; the space on this PCB directly above on the heatsink is reserved for the bridge rectifier. Do *not* solder the transistors directly to the boards – fit PCB pins in the appropriate postions (marked b, c and e). The corresponding emitter resistors (R41 to R45) should be fitted vertically to the board, as shown in Photo 4. Finally, mount the 'Lucar' terminals, and solder into position.

After completing assembly of the boards, check your work thoroughly. Spotting any mistakes before powering up, could save any (possibly expensive!) problems later on.

Mechanical Assembly

Detailed assembly instructions for the case are given in the comprehensive manual supplied with the kit. Assembly is straightforward, but a few remarks made here will save trouble later.

Care should be exercised when installing the regulator pass transistors T4 to T8. These, as already mentioned, are connected via PCB pins to two boards located in the unit's side-mounted heatsinks. To fit, slide the boards into the heatsinks (the correct way up and around – the outline of the transistors is screen-printed on the board to aid you). Looking from the front of the unit, the two-transistor board is fitted to the left heatsink, while the other is fitted to the right one. The transistors are screwed to the heatsink using M3 hardware (an insulating washer and heatsinking compound must be used for each device!), and are then soldered to the corresponding PCB pins. Note that heatsinking compound is also used when attaching the bridge rectifier to the left heatsink. As you can see from the photographs, these two heatsinks form the sides of the case.

When installing the fan, ensure that the arrow, embossed on its side, points to the back of the unit's case. This indicates the airflow direction; in other words, the air is being sucked through the power supply. Air comes in from slots stamped in the top and bottom lids of the case – air flow requirements should be borne in mind when using the finished unit. Do *not* obstruct the ventilation grilles. Note that the fan should be orientated so that its leads appear at the top. It is fixed to the rear panel with 35mm bolts; if these are overtightened, the fan's housing could crack. 'Finger tightness' plus half a turn should be sufficient.

The mains chassis plug and fuseholder are the next items to be installed on the rear panel. These are mounted using zinc-plated M3 bolts. Sleeving (not supplied in the kit) should be used to cover all mains connections; insulating boots are available for the chassis plug and fuseholder – see Optional Parts List. Note the earthing arrangements; as shown in Figure 4, one of the PCB mounting posts, the power supply case and the display transformer are all connected to earth. M3 solder tags are used for the bolted components. Note that the paint *must* be scraped away around the chassis plug's screw hole, on the inside of the back panel, to ensure a good earth connection.

The same applies to one of the display transformer mounting screws on the underside of the power-supply; this item should be fitted as shown in Figure 5.

The two main PCBs are attached to the main panel by four 45mm long countersunk M3 bolts. The paint around the top-right M3 hole should be removed; this will eventually form an earth connection. The bolts are held in place on the other side of the panel by threaded hexagonal spacers. These should be fully tightened, as the screw-heads themselves will eventually be covered by the front panel label. After this has been done, the display board can be inserted over the bolts; if fitted correctly, the display should protrude through the cut-outs. The display board is followed by four non-threaded spacers, and then by the control PCB. The shafts of the control potentiometers should protrude through specially-drilled holes in the display PCB and front panel. The boards are finally held in place by M3 securing nuts. The top right screw must be earthed using one of the tagged leads from the rear panel (see Figure 4). When this has been done,

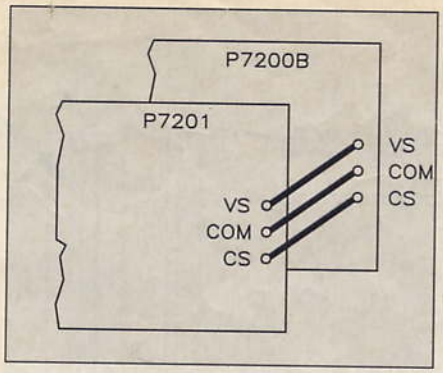


Figure 6. Inter-board wiring.

