PROJECTS BOOK 46

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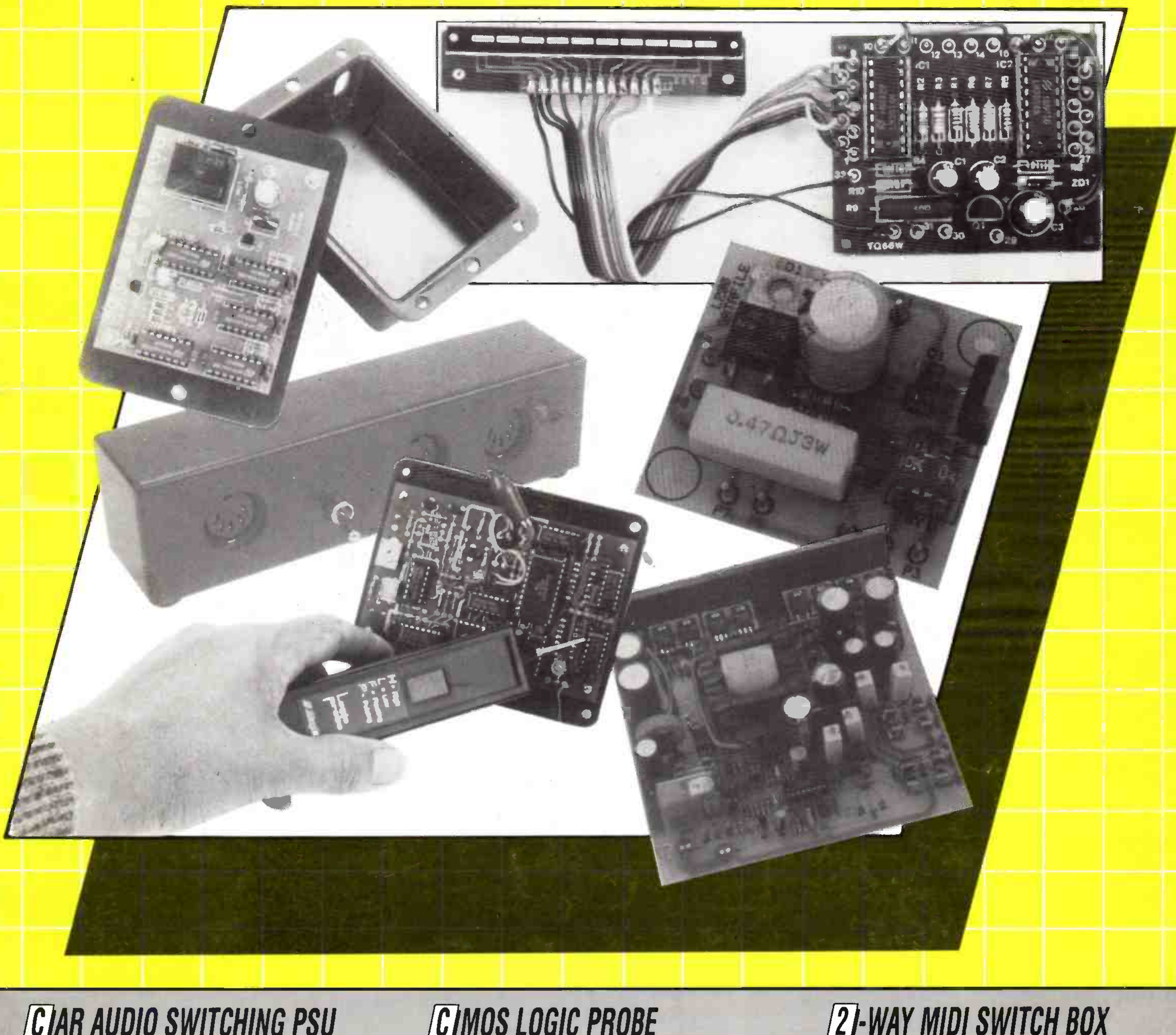

CAR AUDIO SWITCHING PSU
BARGRAPH DISPLAY DRIVERS
CMOS LOGIC PROBE
VEHICLE INTRUDER ALARM
2-WAY MIDI SWITCH BOX
L200 ADJUSTABLE REGULATOR

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MAPLIN PROJECTS BOOK FORTY SIX

EDITORIAL

This Project Book replaces Issue 46 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.

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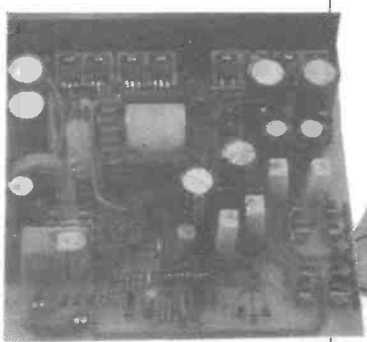

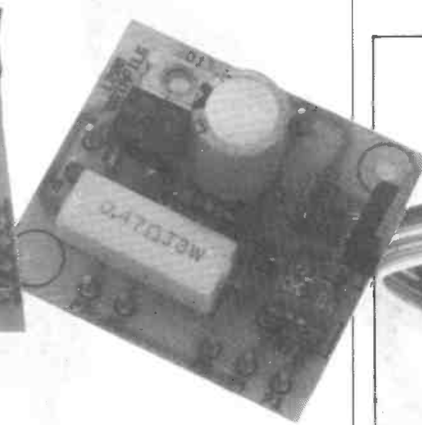

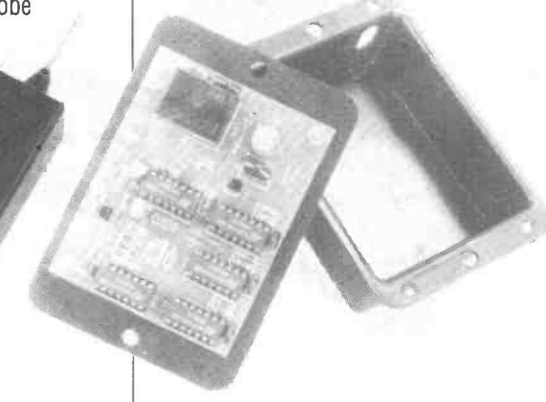

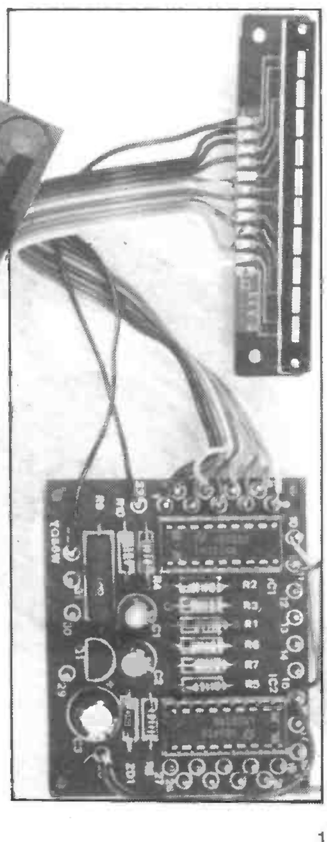

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MIDI Switch Box

by Joe Fuller

Introduction

For the uninitiated, MIDI, or to give it its full title, Musical Instrument Digital Interface, is a means of allowing electronic musical instruments, and other related hardware, to communicate by means of a common standard of information interchange. Most modern music equipment is equipped with MIDI, ranging from a £99.95 Casio synthesizer to a £1999.95 Akai Sampler, a Roland drum machine to an Alesis signal processor, and a proprietary stage lighting controller to an Atari computer. MIDI is available for most musicians to use in various guises. For a full explanation of what MIDI is, and how it works, refer to 'Electronics' March to May 1987 issue 22.

The Two-Way MIDI Switch Box is an extremely handy project for anyone who uses MIDI. The switch box is simple to build and easy to use, best of all it costs less than a tenner! Commercially these units are at least twice that price. So what does it do? It allows either: a MIDI signal to be interrupted or connected to equipment; or a MIDI signal to be routed down one of two paths to other equipment; or even to select between two sources of MIDI signal.

Circuit

Figure 1 shows the circuit diagram of the two-way MIDI switch box, if that is, it really warrants being called a circuit! With only three 5-pin DIN sockets, a double pole change-over switch and no actual electronics at all, it is simplicity itself. I won't patronise you with a circuit description as anyone with a grain of common sense should be able to see just what is going on. The advantage of the totally passive nature of the switch box is that apart from needing no power source, the unit will work 'either way round', i.e. one input and two outputs, or two inputs and one output.

Construction, Testing and Assembly

Referring to Figure 2, assemble the components onto the PCB, it is however recommended that the wire link is fitted first, otherwise it will be found to be a bit tricky to fit it in between the other components. A multimeter set to a resistance or continuity range may be used to verify switching operation. Photo 1 shows the assembled PCB.

The hardest bit comes next – drilling

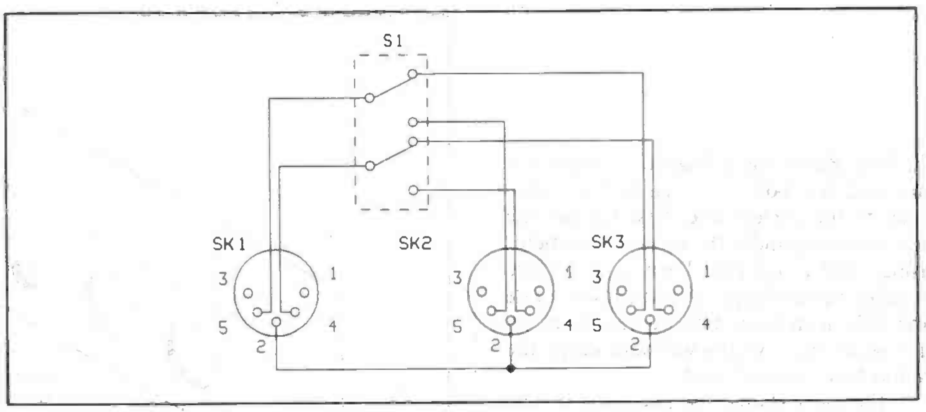


Figure 1. Circuit diagram.

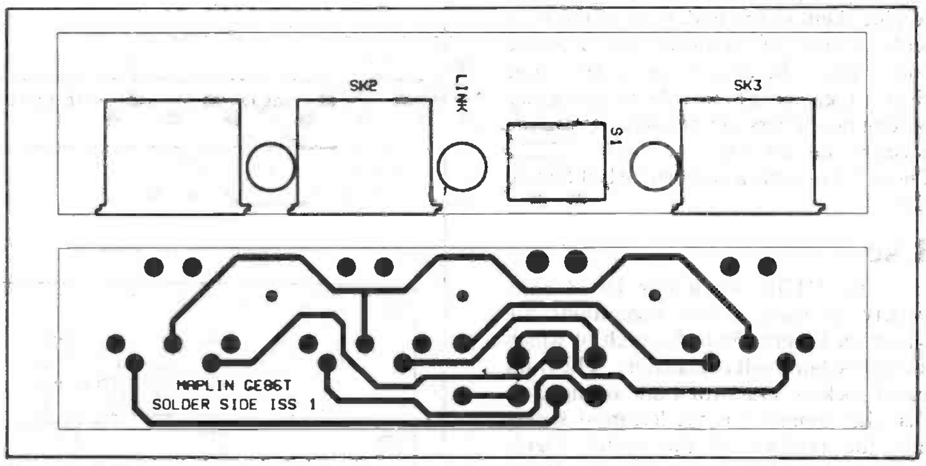


Figure 2. PCB legend and track.

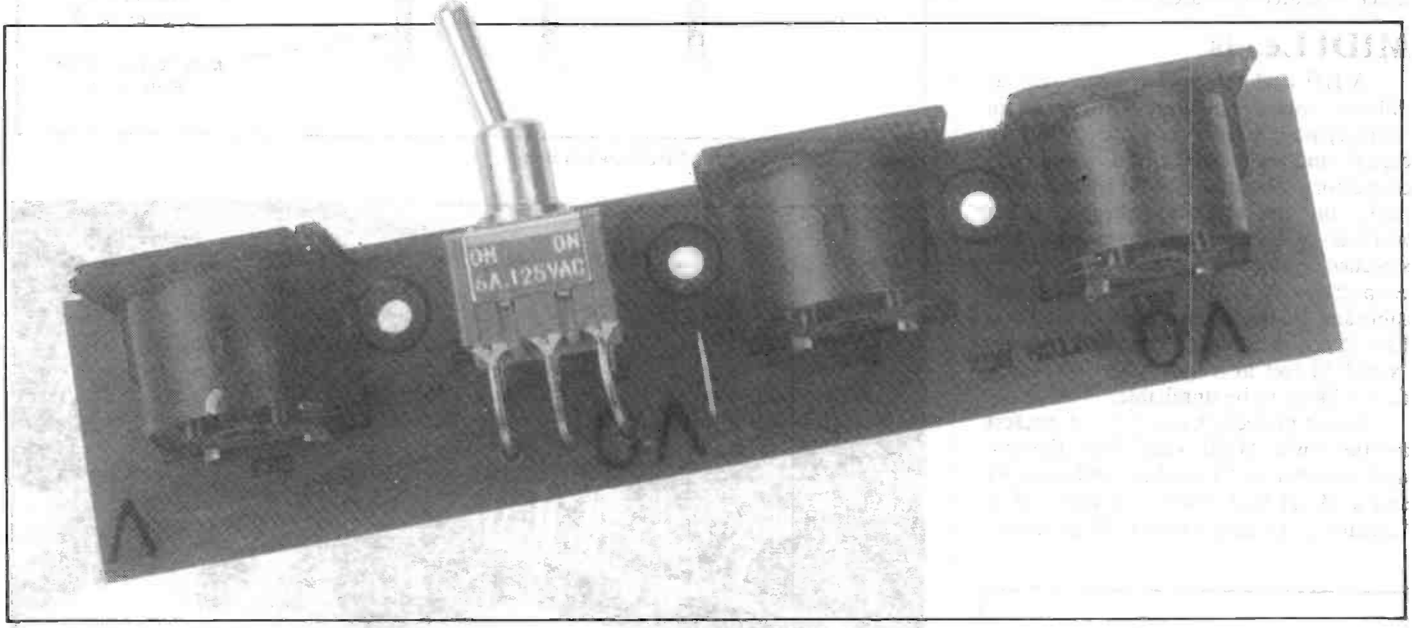


Photo 1. The assembled PCB.

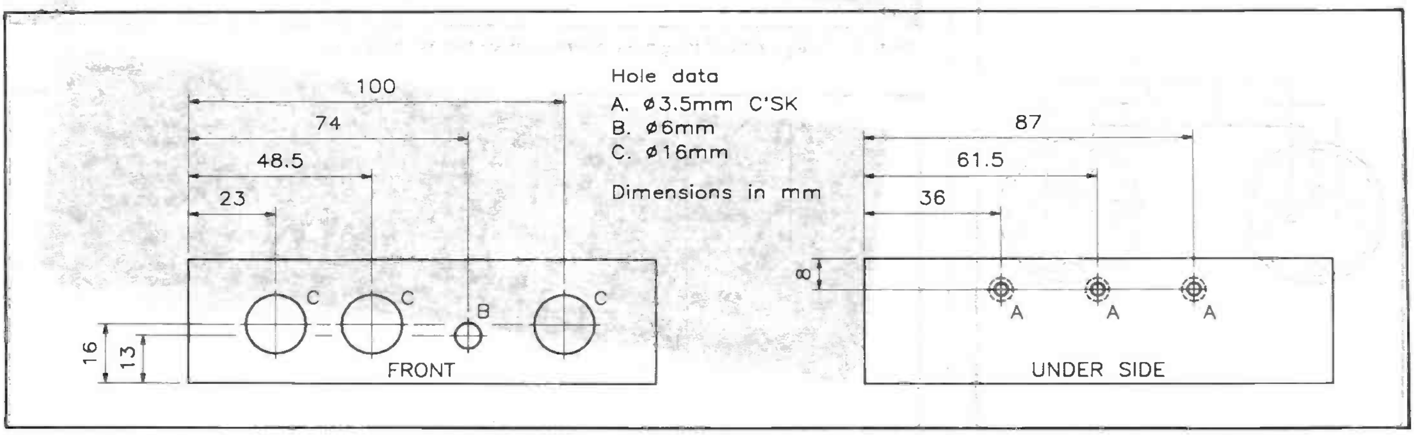


Figure 3a. Box drilling details.

the box! Referring to Figure 3a, mark out and drill the box. To enlarge the socket holes to the correct size, first file out the hole to a little under the required diameter using a half round file. Then insert a piece of rolled up sandpaper into the hole, rotate and slide in and out. This method is shown in Figure 3b; it works well and keeps the round holes 'round' too!

Figure 4 shows the assembly of the switch box, which can be a little fiddly. An easy way of positioning the M3 spacers is to glue them to the underside of the PCB with a spot of cyanoacrylate adhesive (super glue), be careful not to glue your fingers together! Photo 2 shows how a pair of long nose pliers can be used to place the washers and nuts onto the bolts.
Photo 3 shows the assembled MIDI Switch Box.

Use

The MIDI switch box has a wide variety of uses, a few suggestions are shown in Figures 5a to 5e, each of which should be fairly self explanatory. The front panel sockets and switch are arranged so that the 'common' is the left-most socket and the position of the switch toggle indicates from/to which socket the MIDI signal is routed to/routed from.

MIDI Leads

MIDI leads are sold commercially at inflated prices compared to their audio counterparts, simply because 'MIDI is digital and requires special cable and connectors' – not true! MIDI leads may be made up quickly and cheaply using 'normal' good quality connectors and screened cable. Figure 6 shows the connections of a MIDI cable. Suggested cable and connectors are given in the Parts List. Note that MIDI cables should not exceed 50 feet in length otherwise operation is likely to be unreliable.

Other projects that may be of interest are the 8-way MIDI Thru' Box 'Electronics' October to November 1989 issue 34 and a MIDI lead tester, see Bob's Mini Circuits in the next issue of 'Electronics'.

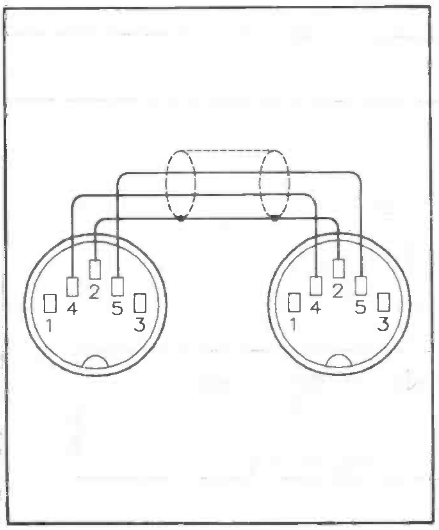


Figure 6. MIDI lead connections.

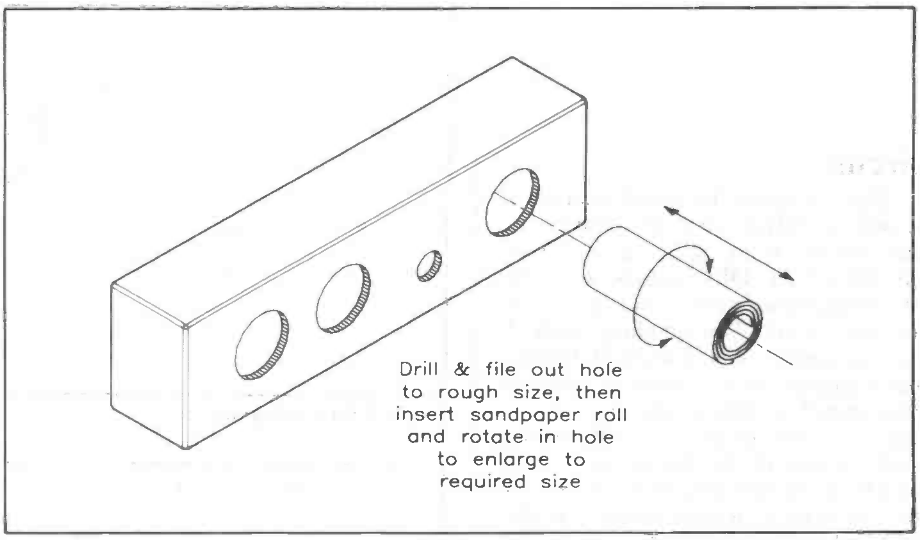


Figure 3b. Enlarging the socket holes with a piece of rolled up sandpaper.

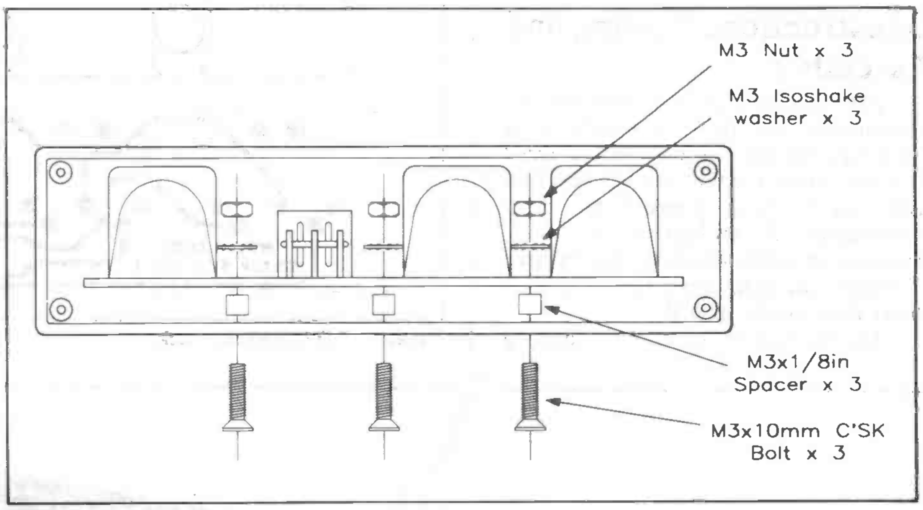


Figure 4. Assembly of the MIDI Switch Box.

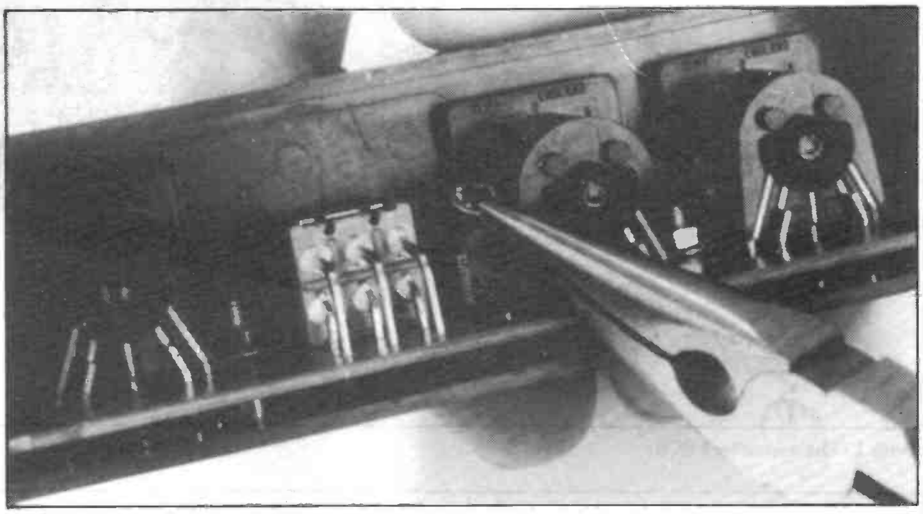


Photo 2. Using a pair of long nose pliers to place the M3 hardware.

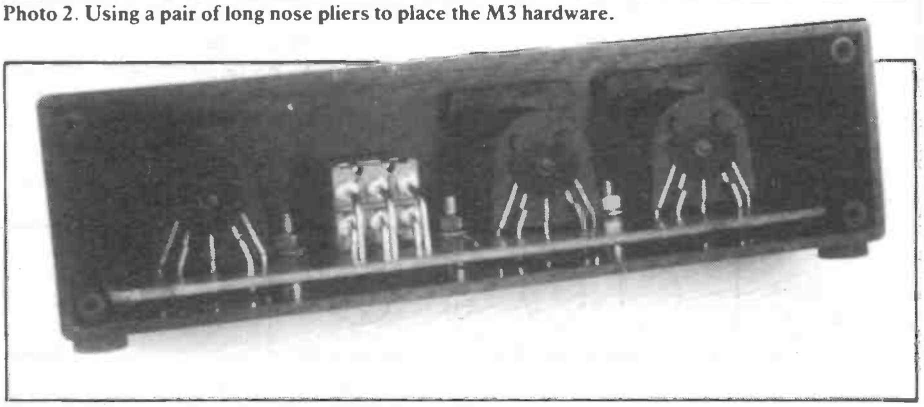


Photo 3. The assembled Two-Way MIDI Switch Box.

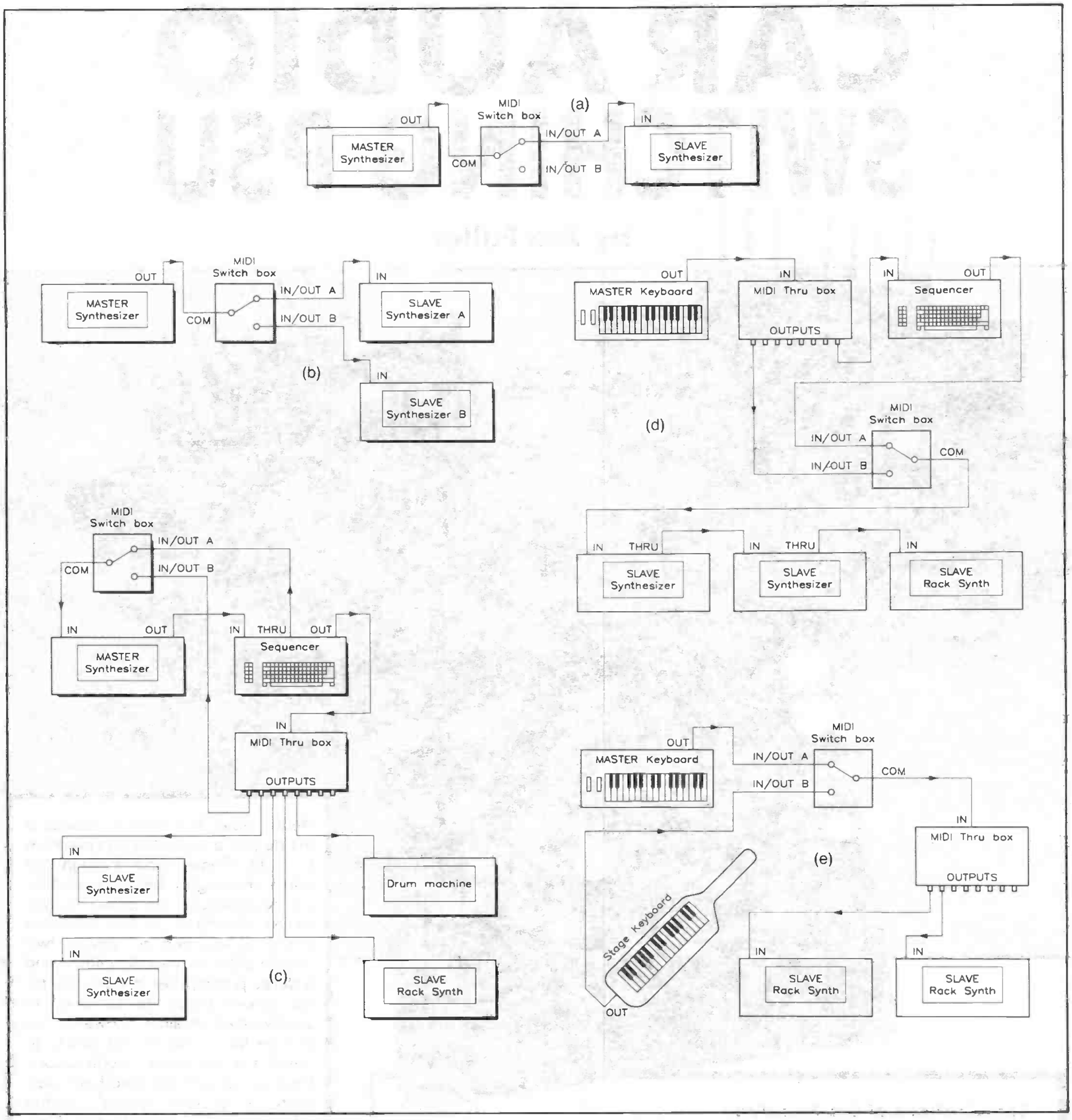


Figure 5a. Simple MIDI on/off use. 5b. Switching between two slave synthesizers. 5c. MIDI IN source selection on a sequencer based system. 5d. Switching between master keyboard or sequencer to drive slave synthesizers. 5e. Switching between master keyboard or stage keyboard to drive slave synthesizers.

