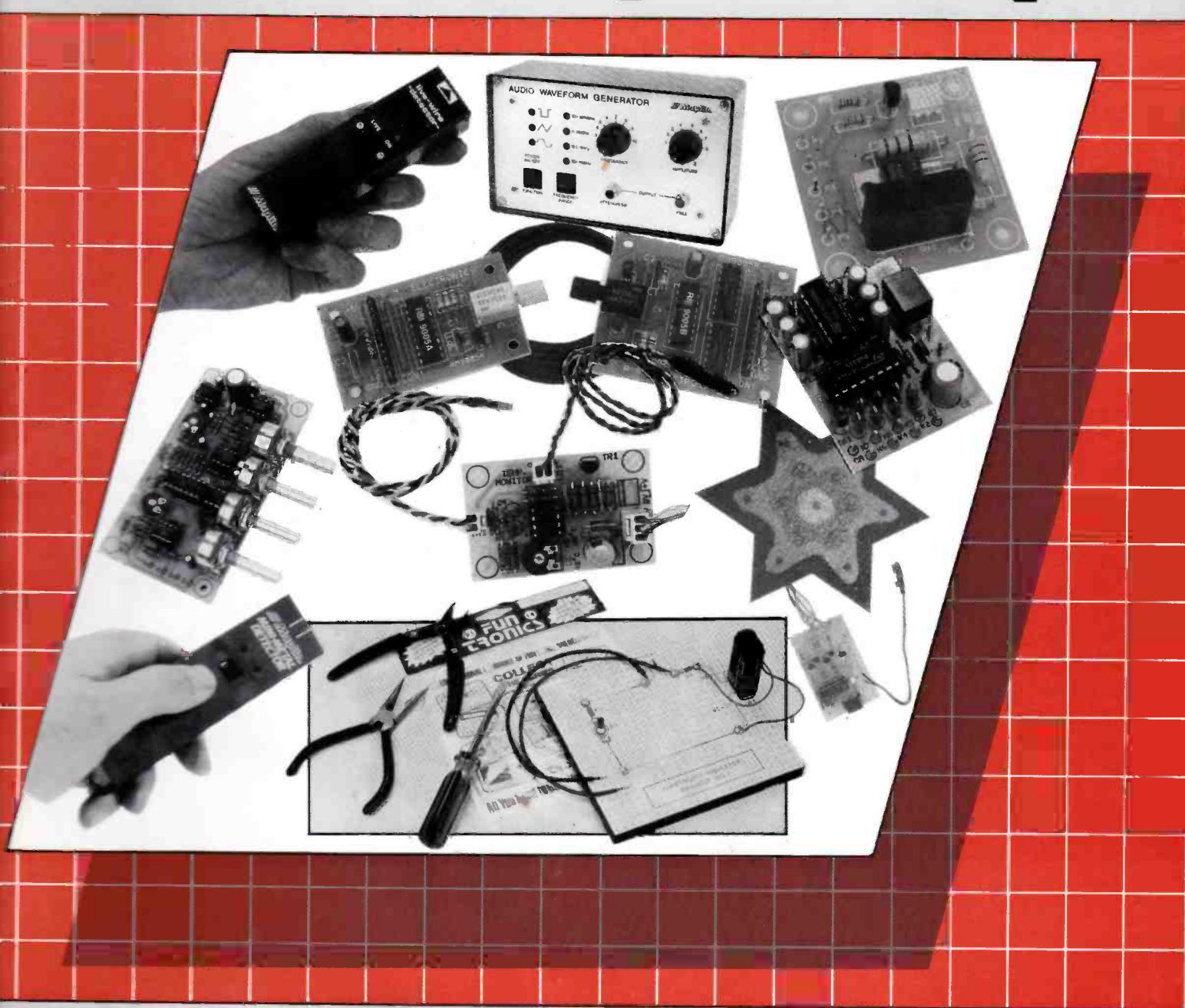


PROJECTS BOOK 48

Maplin Maplin Maplin



21-LED XMAS TREE
TEMPERATURE MONITOR
CONTINUITY TESTER

ZERO CROSSING OPTO-SWITCH
MN3004 BUCKET BRIGADE DELAY-LINE

LOW-COST AUDIO WAVEFORM GENERATOR
XMAS STAR

10-CHANNEL DATA LINK
MINI METAL DETECTOR
LIVE WIRE DETECTOR

CONTENTS

MAPLIN PROJECTS BOOK FORTY EIGHT

EDITORIAL

This Project Book replaces Issue 48 of *Electronics*, which is now out of print, and contains a compilation of projects from this magazine. 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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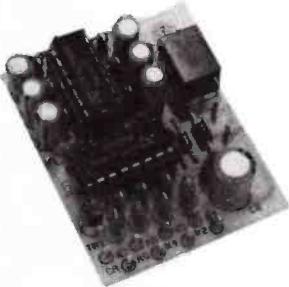
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PROJECTS

21 21-LED CHRISTMAS TREE

■ Miniature Christmas tree display with 21 twinkling coloured LEDs.

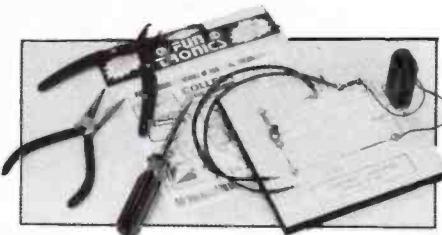


6 TEMPERATURE MONITOR

■ An optional 'add-on' to the Amplifier Monitor Module project, can also be used with the Zero Crossing Opto-Switch.

10 CONTINUITY TESTER

■ A 'Funtronics' project for beginners that also forms a useful test tool.



13 ZERO CROSSING OPTO-SWITCH

■ A noise-free electronic mains switch that changes at the voltage zero-crossing point.

16 BUCKET BRIGADE DELAY-LINE

■ An audio delay-line using a 512 stage, low noise, 'bucket brigade' IC.

21 LOW-COST AUDIO WAVEFORM GENERATOR

■ Ideal for home constructors, offering four frequency ranges of sine, triangular and square waveforms.



31 XMAS STAR

■ A novelty festive project to make a twinkling star for your Christmas tree.

35 10-CHANNEL FIBRE-OPTIC DATA LINK

■ A combined multiplexer and optical fibre data link project, able to carry up to ten digital signals at once with 100% electrical isolation.

39 MINI METAL DETECTOR

■ Search walls for hidden pipes and conduits before drilling any holes.



42 LIVE WIRE DETECTOR

■ Finds hidden mains cables even if no current is flowing.

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Ye Merry Festive LED Christmas Tree

by Alan Williamson

This year's festive project is a Christmas tree, decorated with 21 low-current LEDs in three different colours, which light in random patterns.

The circuit can be powered from a battery or a mains adaptor, the supply voltage requirement is nominally +12V dc, although the tree will operate quite happily over the range +9V to +15V. If an unregulated mains adaptor is used e.g. XX09K, it should be set to 7.5V or 9V.

The LEDs can be made to light at different rates/patterns; for this reason three values of R1 have been included in the kit. The lower the value of R1, the faster the rate of change: R1 = 1M slow change; R1 = 330k fast change; R1 = 2k2 twinkle, in a darkened room the LEDs will appear to twinkle like hot cinders in a breeze.

Circuit Description

Referring to Figure 1, IC1 (a to f) is a hex schmitt-trigger inverter, each inverter is configured as a free-running oscillator. Four of the oscillators IC1 (b to e) feed the inputs (2^0 to 2^3) of the LCD 7-segment display driver, whilst IC1a strobes the input of IC2 - latching the random binary number present at that time. The binary number is then decoded and the appropriate LEDs are illuminated. IC1f is used to drive TR1 which in turn switches the supply voltage to the LEDs on and off, thus conserving power and extending battery life.

Construction

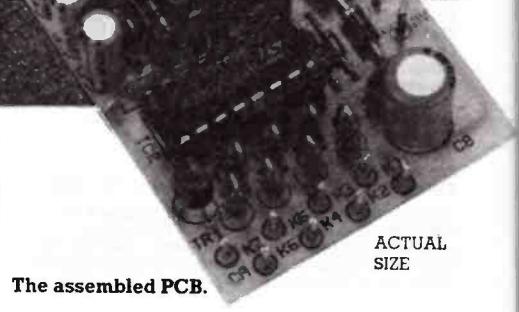
A Constructors' Guide is included with the kit, the Guide contains some useful information on component identification and soldering techniques. Begin construction with D1, D2, C7, R7 and R8, followed by the IC sockets, take care with the polarised devices. R1 to R6 and R9 to R15 should be fitted next, then C1 to C6, the rest of the components can then be installed in any order, the PCB pins are fitted from the track side of the PCB.



The complete tree.

Prototype Specification

Voltage range:	+9V min.	+12V nom.	+15V max.
Supply current (all LEDs illuminated)			
(@ 9V:		12mA nom.	
(@ 12V:		25mA nom.	
(@ 15V:		36mA nom.	



The assembled PCB.

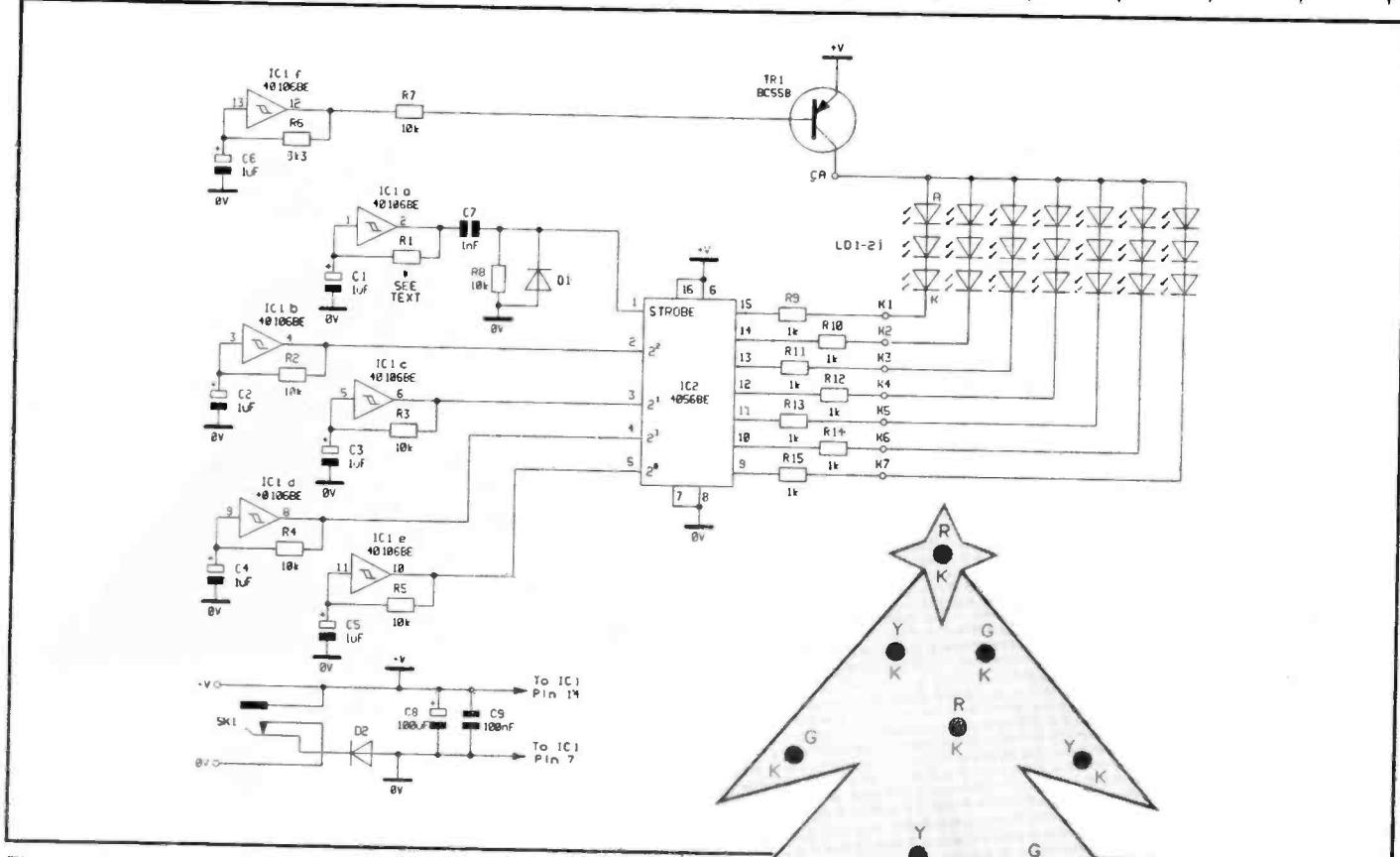
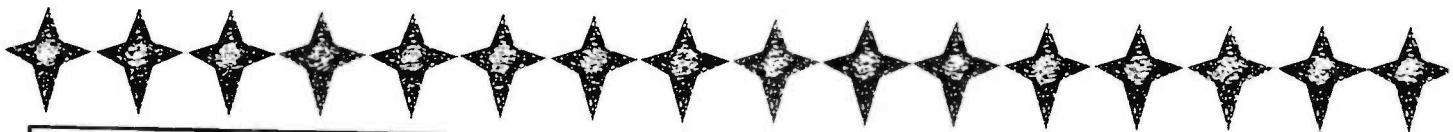


Figure 1. Circuit diagram of the LED Christmas Tree.