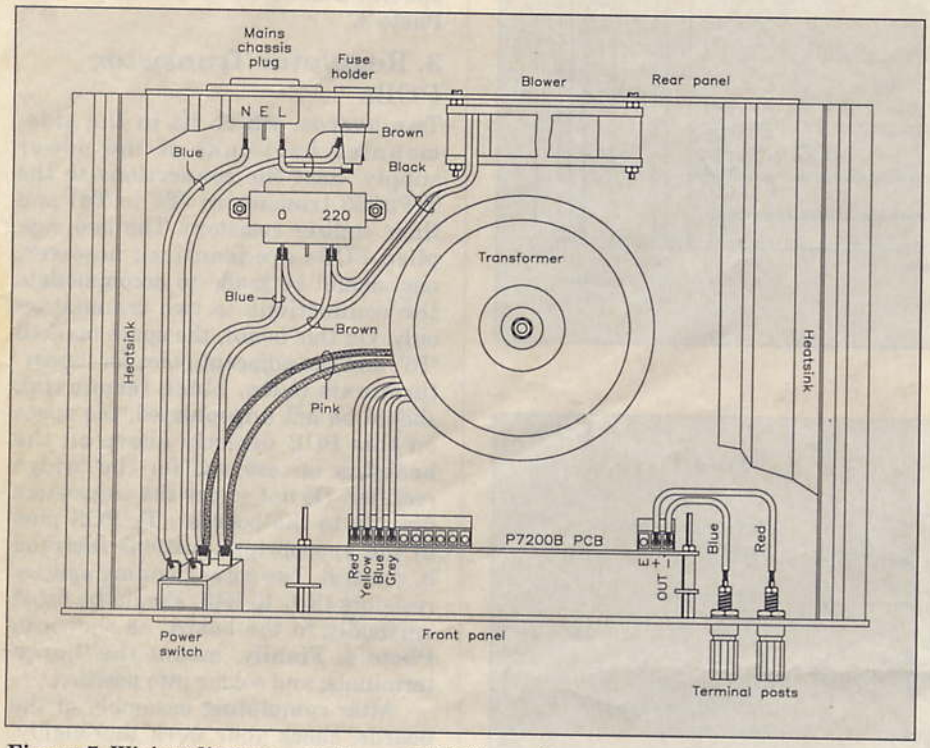


Figure 7. Wiring diagram – mains and PSU transformer secondary winding.

Specifications

Output voltage Range:	0 to 30V DC
Fine Output control Range:	1V
Ripple:	0·5mV RMS (max.)
Voltmeter resolution:	0·1V
Output current:	0 to 8A continuous (10A peak)
Ammeter resolution:	0·01A
Current limit indication:	LED
Power consumption:	300W (max)
Dimensions:	330mm (W) x 90mm (H) x 215mm (D)