TWO-WAY MIDI SWITCH BOX PARTS LIST

MISCELLANEOUS		
R/A Toggle DPDT Lft/Rt	1	(FA73Q)
PC DIN Socket 5-Pin A	3	(YX91Y)
Small Narrow Box	1	(FT31J)
Pozi Screw M3 × 10mm	1 Pkt	(LR57M)
Isoshake M3	1 Pkt	(BF44X)
M3 Spacer ⅛in	1 Pkt	(FG32K)
Small Stick on Feet	1 Pkt	(FE32K)
MIDI Switch Box PCB	1	(GE86T)
Leaflet	1	(XT07H)
Constructors' Guide	1	(XH79L)
OPTIONAL (Not in Kit)		
Din Plug 5-Pin A	As Req	(HH27E)
Fleximic Black	As Req	(XR98G)

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

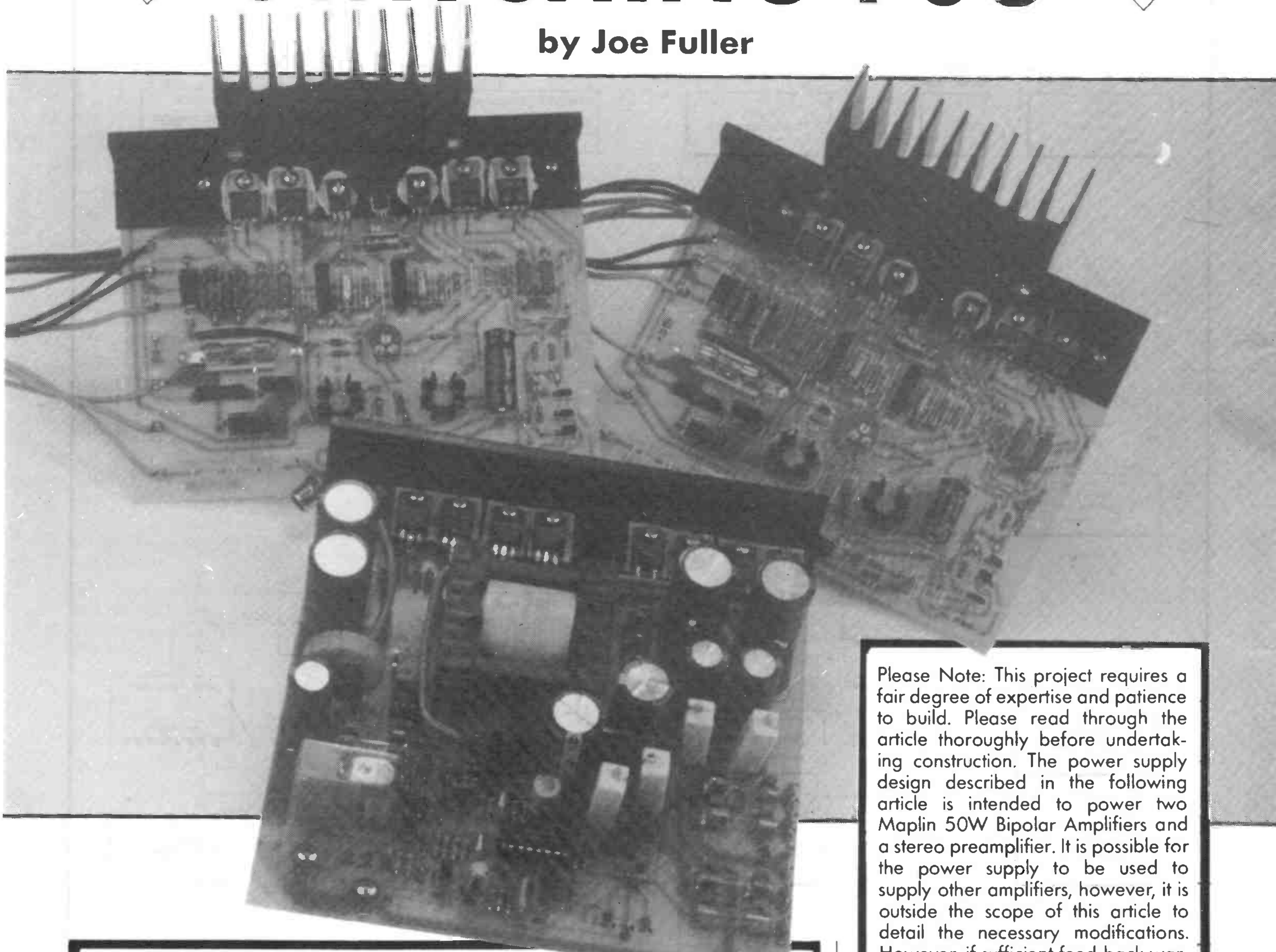
The above items are available as a kit (excluding Optional).
Order As LP75S (Midi Switch Box)

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.

The following new items (which are included in the kit) are also available separately.
Small Narrow Box **Order As FT31J**
Midi Switch Box PCB **Order As GE86T**

CAR AUDIO SWITCHING PSU

by Joe Fuller



Please Note: This project requires a fair degree of expertise and patience to build. Please read through the article thoroughly before undertaking construction. The power supply design described in the following article is intended to power two Maplin 50W Bipolar Amplifiers and a stereo preamplifier. It is possible for the power supply to be used to supply other amplifiers, however, it is outside the scope of this article to detail the necessary modifications. However, if sufficient feed-back warrants a 'project update', further information may be published. Similarly, a stereo preamplifier design is not presented, although information may be published in response to feed-back. It is important to realise that the power supply is specifically tailored for audio applications and is, for a variety of reasons, not intended as a general purpose power supply.

Specifications of the Prototype

Input:	11 to 15V DC, nominally 13·8V
Input current (P_O = 116W):	10·7A (V_S = 11·3V)
Output Power:	120W continuous, see note below
Outputs	
Main:	±30V
Auxiliary:	±12V
Continuous Output Current	
±30V	2 + 2A
±12V	50mA + 50mA
Efficiency:	>90%
Thermal shut-down temperature:	80°C
Thermal shut-down hysteresis:	20°C
Standby input:	Active low
Remote switch-on input:	Active high
Thermal shut-down output:	Active low
Input noise (Po = 120W):	140mV
Output noise (Po = 120W)	
Main:	60mV
Auxiliary:	40mV
Switching Frequency:	25kHz
Converter mode:	Push-Pull

Note:

The supply is capable of delivering instantaneous power levels much higher than the continuous rating, which is ideal for audio applications where the peak current requirement, due to transients, is much higher than the average current requirement. Higher levels of power may be drawn as long as the average power is maintained at 120W. The figure of 120W is based on maintaining a heatsink temperature at less than 65°C.

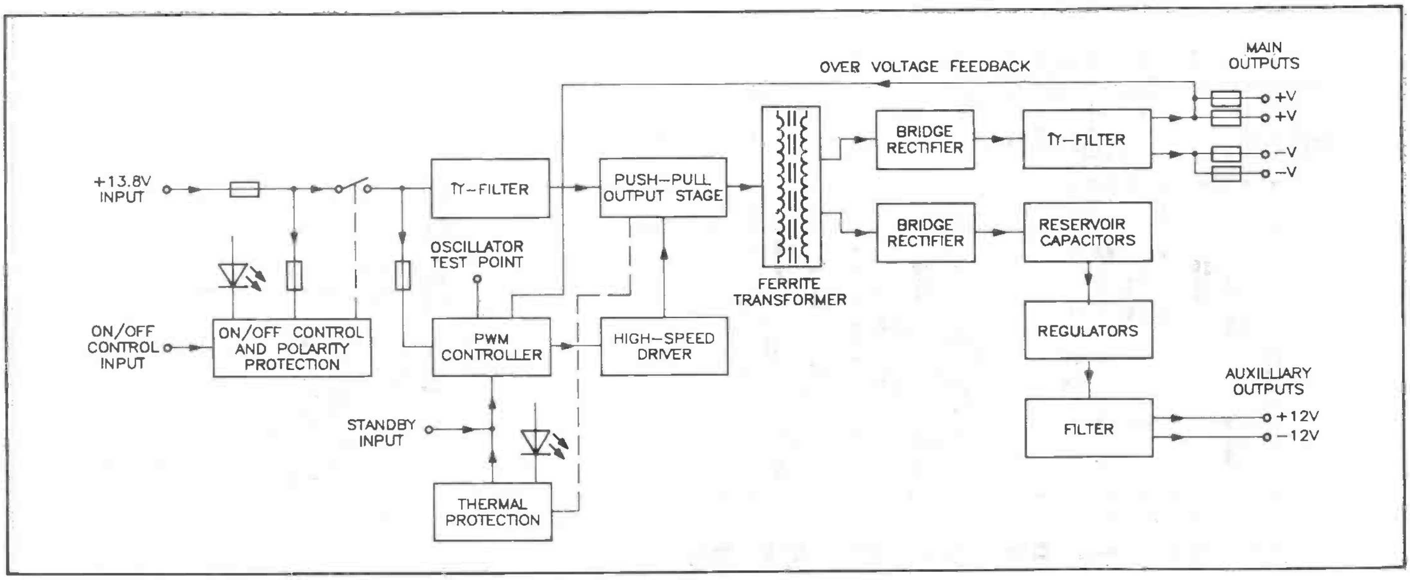


Figure 1. Block diagram of the switching PSU.

F E A T U R E S

★ Designed for high quality in-car entertainment systems ★ Polarity protected ★ Remote switch-on ★ Thermal protection ★ Input and output π-filters ★ Regulated ±12V auxiliary output for preamplifiers ★ ±30V main outputs specifically intended for a pair of Maplin 50W bipolar amplifiers

Introduction

For many years the motorist has not been able to benefit from Hi-Fi quality sound whilst travelling in the car. For the long-distance traveller, business executive or Hi-Fi buff on-the-move, the car is a far from ideal environment for listening to music; this is due to a number of reasons. Firstly, the car's interior is designed for conveying passengers and not for ideal location of conventional 'box design' loudspeakers. Secondly, the sound replay/receiving equipment has to be miniaturised and capable of operation in a very harsh environment. Dashboard temperatures often exceed 60°C in hot weather (yes, even in the English climate!) and fall to several degrees below zero in cold weather. Vibration and humidity also add to the stresses that the equipment must endure. Thirdly, the low, noisey and somewhat variable supply voltage makes life even more difficult for the electronic circuitry.

The environmental and size problems of the car environment have largely been solved by cleverly designed equipment. Car loudspeakers are optimised for operation in rear parcel shelves and door panels instead of conventional sealed or ported enclosures. Car Radio, cassette, CD (Compact disk) and DAT (digital audio tape) equipment is very compact. Such equipment is designed for either mounting in the dash-board/centre console or remote mounting in the boot or under a seat, with just the controls located within the driver's easy reach.

It is however, the third point that is the main reason for this project, the vehicle electrical supply. The 12V electrical system is far from ideal when it comes to powering audio amplifiers. The electrical system itself, although generally referred to as being 12V, usually operates at around 13 – 14V when the engine is running. By convention, the voltage when the engine is running is assumed to be 13·8V.

A singled ended amplifier operating from a supply voltage of this (low) level is capable of delivering around 7W RMS into a 4Ω load. If a BTL (bridge tied load) amplifier is used the power output can be increased to around 22W RMS into a 4Ω load. Most 'high power' radio/cassette players have an output power of around 22W RMS, regardless of how many watts the advertising brochures boast!

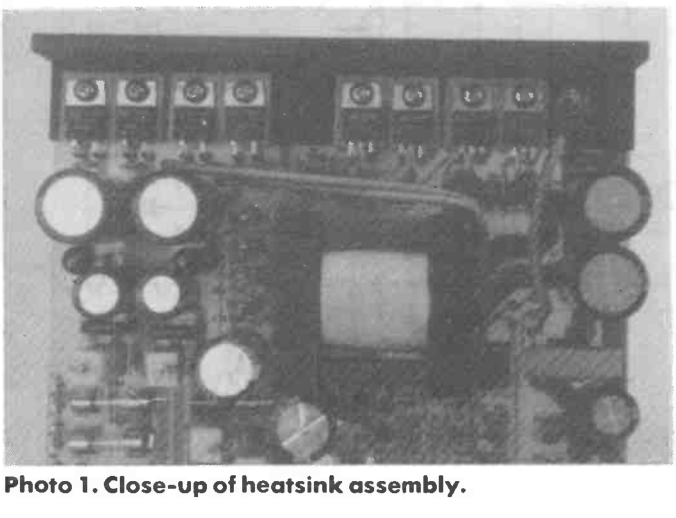


Photo 1. Close-up of heatsink assembly.

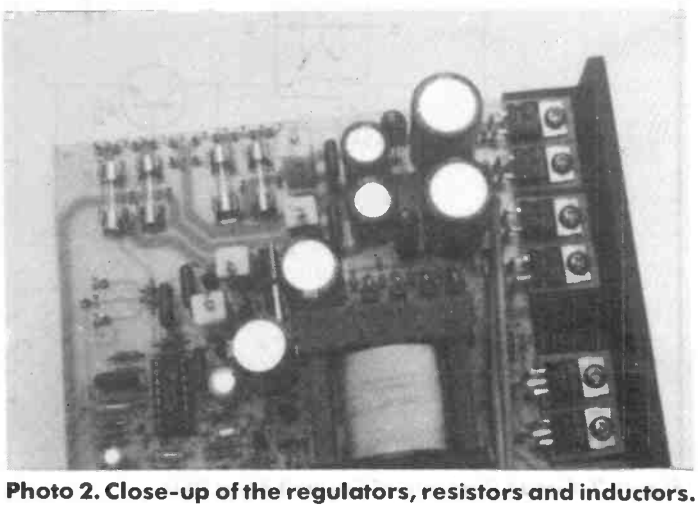


Photo 2. Close-up of the regulators, resistors and inductors.

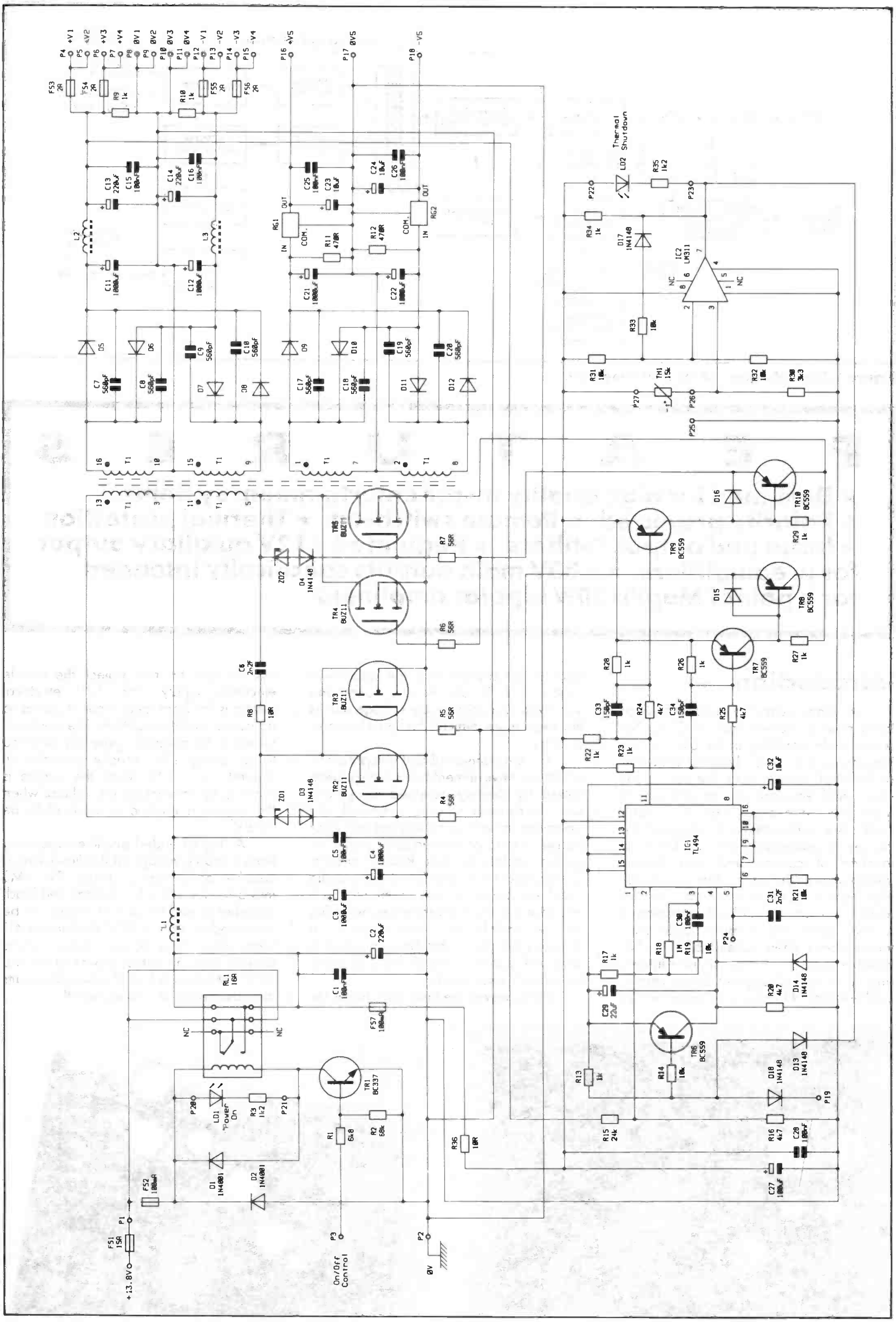


Figure 2. Circuit diagram of the switching PSU.

For Hi-Fi quality sound reproduction in a car it is necessary to have the capability of higher power levels. This not being required for 'blowing out the windows' (although often used as such by drivers of aging Ford Cortina's with pink fluffy dice), but simply because a high power amplifier operating at modest power levels will introduce far less distortion and handle transients far better than a medium power amplifier running almost flat out. This is especially true if the sound source is CD, where the dynamic range of the recording is often very wide.

There are two ways in which the output power can be increased, by either decreasing the loudspeaker impedance or increasing the supply voltage. The main disadvantage of the former method is that car speakers are not commonly produced with impedances below 4Ω and that power losses in cables are increased. The latter method of increasing the supply voltage is commonly used in high power car 'boosters' and in Hi-Fi car audio amplifiers, this is the method that is described here.

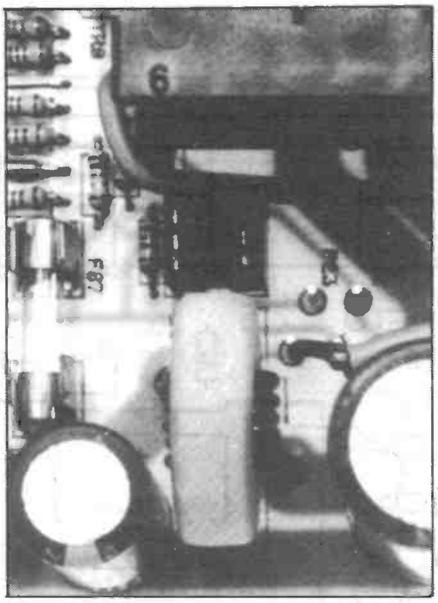


Photo 3. Close-up of the toroid inductor fitted into the PCB.

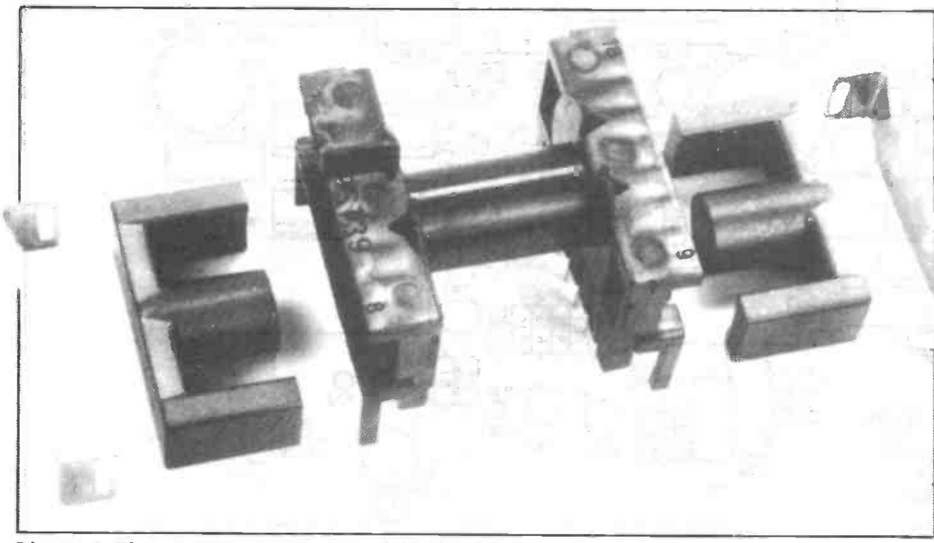


Photo 4. The component parts of the ferrite transformer.

Circuit Description

Figure 1 shows a block diagram representation of the power supply and Figure 2 shows the full circuit diagram.

In the following description it is not intended to explain the principles of switched mode power conversion since these have been adequately covered by a series on this topic, see issues 37 to 39 of 'Electronics'.

The supply input to the power supply is via P1 (+V) and P2 (0V). The power supply is connected directly to the vehicle battery via high current cables, therefore the off-board supply fuse FS1 is essential in case of a fault causing a short circuit directly across the battery. Remote power switching is achieved by TR1, RL1 and associated components. The control input P3, when taken to +V, biases TR1 on and operates RL1, thus powering-up the rest of the supply. LD1 serves to indicate 'power on'. The control signal is provided by the 'electric aerial' output found on most radio-cassette units. D1 clamps the voltage spike produced by RL1 when it de-energises. D2 provides polarity protection by blowing FS2 and preventing the remote power switch from operating.

C1, C2, C3, C4, C5 and L1 form the input π-filter, the output of which supplies the push-pull output stage. The Power MOSFETs are arranged in two pairs TR2 & TR3 and TR4 & TR5, each driving one half of the transformer primary. R8 and C6 form a snubber network to increase the rise-time of switching spikes. ZD1, D3 & TR2 and ZD2, D4 & TR5 form an active spike clamp, employed to protect the MOSFETs drain/source junctions from high voltage switching spikes. This operates by feeding the spike back into the gate of the relevant MOSFET thus turning it on and clamping the spike. Gate resistors R4 to R7 help to balance current flow through each MOSFET pair and also help to reduce switching noise.

T1 is a step up transformer comprising six windings, two connected to form a centre tapped primary winding and four are connected in two pairs to form two centre tapped secondary windings.

R36, C27 and C28 form a simple R-C filter for IC1 which attenuates supply borne noise. C29 and R20 set the soft-start time period for IC1. At switch on C29 is discharged and IC1s outputs are inhibited. As C29 charges via R20, the pulse width of the PWM drive signals are allowed to increase from zero. D14 prevents IC1s soft-start input from being pulled negative at switch-off and also serves to discharge C29 more quickly. TR6 discharges C29 and inhibits IC1s outputs in response to a thermal shutdown condition or a standby input (low) from P19. D18 and D13 form a discrete AND circuit. When the shutdown condition and standby inputs are removed, TR6 allows C29 to charge again and the power supply restarts.

R21 and C31 set the oscillator frequency, P24 may be used to monitor the oscillator waveform. Care should be exercised to ensure that this pin is not subject to undue capacitive loading, otherwise the oscillator frequency will shift.

R17, R18, R19 and C30 form a phase selective network that sets the gain of the over-voltage amplifier. Phase compensation is necessary to ensure good loop stability, otherwise the power supply could break into oscillation. R15 and R16 form a potential divider which is used to apply over voltage feedback to IC1, with the values as shown, the maximum output voltage is ±30V.

TR7 to TR10 and associated components form two high speed driver circuits which are able to charge and discharge the gate capacitance of each of the MOSFETs very quickly. Circuit operation for one of the (two identical) drivers is as follows: R23 is the pull-up resistor for the open collector output of IC1 (pin 8). When pin 8 goes low (output on) TR7 is biased on by R25 (C34 serves to increase switching speed), D15 conducts and TR2, TR3 turn on quickly. At this time TR8 is switched off. When IC1 pin 8 goes high (off) TR7 switches off and TR8 base is pulled low; since the gates of TR2 and TR3 are charged to a positive potential, D15 is reverse biased and TR8 conducts. This action rapidly switches off TR2 and TR3.

IC2 is a comparator with its inputs connected to two potential dividers. R31 and R32 form a reference potential divider and thermistor TH1 and R30 form a temperature sensing network. R33 and D17 provide a large degree of hysteresis when the output changes state. Normally the output from IC2 (Pin 7) is high and the voltage on Pin 2 is around ½ supply. The voltage on Pin 3 is dependent on the resistance of TH1, governed by the heatsink temperature with which it is in contact. As the temperature of the heatsink rises, the resistance of TH1 reduces and the voltage on Pin 3 increase. When the voltage on Pin 3 exceeds the voltage on Pin 2, the output of IC2 goes low. LD2 illuminates indicating thermal shutdown and the power supply shuts down. At this point D17 conducts, this adds R33 to the lower half of the reference divider reducing the reference potential on Pin 2 to around ⅓

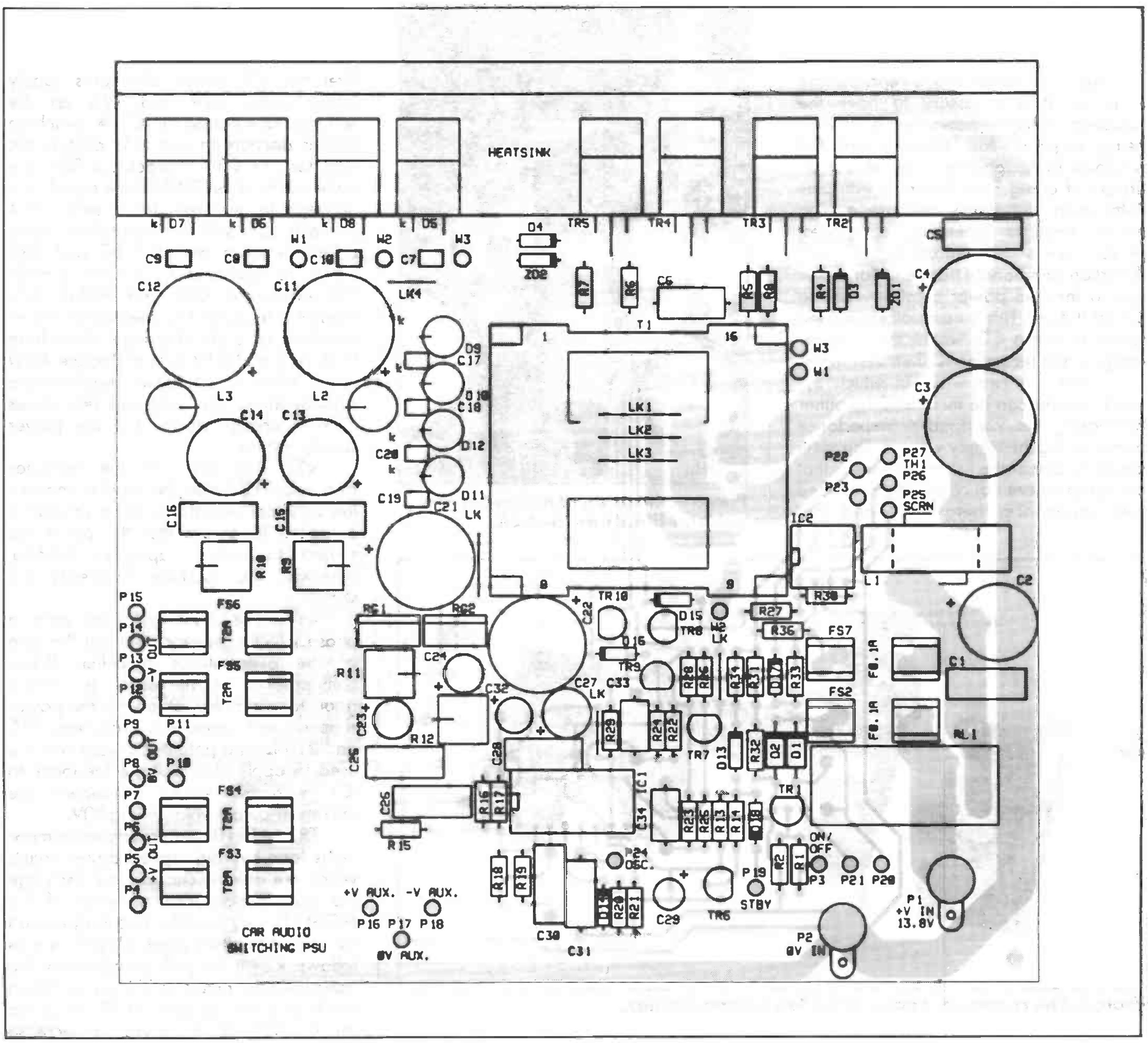


Figure 3 (a). PCB legend.

supply (ignoring D17 voltage drop and saturated output voltage of IC2). The voltage on Pin 3 will now have to fall below ⅓ supply before the circuit will reset and the supply allowed to restart. Correspondingly the resistance of TH1 will have to rise and its temperature fall before supply operation is resumed. With the circuit values as shown, the trip temperature is 80°C and the reset temperature is 60°C.