Construction of the Tree

Supplied with the kit is a full size template of the tree which can be cut out. Alternatively make a 200% enlargement of Figure 3 (which is printed $\frac{1}{2}$ size) on a photo-copier. Your local library or print and copy shop should be able to do this for you for around 10 to 20p.

Stick the template onto a piece of thick card, aluminium laminate, hardboard, plywood or perspex. Do not use metallic materials such as sheet aluminium, etc. as there is the possibility of



Figure 3. Half-size tree template, LED orientation and colour guide.

shorting out the LEDs. Drill, cut or punch out the $21 \times 5\text{mm}$ diameter holes required, then cut out the tree. Decorate the tree using any materials that take your fancy, alternatively you may be able to purchase a pre-decorated tree which would save you a bit of work.

Referring to Figure 3 as an orientation and colour guide, glue each of the LEDs in place; wait for the glue to dry before wiring up the LEDs. Using the double sided sticky pads (double thickness), stick the PCB onto the back of the 'bucket' part of the tree. Figures 4a to 4d show the wiring for the LEDs. You may wish to choose your own arrangement of LEDs,

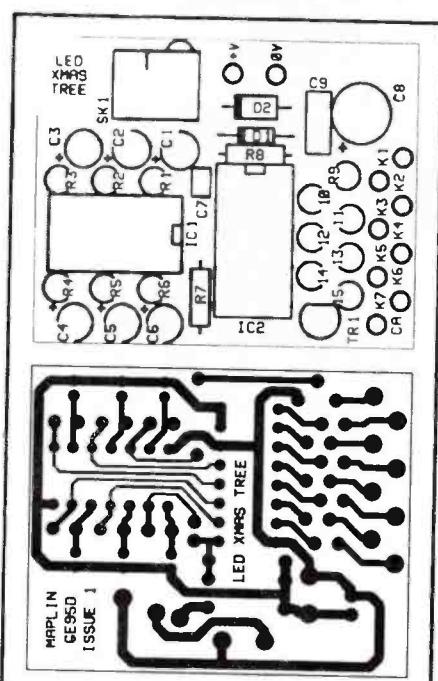


Figure 2. PCB legend and track.

Figures 3 to 4d are merely a suggestion; you may wish to do something different, but bear in mind that K2 would be the 'G' segment of a 7-segment display, which is most often on – this is why it is used for the star at the top of the tree.

Testing

To test the tree, connect a battery or mains adaptor to the PCB via the PCB pins marked +V and 0V or the power socket (the tip is +V and the ring is 0V), after a second or so, some (or all) of the LEDs will light, if any group fails to light, check that you have not inadvertently fitted an LED the wrong way round.

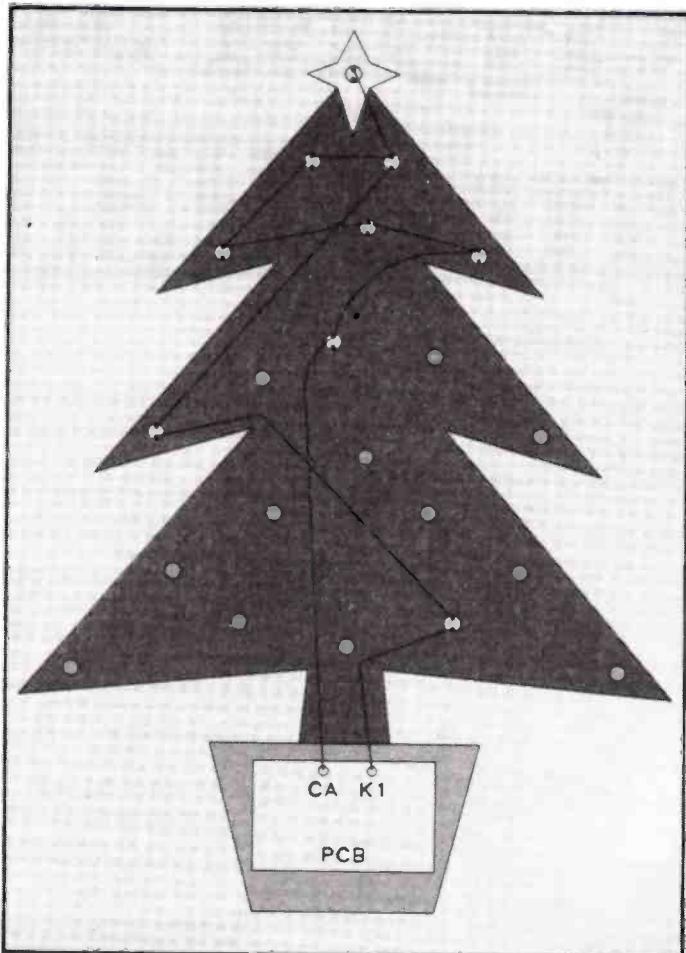


Figure 4a. Wiring stage one.

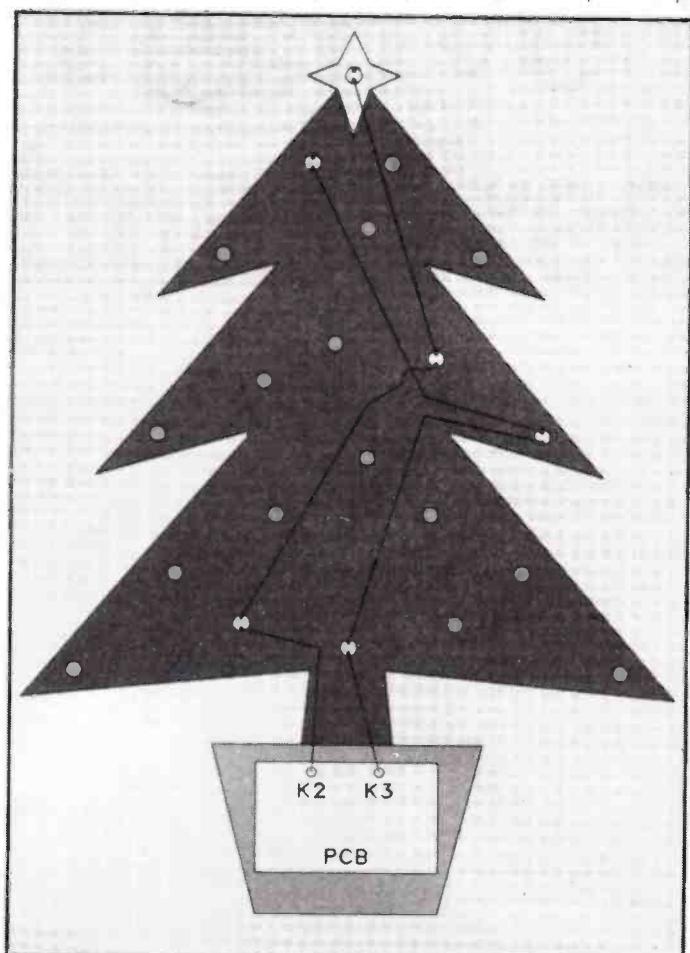


Figure 4b. Wiring stage two.

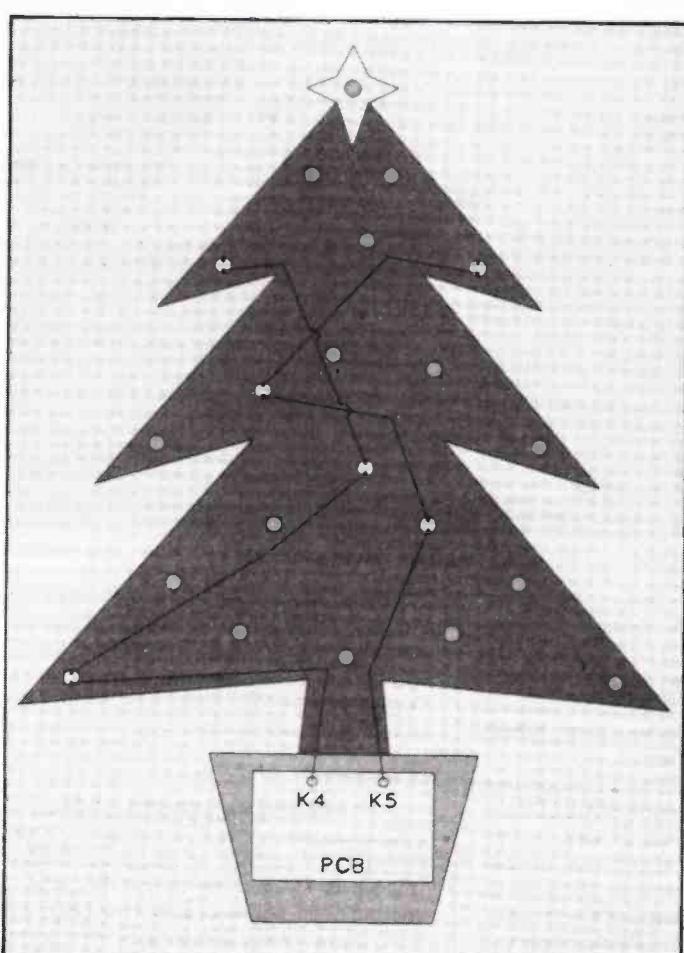


Figure 4c. Wiring stage three.

