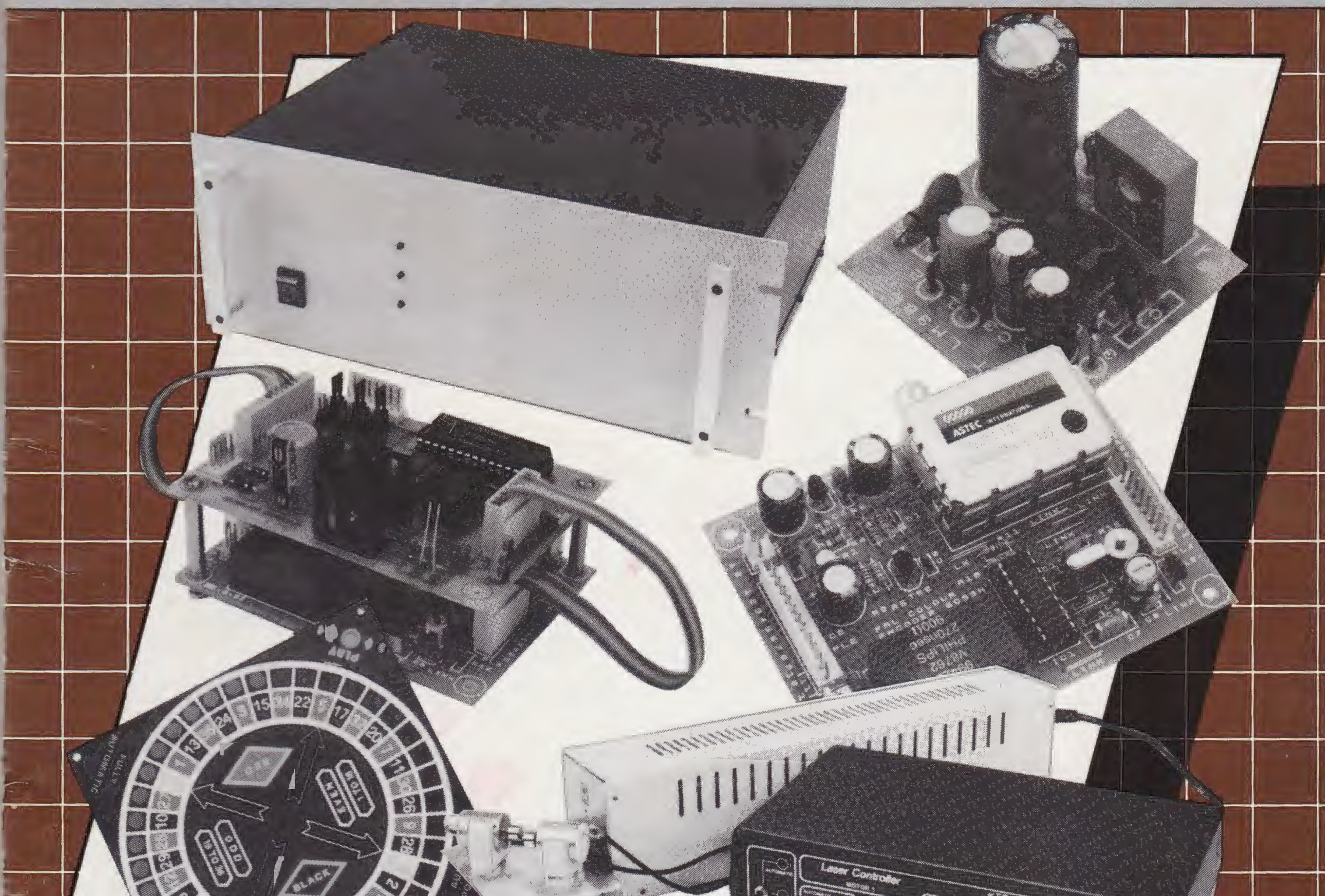
PROJECTS BOOK 29

Maplin Maplin Maplin



1kW MOSFET AMP PART 2

ELECTRONIC ROULETTE WHEEL

LM286 DATA FILE

2mW LASER & CONTROLLER

PAL COLOUR ENCODER

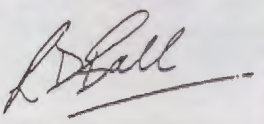
COLOUR BAR GENERATOR

CONTENTS

MAPLIN PROJECTS BOOK TWENTY NINE

EDITORIAL

This Project Book replaces Issue 29 of *Electronics* which is now out of print. Other issues of *Electronics* will also be replaced by Project Books once they are out of print. For current prices of kits please consult the latest Maplin Catalogue or the free price change leaflet, order as CA99H. All projects in this issue are from original magazine Issue 29, with the exception of the Colour Bar Generator, which is from magazine Issue 77.



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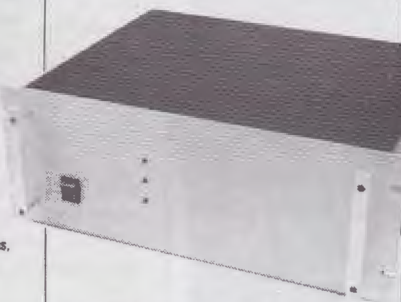
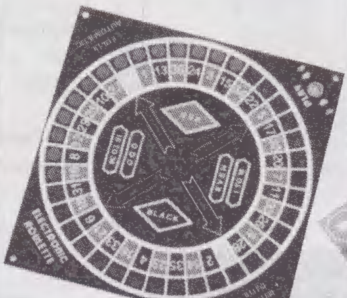
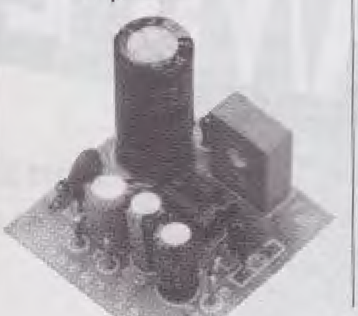
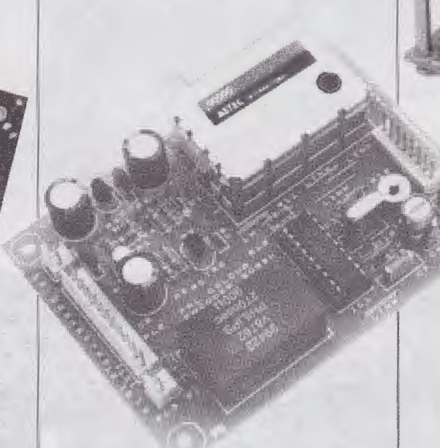
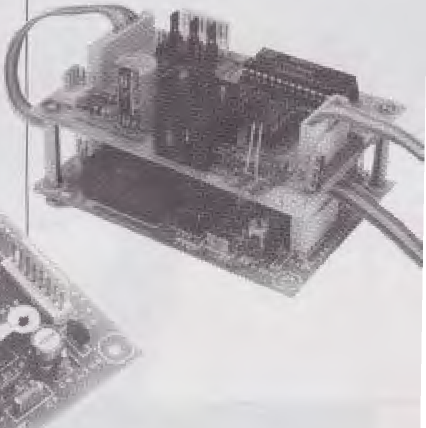
PROJECTS



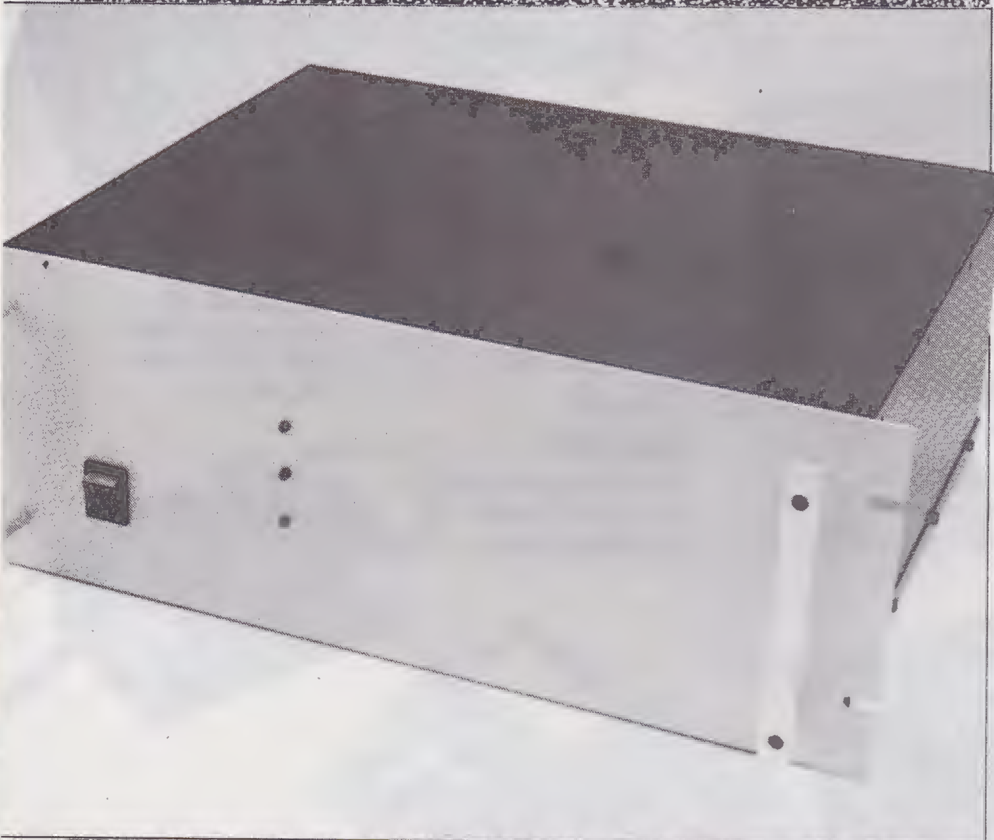








1KW HIGH POWER MOSFET AMPLIFIER



The Maplin High Power Mosfet Amplifier project consists of four modules: Driver and Output modules for the amplifier section, Monitor module and Power Supply module; all available separately in kit form. Articles on the construction and testing of these modules can be found in issue 26 of 'Electronics – The Maplin Magazine' (the information is also supplied with each kit!) and therefore will not be repeated again. This article concentrates on mounting a mono only version of the complete amplifier and PSU into a 19 inch 'rack mount' style case measuring 350mm deep by 176mm (4 units) high; manufactured from 1mm thick steel sheet and finished in heat cured black epoxy, with a 3mm anodised aluminium front panel.

Case kits are supplied in flat pack form with panels pre-punched and drilled, to make life easier for the constructor, and the various wires, bolts etc., can alșo be purchased from Maplin (see Parts List).

Mechanical Assembly

Photograph 1 shows the actual prototype assembly with lid removed; the various component parts also can be individually identified from Figure 1. Before beginning the assembly, identify seven panels that constitute the case and temporarily place them in their correct positions. It is advisable to leave the anodised front panel wrapped up at this stage, as it can be easily scratched and marked, and it is not required at this time.

Sub-Panel

Locate the galvanised sub-panel and orientate it with the smaller S1 cut out

Part 2
by Dave Goodman

positioned at the lower right hand side, as shown in Figure 2 and Photograph 2. Mount the Monitor module using four M3 x 10mm insulated spacers as in Figure 3 and Photograph 3.

Rear Panel

Six items are mounted on the rear panel as shown in Figure 4 and Photographs 4 and 5. Position the fan over the large panel cut-out, from the inside, with open blade side down and the air flow direction arrow, stamped on the fan chassis, facing away from the panel. Air is to be drawn IN from outside of the case and blown over the heatsink to cool the Mosfets and reduce toroidal temperatures. Ensure that the fan corner terminal block is positioned as shown, then place the wire finger guard over the panel cut out from the outside and fix the assembly with four M4 x 16mm bolts and nuts. Fit an M4 isotag terminal onto the fan chassis earthing hole, adjacent to the corner terminals, using an M4 bolt and nut.

Insert XLR connectors SK1 and PL2 into the panel from the outside. SK1 is the signal input socket with latch release mechanism, wiring shown in Figure 13, whereas PL2 is the amplifier output plug with three recessed terminal pins and non-latching! Both connectors are fixed using two countersunk M3 x 10mm bolts, nuts and washers.

Similarly, insert the Euro mains filter connector PL1 and fix with two countersunk M3 x 10mm bolts, as before, ensuring that the connector is orientated with the centre earth terminal closest to the case top (toward FS1 position).

Finally, mount the 20mm fuse holder FS1 into the panel from the outside, tighten the locking nut and insert a 6.3A fuse.

Base Panel

Six items are mounted onto the base panel as shown in Figure 1 and Photographs 1 and 6 through to 7. Orientate the base panel so that the various components

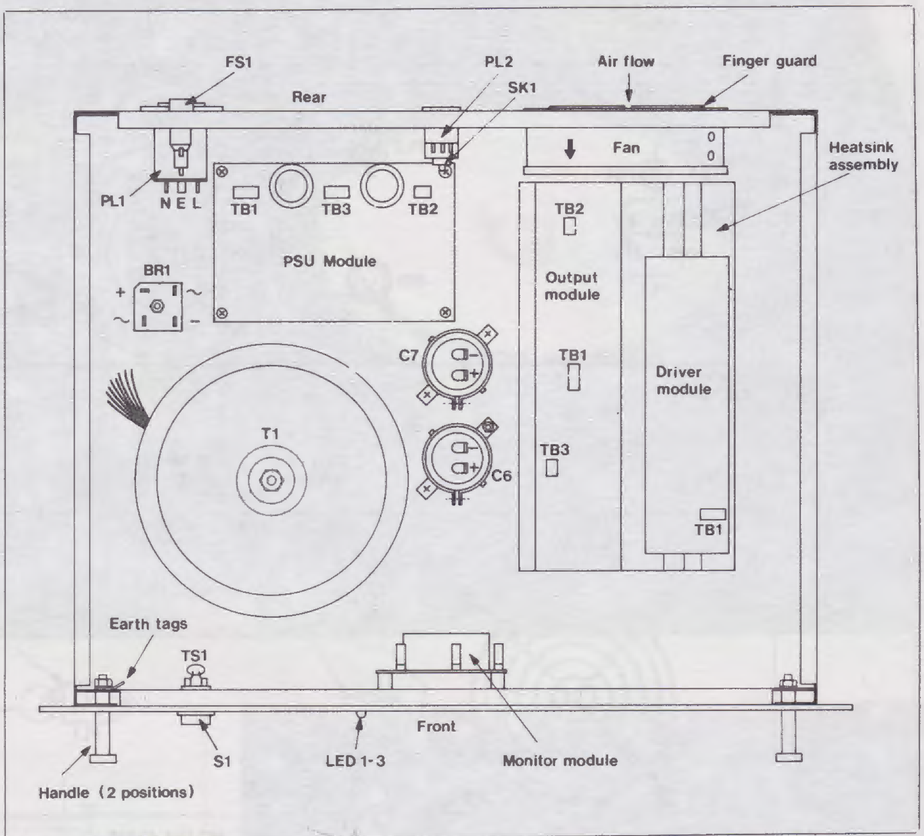


Figure 1. General layout.

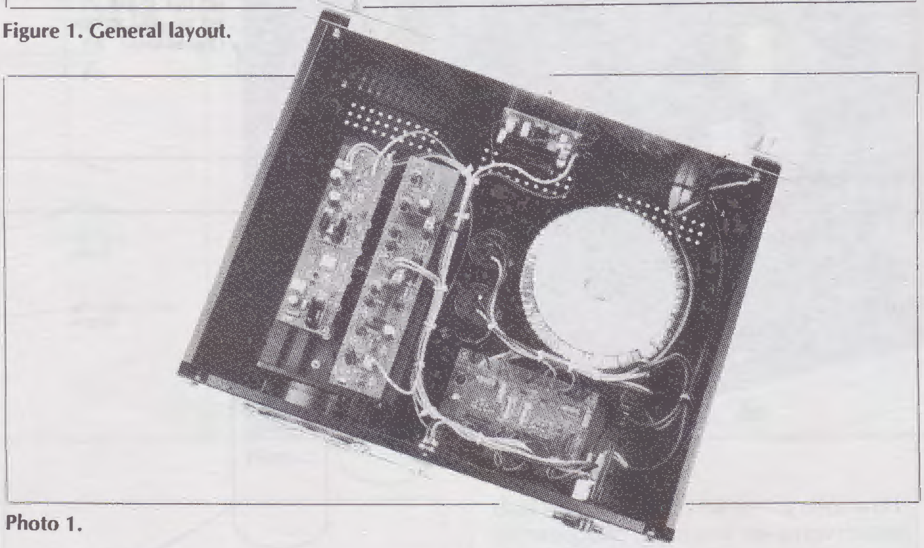


Photo 1.

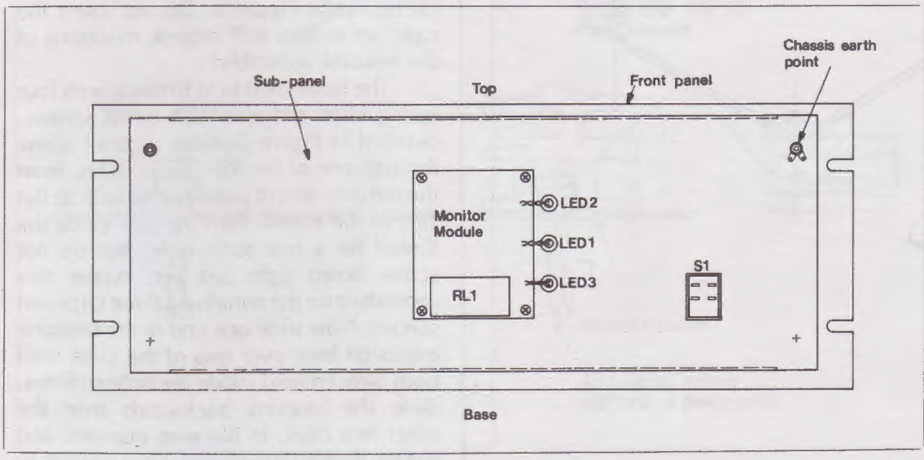


Figure 2. Sub-panel layout.

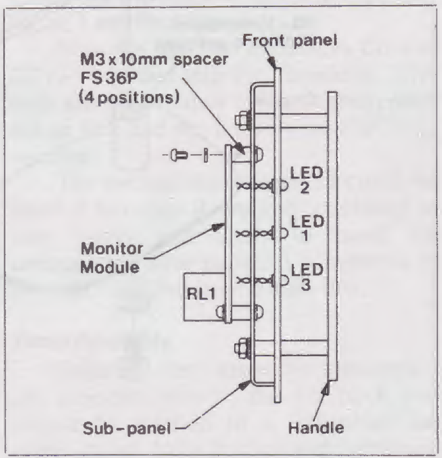


Figure 3. Side view of Front/Sub-panel.

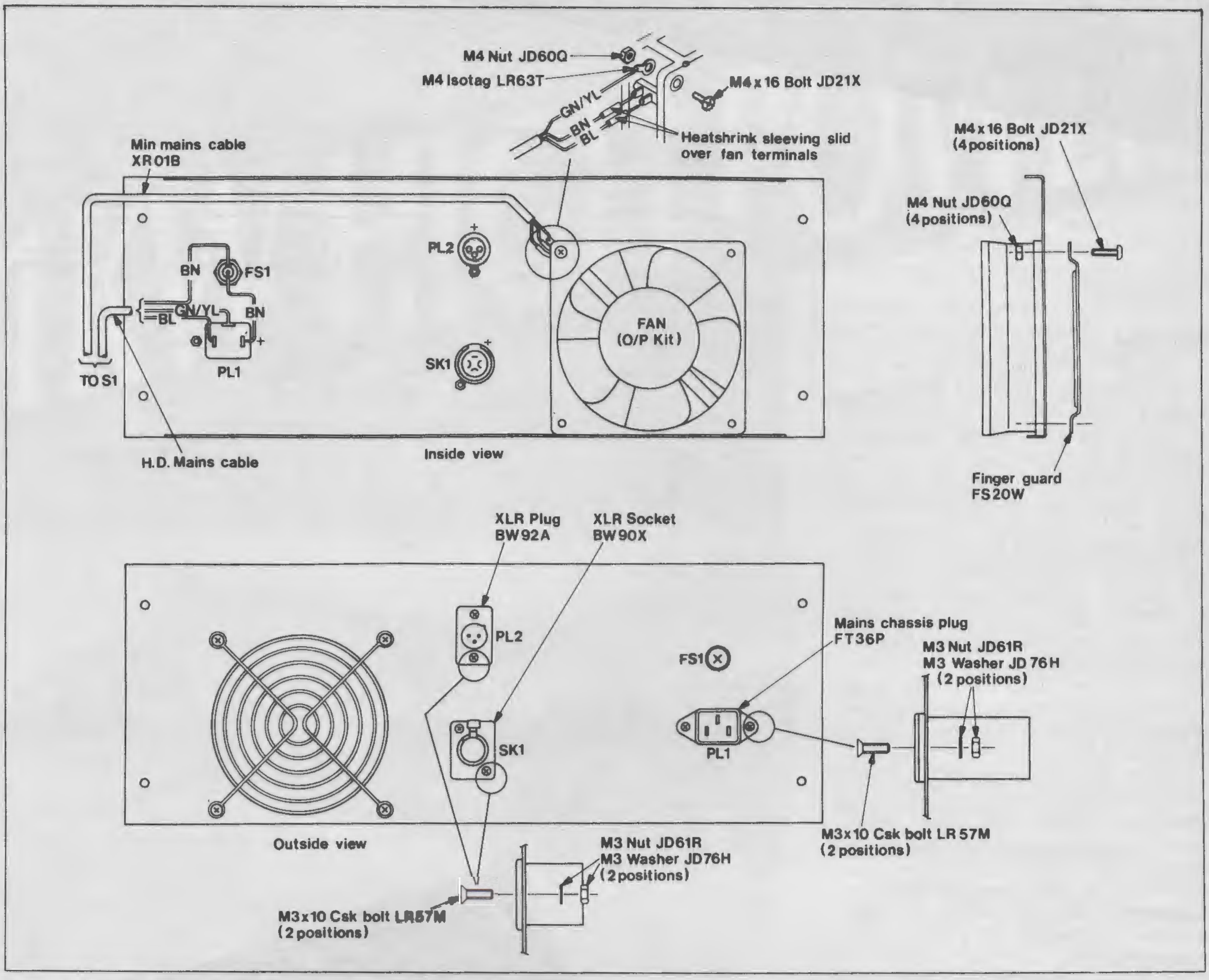


Figure 4. Rear panel layout.

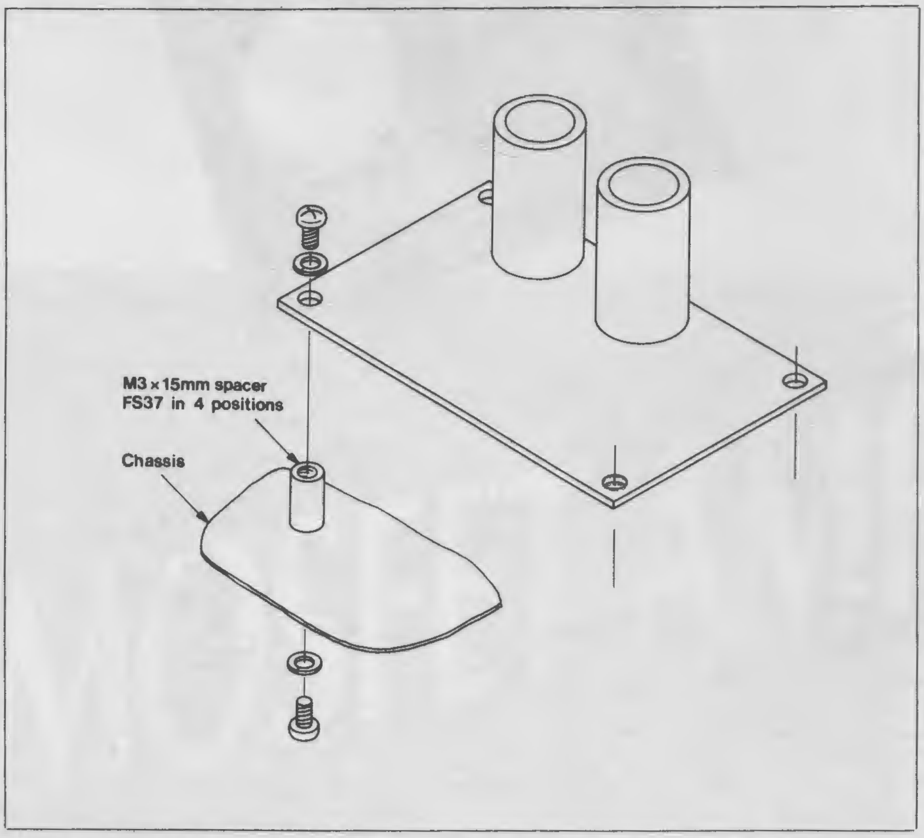


Figure 5. Mounting the PSU.

can be aligned with Figure 1 and mount the Bridge Rectifier BR1 with an M4 x 16mm bolt and nut (see Figure 8).

At the PSU module position, fit four M3 x 15mm insulated spacers in each of the four corner holes; position the module over the spacers, with 'can' capacitors C8 and C9 toward the back edge of the panel, and fit the four screws as shown in Figure 5. Power supply filter capacitors C6 and C7 are pre-fitted with mounting clamp, brackets; these should first be removed and then bolted to their respective positions using two M3 x 10mm bolts and nuts per clamp, as in Figure 6. Do not insert the cans yet as they will impede mounting of the heatsink assembly!

The heatsink is held in place with four spring clips and four 4BA panel screws, detailed in Figure 7. Place a panel screw through one of the four panel holes, from the outside, and fit a spring clip with its flat side to the screw. Turn the clip along the thread for a few turns only, but do not screw down tight just yet; repeat this procedure for the remaining three clips and screws. Now slide one end of the heatsink extrusion base over two of the clips until both have entered inside the bottom flutes. Slide the heatsink backwards over the other two clips, in likewise manner, and tighten the four panel screws just enough to grip the heatsink securely. If the screws are

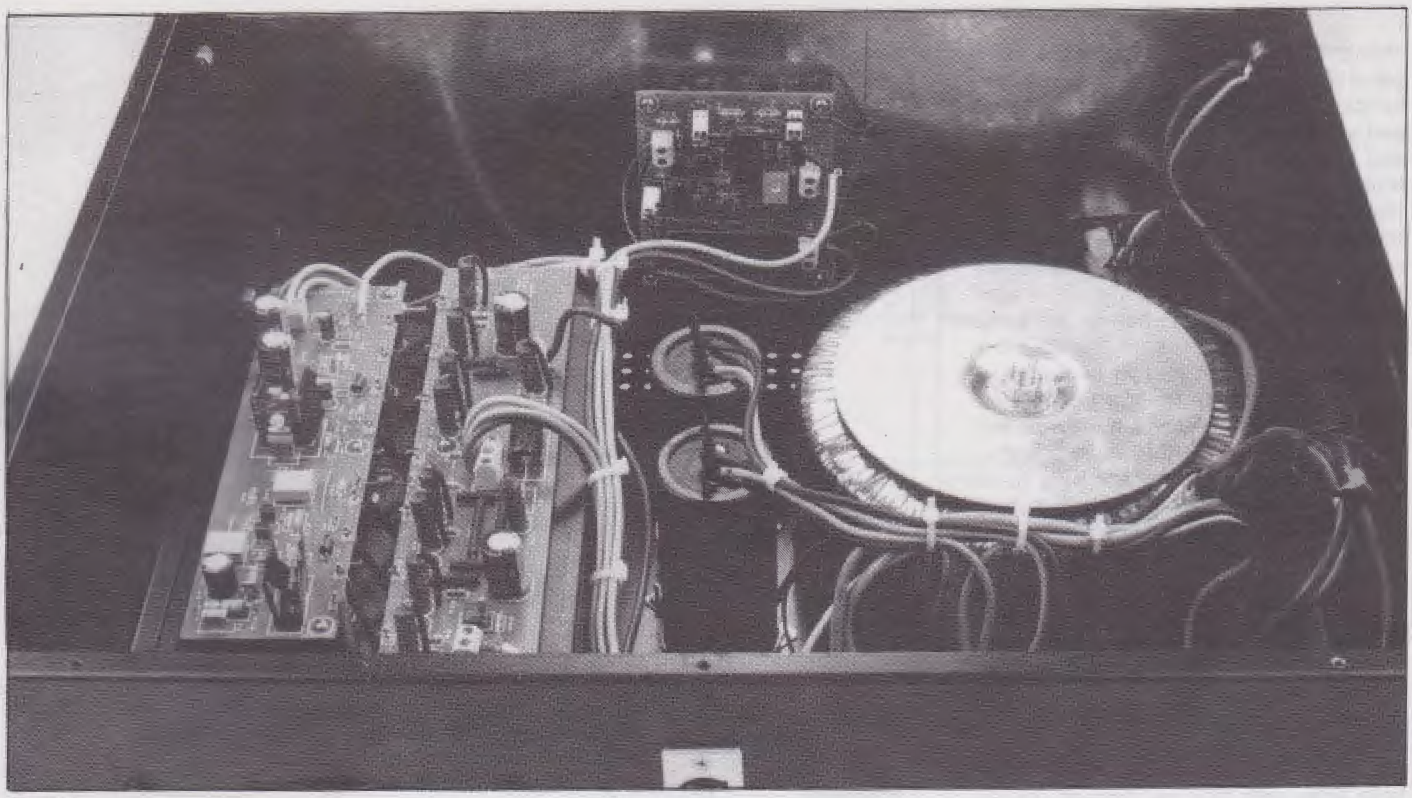


Photo 2.

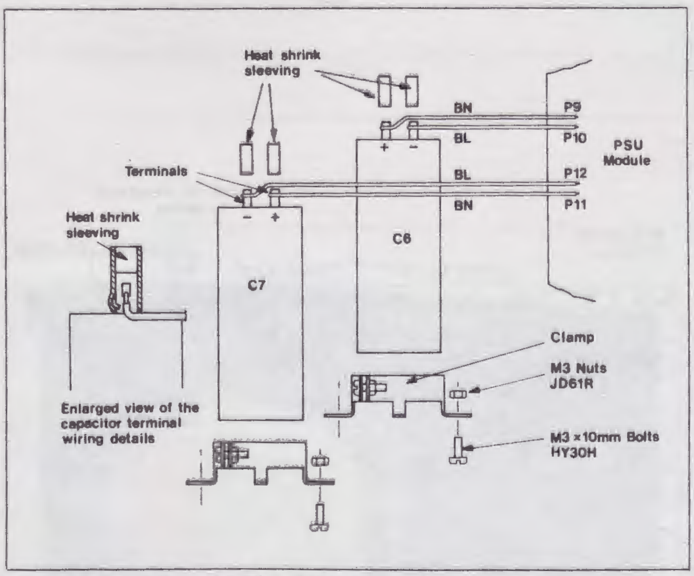


Figure 6. Mounting and wiring C6/C7.

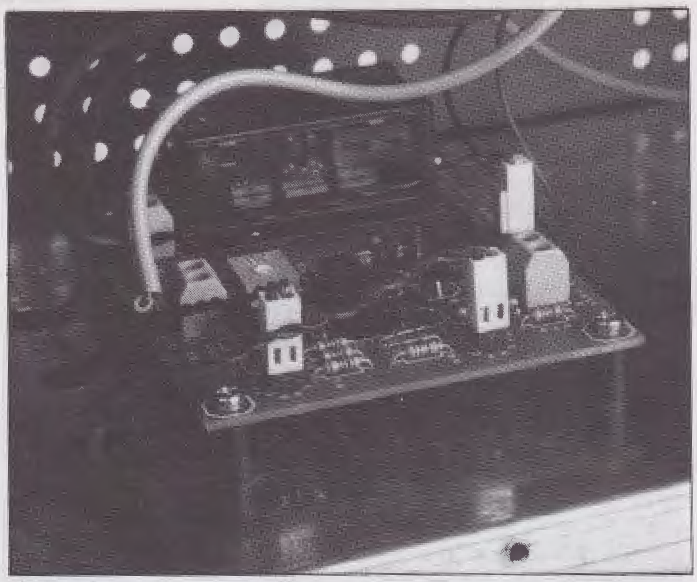


Photo 3.