D5 to D8 form a bridge rectifier (main output), the devices used are high speed types, essential for use in switch mode applications. C7 to C10 help to reduce transients and switching noise. C11, C12, L2, L3, C13, C14, C15 and C16 form π-filter networks for the main outputs. R9 and R10 serve to provide a 'minimum load' for the power supply and also discharge the filter capacitors quickly after switch-off. FS3 to FS6 provide protection against short circuits and overloads. Positive 30V outputs are available from P4, 5, 6 and 7. Negative 30V outputs are available from P12, 13, 14 and 15. Pins 8, 9, 10 and 11 provide a zero volt return.

D9 to D12 form a second bridge rectifier (auxiliary output), again high speed types are used. C17 to C20 help to reduce transients and switching noise. C21 and C22 are the reservoir capacitors for the auxiliary output. R11 and R12 serve the same purpose as R9 and R10 in the main output circuitry. RG1 and RG2 regulate the supply rails and attenuate switching noise on the auxiliary output. C23, C24, C25 and C26 are decoupling capacitors and ensure supply stability. Positive and negative 12V auxiliary outputs are available on P16 and P18 respectively. P17 provides a 0V return.

Construction

The PCB is of the single-sided glass fibre type, with a printed legend to assist insertion of the components. To increase the current rating of some of the tracks it is necessary to tin the exposed areas of track on the underside of the PCB. These tracks will be clearly seen as they are not covered by the solder resist layer. Tinning of the tracks should be the final assembly task. Removal of misplaced components can be very difficult, especially on a densely populated board such as this, so please double check component type, value and orientation (where appropriate) before inserting and soldering the component.

Referring to the following constructional notes, the parts list and Figure 3, begin construction. It is recommended that the following construction order is adhered to closely, otherwise it will be found extremely difficult, to fit some of the components.

Start by inserting the three 20SWG wire links, these are indicated on the PCB by a single straight line and an adjacent 'LK' mark.

Next insert the 1N4148 signal diodes, ensuring correct orientation.

Insert 0·6W Metal Film resistors, do not insert the 3W wire wound resistors at this stage.

Bend and insert the four 16SWG wire links, these are indicated on the PCB by a single straight line and an adjacent 'LKnumber'.

Next insert the 1N4001 diodes and the two 39V zener diodes.

Referring to Figure 4, loosely fit the M3 power input connection hardware and solder the M3 nuts to the PCB pads.

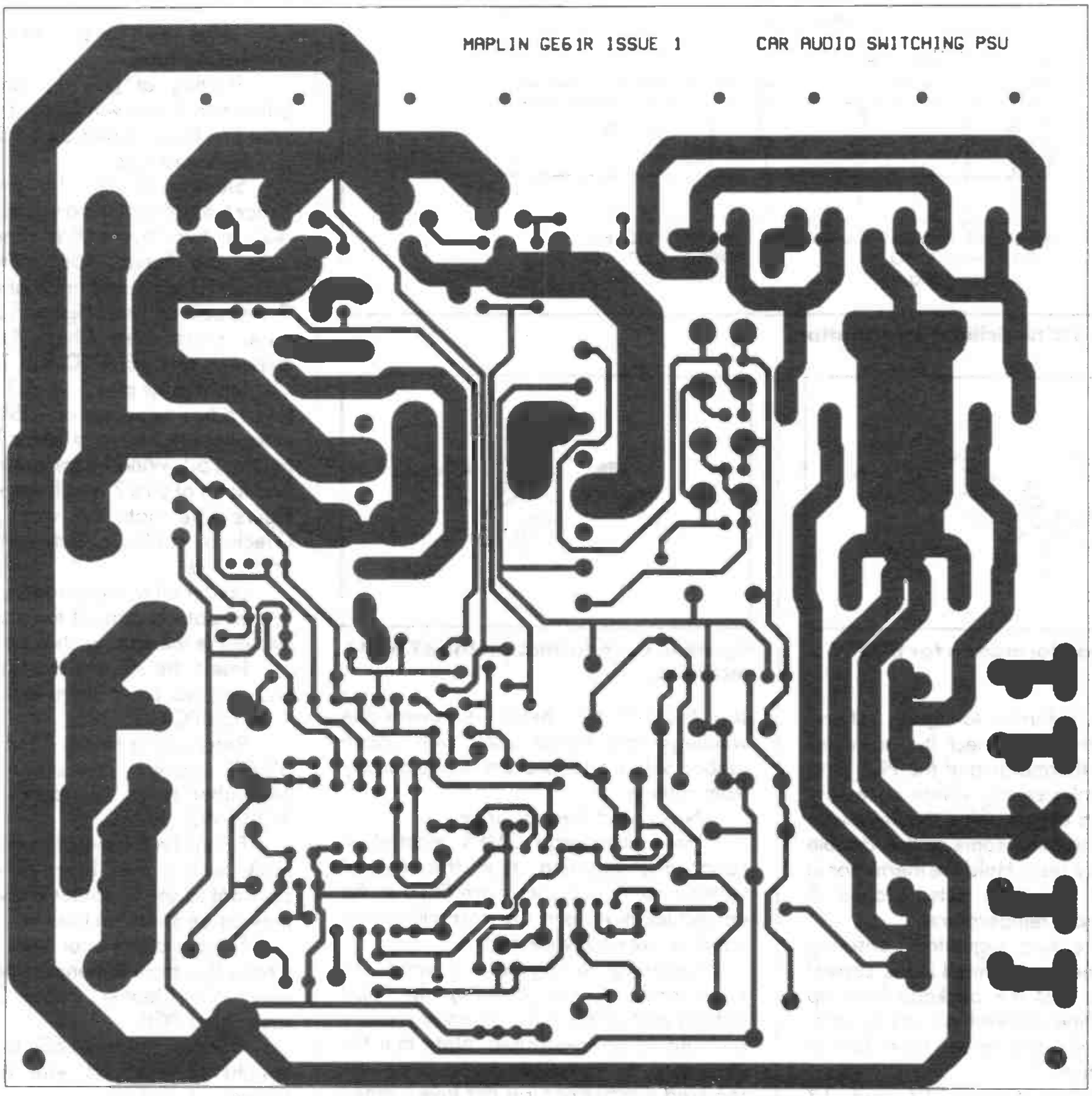


Figure 3 (b). PCB track.

Insert the polystyrene capacitors and the ceramic capacitors.

Next insert the DIL sockets, do not insert the ICs at this stage.

Insert the 45(!) PCB pins into the holes for TR2 to TR5 and D5 to D8; and positions marked with a circle and a 'Pnumber'. Do not insert pins into positions

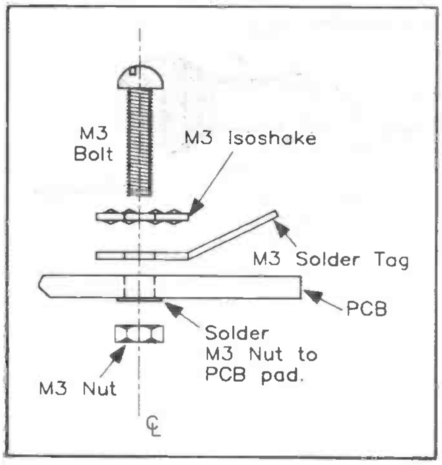


Figure 4. Power input connection assembly.

marked with a circle and a 'Wnumber',

Next Insert the fuse clips, it will be found that by carefully bending over the two legs on the track side of the PCB before soldering, the fuse clips will remain straight.

Insert the BC337 and BC559 transistors, ensuring correct orientation.

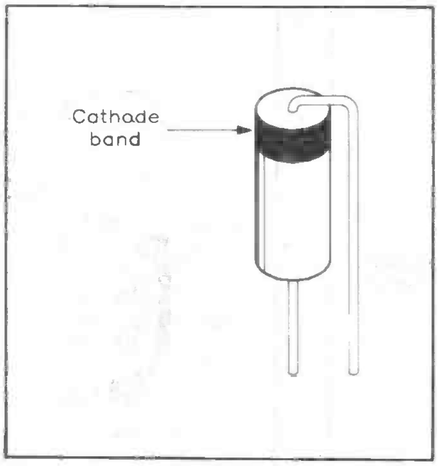


Figure 5. Lead formation for BYW98 rectifiers.

Next insert the tantalum capacitors, ensuring that the correct voltage rating capacitor is inserted in the correct location. The tantalum capacitors are polarised and must be correctly orientated, the plus (+) sign on the body must be inserted into the hole nearest that marked with a plus sign.

Form the leadouts of the BYW98 rectifier diodes, as shown in Figure 5 and insert these into the PCB. Ensure that the cathode lead, which is indicated by a band around the component body is inserted into the hole nearest that marked with a 'k' sign.

Insert the 0·1μF polyester capacitors and the small electrolytic capacitors. The electrolytic capacitors are polarised and must be correctly orientated, the negative (−) stripe on the capacitor can must be inserted into the hole furthest away from the hole marked with a plus (+) sign.

Drill the heatsink as shown in Figure 6. Form the leads of the BUZ11 MOSFETs and the BYW80 rectifiers as shown in Figures 7 and 8. Assemble the heatsink assembly using the M2·5 hardware as shown in Figure 9 and Photo 1. Solder the leadouts of the transistors and rectifiers to

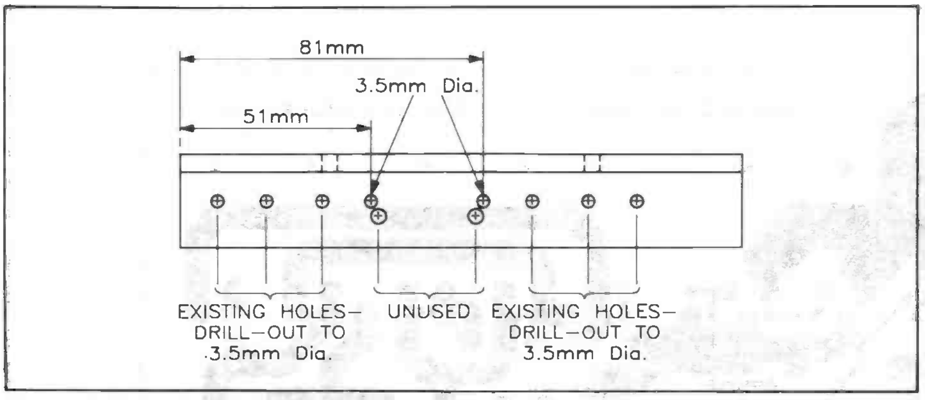


Figure 6. Heatsink drilling information.

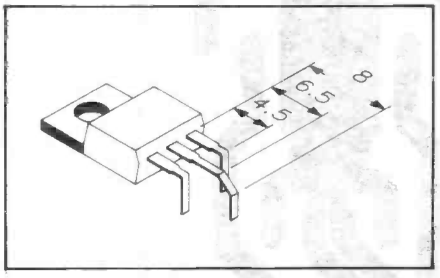


Figure 7. Lead formation for BUZ11 MOSFETs.

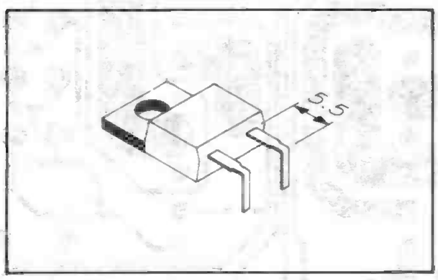


Figure 8. Lead formation for BYW80 rectifiers.

the PCB pins. Referring to Figures 10 and 11 and Photo 1, connect the screened cable to the thermistor and the PCB pins, use heat shrink sleeving where necessary to avoid short circuits. Glue the thermistor to the heatsink using some of the 'double bubble' epoxy resin. Hold the thermistor in place whilst the resin sets (around 5 minutes at room temperature).

Insert the two regulators, ensuring that the correct type is fitted in the correct location and that the package lines up with the outline marked on the legend. Ensure that the two metal tabs do not touch, see Photo 2.

Referring to Figures 12 and 13 extend the leadouts of the 3W resistors and axial inductors and insert these into the PCB, see Photo 2.

Referring to Figure 14 wind 2½ turns of two lengths of 16SWG EC wire wound bifilar (side by side) around the toroid core. Prepare the ends of the EC wire to facilitate soldering and insert this inductor into the PCB at the position marked L1, see Photo 3. It is helpful to smear the windings and toroid core with silicon rubber sealant to prevent the assembly from rattling.

Next insert the power relay.

Insert the large SMPS electrolytic capacitors, ensuring that the correct voltage rating capacitors are fitted in the correct locations and are correctly orientated as previously described.

Referring to Figure 15 wind the transformer, this is probably the most difficult part of the construction procedure and should not be rushed. Note that the diagrams do not figuratively show the required number of turns per layer. When winding the transformer take care not to over stress the bobbin otherwise pins may break off – use pliers to carefully bend the wire around the pins. It will be necessary to remove the enamel coating from the wire to allow soldering, emery paper is ideal for this. Photo 4 shows an exploded view of the component parts of the transformer.

Cover each layer with a single layer of masking tape.

Starting at pins 13 and 11 wind bifilar two 9 turn windings of 18 SWG EC wire first finish at pins 3 and 5 respectively, see Figure 15a.

Starting at pins 16 and 15 wind bifilar two 26 turn windings of 22SWG EC wire in two layers; first wind bifilar 13 turns, see Figure 15b. Wind bifilar a further 13 turns and finish at pins 10 and 9 respectively, see Figure 15c, note the wires cross over. Check for continuity between pins 16 & 10 and 15 & 9.

Starting at pins 1 and 2 wind bifilar two 15 turn windings of 22SWG EC wire in two layers; first wind bifilar 13 turns, see Figure 15d. Wind bifilar a further 2 turns and finish at pins 7 and 8 respectively, see Figure 15e, note the wires cross over. Check for continuity between pins 1 & 7 and 2 & 8.

Solder all of the leadouts to the transformer bobbin pins, fit the cores and clip into place the sprung steel core retainers.

Insert the transformer into the PCB, ensuring that pin 1 aligns with the number 1 on the PCB.

Referring to Figure 11 and using the 32/0·2 power connection wire, link 'Wnumber' holes; W1 to W1, W2 to W2, W3 to W3.

Finally tin the exposed lengths of PCB tracks with a *thick* layer of solder. Take care not to splash solder elsewhere which may cause short circuits.

Double-check your work and remove excess flux from the underside of the PCB using PCB Cleaner. Photo 5 shows the assembled PCB.

Connect the two LEDs to the PCB via lengths of insulated wire as shown in Figures 11 and 16.

Testing

Figure 11 shows the location of the input and output connections referred to in this section.

Fit IC1, IC2 and the fuses.

Using a multimeter on a suitable resistance range, measure the resistance

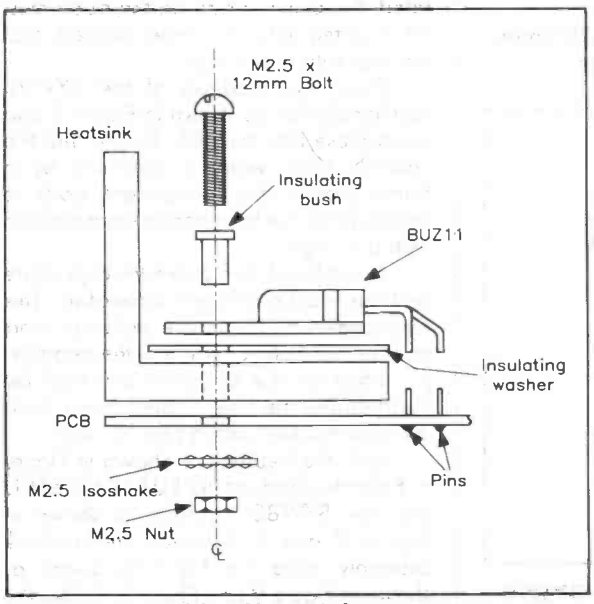


Figure 9. Assembly of heatsink components.

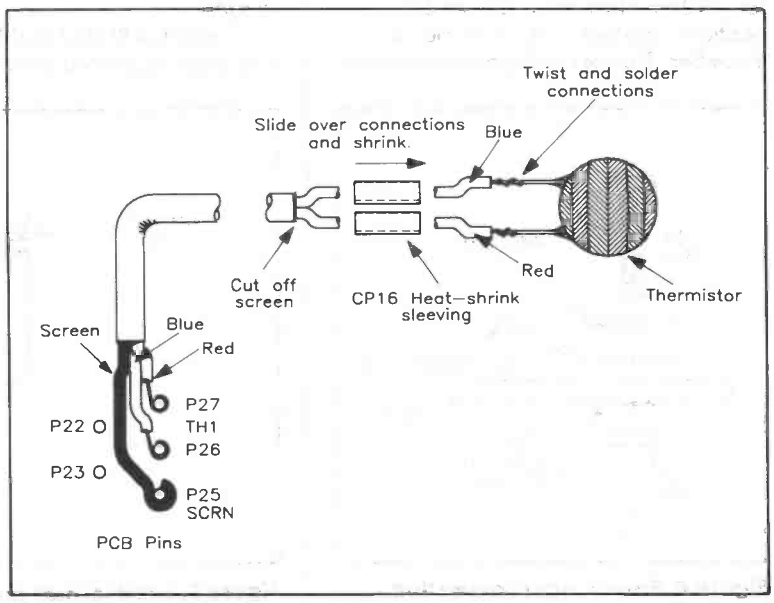


Figure 10. Thermistor connection.

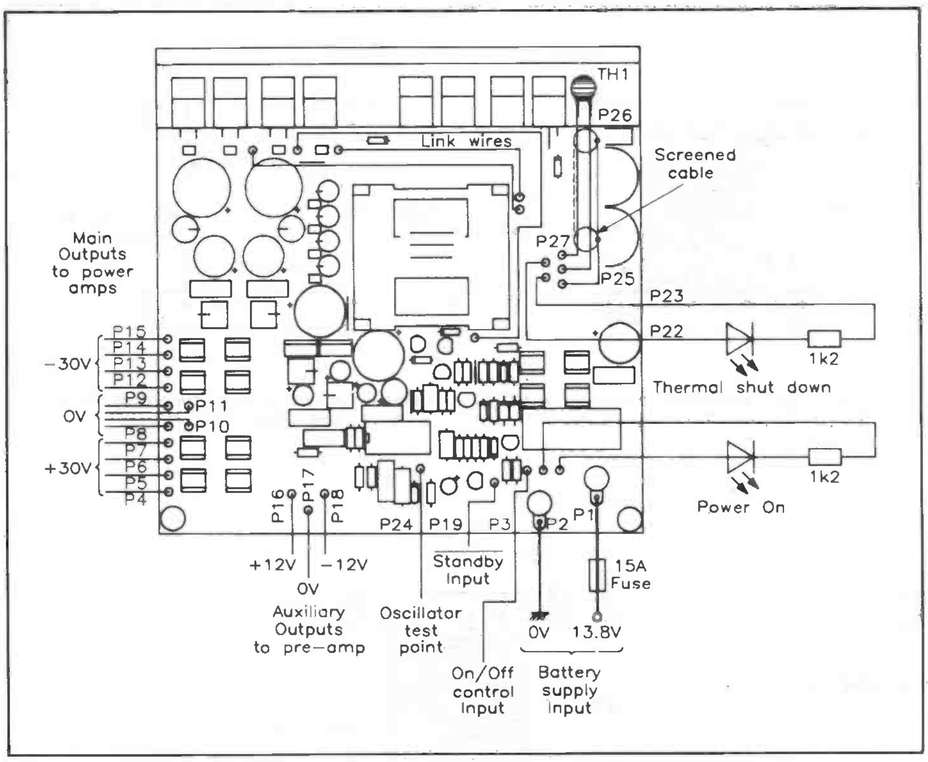


Figure 11. Wiring to switching PSU.

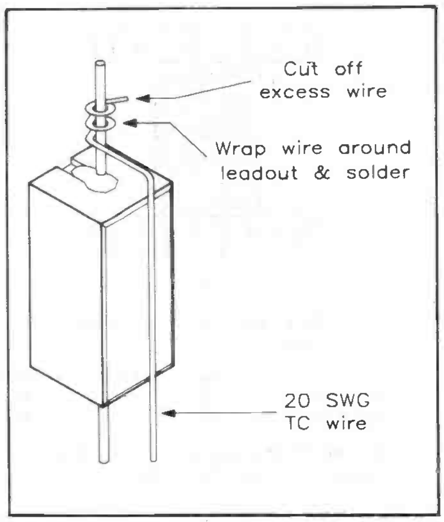


Figure 13. Extending leadouts of axial resistors.

between FS7 and P2, the resistance should be greater than 2kΩ. Check also the resistance between FS2 and P2, the resistance should be greater than 2kΩ. If significantly lower readings than stated are measured, recheck all of your work as there is likely to be a short circuit or a misplaced component.

Connect a 12V supply capable of delivering 5A to the input pins P1 (+V) and P2 (0V) via a 5A fuse (for FS1) and a multimeter on 5A or higher range. The quiescent current should be less than 1mA.

Link P3 and P1 with light duty wire, whereupon the relay should energise and the power-on LED (LD1) should illuminate. The current indicated on the meter should

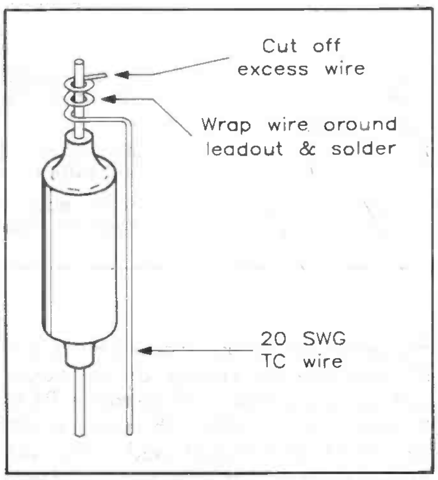


Figure 12. Extending leadouts of axial inductors.

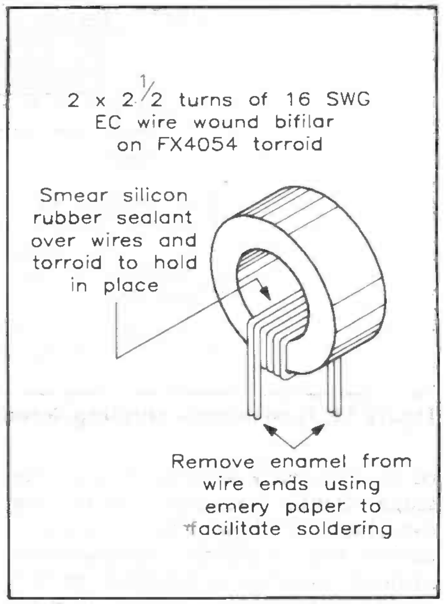


Figure 14. L1 winding information.

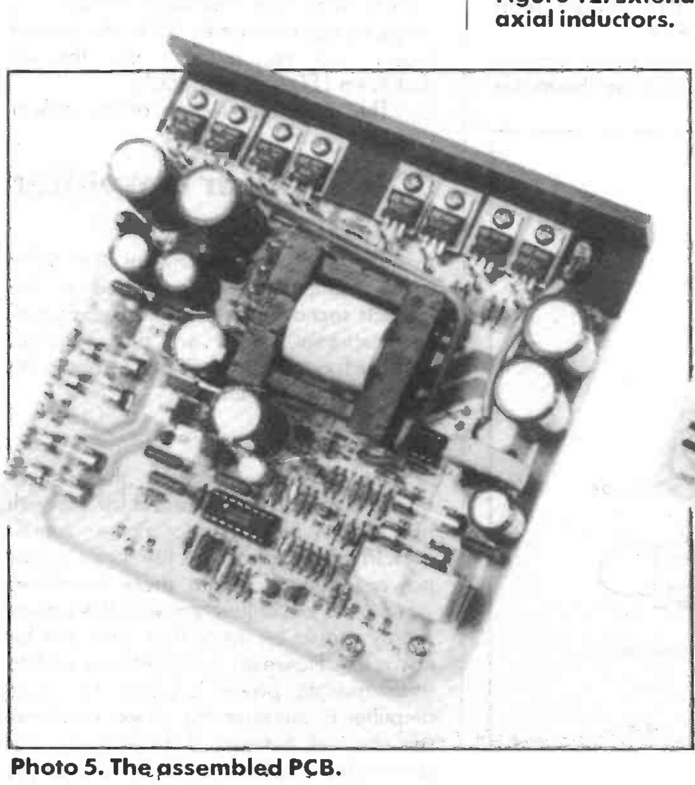


Photo 5. The assembled PCB.

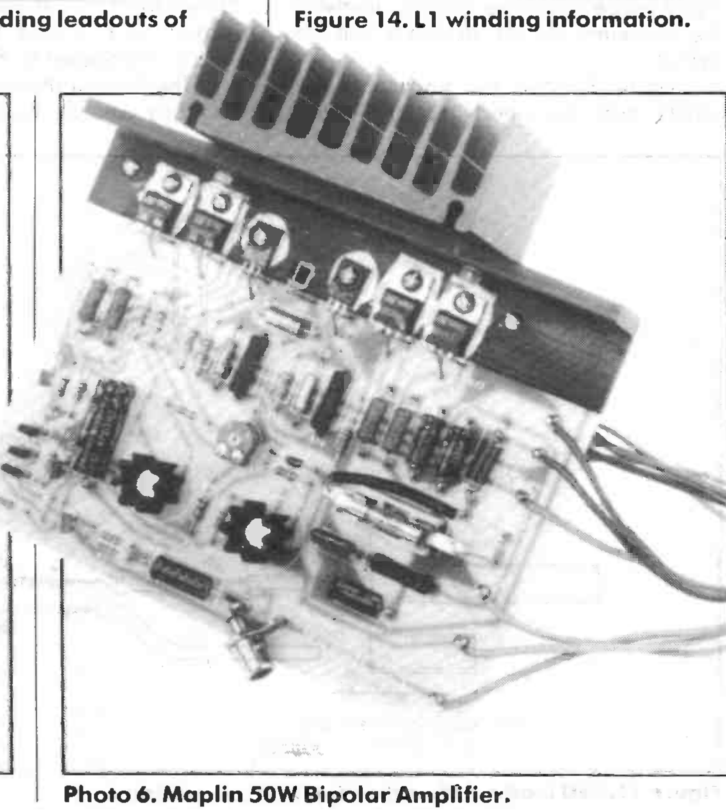


Photo 6. Maplin 50W Bipolar Amplifier.