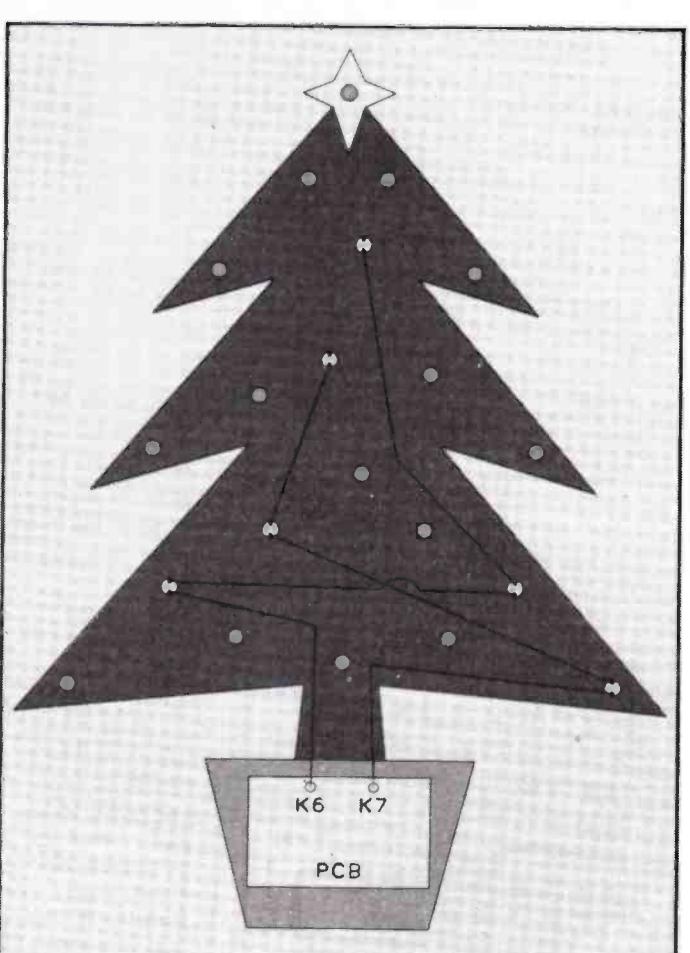


Figure 4d. Wiring stage four.

CHRISTMAS TREE PARTS LIST

RESISTORS: All 0.6W 1% Metal film

R1	2k2 See text	1	(M2K2)
R1	330k See text	1	(M330K)
R1	1M See text	1	(M1M)
R2-5,7,8	10k	6	(M10K)
R6	3k3	1	(M3K3)
R9-15	1k	7	(M1K)

CAPACITORS

C1-6	PC Elect 1μF 100V	6	(FF01B)
C7	Ceramic 1000pF	1	(WX68Y)
C8	PC Elect 100μF 25V	1	(FF11M)
C9	Minidisc 100nF 16V	1	(YR75S)

SEMICONDUCTORS

IC1	40106BE	1	(QW64U)
IC2	4056BE	1	(QW39N)
TR1	BC558	1	(QQ17T)
D1	IN4148	1	(QL80B)
D2	IN4001	1	(QL73Q)
LD1-21	LED Red 5mm 2mA	7	(UK48C)
	LED Green 5mm 2mA	7	(UK49D)
	LED Yellow 5mm 2mA	7	(UK50E)

MISCELLANEOUS

P1-10	Pins 2145	10 Pins	(FL24B)*
	DIL Socket 14-pin	1	(BL18U)
	DIL Socket 16-pin	1	(BL19V)
SK1	PCB 2.5mm DC Power Socket	1	(FK06G)
	PP3 Clip	1	(HF28F)

7/0.2 Wire 10m Green	1 Pack	(BL03D)
Double Bubble Sachet	1	(FL45Y)
PCB	1	(GE95D)
Quickstick pads	1 Strip	(HB22Y)
Leaflet	1	(XT25C)
Constructors' Guide	1	(XH79L)

OPTIONAL (Not in kit)

Battery PP3 Alkaline	1	(FK67X)
AC Adapter Unreg. 300mA	1	(XX09K)
Aluminium Laminate Small	1	(XY19V)

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

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

Order As LP83E (LED Xmas Tree)

Please Note: Order Code marked with a * is not available singly, see current Maplin Catalogue for full ordering information.

The following new item (which is included in the kit) is also available separately.

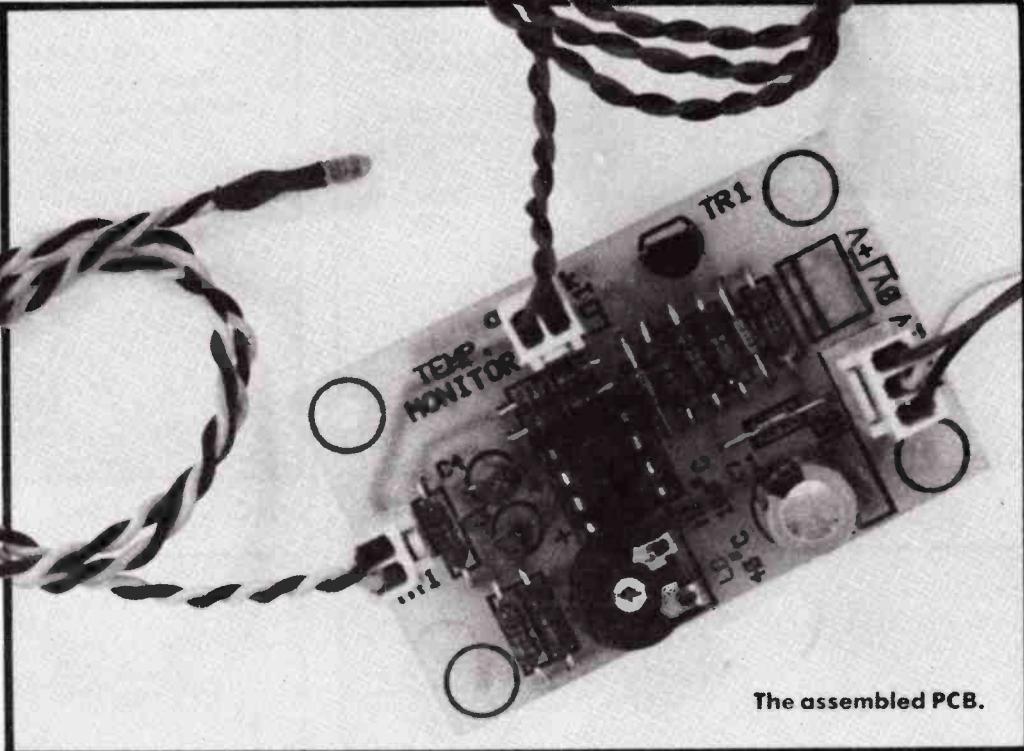
LED Xmas Tree PCB Order As GE95D

TEMPERATURE MONITOR

FEATURES

- * 39 TO 98°C Temperature Range
- * Active high and active low outputs
- * Trip temperature easily adjustable
- * In-built hysteresis * LED indicator

by Alan Williamson



The assembled PCB.

MONITOR

Introduction

The Temperature Monitor described here is an optional 'add on' to the Amplifier Monitor module LP32K (published in 'Electronics' November '91, issue 48), thus providing a complete monitoring system for amplifiers. The Temperature Monitor module can be used with other protection circuits, providing that they have an external trigger input. Alternatively the Temperature Monitor may be used in conjunction with the Zero Crossing Opto-switch LP55K (see page 34 of this issue) to turn a fan on at a preset temperature. The Temperature Monitor circuit is a well-known 'building block' circuit, those of you who are eagle-eyed will remember a very similar circuit as part of the Car Audio Switching Power Supply LP39N (published in 'Electronics' October '91, issue 46).

Prototype Specification.

Supply voltage:	12V nom.	15V max.
Quiescent current		
@ 12V:	3.6mA max.	
@ 15V:	3.9mA max.	
Operating current		
@ 12V:	45.7mA max.	
@ 15V:	56.4mA max.	
Temperature range:	39°C to 98°C	
Low temperature:	trip 39°C	reset 31°C
High temperature:	trip 98°C	reset 86°C

Circuit Description

Referring to Figure 1, the Temperature Monitor is based around a voltage comparator and a thermistor. Below the preset temperature, which is determined by VR1, the voltage at the inverting input

(-) of the comparator is lower than the voltage at non-inverting input (+) which is set by R1 and R2. Whilst this condition persists, the output of the comparator is high. As temperature increases the thermistor's resistance decreases, thus increasing the voltage at the inverting input. When the

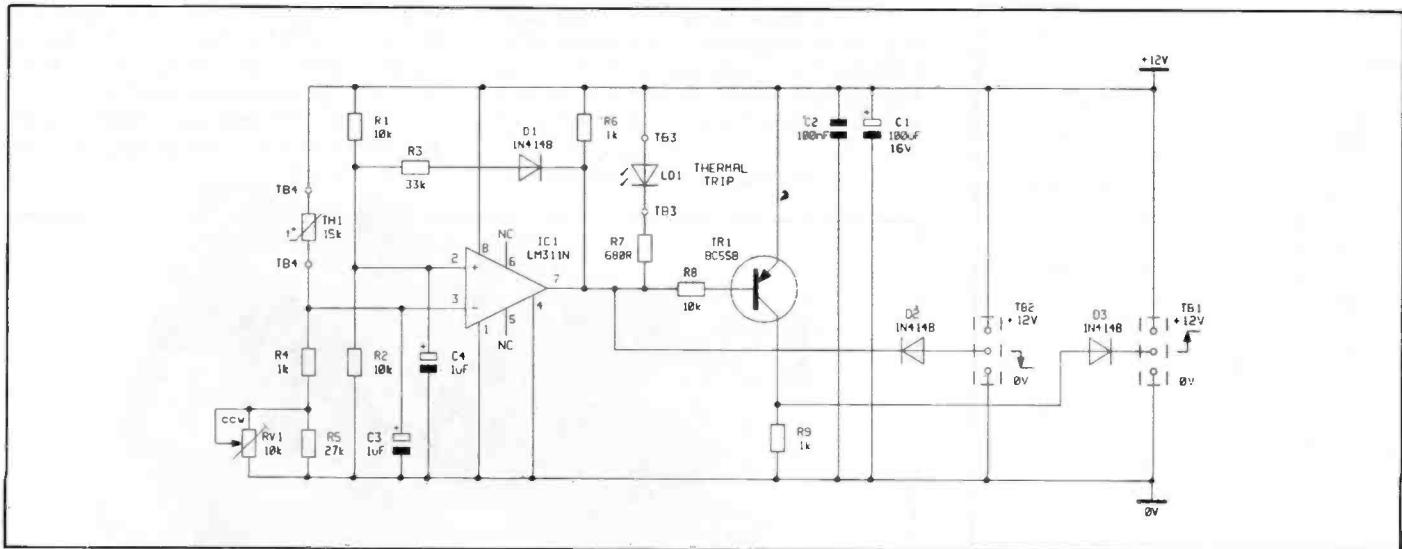


Figure 1. The Temperature Module circuit diagram.

Applications

**Amplifier protection
Power supply protection
Automatic fan switching
Overtemperature warning**

voltage at the inverting input is greater than the voltage at the non-inverting input, the output of the comparator will swing from high to low illuminating LD1. R3 and D1 now come into play, providing around 10°C hysteresis, this is due to R3 and D1 being effectively in parallel with R2; this will prevent the circuit from toggling back-and-forth at the preset temperature. If more (or less) hysteresis is required, the value of R3 can be reduced (or increased) respectively. TR1 is merely an inverter, providing a low to high output, i.e. the opposite of that provided by the output of the comparator.

The temperature range of the module can be altered by changing the values of R4, R5 and VR1, i.e. if VR1 is fully clockwise and the value of R4 is reduced, then the maximum temperature would be over 100°C, but the minimum temperature would also increase; similarly if the value of R4 is increased, the minimum and maximum temperature would be reduced.

Construction

A Constructors' Guide is provided with the kit, the Guide contains some useful information on construction and soldering techniques.

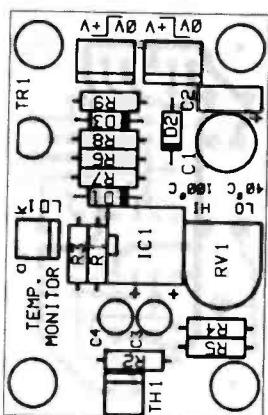


Figure 2. PCB legend and track.

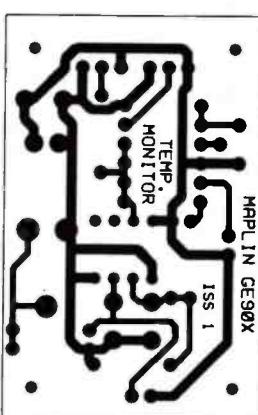


Figure 3. Connecting the thermistor.