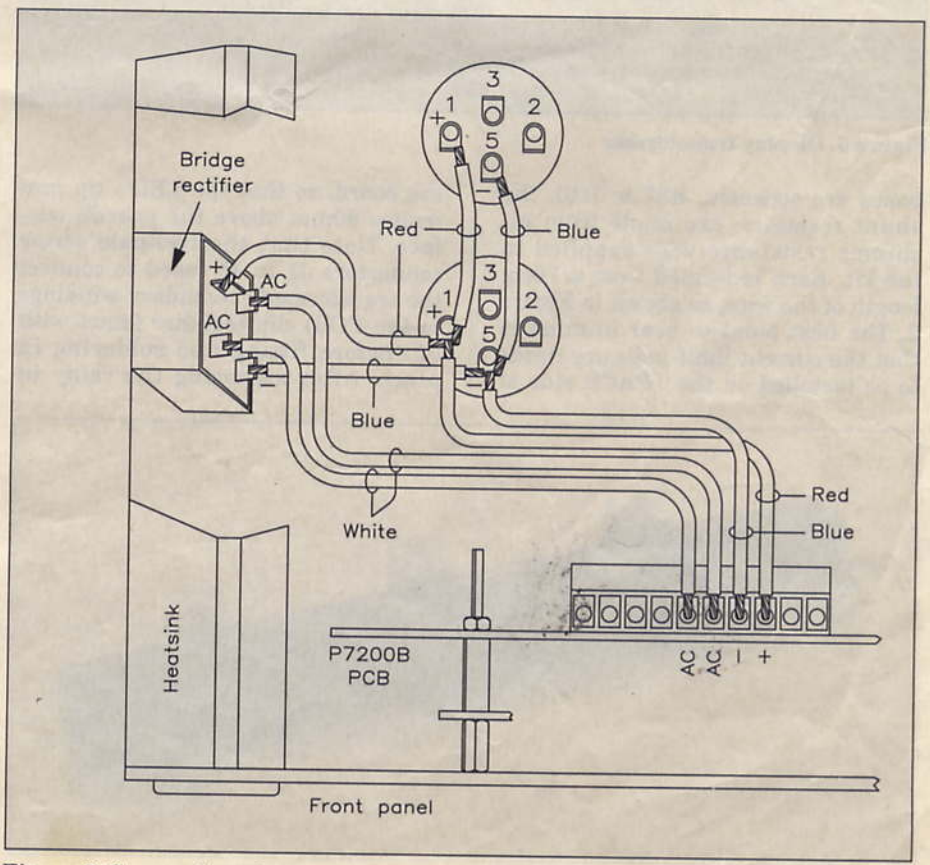


Figure 8. Connection of reservoir capacitors and bridge rectifier.

the three control knobs can be fitted as shown in the photographs. Finally, three connections must be made between the two boards; see Figure 6.

Wiring Notes

Please *disregard* Figure 6.2 of the construction guide supplied with the kit, as this does not include earthing arrangements, and shows only a single-pole switch. A replacement wiring diagram is shown in Figure 7. Please follow the revised circuit diagrams of Figures 1 and 2, rather than the versions printed in the manual. For safety reasons, Figure 1 incorporates a double-pole mains switch. For clarity, Figure 7 shows only the mains wiring and that of the toroidal transformer's secondaries. Earthing arrangements and the reservoir capacitor wiring are shown in Figures 4 and 8 respectively. For the same reason, the display transformer's secondary wiring has been omitted from Figure 7; it is shown in Figure 9. Earthing apart, output terminals and the display transformer's secondary should be wired up first, as these may prove difficult to get at once the other wiring has been completed. At this stage, do not connect the fan, or the pass transistor PCBs (shown in Figure 10); this will be done during the testing stage. Connections at mains potential should be covered with heat-shrink sleeving, for safety's sake. The wires to the front-panel mains switch are attached via 'Lucar' receptacles – don't forget those insulating boots! As seen in Figure 7, the primaries of both transformers are connected to the mains switch; extra care should be taken when connecting two wires to each terminal.