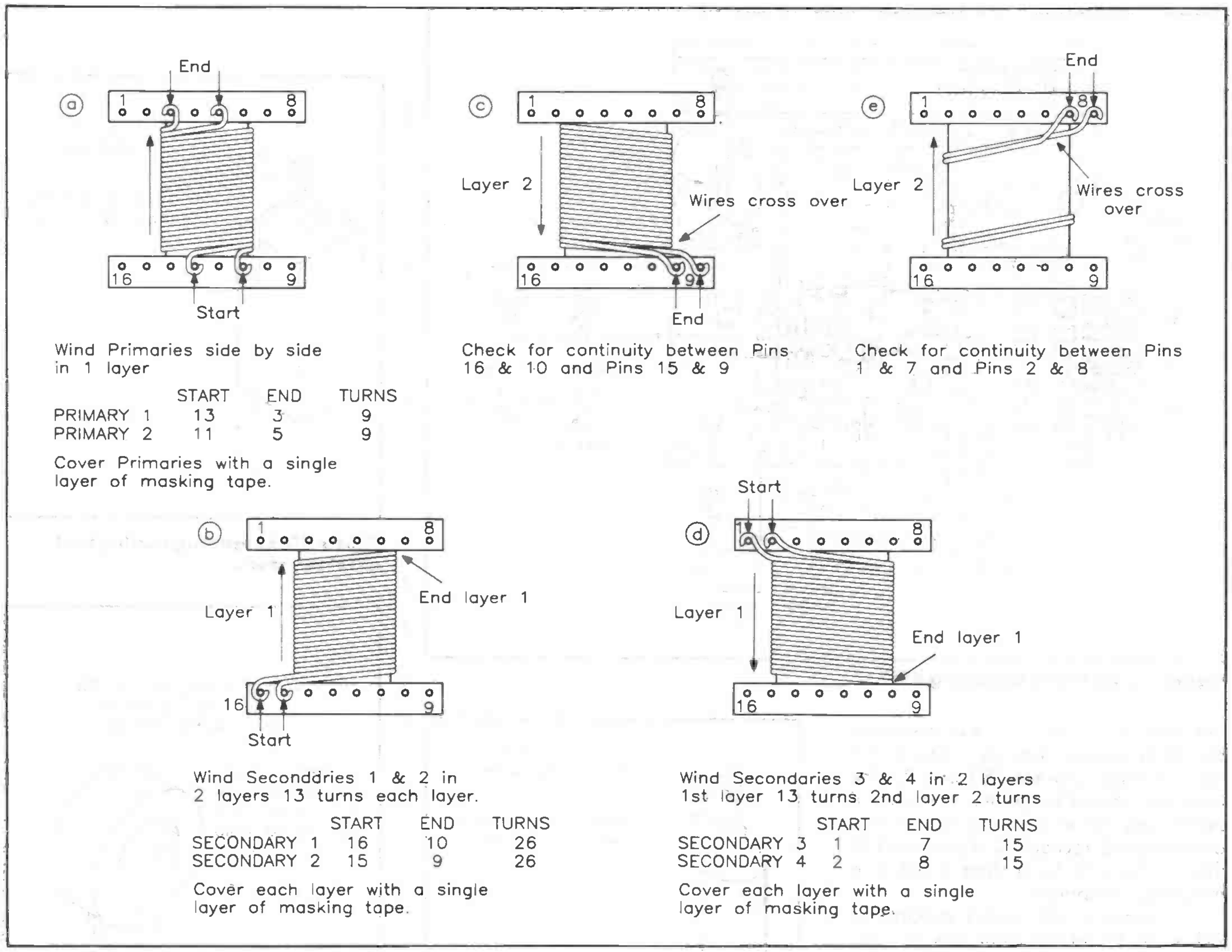


Figure 15. Transformer winding details.

be approximately 400mA. If an oscilloscope and/or frequency counter are available then these may be used to confirm that a 50kHz (approximately) sawtooth waveform is available on P24. Avoid undue capacitive loading otherwise the frequency of the oscillator will be shifted.

Unlink P3 and P1, disconnect the supply and disconnect the multimeter. Reconnect the supply and re-link P3 and P1. Measure the voltage on the output pins, using a suitable voltage range. P4 to P7 should read +30V with respect to P8. Pins P12 to P15 should read −30V with respect to P8. P16 should read +12V with respect to P17 and P18 should read −12V with respect to P17.

The thermal shutdown circuit may be tested by carefully heating the thermistor with a hairdryer. When the thermistor reaches a temperature of approximately 80°C the thermal shutdown LED (LD2) will illuminate and the power supply will shutdown, this can be confirmed by measuring one of the supply voltage outputs. When the thermistor temperature drops to approximately 60°C the power supply will restart and the thermal shutdown LED will extinguish.

This completes testing of the power supply.

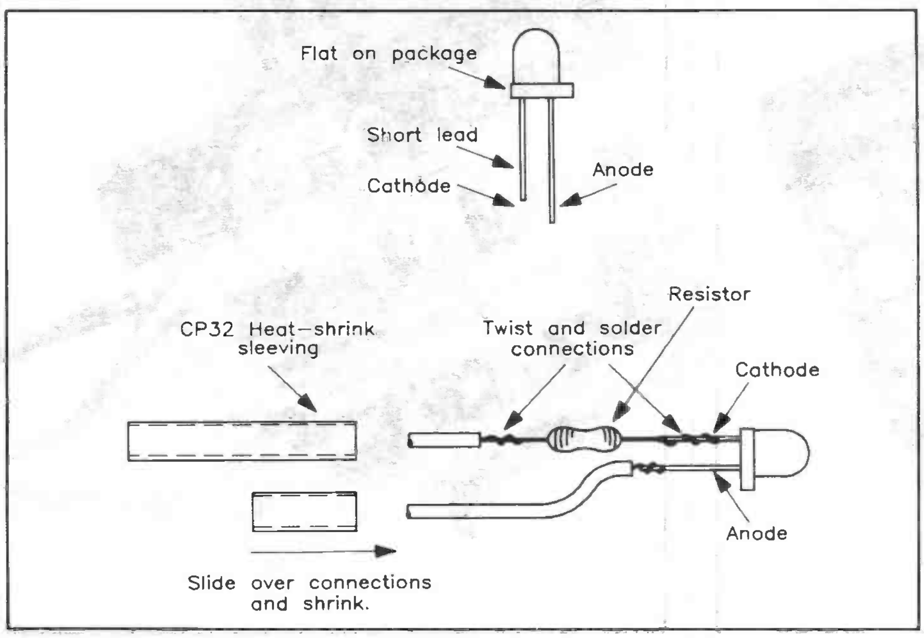


Figure 16. LED leadout identification and connections.

50W Bipolar Amplifier Construction

Constructional details for the 50W bipolar amplifier are published in the Projects section of the Maplin Catalogue, constructional details are also supplied with each amplifier kit. Photo 6 shows the 50W Bipolar Amplifier.

Use

As previously stated, the power supply is specifically intended for use with two Maplin 50W Bipolar Power Amplifiers. In most applications the audio output power attainable from these amplifiers when used in conjunction with this power supply should be more than sufficient for in-car use. However the purist may wish to use separate power supplies for each amplifier to increase the power available per channel. Similarly if a single channel subwoofer amplifier is required, a single amplifier may be driven from one power supply. It should be pointed out that excessive sound pressure levels may lead to long term, irreversible hearing problems. High levels of sound may also blot out other external sounds, which could be dangerous when on the move. Please use common sense when using a high power in-car entertainment system.

It is strongly recommended that the power supply is fully cased and provided with an additional external heatsink, type 2E is suggested. Metal cases are ideal for this purpose, and also provided a degree of shielding against radiated radio frequency emissions. The audio amplifiers may also be housed in the same case, which could be conveniently mounted in the car boot or under a seat. The audio amplifiers should also be heatsinked, again type 2E is suggested.

To connect the 50W Bipolar amplifiers to the power supply, treat the switching power supply as a conventional power supply (as shown in the amplifier constructional details) and connect accordingly (HT1 and HT2 are positive, HT3 and HT4 are negative). Refer to Figure 11 for connections to the power supply. The amplifier set-up procedures should be followed in the same way as for the conventional power supply. Connections from the power supply to the amplifiers should be made using 32/0·2 wire.

Loudspeakers should be suitably rated for high power use. Beware, many car loudspeakers are given misleadingly high power ratings, try and find out what the true RMS ratings are. Usually car loudspeaker ratings are giving in peak power or total peak power, be prepared to divide the rating by 1·414 or even 2·828! Loudspeaker wiring should also be sufficiently rated for the purpose.

Connections from the power supply to the car electrical system should be made using very heavy duty cable. It is advisable to connect the power supply directly to the car battery via its own in-line fuse at the car battery end. Assuming a negative earth car, the chassis may be used to provide the 0V connection, which saves on wire.

CAR AUDIO SWITCHING PSU PARTS LIST

RESISTORS: All 0·6W 1% Metal Film (Unless specified)			
R1	6k8	1	(M6K8)
R2	68k	1	(M68K)
R3,35	1k2	2	(M1K2)
R4,5,6,7	56Ω	4	(M56R)
R8,36	10Ω	2	(M10R)
R9,10	1k 3W	2	(W1K)
R11,12	470R 3W	2	(W470R)
R13,17,22,23, 26,27,28,29,34	1k	9	(M1K)
R14,19,21,31, 32,33	10k	6	(M10K)
R15	24k	1	(M24K)
R16,20,24,25	4k7	4	(M4K7)
R18	1M	1	(M1M)
R30	3k3	1	(M3K3)
TH1	Bead Thermistor 15k	1	(FX22Y)
CAPACITORS			
C1,5,15,16,25, 26,28,30	100nF Polyester	8	(BX76H)
C2,13,14	220μF 50V SMPS	3	(JL51F)
C3,4,11,12	1000μF 50V SMPS	4	(JL57M)
C6,31	2n2F 1% Polystyrene	2	(BX60Q)
C7,8,9,10,17,18, 19,20	560pF Ceramic	8	(WX65V)
C21,22	1000μF 25V SMPS	2	(JL56L)
C23,24	10μF 25V Tantalum	2	(WW69A)
C27	100μF 25V PC Elect	1	(FF11M)
C29	22μF 25V PC Elect	1	(FF06G)
C32	10μF 16V Tantalum	1	(WW68Y)
C33,34	150pF Polystyrene	2	(BX29G)
SEMICONDUCTORS			
D1,2	1N4001	2	(QL73Q)
D3,4,13,14,15, 16,17,18	1N4148	8	(QL80B)
D5,6,7,8	BYW80-150	4	(UK63T)
D9,10,11,12	BYW98-150	4	(UK65V)
ZD1,2	BZX61C/BZX85C 39V	2	(QF67X)
TR1	BC337	1	(QB68Y)
TR2,3,4,5	BUZ11	4	(UJ33L)
TR6,7,8,9,10	BC559	5	(QQ18U)
LD1,2	Red LED	2	(WL27E)
RG1	μA7812UC	1	(QL32K)
RG2	μA7912UC	1	(WQ93B)
IC1	TL494	1	(RA85G)
IC2	LM311	1	(QY09K)
MISCELLANEOUS			
L1	FX4054 Ferrite Toroid	1	(JR84F)
L2,3	RF Suppressor 3A	2	(HW06G)
T1	ETD39 Ferrite Core	2	(JR81C)
	ETD39 Former	1	(JR82D)
	ETD39 Clip	2	(JR83E)
RL1	12V 16A Relay	1	(YX99H)
FS1	15A 1¼in AS Fuse	1	(UK13P)
FS2,7	100mA 20mm QB Fuse	2	(WR00A)
FS3,4,5,6	2A 20mm AS Fuse	4	(WR20W)
	1¼in Chassis F/Holder	1	(RX50E)
	Fuse Clip	12	(WH49D)
	Isobolt M3 6mm	1 Pkt	(BF51F)
	Isobolt M2·5 12mm	1 Pkt	(BF55K)
	Isonut M3	1 Pkt	(BF58N)
	Isonut M2·5	1 Pkt	(BF59P)
	Isoshake M3	1 Pkt	(BF44X)
	Isoshake M2·5	1 Pkt	(BF45Y)
	Isotag M3	1 Pkt	(LR64U)
	TO220 Insulator	8	(QY45Y)
	TO220 Bush Long	1 Pkt	(UL69A)
	50W Heatsink	1	(HQ69A)
	16-pin DIL Skt	1	(BL19V)
	8-pin DIL Skt	1	(BL17T)
	Pins 2145	1 Pkt	(FL24B)
	Pins PCB	1	(GE61R)
	TC Wire 0·9mm 20swg	1 Reel	(BL13P)
	TC Wire 1·6mm 16swg	1 Reel	(BL11M)
	Wire 3202 Green	1m	(XR35Q)
	EC Wire 1·6mm 16swg	1 Reel	(BL24B)
	EC Wire 1·25mm 18swg	1 Reel	(BL25C)
	EC Wire 0·71mm 22swg	1 Reel	(BL27E)
	Lapped Pair	1m	(XR20W)
	Heat Shrink CP 32	1m	(BF88V)
	Heat Shrink CP 16	1m	(BF86T)
	Constructors' Guide	1	(XH79L)
	Instruction Leaflet	1	(XK50E)
	Double Bubble Sachet	1	(FL45Y)
OPTIONAL (not in kit)			
	Car Fuse Holder	1	(RX51F)
	15A 1¼in AS Fuse	1	(UK13P)
	HC Wire Black	As Req	(XR57M)
	HC Wire Red	As Req	(XR59P)
	32/0·2 Wire Red	As Req	(XR36P)
	32/0·2 Wire Black	As Req	(XR32K)
	32/0·2 Wire Blue	As Req	(XR33L)
	Zip Wire	As Req	(XR39N)
	50W Power Amp	2	(LW35Q)
	2E Heat Sink	2	(HQ70M)

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

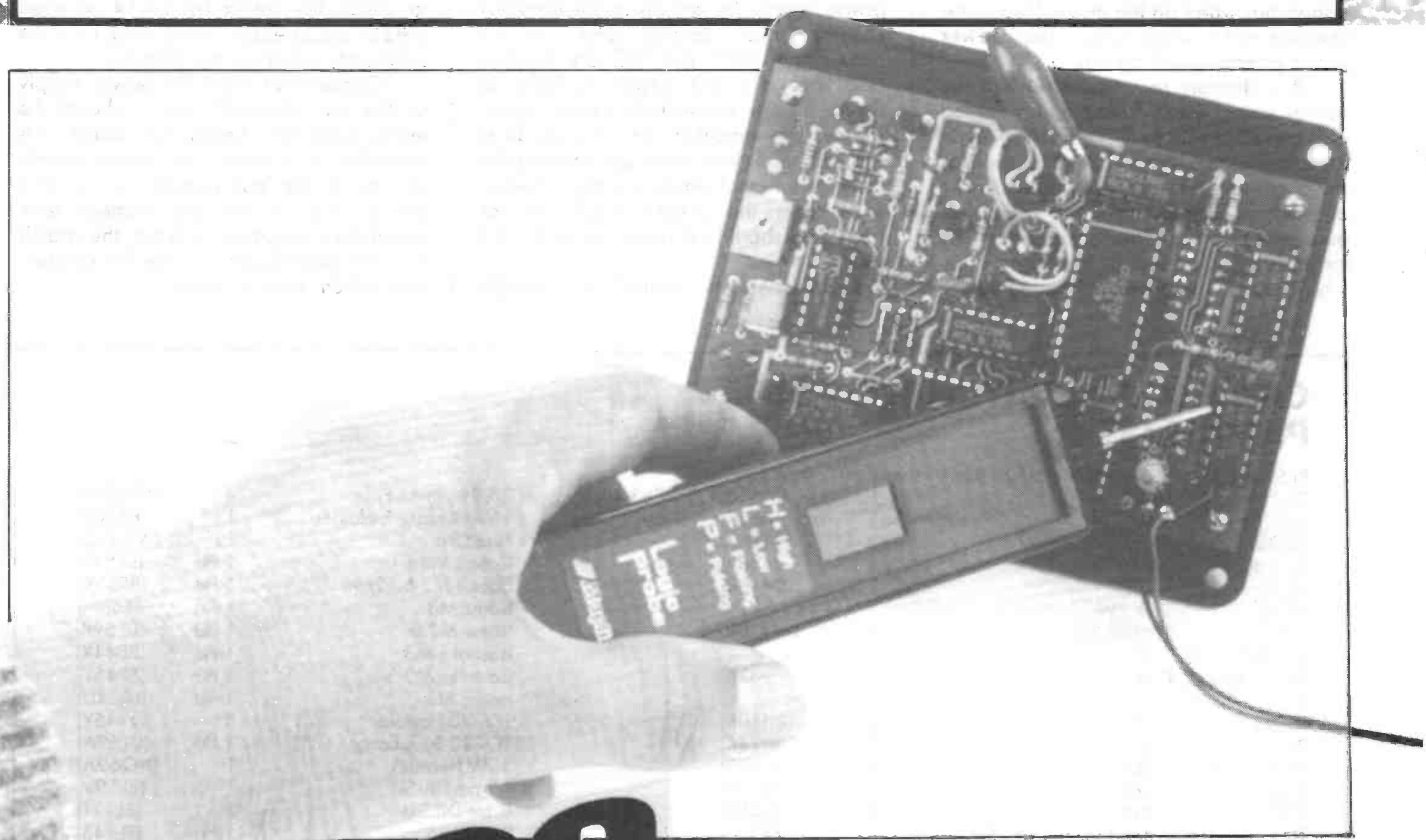
The above items are available as a kit (excluding Optional).

Order As LP39N (Switching PSU 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.

The following new item (which is included in the kit) is also available separately.
Switching PSU PCB **Order As GE61R**

Many projects from Maplin's range of kits have proved to be very popular over the years, but some of the older ones need updating and improving to meet the higher modern standards expected of them, and to use the current technology now available. This newly developed design supersedes the original and has a new probe and case design for easier construction.

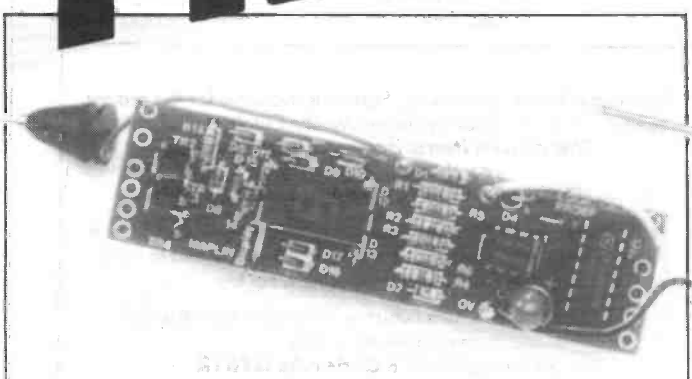


CMOS LOGIC PROBE

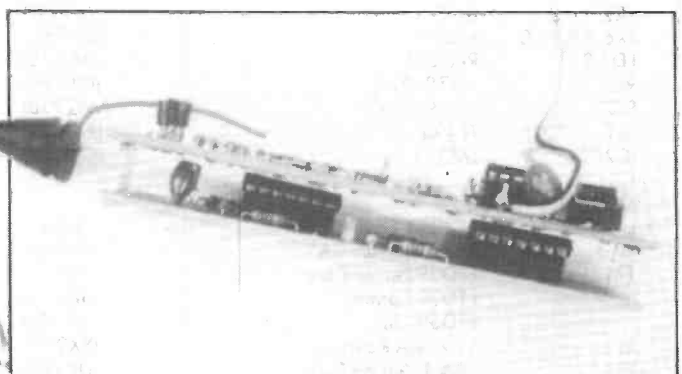
FEATURES

★ Designed specifically for high CMOS levels ★ High, low, floating and pulse indication ★ Instantly recognisable logic states ★ Over volts protection ★ Low current consumption

by Graeme Durant



Plan view of the assembled Logic Probe PCBs.



Side view of the PCBs.

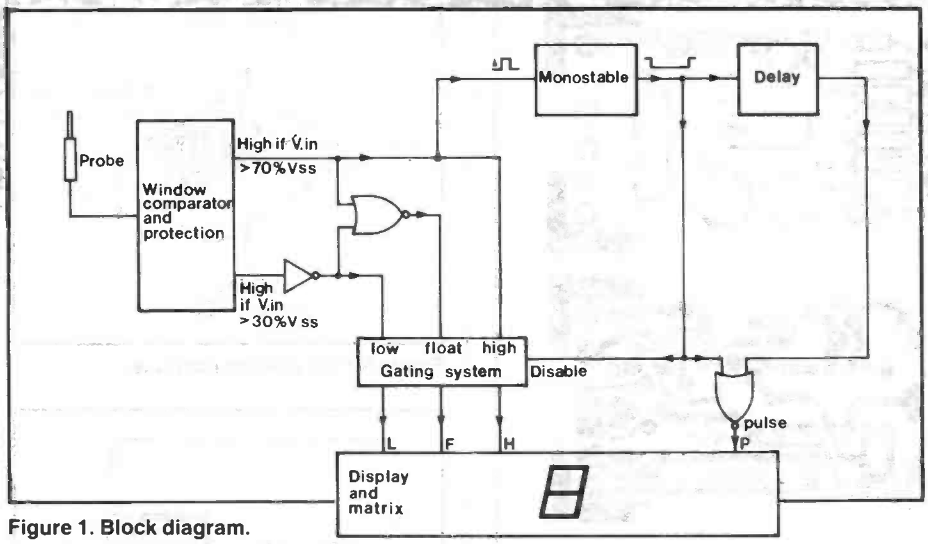


Figure 1. Block diagram.

Over the years, countless designs have appeared in the electronics press for logic probes; ranging from very simple High/Low indicators, to complex pulse stretching probes. The logic probe described here, has a number of features found only on the more complex probes, and as such, lies somewhere between these two extremes. Thus it is perfectly suited to day to day fault diagnosis.

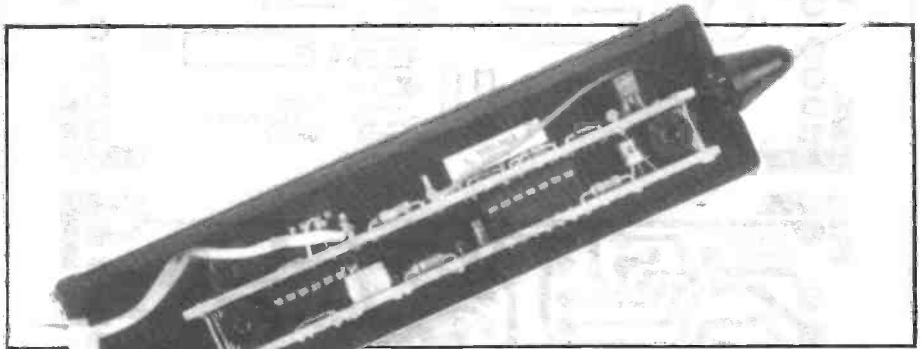
As well as detecting High and Low logic states, open circuit (floating input) and pulsing inputs are displayed. Pulse trains from around 1Hz are detected as a pulsing input, the upper limit is above that attainable in most common CMOS logic (not low voltage type).

The main difference between this logic probe and all others is that the output is shown on a seven segment LED display, as a letter of the alphabet; H for High; L for Low; F for Floating; P for Pulsing. In this way, the logic state is instantly recognisable and totally unambiguous. The use of a special high efficiency display means that the total current consumption at a supply voltage of 15V is only 15mA — quite suited to battery operated circuits. In addition, the probe is protected against over-voltage inputs, and reversed supply.

Block Diagram

The input from the probe goes via a protection network to a window comparator, with switching levels of 70% V_{ss} and 30% V_{ss}; these are the standard CMOS limits. If the upper limit is exceeded, then the probe input is CMOS logic high. Thus, the upper output goes on to the display circuitry for HIGH indication.

If the probe input does not exceed the lower limit, then it is at CMOS logic



Internal view of Logic Probe.

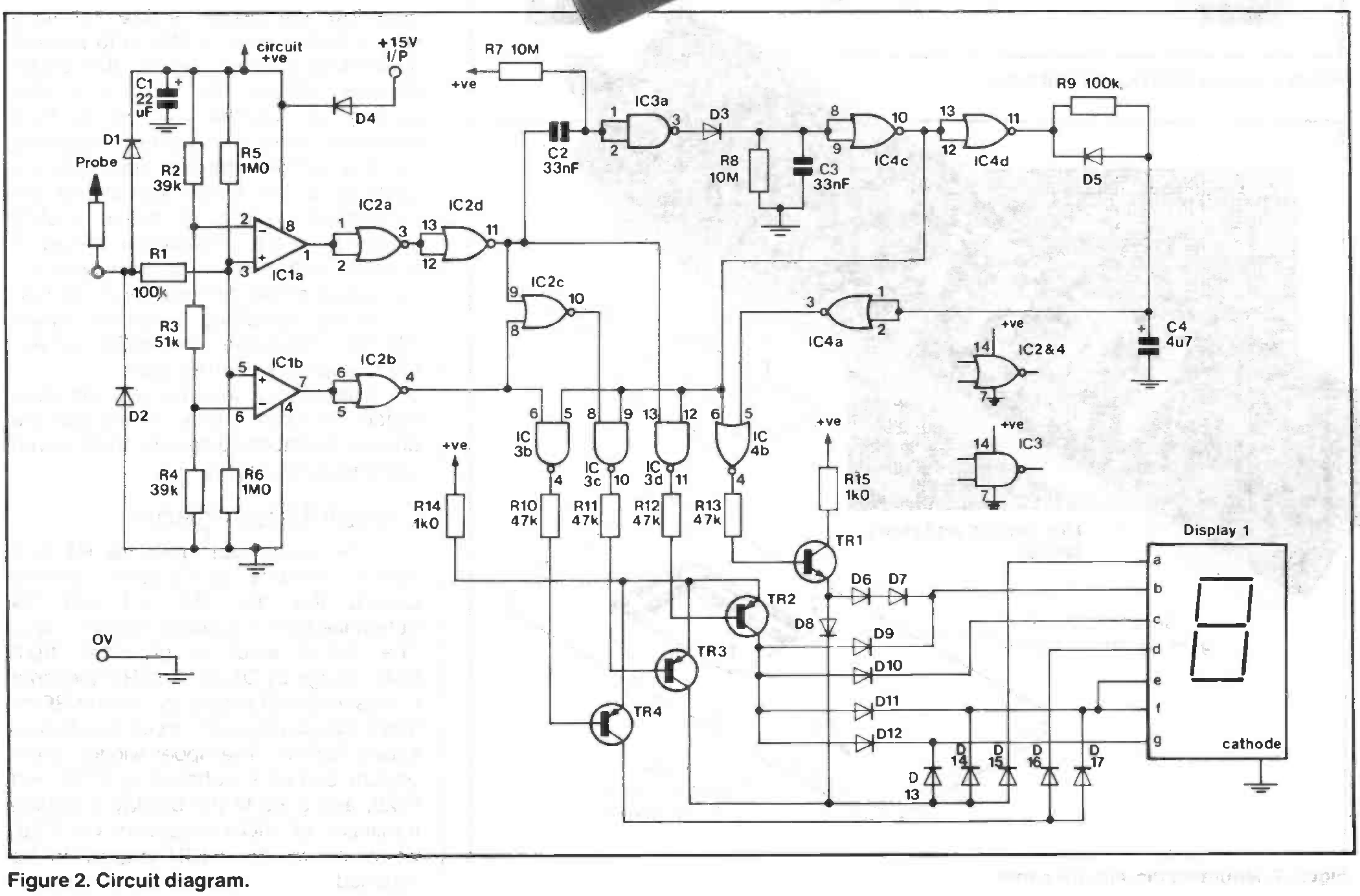


Figure 2. Circuit diagram.