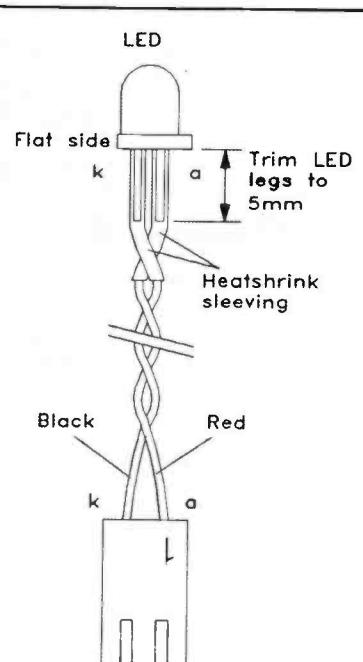


Figure 4. Connecting the LED.

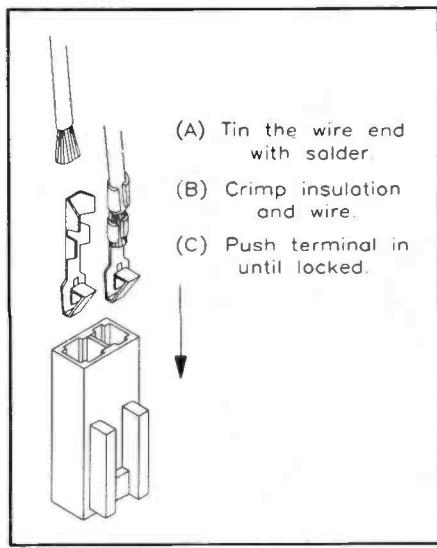


Figure 5. Assembling the minicon connectors.

If you intend to use the Temperature Monitor in conjunction with the Amplifier Monitor LP32K; you will need to use the high to low output, so fit the three-way minicon plug in the position closest to C1 and C2.

If you require the Temperature

monitor to operate the Zero Crossing Optoswitch LP55K, then you will need to use the low to high output, fit the minicon plug in the position closest to TR1.

R7, the LED and associated minicon plug and socket may not be required and can be omitted.

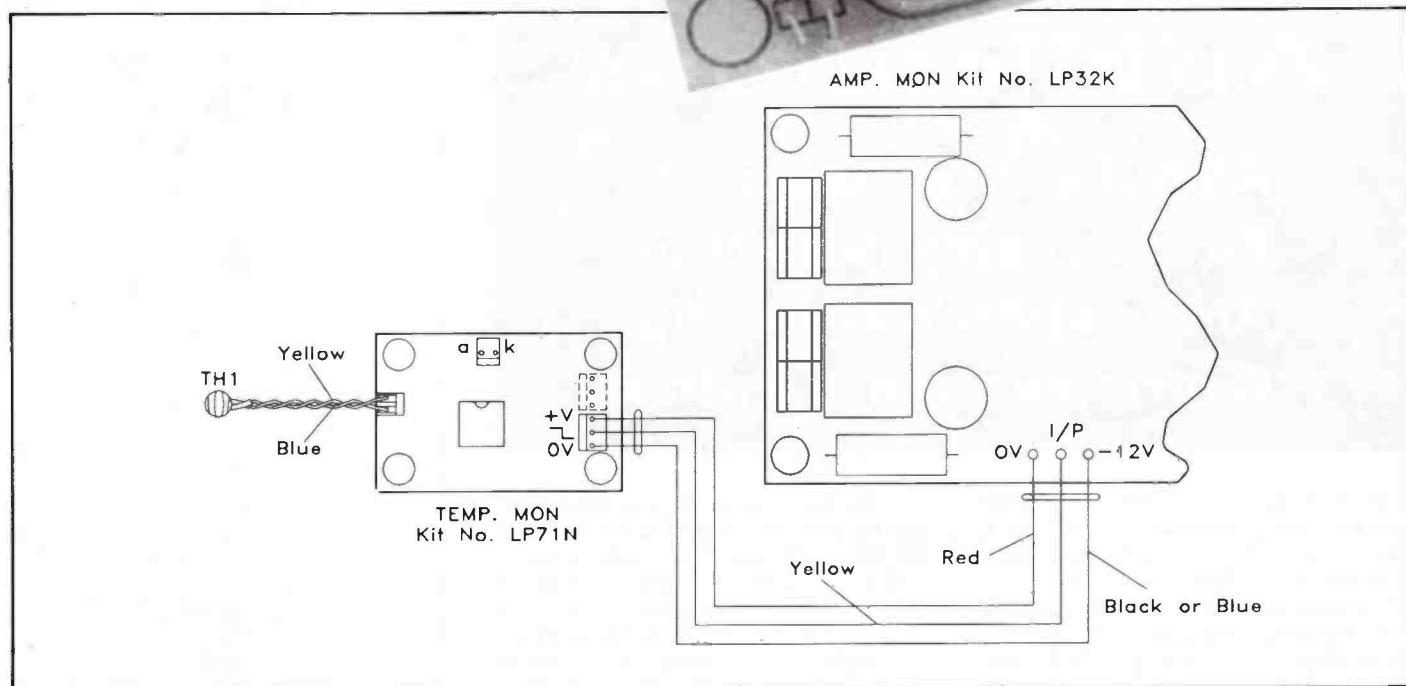
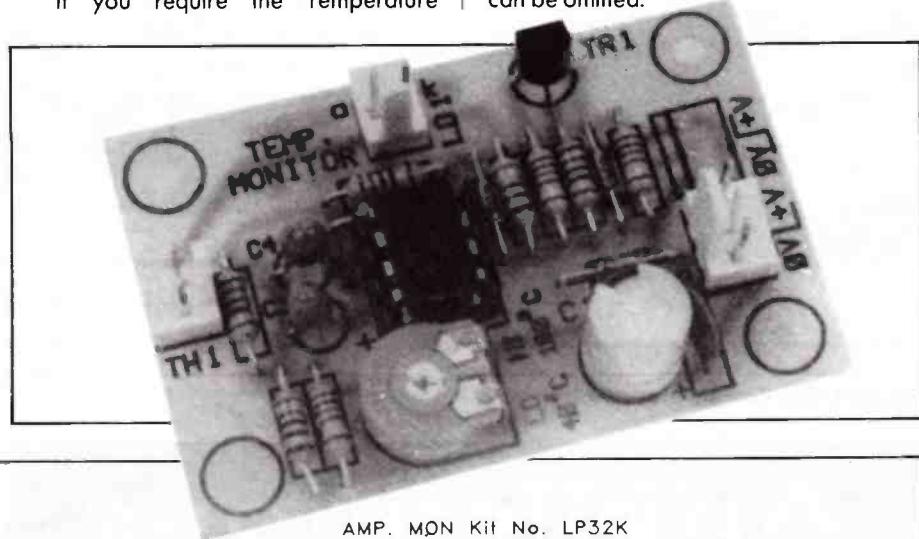


Figure 6. Wiring diagram; shows how to connect the Temperature Monitor to the Zero Crossing Optoswitch.

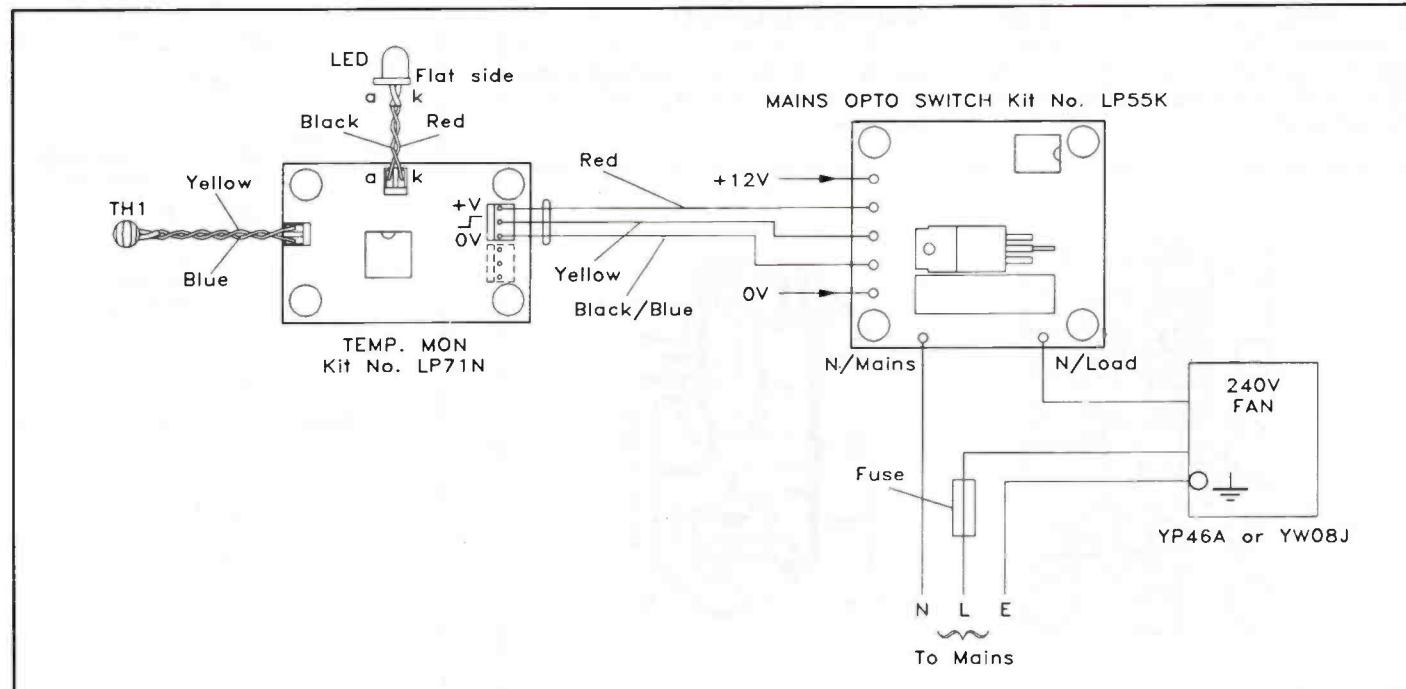


Figure 7. Wiring diagram; shows how to connect the Temperature Monitor to the Amplifier Monitor.

Referring to Figure 2 and the Parts List, begin construction by inserting the resistors, followed by the diodes, and the rest of the components — taking care with the polarised devices. After all the components have been fitted to the PCB, clean off the flux residue with a suitable solvent e.g. PCB cleaner YJ45Y or Ultraclene YT66W. Check the PCB for solder whiskers, bridges and dry joints.

From the cable supplied, cut off the required length for the LED and thermistor and strip off the outer insulation. Crop the leads on the thermistor and LED to 5mm. Strip and tin then solder the appropriate colour cable to the thermistor and LED as shown in Figures 3 and 4. Cut the heatshrink sleeving into four equal lengths, fit the sleeving over the solder joints of the LED and thermistor, carefully shrink the sleeving using a heat source i.e. a match, lighter, soldering iron, hot air gun, etc. Twist the two thermistor leads together and do the same for the LED. Fit the minicon terminals to the LED, thermistor as shown in

Figure 5. Last of all, turn the pre-set VR1 fully clockwise.

The Temperature Monitor module is now complete and ready for testing.

Testing

First of all, decide at what temperature you wish the Monitor to trip, the temperature range of the module is between 40°C and 100°C. If you are using the Temperature Monitor in conjunction with the Amplifier Monitor, I would suggest a temperature of 80°C to 85°C would be a good starting point. If you wish to use the Temperature Monitor with the Zero Crossing Optoswitch to start a fan at a pre-set temperature, then I would suggest a temperature of 50°C to 60°C.

Having now decided at what temperature you wish the Temperature Monitor to trip, you will need some form of thermometer for calibration, this could be a glass type (NOT the medical variety) or some form of digital thermometer, which could be a multimeter with thermocouple,

you will also require a 12V dc supply.