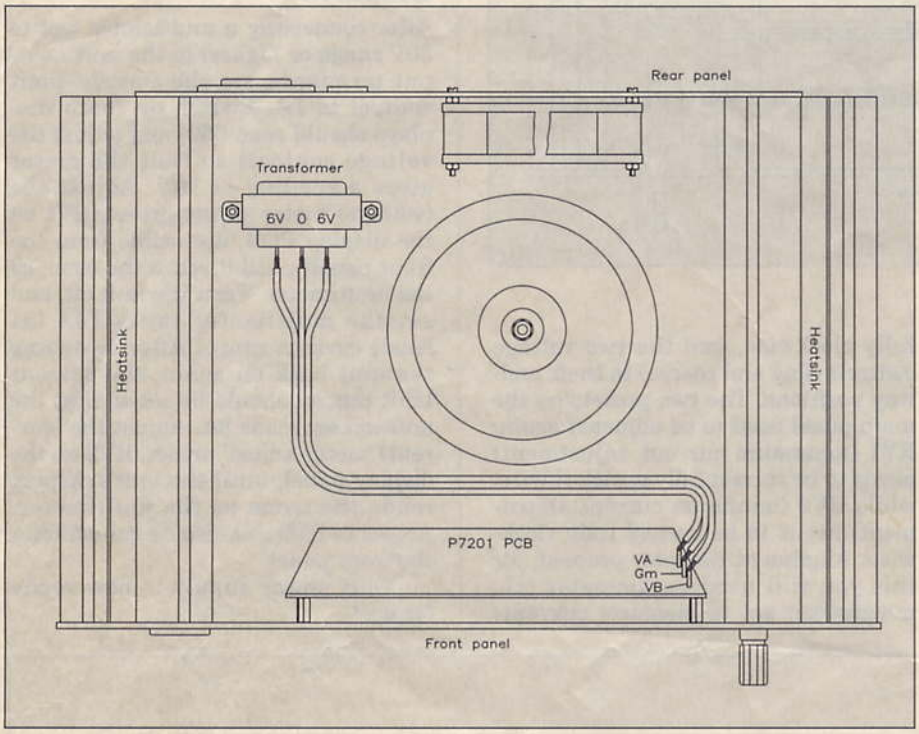
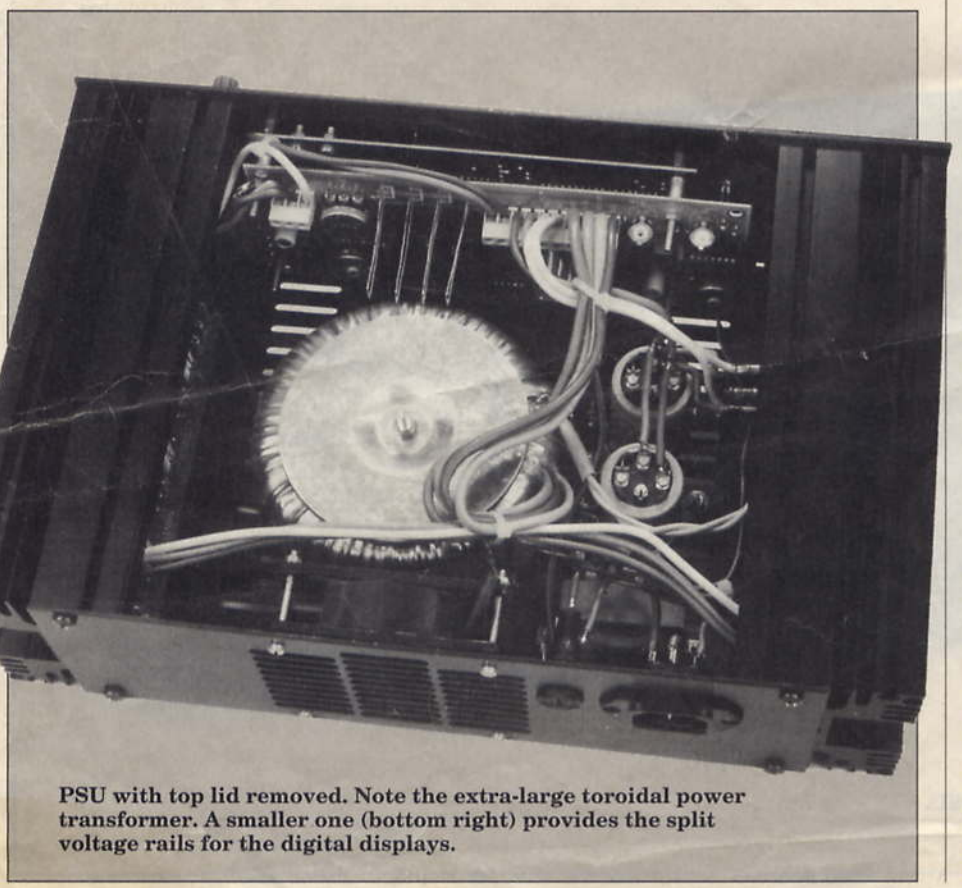


Figure 9. Display transformer



PSU with top lid removed. Note the extra-large toroidal power transformer. A smaller one (bottom right) provides the split voltage rails for the digital displays.