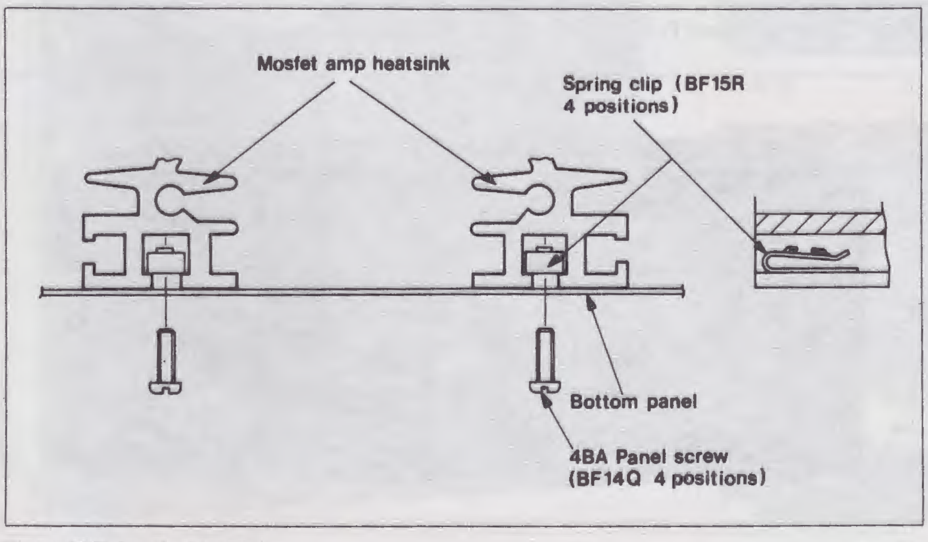


Figure 7. Fixing the Heatsink.

over tightened, then the spring clips will be damaged and fail to grip the screw threads. Check that the heatsink is positioned as per Figure 1 and Photograph 6.

Now the two can capacitors C6 and C7 can be fitted into their brackets. With both sets of terminals in line, tighten each clamp bolt and nut until the can is firmly secured.

The toroidal transformer T1 could be fitted at this stage if required, but being so very heavy and likely to bend the unsupported base panel, it is better to fit the side, rear and front panels first.

Panel Assembly

Separate case assembly instructions are supplied in with the flat pack and should be referred to if difficulties are experienced. Note that left and right hand panels are identical and therefore, interchangeable! Unwrap the anodised front panel and identify two flat aluminium handles, four tubular aluminium spacers and allen screws, four short brass spacers and nuts/lock washers. Insert two allen screws through the holes in each handle – notice the recess machined to take the screw heads – and slide an aluminium spacer over each screw thread, behind the handle! Position the front panel with mains switch cut-out S1 to the bottom left hand side. Insert both allen screw threads from one handle assembly into the two holes in the left hand side of the front panel and offer up the end plate of a side panel. Figure 1 may show this more clearly. Repeat the procedure for the right hand side handle and panel then place a short brass spacer over each allen screw thread, behind the side panel end plate! The galvanised sub-panel, now holding a monitor module, is placed over the four brass spacers and held in place with one locking washer and nut to each screw. Tighten all four allen screws/nuts, just enough to hold the four panels together; place the assembly over the base panel – inside the panel lipped edges – and fasten both sides with four self tapping screws from the case pack.

The rear panel can now be fitted and fixed with four bolts, nuts and washers from the case pack. It may be found necessary to slacken the heatsink mounting screws and move the extrusion forward slightly to accomodate the fan.

Transformer

Figure 8 shows details for mounting T1. Insert the large bolt through the base panel from the outside and, on the inside, place a rubber insulating pad over the bolt; put the transformer onto the pad and position the eight primary/secondary wires adjacent to the bridge rectifier BR1. Fit the second rubber pad, steel disc and securing nut as shown.

Note: If the amplifier is to be run continuously at very high power output levels, then the toroidal will dissipate a considerable amount of heat! Under this condition the outer temperature of the steel disc reaches 50 to 55 degrees Centigrade and the inner core, even higher. Tests have shown that the toroidal runs without problem at this temperature, but it would be beneficial for long term reliability if air flow through the centre were created. Therefore, several small holes (approximately 3mm) should be drilled through the base panel, steel disc and rubber pads, positioned around the centre area of T1, before assembly (not shown in photographs).

Electrical Wiring

All heavy power and mains connections are made from heavy duty mains cable. The 2 metre length included with the PSU kit is used for DC wiring between modules, PSU capacitors, BR1 and PL2 and the 1 metre length for mains connections. Fan wiring is made from the miniature mains cable.

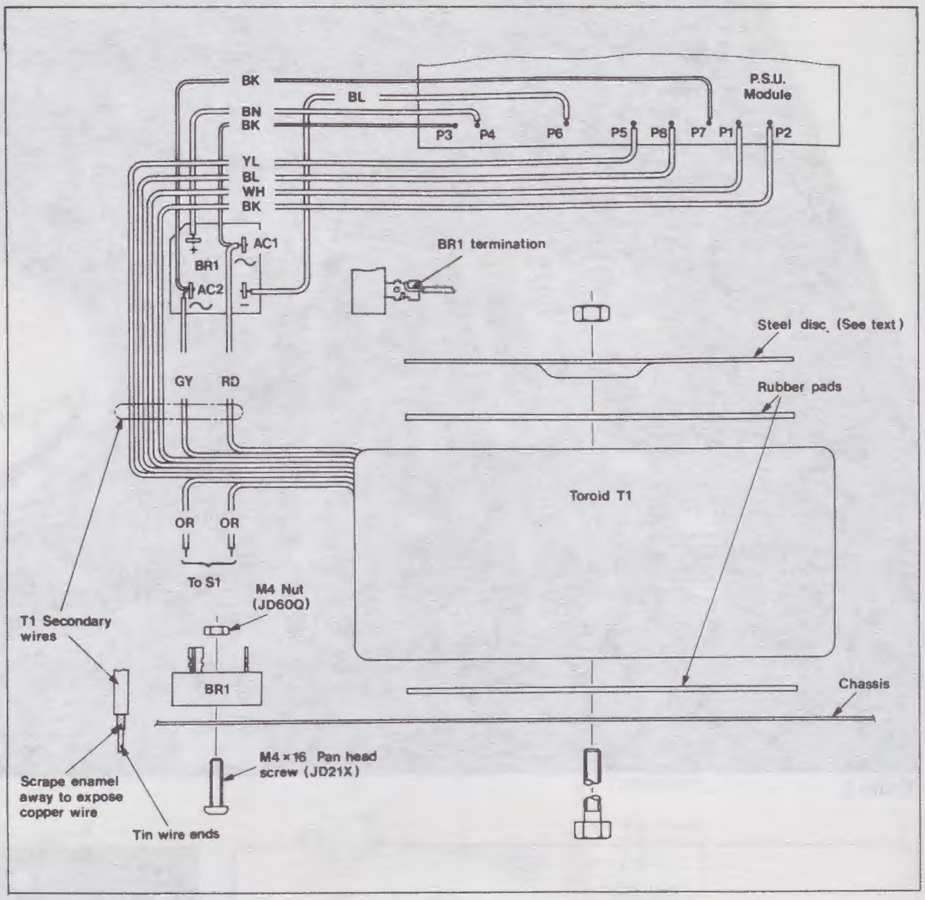


Figure 8. PSU wiring.

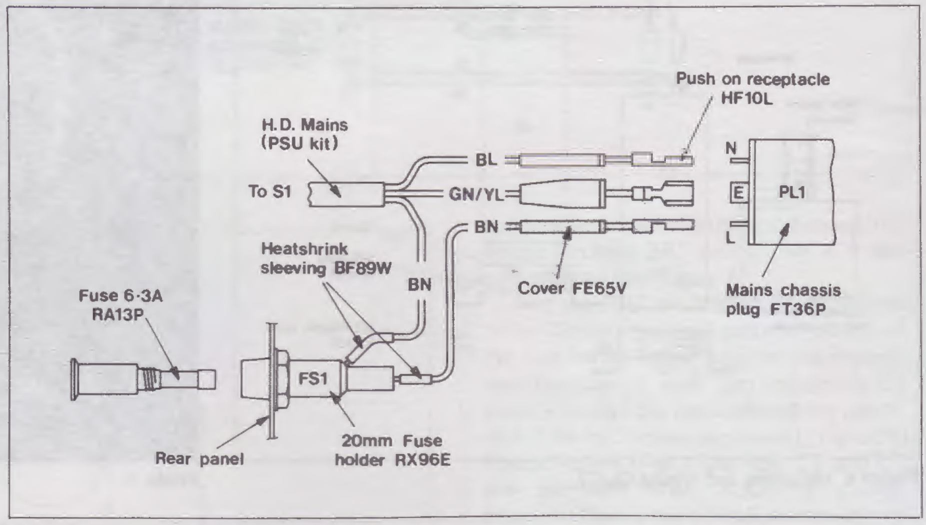


Figure 9. Wiring FS1 and PL1.

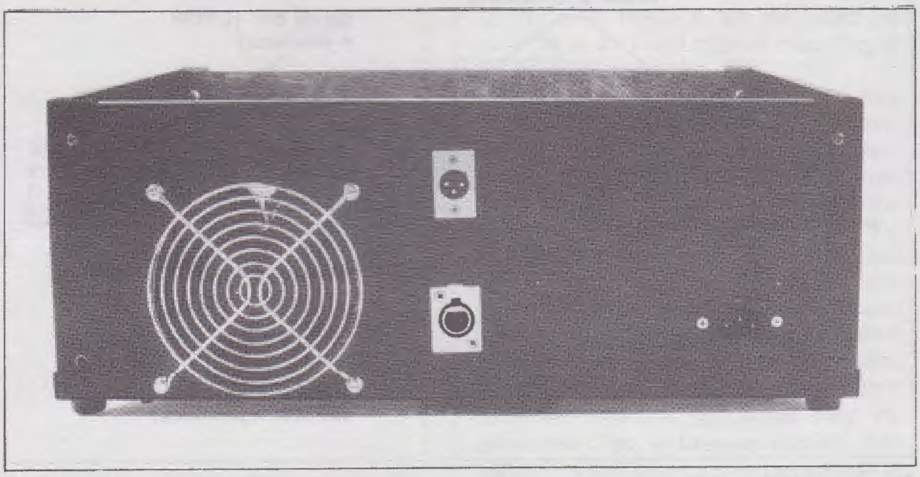


Photo 4.

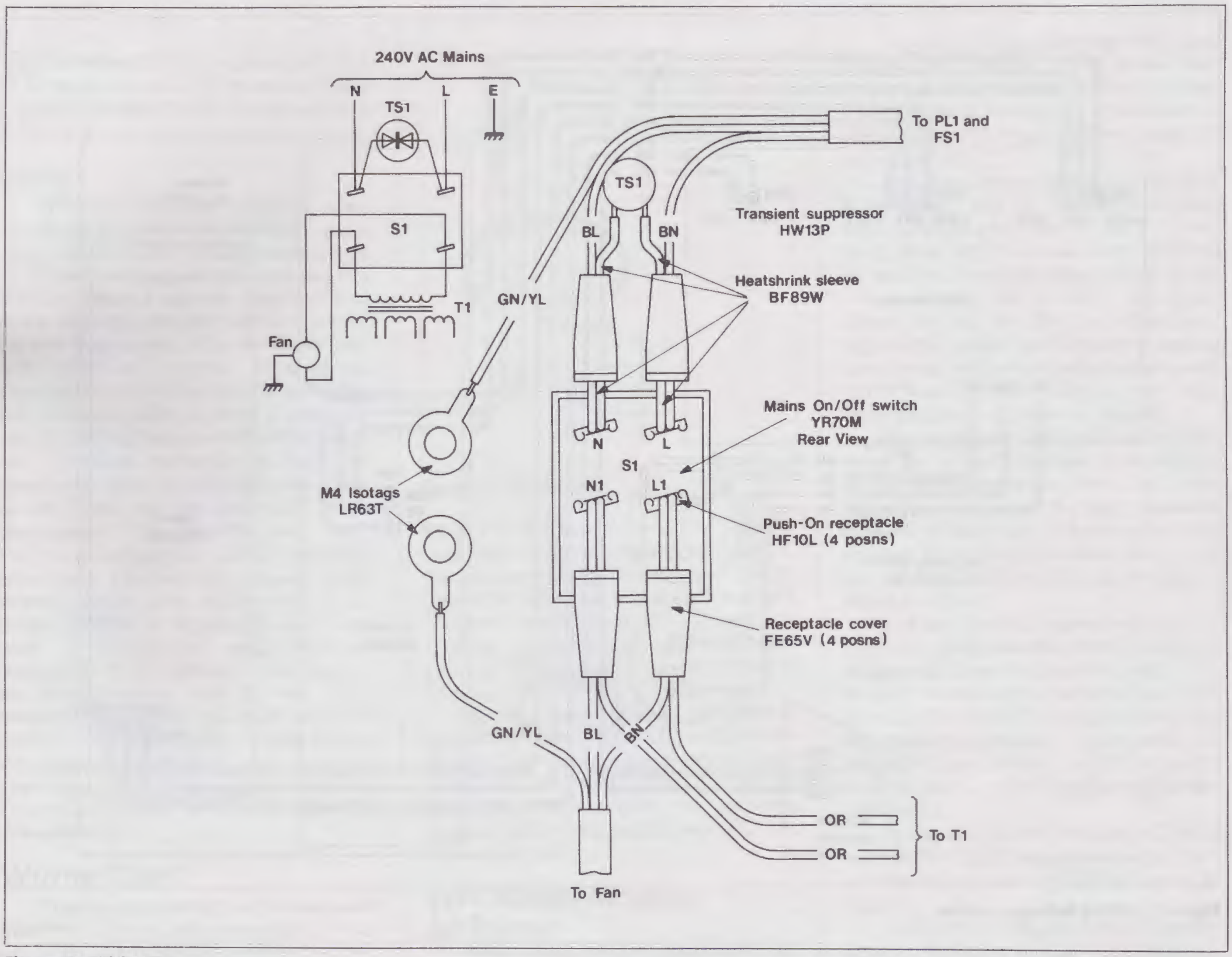


Figure 10. Wiring S1.

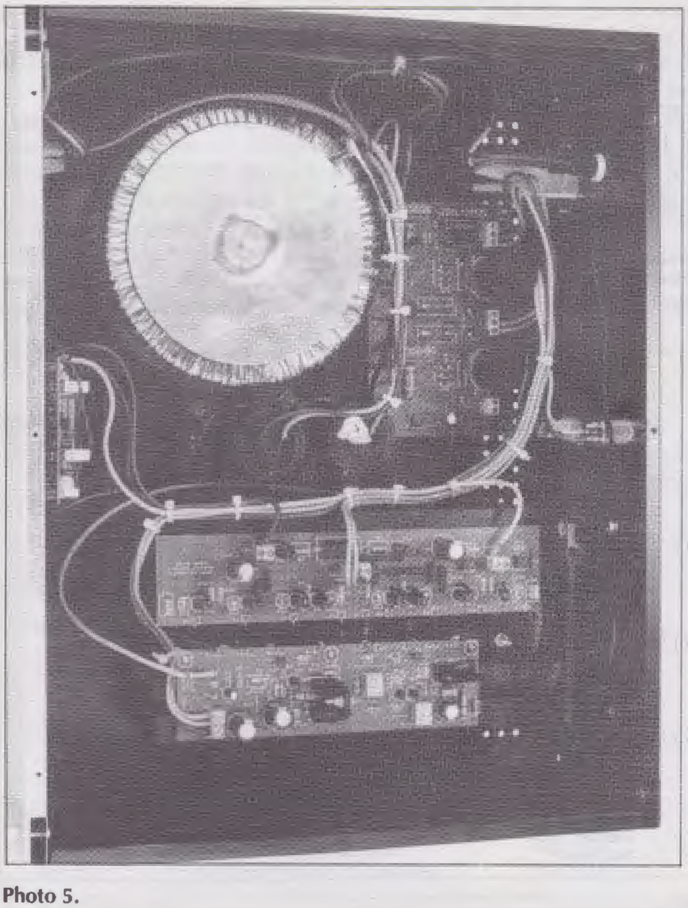


Photo 5.

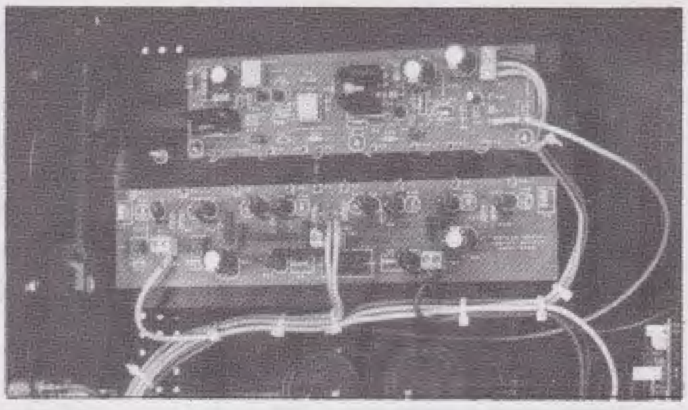


Photo 6.

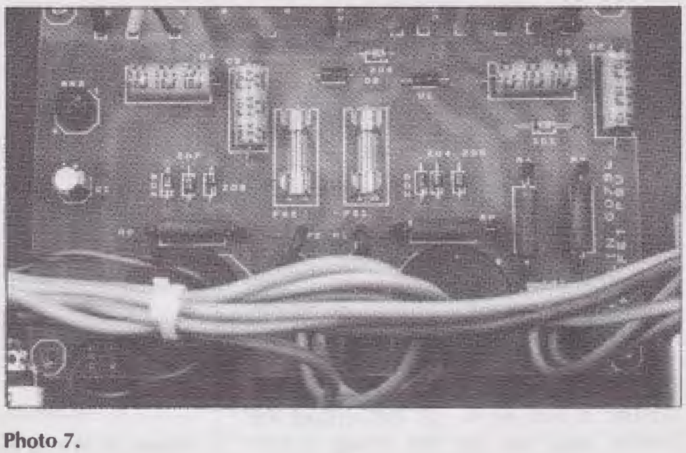


Photo 7.

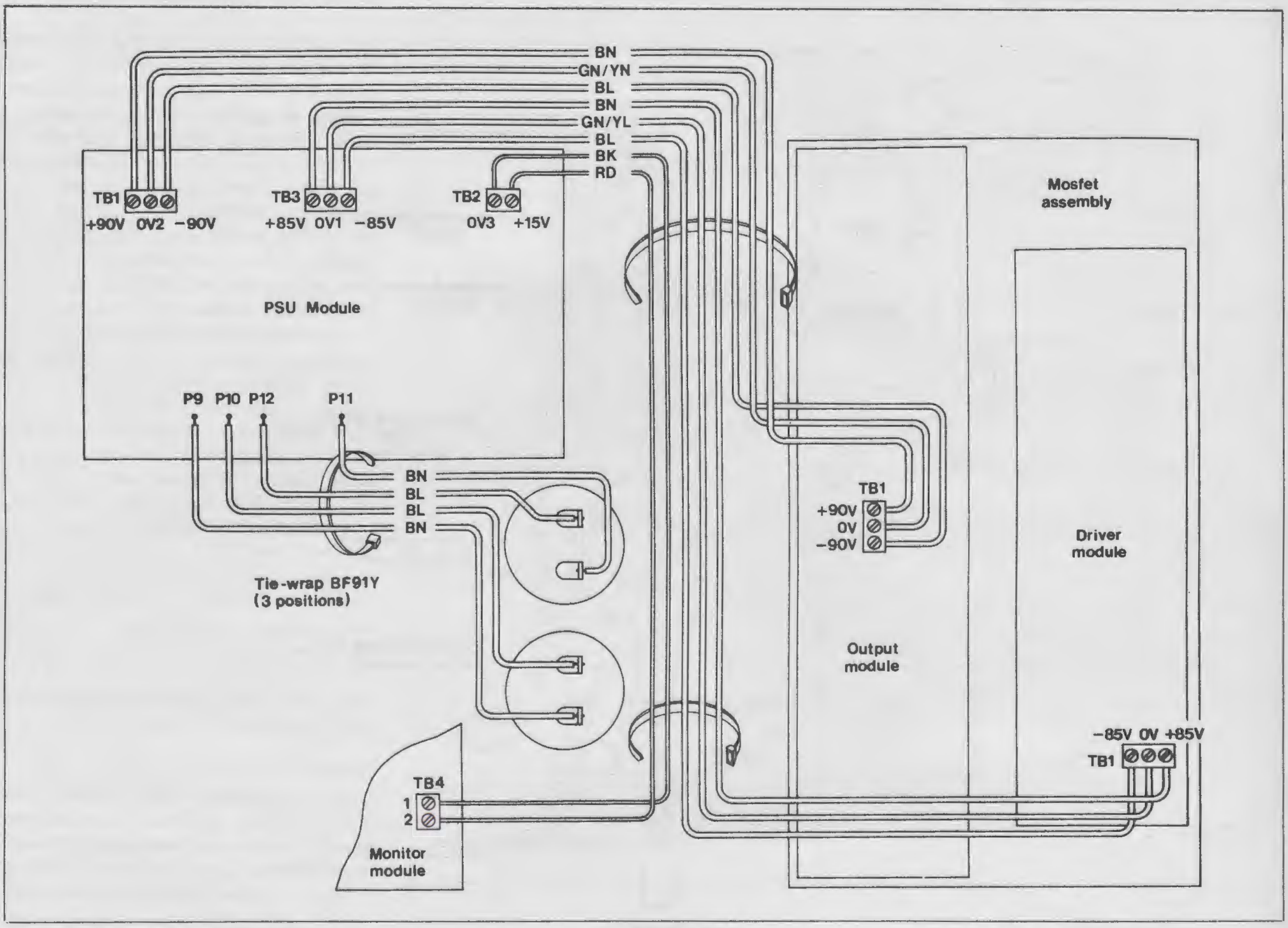


Figure 11. Wiring between modules.

Strip the outer covering from the 2 metre cable length only to expose the brown, blue and green/yellow wires. They will be used for the wire connections shown in Figures 6, 11 & 12; BR1 to PSU wiring appears in the top half of Figure 8.

Receptacles

Mains wiring from the input connector PL1 to switch S1 is detailed in Figures 9 and 10. Push on receptacles are used for terminating these wiring connections and insulated covers are fitted for reasons of safety. In Figure 10, the Live (BN) and Neutral (BL) wires from FS1/PL1 are terminated at S1 with a transient suppressor (TS1) connected between them. The suppressor wires are insulated with suitable lengths of heat shrink sleeving and inserted, with the mains wire, into each cover and then receptacles are fitted. Both orange primary wires from T1 and miniature mains fan wires are terminated in a similar fashion.

Earthing

Approximately 120mm of the green/yellow earth wire from both cables, is used for connecting to the case chassis earthing point, which is at the left hand side handle screw above S1 (see Figures 1 and 2). Solder an M4 isotag to each earth wire (Figure 10), remove the allen screw nut and washer, fit both earth tags and replace the washer and nut. An M4 isotag is also

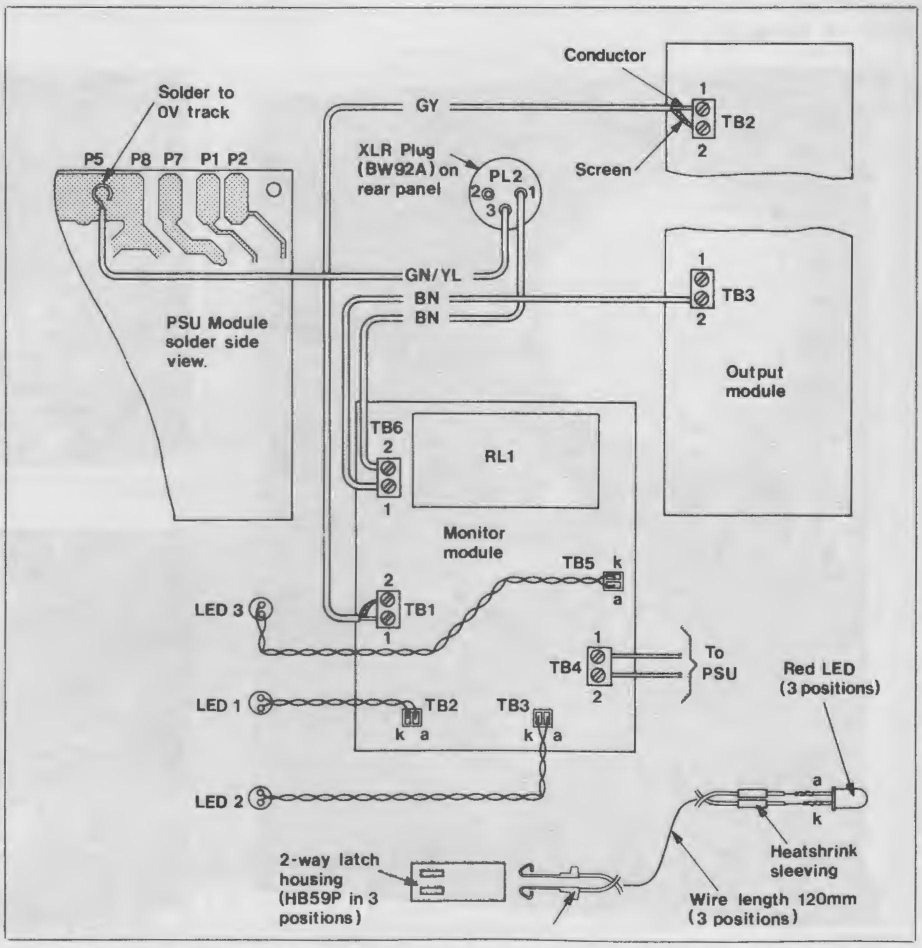


Figure 12. Wiring the LEDs.

required to be soldered onto the earth wire on the opposite end of the fan mains cable. The tag is bolted to the fan chassis as shown in Figure 4.

Sleeving

Whenever possible, exposed wires and terminals should be insulated, especially where mains is concerned. Once wires have been prepared for soldering to a terminal, place a suitable length of heat shrink sleeving onto the wire first, solder the wire in place and slide the sleeve over both joint and terminal. Heat shrink sleeving reduces its diameter considerably with the application of heat; a soldering iron placed in close proximity will acheive this. Therefore, remember to keep the sleeve well clear of any joint until it has cooled down, else the sleeve will shrink prematurely! FS1 requires two such sleeves, as in Figure 9, and the two PSU capacitors, C6 and C7, should have sleeves placed over each terminal as shown in Figure 6. Receptacle covers are used to insulate the seven push-on receptacles on PL1 and S1 mains terminals. Place a cover over the wire first, prepare the wire end and solder onto the push-on receptacle, fit the receptacle onto the appropriate terminal and slide the cover over both receptacle and terminal. Figure 9 and Figure 10 show the sleeving arrangements.

Wiring Chart

Point to point wiring can be followed from the diagrams and photographs in the article, but as mistakes are easily made, the chart given in Table 1 can be used as a guide or checklist.

Indicator LEDs

The three LEDs associated with the Monitor module are wired to 'minicon' terminals, see Figure 12, and glued into the front panel as shown in Figure 3. Cut three 120mm lengths each of the red and black hook up wire, prepare the ends and solder a red wire to each of the three LED anode leads (longest lead of the two). Solder a black wire to each of the LED cathode (K)

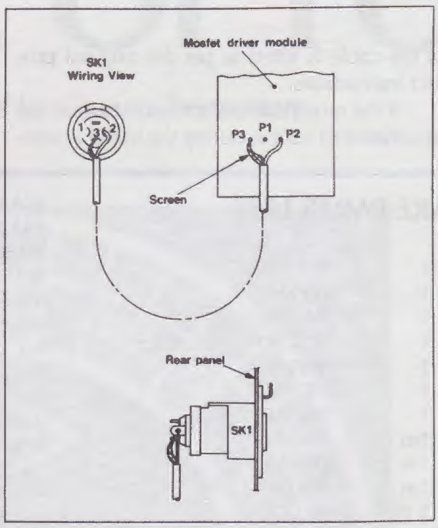


Figure 13. Wiring SK1.

leads and fit a suitable length of sleeving over each of the six leads and joints as shown. Carefully solder a minicon terminal onto the remaining end of each lead and insert the terminal pairs into a 2 way latch housing, noting the polarity of each wire. LED3 to TB5 wires are reversed to those of TB2 and TB3!

Apply a small amount of adhesive around the body of each LED and position them through the sub-panel into the front panel and allow to dry. Viewed from the case front, LED 2 takes the top hole position, LED 1 the middle and LED 3 to the bottom hole.

1kW Mosfet Amplifier Additional

Some customers have experienced problems with this amplifier due to instability. The problem can manifest itself in the form of mains hum from a connected loudspeaker, and becomes more or less apparent depending on where the amplifier is situated. The expected noise output is usually very low, and when viewed on an oscilloscope you should expect to see wideband and hum noise levels in the order of 10 to 20mV. A few amplifiers have exhibited 2 to 3V of RF signal, modulated by 50 and 100Hz with the input pins shorted (or open circuit); and the low-frequency component can be heard.

The amplifier has a very high frequency response and slew rate, which is desirable for good quality sound reproduction, but does it susceptible to external RF interference – radiophones and telephones are a typical example of this.

Also, due to the number of Mosfets used in the design, and the large differences of input capacitance between 'N' and 'P' Mosfet types, some amplifiers have been noted to go unstable at medium output power levels – approximately 100 to 200W. The effect, when viewed on the oscilloscope, approaches small, low-frequency square wave bursts, within the signal waveform, and can be more prevalent following very large signal excursions or transient clipping.

Our development lab points out that this is not the normal behaviour of the design, neither is it a common occurrence, but in the interest of maintaining the high standards expected of this project, a few simple modifications have been developed which will cure any such problems that may be experienced as follows:

1. A pre-punched, galvanised steel, 19 inch rack case is available (XM13P) which is designed to house the amplifier, and should be used. Various other installation hardware is included in kit LM65V, along with the case. With the case grounded to mains earth, the amplifier's susceptibility to RF is greatly reduced, and the case is therefore highly recommended.

2. On the Driver Module (GD80B) replace C10 (100pF polystyrene) with a 22pF polystyrene capacitor (BX24B) as shown in Figure 1.

3. Fit a 390pF 1% polystyrene capacitor between the Driver Module (GD80B) pin 4 and the junction of the wire-wound resistors R12 and R14 on the Output Module (GD81C). This assumes that both the driver and output modules have been installed onto the heatsink as shown in the project instructions supplied with the kit.

4. Fit a simple low-pass filter between the input XLR socket, SK1, and the input pins of the Driver Module. The simplest way to install the filter is to solder the two components straight onto the back of SK1, with an M4K7 resistor soldered to pin 2, and a 1000pF (1nF) capacitor (BX56L) soldered to

From	To	Type	Description
1. PL1 'L'	FS1 (END)	BROWN	HD MAINS CABLE
2. PL1 'N'	S1 'N'	BLUE	HD MAINS CABLE
3. PL1 'E'	CHASSIS ETH	GRN/YEL	HD MAINS CABLE
4. FS1 (CENTRE)	S1 'L'	BROWN	HD MAINS CABLE
5. TS1	S1 'L'	SLEEVED	FIGURE 10
6. TS1	S1 'N'	SLEEVED	FIGURE 10
7. FAN T/BLOCK	S1 'L1'	BROWN	MIN MAINS CABLE
8. FAN T/BLOCK	S1 'N1'	BLUE	MIN MAINS CABLE
9. FAN CHASSIS	CHASSIS ETH	GRN/YEL	MIN MAINS CABLE
10. T1	S1 'L1'	ORANGE	MAINS PRIMARY
11. T1	S1 'N1'	ORANGE	MAINS PRIMARY
12. T1	BR1 AC1	RED	FIGURE 8
13. T1	BR1 AC2	GREY	FIGURE 8
14. T1	PSU MODULE pin 5	YELLOW	FIGURE 8
15. T1	PSU MODULE pin 8	BLUE	FIGURE 8
16. T1	PSU MODULE pin 1	WHITE	FIGURE 8
17. T1	PSU MODULE pin 2	BLACK	FIGURE 8
18. BR1 AC1	PSU MODULE pin 3		FIGURE 8
19. BR1 AC2	PSU MODULE pin 7		FIGURE 8
20. BR1 +	PSU MODULE pin 4	BROWN	FIGURE 8
21. BR1 –	PSU MODULE pin 6	BLUE	FIGURE 8
22. C7 +	PSU MODULE pin 11	BROWN	FIGURE 6
23. C7 –	PSU MODULE pin 12	BLUE	FIGURE 6
24. C6 +	PSU MODULE pin 9	BROWN	FIGURE 6
25. C6 –	PSU MODULE pin 10	BLUE	FIGURE 6
26. PL2, pin 3	PSU MODULE 0V TRACK	GRN/YEL	FIGURE 12
DRIVER MODULE			
27. pin 3	SK1 pin 3	SCREEN	FIGURE 13
28. pin 2	SK1 pin 2	INNER	FIGURE 13
29. TB1 +85V	PSU MODULE TB3 +85V	BROWN	FIGURE 11
30. TB1 0V	PSU MODULE TB3 0V1	GRN/YEL	FIGURE 11
31. TB1 –85V	PSU MODULE TB3 –85V	BLUE	FIGURE 11
OUTPUT MODULE			
32. TB1 +90V	PSU MODULE TB1 +90V	BROWN	FIGURE 11
33. TB1 0V	PSU MODULE TB1 0V2	GRN/YEL	FIGURE 11
34. TB1 –90V	PSU MODULE TB1 –90V	BLUE	FIGURE 11
35. TB3 2	MONITOR TB6 1	BROWN	FIGURE 11
36. TB2 2	MONITOR TB1 2	SCREEN (+10V)	FIGURE 12
37. TB2 1	MONITOR TB1 1	INNER (I/P)	FIGURE 12
MONITOR MODULE			
38. TB6 2	PL2, pin 1	BROWN	FIGURE 12
39. TB4 1	PSU MODULE TB2 0V3	BLACK	FIGURE 11
40. TB4 2	PSU MODULE TB2 +15V	RED	FIGURE 11

Table 1. Wiring list.

pin 3. Solder the two unterminated leads together, and connect the core of the input screened lead to this point. Connect the lead screen to pin 3 on SK1. The remaining end of the cable is fitted as per the original project instructions.