Now is a good time to make a cup of tea because you are going to have to boil the kettle! Pour some hot water into a cup, preferably of the plastic expanded polystyrene type as this will hold the heat, pour the rest of the hot water into a tea pot and add a tea bag. Place the thermometer into the cup and power up the module, wait until the water cools to the required temperature. Whilst waiting for the water in the cup to cool, pour out the tea, add milk and sugar to taste. When the required temperature has been reached, dangle the thermistor in the cup of water and turn the pre-set VR1 anti-clockwise until the LED illuminates. Remove the thermistor from the cup and disconnect the 12V supply.

The Temperature Monitor is now ready for use and can be installed into your amplifier. Figure 6 shows how to connect the Temperature Monitor to the Amplifier Monitor; whilst Figure 7 shows how to connect the Temperature Monitor to the Zero Crossing Optoswitch to operate a fan.

TEMPERATURE MONITOR PARTS LIST

RESISTORS: All 0.6W 1% Metal film (Unless specified)

R1,2,8	10k	3	(M10K)
R3	33k	1	(M33K)
R4,6,9	1k	3	(M1K)
R5	27k	1	(M27K)
R7	680Ω	1	(M680R)
RV1	Hor Encl Preset 10k	1	(UH03D)
TH1	15k Thermistor	1	(FX22Y)

CAPACITORS

C1	Minelect 100μF 16V	1	(RA55K)
C2	Minidisc 100nF 16V	1	(YR75S)
C3,4	Tant 1μF 35V	2	(WW60Q)

SEMICONDUCTORS

IC1	LM311N	1	(QY09K)
D1,2,3	IN4148	3	(QL80B)
LD1	LED Red	1	(WL27E)
TR1	BC558	1	(QQ17T)

MISCELLANEOUS

TB1 or 2	PCB Latch Plug 3-way	1	(BX96E)
TB3,4	PCB Latch Plug 2-way	2	(RK65V)
	DIL Socket 8-pin	1	(BL17T)
	Minicon Latch Hsng 3-way	1	(BX97F)
	Minicon Latch Hsng 2-way	2	(HB59P)
	PCB Terminals	1 Strip	(YW25C)
	4-Wire Burglar Cable	1m	(XR89W)

Heat Shrink CP 16	5cm	(BF86T)*
PCB	1	(GE90X)
Leaflet	1	(XK99H)
Constructors' Guide	1	(XH79L)

OPTIONAL (Not in kit)

PCB Latch Plug 3-way	1	(BX96E)
M3 Insulated Spacer	1 Pkt	(FS36P)
Double Bubble Sachet	1	(FL45Y)
Minicon Latch Hsng 3-way	1	(BX97F)

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

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

Order As LP71N (Temp Monitor)

Please Note: Order Code marked with a * is not available singly, see current Maplin Catalogue for full ordering information.

The following new item (which is included in the kit) is also available separately.

Temp Mon PCB Order As GE90X



BULB AND FUSE TESTER

Text by Robert Penfold

Introducing Funtronics

This is the first in a series of easy to build electronics projects for complete beginners, who require a simple and fun starter to electronic project building. The projects are ideal for the young person as no

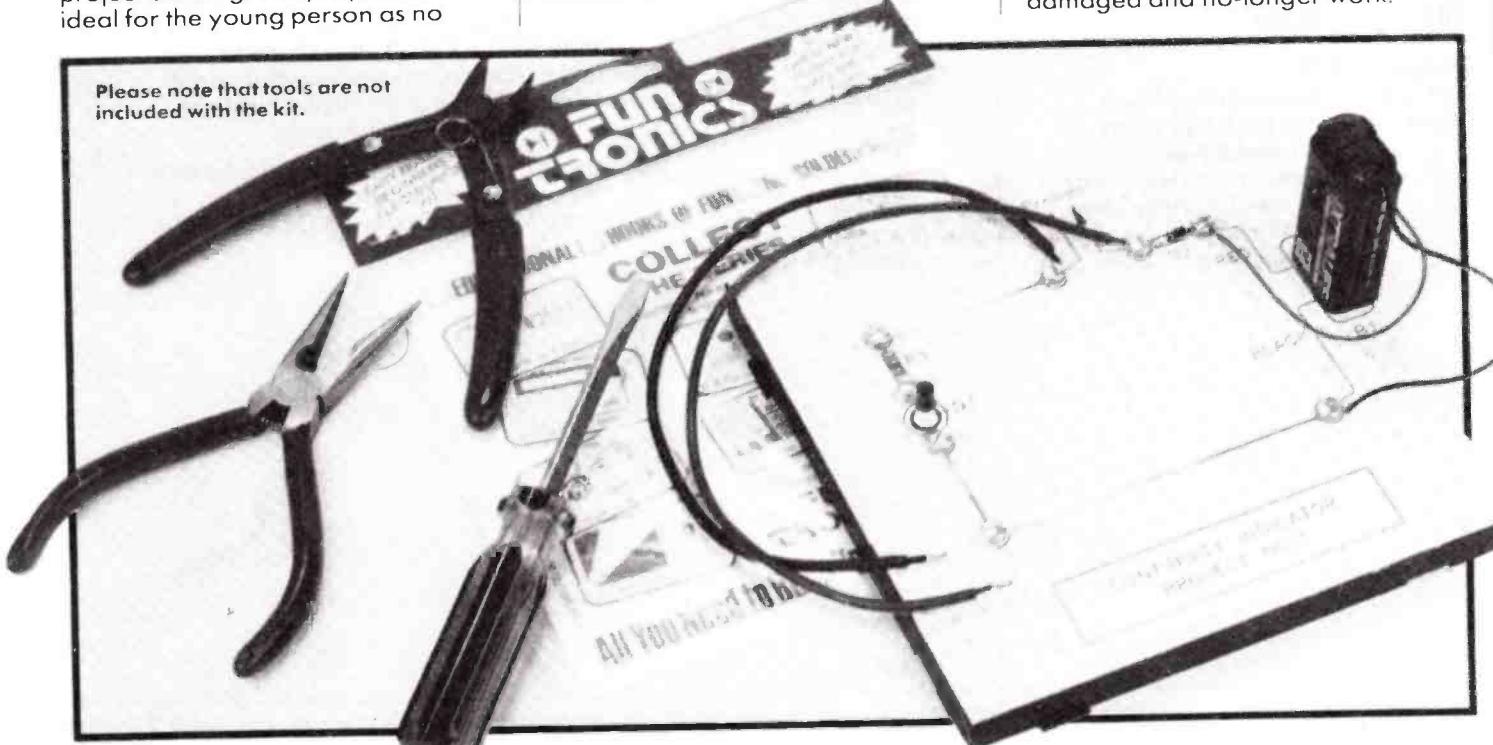
soldering is needed. All the projects are built on the same type and size of plastic 'peg-board'. The only tools needed to build this project, and the others in the series, are a pair of wire cutters/strippers and a small screwdriver; a pair of pliers will also be useful.

This Month's Project

This first Funtronics project is very simple indeed, it is intended to allow testing of bulbs, fuses, switches, etc. The proper name for this project is a 'continuity tester' and is the modern answer to the older 'torch bulb and battery' way of testing circuits. With a bulb-type tester, the battery is connected to the bulb by means of a pair of test probes. If there is an electrical 'path' between the two test probes, the circuit is completed and the torch bulb lights up. A use, which has already been mentioned, is testing fuses; if a good fuse is connected across the probes the bulb will light up — if the fuse is no good the bulb will not light.

Figure 1 is a diagram that shows the parts in the circuit and how they are connected; it is called a circuit diagram. Different symbols are used to show the separate parts and lines show how they are connected together.

In this project, the torch bulb has been replaced with a light emitting diode (LED for short), this is marked D1 on the circuit. The reason for this is that there is a slight problem with the older bulb-type continuity testers, in that the bulb requires quite a high current to flow for it to light up. This means that it is no good for such things as testing for short circuits on circuit boards (as found inside transistorised radios and other pieces of electronic equipment). This is because the high current needed for the bulb could easily damage some of the very sensitive components found in electronic circuits. You would not see the smoke rise, but the components inside would be damaged and no-longer work.



The operating current of this tester is a lot, lot, less than for most torch bulbs. The current is also low enough to be used safely on your electronic projects, as well as for simple electrical testing.

It would be wrong to regard an LED as just a low-current light bulb. Firstly, it is a diode — a component that will only let electricity flow in one direction. This means that it will only light up if it is fitted the right way around in the circuit. A second main difference is that LEDs are very fussy about voltage. Slightly too low a voltage and an LED will not light up, but slightly too much voltage and it will be damaged for good. The usual way around this is to use a supply voltage that is higher than needed and include a resistor in between (in 'series' with) the LED and the supply. This resistor is R1 in the circuit, and it makes sure that too much current cannot flow. The result is that this resistor makes the LED 'set' its own supply voltage at the correct level.

In the circuit there is also a diode (D2) connected in series with the LED. Such a diode is fitted in almost all of the Funtronics projects, it is to 'block' the supply if the battery is accidentally connected with the wrong way round. This is to stop the circuit being damaged.

Getting it Together

First read through steps 1 to 3 of the instructions and then carefully follow the list, one step at a time, look at the photographs of the finished project if this helps.

1. Cut out the component guide-sheet provided with the kit (which is a full-size copy of Figure 2) and glue it in place on the board. Paper glue or gum should be okay. Do not soak the paper with glue, just a few small 'dabs' will do.

2. Fit the link-wires to the board using the self-tapping screws and washers. The link-wires are made from bare wire. Loop the wire, in a clockwise direction around each screw to which it must connect, taking the wire under the washers, the way to do this is shown in Figure 3. Do not fully tighten a screw until all the leads that fit under it are in place.

3. Recognise and fit the components, in the order stated, using the same method as for the link wires. Cut the components' wires so that they are just long enough to loop around the screws; otherwise long leads left flapping around might cause short circuits and stop your project from working.

a) Fit the resistor, R1; this component may be connected either way round.

R1 is a small sausage-like

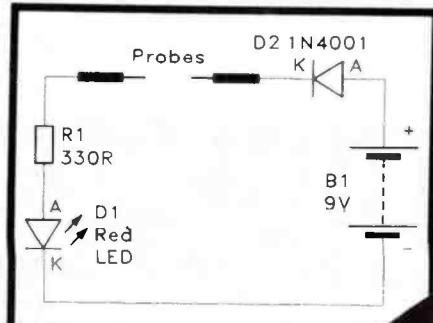
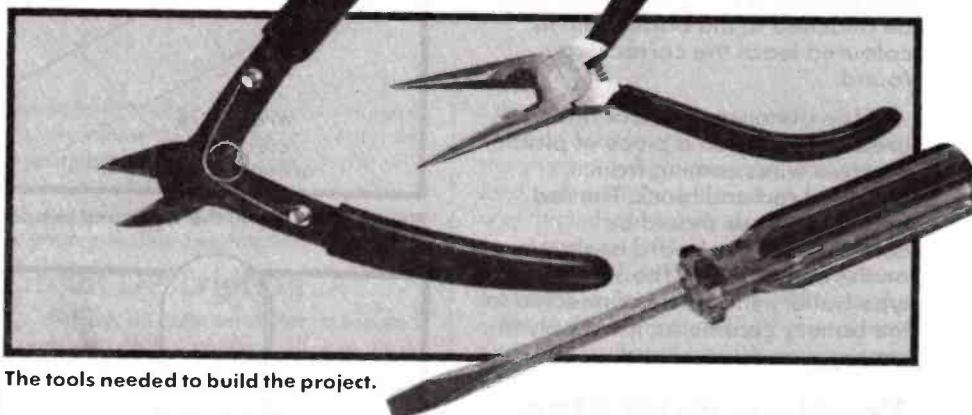


Figure 1. The circuit diagram of the Fuse and Bulb Tester.