Testing

Before testing, you should thoroughly check your work for any problems, such as short circuits, solder bridges, missing or misplaced components.

The following tests involve procedures to be carried out with the case top removed and 240V AC mains connected. It is imperative that every possible precaution is taken to prevent electric shock. 240V AC mains CAN KILL!

Initial testing involves wiring a 240V 40W lamp bulb across the mains fuseholder; do not fit the fuse in the fuse holder at this stage. The bulb is now effectively wired in series with the transformer primary winding. If the lamp should illuminate brightly when mains voltage is applied, then too much current is being drawn by the power supply, which indicates a fault (for example, the primary winding could be short-circuit). If the lamp is permanently unlit, there is likely to be an open-circuit on the primary winding of the transformer. If all is OK, the bulb will light for a short instant, and then go out again (or illuminate dimly) – as a surge of current flows through the transformer. If this does not happen, or one of the other symptoms is noted, then you should investigate the problem further.

With RV1/RV2 (main board) set to their mid-positions, and the current limit potentiometer turned all the way to the right, testing can begin. When the power supply is switched on, the digital displays should now light up. A voltmeter connected between the output terminals should give 0 to 30V when the voltage adjustment control is advanced from left to right. At around 12V, the relay should 'click', indicating that the other secondary winding of the unit's transformer has been switched into circuit.

Turn off the power (and unplug the unit!), then turn the display presets (RV1/RV2, display PCB) fully clockwise. Connect up the pass transistor PCBs, as shown in Figure 10. After switching the unit back on again, check that the voltage can be adjusted as before. Switch off and disconnect the mains supply; the lamp can now be disconnected, and a 4A fuse fitted to the fuseholder. At this stage, the fan can be wired up – see Figure 7.

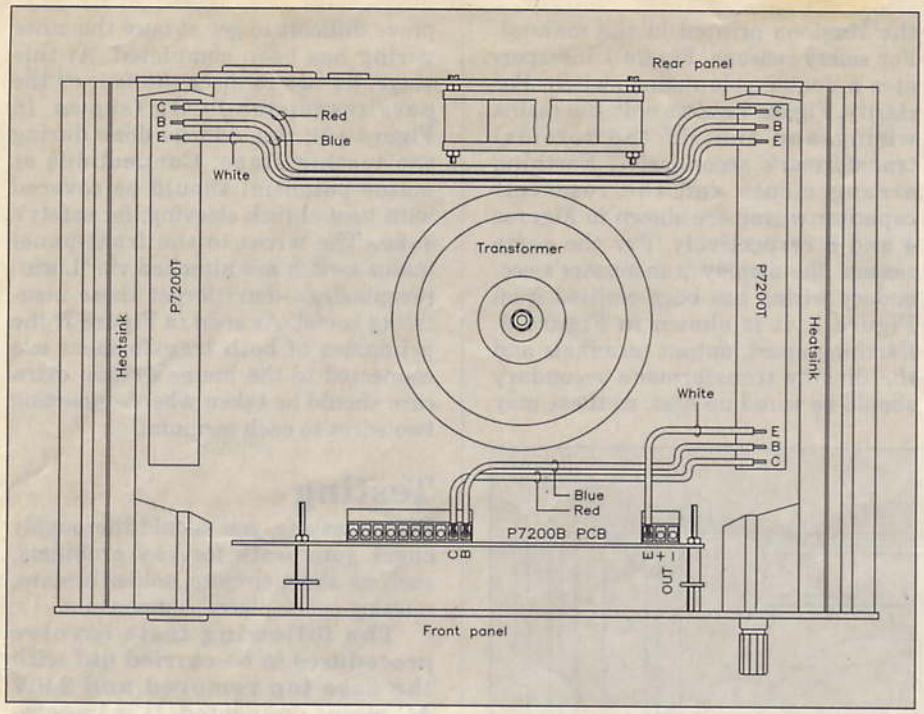


Figure 10. Wiring of pass transistor PCB.