If the modifications are to be carried out as a matter of course during the initial assembly of the modules then, on the Driver Module, R1 can be increased to 4k7 and C3 increased to 1nF instead of fitting these components on the rear of SK1.

1kW H.P. MOSFET AMP HARDWARE PARTS LIST

MISCELLANEOUS			
PL1	Mains Inlet Filtered Plug	1	(FT36P)
PL2	XLR Chassis Plug	1	(BW92A)
SK1	XLR Chassis Socket	1	(BW90X)
FS1	6·3A A/S Fuse	1	(RA13P)
TS1	250V AC Suppressor	1	(HW13P)
S1	Dual Rocker Neon Switch	1	(YR70M)
	20mm Fuseholder	1	(RX96E)
	Black Mains Lead	1m	(XR09K)
	Min. Black Mains Lead	1m	(XR01B)
	Grey Single Screened Cable	1m	(XR13P)
	Blue Hookup Wire	1 Pkt	(BL00A)
	Red Hookup Wire	1 Pkt	(BL07H)
	48mm Heat Shrink Sleeving	1m	(BF89W)
	24mm Heat Shrink Sleeving	1m	(BF87U)
	100mm Tie-Wrap	10	(BF91Y)
	Push On ¼in. Receptacle	1 Pkt	(HF10L)
	¼in. Receptacle Cover	1 Pkt	(FE65V)
	M4 Tag Washer	1 Pkt	(LR63T)
	M3 Steel Nut	1 Pkt	(JD61R)
	M4 Steel Nut	1 Pkt	(JD60Q)
	4BA Panel Screw	4	(BF14Q)
	4BA Spring Clip	1 Pkt	(JX59P)
	M3 Insulated Spacer	1 Pkt	(FS36P)
	M3 Insulated Spacer	1 Pkt	(FS37S)
	M4 x 16mm Bolt	1 Pkt	(JY16S)
	M3 x 10mm Bolt	1 Pkt	(HY30H)
	M3 Steel Washer	1 Pkt	(JD76H)
	M3 x 10mm Pozi Screw	1 Pkt	(LR57M)
	120mm Fan Guard	1	(FS20W)
	2-Way PCB Latch Housing	3	(HB59P)
	PCB Latch Terminals	1 Strip	(YW25C)
	Pre-Drilled 19in. Case	1	(XM13P)
	Instruction Leaflet	1	(XU83E)
	Constructors' Guide	1	(XH79L)

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

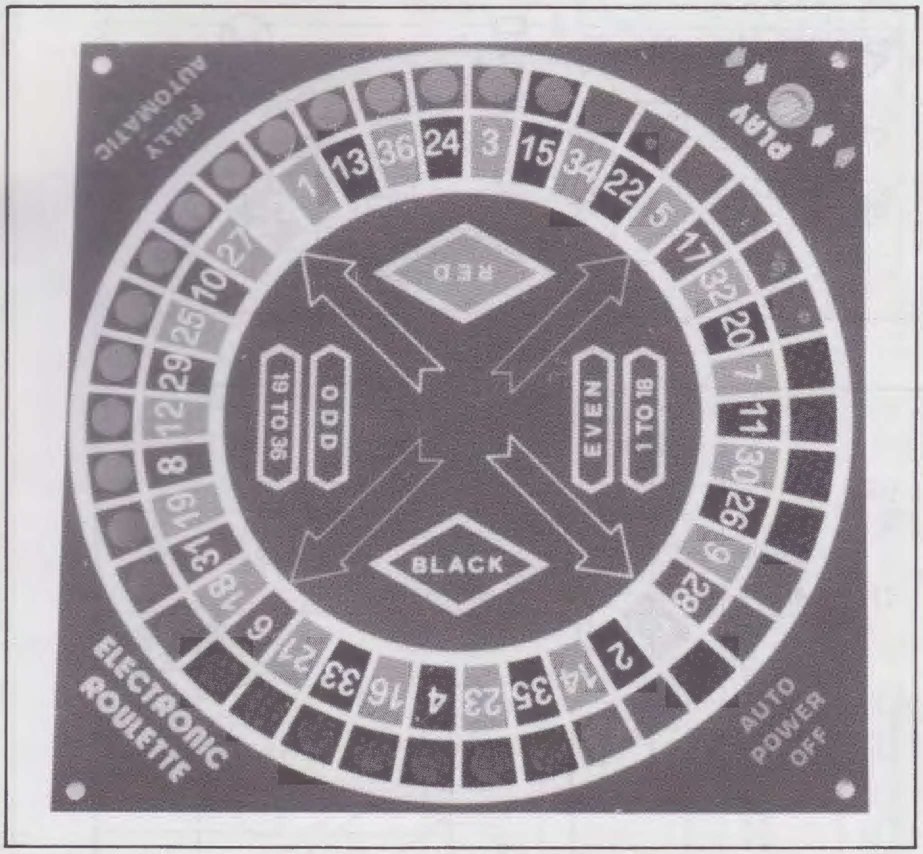
The above items are available as a kit, which offers a saving over buying the parts separately.

Order As LM65V (1kW MOSFET Amp Hardware Kit)

Please Note: Where 'package' quantities are stated in the Parts List (e.g., packet, strip, reel, etc.), the exact quantity required to build the project will be supplied in the kit.

WHEEL OF FORTUNE

Super Electronic Roulette reviewed by Gavin Cheeseman



The 'Super Electronic Roulette' kit is an electronic version of the well-known game played in gambling casinos. A roulette wheel is an effective random number generator, where a ball is thrown onto the spinning roulette wheel, which eventually stops on a number. The 'Super Electronic Roulette' game simulates this with 38 LEDs that individually flash in succession in a ring, producing a spinning effect; this slows down and eventually stops, leaving just one LED lit. Each LED has an associated numeric value, and the position of the LED corresponds to its number on the plastic front panel design.

The game is based on the probability of the ball (LED) stopping on a chosen number. Although a roulette wheel is normally used as a 'gambling machine', the Super Electronic Roulette is intended to be used purely for the fun of playing the game, and not for serious gambling!

The kit comes complete with a plastic front panel with the roulette wheel legend, a PCB and all the components needed to produce the finished roulette game. The components are supplied in separate bags to prevent the front panel from being scratched. A second bag contains resistors, capacitors, semiconductors and other miscellaneous items needed to build the kit. Four plastic spacers are included together with screws for mounting the front panel onto the PCB. The buzzer is a flat piezo disc, and must be handled carefully so that it is not damaged. A roulette table layout is also included for added realism when playing the game, but in the case of the 'chips', you will need to improvise.

PCB Assembly

Figure 1 shows the circuit diagram together with circuit references and component values. The components should be carefully inserted into the PCB and soldered, starting with the resistors, referring to the Parts List and Figure 2. Cut off excess leads on the track side of the PCB after soldering. The remaining component leads should not protrude from the track side of the PCB by more than 1mm. Keep the off cut component leads to use as links. R1 to R11 are actually links, supplied in a resistor like body; these are marked with a black band around the centre of the body.

Component lead offcuts should be used for links LK1 to 30 (marked as 'J' on the PCB). It is important to keep the links as straight as possible when they are fitted, to prevent them touching other links or component leads. The IC sockets are installed next, making sure that the notch at one end corresponds with that on the PCB legend. The ICs themselves are NOT fitted at this stage.

Next, fit capacitors C1 to C8. It is important that the electrolytic capacitors are fitted observing correct polarity. The negative lead is indicated by a stripe and a negative sign (–) on the side of the capacitor, and must be inserted into the hole on the shaded half of the outline on the PCB legend (furthest away from the positive (+) symbol on the legend).

Transistors Q1 to Q10 are positioned so that their cases correspond exactly with the outline on the PCB legend. The diodes D1 to D4 are fitted, observing the correct polarity, and the cathode is indicated by a band at one end of the diode, see Figure 3.

It is important that the buzzer, BZ1, is not overheated when soldering, otherwise it will suffer permanent damage. First, two wires are soldered onto the buzzer, see Figure 4. The insulated wire supplied should be used for this purpose. These wires are then soldered to the PCB. The buzzer should be positioned flat on the PCB.

LEDs D5 to D42 are then fitted, observing the correct polarity, see Figure 5. The cathode is the short lead on the flat side of the LED. The distance between the PCB and the top of the LED should be kept at 18mm, see Figure 6. It is important that D5 to D42 are spaced evenly apart and kept at the same height, to line up with the LED windows in the front panel. For ease of construction, each LED is inserted and soldered individually. The push switch S1 is installed, making sure that it is kept vertical to the PCB, see Figure 7. The distance between the top of the push-button and the PCB must be 25mm, see Figure 8.

The PP3 battery clip wires are then connected, making sure that the red wire is soldered to the pad marked positive (+) and the black wire to the pad marked negative (–). Take care as the holes are slightly oversized.

Ensure that all components are soldered and surplus leads are removed, and clean up the track area. IC1, 2 and 3 can now be installed, once again observing the correct polarity. The notch at one end of the IC should line up with the notch at one end of the socket. The plastic roulette front panel is not fitted until after the unit is tested.

Testing

Before installing the battery, the soldering should be checked to make sure that there are no dry joints or solder short circuits. The battery may now be connected and placed on the PCB in the position shown, see Figure 2. At this point, none of the LEDs should be lit. When the button S1 is pressed, the LEDs should flash in succession in a clockwise direction, producing a spinning effect accompanied by a bleeping sound from the buzzer. As the button is released the effect slows down and stops, after which only one LED should remain lit. If the button is not pressed any more, the unit will automatically switch off after a couple of minutes. As the unit shuts down, the LEDs are sequenced a second time to indicate that the unit is switching off. Although the circuit is still powered, the unit is effectively switched off, as the current drain is negligible. If all is well, the plastic cover may be fitted using the spacers and screws provided. The automatic shut off facility is included to prolong battery life when the game is not in use. The game switches on when push switch S1 is pressed.

Finally

The supply voltage required for the circuit is 9V, and this is provided by a PP3 battery. The running current is 11mA approximately, and the quiescent current is typically 500nA after 15 minutes without use. It is recommended

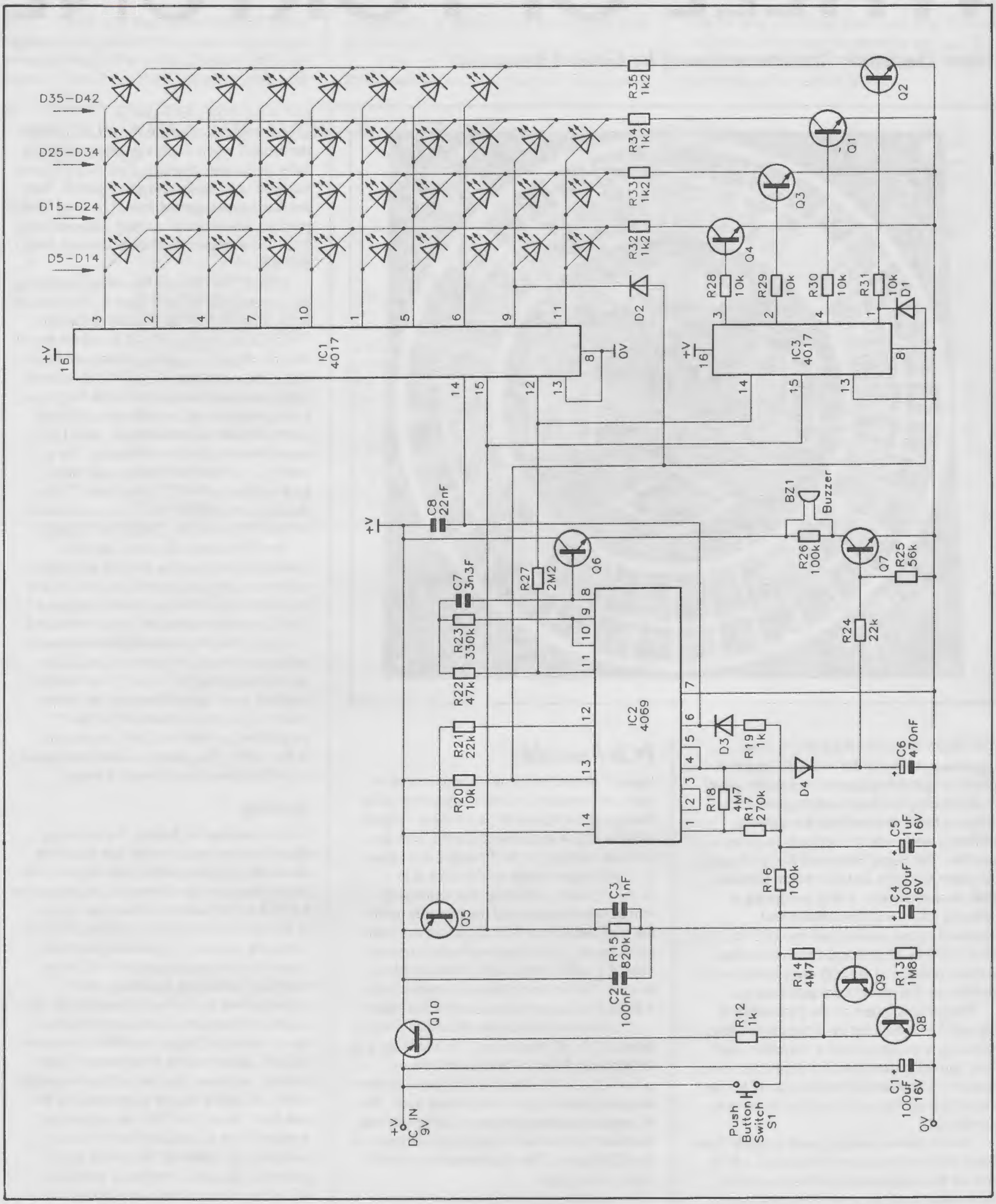


Figure 1. Circuit diagram.

that the battery is removed if the unit is not going to be used for a long period of time.

Playing the Game

In addition to the roulette wheel, a roulette table and some 'chips' are required to play the game. The 'chips' are counters which are placed over the chosen number (or set of numbers) on the roulette table to indicate the amount of money that has been bet, and these are marked to indicate the value they represent. The layout of a roulette table is shown in Figure 9. The 'chips', however, have to be improvised, and these can be made from thin card or something similar.

Roulette is based on the probability of the ball stopping on a number or series of numbers that have been picked previously by the player. The electronic roulette wheel produces relatively random results and does not appear to follow any set sequence. The game can be played by simply guessing which number the 'ball' will stop on, but for full enjoyment it is well worth learning some of the rules and systems of betting. A full description of how to play roulette is outside the scope of this article; however, it would be useful to include a few ideas to help the first time player.

There are several systems of betting used

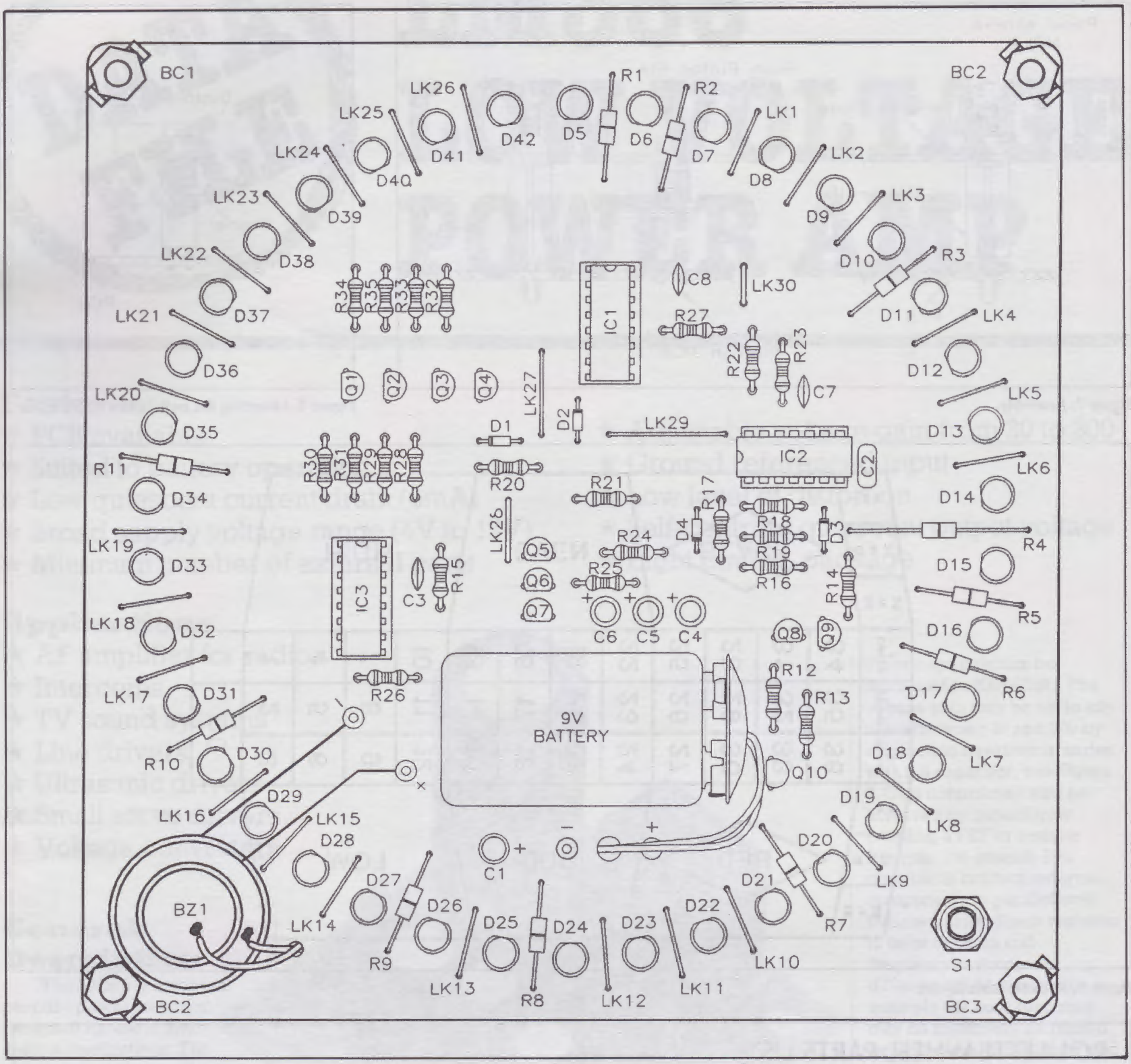


Figure 2. PCB layout.

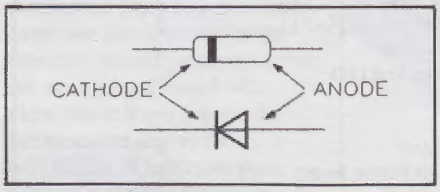


Figure 3. Diode polarity.

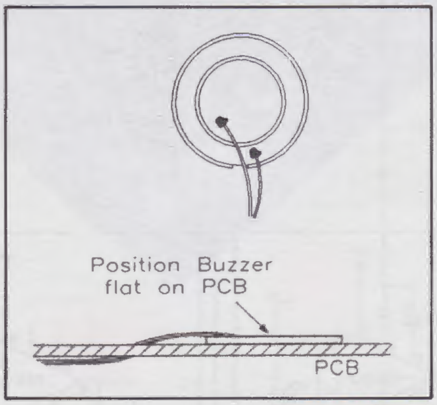


Figure 4. Mounting the buzzer.

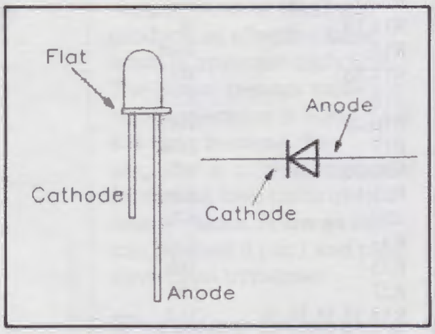


Figure 5. LED polarity.

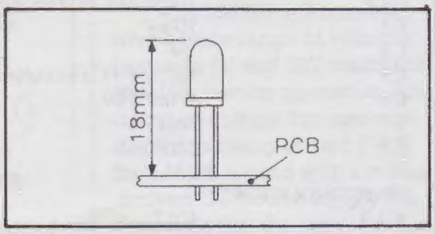


Figure 6. Mounting the LEDs.

when playing roulette, and all of these have been devised to increase the probability of winning. In one system, known as 'Biarritz', a bet is placed on a number when it has not appeared for 111 spins of the wheel; the number is then backed until it appears. The amount that is bet is then doubled for each of the next 36 spins where the chosen number does not appear. It is interesting to experiment with variations of the Biarritz system, using a different number of spins; which can be intriguing.

Another system of betting is called 'column and black'. This is a bet on the right most column of the roulette table (which contains 8 red numbers) and on all black numbers. As an alternative to using established systems of betting, it can be fun to invent your own methods. It is surprising just how effective even simple betting systems can be, although winning is still, of course, very much a matter of chance.

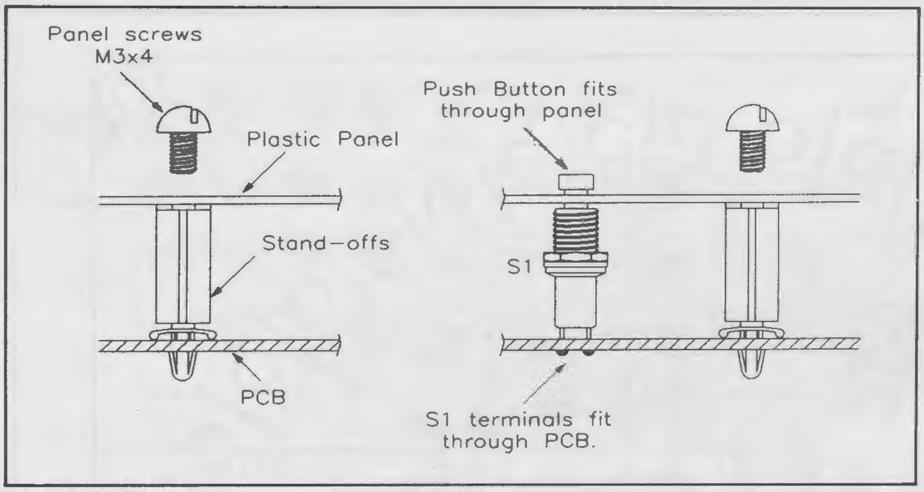


Figure 7. Assembly.

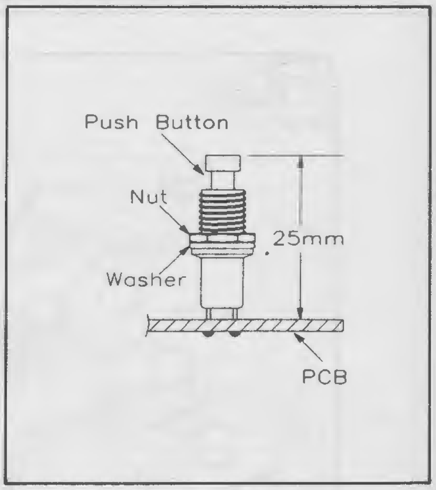


Figure 8. Mounting the switch.

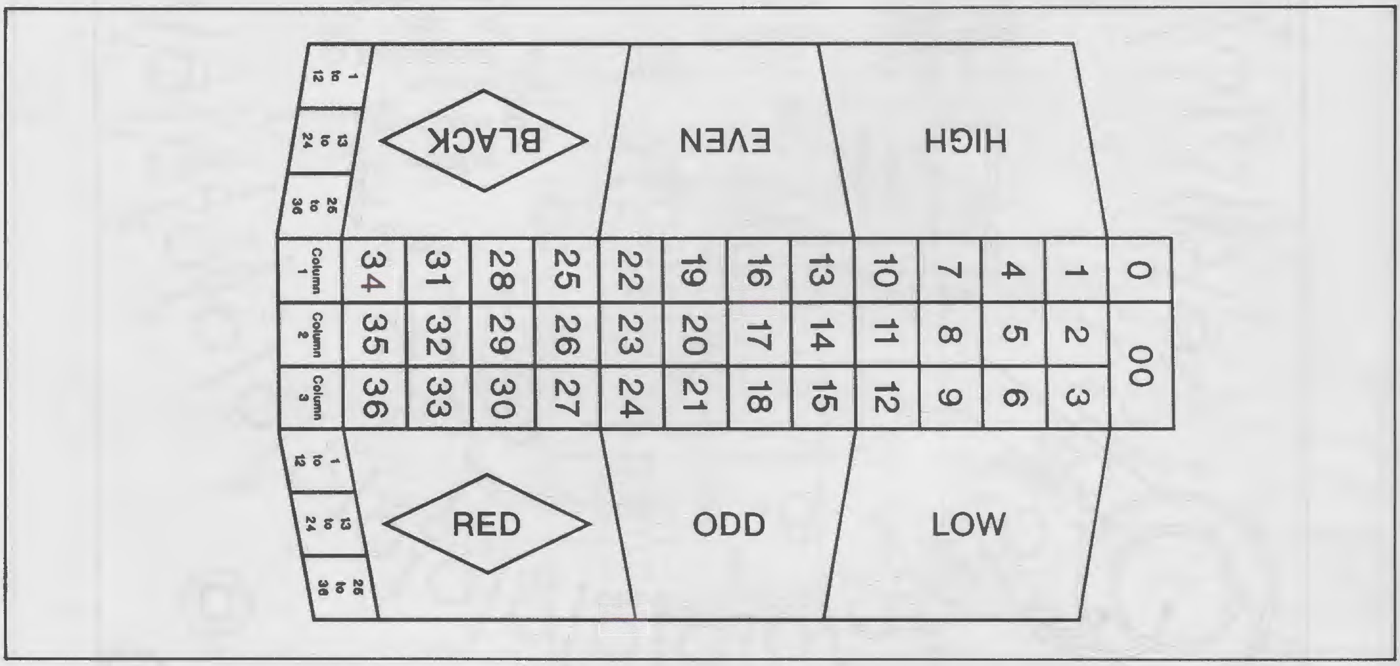


Figure 9. Roulette table layout.

ROULETTE WHEEL PARTS LIST

RESISTORS		
R1-11	0Ω	11
R12,19	1k	2
R13	1M8	1
R14,18	4M7	2
R15	820k	1
R16,26	100k	2
R17	270k	1
R20,28,29,30,31	10k	5
R21,14	22k	2
R22	47k	1
R23	330k	1
R25	56k	1
R27	56k	1
R32,33,34,35	1k2	4
CAPACITORS		
C1,4	100µF 16V PC Electrolytic	2
C2	100nF	1
C3	1nF	1
C5	1µF 16V PC Electrolytic	1
C6	470nF 16V	1
C7	3n3F	1
C8	22nF	1
SEMICONDUCTORS		
IC1,3	4017	2

IC2	4069	1	
Q1-4,6-9	2SC1815 or 2SC945	8	
Q5,10	2SA1015 or 2SA733	2	
D1-4	1N4148	4	
D5-42	5mm Red LED	38	
MISCELLANEOUS			
BZ1	Buzzer	1	
S1	Push Button Switch	1	
	Standoffs	4	
	9V PP3 Battery Clip	1	
	14-Pin DIL IC Socket	1	
	16-Pin DIL IC Socket	2	
	M3.5 Self-tapping Screw	4	
	Front Panel	1	
	Insulated Wire	2 Pieces	
	PCB	1	
	Constructors' Guide	1	(XH79L)

The Maplin 'Get-You-Working' Service is available for this project, see Constructors' Guide or current Maplin Catalogue for details.
The above is available in kit form only.
Order As LM67X (Roulette Wheel Kit)

DATA FILE

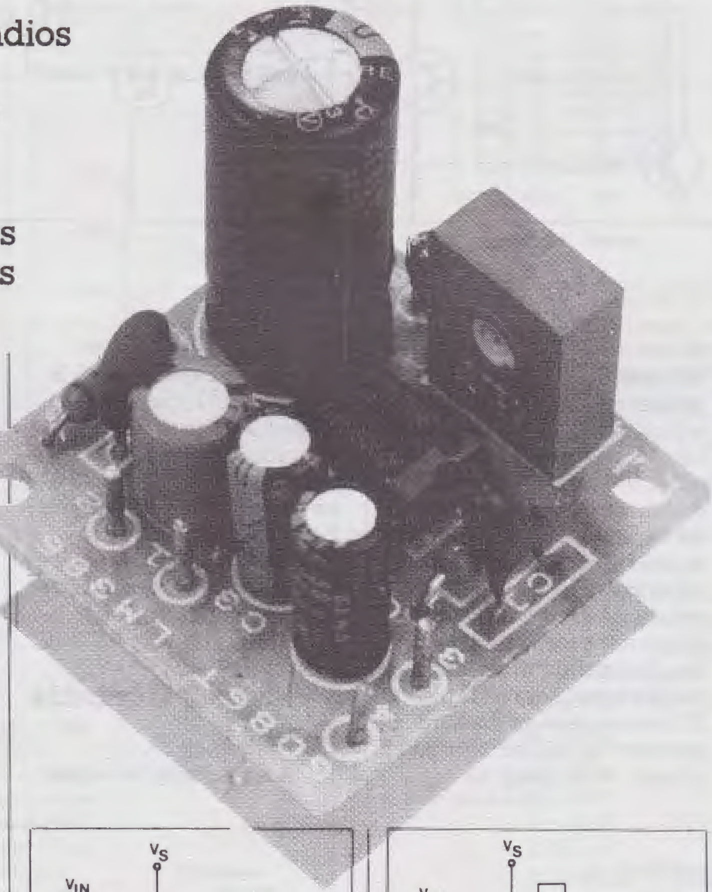
LM386 LOW VOLTAGE POWER AMP

Features

★ PCB available
★ Suited to battery operation
★ Low quiescent current drain (6mA)
★ Broad supply voltage range (4V to 12V)
★ Minimum number of external parts
★ Adjustable voltage gain from 20 to 200
★ Ground referenced input
★ Low level of distortion
★ Self-centring quiescent output voltage
★ Eight pin DIL package

Applications

★ AF amplifier for radios
★ Intercoms
★ TV sound systems
★ Line drivers
★ Ultrasonic drivers
★ Small servo drivers
★ Voltage converters



General Description

The LM386 is a general purpose power amplifier designed for use in low voltage applications. The voltage gain is internally set to 20 (26dB) to keep the number of external parts to a minimum. However, the addition of an external resistor and capacitor between pins 1 and 8 will allow the voltage gain to be increased to any value up to 200 (46dB). When operating from a 6V supply the quiescent power drain is only 36mW making the LM386 particularly useful for battery operation.

Application Hints

To make the LM386 more versatile, two pins (1 and 8) are provided for gain control. If pin 1 and pin 8 are left open, as in Figure 1, the internal 1.35kΩ resistor sets the voltage gain to 20 (26dB). By connecting a capacitor from pin 1 to pin 8, as in Figure 2, bypassing the internal resistor, the voltage gain can be increased to 200 (46dB). The voltage gain may be set to any value between 20 and 200 by connecting a resistor in series with the capacitor, see Figure 3. Gain control may also be achieved by capacitively coupling a FET or resistor from pin 1 to ground. It is possible to connect external components in parallel with the internal feedback resistors to tailor the gain and frequency response for different applications; for example the bass response may be effectively increased by connecting a capacitor and resistor in series between pin 1 and pin 5, see Figure 4. A resistor value of 15kΩ will produce an effective bass boost of approximately 6dB. The lowest resistor value for stable operation is 10kΩ if pin 8 is open because the amplifier is only compensated for closed loop gains greater than 9; values as low as 2kΩ can be used if pin 1 and pin 8 have been bypassed.