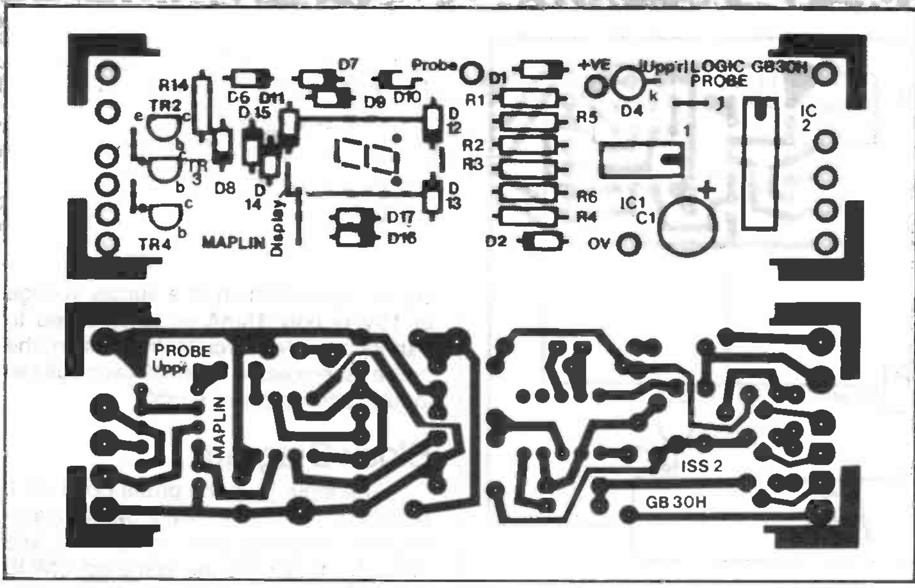


Figure 3. Upper PCB legend and track.

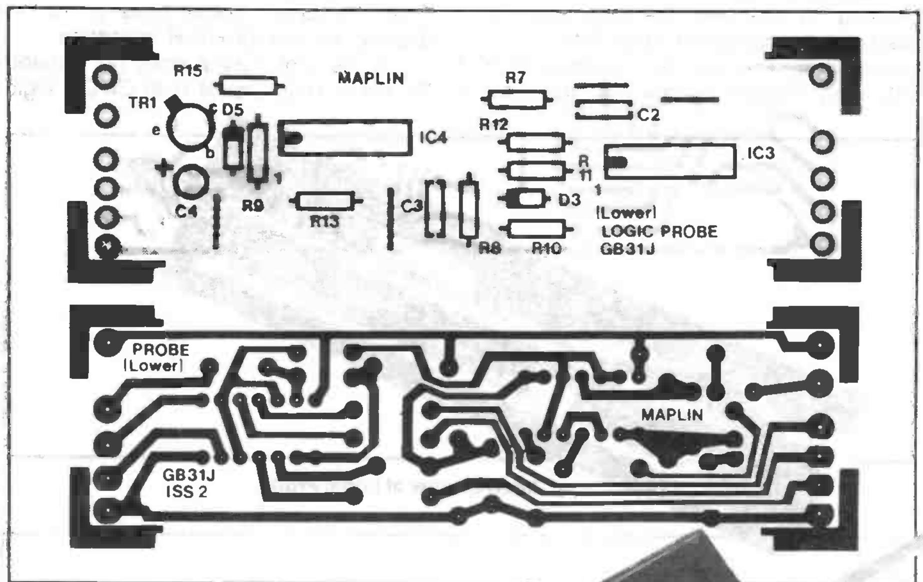
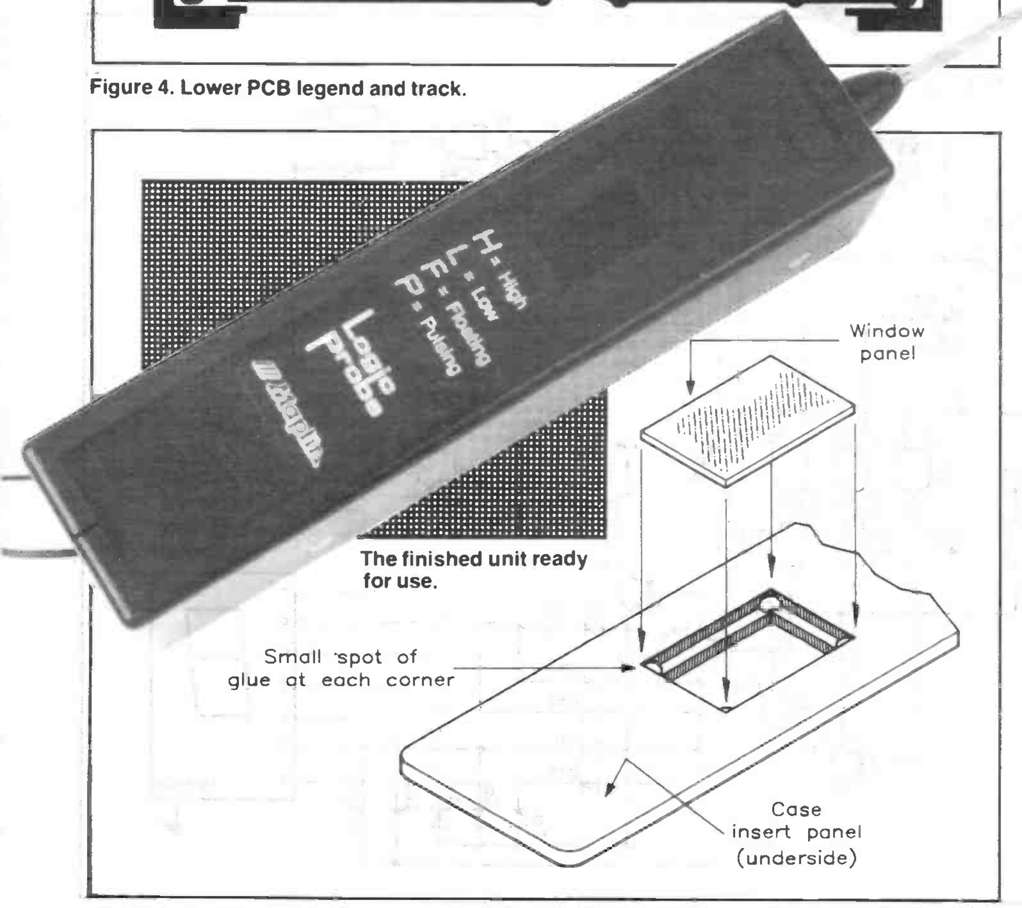


Figure 4. Lower PCB legend and track.



The finished unit ready for use.

Figure 7. Mounting the window panel.

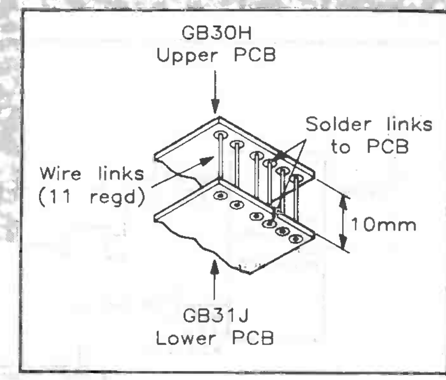


Figure 5. PCB interconnections.

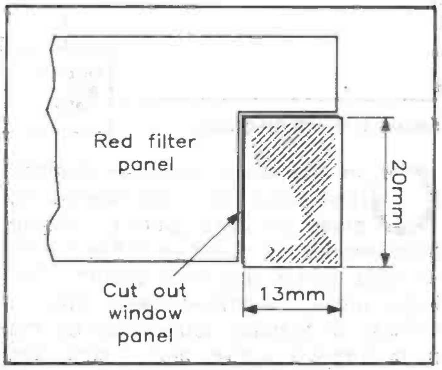


Figure 6. Display window panel.

low. The output of the lower comparator is inverted to give a high level at the display circuitry for LOW indication. If the probe input is between logic levels, then the upper comparator will be low and the lower comparator high. These two outputs are fed to a NOR gate, which gives a high level to the display circuitry on FLOAT.

The HIGH indication also drives a retriggerable monostable, to produce a continuous low output. If this monostable goes low, the display is disabled via a simple gating system. This is to prevent misleading displays, whilst the circuit decides whether the input is indeed pulsing, or whether a low to high transition has taken place (e.g. the probe has just touched a point at logic high). As soon as a low pulse appears at the monostable output, a delay, slightly longer than the monostable period is initiated. At the end of this time period, if the output of the monostable is still low, i.e. the input is pulsing, the display shows PULSE. Otherwise, the HIGH/FLOAT/LOW display is enabled again.

The display consists of driver transistors, a diode matrix to produce the desired alphabetic displays, and a seven segment LED display.

Circuit Description

The probe input goes via R1 to a simple window comparator formed around IC1 and R2, R3 and R4 determine the changeover voltage levels. The circuit input is protected from over-voltage by D1, D2 and R1; the input is biased at half supply by R5 and R6 so that if the input is open circuit, the display shows FLOAT. The upper window comparator output is buffered by IC2a and IC2d, and goes to the display switching transistor for HIGH indication, via IC3d, which allows the HIGH display to be disabled.

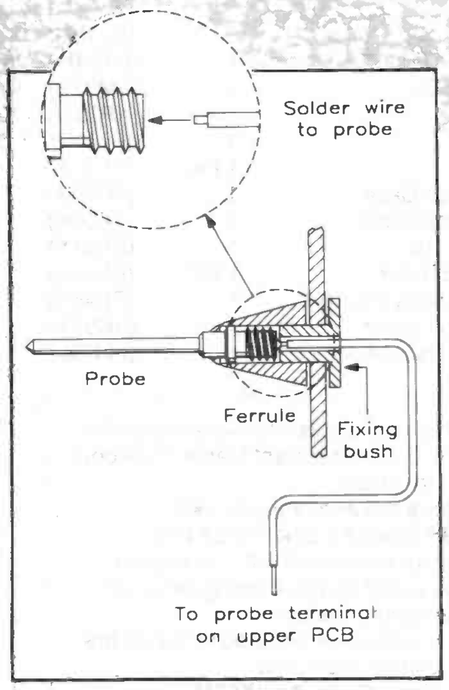


Figure 8. Probe assembly.

The low and float displays are similarly connected, using IC2b and IC3b for LOW, and IC2c and IC3c for FLOAT.

A simple CMOS monostable wired around IC3a and IC4c, and having a period of around 0·5 seconds senses a pulsing input. Its output, which is normally high, disables the HIGH/FLOAT/LOW display, and starts a delay, formed around C4 and R9, which is a little over the monostable period. The output of the RC delay is inverted and fed to IC4b, which senses whether the input is still pulsing. If it is, TR1 is switched on, and PULSE is displayed. Otherwise TR1/4 are enabled. A diode matrix and seven segment common cathode display decode the signals, so as to give H, F, L and P displays.

Construction

Before soldering in any components, solder in wire links on both PCBs, there are eight in all. Fit in all the resistors and capacitors taking care with polarity on C1 and C4. Insert the IC sockets and diodes – again be careful about polarity. Note also that D4 is fitted vertically on the PCB. Fit the transistors and finally the ICs. PCB pins should be used for all cable to PCB connections as this makes wiring easier. This only leaves the display, which requires setting at the correct height to fit inside the case.

The PCBs are mounted one on top of the other in the case, with connections between both made by solid wire links — cropped component leads are ideal. Solder eleven lengths of wire, about 20mm long, to the underside end connections of the upper board, passing the wire through the holes until level with the topside of the PCB. See Figure 5.

Slide on the lower board until there is a gap of 10mm between the upper board and the lower PCB, solder the wires to the bottom board and crop.

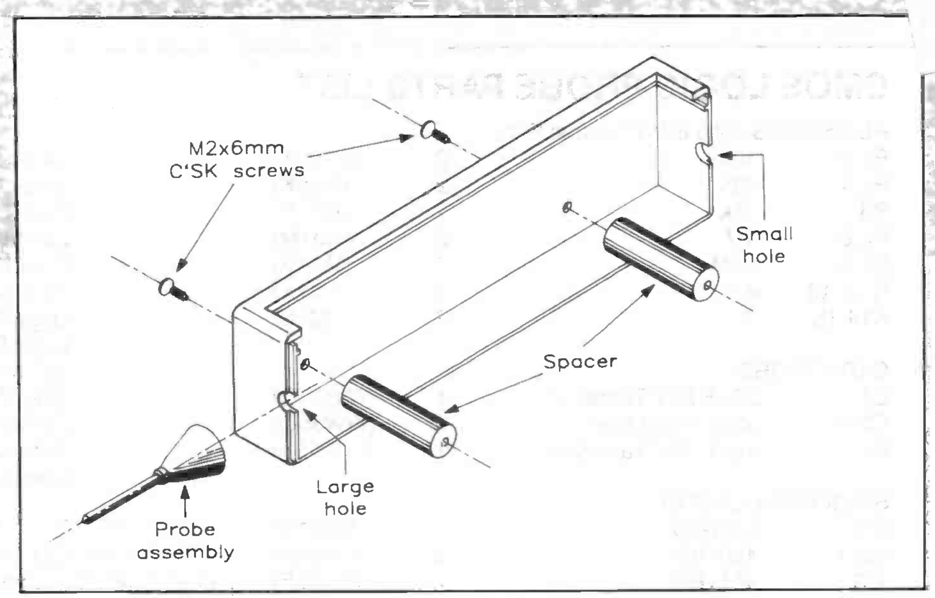


Figure 9. Case assembly.

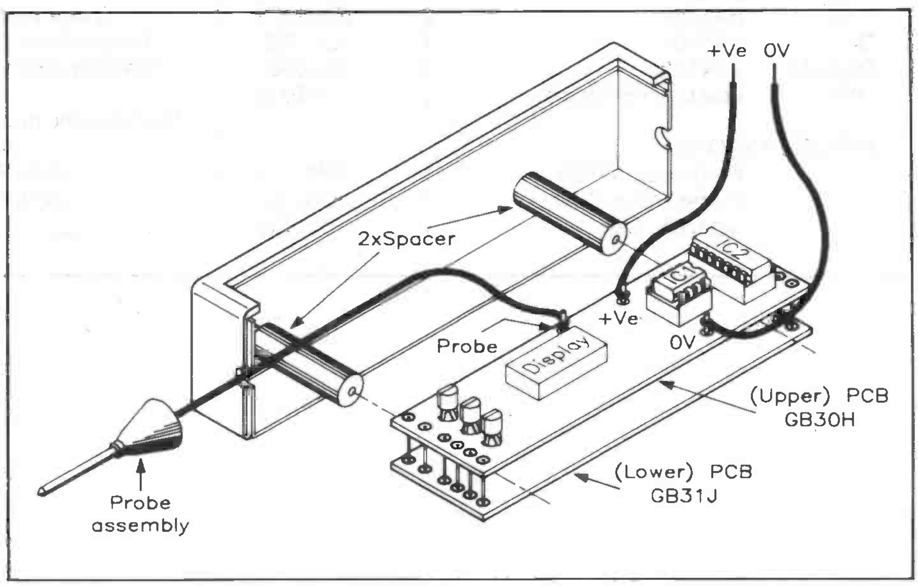


Figure 10. PCB mounting.

Carefully cut out a rectangular 20mm x 13mm section from the sheet of red filter as shown in Figure 6, and place into the display window recess on the inside of the insert panel, matt side outward. Figure 7 shows the method, and a *small* spot of adhesive can be placed in the four corners, to hold the filter in place. If you apply too much adhesive it will spread out over the filter, which is not desirable, so be frugal. Figure 8 shows the new probe assembly. Solder 10cm of 7/0·2 wire to the probe end and once it has cooled, insert the probe into the plastic ferrule. Thread the remaining wire end through the fixing bush, and press the bush into the ferrule; the bush is an interference fit and will offer some resistance.

You will notice that the case shells have a hole at each end. One of these holes has been made larger to take the probe assembly, as shown in Figure 9, while the other hole allows access for connection to an external power supply. Place a small spot of adhesive into the large half hole section and slot the fixing bush and probe assembly into place. Note — allow adhesive to dry before assembling both case halves together!

Fit both spacers as shown, using an M2 x 6mm screw in each, and mount the PCB assembly as shown in Figure 10; the two spacers will hold the PCBs in position. Solder the probe wire onto the upper board terminal and two wires to the +Ve and 0V terminals. The power wires should be secured using a cable-tie. Croc' clips should be fitted to these wires. Finally, fit the insert panel with the window filter positioned above the PCB display, and fix the remaining case shell with two M2 x 6mm screws.

Testing and Use

Power the circuit up with a typical CMOS supply voltage. After around half a second, the display should show a letter F. If not, disconnect quickly, and recheck the circuit. If all is well, touch the probe to positive — a letter H should light after a brief delay. Tap the probe on and off positive a few times a second — a letter P should be displayed after a delay. Then, touch the probe to 0V — a letter L should light immediately. If all this happens, the probe is working perfectly.

The probe is designed for use with CMOS logic circuitry *only,* and may be used to trace faults on any such logic. All that remains now is to find a suitable circuit to test!

CMOS LOGIC PROBE PARTS LIST

RESISTORS: All 0·6W 1% Metal Film

R1,9	100k	2	(M100K)
R2,4	39k	2	(M39K)
R3	51k	1	(M51K)
R5,6	1M	2	(M1M)
R7,8	10M	2	(M10M)
R10–13	47k	4	(M47K)
R14,15	1k	2	(M1K)

CAPACITORS

C1	22µF 25V Tantalum	1	(WW73Q)
C2,3	33nF Poly Layer	2	(WW35Q)
C4	4µ7F 35V Tantalum	1	(WW65V)

SEMICONDUCTORS

IC1	CA3240	1	(WQ21X)
IC2,4	4001BE	2	(QX01B)
IC3	4011BE	1	(QX05F)
TR1	BC107	1	(QB31J)
TR2–4	BC557	3	(QQ16S)
D1,2	BAR28	2	(QQ13P)
D4	1N4001	1	(QL73Q)
D3,5–17	1N4148	14	(QL80B)
DY1	Low Current Display	1	(QY54J)

MISCELLANEOUS

	Probe Upper PCB	1	(GB30H)
	Probe Lower PCB	1	(GB31J)
	8-pin DIL Skt	1	(BL17T)
	14-pin DIL Skt	3	(BL18U)
	Black Croc Clip	1	(FK34M)
	Red Croc Clip	1	(FM37S)
	Zip Wire	1m	(XR39N)
	Filter Red	1	(FR34M)
	Pin 2141	1 Pkt	(FL21X)
	Logic Probe Case	1	(JX57M)
	Logic Probe Label	1	(JX58N)
	Tie-Wrap 100	1	(BF91Y)
	7/0·2 Wire Black	1 Pkt	(BL00A)
	Double Bubble Sachet	1	(FL45Y)
	Instruction Leaflet	1	(XK91Y)
	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.

Order As LK13P (CMOS Logic Probe Kit)

Please Note: Order Codes marked with a ★ are not available singly, see current Maplin Catalogue for full ordering information.

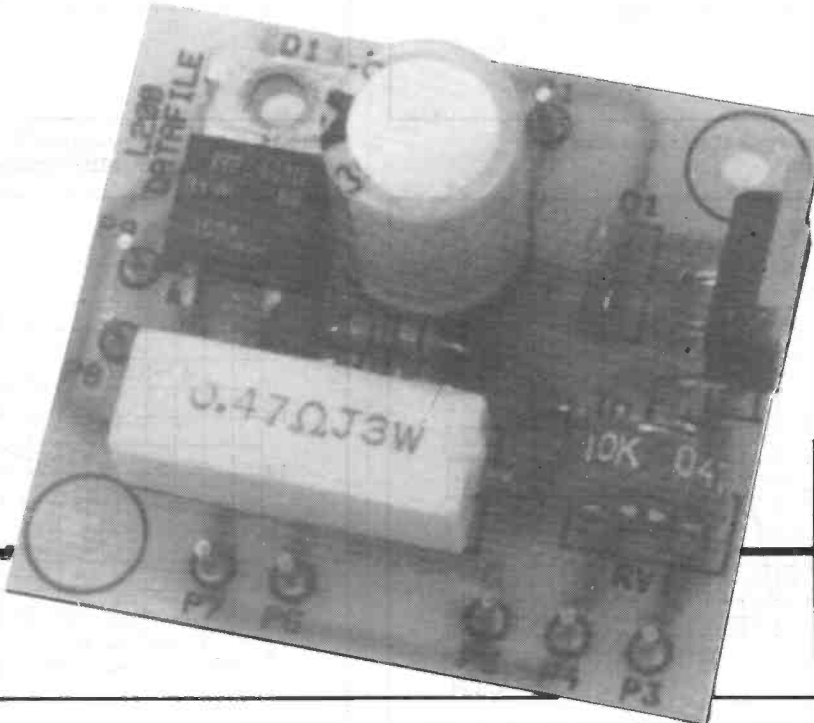
The following new items (which are included in the kit) are also available separately:

Logic Probe Case **Order As JX57M**

Logic Probe Label **Order As JX58N**

DATA FILE

L200 ADJUSTABLE VOLTAGE/CURRENT REGULATOR



'Data Files' are intended as 'building blocks' for constructors to experiment with and the components supplied provide a good starting point for further development.

FEATURES

★ **Adjustable output current** ★ **Adjustable output voltage** ★ **Low quiescent current** ★ **Short circuit protection** ★ **Thermal overload protection**

APPLICATIONS

★ **Power supplies** ★ **Battery chargers** ★ **DC–DC converter**

Parameter	Conditions	Min.	Typ.	Max.
DC input Voltage	Absolute Maximum			40V
Quiescent Current Drain (pin 3)	Input Voltage (V_i) = 20V		4·2mA	9·2mA
Output Voltage Range	Output Current = 10mA	2·85V		36V
Operating Junction Temperature Range (L200C)	Absolute Maximum	−25°C		+150°C
Line Regulation	V_i = 8V to 18V, V_o = 5V	48dB	60dB	
Dropout voltage between pins 1 and 5	Output Current = 1·5A $\Delta V_o \leq 2\%$		2V	2·5V
Reference Voltage (pin 4)	Input Voltage (V_i) = 20V Output Current (I_o) = 10mA	2·64V	2·77V	2·86V

Table 1. L200 typical electrical characteristics.

Introduction

The L200 is a monolithic IC designed for programmable voltage and current regulation. Voltage outputs between 2·85V and 36V may be accommodated, at currents of up to 2A. The device is supplied in a 5-pin package; the IC pin-out is shown in Figure 1. The L200 has internal protection to minimise the possibility of damage to the device; this comprises current limiting, power limiting, thermal shutdown and input over-voltage protection (up to 60V for 10mS). Table 1 shows typical electrical characteristics for the device. In addition some typical performance figures are shown in Figure 2.

General Description

As can be seen from the block diagram shown in Figure 3, the L200 regulator uses a relatively sophisticated design. The device may be used in several different configurations to provide voltage or current regulation.

Current limiting is controlled by connecting a resistor between pin 2 and pin 5 of the L200. The current limit

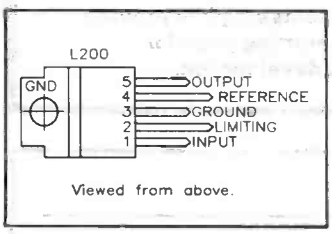


Figure 1. L200 IC pinout.

threshold is approximated by the expression:

$I_o = V_{sc} \div R_{sc}$

where:

I_o = Output Current (A)
V_{sc} = Current Limit Sense Voltage (V)
R_{sc} = Resistance between pin 5 and pin 2 (Ω)

The current limit sense voltage is variable depending on several factors including load and temperature but is typically 0·45V.

Power dissipation is controlled by the internal Safe Operating Area (SOA) protection circuitry of the L200. The device can supply a current of up to 2A as long as the input/output differential voltage is less than 20V. With differential

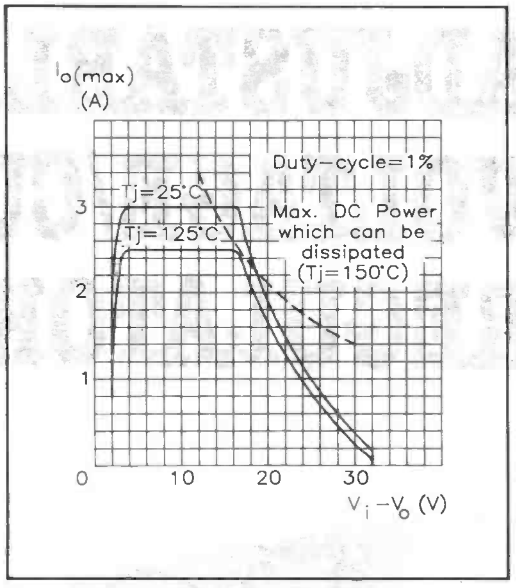


Figure 2a. Typical safe operating area protection.

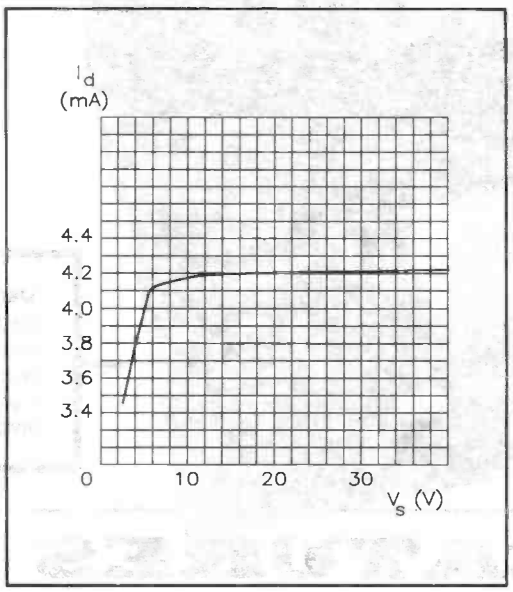


Figure 2b. Quiescent current (I_d) vs. voltage (V_s).

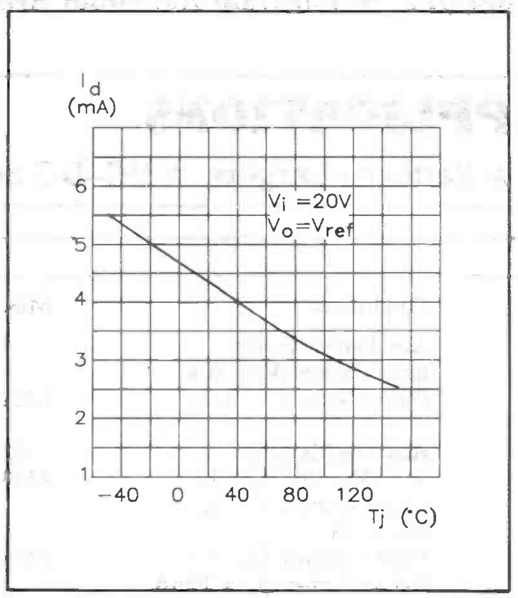


Figure 2c. Quiescent current (I_d) vs. junction temperature (T_j).

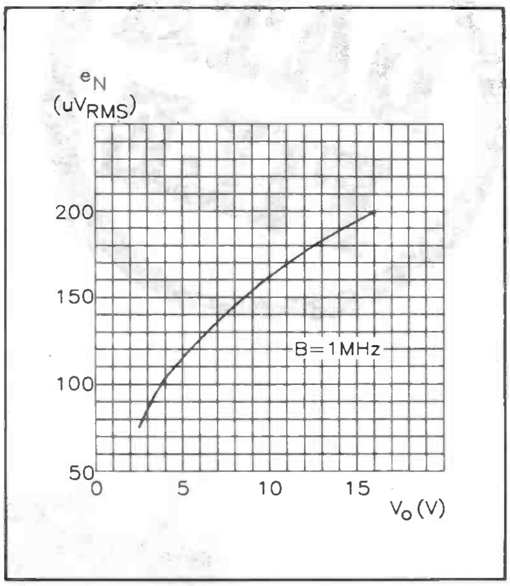


Figure 2d. Output noise voltage (°N) vs. output voltage (V_o) for 1MHz bandwidth.