The tools needed to build the project.

component with wires at each end. It has four coloured bands, the first three of which show its value, which in this case is 330 ohms (written 330Ω or 330R for short). The three coloured bands are orange, orange, and brown. The fourth band is gold and shows how near to the 330Ω value the resistor is likely to be, this is called the tolerance.

b) Next fit the LED, D1; this component must be connected the correct way round.

D1 is the component with the red plastic body and both leads coming from the same end of the component. One of the leads is known as the cathode (K) and the other the anode (A). Figure 4 shows how to work out which lead is

which. The side of the LED that has a slightly flattened edge on it is the cathode. The LED should be fitted so that it matches the flat edge on the drawing of the LED on the guide-sheet.

c) Next fit the diode, D2; this component must also be connected the correct way round.

D2 looks a bit like R1, but the body is black and there is a white or silver band at one end of the body. The diode should be fitted so that this band lines up with the band on the drawing of the diode on the guide-sheet.

d) Next fit the probes.

The probes are made up from two pieces of insulated wire (coloured red and black) and two pieces of hollow insulated sleeving (also coloured red and black). The wire is multi-stranded, which means that the inside is made up of several very fine wires. The probes should be made up as shown in Figure 5, use wire cutters/strippers to remove the insulation where shown. The bare ends of the leads should be

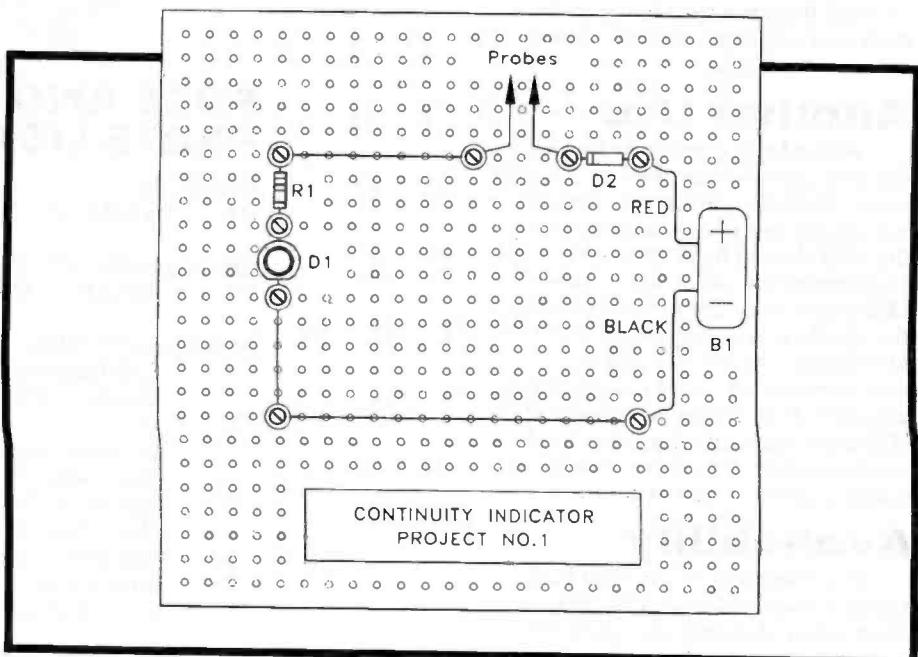


Figure 2. The layout of the components.

twisted together to prevent the wires from spreading out and breaking off. Slide the red sleeving over the red wire and the black sleeve over the black wire. Connect the two wires to the screws on the board marked 'Probes' – the red wire should go to the screw nearest to D2. The free ends of the two wires allow you to make connection with the item to be tested.

e) Lastly fit the battery connector and battery, B1; the connector must be attached to the board with its coloured leads the correct way round.

The battery connector has two press-stud clips on a piece of plastic and two wires coming from it, coloured red and black. The red and black leads should be connected to the board as shown on the layout sheet. The 9V PP3 type battery should be connected to the battery connector, it will only fit properly one way round.

Testing and Use

To test the finished Fuse and Bulb Tester, touch the bare ends of the test probes together (with the battery connected). If the unit is working okay the LED should light up when the probes are connected together. If the LED does not light up, then B1, D1, or D2 may be connected the wrong way round. Check each of these carefully, and also make sure that there are no loose connections.

The Fuse and Bulb Tester may now be used for any continuity tests that you may wish to do. Please remember that the tester must not ever be used on mains wiring or appliances when they are connected to the mains electricity supply in any way. If you are not sure that what you are doing is correct, then the best thing to do is stop and ask someone, who does know, what to do.

Another Use

Apart from continuity testing, the unit can also be used as a diode tester. With the diode connected across the test prods one way round the LED should light up, with it connected the other way round the LED should not light; if this happens the diode is working okay. If the LED lights when the diode is connected both ways round, the diode is short circuit and faulty. If the LED does not light when the diode is connected both ways round, the diode is open circuit and faulty.

Availability

The Funtronics Fuse and Bulb Tester is available from Maplin Electronics, through our chain of regional stores, or by mail order, order code LP82D.

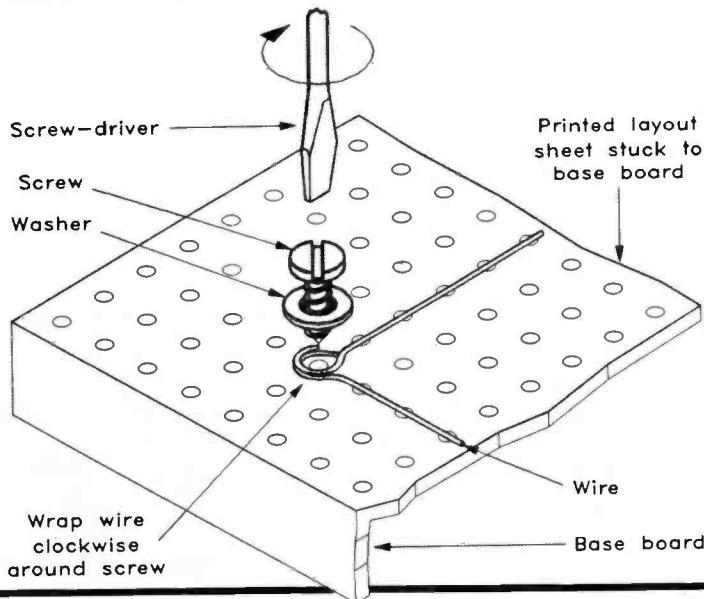


Figure 3. How to fit the wires and components to the board.

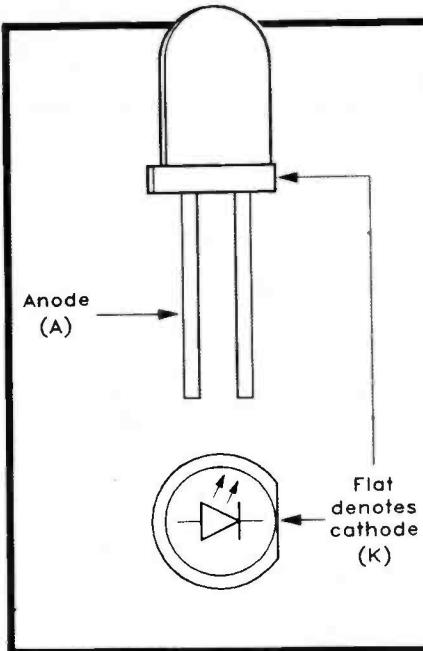


Figure 4. Recognising the LED connections.

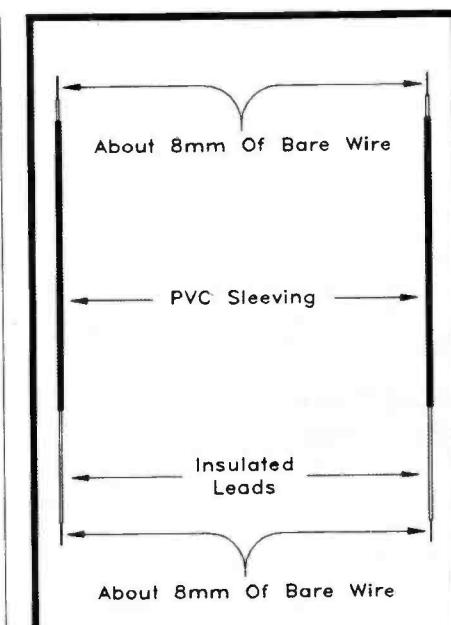


Figure 5. How to make the probes.

FUSE AND BULB TESTER PARTS LIST

RESISTOR		
R1	330Ω 1/4W 5% Carbon Film	1
SEMICONDUCTORS		
D1	Red LED 1 D2 1N4001	1
MISCELLANEOUS		
	Self Tapping Screw No.6 x 3/8in.	8
	Washer 4BA	8
	PP3 Clip	1
	Tinned Copper Wire 0.71mm	30cm*
	Black Wire 7/0.2mm	30cm*
	Red Wire 7/0.2mm	30cm*
	Black 2mm Sleeving	30cm*
	Red 2mm Sleeving	30cm*
	Base Board	1
	Instruction Leaflet & Layout Sheet	1

*Please Note: lengths are approximate

zero CROSSING *opto switch*

by Alan Williamson

This is the second of our two Christmas novelty projects, something to make your Christmas tree fairy lights flash in time with the festive star, but no doubt this useful little project will find numerous applications elsewhere.

The previously described LED controller for the festive star is able to control up to four zero crossing, optoisolator switches, each of which can handle a 250 watt resistive load, with a triac package temperature of approximately 65°C. The

triac used here *does not* have an insulated tab, so please *do not* try to verify the temperature with your finger as you will receive a nasty shock!

For safety reasons this project is not recommended for beginners.

Circuit Description

The circuit diagram shown in Figure 1 is very simple, consisting of just three major components. These are a transistor TR1, an optoisolated zero crossing triac

OP1, and a power triac TI1. A zero crossing optoisolator was chosen to avoid the inherent interference problems associated with switching a load on while part way through the mains voltage cycle.

Transistor TR1 is used as a switch. Applying a positive voltage to C will cause a current to flow (limited by R2) into the base of the transistor (TR1); this current turns the transistor on, allowing a larger current to flow through R1 and the opto LED. The internal triac of the optoisolator will then fire the next time the mains supply crosses zero volts. Current is then fed via R3 to the gate of TI1, activating the power triac. Resistor R4 ensures that the power triac turns off whilst crossing the 0V part of the sinewave, and the snubber network SN1 suppresses any unwanted noise generated by the switching action of the triac (TI1).

Construction

As mentioned before this is a simple project, but for safety reasons it is *not* recommended for beginners; not only does the mains supply bite – IT CAN KILL! If you have no practical building experience and you would like to build this project, then please study the Constructors' Guide supplied with this kit very carefully.

Referring to Figure 2 and the Parts List, begin construction with the resistors first. The pins are inserted from the track side of the PCB using a hot soldering iron. After the PCB is completed, it should then be cleaned using alcohol, Ultraclene or PCB cleaner (Maplin stock codes YT66W and YJ45Y respectively).

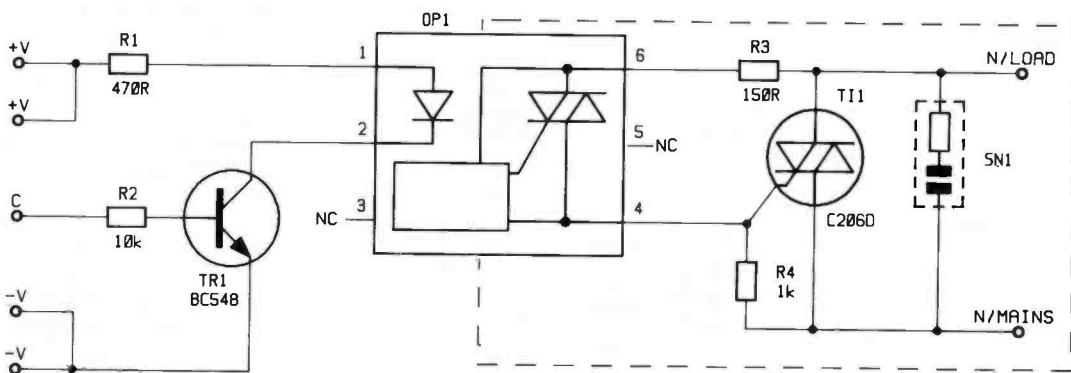


Figure 1. Circuit diagram.