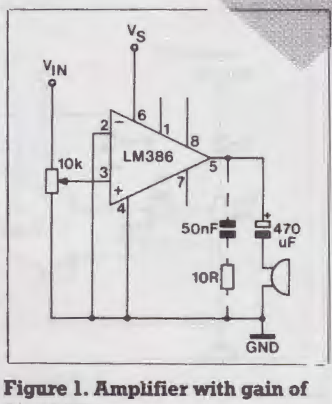


Figure 1. Amplifier with gain of 20 (26dB).

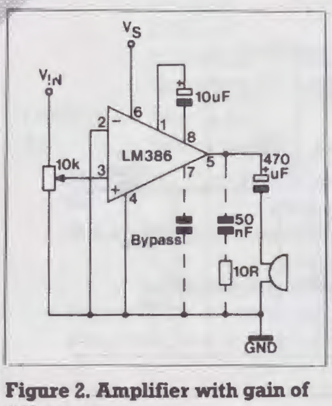


Figure 2. Amplifier with gain of 200 (46dB).

Power Supply Requirements

The LM386 will operate over a wide range of voltages between 4V and 12V making it ideal for battery operation, the optimum voltage for minimum distortion being around 6V. If the LM386 is used with a mains derived DC power supply it is important that the supply rail is adequately decoupled to

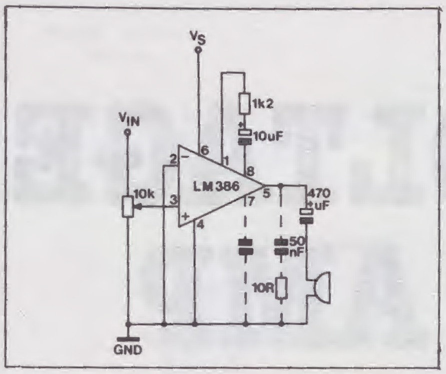
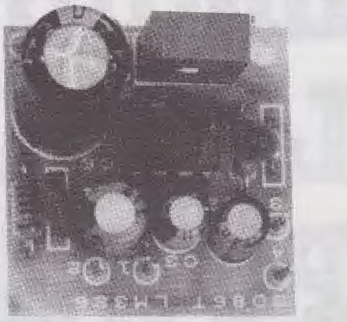


Figure 3. Amplifier with gain of 50 (34dB).



An assembled pcb.

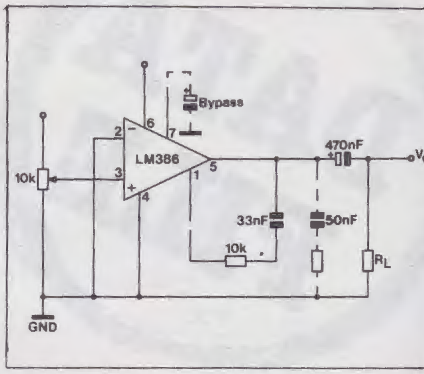


Figure 4. Amplifier with bass boost.

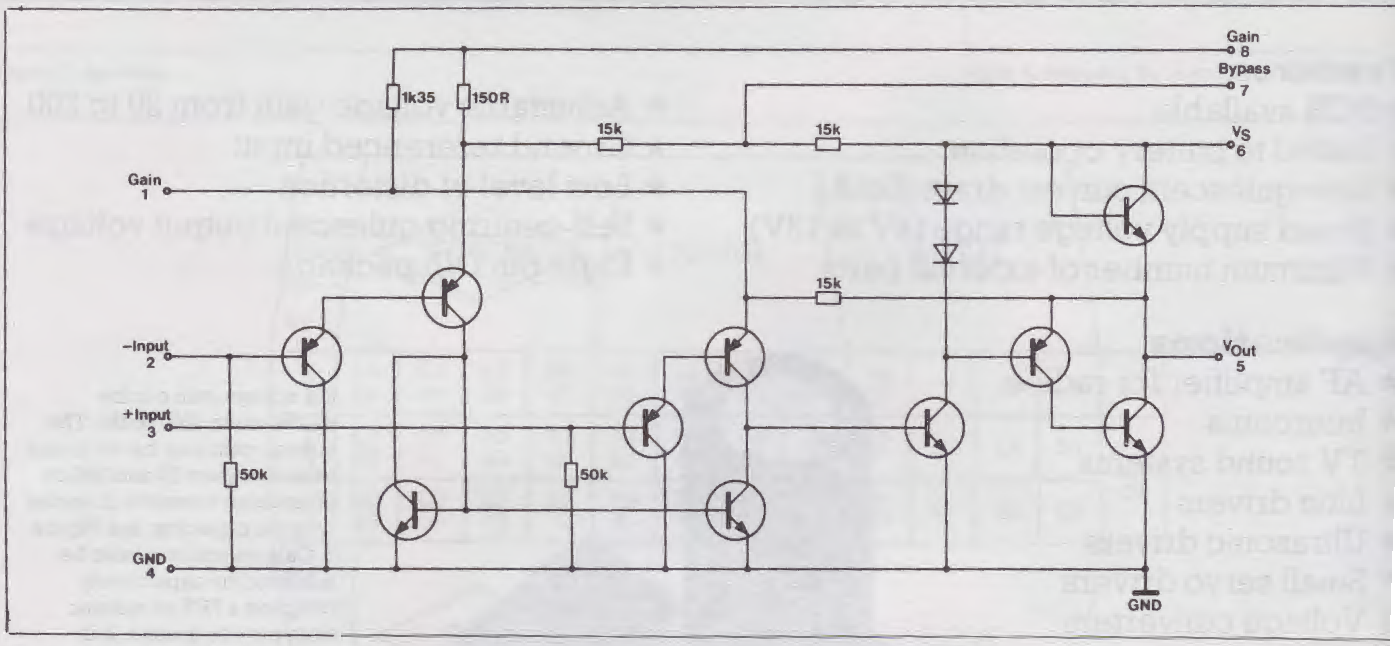


Figure 5. IC schematic diagram.

prevent the introduction of mains derived noise into the amplifier. Decoupling close to the IC is also necessary, to prevent any high frequency instability.

Input Biasing

Referring to the IC schematic, Figure 5, it may be seen that both inputs are biased to ground with a 50kΩ resistor. The base current of the input transistors is around 250nA, so the inputs are at approximately 12.5mV when left open. If the DC source resistance driving the LM386 is higher than 250kΩ there will be very little additional DC offset. Where the DC source resistance is less than 10kΩ, the unused input can be shorted to ground to keep the offset low. For DC source resistances between these values any excess offset may be eliminated by connecting a resistor equal in value to the DC source resistance, between the unused input and ground. When using the LM386 with higher gains it is necessary to bypass the unused input to prevent degradation of gain or any possible instability; this may be achieved by connecting a 0.1μF capacitor or a short (depending on the DC source resistance on the driven input) from the unused input to ground.

Printed Circuit Board

A high quality fibreglass PCB, with printed legend is available as an aid to construction of the basic LM386 amplifier circuit. Referring to Figure 6, the power supply is connected between P1 (+V) and P2 (0V the optimum voltage being around 6V (see Table 1). Inpu signals are applied between P3 and P4 and the output is taken from P5 and P6 (the amplifier will operate satisfactorily into an 8Ω load The overall voltage gain of th amplifier is set by RV1, the

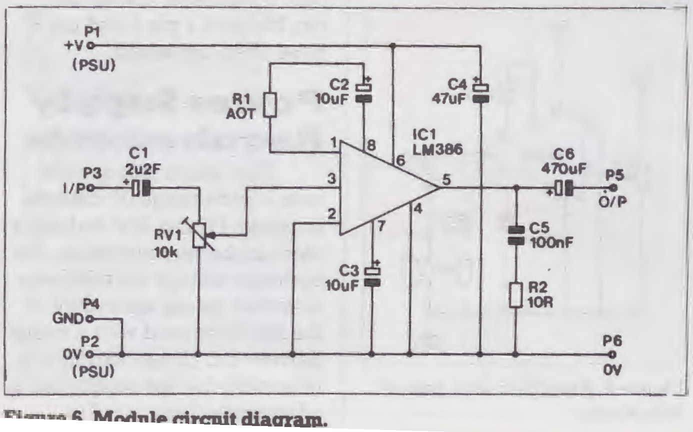


Figure 6. Module circuit diagram.

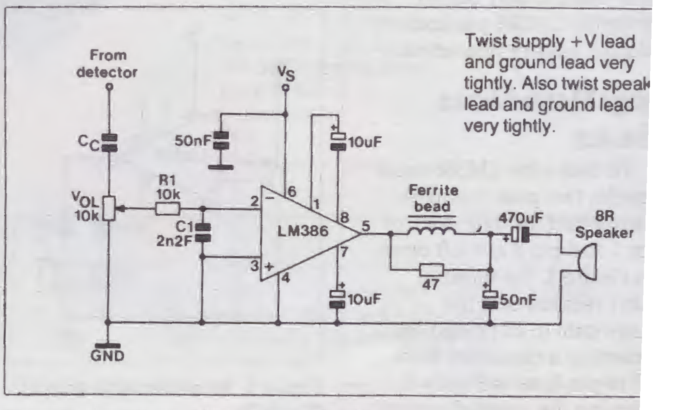


Figure 7. Power amplifier for AM radio.

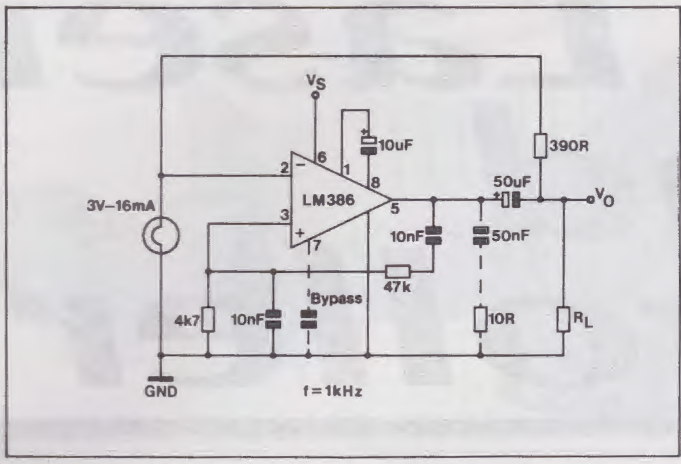


Figure 8. Low distortion power Wien bridge oscillator.

maximum gain being determined by the value of R1. Figures 7 to 9 show various applications and Figure 10 gives details of various functions of the LM386. Pin out information is given in Figure 11. The layout of the PCB is shown in Figure 12.

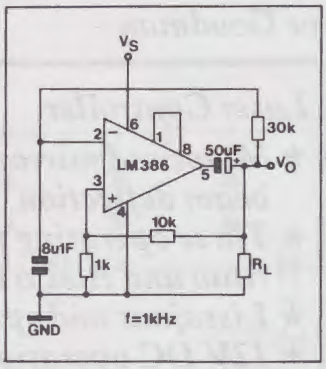


Figure 9. Square wave oscillator.

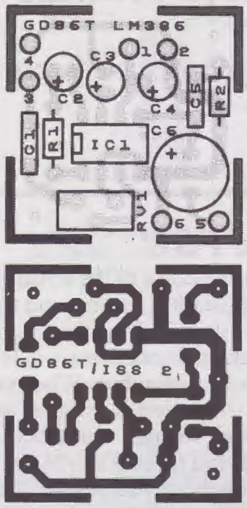


Figure 12. PCB overlay and track.

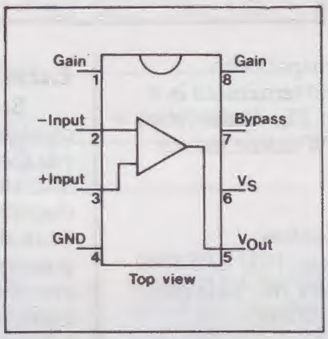


Figure 11. LM386 pinout.

Parameter	Conditions	Min.	Typ.	Max.
Supply voltage (Vs)			4V DC	12V DC
Quiescent current (Iq)	Vs = 6V, Vin = 0V		4mA	8mA
Input resistance (R in)			50kΩ	
Output power (Pout)	Vs = 6V, R1 = 8Ω, THD = 10%	20mW	325mW	
Voltage gain (Av)	Vs = 6V, f = 1kHz		26dB	
	10µF capacitor from pin 1 to pin 8 of IC			46dB
Bandwidth (BW)	Vs = 6V, pin 1 and pin 8 of IC open		300kHz	
Total Harmonic Distortion (THD)	Vs = 6V, R1 = 8Ω, Pout = 125mW, f = 1kHz pin 1 and pin 8 of IC open		0·2%	
Input Bias Current (I bias)	Vs = 6V, pin 2 and pin 3 open		250nA	

Table 1. Electrical characteristics of LM386.

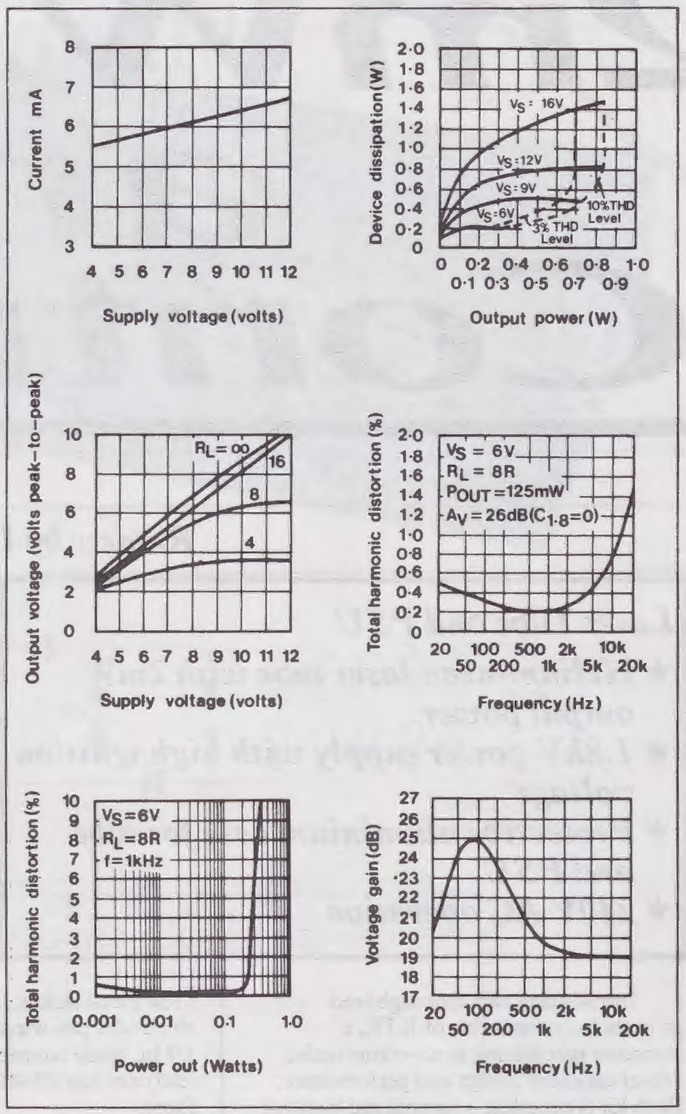


Figure 10 (a). Supply voltage vs quiescent current. (b). Device dissipation vs output (8Ω load). (c). Peak-to-peak output voltage swing vs supply voltage. (d). Distortion vs frequency. (e). Distortion vs output power. (f). Frequency response with bass boost.

LM386 BOARD PARTS LIST

RESISTORS: All 0·6W 1% Metal Film (Unless specified)			
R2	10Ω	1	(M10R)
RV1	10k Vert Enclosed Preset	1	(UH16S)
CAPACITORS			
C1	2µ2F 35V Tantalum	1	(WW62S)
C2,3	10µF 50V PC Electrolytic	2	(FF04E)
C4	47µF 16V Minelect	1	(YY37S)
C5	100nF Minidisc	1	(YR75S)
C6	470µF 16V PC Electrolytic	1	(FF15R)
SEMICONDUCTORS			
IC1	LM386	1	(UJ37S)
MISCELLANEOUS			
	Pin 2145	6	(FL24B)★
	PCB	1	(GD86T)
	Instruction Leaflet	1	(XU26D)
	Constructors' Guide	1	(XH79L)
OPTIONAL (Not in Kit)			
R1	Select on test	1	

The Maplin 'Get-You-Working' Service is available for this project.

The above items (excluding Optional) are available as a kit.

Order As LM76H (LM386 Kit).

Please Note: Items in the Parts List marked with a ★ are supplied in 'package' quantities (e.g., packet, strip, reel, etc.).

2mW Laser and Controller

Review by Dave Goodman

Laser Tube and PSU
- ★ *Helium-neon laser tube with 2mW output power*
- ★ *1.8kV power supply with high ignition voltage*
- ★ *Protective aluminium case for tube and PSU*
- ★ *240V AC operation*

Laser Controller
- ★ *Motorised mirrors for x and y light beam deflection*
- ★ *Three operating modes for Manual, Auto and Audio input*
- ★ *Lissajous and spiral graphics effects*
- ★ *12V DC operation*

Introducing two thoroughbred projects from the stable of KTE, a company specialising in no-compromise kits of excellent design and performance. Each kit is complete – no optional boxes or miscellaneous items to buy – and contains only those parts capable of meeting stringent quality control requirements. A booklet is also supplied with each kit giving full constructional and operational details of the project.

Although the laser controller project has been primarily designed for use with the KTE laser system, it can equally be used with any similar laser having an exit port aperture of 0.5 to 0.75mm diameter.

The KTE Laser tube is available as a separate stock item under the code number XL11M. However, PCB's, boxes and components used in these projects are only available with the kit and are not supplied separately.

Laser tube Specification:

Type:	Helium-Neon
Wavelength:	632.8nm (red light)
Typical power:	2.0mW
Ballast resistor:	68kΩ 4W
Starting voltage:	8kV
Operating voltage:	1.5kV
Operating current:	5mA
Tube voltage drop:	1.15kV ± 100V
Beam exit diameter:	0.75mm
Full angle divergence:	1.43mRadians
Overall dimensions:	260mm x 37mm Dia.

It is interesting to note that the laser tube is supplied in an aluminium sleeve ('full metal jacket', perhaps?) with electrodes pre-wired and terminated in a 1/4 in. blade connector. The Anode (black lead) also has a 64kΩ 4W ballast resistor fitted.

Power Supply Specification:

Type:	Laser PSU LPS 8000
Supply:	240V AC 50Hz mains
Power:	15 Watts
Ignition voltage:	8kV
Dimensions:	360 x 70 x 92mm

Both the Laser/PSU project and the controller project can be purchased ready-built and tested, for those of you that do not want the DIY version, the various versions, order codes, and prices are listed at the end of this article.

Controller Specification:

Type:	Laser controller, LSG 7000
Image dimension:	0.35 x distance of projection
Mirror angle:	5 Degrees (x2)
Supply:	12V DC
Current:	0.25A (both motors at maximum)
Functions:	Automatic, manual, audio mono and stereo
Dimensions:	260 x 150 x 75mm

No power supply is contained in with this kit and I suggest a 12V @ 300mA AC adaptor is used, such as the Maplin XX09K.

Laser and PSU

Before getting down to the actual construction of the kit, I recommend that you spend some time reading the instruction booklet supplied, especially the chapter concerned with safety. When you think about it, the project is designed to generate very high voltages which can arc over if misused, and there is also 240V mains directly on the circuit board! The laser itself emits a very high intensity light beam, which could possibly damage the retina when directed into the eye, so please keep these aspects in mind and make safety your priority.

So, down to business. The kit comes with components split into a series of polythene bags and the laser tube, see Photo 1, and case are neatly fitted into a moulded polystyrene block. What immediately impressed me was the tube. Instead of the expected glass envelope, with a few electrode pins projecting from

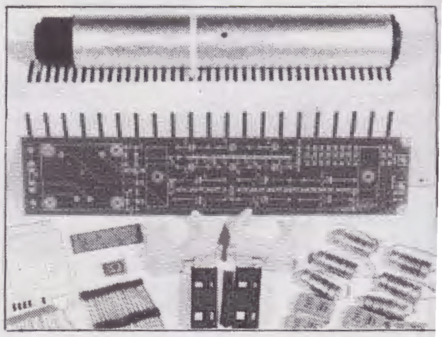
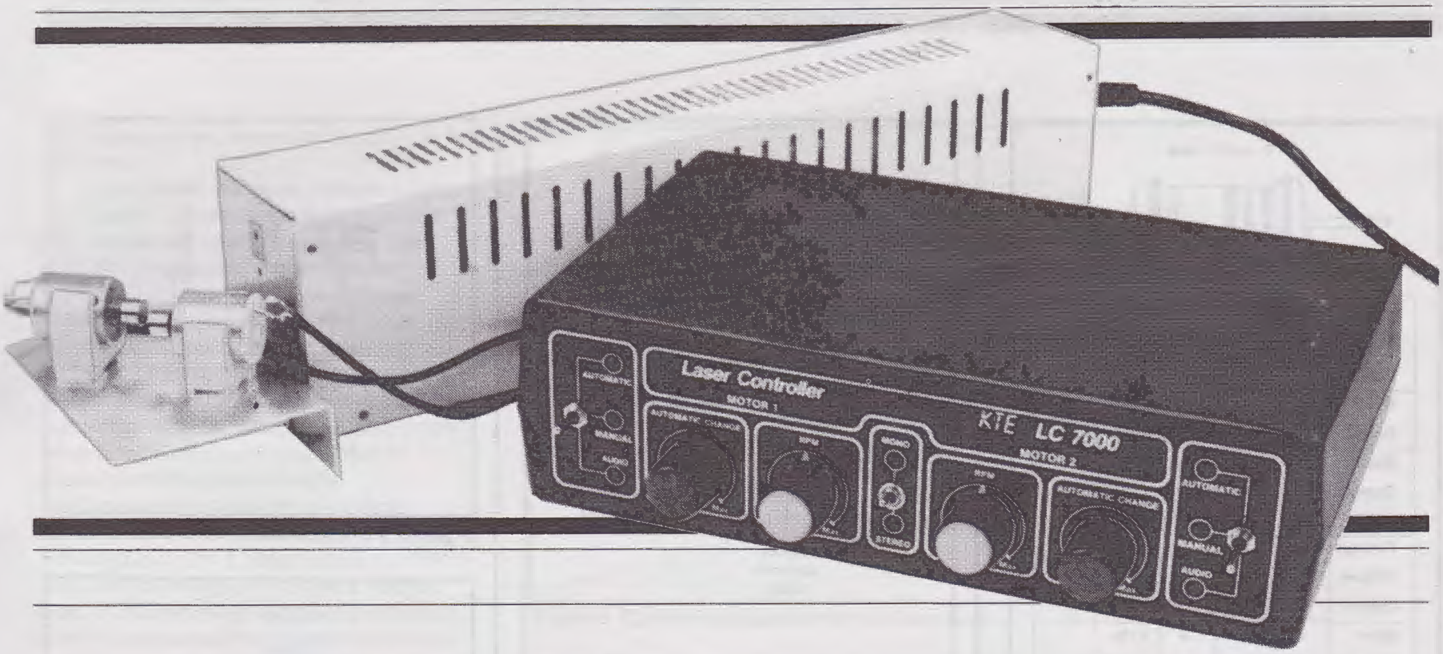


Photo 1. The laser tube.



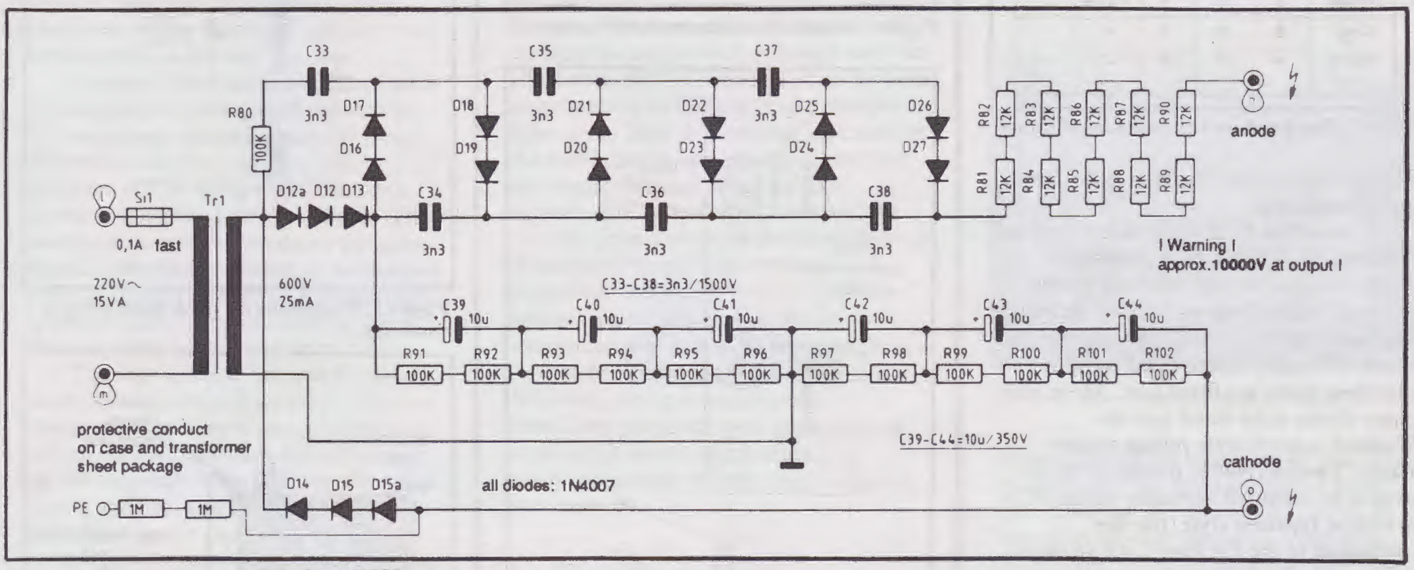


Figure 1. Circuit diagram of the laser PSU unit.

one end, we have the laser fitted into an aluminium housing with plastic end caps and pre-wired terminals. The anode wire exits the tube at the output port end, is black in colour and has a 64kΩ ballast resistor fitted, whereas the cathode wire is the white conductor, and both are terminated with insulated spade terminals.

Two clamps and spacer blocks are supplied for mounting the tube onto the PCB. I found a fair amount of pressure was required to insert the tube into these clamps and the fear was that either the tube or the clamps may be damaged during this operation, but no problems here as the clamps are reasonably flexible.

The printed circuit board is of excellent quality and made from glass fibre. Component positions are printed in yellow and the track layout has been printed in reverse on the top face of the PCB. This clearly shows the layout relationship between components and also gives the effect of being a double-sided circuit board, which of course, it is not.

A case is supplied for housing the electronics and laser tube and is made from 1.5mm aluminium, covered with a removable plastic film; all holes have been pre-drilled, so there is no immediate need to search for the Black and Decker! At one end of the case, there is a 3.5mm diameter hole, from which the light beam exits; beneath this hole are three smaller holes that do not appear to serve any immediate function. In fact, this is the mounting position for the deflection motor bracket, which is included in the controller kit (More on this later).

Components supplied are all of high grade, European origin, and not a single sign of the Far East! The transformer, notated unconventionally as Tr1 on the legend and diagrams, is a PC mounting version and this explains why mains voltages are present on the PCB.

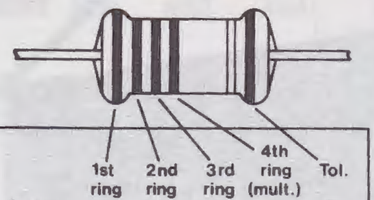
Assembly Notes

Regular readers of 'Electronics' will notice a few deviations from the usual standard component designation on the circuit diagrams. Look at Figure 1 – Si1 is a 20mm x 100mA fast-blow mains fuse, Tr1 is the mains transformer (and not a semiconductor) and termination points are identified by letters, not numbers. The mains voltage connection to the module is: LIVE to 'l', NEUTRAL to 'm' and EARTH to 'PE'.

I found the kit instructions easy enough to follow, but thought that certain 'grey' areas could best be explained with the aid of explanatory drawings included here; a 'picture paints a thousand words' etc. Resistor identification can be a problem, especially if you are used to a particular colour code, or have no knowledge whatsoever. Some of the resistors in the kit have the standard four band markings and some have a five band marking – if in doubt, use an ohm-meter. Table 1 shows the five band resistor code, where the third band is always black.

One thing not explained in the text concerns an area of the PCB without any legend markings. This area, shown in Figure 2, is adjacent to the cathode terminal (Kathode) and has been added for future development. Having access to top secret future developments, and sneaking a look at various circuit diagrams, I am able to tell you that additional components could be added to allow the laser cathode to be modulated. This could be extremely useful for communication and measuring purposes and may well be a subject for future article or project developments. However, back to the present, I've shown how to link out this area of track in Figure 2 using three links made from scrap wire.

5 band code



Colour	1st ring 1	2nd ring 2	3rd ring 3	4th ring (mult.) 4	Tol. 5
Silver	–	–	–	x0.01	–
Gold	–	–	–	x0.1	±5%
Black	–	0	0	x1.0	–
Brown	1	1	1	x10	±1%
Red	2	2	2	x100	±2%
Orange	3	3	3	x1k	–
Yellow	4	4	4	x10k	–
Green	5	5	5	x100k	–
Blue	6	6	6	x1M	–
Violet	7	7	7	x10M	–
Grey	8	8	8	–	–
White	9	9	9	–	–

Table 1. Five band resistor code identification.

Without these links, the laser cathode will not be connected.

I found the PCB quite straightforward to assemble, with all the components easily recognisable and positions clearly marked. Figure 3 shows the laser terminal lug assembly and Figure 4 shows how the mains terminal pins are fitted. I suggest that these items are fitted first. There are many diodes to be fitted into the Walton/Cockroft style voltage tripler stages. Twelve 1N4007 diodes (D16-27) have to be mounted vertically on the PCB in typical Japanese style (the one concession to the Far East!) as I've shown in Figure 5. Once the main components had been inserted, I soldered them in place and cut off the excess wire ends. Doing this left various sharply pointed ends sticking out at intervals around the board, not a very desirable situation where high voltage is concerned, so I thought it prudent to re-solder the board again ensuring all joints were nicely rounded and smooth. No sense in taking risks, especially as once fitted into the case, the module is difficult to remove again.

In the final paragraph of the booklet, recommendations are made for fitting 2 x 1MΩ resistors from the cathode to mains earth; this has the effect of lowering the potential between cathode and case (which must be earthed!) and reducing the possibility of breakdown between transformer windings. Reference is also made to additional diode modifications, but in fact, they are included already. Just at one side of diode D15a anode on the PCB, is an unmarked hole; this is where two 1MΩ or a single 2.2MΩ resistors are fitted, as I've shown in Figure 6.

After straightening the four terminal legs, the transformer was inserted into the PCB, again repeating the earlier procedure for soldering. The project now started to take shape and just required fitting the 20mm fuse and clips and the laser tube

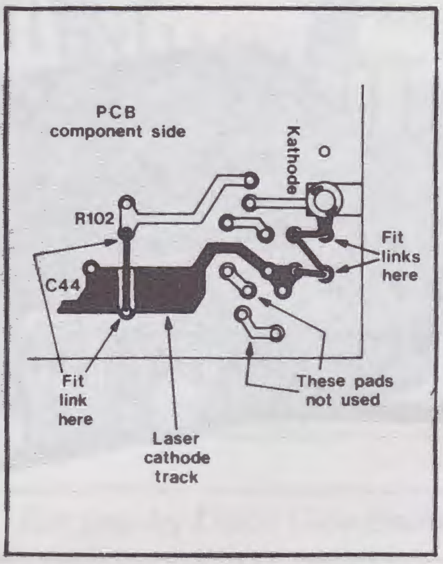


Figure 2. Future development modifications.