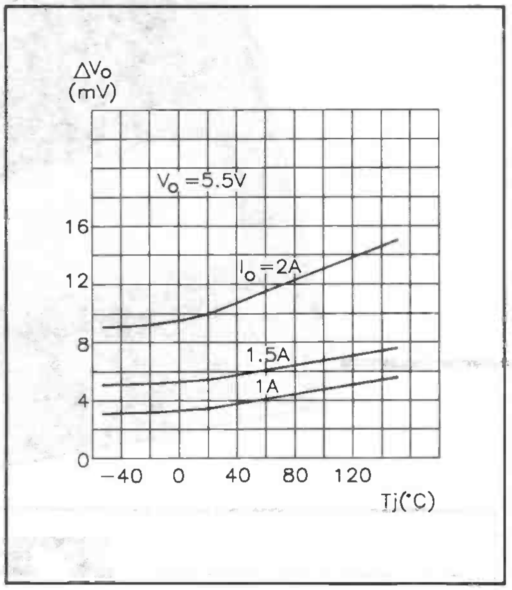


Figure 2e. Voltage load regulation (ΔV_o) vs. junction temperature (T_j).

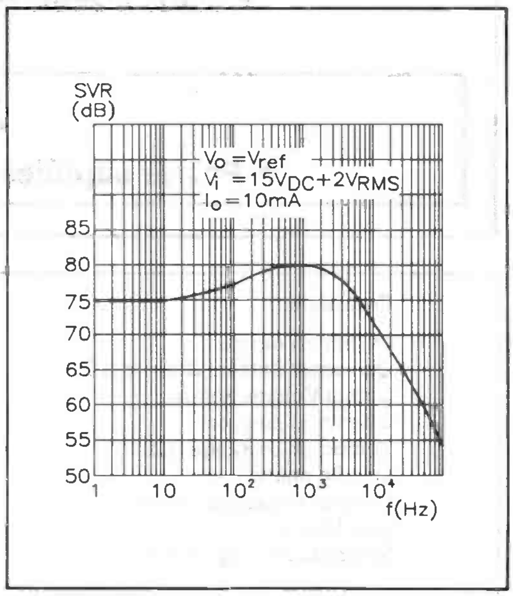


Figure 2f. Supply voltage rejection (SVR) vs. frequency (f).

voltages above 20V the maximum current output drops considerably; if this value is exceeded, then the SOA protection limits the output current so as to reduce power dissipation and prevent damage to the device.

Output voltage is determined by the value of the resistors connected between pin 3 & pin 4 and pin 4 & pin 2 of the device. The final output voltage may be approximated by the expression:

$V_o = V_{ref}(1 + (R2 \div R1))$

where:

V_o = output voltage (V)
V_{ref} = reference voltage on pin 4 (V)
R1 = resistance between pin 4 & pin 3 (Ω)
R2 = resistance between pin 2 & pin 4 (Ω)

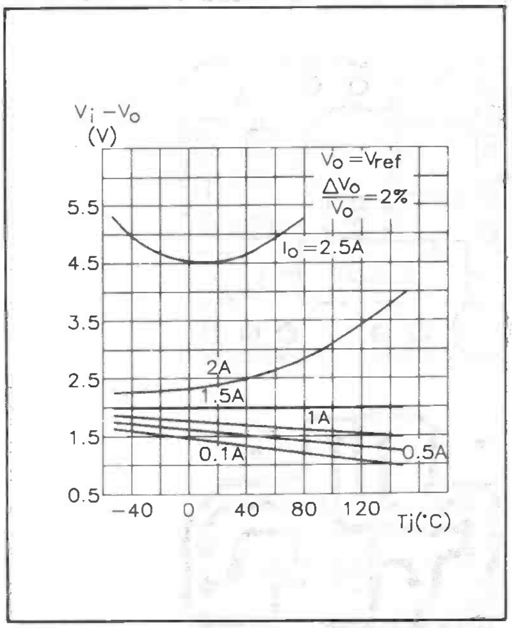


Figure 2g. Dropout voltage ($V_i - V_o$) vs. junction temperature (T_j).

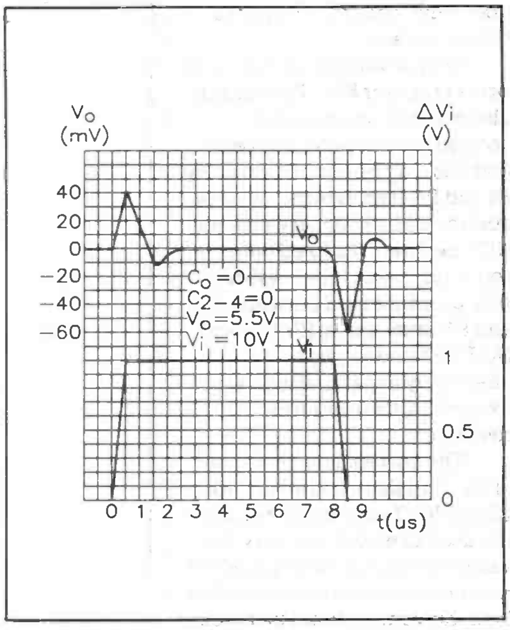


Figure 2h. Voltage transient response.

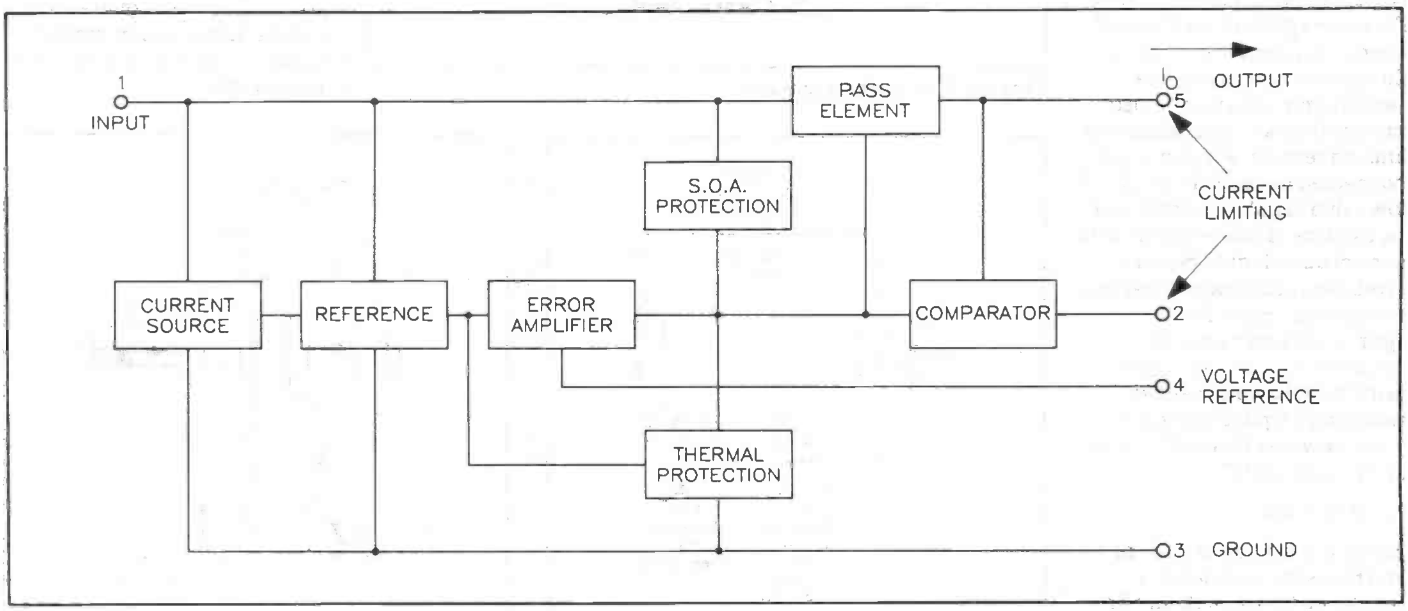


Figure 3. L200 block diagram.

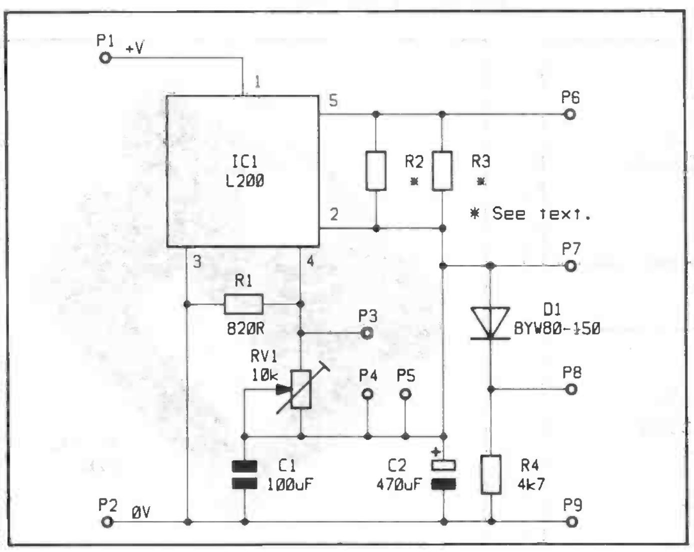


Figure 4. Module circuit diagram.

For the purpose of approximate calculation, V_{ref} may be taken at a typical value of 2·77V although in practice this figure may vary very slightly.

Kit Available

A kit of parts is available for a basic application circuit using the L200 regulator IC. The kit includes a high quality fibreglass PCB with a printed legend to aid component positioning. Figure 4 shows the circuit diagram of the module and Figure 5 shows the legend. To allow the module to be as versatile as possible, some of the component positions on the PCB are left open, so that the parameters of the module may be determined by the user. In particular, the values of resistors R2 and R3 (which determine the current limiting threshold of the regulator) are subject to selection, depending on the individual application.

For connection information reference should be made to the wiring diagram shown in Figure 6. Input connections to the module are made to P1 (Input +V) and P2 (0V). Output connections are made to P8 (Output +V) and P9 (0V).

To maintain correct regulation, it is important that the input/output differential voltage is never allowed to fall below the regulator dropout voltage. The dropout voltage may vary but as a general rule, it is recommended that the input voltage is always at least 4V above the maximum required output voltage.

Output voltage control is via preset resistor RV1. Provision is also made for an external voltage control potentiometer and this may be connected to P3, P4 and P5. If an external voltage control is used, then RV1 should NOT be fitted. If a fixed output is required, then a fixed resistor may be connected between P3 and P4; once again, RV1 should NOT be fitted as this is effectively in parallel with any external voltage control resistors.

The current limit threshold of the module is set by resistors, R2 and R3. Two Parallel resistors are used to enable the very low values of resistance required for higher current limit thresholds to be achieved. It should be noted that R3 may either be a 0·6W or a 3W type and a separate set of holes is provided for both types. For some applications it may of course be possible to achieve the correct value using one resistor only. Provision is also provided for an external current limiting resistor, which may be connected between P6 and P7. A low value variable resistor may be used for variable current limit control but at higher current levels the resolution will become increasingly poor. The approximate current limit threshold may be calculated using the following method, assuming a typical voltage of 0·45V between P6 and P7 (pin 5 and pin 2 of the IC):

$I_o = 0{\cdot}45 \div Rsc$

where I_o is the output current and Rsc is the total parallel resistance between P6 and P7 (R2, R3 and any external current limit resistor in parallel) in ohms.

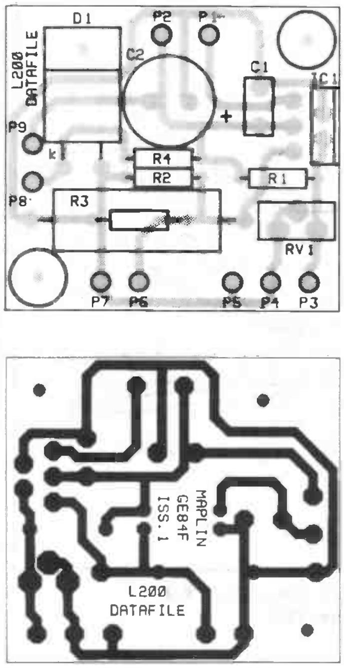


Figure 5. PCB legend and track.

Heatsink

At higher power levels, it is necessary to use a suitable heatsink to prevent IC1 from reaching excessive temperatures. The type of heatsink used is dependant on the individual application. In some cases, a large area of metal such as the side of an enclosure may already be available. The tab of the L200 is at 0V potential and will bolt directly to a heatsink if this is also at 0V potential; however, in some cases it may be necessary to isolate the tab of the L200 (if the heatsink is not at 0V potential). An insulating bush and a greaseless or mica washer should be used for this purpose, as illustrated in Figure 7.

Typical heatsinks for use with the L200 up to 20W are shown in Table 2. The parameters shown are intended to provide general guidelines and the power ratings may be found to vary slightly in different applications.

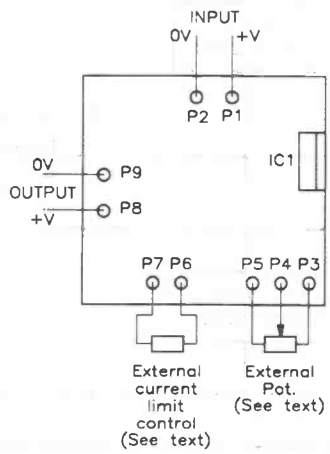


Figure 6. Wiring diagram.

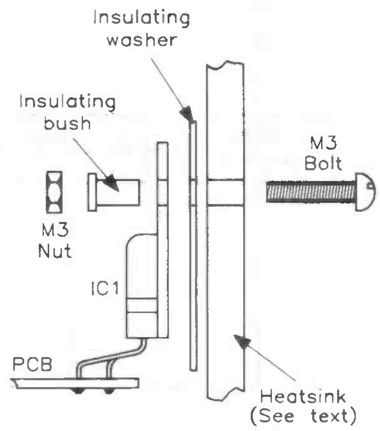


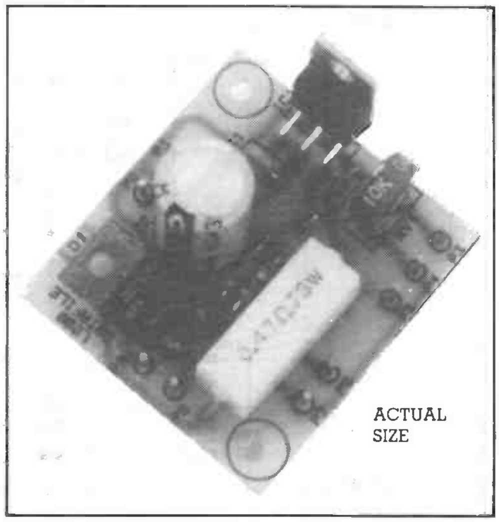
Figure 7. Heatsinking.

Regulator Power Dissipation	Heatsink (Stock Code)
Up to 500mW	No heatsink required
500mW–1·5W	Vaned Heatsink TO126 (JX21X)
1·5W–3·5W	High Power Twisted Vane (FG55K)
3·5W–10W	Heatsink 4Y (FL41U)
10W–20W	Flat Heatsink (FL42V)

Table 2. Typical heatsinks for the L200.

Parameter	Conditions	
Input Voltage		5V–35V
Output Voltage		2·8–32·8V
Output Current (Max)	For Input/Output Differential Voltage Less than 20V	2A
Quiescent Current (Max)		11mA

Table 3. Specification of prototype module.



ACTUAL SIZE

The assembled L200 module.

Please note: any of the higher power heatsinks are also suitable for lower power applications and where the power dissipation is variable, the maximum power dissipation under worst case conditions should be used for the purposes of selecting a heatsink.

In addition to heatsinking for the L200, it is also recommended that a small heatsink (such as JX21X) is used for D1 when the module is used at current levels in excess of 750mA; in this case D1 should be mounted vertically and the heatsink bolted to the tab. Table 3 shows the specification of the prototype module.

L200 VOLTAGE/CURRENT REGULATOR PARTS LIST

RESISTORS: All 0·6W 1% Metal Film (unless specified)

R1	820Ω	1	(M820R)
R2	*See Text*	1	
R3	*See Text*	1	
R4	4k7	1	(M4K7)
RV1	Vert Encl Preset 10k	1	(UH16S)

CAPACITORS

C1	Monores Cap 100nF	1	(RA49D)
C2	PC Elect 470μF 35V	1	(FF16S)

SEMICONDUCTORS

IC1	L200	1	(YY74R)
D1	BYW80-150	1	(UK63T)

MISCELLANEOUS

P1-9	Pins 2145	1 Pkt	(FL24B)
	L200 PCB	1	(GE84F)
	Instruction Leaflet	1	(XT00A)
	Constructors' Guide	1	(XH79L)

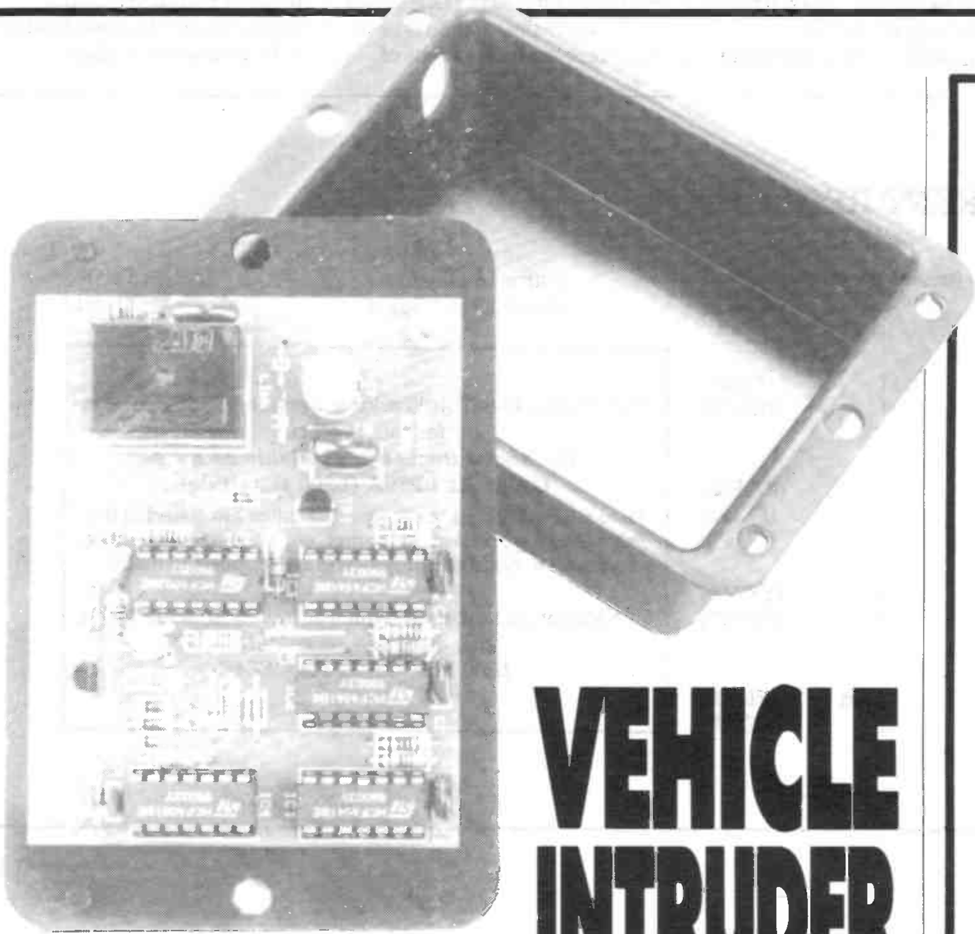
The Maplin 'Get-You-Working' Service is not available for this project.

The above items are available as a kit.
Order As LP69A (L200 Data File)

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.

The following new item (which is included in the kit) is also available separately:
L200 PCB **Order As GE84F**

Many projects from Maplin's range of kits have proved to be very popular over the years, but some of the older ones need updating and improving to meet the higher modern standards expected of them, and to use the current technology now available. This newly developed design supersedes the original Car Burglar Alarm Kit LW78K, which was first published in the September to November issue of the Maplin magazine in 1982. The new unit now has several additional features which are only found on the more expensive ready-made alarms available on today's market.



VEHICLE INTRUDER ALARM

by Chris Barlow

Original Car Burglar Alarm (Kit LW78K)

Features:

★ Exit Delay
★ Entry Delay
★ Car Horn Time Out
★ Compact Design
★ Inexpensive

New Vehicle Intruder Alarm (Kit LP65V)

Extended Features:

★ Exit Delay
★ Entry Delay
★ Status Indicator
★ Exit / Entry Sounder
★ Two Trigger Inputs
★ Pulsed Car Horn with Time Out
★ Large 10 Amp Switching Capacity
★ Function Options
★ Compact Design Retained
★ Same Super Low Price

Specification of Prototype

Exit delay:	30 Seconds	
Entry delay:	15 Seconds	
Car horn time out:	30 Seconds	
Car horn pulses:	1 Second	
Switching capacity:	10 Amps	
Status indicator:	Red Light Emitting Diode (LED)	
	LED off	= Alarm in standby mode
	LED flashing	= Alarm set
	LED on	= Alarm triggered
Exit/Entry sounder:	Miniature Buzzer	
	Buzzer on	= Alarm arm activated (Exit)
	Buzzer off	= Alarm set
	Buzzer on	= Alarm triggered (Entry)
Power supply:	Car battery	(12V negative earth vehicles)
DC voltage range:	10V to 14V	
Exit current:	37 mA	(LED off and Buzzer on)
Alarm set current:	5 mA average	(LED flashing and Buzzer off)
Entry current:	47 mA	(LED on and Buzzer on)
Pulsed horn current:	60 mA average	(LED on and Buzzer on)

Introduction

The need for an inexpensive but effective vehicle intruder alarm is becoming increasingly important as time passes. No alarm can offer complete protection against the determined professional thief, but it will act as a deterrent to the small-time thief or joyrider. This new improved version of Maplin's popular Car Alarm is, like most simple car alarms, triggered by the door switches used to operate the courtesy light(s). However, provision for an extra triggering device has been included, which could be for example an ultrasonic movement detector.

The vehicle intruder alarm will only work when fitted to a vehicle with a 12 volt negative earth system, which fortunately covers some 99% of all cars manufactured since the early 1960's.

The principle of operation is that the alarm is activated upon leaving your vehicle by the arming switch. This can take the form of a concealed push, toggle, or slide switch. However, a key switch will

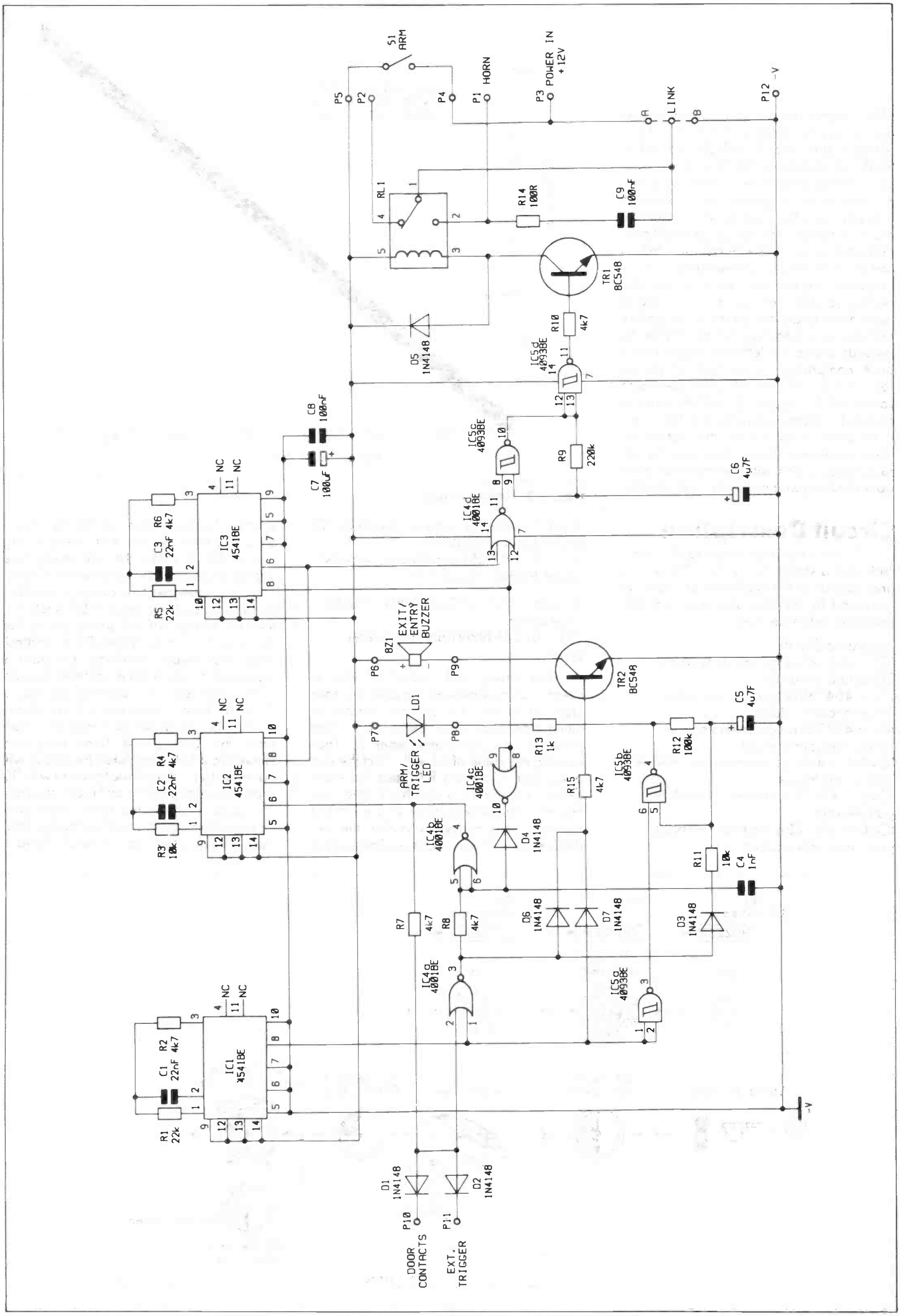


Figure 1. Circuit diagram.

offer a higher degree of security and does not have to be concealed. You then have 30 seconds to clear the vehicle and shut all the doors, and during this time a buzzer will be sounding. After this exit delay the alarm is ready to be triggered, and a flashing indicator can be used to show that the alarm is armed and act as an additional deterrent to the potential car thief. When one or more doors are opened the alarm is triggered; the indicator stays on and the buzzer sounds. You have a 15 second entry delay to deactivate the alarm before the horn begins to pulse on and off for 30 seconds. If a door is left open a continuous cycle comprising 15 seconds of silence followed by 30 seconds of pulsed horn sound will be repeated until the door is shut, or the alarm is deactivated. However, if the alarm is not deactivated but all the doors have been closed the unit will return to its ready mode with the indicator once again flashing waiting for the next intruder.