Setting Up

The following procedures should be carried out very carefully and not rushed. The performance of the project is dependant on the accuracy of these adjustments.

Power Supply Alignment

With the unit disconnected, turn the front panel current limiting control fully clockwise, and the two voltage controls (fine and coarse) to their midway positions. The two presets on the main panel need to be adjusted again; RV1 (maximum current adjustment) needs to be turned fully anticlockwise, while RV2 (minimum current adjustment) needs to be turned fully clockwise. Alignment can now proceed; for this you will need an ammeter (i.e. multimeter set to measure current) with a range of at least 10A. This should be connected across the power supply's output terminals. After powering up, the 'current limit' LED will light up (the low resistance of the ammeter presents a virtual 'dead short' to the PSU). RV1 should now be adjusted until the meter reads 10A. Disconnect the meter, and turn the voltage/current limit adjustment controls fully anticlockwise. RV2 should now be adjusted until the current limit LED lights up dimly.

Calibration of Digital Displays

After connecting a multimeter (set to 30V range or higher) to the unit's output terminals, set the current limit control to 1A. Switch on (both displays should read 000) and adjust the voltage controls so that the meter gives a reading of 30V. Adjust the (voltage) 'meter adjust' preset (RV1 on the display PCB, accessible from the front panel) until it reads the same as the multimeter. Turn the unit off, and set the multimeter to its 10A (at least) current range. After switching the unit back on again, the current limit control should be set so that the multimeter reads 8A. Adjust the (current) 'meter adjust' preset, RV2 on the display panel, until the unit's display reads the same as the multimeter. Access to RV2 can also be gained from the front panel.

Your power supply is now ready for use!

The completed 10A 30V Laboratory PSU.

10A 30V LABORATORY PSU PARTS LIST

1. CONTROL PCB

RESISTORS

R1	6k8	1
R2	8k2	1
R3-8	4k7	6
R9-12	220Ω	4
R13,14	2k2	2
R15,16	2k7	2
R17,18	820Ω	2
R19-22	22k	4
R23,24	1k2	2
R25	100k	1
R26	15k	1
R27	100Ω	1
R28,29	1k	2
R30	220k	1
R31	18Ω	1
R32	270k	1
R33	12k	1
R34	27k	1
R35	39Ω	1
R36	180Ω (1/2 W)	1
R37-40	Constructed from resistance wire	1m
RV1	100Ω Vertical Preset	1
RV2	47k Vertical Preset	1
RV3	4k7 Pot Log	1
RV4	10k Pot Lin	1
RV5	1k Pot Lin	1

CAPACITORS

C1	150pF Ceramic	1
C2	33nF Metallised Polyester Film	1
C3	68nF Metallised Polyester Film	1
C4	100nF Ceramic	1
C5	1µF Metallised Polyester Film	1
C6,C7	10µF 35V Electrolytic	2
C8,C9	100µF 35V Electrolytic	2
C10	470µF 35V Electrolytic	1

SEMICONDUCTORS

IC1	741	1
IC2,IC3	µA723	1
T1	BC557B (or equiv.)	1
T2	BC547B (or equiv.)	1
T3	BD646	1
D1-D3	1N4000 Series Diode	3
ZD1	10V 500mW zener	1
ZD2	18V 1·3W zener	1
LD1	Red LED 3mm	1

MISCELLANEOUS

L1	4m7H	1
RY1	Single Pole Changeover Relay	1
J1-J5	2-way PCB-mounting Terminal Block	5
J6	3-way PCB-mounting Terminal Block	1
	PCB Pin	3
	14-pin DIL socket	2
	8-pin DIL socket	1
	PCB	1
	Heatsink for BD646	1
	Screw M3 x 12mm	1
	Nut M3	1
	Shakeproof Washer M3	1