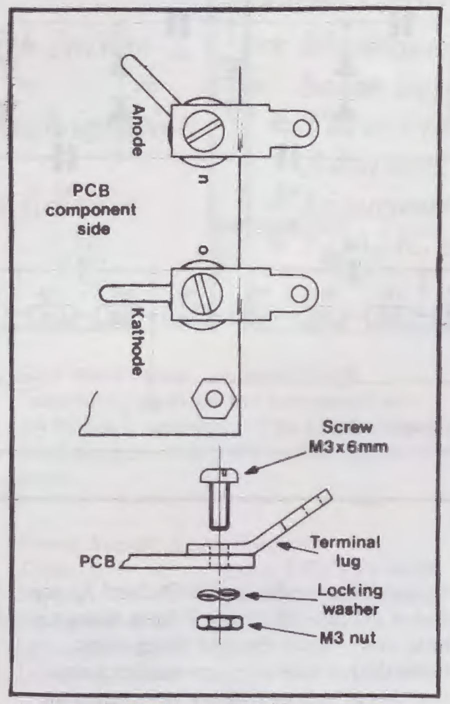


Figure 3. The laser terminal lug assembly.

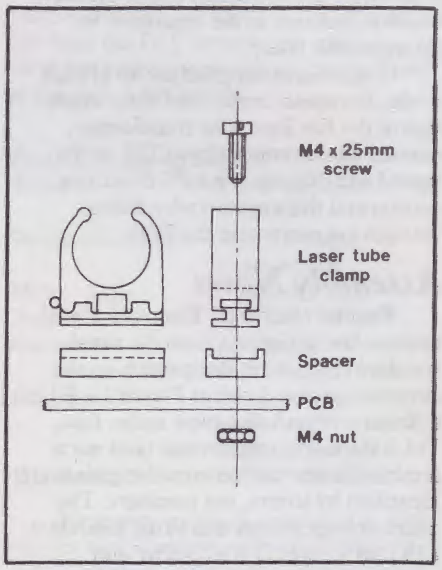


Figure 7. Details of the laser tube mounting.

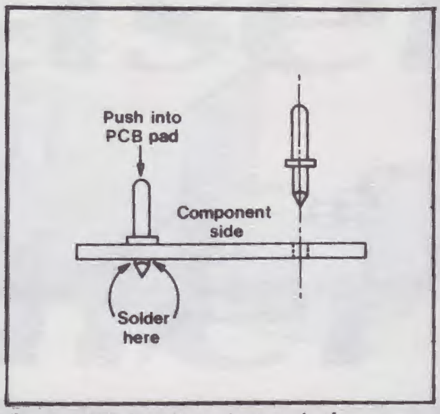


Figure 4. Fitting the mains terminals.

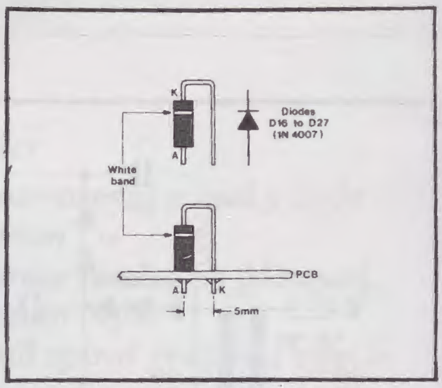


Figure 5. Preforming the diode leads prior to mounting.

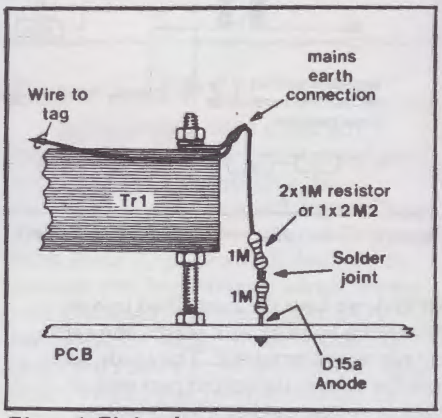


Figure 6. Fitting the two safety resistors.

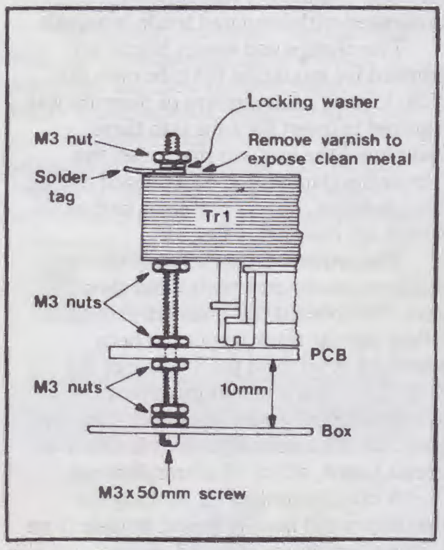


Figure 8. Transformer mounting details – these need to be followed very carefully.

mounting clamps, shown in Figure 7, to be complete.

Now comes the more confusing part. In Figure 8, I have shown how to mount the transformer end of the PCB as this does not come across too well in the booklet. To begin with, four x 50mm screws are inserted into the case, from the outside first, and fixed with a nut and lock-nut. A third nut was then fitted and wound down to 10mm as shown. At the opposite end of the case, two 15mm screws were fitted in the same way as before. I found that if the 10mm height measurement is varied by more than 0.5mm, then the laser tube exit port does not align with the 3.5mm hole in the case end, and the beam deflects back into the case. KTE have even included a threaded bush for mounting the laser onto a camera tripod – thoughtful touch that – and a plastic cap covers both bush and lock nut on the inside, to prevent arc over.

I lowered the module over the 50mm screws until they just poked through on the component side and wound two nuts onto each of the four screws. This operation is a bit tricky and demands a degree of dexterity from the fingers. The nuts must now be wound down the screw thread to enable the module to be lowered onto the 10mm spacer nuts. Perhaps this operation could be made easier by using plastic spacing bushes instead of nuts?

To make access to the transformer metalwork for earthing purposes, I had to scrape away the layer of varnish covering each of the four mounting holes. A solder tag fits onto each screw, followed by a lock washer and nut, and the complete assembly is gently tightened up. The finishing stages involve wiring all four tags together and fitting the mains cable, all of which are shown in Figure 9 and Photo 2. Don't forget to fit the two front PCB mounting nuts!

As I mentioned earlier on, fitting the laser tube into the two clamps was a bit worrying at first, but you can be assured that it does fit. The black wire plugs onto the connector marked 'Anode' and the white connector onto the remaining 'Kathode' terminal. The clips click in place once they have been fitted and are quite hard to pull off again. A short length of insulating tape came in handy for holding these two high voltage wires onto the laser body thus preventing them from getting trapped in the case lid. A quick check of laser aperture alignment with the case exit hole proved worthwhile, as a slight re-adjustment was needed. Finally, the case lid was fitted and screws inserted. The extra three screws were fitted into the end panel holes and rubber feet stuck onto the base to complete the project, see Photo 4.

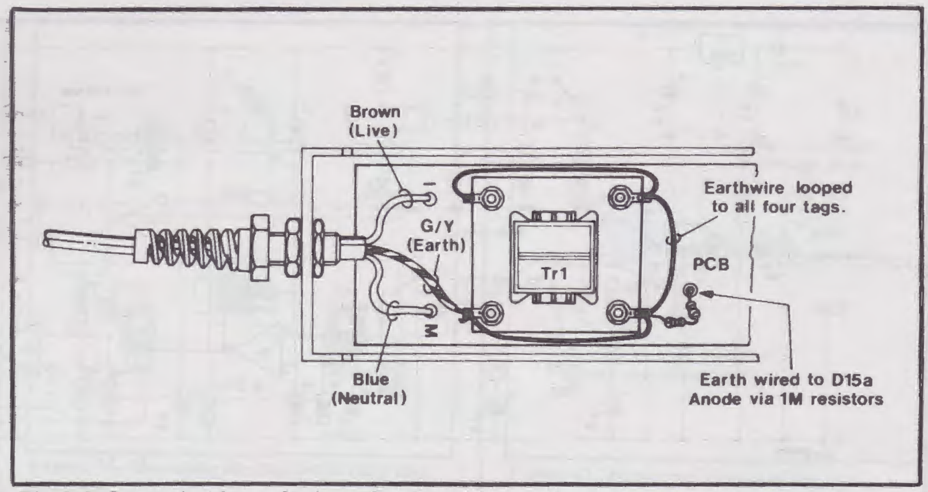


Figure 9. Connecting the earth wire and mains cable.

Test of Nerves

Why is it that a 13A plug is never around when you need one, when at any other time there are usually several lurking in the tool box? Connecting any DIY kit to the mains is always a time of trial for both constructor and project, although any fears I had were quickly dispelled when the laser silently burst into life. A bright red spot of light, some 5mm in diameter, appeared on the wall opposite and placing my hand in the beam produced no sensation of warmth. The laser was left 'on soak' for the rest of the day – with the beam well out of eye view I might add – to see how it performed over a long period. The tube does get warm, and so does the transformer which is to be expected, hence the case becomes warm after a while. No flash over, arcing or component breakdown problems were apparent and no odour of ozone, which often accompanies high voltage power supplies, were noticed.

In Conclusion

The KTE laser and power supply kit is well presented, easy to build, of very good quality throughout and excellent value for money. The instructions supplied might have been a little more explicit for beginners to the hobby, but certainly adequate enough for the more seasoned constructor. Basic tools only are required for building this project and test gear is not necessary, which means that very few people from any age group would be likely to encounter problems with assembly. Having said that, I believe it important to understand that children should not be allowed near a working laser, unless under experienced supervision of course, and precautions are taken to avoid any direct eye contact with the beam. You also require a mains plug (not supplied) and to do something different with the laser (and who wouldn't?) you will need the controller project which I will review next.

Laser Controller

The laser controller module circuit shown in Figure 10 is quite straightforward to assemble, and except for four sockets, all components mount directly onto the PCB. Ten 200mm lengths of wire were required for connecting these sockets to the PCB and you will need a metre or so of spare hook-up wire to do this. The PCB legend becomes confused on some areas of the board where components have been tightly laid out and this is hardly surprising considering the quantity of parts that populate the board. Occasional reference to the overlay diagram helped when difficulties were encountered, and in similar fashion to the laser PCB, this board also has tracks printed on the top component side.

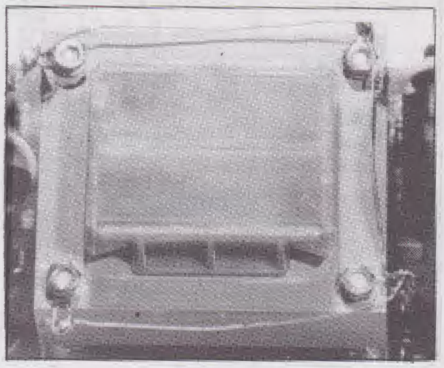


Photo 2. The essential earth protection loop.

Once completed, the module fits into a moulded plastic box with a pre-printed front panel. Eight indicator LED's, fitted on the PCB, do not protrude through the front panel, but instead they are visible through translucent areas of the print mask – this makes a very neat finish.

Standard 3.5mm sockets, for the motor drive outputs and power supply input, are mounted on the rear panel along with a 5-pin DIN socket for audio input. Two 3.5mm plugs and a seven metre length of wire are also included for connecting up the deflection motors, but a 5-pin DIN plug, for making the audio connection, must be purchased separately. You will also need a power supply capable of delivering 12VDC at approximately 250mA. The total current requirement depends on the motor speed at any one time and varies accordingly up to a maximum of 0.25A with both motors running at maximum. I can recommend

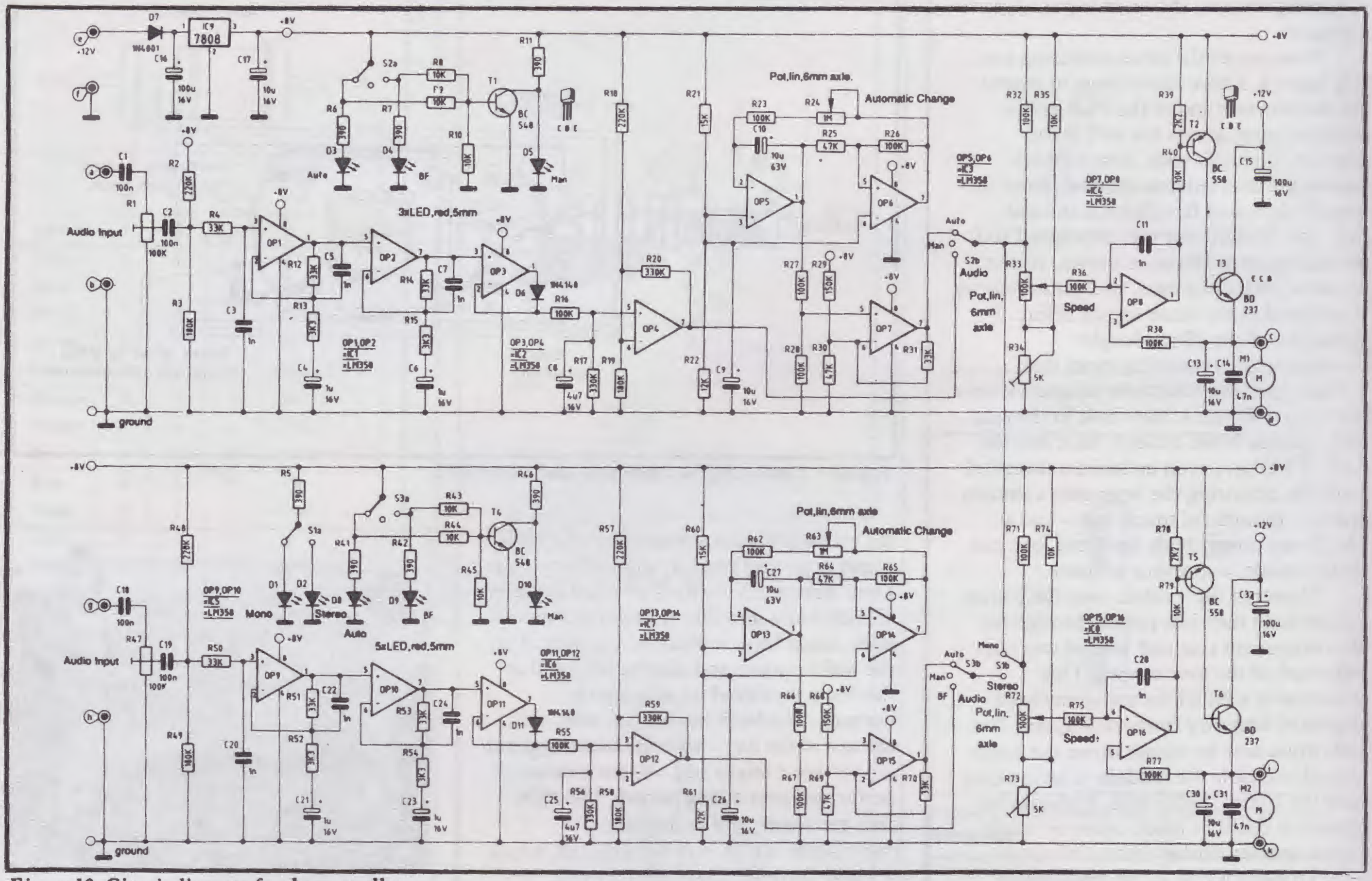


Figure 10. Circuit diagram for the controller.

the Maplin XX09K adaptor, which delivers 12.5V at 250mA, for this project – assuming you wish to use the 240VAC mains supply!

Operating Principle

If a laser beam is directed onto a mirrored surface then a large percentage of the beam will be deflected, with some energy losses due to absorbtion. In this project, the mirror is made from a section of plated brass rod that has been mounted onto a small electric motor, see Figure 11 and Photo 3. You will notice that the top face has been machined down at an angle of five degrees from the perpendicular and given a highly polished finish. Two such mirrors, known as motor deflection drive units, are mounted at 45 degrees to each other (and to the direction of the laser beam) so that the beam is deflected through 90 degrees by each mirror, as represented in Figure 12. A motor rotates the mirror and as the laser beam strikes its angled surface, a small circle of light is transcribed, which is then reflected onto the second mirror. If this second mirror were motionless, the image would be deflected through 90 degrees, thus projecting a circular image on the screen. However, if both mirrors are rotating, then the image is moved through 360 degrees, thus forming eliptical patterns of differing shapes and sizes according to the relating motor speeds.

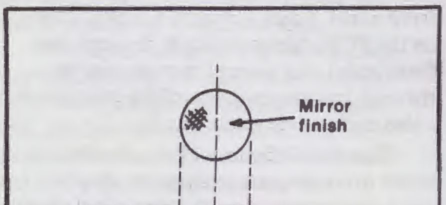


Figure 11. Details of the 'motor deflection units'.

Beam Bending

Three different methods of controlling the motors are available and these are MANUAL, AUTO and AUDIO. In MANUAL mode, the speed of each motor is determined by the appropriate channel RPM control (one for each motor channel) and both controls operate independently when either MONO or STEREO mode is selected. The maximum speed can be preset and the minimum speed is zero. Selecting AUTO mode allows the speed of each motor to be increased and decreased at a rate determined by the AUTOMATIC CHANGE control which varies the frequency of a triangular output waveform. In STEREO mode, RPM and AUTOMATIC CHANGE controls on each channel work independently; whereas MONO mode disables the channel 2 AUTOMATIC CHANGE control and both motors are then ramped up and down in unison from channel 1. Both channel RPM controls remain independent however!

The deflection motors can also be pulsed from a music signal, connected to the DIN socket input, when the AUDIO mode is selected. Either stereo or mono music sources can be used, provided that the minimum signal level is approximately 0.25 to 0.5V RMS. A sensitivity preset control at the input of each channel allows

Figure 12. Basic light beam deflection.

for large variations in signal voltages, up to 30VAC or so, therefore it is possible to use the speaker outputs from small disco's or domestic Hi-Fi units to modulate the laser. The effects produced in this mode are not actually 'sound to light' as the drive motors obviously cannot respond fast enough to music beats. Patterns produced tend to vary in shape and rotation direction, according to the music tempo and signal amplitude, and I found the best effects were made with both channel RPM controls set very close to minimum speed.

PCB Assembly

There are a few points which I think are worth explaining in greater detail, as they may not be immediately obvious! For example, 18 links are required to be made and fitted in positions marked with a yellow line on the PCB – component lead cut-offs are useful for doing this. The two power transistors T3 and T6, and also regulator IC9, should lay flat after installation, see Figure 13 otherwise the front panel will not fit. For the same reason, LED's D1-5 and D8-10 are mounted such that the distance from PCB to LED base is 4mm, as shown in Figure 14. As with the laser PSU module, many of the resistors supplied in this kit are of the five band variety, so if in doubt refer to Table 1 or use a suitable meter. I initially found the mounting position for resistor R74 confusing, due to it being placed over two of the pads associated with potentiometer R72. The resistor does fit in accordance with the legend and terminals from R72 solder on underneath (more on this later).

IC's 1-8 are dual op-amps, referred to as OP1-OP16 on the circuit diagram, and relate as follows:

IC No	Op Amp Nos
1	1-2
2	3-4
3	5-6
4	7-8
5	9-10
6	11-12
7	13-14
8	15-16

No sockets are supplied in the kit and the op-amps are soldered directly into the PCB which, being single sided, presents little problem if they have to be removed for any reason.

I found a few deviations from the parts list with both 10μF and 4.7μF capacitor voltage ratings. Some devices are of a higher voltage rating and therefore physically larger in size, but they still fitted the board – just! The + symbol for capacitor C9 is not clearly visible on either the PCB or overlay diagram and in case this is general with other boards, C9 positive lead fits into the position closest to R27.

Four potentiometers mount directly onto the PCB from the track side, as Figure 15 shows. The three potentiometer terminals do in fact solder directly to the board on this side, and the legend on the opposite face shows this in dotted print; you will need to bend the terminals at right angles first though.

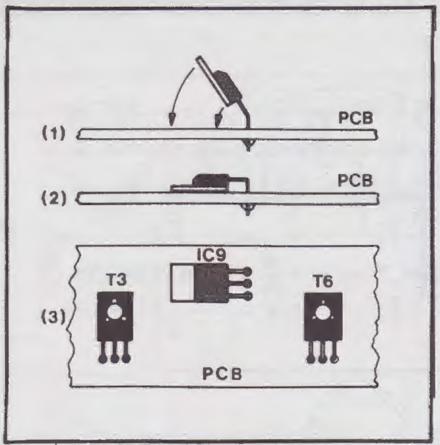


Figure 13. Mounting the two transistors and regulator.

Mode switches S1-3 are mounted on the component side of the PCB Figure 16, in both end and centre positions. They also serve as fixing positions for the front panel and therefore, must be kept vertical during soldering.

The motor drive panel is simple to assemble and the bracket is screwed onto the laser PSU end panel, as can be seen from the various photo's and Figure 17. Final adjustments to angle the mirrors correctly were left for later on. The twin cable supplied was cut into two equal lengths and soldered onto the motor terminals and both 3.5mm plugs (the order is not important).

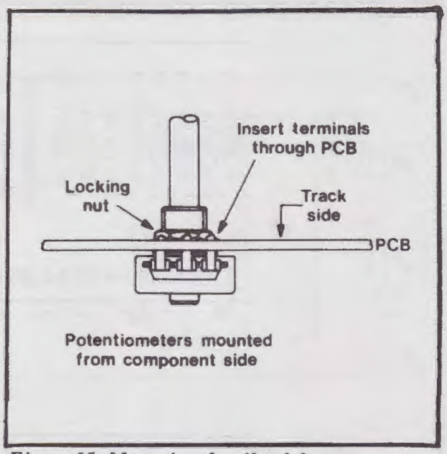


Figure 15. Mounting details of the potentiometers.

I had to drill four holes in the plastic case back panel to take four sockets: one 16mm for the DIN socket and three 6mm holes for the 3.5mm sockets. Each socket was then wired to the appropriately lettered position on the track side of the PCB. For plug and socket terminations, see Figure 18. I found it did not really matter which wire went to the socket

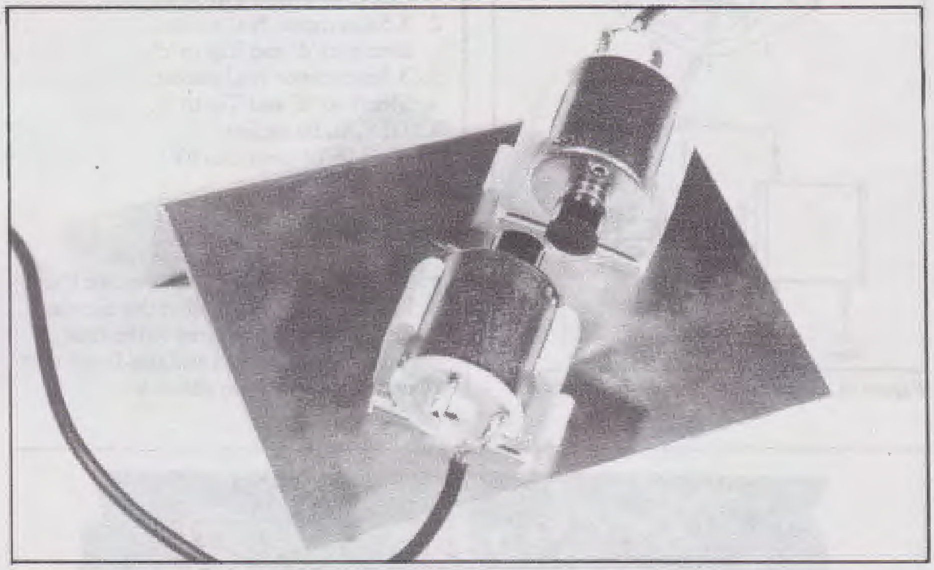


Photo 3. The two motor drive units.

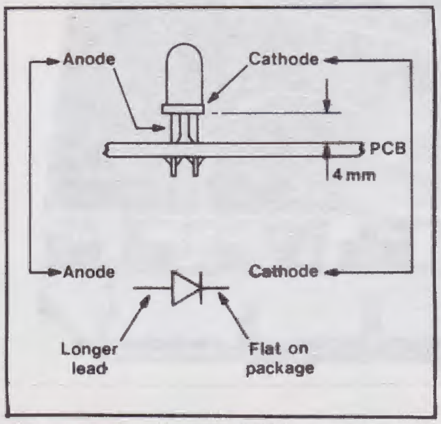


Figure 14. Details of the LED's.

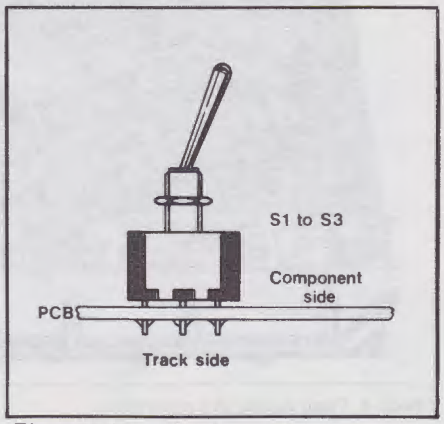


Figure 16. Mounting the switches.

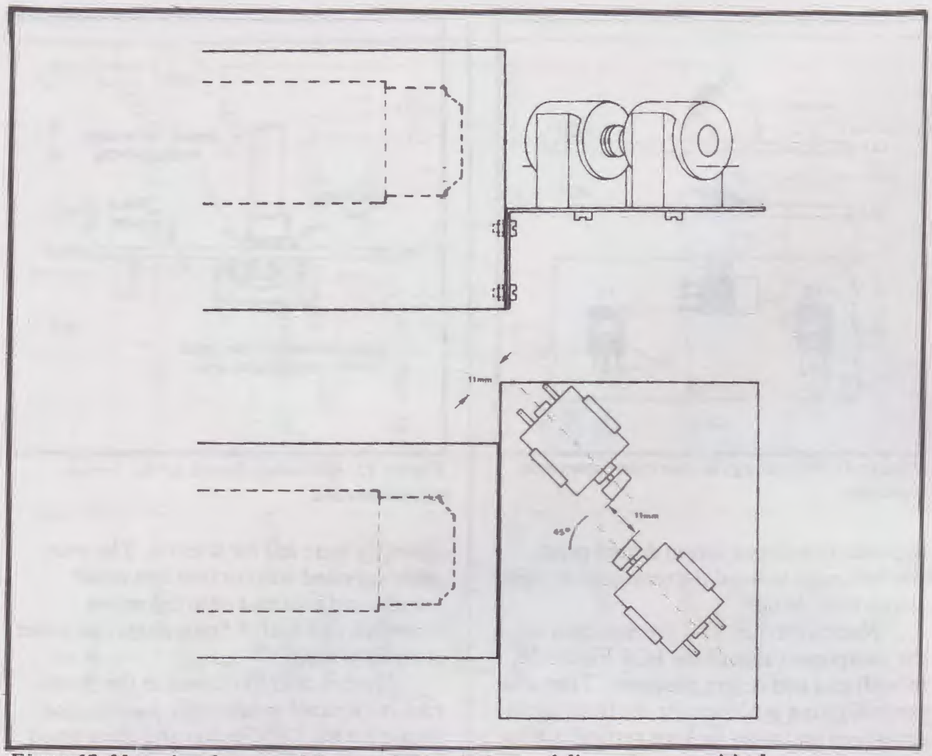


Figure 17. Mounting the motor drive panel on to the laser. Adjustments are critical.

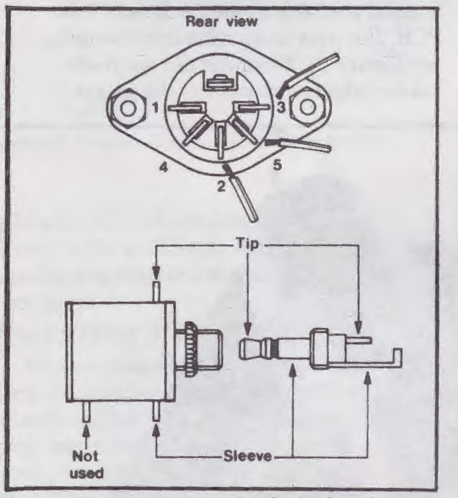


Figure 18. Terminations for the jack sockets.

terminal, but to clarify matters I suggest that you connect the wiring as follows:

1. 3.5mm Power socket.
   Sleeve to 'f' and Tip to 'e'.
2. 3.5mm motor No1 socket.
   Sleeve to 'd' and Tip to 'c'.
3. 3.5mm motor No2 socket.
   Sleeve to 'k' and Tip to 'i'.
4. DIN Audio socket.
   pin 2 to 'b' (common 0V)
   pin 3 to 'a'
   pin 5 to 'g'.

By this time, the module was completed and ready for testing, see Photo 4. I left the front panel off at this time as adjustments were required to the four board mounted presets and this is not easy to do with the panel in place!

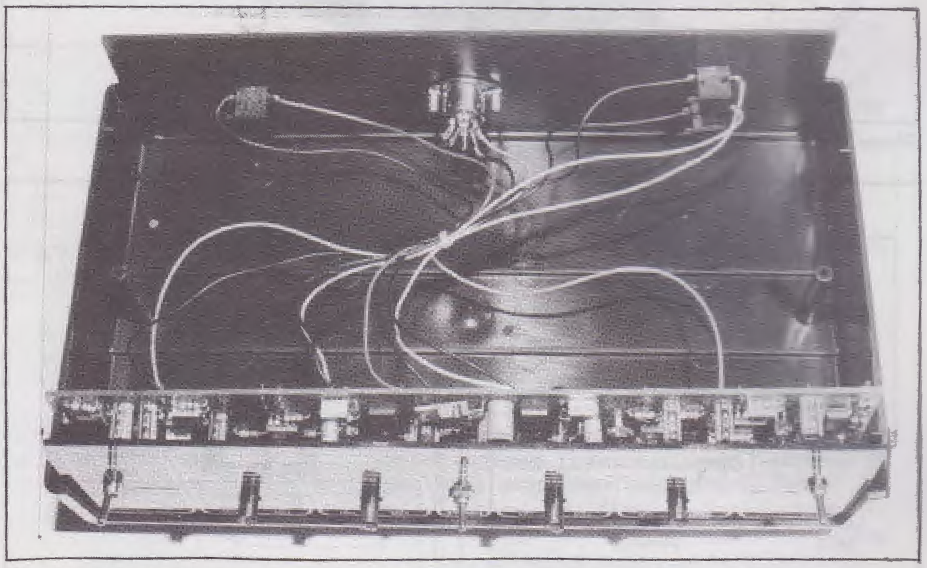


Photo 4. View inside the controller.

Testing

Immediately after powering up the controller from a Maplin XX09K adaptor, the two motors ran at some speed. A few quick checks with a bench meter showed that under load, the regulator supplied 248mA at 12.52V DC. LED's appropriate to the switch position came on as each mode was selected and all was well. As the main instructions point out, preset R34 (for channel 1) and R73 are adjusted for minimum motor revolutions (or zero as required) with the RPM controls set to minimum. This is done in the MANUAL position.

The laser was then powered up and the beam passed between the mirrors which necessitated further adjustments to the motor units. Figure 17 needs to be followed closely and I would remind you to keep your face well away from the mirrors. A fair amount of jiggering around and fine tweeking is required to set the mirrors and you may have to loosen the three bracket mounting screws along the way. I ran the first motor (nearest to the laser port) and positioned it so that the beam hit the mirror exactly at its centre; the second motor was then positioned until the reflected circular image (from the first mirror) fitted symmetrically into the second mirror. A sheet of white card placed approximately 30cm in front of the motor assembly showed a slightly elliptical, spinning circle which turned into a close resemblance of a daisy when the second motor was run, see Photo 8. A further adjustment was needed to prevent one corner of the image from clipping the edge of motor No1.

Presets R1 and R47 are set according to the available signal voltage as was mentioned earlier, but for a temporary measure, both preset wipers were set to half travel before finally boxing up the module and panels.