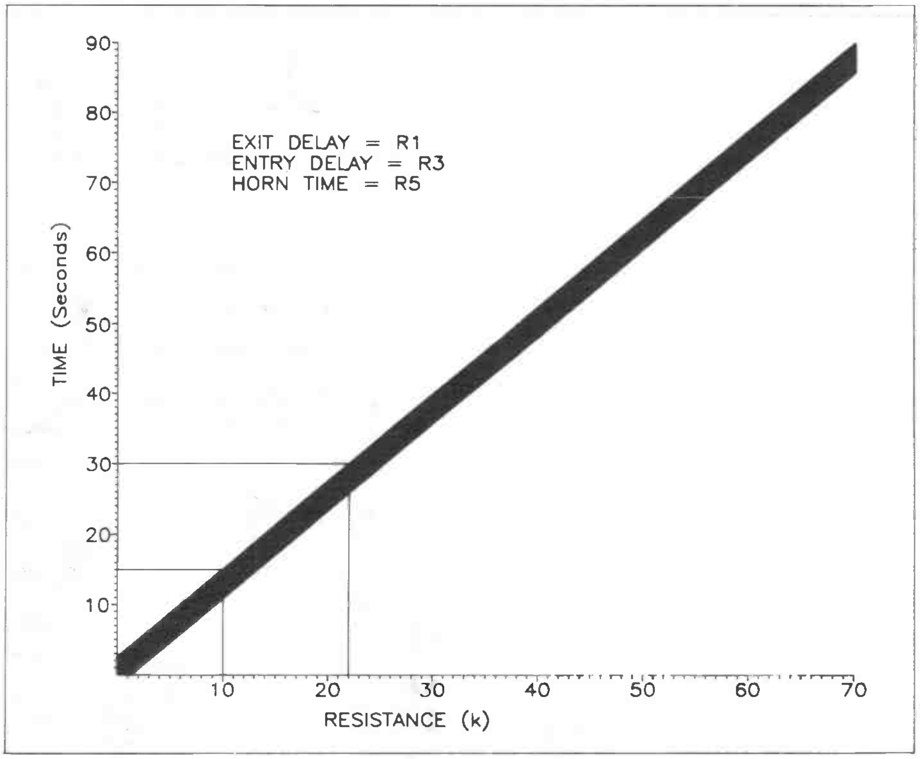


Figure 2. Timing chart.

Circuit Description

A circuit diagram detailing the complete unit is shown in Figure 1. The timing and control of the sequence of events is governed by the logical functions of the following active devices:

Integrated Circuits:
IC1 = 4541BE programmable timer, 30 second exit delay.
IC2 = 4541BE programmable timer, 15 second entry delay.
IC3 = 4541BE programmable timer, 30 second horn time out.
IC4 A, B = 4001BE quad two-input NOR gate, alarm trigger.
IC4 C = 4001BE quad two input NOR gate, re-arm.
IC4 D = 4001BE quad two input NOR gate, horn active output.
IC5 A, B = 4093BE quad two input NAND schmitt trigger, LED flasher.
IC5 C, D = 4093BE quad two input NAND schmitt trigger, relay pulser.

Transistors: TR1 = BC548 NPN transistor, relay driver.
TR2 = BC548 NPN transistor, buzzer driver.

The timing and control of various events can be modified. To alter the time lapse of an event is a simple matter of fitting a different value resistor (R) for that particular programmable timer IC. Thus altering the value of R1 will affect the exit delay time, changing R3 alters the entry delay, and R5 fixes the horn time, see Figure 2. The only instance where it might become really necessary to alter the exit delay period is if your vehicle is fitted with a courtesy light extender unit. To accommodate this *increase* the exit delay timing resistor R1 to make the exit delay time slightly longer than the light switch-off time.

The sequence of the events is modified by omitting certain diodes. If D7 is left out, then the buzzer will not sound during the 30 second exit time. When D6 is omitted, the buzzer remains silent when the alarm is triggered. Finally, if D4 is not fitted the end of the alarm sequence is altered, see Figure 3. With D4 in circuit and all car doors closed, the alarm will automatically reset after the 30 second horn time out. However, if D4 is *not* fitted the alarm will not reset, but will continue to sound with 30 second pauses until the unit is deactivated.

Table 1 shows the major logic conditions present in the circuit during the standard configuration (i.e. all diodes fitted).

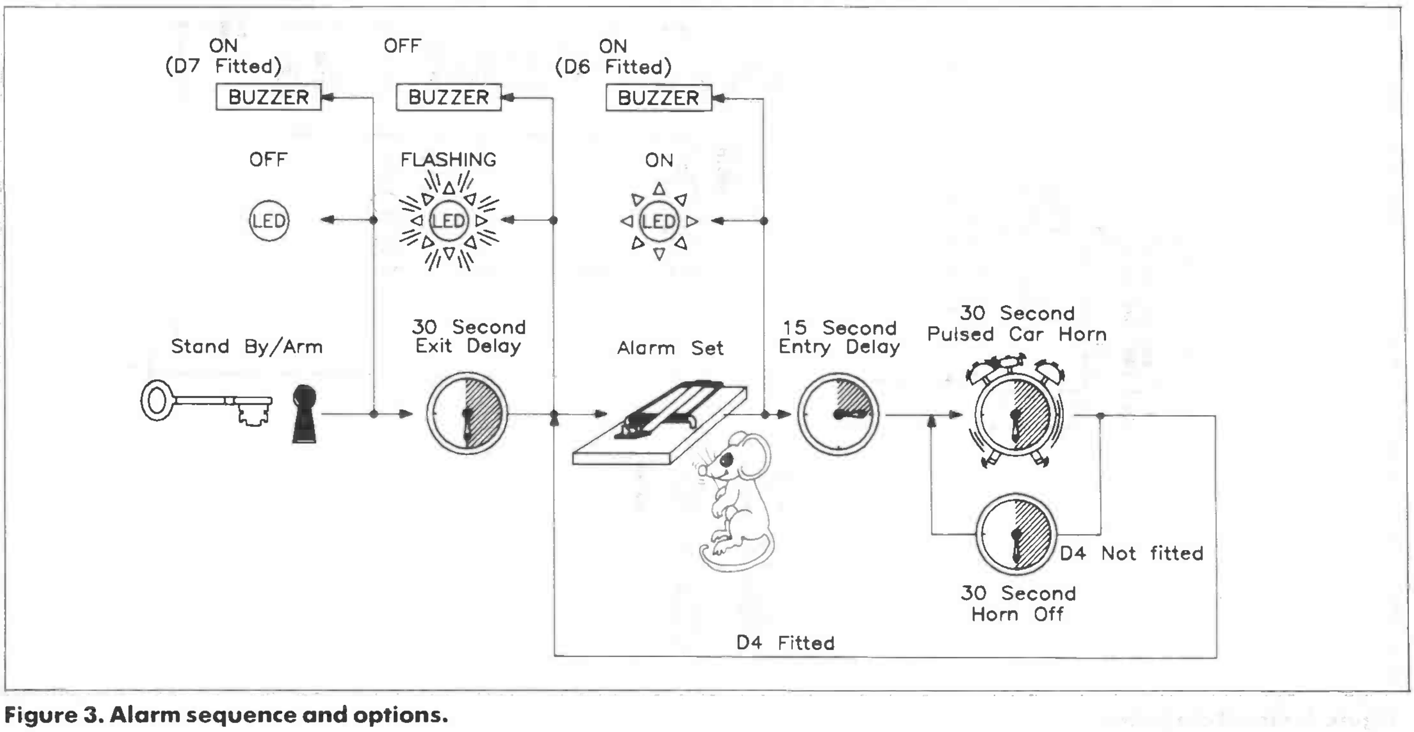


Figure 3. Alarm sequence and options.

Pin No.	Standby	Arm + 30 Second Exit Delay	Alarm Set	Trigger + 15 Second Entry Delay	30 Second Pulsing Horn
P1	–	–	–	–	1 LKA 0 LKB P1
P2	–	1 LKA 0 LKB	1 LKA 0 LKB	1 LKA 0 LKB	1 LKA 0 LKB P1
P3	1	1	1	1	1
P5	–	1	1	1	1
P8	–	1	+12/10V P.5	+10V	+10V
P9	–	0	1	0	0
P10/11	–	1	1	0	0
P12	0	0	0	0	0
IC1-8	–	1	0	0	0
IC2-6	–	1	1	0	0
IC2-8	–	1	1	1	0
IC3-8	–	0	0	0	1 PE
IC4-3	–	0	0	1	1
IC4-4	–	1	1	0	0
IC4-10	–	1	1	1	0 PE
IC4-11	–	0	0	0	1
IC5-3	–	0	1	1	1
IC5-4	–	1	1/0 P.5	0	0
IC5-10	–	1	1	1	1/0 P1
IC5-11	–	0	0	0	0/1 P1
TR1-C	–	1	1	1	1/0 P1

Key

– = not applicable
0 = Logic LOW (0 Volts)
1 = Logic HIGH (+12 Volts)
0/1 = LOW going HIGH
1/0 = HIGH going LOW
LKA = Link A on PCB (10 Amps)
LKB = Link B on PCB (10 Amps)
P1 = Pulsing every second
P5 = Pulsing every half second
PE = Pulse at end of time period
IC1-11 = IC pin number
TR1-C = Transistor collector

Table 1. Logic conditions.

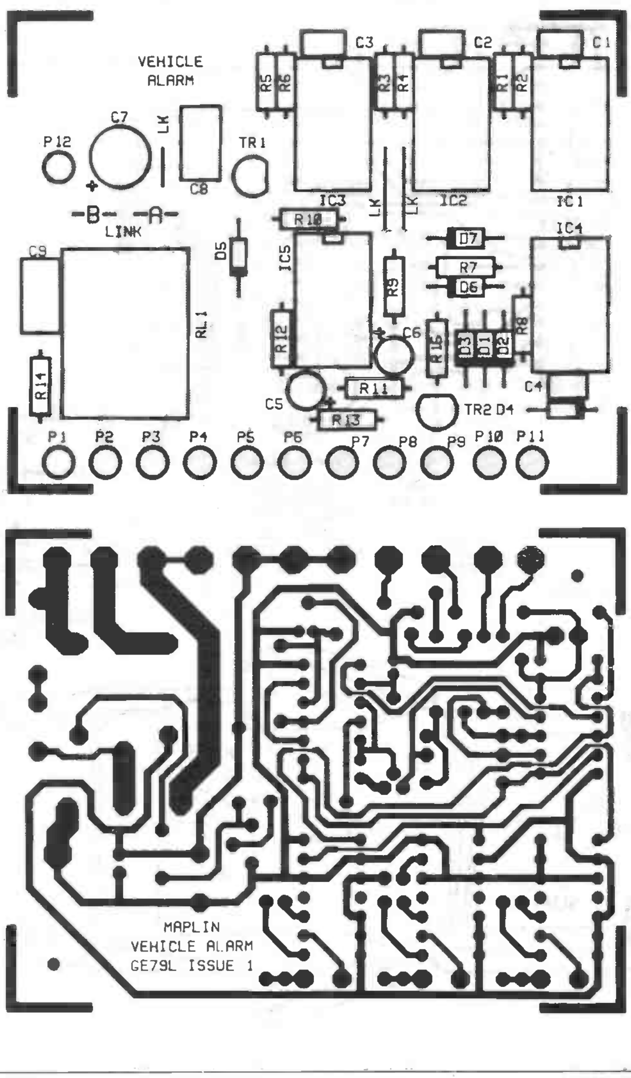


Figure 4. PCB Legend.

PCB Assembly

All the information required to help you with soldering and assembly techniques, should you need it, can be found in the Constructors' Guide included in the kit (also separately available as stock code LP65V). Removal of a misplaced component can be fairly difficult without causing too much damage, so *please* double-check each component type, value and its polarity where appropriate, before soldering! The printed circuit board (PCB) has a legend to assist you in correctly positioning each item, see Figure 4. Install, solder and trim the excess leads from all the components commencing with the resistors and capacitors, and finishing with the IC sockets, diodes and transistors last. Only after all other components have been fitted do you then carefully insert the relevant ICs into their sockets making sure to correctly align the pin number 1 marker at one end of each DIL package with the white block on the legend. All the ICs in this design are CMOS types which can be at risk from static electric charge during handling, so do not remove them from their protective packaging until they are needed and handle them carefully when you do so. The off-board items LD1, BZ1 and S1 can be temporarily soldered to the appropriate terminals for testing, see Figure 5.

Finally, it is *very important* that you fit a 10 Amp rated wire at link A or B, *not both!* This link is used to set the type of horn switching employed by your vehicle, and you can determine which is correct using the following procedure:

1. If the horn has one of its terminals connected directly to earth (vehicle body) link A must be fitted, see Figure 5.
2. If the horn has one of its terminals connected directly to the +12V supply link B must be fitted, see Figure 6.

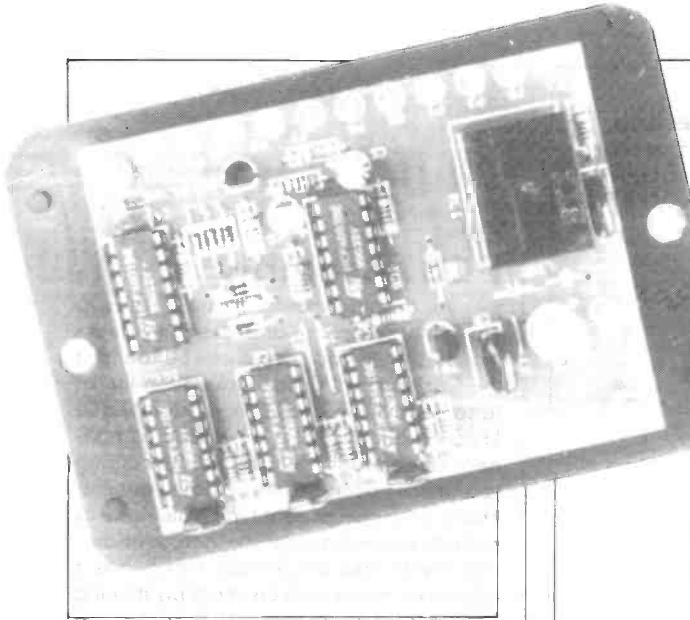
In practice it was found that most car horns have the +12V supply switched and the '–' side connected to earth, so link A was used in the majority of installations.

This completes the assembly of the PCB and you should now check your work very carefully making sure that all the solder joints are sound. It is also very important that the solder side of the circuit board doesn't have any trimmed component leads standing proud by more than 2mm, as this may result in a short circuit.

Testing

All the tests can be made with a minimum of equipment. You will need a multimeter and a regulated +12V DC power supply capable of supplying up to 250mA. The readings were taken from the prototype using a digital multimeter; some of the readings you obtain may vary slightly depending upon the type of meter employed.

The first test is to ensure that there are no short circuits before you connect the



Completed PCB

power supply. Set your meter to read kΩ on its 20kΩ resistance range and connect the test probes to terminal pins P3 and P12. Switch on S1 ('ARM') and with the probes either way round a reading greater than 4kΩ should be obtained.

Next, select a suitable range on your meter that will accommodate a 250mA DC current reading and place it in the positive power line (P3). Connect your +12V power supply and switch on, a current reading of approximately 37mA should be observed. This current reading should continue for the 30 second exit delay time with the LED indicator, LD1, off and the buzzer, BZ1, on. At the end of this time period the indicator should start to flash and the buzzer should stop, resulting in an average current reading of approximately 5mA.

The alarm is now set and waiting to be triggered. This can be achieved by the momentary connection of terminal pin P10 or P11 to P12 (−V earth). When triggered the indicator should stay on, the buzzer sound and the current increase to approximately 47mA over the 15 second entry delay period. The relay RL1 should then start to pulse on and off approximately every second for 30 seconds increasing the average current to 60mA. If link A has been fitted then pulses of +12V should appear on P1, while link B produces momentary grounding. At the end of this period the alarm should return to its ready mode with its indicator flashing and the average current back at 5mA.

This completes the testing of the unit. You should now remove your DC power supply and multimeter. If you have experienced any difficulties in obtaining the correct results the circuit logic conditions shown in Table 1 should be of some help in tracing the fault.

Installation and Wiring

Before the completed circuit board is installed into a vehicle it must first be enclosed in a non-conductive protective housing. The PCB is designed to fit into a small plastic box and base type 2 (stock code YN36P). It has a loose fitting base which is secured when the box is fixed to a panel or bulkhead. Alternatively, the base

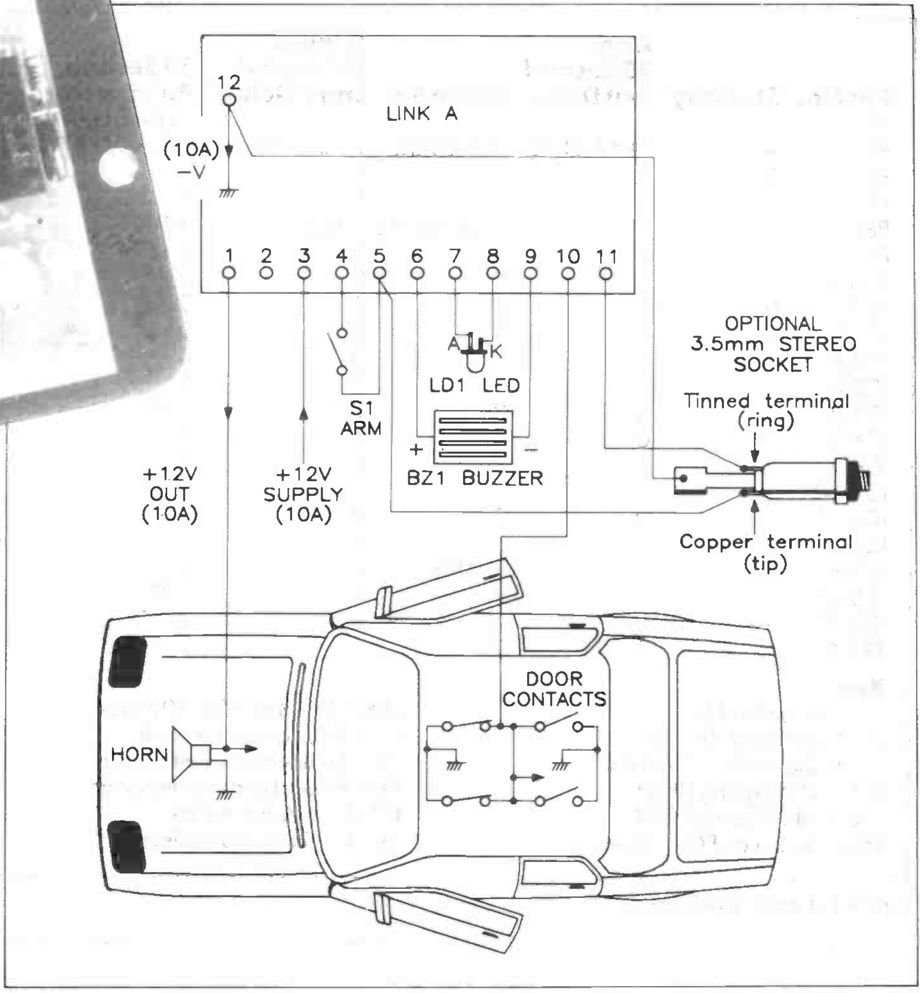


Figure 5. Link A wiring.

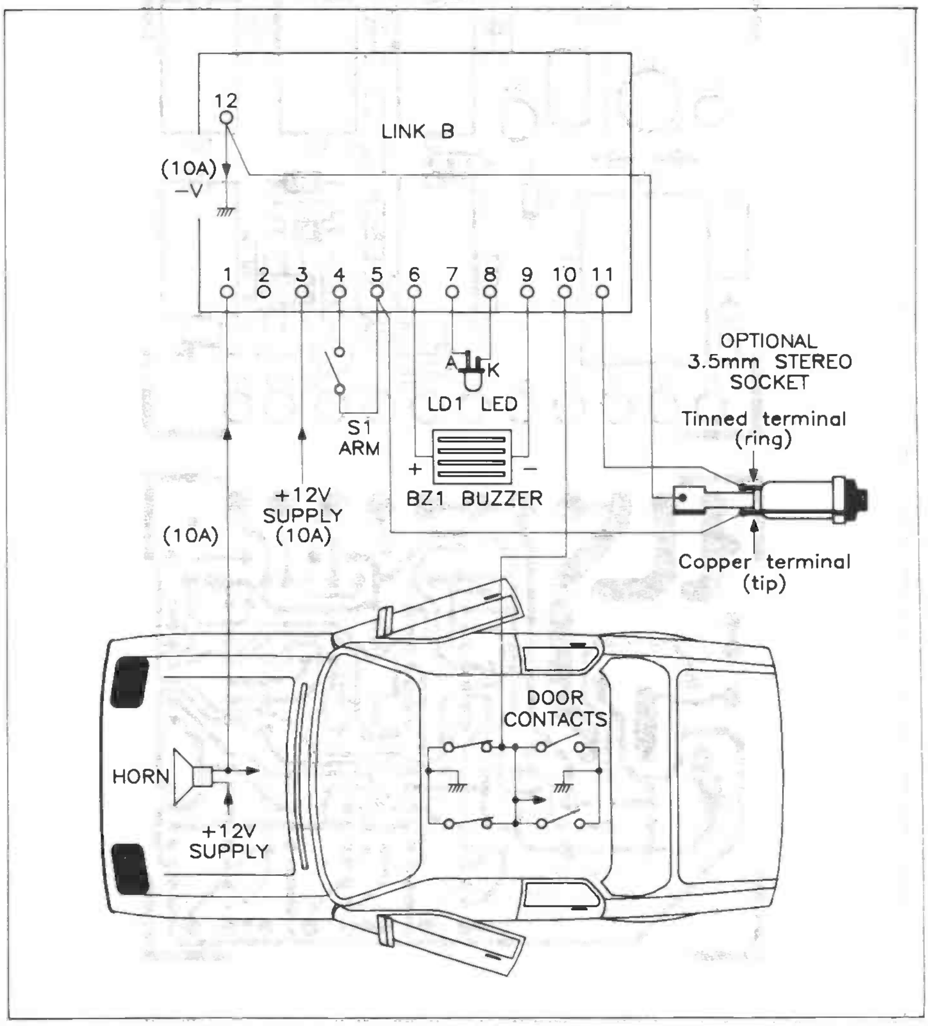


Figure 6. Link B wiring.

may be bolted to the box if the unit is to be left floating amongst the general interior wiring of your vehicle.

The additional off board components, arming switch S1, LED indicator LD1 and buzzer BZ1 are wired to the alarm using coloured general purpose hook-up wire (7/0·2). If you are not using a key switch S1 must be mounted in a concealed position, e.g. fitted under the dashboard or in the glove compartment etc. However, the opposite is true when positioning the LED indicator, this needs to be seen if it is to act as an additional deterrent. The buzzer should be placed so that it can be clearly heard by you and your passengers.

Make sure that you have the correct link (A or B) fitted and with reference to Figure 5 or 6 proceed as follows:

1. Ensure that the arming switch S1 is OFF (Alarm deactivated).
2. Find a convenient fuse-protected positive supply source, and using 10A *red* insulated wire connect the +12V to pin P3.
3. Using 10A *black* insulated wire, connect the negative return on P12 to a metal part of the vehicle, or directly back to the negative terminal of the battery.
4. Double check which horn wiring is correct for your type of vehicle, see Figures 5 and 6. Then connect a 10A insulated wire from P1 to the horn as shown.
5. Using hook-up wire connect the trigger input P10 to the courtesy light door contacts.

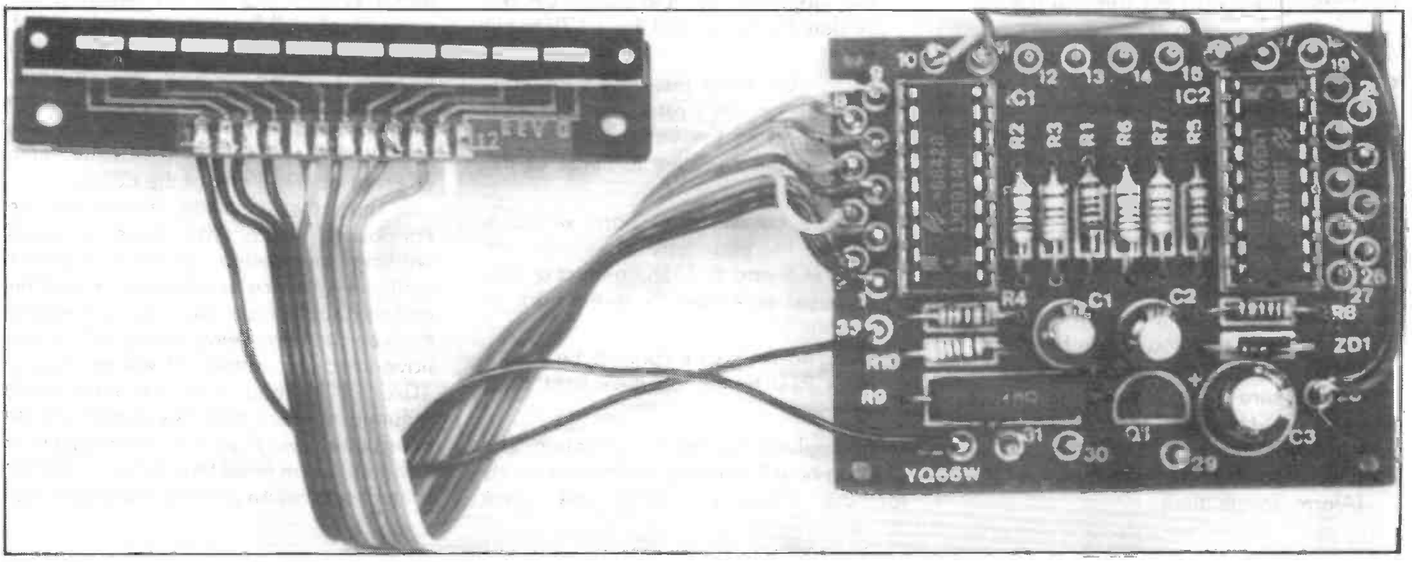
This completes the basic installation. The unit can now be armed and tested ready for use. However, there are some additional options that can be fitted to the alarm system, the first of which is the addition of a 3·5mm stereo jack socket, supplying a switched +12V to a remote triggering device such as an ultrasonic movement detector. When triggered, the output of this can be taken via the jack socket back to P11 which has the same effect as opening one of the doors.

The other addition should not be considered unless you have a good working knowledge of your vehicle's ignition system. It is possible to interrupt this and so disable the engine, thus preventing the vehicle from being driven off. If you have fitted link A then P2 will produce a 10A +12V feed until the horn starts pulsing, at which time this output will be interrupted every second. Alternatively, if link B has been fitted then P2 is connected to the earth return until the horn starts up.