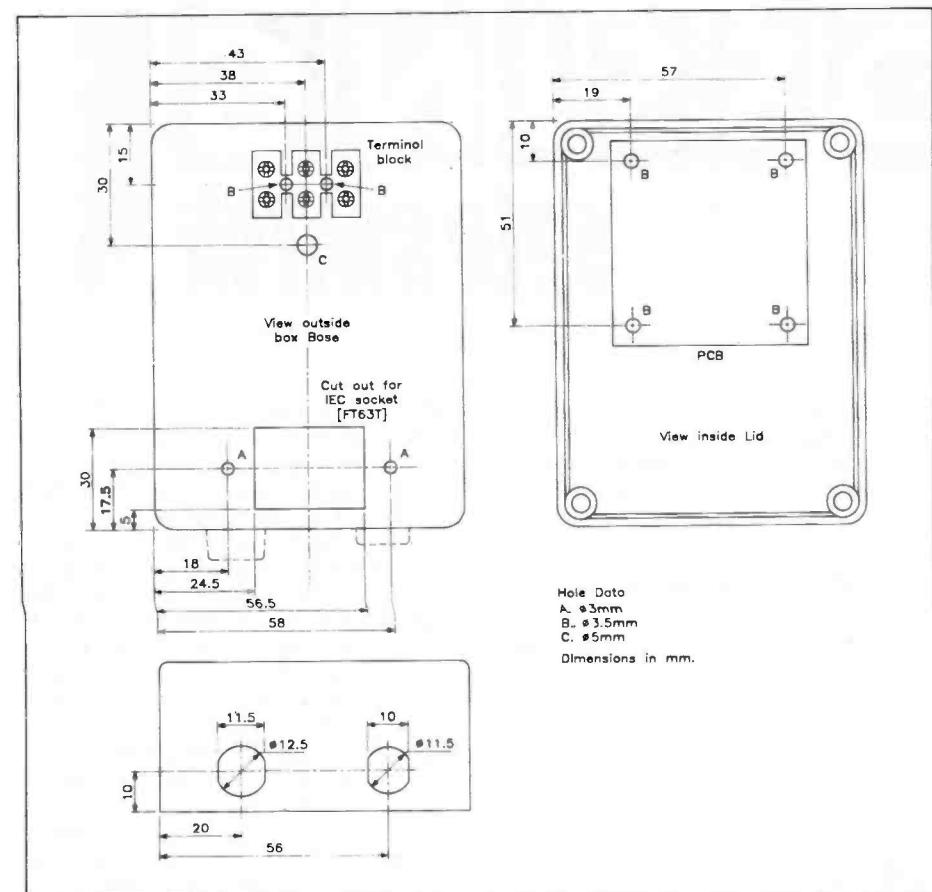


Figure 3. Box drilling details.

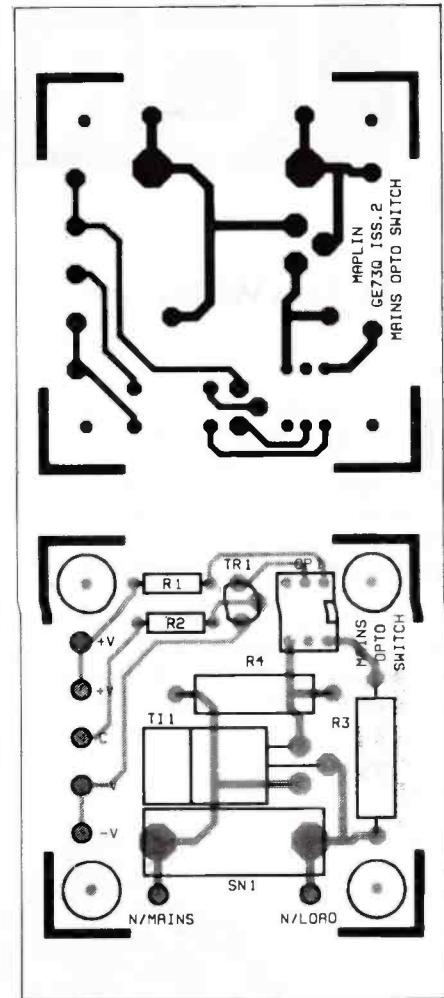


Figure 2. PCB track and legend.

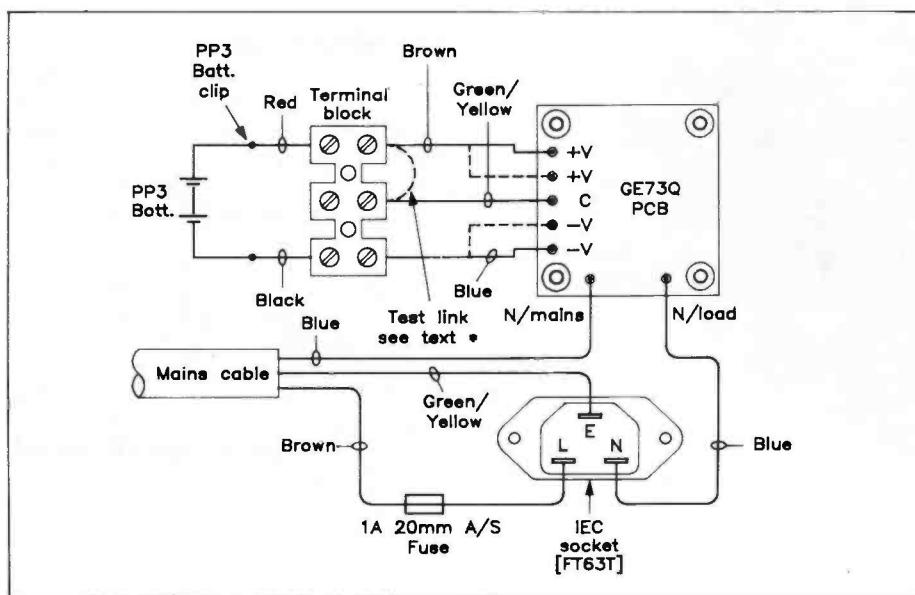


Figure 4. Wiring diagram.

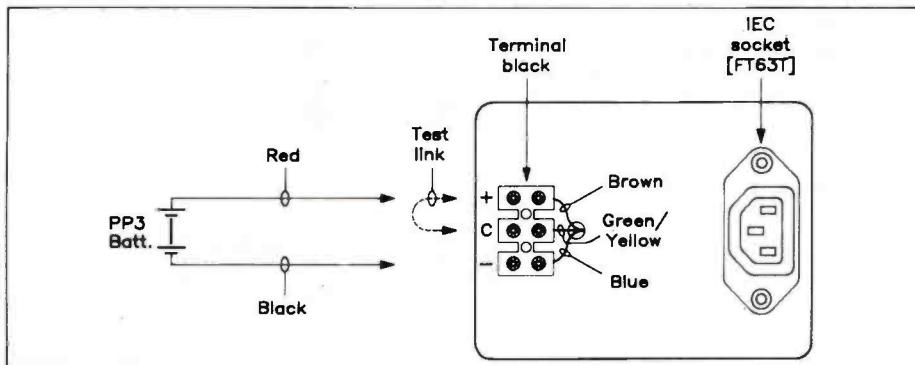


Figure 5. Box assembly.

Testing

Before testing can begin, the optoswitch must be safely housed in a non-conductive box; this will prevent possible injury to the user during testing and use. See Figure 3 for drilling details. The wiring of the optoswitch is shown in Figure 4, please follow the instructions carefully.

Having now fitted the project into a suitable box and completed the wiring, testing can now begin. You will need some kind of load, so dig out your fairy lights. Plug the lights into a 13A wall socket to check that they are working properly. Unplug the lights from the wall socket and change the plug if you wish to use the IEC type mains connector, and then plug the lights into the optoswitch's mains socket. Next, connect a 9V DC supply to the terminal block as shown in Figure 5, connect the optoswitch mains lead to a 13A wall socket and switch on. The lights should be off. To turn the lights on, connect a wire link from the battery positive to the control input C. The unit has now been tested and is ready for use. Figure 6 shows the interconnecting wiring between the two modules.

An alternative use for the optoswitch would be to use it as an interface for computers to control mains equipment, although the value of R1 would have to be reduced to 220Ω .

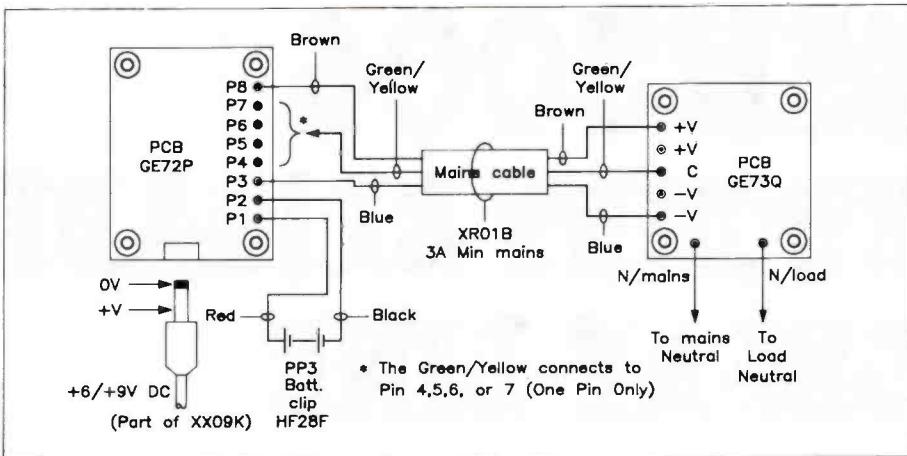


Figure 6. Interconnecting wiring.

Happy Flashing !

Specification

Maximum voltage, control supply:	12V DC
Maximum voltage, mains supply:	240V AC
Maximum power rating:	250W Resistive

+V	Positive Supply
+V	
C	Control Input
-V	
-V	Negative Supply
-V	

Note: +V and -V pins are duplicated to facilitate other opto switches being connected.