In Conclusion

The KTE laser controller kit is easy to build and set up, and is of quite good quality for the price. The PCB legends (see Figure 19) could be clearer and the instructions could be a little more explanatory for the less experienced constructor. As with the laser PSU, only basic tools are required for building and testing the controller and experience in soldering techniques is obviously a must. This project does have the limitation of being an add-on for the laser project, but could easily be used to modulate other low power laser systems of similar style.
The following items are available from Maplin Electronics:

Laser and PSU Kit	(LM72P)
Laser and PSU Ready Built	(XM14Q)
Laser Controller Kit	(LM73Q)
Laser Controller Ready Built	(XM15R)
12V 300mA AC Adaptor	(XX09K)
13A Nylon Plug	(RW67X)
DIN Plug 5-pin A	(HH27E)

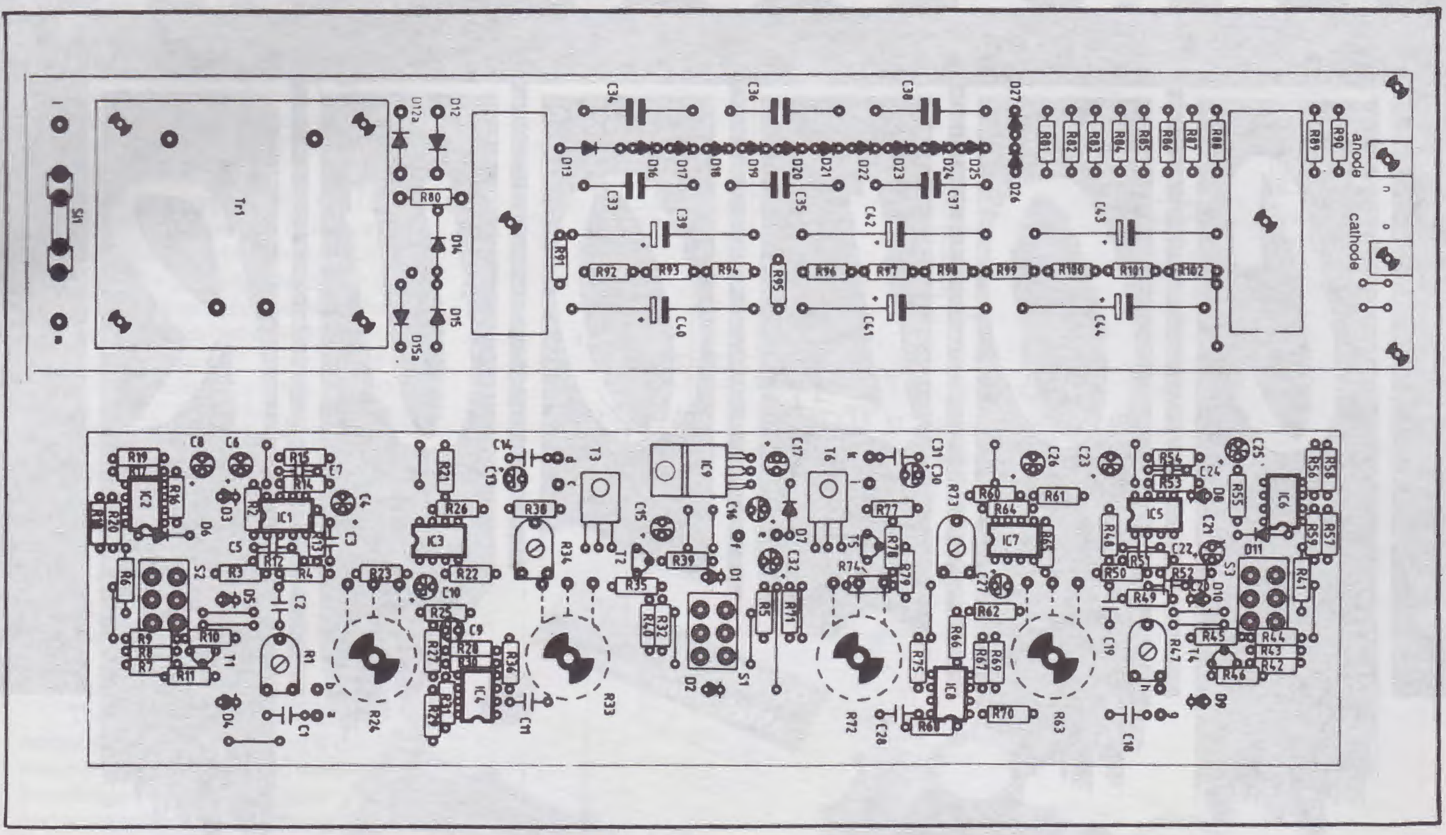
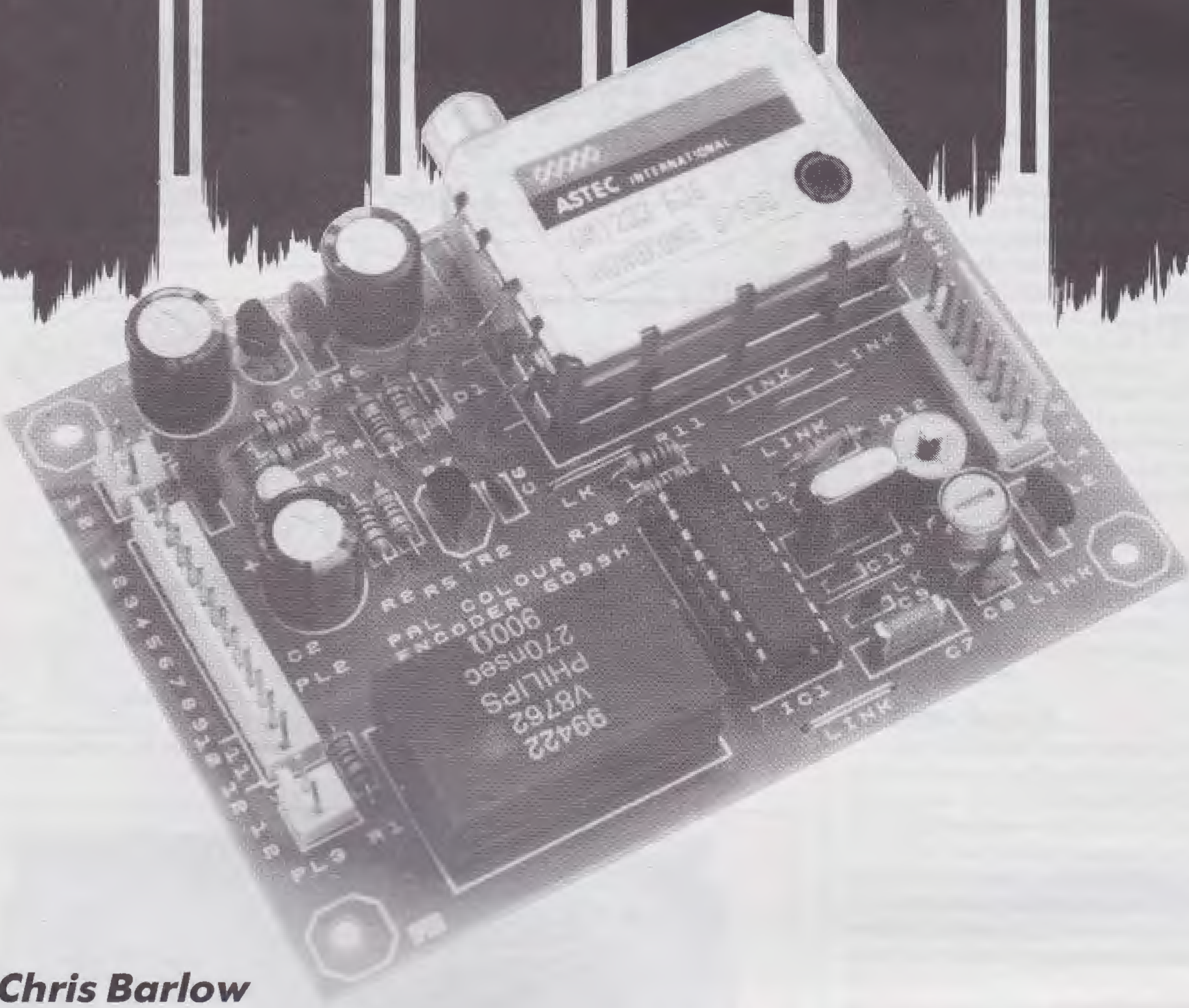


Figure 19. PCB legends.

TEA2000 PAL COLOUR ENCODER



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- *Crystal Controlled Oscillator*
- *On-board Voltage Regulator*

General Description

The PAL colour encoder module is a building block used to convert digital signals in to colour video, see Figure 1. The module provides two outputs, direct video for a monitor and modulated RF for domestic colour televisions.

At the heart of the unit is the TEA2000 which, until now, has only been presented with an application circuit in the Maplin catalogue. The project offered here is basically the same circuit but with the addition of a video buffer and a five volt regulator, see Figure 2. Table 1 gives all the electrical characteristics of the TEA2000.

Application Hints

The digital circuits used to drive the encoder can be very diverse, from computer displays and arcade games to video pattern test generators. However, all these devices must provide the following TTL signals:

1. Composite sync (negative logic).
2. Composite blanking.
3. Red, green and blue (2 bits per primary colour).

The exact timing relationship of composite sync and blanking is quite involved. Therefore a good working knowledge of video techniques is essential and an excellent book on this subject is the Video Handbook (second edition) by Ru van Wezel. In addition to this Maplin have introduced a new IC, the SAA1043 Universal Sync Generator for PAL and NTSC standards.

The six bit binary colour data inputs are organised as two bits per primary colour and gamma correction is applied by the TEA2000 to the resultant luminance and chrominance levels. Each of the equally spaced intensity levels (for each primary colour) is combined with those of the other primary colours. This produces 64 output colours comprising a wide range of saturated and desaturated colours, black, white and two levels of grey.

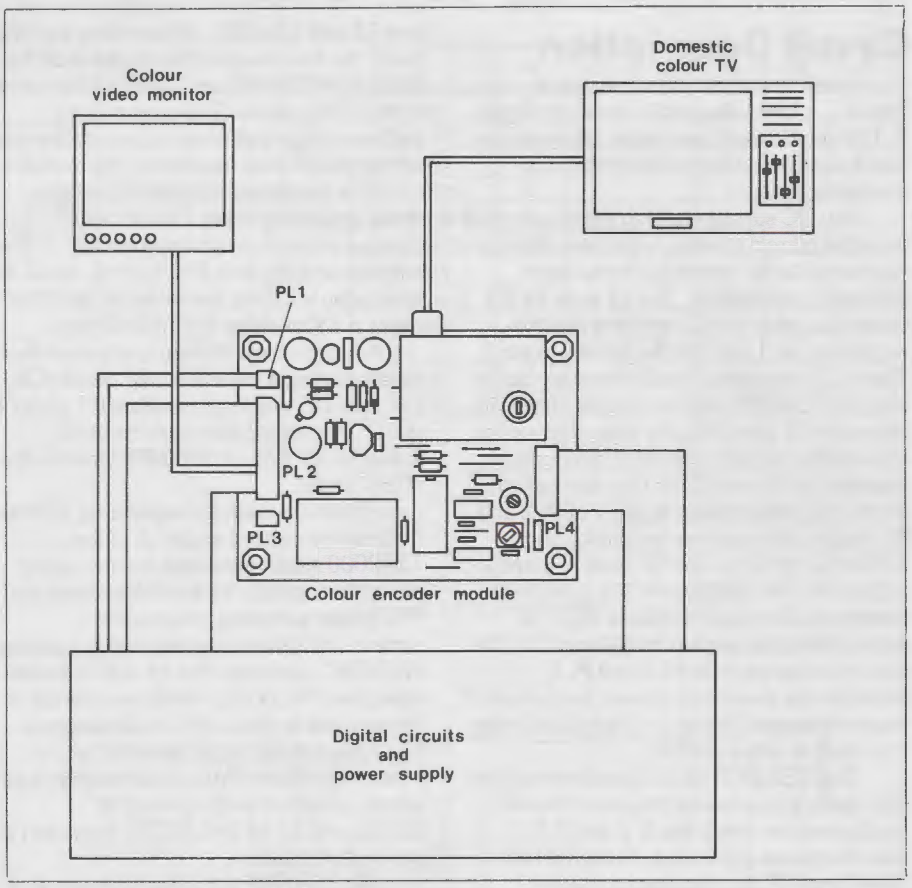


Figure 1. Digital to colour video.

COMPONENT	PAL	NTSC
XT1 CRYSTAL	8.867238MHZ	* 7.159100MHZ
L1 DELAY LINE	DL270 (270NS)	* DL330 (330NS)
L2 ADJUSTABLE COIL	15UH	* 18UH
C8 PLATE CERAMIC	82PF	100PF
R10 METAL FILM 1%	510R	750R
R11 METAL FILM 1%	430R	510R
MD1 MODULATOR	UM1233	* UM1622
PAL/NTSC SELECT	HIGH (OPEN CIRCUIT)	LOW (PL4,PIN 5 TO 6)
* COMPONENT NOT AVAILABLE FROM MAPLIN		

Table 1. Electrical characteristics of the TEA2000.

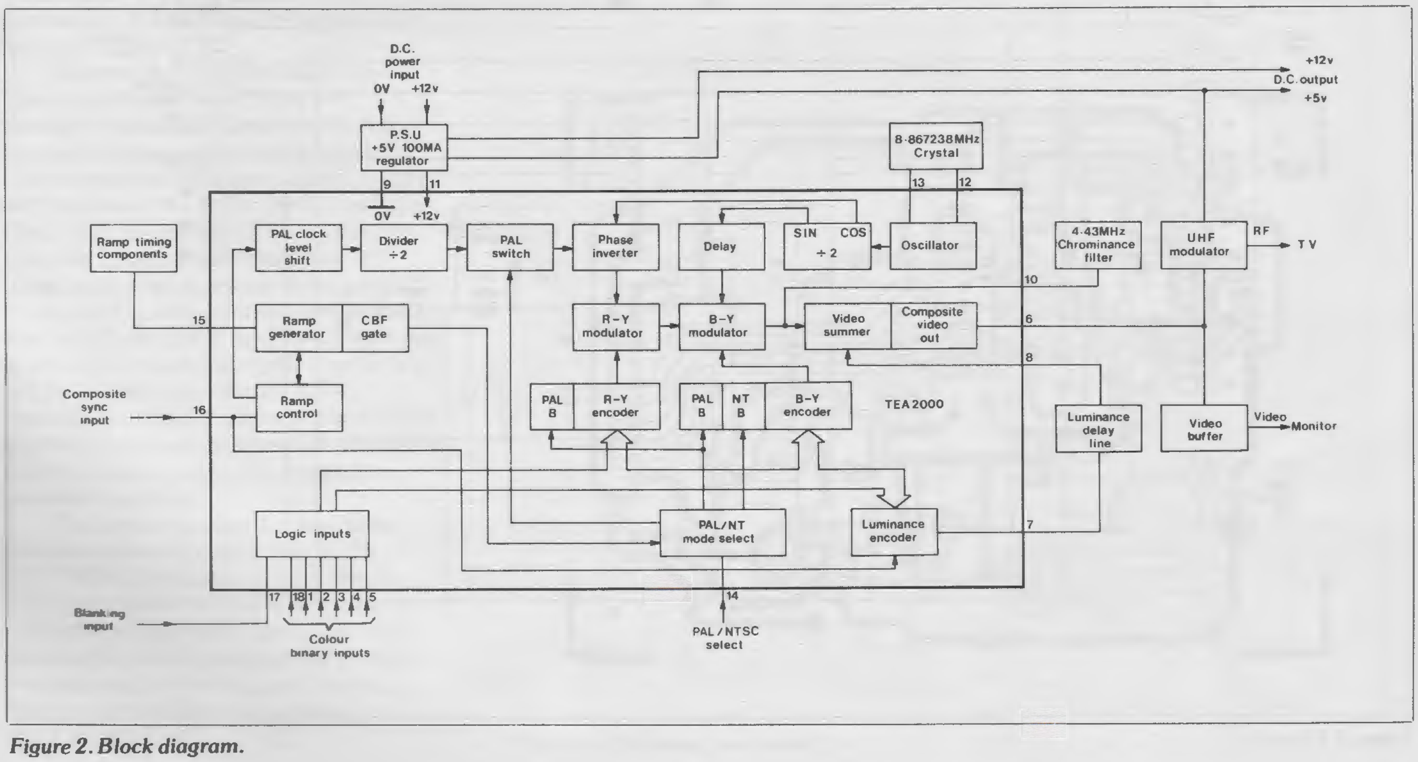


Figure 2. Block diagram.

Circuit Description

In addition to the circuit shown in Figure 3, a block diagram is shown in Figure 2. This should assist you when following the circuit description or fault finding in the completed unit.

Any DC supply entering the circuit must have the correct polarity, otherwise damage may occur to the semiconductors and polarised components. The 12 volts for the circuit is applied to PL1 with the positive supply on pin 1 and the 0V ground to pin 2. The +12V supply rail feeds the video buffer and the TEA2000 colour encoder chip, with capacitor C1 providing the main decoupling and additional high frequency decoupling supplied by C3 and C12. This decoupled supply rail is then taken to pin 1 of PL2 and PL4 to provide a power output for any additional circuitry. The RF modulator MD1 requires a +5V supply which is generated using a small voltage regulator RG1, its output being decoupled by C4 and C5. This supply is also taken to PL2 and PL4, however the maximum current load on pin 2 must not exceed 90mA as overload damage may start to occur in RG1.

The TEA2000 (IC1) is a colour encoder and video summer which has an internal oscillator from which the R-Y and B-Y waveforms are generated. As can be seen from Figure 2, the chip has a complex internal structure which requires only a few additional components to make a finished working unit. The frequency of the internal oscillator is set using a crystal (XT1) and a trimmer capacitor (VC1) connected between pins 12 and 13 of IC1. When using the PAL mode the frequency of the crystal must be set to 8.867238MHz or 7.15909MHz when in the NTSC mode. The output of the oscillator stage is divided to provide the four sub-carrier phases required in the encoder.

The combined luminance and sync signal appearing at pin 7 must be DC coupled to pin 8 via an appropriate luminance delay line. For the PAL mode the time delay is 270ns, but when in the NTSC mode a 330ns delay line must be used.

Chrominance filtering is accomplished by connecting a parallel tuned circuit (C8, L2) via a DC blocking capacitor C7 to pin 10 of IC1. The tuned filter must be set to 4.43MHz for PAL or 3.57MHz when in the NTSC mode.

The ramp timing components, C11 and R12, are connected to pin 15 of the TEA2000 which generates the necessary timing information for the colour burst and PAL phase switching. Alternative component values may be used to optimise the NTSC operation. Pin 14 of IC1 is used to select the PAL/NTSC mode and this pin is brought out to pin 5 of PL4. This input is TTL compatible and an internal pull-up resistor selects the PAL mode when this pin is not connected to 0V ground. A component list for PAL/NTSC operation is shown in Table 2.

Pin 16 of IC1 is connected to pin 4 of PL4 which is the composite sync input requiring a negative TTL logic signal, see Figure 4. For PAL operation the field sync must include line sync information.

Pin 17 of IC1 is connected to pin 3 of PL4 which is the composite blanking input and must be high during sync and colour burst unless all the colour inputs are low at this time.

The colour inputs of are as follows:

RED	R0 = IC1 pin 18	–	PL2 pin 3
RED	R1 = IC1 pin 1	–	PL2 pin 4
GREEN	G0 = IC1 pin 2	–	PL2 pin 5
GREEN	G1 = IC1 pin 3	–	PL2 pin 6
BLUE	B0 = IC1 pin 4	–	PL2 pin 7
BLUE	B1 = IC1 pin 5	–	PL2 pin 8

There are two binary bits per primary colour and these inputs are TTL compatible A table showing 18 out of the 64 possible colours is given in Figure 5.

The composite video generated by the TEA2000 appears on pin 6 of the chip and i taken off to the TV modulator MD1 via R10 and R11. This signal is also capacitively coupled in to the input of the video buffer using a 10nF capacitor C6. The input impedance at the gate of the FET transistor TR2 is approximately 10MΩ, while the output impedance at the collector of TR1 is much lower, approximately 100Ω. The buffered video signal is then taken via C2 to pin 9 of PL2 and pin 1 of PL3. When using a video monitor with a high input impedance the termination resistor R1 must be placed i circuit by linking pins 1 and 2 of PL3.

Printed Circuit Board

A high quality fibreglass PCB (stock code GD99H), with a printed legend to assist you in correctly positioning each component is shown in Figure 6. The following assembly hints should also prove

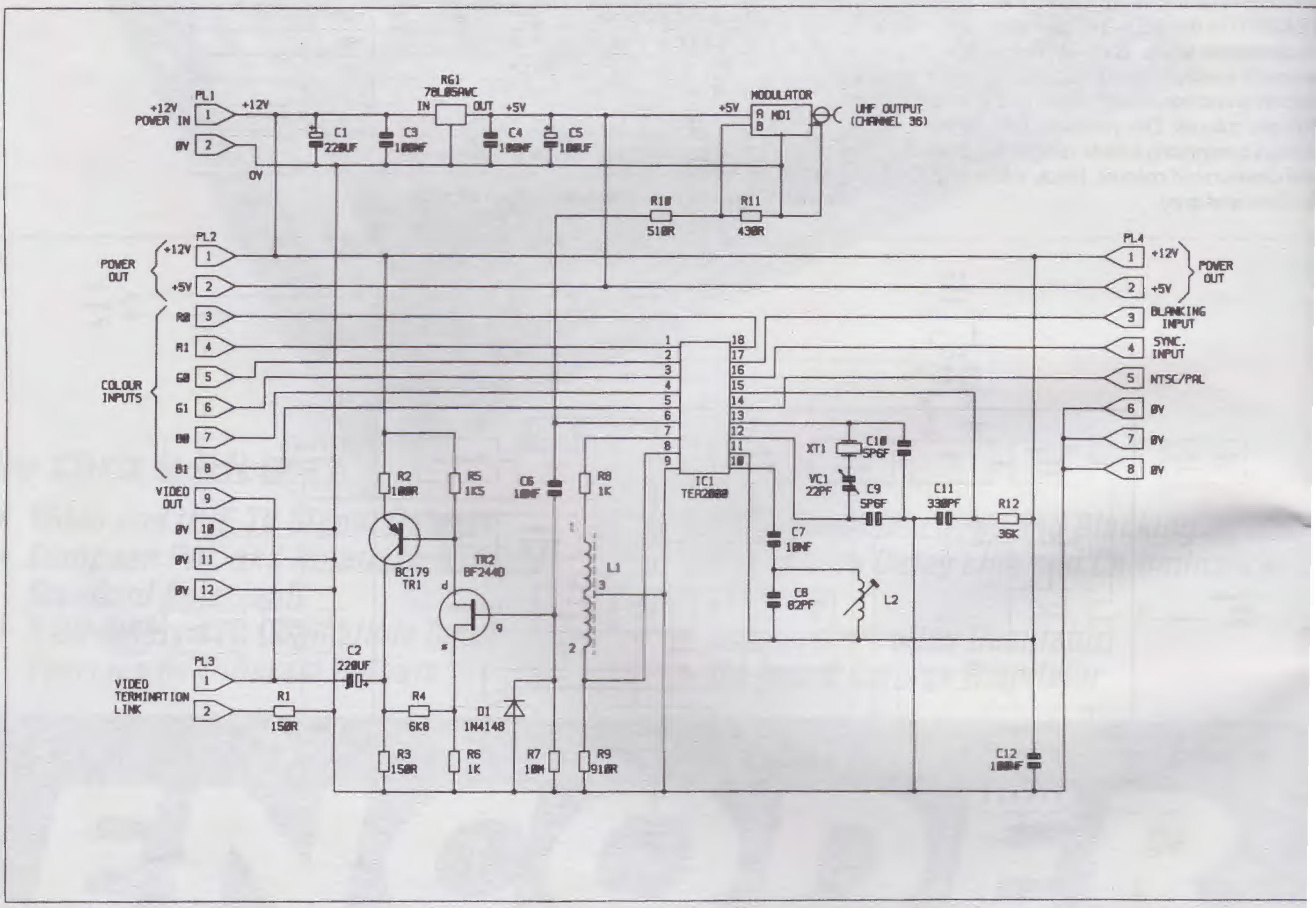


Figure 3. Circuit.

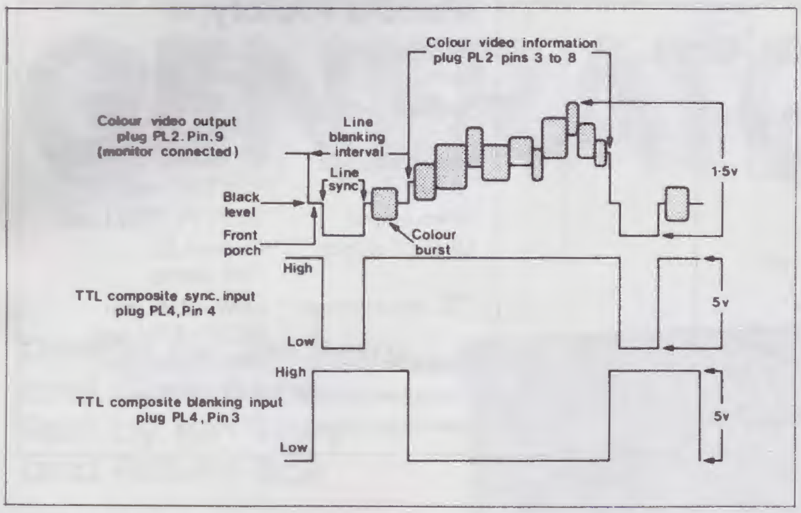


Figure 4. Video signal.

COLOUR	R0	R1	G0	G1	B0	B1
DARK RED	1	0	0	0	0	0
MEDIUM RED	0	1	0	0	0	0
LIGHT RED	1	1	0	0	0	0
DARK GREEN	0	0	1	0	0	0
MEDIUM GREEN	0	0	0	1	0	0
LIGHT GREEN	0	0	1	1	0	0
DARK BLUE	0	0	0	0	1	0
MEDIUM BLUE	0	0	0	0	0	1
LIGHT BLUE	0	0	0	0	1	1
BLACK	0	0	0	0	0	0
DARK GREY	1	0	1	0	1	0
LIGHT GREY	0	1	0	1	0	1
WHITE	1	1	1	1	1	1
ORANGE	0	1	1	0	0	0
YELLOW	1	1	0	1	1	0
PURPLE	0	1	0	0	1	0
PINK	0	1	1	0	1	0
CYAN	0	0	1	0	0	1

Figure 5. 18 of the 64 possible colours.

useful in making construction as straightforward as possible.

1. It is usually easier to start with the smaller components.
2. DO NOT forget to fit the wire links (LINK or LK).
3. When fitting the 'Minicon' connectors ensure that the locking tags are facing outwards to the edge of the PCB.
4. When fitting the semiconductors you must carefully match the case to the outline shown on the legend.
5. DO NOT over heat the crystal XT1.

Testing and Alignment

Connect a 12 volt power supply to PL1, positive to pin 1 and negative to pin 2. Using a test meter in the positive line, measure the DC current which should be approximately 68mA. Remove your meter from the supply input and set it to read DC volts. Connect the meters negative lead to a convenient ground point (PL2 pin 12) and measure the positive 5 volts which should be present on pin 2 of PL2 and PL3.

Next connect the video output to a colour monitor, or the RF from the modulator to a colour television. Until the composite sync and blanking is applied to PL4 the monitor/TV screen should be blank, with the state of the colour inputs having no effect. With the correct sync and blanking the entire screen should change to the colour set by the bit pattern of the colour inputs, see Figure 5. If no colours are seen then try adjusting VC1 until the colour locks in, this will be when the crystal is oscillating at 8.867238MHz, see Figure 7. The chrominance filter L2 will have little effect at this time. However, its setting will determine the final picture quality of the digitally generated graphics.

The frequency output of the video modulator is factory set to channel 36 (591.5MHz). This should be suitable for most applications but if necessary it can be retuned by adjusting the ferrite core in its oscillator stage. All the adjustments should be made using a trimming tool, the one found most suited was the pot core type (stock code BR51F).

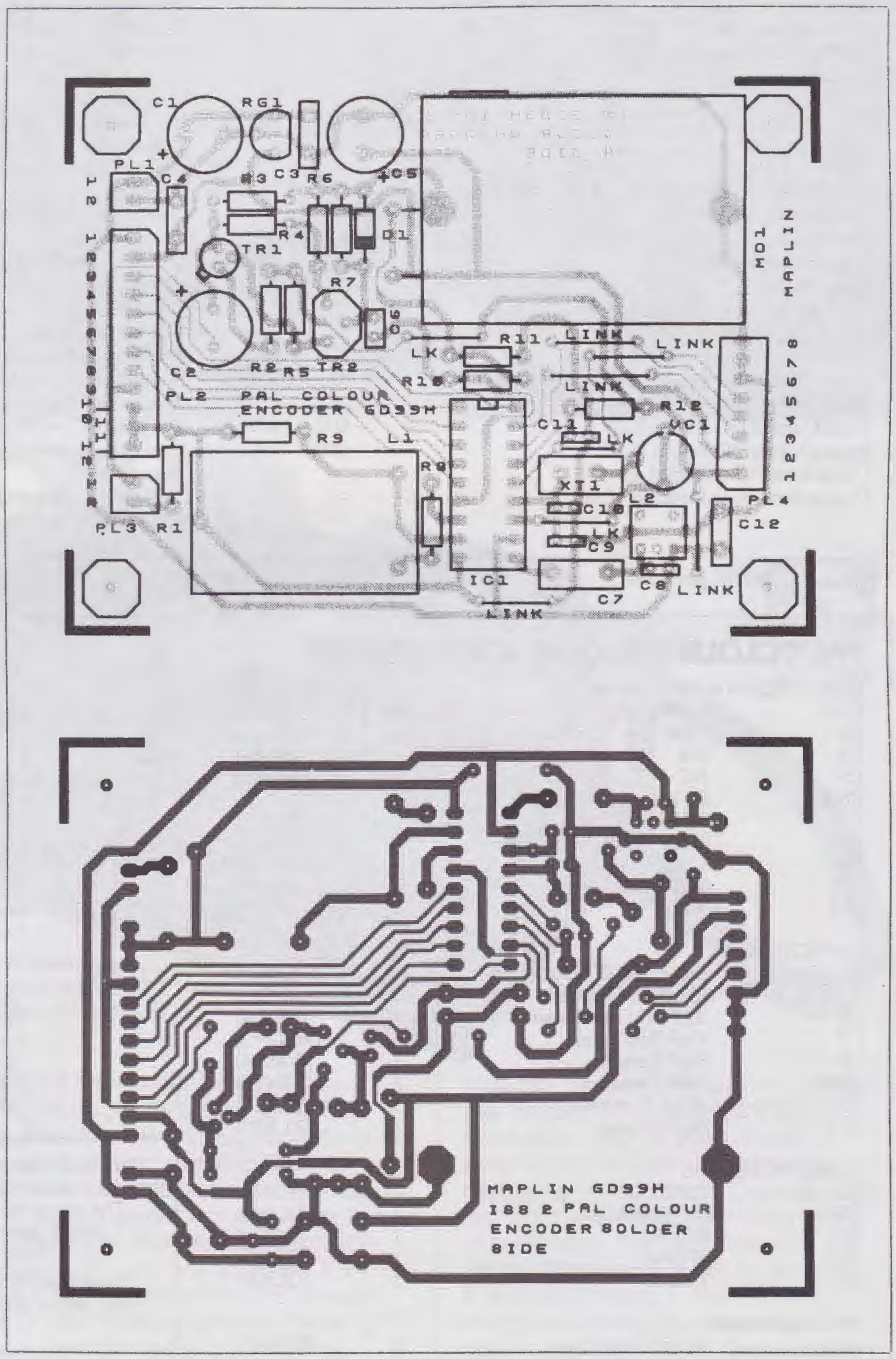


Figure 6. PCB layout and overlay.

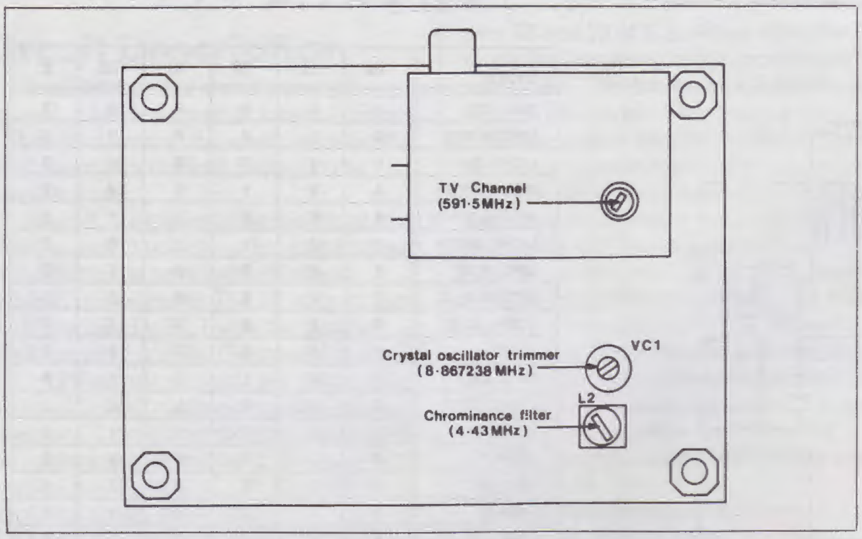


Figure 7. Encoder adjustment.