VEHICLE ALARM PARTS LIST

RESISTORS: All 0·6W 1% Metal Film			
R1,5	22k	2	(M22K)
R2,4,6,7,8, 10,15	4k7	7	(M4K7)
R3,11	10k	2	(M10K)
R9	220k	1	(M220K)
R12	100k	1	(M100K)
R13	1k	1	(M1K)
R14	100Ω	1	(M100R)
CAPACITORS			
C1,2,3	Mylar 0·022µF	3	(WW19V)
C4	Mylar 0·001µF	1	(WW15R)
C5,6	PC Elect 4·7µF 63V	2	(FF03D)
C7	PC Elect 100µF 25V	1	(FF11M)
C8,9	Mylar 0·1µF	2	(WW21X)
SEMICONDUCTORS			
IC1,2,3	4541BE	3	(QQ47B)
IC4	4001BE	1	(QX01B)
IC5	4093BE	1	(QW53H)
TR1,2	BC548	2	(QB73Q)
D1-7	1N4148	7	(QL80B)
LD1	LED Red	1	(WL27E)
MISCELLANEOUS			
RL1	12V/10A Min Relay	1	(JM67X)
P1-12	Pin 2141	1 Pkt	(FL21X)
	Box and Base Type 2	1	(YN36P)
	DIL Socket 14-pin	5	(BL18U)
	Buzzer 12V	1	(FL40T)
	Table Light Switch	1	(FH94C)
	Vehicle Alarm PCB	1	(GE79L)
	Constructors' Guide	1	(XH79L)
	Vehicle Alarm Leaflet	1	(XK62S)
	Posiscrew M3 10mm	1 Pkt	(LR57M)
	Steel Nut M3	1 Pkt	(JD61R)
	Steel Washer M3	1 Pkt	(JD76H)
	Isoshake M3	1 Pkt	(BF44X)
OPTIONAL (not in kit)			
	Min Key Switch	1	(FE44X)
	Wire 3202 Black	1	(XR32K)
	Wire 3202 Red	1	(XR36P)
	16/0·2 Wire 10M Green	1	(FA29G)
	16/0·2 Wire 10M Orange	1	(FA31J)
	16/0·2 Wire 10M White	1	(FA35Q)
	16/0·2 Wire 10M Yellow	1	(FA36P)
	LED Clip Convex 5mm	1	(UK14Q)
	Piezo Electronic Siren	1	(YP11M)
	Stereo 3·5mm Ch Jk Skt	1	(FK03D)
	Alarm Sticker	1	(JR91Y)
	Self-Tap No.8 × ½in	1 Pkt	(BF69A)
	Isobolt M4 12mm	1 Pkt	(BF49D)
	Isonut M4	1 Pkt	(BF57M)
	Spring Washer M4	1 Pkt	(JD95D)

The above items, excluding Optional, are available as a kit:
Order As LP65V (Vehicle Alarm Kit)
The following item is also available separately but not shown in our 1991 catalogue:
Vehicle Alarm PCB **Order As GE79L**



DISPLAY DRIVER MODULE

by Dave Goodman

★ **Many Types of Display can be Driven**
★ **Choice of Driver Chips**
★ **Flashing Option**
★ **Easy to Build**

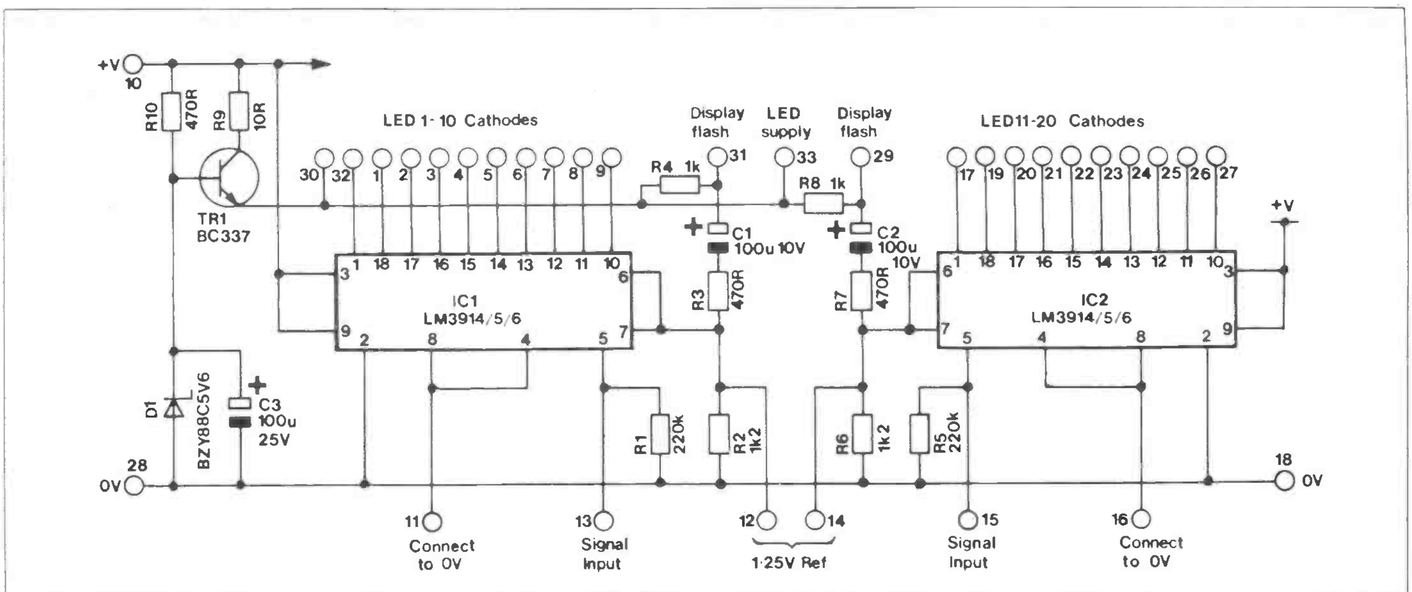


Figure 1. Circuit diagram

Many projects built by the Home Constructor require a LED display to give an indication or show a response to a set of circumstances. This article will describe a module which will drive up to 20 LED's and also show how to make those LED's flash on and off. Many different types of LED display can be used with this module and in addition to this, different driver chips can be used to give varying displays.

A dual display driver PCB for the LM3914-16 range of display driver IC's can be used for single DOT or sequential BAR mode control of the 20 LED's. Display brightness is adjustable and FLASH can be determined from any desired LED position. Three types of IC are available from MAPLIN's range which have identical operating characteristics but offer different response of input voltage to display output. Figure 5 is a graphic representation which shows the response curves of these IC's in BAR mode. Each of the LED's (1 to 10) are sequentially operated in turn as the input DC voltage is increased from approximately 50mV to 1.3V, and for the LM3914 a linear scale can be observed. For a logarithmic scale, the LM3915 is chosen, which increments each LED in 3dB steps and the LM3916 is suitable for VU displays.

Circuit Operation

IC1 (2) requires very little external components as all LED controlling elements are internal to the IC (see figure 7). Ten comparator output stages control each LED via an internal resistor ladder network, referenced to a 1.25V constant voltage source, and an increasing signal voltage applied to the high impedance voltage follower, switches each comparator in turn. Figure 1 shows the 5V regulator: R10, D1 and TR1, which feeds each anode of LED's 1 to 20, Either single LED's or common anode 10 LED displays can be used here, and R2 determines LED current or brightness. Reducing the value of R2 increases LED current (and vice-versa) and with the recommended value of 1k2, approximately 10mA flows through each LED. PCB pins 4 and 8

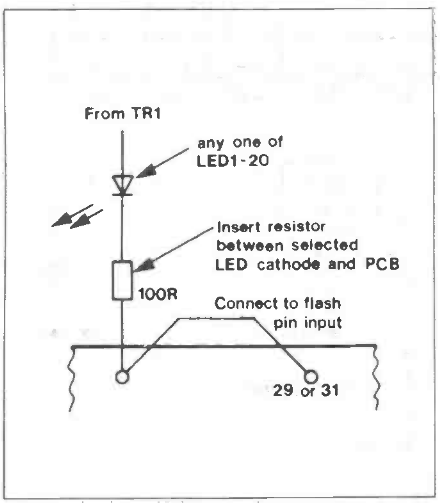


Figure 4. Connection for flashing mode

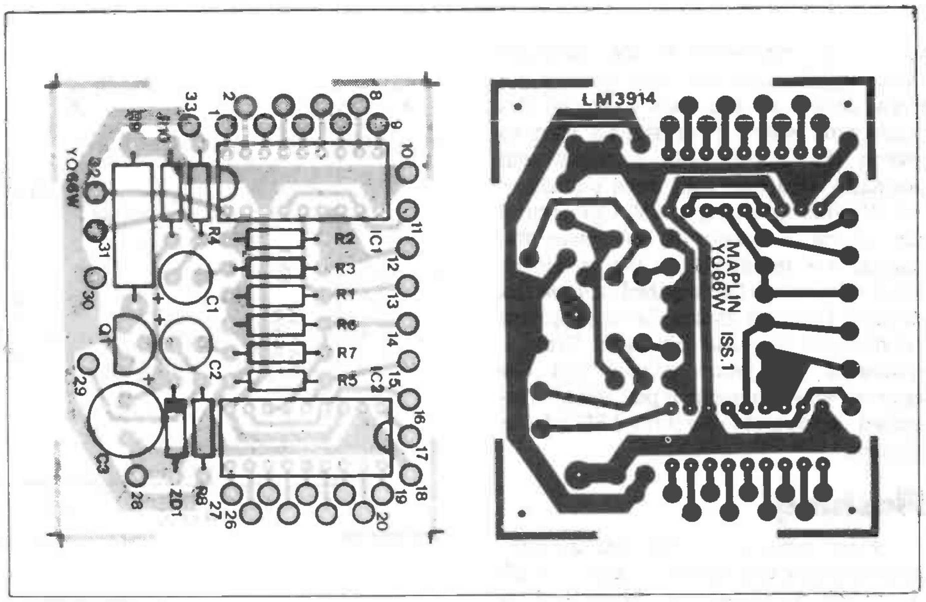


Figure 2. PCB track layout and overlay

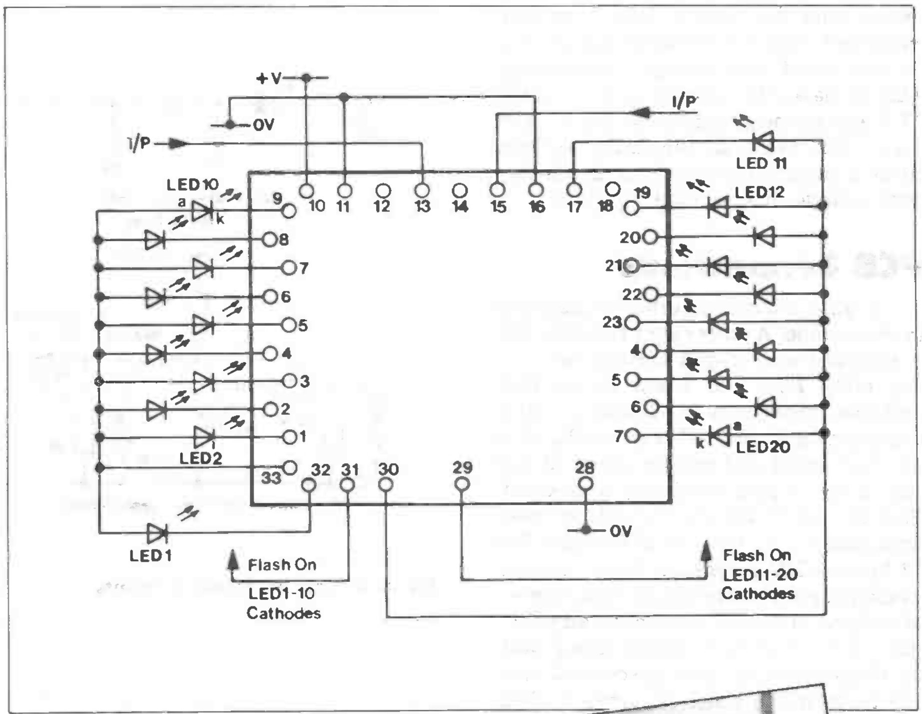
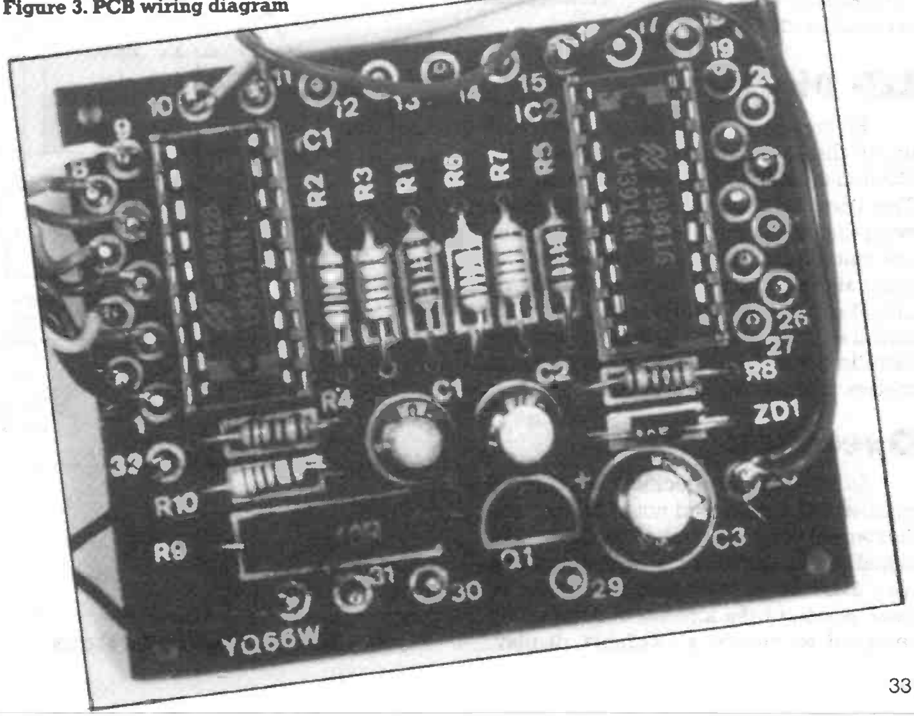


Figure 3. PCB wiring diagram



should be connected to 0V, although these inputs could be referenced positively above ground, thus changing the point with which input signals start to switch the LED's. LED 1 output will normally be active with input signals ≃ +0.1V when pin 11 is at 0V. Connecting pin 11 via a resistor to 0V raises the comparator threshold so that a higher input voltage will be required to drive the display. Figure 8 shows the appropriate connections to those pins and Table 1 indicates resistance values and the approximate minimum input voltage required to operate the first LED of the display.

Flashing

Flash input pin 31 (29) can be connected to any one (only) of LED's 1 to 10 (11 to 20) as shown in Figure 4. It is important to connect a 100Ω resistor in series with the chosen LED otherwise insufficient discharge current for C1 (C2) is developed. For example, connecting LED 10 via a 100Ω resistor to pin 9 on the PCB and connecting pin 9 to pin 31 flash input, will cause all ten LED's to flash twice a second and could signify display over voltage in a voltmeter project.

PCB Connections

Figure 3 shows external connections to the module. A power supply of 5 to 15V is required with 150mA current handling capability. Pins 1 to 9 and 33 are LED cathode connections to IC1 and pin 30 is the common anode +5V supply. Pin 31 is the flash input and can be wired to any one of the 10 pins previously mentioned. Pins 18 and 28 are common 0V connections and pin 10, the 5 to 15V supply. Pin 12 has a 1.25V reference output voltage available, pin 13 is the signal input terminal and pin 11 should be connected either directly to 0V or via a resistor (see Figure 8). Corresponding pins associated with IC2 perform the same functions as their counterparts on IC1 and operation of both sections is identical.

LED Displays

Figure 9 shows five of the most useful displays available from MAPLIN's Catalogue, along with terminal notations. The Parts List has stock codes of these components if required. These displays are suitable for use as voltmeter indicators, alarm flashers, sensor indicators, amplifier power level meters, graphic equaliser response, VU meters and the module could be used to replace panel meters in these applications.

Operation

So far, all input specifications refer to positive DC signals and not to AC signals. Sinewaves can be fed directly to the signal input for display, but problems may arise when calculating average or peak levels, or the amount of dampening required to ensure a readable display.

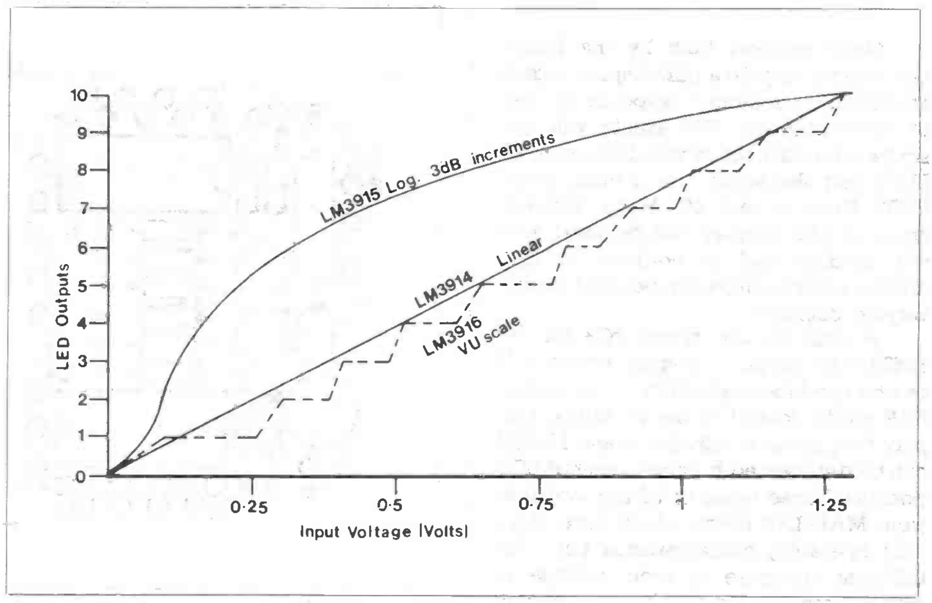


Figure 5. IC response curves

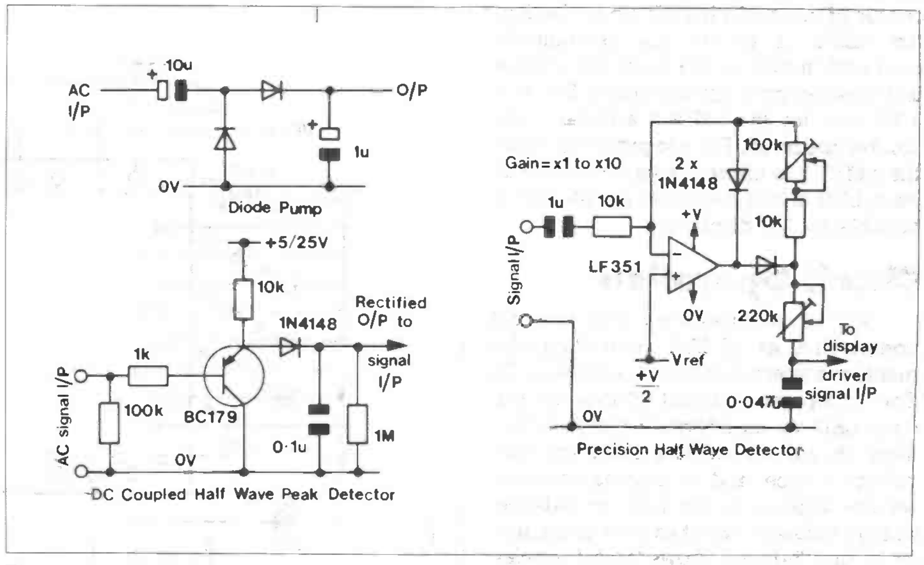


Figure 6. Input AC detector circuits

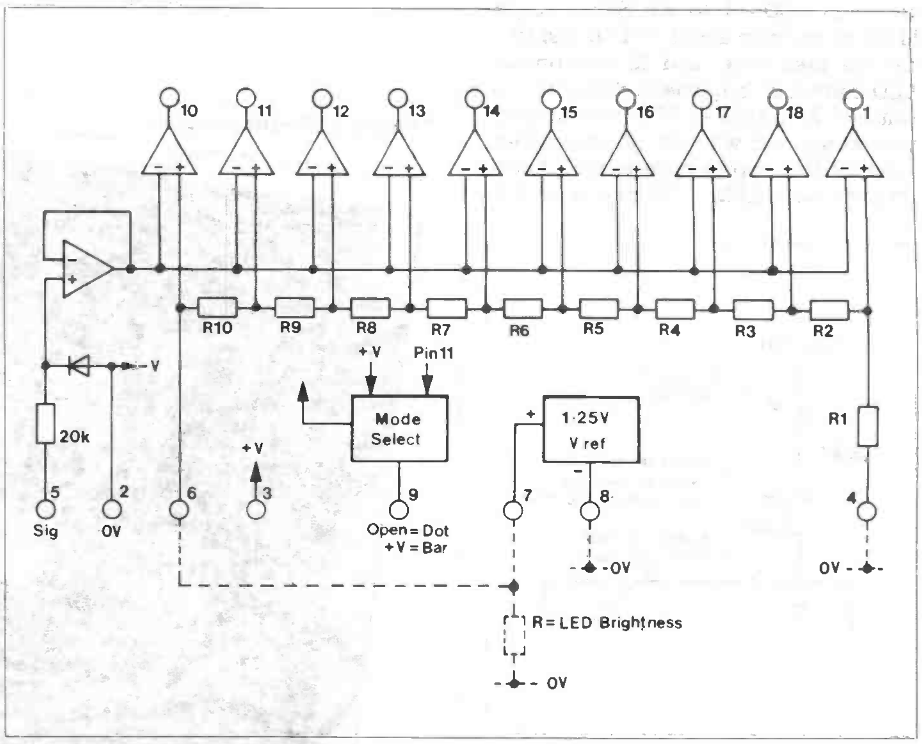
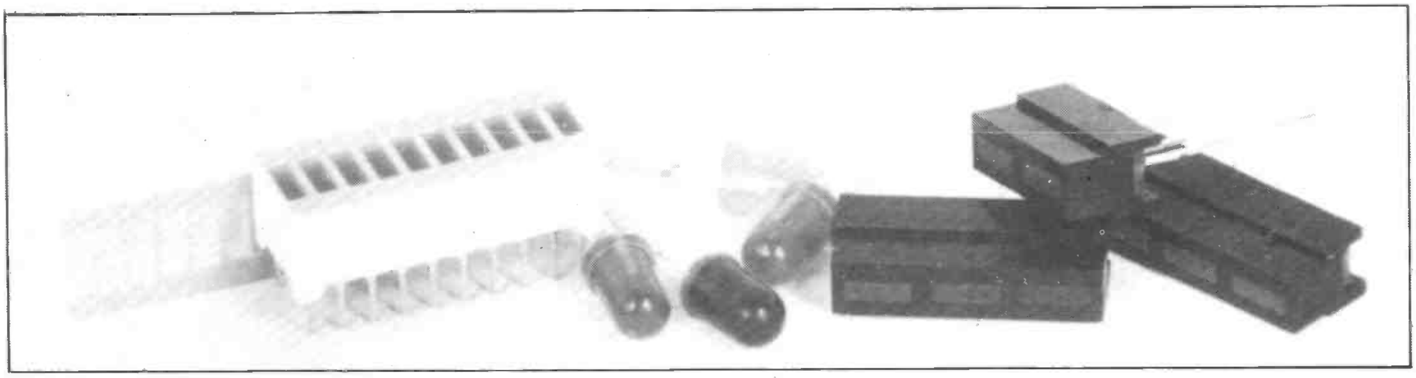


Figure 7. Internal circuit of LM3914/5/6



Some example circuits are given in Figure 6 which convert AC signals to DC voltages suitable for driving the module. The diode pump is the simplest to use, although its input impedance is low, and diode forward voltage drop must be considered. A capacitor at the output damps the display for a slow response reading and values are chosen accordingly.

Absolute maximum input signal voltages should be kept below 35V peak and wiring from LED's to module must be as short as possible to avoid HF noise radiation causing interference in audio equipment. DOT or single LED mode is simply produced by not inserting pin 9 on IC1 (2) into the PCB and is left floating.

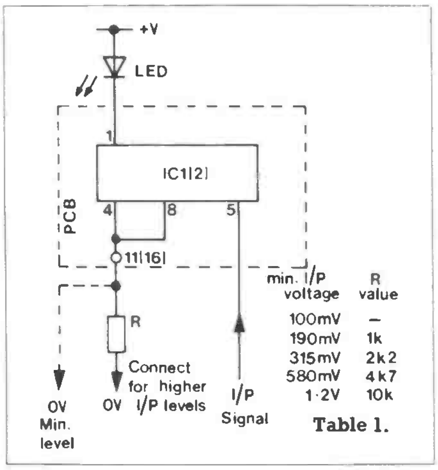
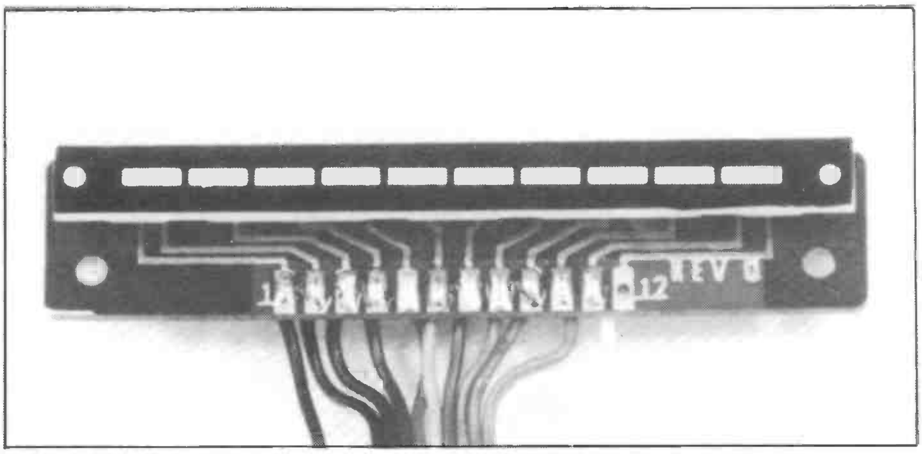


Figure 8. Input level reference



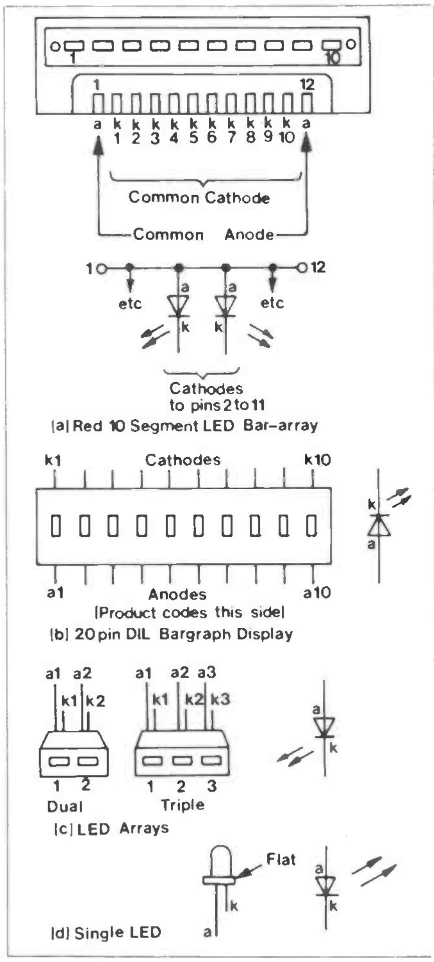


Figure 9. Pin connections of various displays

BARGRAPH DISPLAY DRIVER PARTS LIST

RESISTORS: All 0·6W 1% Metal Film (Unless Specified)

R1,5	220k	2	(M220K)
R2,6	1k2	2	(M1K2)
R3,7,10	470Ω	3	(M470R)
R4,8	1k	2	(M1K)
R9	10Ω 3W Wirewound	1	(W10R)

CAPACITORS

C1,2	PC Elect 100μF 10V	2	(FF10L)
C3	PC Elect 100μF 25V	1	(FF11M)

SEMICONDUCTORS

ZD1	BZY88C5V6/X55C5V6	1	(QH08J)
TR1	BC337	1	(QB68Y)
IC1,2	LM3914 or	2	(WQ41U)★
	LM3915 or	2	(YY96E)★
	LM3916	2	(YY97F)★

★ Select device as appropriate, see text.

MISCELLANEOUS

PCB	1	(YQ66W)
Pin 2145	1 Pkt	(FL24B)
Instruction Leaflet	1	(XT48C)
Constructors' Guide	1	(XH79L)

OPTIONAL – Choose as required:

Red 10-Seg Bargraph	As Req.	(YH76H)
Red Bargraph Display	As Req.	(BY65V)
Green Bargraph Display	As Req.	(YG33L)
Dual LED Array Red	As Req.	(YH77J)
Tri LED Array Red	As Req.	(YH78K)
Dual LED Array Green	As Req.	(YH79L)
Tri LED Array Green	As Req.	(YH80B)
Dual LED Array Yellow	As Req.	(YH81C)
Tri LED Array Yellow	As Req.	(YH82D)
LED Red	As Req.	(WL27E)
LED Green	As Req.	(WL28F)
LED Orange	As Req.	(WL29G)
LED Yellow	As Req.	(WL30H)

Because of the many different applications possible for this project, none of the above parts are available as a kit. Select and make up a list to order the parts required.

/// Maplin /// Maplin /// Maplin