2. DISPLAY PCB

RESISTORS

R1-R4	100k	4
R5,R6	22k	2
R7,R8	47k	2
R9,R10	470Ω	2
RV1,RV2	1k Horizontal Preset	2

CAPACITORS

C1,C2	100pF Ceramic	2
C3-C8	100nF Resin-dipped Ceramic	6
C9,C10	100nF Metallised Polyester Film	2
C11,C12	220nF Metallised Polyester Film	2
C13,C14	470nF Metallised Polyester Film	2
C15,C16	1000µF 16V Electrolytic	2

SEMICONDUCTORS

IC1,IC2	7107	2
VR1	7805	1
VR2	7905	1
D1-D4	1N4000 Series Diodes	4
DY1-6	7 Segment Display (Common Anode)	6

MISCELLANEOUS

	40-Pin DIL socket	4
	PCB Pin	3
	PCB	1
	Screw M3 x 12mm	2
	Nut M3	2
	Shakeproof Washer M3	2

3. PASS TRANSISTOR PCBs

RESISTORS

R41-R45	220mΩ 5W	5

SEMICONDUCTORS

	TIP3055	5

MISCELLANEOUS

	Blade Terminal 1/4 in.	9
	PCB Pin	15
	Mica Washer	5
	Insulating Bush	5

4. HARDWARE

MISCELLANEOUS

B1	Bridge Rectifier	1
C11,C12	4700µF 63V Electrolytic Capacitor	2
SW12	Pole Mains Rocker Switch	1
F1	20mm Panel-mounting Fuseholder	1
	20mm Fuse 4A	1
	Chassis-mounting Europlug	1
	Europlug Lead	1
TRANSFO	Display Transformer (6-0-6V)	1
TRANSFO1	PSU Main Transformer (15-0-15V 300VA)	1
	Mounting hardware (for above)	1 set
	Cooling Fan	1
	Red Terminal Post	1
	Black Terminal Post	1
	Blade Receptacle 1/4 in.	17
	Blade Receptacle Insulating Boots 1/4 in.	4
	Heatsink	2
	Front panel	1
	Front panel foil	1
	Control knob	3
	Rear panel	1
	Base	1
	Top Lid	1
	Electrolytic Capacitor Mounting Bracket	2
	Rubber foot	4
	Zinc-plated Bolt M3x12mm	12
	Zinc-plated Countersunk Bolt M3 x 12mm	2
	Hex. Head Bolt M3 x 15mm	6
	Zinc-plated Bolt M4 x 25mm	1
	Black Bolt M4 x 25mm	4
	Black M4 Countersunk Bolt M4 x 25mm	4
	Zinc-plated Bolt M4 x 25mm	4
	Zinc-plated Bolt M4 x 45mm	4
	Spacer M3 x 15mm	4
	Solder Tag M3	5
	Washer M3	6
	Shakeproof Washer M3	20
	Nut M3	28
	Threaded Bush M3 x 12mm	4

OPTIONAL (Not in Kit)

	13A Nylon Mains Plug	1	(RW67X)
	3A Fuse	1	(HQ32K)
	Insulating Boot for Fuseholder	1	(FT35Q)
	Insulating Boot for Chassis Plug	1	(JK66W)
	Heat Transfer Compound	1 syringe	(FL79L)
	BC Lampholder	1	(FQ02C)
	40W Mains Lamp Bulb	1	

The Maplin 'Get-You-Working' Service is available for this project, see Constructors' Guide or current Maplin Catalogue for details.

The above items (excluding Optional) are available in kit form only.

Order As VF14Q (30V 10A Laboratory Power Supply Kit)
Price £239.95. H

Please Note: Some parts, which are specific to this project (e.g. PCBs, front panel, transformers etc.), are not available separately.