Specification of Encoder Module Prototype

Power supply voltage:	+11·5V to +12·5V
Supply current at +12V:	68mA
Voltage regulator output:	+5V 90m max.
Video output:	1V Pk-Pk (75Ω Load)
UHF TV output:	Channel 36 (591·5MHz)
TTL input voltage:	LOW +2·0V min. HIGH +2·0V min.
Crystal frequency:	8·867238MHz
Chrominance filter:	4·433619MHz
Luminance delay:	270ns

Parameter	Min	Typ	Max	Unit
Supply Voltage pins 11/9	10.8	12	13.2	V
Supply Current at 12V	–	55	–	mA
Oscillator Stability, pins 12/13				
(Crystal type 4322 143 04051)				
Vp = 10.8 to 12V	–	+50	–	Hz
Vp = 12 to 13.2V	–	–50	–	Hz
Digital Inputs				
CSYNC, CBLNK, PL/NT pins 16,17,14				
R0, R1, G0, G1, B0, B1 pins 18, 2, 3, 4, 5				
Vin (low)	–0.5	–	0.8	V
Vin (high)	2	–	Supply	V
Input Capacitance	–	–	10	pF
Input rise and fall times	–	–	200	ns
CSYNC, CBLNK, R0, R1, G0, G1, B0, B1 pins 16, 17, 18, 1, 2, 3, 4, 5				
Input Current DC for Vin = 0V	–	–	–100	μA
Input Current DC for Vin = 2V	–	–	20	μA
PL/NT, pin 14				
Input Current DC for Vin = 0V	–	–	–500	μA
Input Current DC for Vin = 2V	–	–	–200	μA
Composite Video Output, pin 6				
Output Amplitude (sync tip-white)	–	2	–	V

Parameter	Min	Typ	Max	Unit
Sync tip level	–	5	–	V
Output load resistor	0.47	1	–	kΩ
Variation of output amplitude				
Tamb = 0 to +70°C	–	–	tbf	V(p-p)%
Over supply range				
V on pins 11/9 = 10.8 to 13.2V	–	–	tbf	%
Output Impedance (with 1kΩ load)	–	15	–	Ω
Residual Chrominance on white	–	30	–	mV rm
Tolerance on luminance amplitude	–	10	–	V%
Tolerance on chrominance amplitude	–	10	–	V%
Tolerance on chrominance phase	–	tbf	–	Q%
Chrominance band limiting, pin 10				
Internal resistance	–	1.5	–	kΩ
Luminance delay, pins 7/8				
Nominal series resistor (±5%)	–	1.2	–	kΩ
Nominal load resistor at luminance input (±5%)	–	1	–	kΩ
Ramp timing, pin 15				
With external RC circuit				
R = 36kΩ; C = 330pF				
Start of burst from line sync	–	5.7	–	μs
Burst width	–	2.5	–	μs
Threshold for seperation of equalising pulses and sync pulses	36	44	56	μs

Table 2. PAL/NTSC parts list.

PAL COLOUR ENCODER KIT PARTS LIST

RESISTORS: All 0·6W 1% Metal Film			
R1,3	150Ω	2	(M150R)
R2	100Ω	1	(M100R)
R4	6k8	1	(M6K8)
R5	1k5	1	(M1K5)
R6,8	1k	2	(M1K)
R7	10M	1	(M10M)
R9	910Ω	1	(M910R)
R10	510Ω	1	(M510R)
R11	430Ω	1	(M430R)
R12	36k	1	(M36K)
CAPACITORS			
C1,2,5	220μF 16V PC Electrolytic	3	(FF13P)
C3,4,12	100nF 16V Minidisc	3	(YR75S)
C6	10nF 50V Disc Ceramic	1	(BX00A)
C7	10nF Poly Layer	1	(WW29G)
C8	82pF Ceramic	1	(WX55K)
C9,10	5p6F Ceramic	2	(WX41U)
C11	330pF Ceramic	1	(WX62S)
VC1	22pF Trimmer	1	(WL70M)
SEMICONDUCTORS			
IC1	TEA2000	1	(UH66W)
RG1	LM78L05ACZ	1	(QL26D)
TR1	BC179	1	(QB54J)
TR2	BF244A	1	(QF16S)
D1	1N4148	1	(QL80B)
MISCELLANEOUS			
L1	DL270 Delay Line	1	(UH84F)
L2	15μH Adjustable Coil	1	(UH86T)
XT1	8·867238MHz Crystal	1	(UH85G)
MD1	UHF Modulator UM1233	1	(FT30H)
PL1,3	2-Way PCB Latch Plug	2	(RK65V)
PL2	12-Way PCB Latch Plug	1	(YW14Q)
PL4	8-Way PCB Latch Plug	1	(YW13P)
	18-Pin DIL Socket	1	(HQ76H)
	2-Way PCB Latch Housing	2	(HB59P)
	12-Way PCB Latch Housing	1	(YW24B)
	8-Way PCB Latch Housing	1	(YW23A)
	PCB Latch Terminals	3 Strips	(YW25C)
	PCB	1	(GD99H)
	Instruction Leaflet	1	(XU85G)
	Constructors' Guide	1	(XH79L)
OPTIONAL			
	Trimmer Tool	1	(BR51F)
	Phono to Coax Video Lead	1	(FV90X)
	M3 Threaded Spacer	1 Pkt	(FG38R)
	M3 x 6mm Bolt	1 Pkt	(BF51F)
	M3 Shakeproof Washer	1 Pkt	(BF44X)
	M3 Steel Nut	1 Pkt	(BF58N)

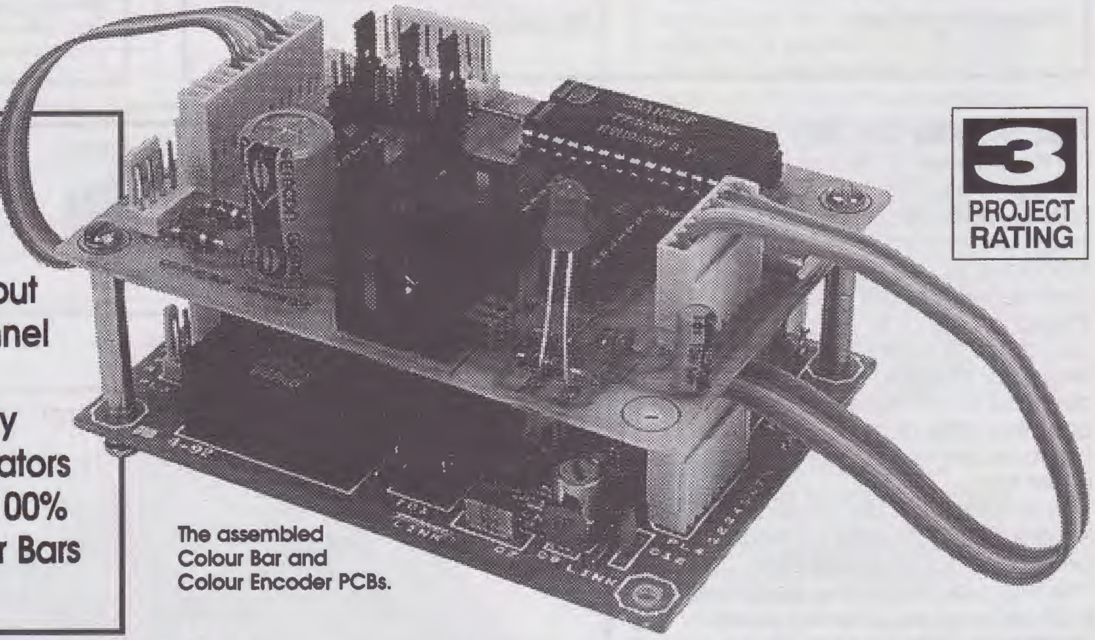
The Maplin 'Get-You-Working' Service is available for this project, see Constructors' Guide or current Maplin Catalogue for details.
The above items (excluding Optional) are available as a kit, which offers a saving over buying the parts separately.
Order As LM66W (PAL Colour Encoder Kit)

Please Note: Where 'package' quantities are stated in the Parts List (e.g., packet, strip, reel, etc.), the exact quantity required to build the project will be supplied in the kit.

TV COLOUR BAR GENERATOR

Design by Ian Berry and Chris Barlow
Text by Ian Berry and Robert Ball

If you are involved in sending television pictures up and down cables, or to and from VTRs and monitors, it is really necessary to be able to check if the pictures at the far end are being displayed correctly. Whilst the black and white test stripe that some VTRs give out in their 'test mode' is useful, it is not normally possible to properly adjust a TV or monitor to *exactly* the right settings to display correct colour pictures.



The assembled Colour Bar and Colour Encoder PCBs.

3
PROJECT RATING

FEATURES

* PAL Composite Video Output
* PAL UHF RF Output
* RF Output Channel Adjustable
* AC or DC supply
* Onboard Regulators
* Produces EBU, 100% and 75% Colour Bars
* Easy to Build

APPLICATIONS

* TV/Monitor Servicing
* Video Servicing
* Workshop and Field Use
* TV Outside Broadcasts
* TV Studio

SIMILARLY, when servicing TVs, monitors, VTRs or other video equipment it is necessary to have a constant and stable colour test signal to be able to accurately set up the various preset controls. Over the last decade, the previously familiar colour test card has vanished from our TV screens much to the chagrin of TV and video engineers the length and breadth of the country. The younger readers of this magazine may not remember the days before the 'Breakfast TV' and '24hr TV' revolutions, prior to these it was easy to find at least one channel displaying a 'test card'. Originally, the test card was literally placed in front of a camera, the most popular (famous?) being the BBCs 'Test Card F' shown in Photo 1. Modern test cards are entirely electronically generated and usually personalised so that the signal can be identified.

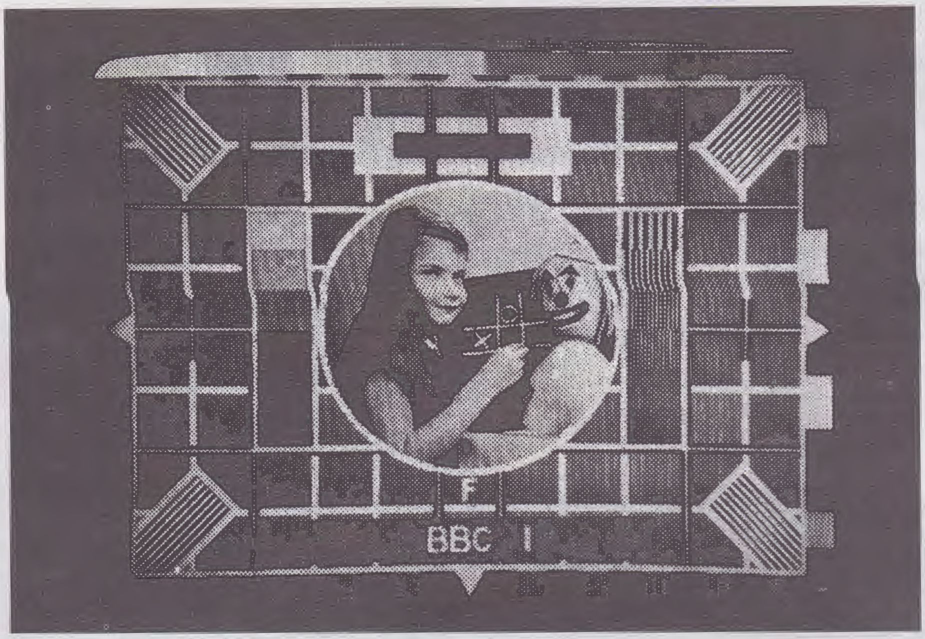


Photo 1. Test Card F. © Copyright BBC Engineering.

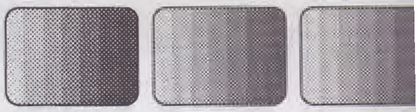
Specifications of Colour Bar Generator

Power supply voltage range:	15V to 25V AC or DC
Power supply current:	105mA at 15V DC
Colour system:	PAL
Colour bar standards:	100%, EBU and 75%
Composite video output:	1V Pk-to-Pk into 75Ω (EBU Bars)
UHF RF output:	591·5MHz (Channel 36)
UHF RF output connector:	Phono
PCB Dimensions (WDH)	
Colour Bar PCB:	99 x 73 x 31mm
Colour Encoder PCB:	99 x 73 x 20mm
Mounting holes:	M3 clear

Test Signals On Tap

For the engineer or technician an 'on tap' colour test signal is needed, units to generate such a signal vary in complexity from an expensive broadcast standard electronic test card generator costing several thousand pounds to a much simpler and cheaper colour bar generator. Broadcast standard equipment is designed to the highest standards possible – after all the test equipment has to be better than the system under test.

A simple colour bar generator is more than adequate for most general setting up procedures, and when aligning video equipment a full test card provides *too much* information. Often servicing information specifies a standard colour bar test signal. This type of test signal is widely used by broadcasters for checking and setting up all manner of equipment which is required to operate with colour pictures. Colour bars are also the test signal used when timing colour pictures together for use in any situation where sources need to be switched or mixed; a studio vision mixer for example. In this case the pictures need to appear in the same relative time (horizontal phase) and also the same relative colour phase (subcarrier phase) – controls normally being provided on the source equipment to vary these two parameters. Correct subcarrier phase is important because if two sources are switched, which are not in the same phase, then the monitor or video equipment will be required



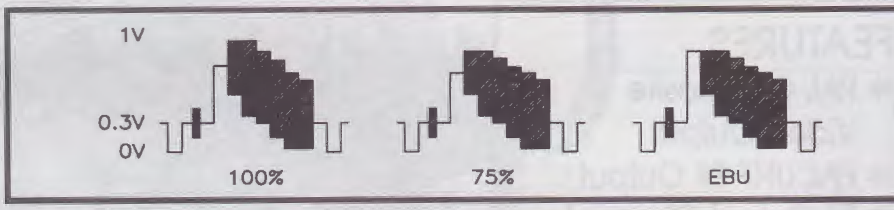


Figure 1. Idealised colour bar video waveforms.

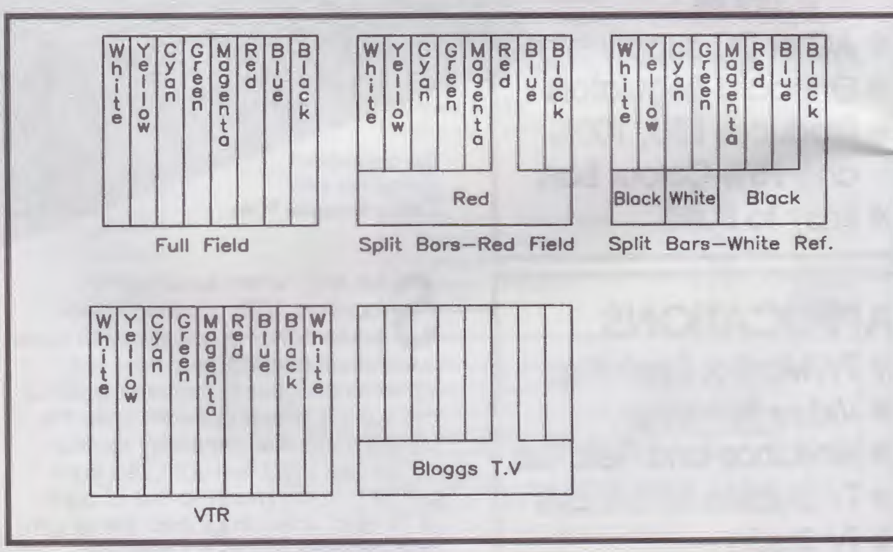


Figure 2. Various colour bar screen displays.

Important Safety Note:

Because of the wide range of possible final construction methods, ultimately determined by the constructor, full details of mains wiring connections are not shown in this article. However for safety reasons it is essential that a suitably rated mains fuse and switch is fitted if a mains power supply is to be constructed. Whilst by no means exhaustive, the following recommendations are made:

If the final unit is housed in a plastic case and a mains supply is integral, Class II (double insulated) construction techniques must be employed and the mains transformer must comply with class II requirements.

If the final unit is housed in a metal case with integral mains supply, Class I construction techniques must be employed; the case and metalwork of the mains transformer must be earthed.

Other precautions and steps necessary to comply with published safety standards must be employed to ensure safety of the user and servicing personnel.

Every possible precaution must be taken to avoid the risk of electric shock during maintenance and use of the final unit. Safe construction of the unit is entirely dependent on the skill of the constructor.

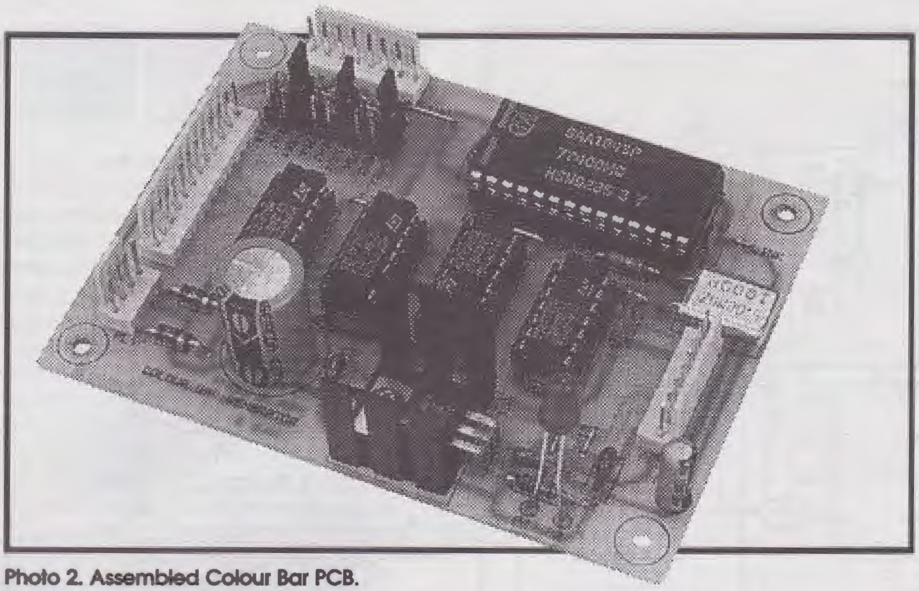


Photo 2. Assembled Colour Bar PCB.

to relock its colour decoder, the effect will be at best, a colour flash, and at worst, complete picture breakup.

Variations

There are several different styles of colour bars in use around the world, each suited to a particular task. They are all based on eight vertical coloured stripes, which can sometimes be seen when the vision mixer at the TV studio pushes the wrong button!

The first variation lies in the amplitude of the various parts of the waveform. The bars are actually made up of a series of black and white steps reducing in amplitude from right to left. This is the luminance (brightness) part of the signal and as a reference signal is used to set the overall gain of the signal path. 1V Pk-to-Pk from the bottom of the sync pulse to the top of the white bar is the normal level. Superimposed on this luminance signal is the chrominance (colour) signal, a suppressed carrier quadrature amplitude modulated signal based on a reference frequency of 4·43361875MHz. The amplitude and phase of this signal indicates the colour (hue) and amount of colour (saturation). There is also a quick burst of the subcarrier at reference level and phase in the line blanking interval just before the picture starts, this is the colour burst and is used to synchronise colour decoding circuitry and provide automatic level adjustment. The finer technical points of the colour encoding and decoding process have been omitted here and the reader is referred to one of the many books written on the subject.

In the old days of television the amplitude of colour bars was specified by the maximum height of the luminance signal, 1V, and the maximum amount of colour modulation allowed, 100%. While there was only the one system of colour bars this was fine. But then it was found that for some uses 100% colour modulation was a little excessive. Setting up of radio links became difficult, and the fact that the chrominance signal extended well above the maximum white level, was also a problem. So engineers began to use another set of colour bars with the amplitude reduced to 75%. The original bars were then referred to as 100% bars.

This cured the problem of too much chrominance but the white bar was also reduced to 75% and this brought its own problems. Many an engineer has seen 100% bars, thought they were 75% bars and proceeded to increase the video level accordingly, thus producing 125% pictures with disastrous results!

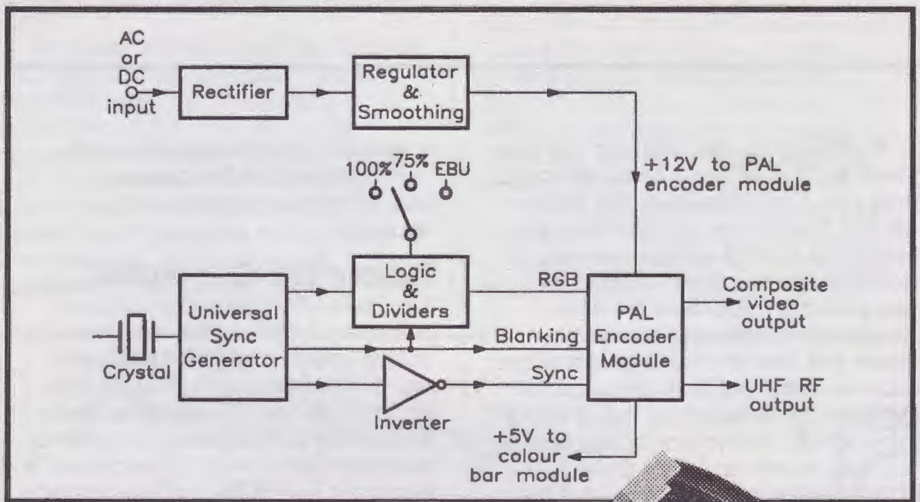


Figure 3. Block diagram of Colour Bar Generator.

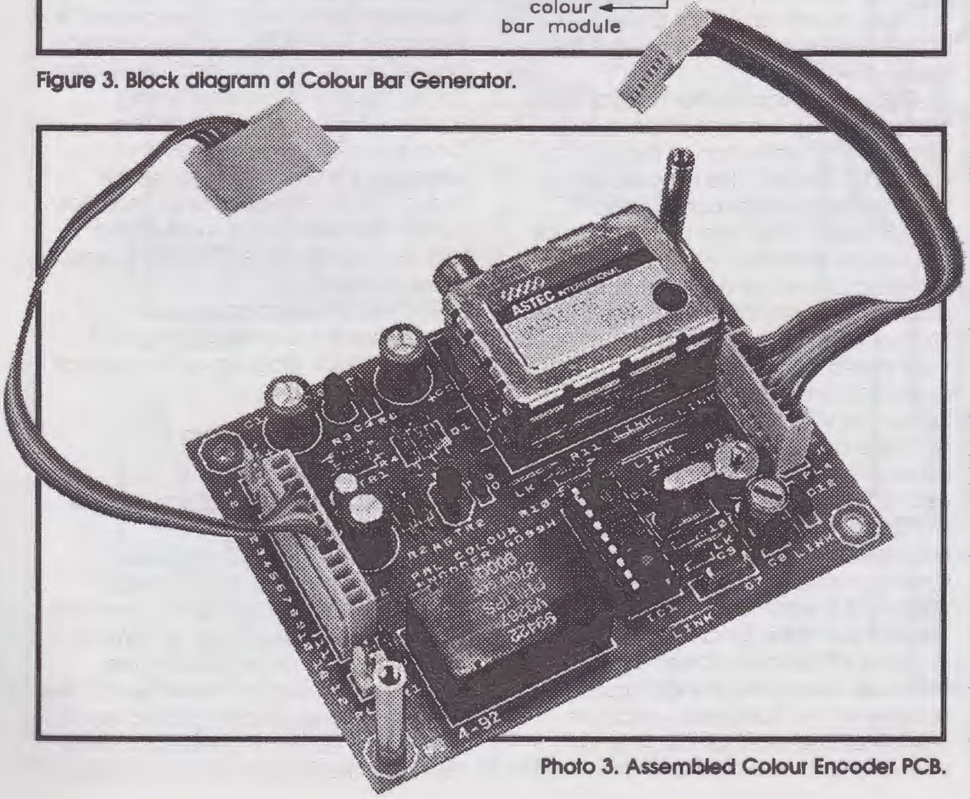


Photo 3. Assembled Colour Encoder PCB.

Important Note about Servicing Mains Equipment

It is important to note that servicing mains powered equipment, such as TVs, video monitors, VTRs, etc. is potentially dangerous. Mains voltage and EHT voltage are potentially lethal. Live working should not be undertaken except where absolutely necessary; in such cases suitable safety precautions must be taken as described in published safety standards and legislative acts, e.g., use of isolation transformer, RCD, correct working procedures, etc. Manufacturers instructions to servicing personnel with regard to servicing methods, necessary equipment, spare parts (especially safety critical components), etc., must be followed. If in any doubt as to the correct way to proceed, seek advice from a suitably qualified engineer.

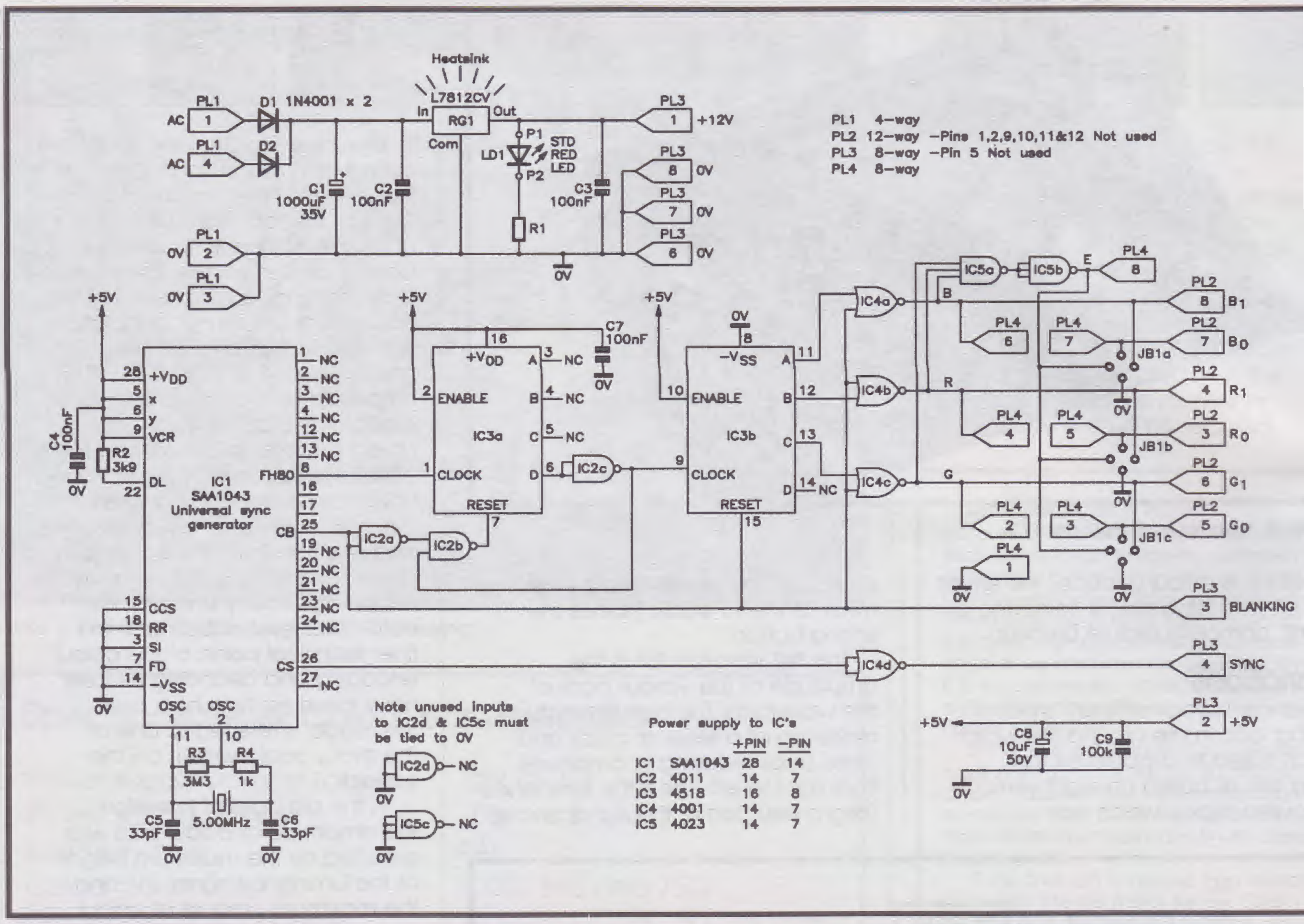


Figure 4. Circuit diagram of Colour Bar Module.

To get over the problem of the 75% bars looking the same as the 100% bars, the European Broadcasting Union (EBU) designed another set of bars, known as EBU bars, having the same specifications as 75% bars except that the white bar is increased in level to 100%. The video waveforms for all three colour bar standards are shown in Figure 1.

With EBU standard bars the first step is bigger than the rest, but this is far outweighed by the fact that now there is a set of bars which has 100% luminance and 75% chrominance which seems to suit just about everybody.

More Variations

The second variation is how the bars are combined with other signals.

In some cases the bars are divided horizontally about two thirds of the way down the frame, normal bars appearing in the top section but other signals appearing in the bottom section. These are known as split bars and can contain various signals in their bottom section. The most common of these is a red field to the same specification as the red bar in the upper section. This is used to check for various distortions and non-linearity in the chrominance information. It also has the effect of making the dots in the red boxes on a vectorscope display larger than the rest thus making it possible to set up correct chroma phase without a colour monitor which can sometimes be useful.

A variation of the split bars has the lower section at black level with a bar inset into it at white level. This allows full 75% bars to be used in the upper section as a 100% white reference is contained in the lower section. It is also possible to observe the low frequency response of the system under test and to check for distortions such as overshoot or ringing which are normally masked by the chroma information. This type of colour bars is normally found on Philips (now BTS) equipment but this is not always the case.

One exception to the normal eight bar sequence is a nine stripe design which has a white bar at the right as well as at the left. The purpose of this is to define the right-hand edge of the picture so that the picture can be accurately centred within the line blanking period when using timebase correctors or anything else where the picture is movable sideways. Due to their widespread use in video recording areas these are usually known as VTR Bars.

These days it is common practice among the broadcast companies and others communications companies such as BT and satellite link providers to use split bars and insert a name or logo into the bottom section. It is easy to see how useful this is, if you think for a moment of the situation at Telecom Tower for example where incoming circuits number in the hundreds – most of them inactive most of the time and so showing colour bars as a standby signal. Just which bars are which!

Examples of all the colour bars mentioned are shown in Figure 2.

Colour Bar Generator

The Colour Bar Generator project presented here is of the simplest configuration, that of full field bars. Any of the three 100%, EBU, or 75% standard levels can be generated - the choice is either set by jumpers o by an off-board switch. The project based on two PCBs: the first contain power supply circuitry and generate the necessary video and timing signals – this is referred to as the Colour Bar Module. The second encodes the colour video signals to the PAL TV standard and provide composite video and modulated UHF RF outputs – the TEA2000 Colou Encoder Module.

To help understand operation of the Colour Bar Generator, Figure 3 shows a block diagram of the over project.

Circuit Description

Colour Bar Module

The circuit of the Colour Bar Module is shown in Figure 4.

Either an AC or DC extra low voltage supply can be applied to the power connector PL1; in the ca of an AC supply D1 and D2 form a bi-phase full wave rectifier, in the case of a DC supply the same dioc provide reverse polarity protection. is the main reservoir capacitor. Sinc the equivalent series resistance (ESR of large value electrolytic capacitors increases significantly at high frequencies, C2 provides high frequency decoupling thus attenuating supply borne noise and spikes. The incoming supply is regulated to +12V DC by RG1. C3 provides high frequency decoupling at the output of the regulator to promote stability. LD1 provides power on indication; R1 limits the current through LD1 to approximately 20mA. The regulated +12V supply is required by the Colour Encoder Module and supplied to it through PL3-1, which in turn supplies a +5V regulated supply back to the Colour Bar Module through PL3-2 – a symbiotic existence – each module requires the other to operate! The +5V supply from the Colour Encoder Module is decoupled by C8 and C9. Additional decoupling is provided by C4 (physically adjacent to IC1) and C7 (physically adjacent to IC2 to IC5). Such decoupling is essential when working with digital logic ICs to prevent erratic operation, digital noise breakthrough and reduce electromagnetic interference (EMI).

The heart of the Colour Bar Module is IC1 which is an SAA1043 Universal Sync Generator IC, this device generates all the required timing signals for a television picture. Before such devices were developed, a whole board of logic ICs would be necessary to generate the required timing signals. The IC does not, however, generate the colour

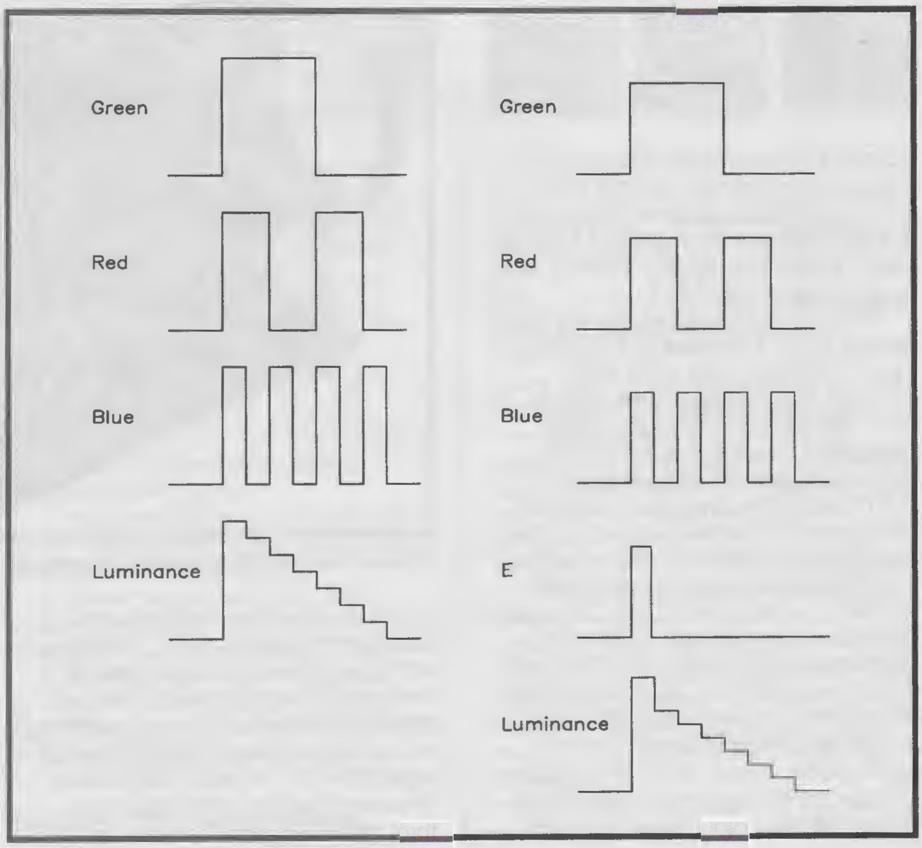


Figure 5. Relative timing of component video signals.

subcarrier which is generated by the Colour Encoder Module. IC1 has several programming pins which define its operating parameters such as the TV standard it is to be used on. These are tied either high or low as shown in the circuit diagram.

Very few external components are required for the SAA1043 to operate. Crystal XT1, its associated RC network comprising R3 & C5 and R4 & C6, and circuitry within the IC form an accurate 5MHz oscillator. This oscillator provides the master reference for all system timing. The only other component is a single pull up resistor on the DL input.

One problem often encountered when generating timing signals electronically is finding a locked source of correctly timed pulses at a much higher frequency than the

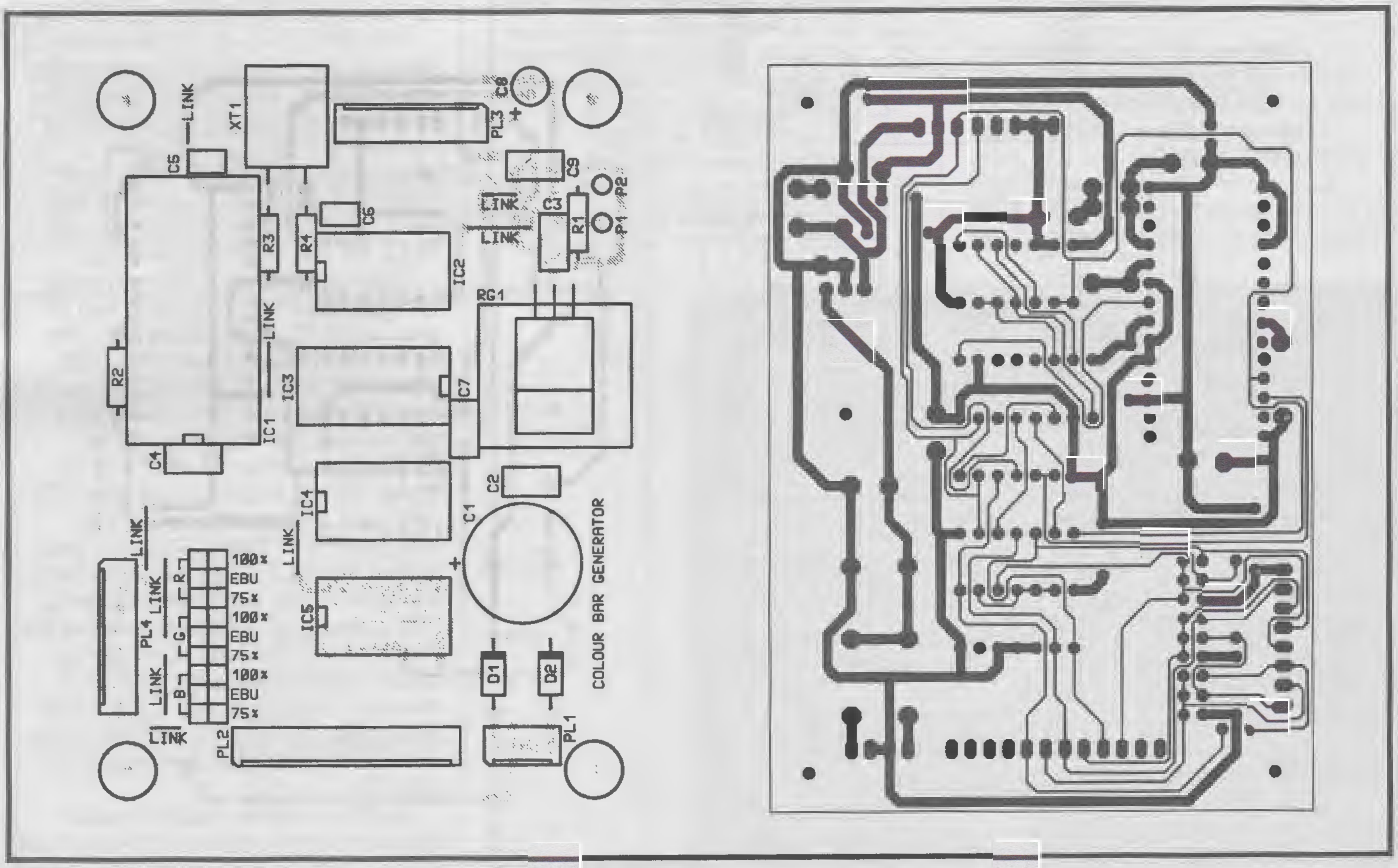


Figure 6. PCB legend and track for Colour Bar Module.

normal line and frame rate, so that the picture area can be split into various vertical segments. Fortunately the SAA1043 has an output of 1·25MHz which is eighty times the line rate and is, of course, locked to it.

The FH80 (eighty times the line rate) output signal is passed to the clock input of IC3A, a 4518 dual BCD counter. The D output from IC3A is now FH80 divided by eight, which gives ten times the line rate (FH10). This would give ten bars, not eight, but most of the unwanted two bars are contained within the line blanking period and as such are gated off by the $\overline{CB}$ (negative going composite blanking) signal from IC2A. IC2A (used as an inverter) provides CB from the $\overline{CB}$ output of IC1. This is NANDed with the $\overline{D}$ output from IC2C (also used as an inverter), to reset IC3A. The input to IC3B is a series of eight normal width pulses and a final narrow pulse giving nine in total. From this it will be seen that the colour bars produced

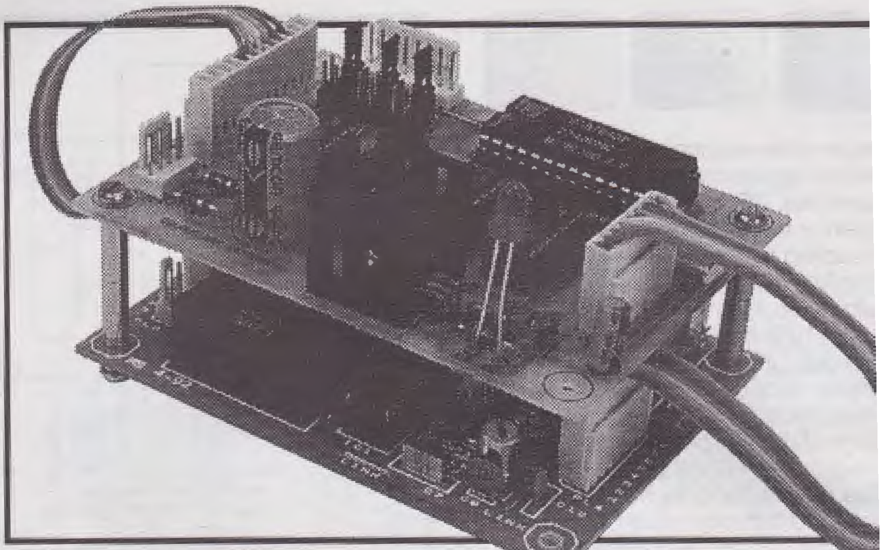


Photo 4. The two PCBs mounted piggyback

will have nine bars, not eight, the final right hand bar being a narrow white bar. This will actually give a form of VTR Bars; for most, if not all, applications this will be an advantage not a disadvantage. The CB output signal from IC1 is fed to the Colour Encoder Module's blanking input through PL3-3.

The Colour Encoder Module requires RGB (Red, Green and Blue) component video signals. The combinations and relative timing of RGB signals to produce familiar staircase luminance waveform are shown in Figure 5. The encoder sum the RGB signals at the correct levels to generate the luminance signal, superimposes the chrominance information and colour burst, and adds the synchronising signals resulti in the waveforms shown in Figure 1.

To provide the RGB signals, the FH10 signal from IC2C needs to be divided by two, four and eight to gi $\overline{B}$, $\overline{R}$ and $\overline{G}$ signals respectively. This is achieved by IC3B. IC4A to IC4C inve the $\overline{RGB}$ signals to provide RGB signa for the inputs of the Colour Encoder Module. These three gates, by mea of the CB signal fed to the second input of each gate, remove any signals outside the active picture are

IC5 detects when all the three ba outputs are high, which is only durin the white bar period, and generates a peak white bar signal, sometimes called the E bar. This is added to the three colour outputs in the Colour Encoder Module to give a true EBU level output. Figure 5 indicates how the E bar is used to achieve this.

The inputs to the Colour Encoder Module are in the form of a two bit per colour TTL compatible port. The RGB signals are input into the MSB inputs (R1, G1 and B1). What is input into the LSB inputs (R0, G0 and B0) determines the final form of the Colour Bar output. Connecting all three LSB bits to ground will give 75% bars with a 75% white reference. Connecting all three LSB bits to the output from IC5 (E signal) will increas the level during the white bar giving 75% colour and 100% white referenc that is to say EBU bars. Connecting each LSB to its associated MSB will produce 100% bars with 100% white reference. The RGB signals are to the Colour Encoder Module through PL2 ti PL2-8.

Selection of the required colour bar standard is achieved by a jump block, JB1a to JB1c, on the PCB or a three pole switch connected to PL4.

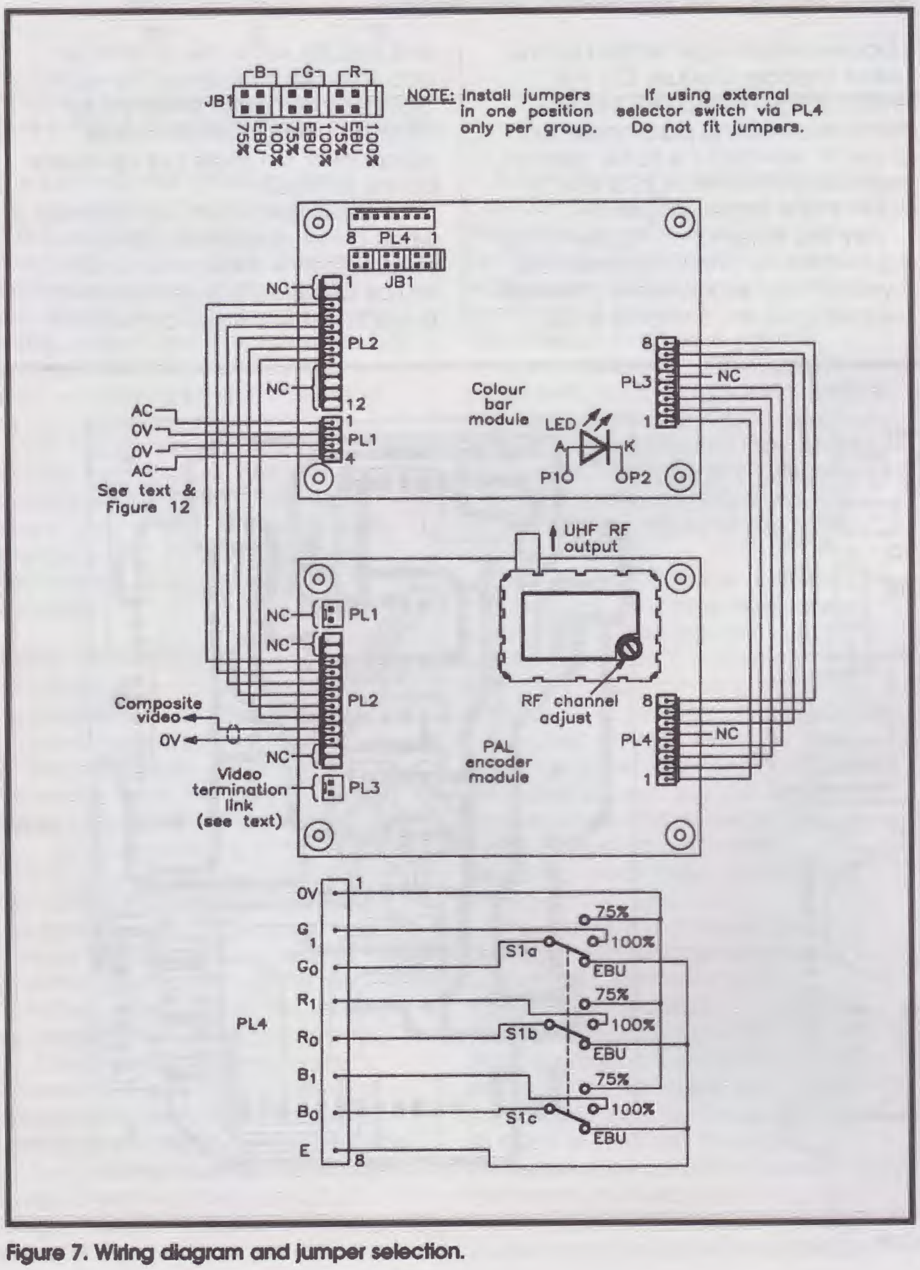


Figure 7. Wiring diagram and jumper selection.

The CS (composite sync) output signal from IC1 is inverted by IC4D to give $\overline{CS}$ (negative going composite sync) which is fed to the Colour Encoder Module's sync input through PL3-4.

Construction

Assembly of the the PCB should prove straightforward providing a logical assembly sequence is followed. Double check component type, value and polarity before soldering as subsequent component removal may damage PCB tracks unless great care is taken. It is recommended that the smallest components are fitted first (wire links, diodes, resistors, etc.), working up to the largest components (large electrolytic capacitors, modulator, regulator and heatsink, etc.). It is a good idea to leave fitting the ICs into their sockets until last; precautions should be taken to prevent electrostatic discharge as this may permanently damage the ICs or cause premature failure in service. For further information on general construction techniques and component identification, please refer to the Constructors' Guide (XH79L) which is included in the kits. Figure 6 shows the PCB legend and track for the Colour Bar Module. After the PCB has been assembled, remove excess flux from the board using an environmentally friendly PCB cleaner and double check for misplaced components, solder splashes, etc. Photos 2 and 3 show the assembled PCBs.

The PCBs are interconnected by means of ribbon cable and Minicon connectors. Connections should be made as indicated in the wiring diagram shown in Figure 10. Selection of the colour bar standard is by means of PCB jumpers or an off-board switch. Jumper positions and wiring for the switch are also shown in Figure 7. Do not fit more than one jumper per group. If the off-board switch is to be used, do not fit any jumpers. The switch chosen should have break before make contacts.

Figure 8 shows three possible power supply options; these are:

A mains transformer with a centre-tapped 12-0-12V to 15-0-15V secondary winding and able to supply at least 150mA.

A mains transformer with twin 12V to 15V secondary windings and able to supply at least 150mA.

A power supply with an output voltage between +12V and +25V DC and able to supply at least 150mA.

Since the PCBs have the same dimensions and fixing centres, they may be piggy back mounted as shown in Figure 9 and Photo 5.

Testing and Alignment

For the purposes of testing and alignment a power supply able to supply between +15V and +25V DC is required.

Connect the supply to the Colour Bar Generator as shown in Figure 8 with a multimeter set to read DC mA on a 250mA or higher range in series with the positive supply. Measure the current, which should be approximately 100mA.

Remove the multimeter from the supply, set it to read DC V on a 15V or higher range and reconnect the supply. On the Colour Bar Module measure the voltage on PL3-1 with respect to PL3-8, which should be approximately +12V. Measure the voltage on PL3-2 with respect to PL3-8, which should be approximately +5V.

If readings are markedly different from those listed, disconnect the supply and recheck for errors in construction.

Connect the composite video output to a colour monitor or the UHF RF output to a colour TV (TV will require tuning). Once a picture is displayed, adjust VC1 on the Colour Encoder PCB for correct locked colour. Using an oscilloscope monitor the composite video output and adjust L2 for minimum rounding or overshoot on the chrominance envelope of the video waveform. If an oscilloscope is not available, adjust L2 for best picture, i.e. minimum colour bleed between adjacent bars and minimum colour variation between adjacent TV lines (venetian blind effect). Photos 5 and 6 show a correctly adjusted colour bar display on a TV screen and the corresponding video waveform on an oscilloscope. Photo 7a show the 100% colour bar waveform, Photo 7b shows the EBU colour bar waveform and Photo 7c shows the 75% colour bar waveform.

The output frequency of the RF modulator is factory set to channel 36. If it is necessary to adjust the frequency, this can be achieved by retuning the ferrite core visible from the top of MD1's case. Since the ferrite core is extremely fragile a suitable non-magnetic adjustment tool must be used – Do not use a screwdriver. Adjustment of the modulator frequency may be necessary, e.g. when adding the RF signal into a TV distribution amplifier in a TV repair workshop to avoid clashing with other equipment on channel 36, e.g., satellite receiver, VCR, etc.

Professional Users Please Note

Although the Colour Bar Generator appears to generate Bars to full EBU specification this is in fact not the case. The line and frame frequency rate, while adequate for viewing on a monitor, will not be sufficiently accurate to record on a professional

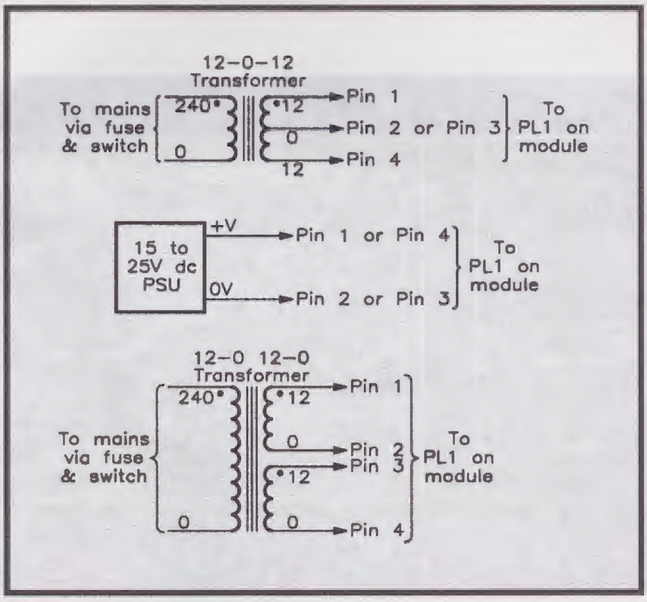


Figure 8. Power supply options.

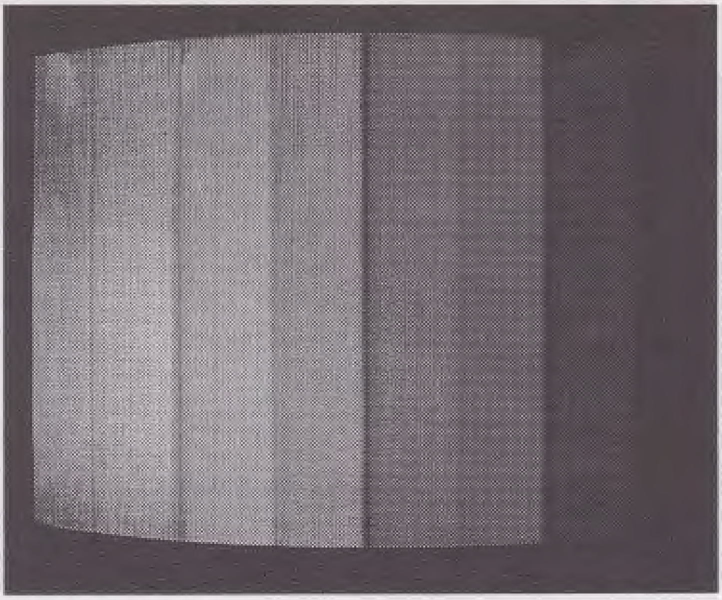


Photo 5. Colour Bars displayed on a TV screen.

VTR (although a VHS recorder should be fine). For the same reason the Colour Bar Generator should not be used as a Genlock source in multi-camera studios. The EBU specification includes a requirement for the subcarrier to be locked to the horizontal timing pulses. Of course this is also not the case in the Colour Bar Generator as separate crystals are used to obtain the luminance and chrominance parts of the output.

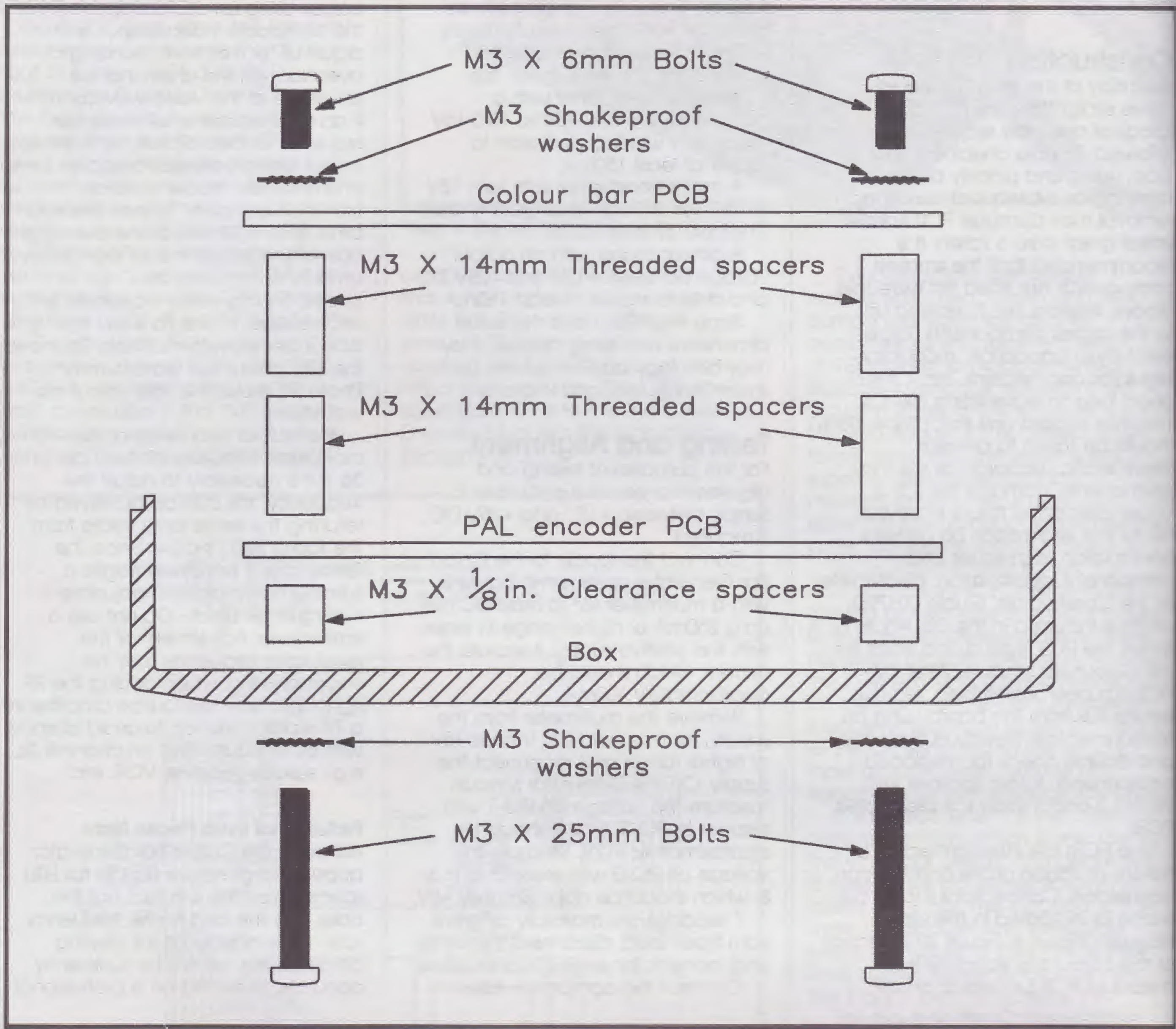


Figure 9. Piggyback mounting arrangement.

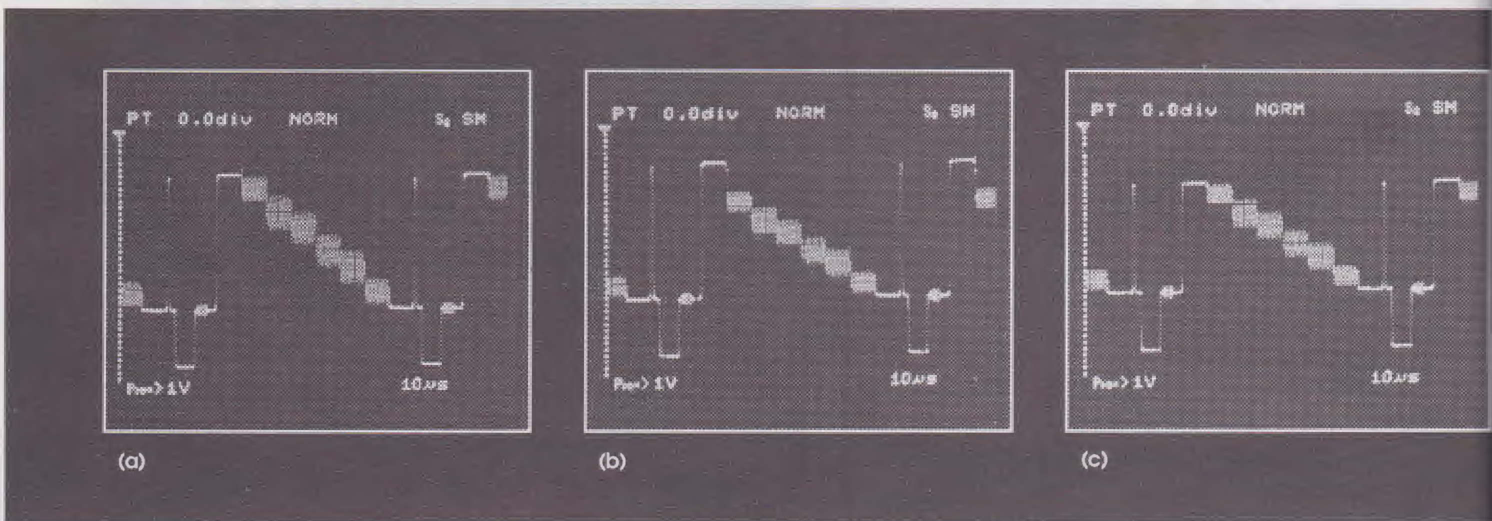
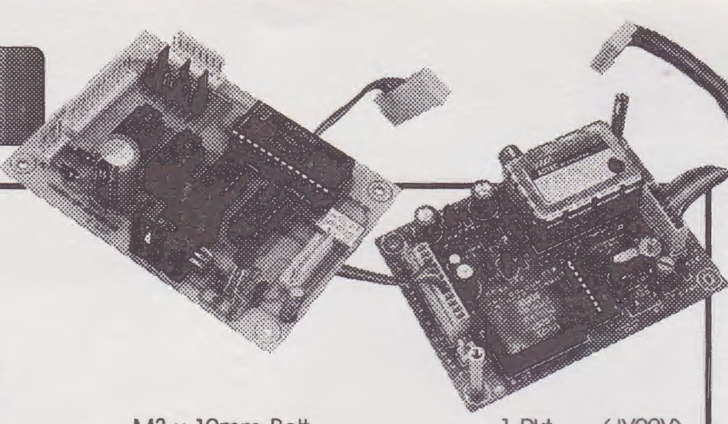


Photo 6. Colour Bar waveforms on an oscilloscope: (a) 100%, (b) EBU, (c) 75%.



PARTS LISTS
COLOUR BAR MODULE

RESISTORS:	All 0·6W 1% Metal Film		
R1	560Ω	1	(M560R)
R2	3k9	1	(M3K9)
R3	3M3	1	(M3M3)
R4	1kΩ	1	(M1K)
CAPACITORS			
C1	1,000µF 35V PC Elect	1	(FF18U)
C2,3,4,7,9	100nF Monolithic Ceramic	5	(RA49D)
C5,6	33pF Ceramic	2	(WX50E)
C8	10µF 50V PC Elect	1	(FF04E)
SEMICONDUCTORS			
D1,2	1N4001	2	(QL73Q)
RG1	L7812CV	1	(QL32K)
LD1	5mm Red LED	1	(WL27E)
IC1	SAA1043	1	(UK85G)
IC2	4011BE	1	(QX05F)
IC3	4518BE	1	(QX32K)
IC4	4001BE	1	(QX01B)
IC5	4023BE	1	(QX12N)
MISCELLANEOUS			
XT1	5MHz Crystal	1	(UL51F)
	28 pin DIL IC socket	1	(BL21X)
	16 pin DIL IC socket	1	(BL19V)
	14 pin DIL IC socket	3	(BL18U)
PL1	4-way Minicon Plug	1	(YW11M)
PL2	12-way Minicon Plug	1	(YW14Q)
PL3,4	8-way Minicon Plug	2	(YW13P)
	4-way Minicon Socket	1	(HB58N)
	12-way Minicon Socket	1	(YW24B)
	8-way Minicon Socket	2	(YW23A)
	Minicon Terminal Strip	3	(YW25C)
JB1	2x36 Pin Strip	1	(JW62S)
	Mini Pin Jumper	3	(UL70M)
	1mm Vero Pin	1 Pkt	(FL24B)
	Slotted Heatsink	1	(FL58N)
	M3 x 10mm Bolt	1 Pkt	(JY22Y)
	M3 Shakeproof Washer	1 Pkt	(BF44X)
	M3 Nut	1 Pkt	(JD61R)
	PCB	1	(GH67X)
	Instruction Leaflet	1	(XU60Q)
	Constructors' Guide	1	(XH79L)
OPTIONAL (Not in Kit)			
	3-pole 4-way Rotary Switch	1	(FF75S)
	10-way Ribbon Cable	1m	(XR06G)
	Miniature Coax	As Req.	(XR88V)
	Red 1·4A Wire	As Req.	(BL07H)
	Black 1·4A Wire	As Req.	(BL00A)
	Phono to Coax Cable	1	(FV90X)
	M3 x 25mm Bolt	1 Pkt	(JY26D)
	M3 x 6mm Bolt	1 Pkt	(JY21X)
	M3 Nut	1 Pkt	(JD61R)
	M3 Shakeproof Washer	1 Pkt	(BF44X)
	M3 x 14mm Threaded Spacer	1 Pkt	(FG38R)
	M3 x 1/8in. Clearance Spacer	1 Pkt	(FG32K)

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 as a kit, which offers a saving over buying the parts separately.
Order As LT50E (Colour Bar Kit).
Both kits are available at further discount if purchased together.
Order As BE75S (Colour Bar & Colour Encoder Kits).
Please note: Where 'package' quantities are stated in the Parts List (e.g., packet, strip reel, etc.), the exact quantity required to build the project will be supplied in the kit.

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