MAINS OPTO SWITCH PARTS LIST

RESISTORS: All 0.6W 1% Metal Film (unless specified)

R1	470Ω	1	(M470R)
R2	10k	1	(M10K)
R3	150Ω 1W Carbon	1	(C150R)
R4	1k 1W Carbon	1	(C1K)

CAPACITORS

SN1	R-C Contact Suppressor	1	(YR90X)
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SEMICONDUCTORS

TR1	BC548	1	(QB73Q)
OP1	Zero Crossing Optotriac	1	(RA56L)
TI1	C206D Triac	1	(WQ24B)

MISCELLANEOUS

P1-7	Pin 2145	1 Pkt	(FL24B)
PC Board		1	(GE73Q)
Constructors' Guide		1	(XH79L)
Instruction Leaflet		1	(XK38R)

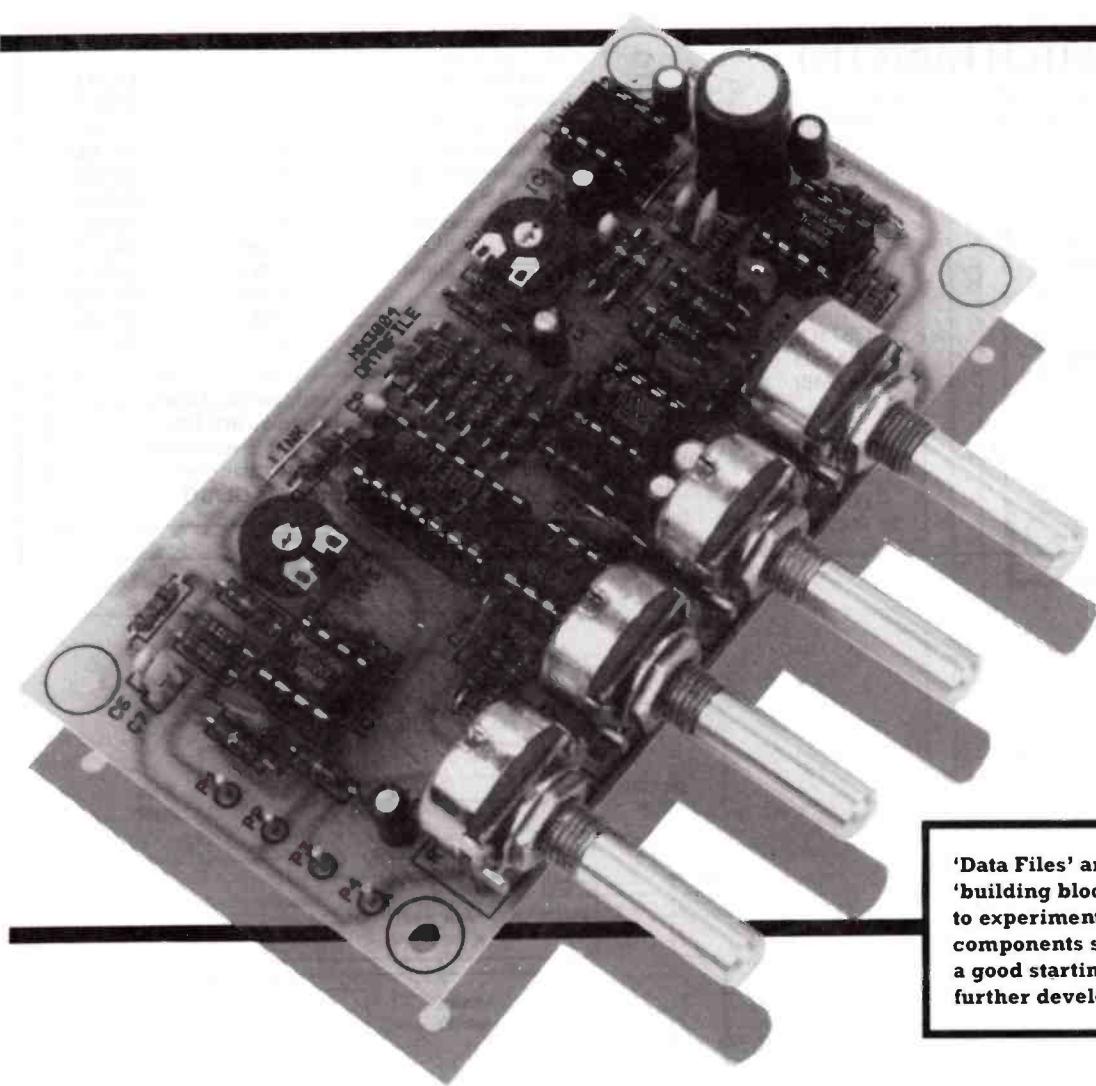
OPTIONAL (not In kit)

ABS Box MB2	1	(LH21X)
Euro Outlet Skt	1	(FT63T)
Euro Outlet Plug	1	(FT64U)
Terminal Block 2A	1	(FE78K)
Safuseholder 20	1	(RX96E)
Fuse A/S 1A	1	(WR19V)
SR Grommet SR2	1	(LR48C)
Min Mains Black	3 Mtr	(XR01B)
Isobolt M3 20mm	1 Pkt	(JD17T)
Isonut M3	1 Pkt	(BF58N)
Isoshake M3	1 Pkt	(BF44X)
M3 Insulated Spacer 10	1	(FS36P)

The above items, excluding Optional, are available as a kit:
Order As LP55K (Mains Opto Switch Kit)

The following item is also available separately
but is not shown in our 1991 catalogue:
Mains Opto Sw PCB Order As GE73Q

MN3004 BUCKET BRIGADE DELAY-LINE



'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

★ **VARIABLE DELAY OF AUDIO SIGNAL:**

2.56ms TO 25.6ms

SINGLE +15V SUPPLY KIT AVAILABLE

APPLICATIONS

- ★ Tremolo, vibrato and chorus effects
- ★ Variable or fixed delay of analogue signals
- Telephone time compression
- ★ Delay line for voice communication systems

Parameter		Min	Typ	Max	Unit
Drain supply voltage	V _{DD}	-14	-15	-16	V
Gate supply voltage	V _{GG}		V _{DD} +1		V
Clock frequency	f _{CP}	10	100	kHz	
Signal delay time	t _D	2.56	25.6	ms	
Signal frequency response	f _i		0.3 × f _{CP}	kHz	
Insertion loss	L _i	-4	1.5	4	dB
Total harmonic distortion	THD		0.4	2.5	%
Signal to noise ratio	S/N	f _{CP} = 100kHz weighted by 'A' curve		85	dB

Table 1. MN3004 Typical electrical characteristics.

Introduction to MN3004

The MN3004 is a 512 stage, low noise, bucket brigade delay line. Figure 1 shows the IC pinout and Table 1 shows some typical electrical characteristics for the IC. The device features low insertion loss, a signal to noise ratio of 85dB, and no gate back-bias is required. Figure 2 shows the MN3004 block diagram, and Figure 3 shows its internal schematic.

Analogue signals, in the audio band, can be delayed by 2.56ms to 25.6ms by adjusting the clock frequency. The device is ideally suited for processing audio signals to produce an artificial delay in public address systems.

Bucket Brigade?

Sampled values of the analogue signal to be delayed are stored in the form of charges on a series of capacitors. Between each capacitor is a switch that transfers the charge from one capacitor to the next, upon command of a clock pulse. Using the old analogy of the 'fire-fighting' method, in which buckets of water were passed along a line, from man to man, a delay line of this sort is known as a bucket-brigade.

Since each capacitor cannot take-up a new charge until it has passed on its previous one, only half the capacitors carry information at

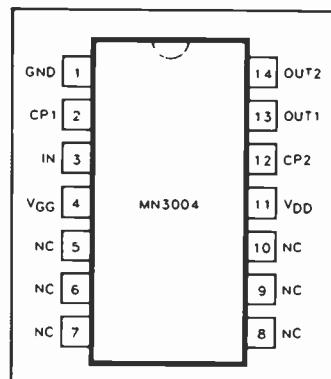


Figure 1. MN3004 pinout.

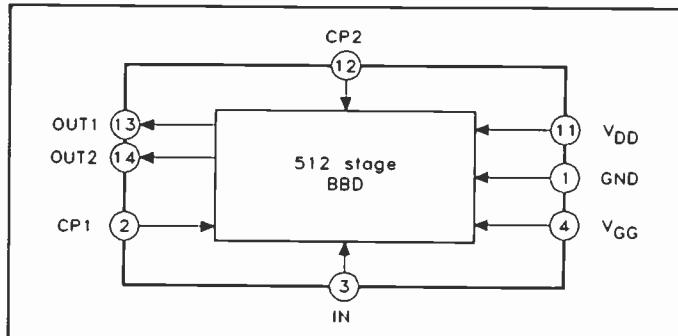


Figure 2. IC Block diagram.

any one-time and the ones in between are empty. Starting from the condition shown in Figure 4a, the transfer proceeds in two stages:

In the first stage, bucket 1 empties into bucket 2, and bucket 3 into bucket 4.

In the second stage, bucket 2 empties into bucket 3, and bucket 4 into bucket 5.

Two antiphase clock signals are therefore required;

one to empty the even-numbered buckets, and the other to empty the odd-numbered buckets.

There is, however, a practical drawback to the above method, as the buckets in which the samples are stored must empty completely during each transfer. In practice, owing to internal resistance of the capacitors, complete discharge is difficult to ensure. So instead, the system illustrated in Figure 5 is employed.

the buckets empty from right to left, the sampled quantities move from left to right.

Kit Available

A kit of parts is available to build a versatile application circuit using the MN3004. The kit includes a high quality fibreglass PCB with screen printed legend to aid construction. Figure 6 shows the circuit diagram and Figure 7 shows the PCB legend and track. A block diagram of the module is shown in Figure 8.

Setting-Up

The module requires a single +15V supply that is capable of delivering at least 40mA. It is important that the power supply is adequately smoothed and regulated to prevent any mains derived noise from entering the system via the supply rails. Power supply connections are made to P1 (+15V) and P2 (0V). Signals to the delay line are applied via P3 (input) and P4 (0V), and signals are output from the module via P5 (output) and P6 (0V). Figure 9 shows the wiring diagram.

Delay Line Biasing

The DC offset at the signal input of the MN3004 must be adjusted for minimum distortion. Starting from a level of half the supply voltage (RV6 set to mid-way), a potential change of up to 2V may be necessary. Connect the module as per Figure 9, set RV5 to its mid-way position, RV3 fully anti-clockwise (no feed-back) and RV4 fully clockwise (pure effect output). Increase the input level by rotating RV1 clockwise, followed by RV5, until the output signal is distorted. Next, adjust RV6 for minimum distortion, and increase the input level for a second adjustment. Optimise the drive margin this way until no further improvement is noted.

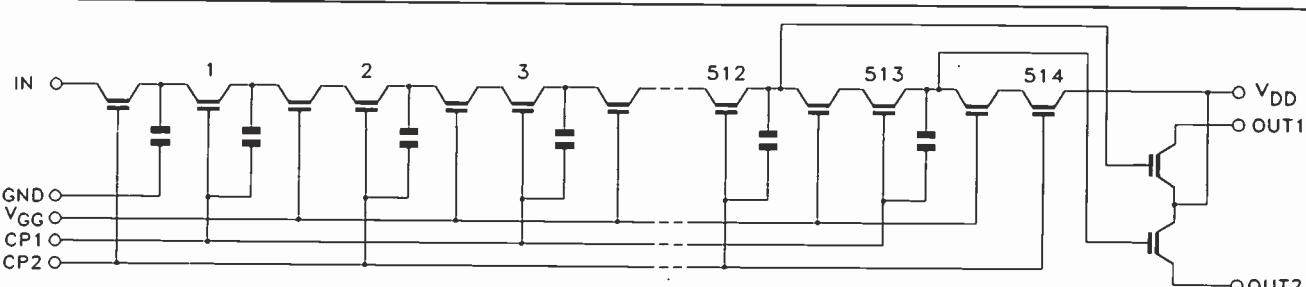


Figure 3. MN3004 internal schematic.

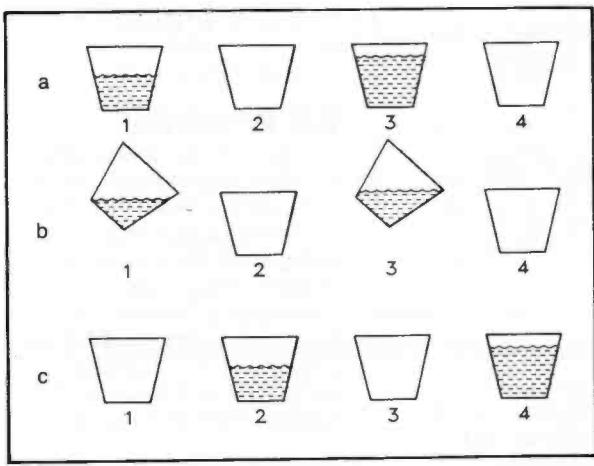


Figure 4. Simplified scheme of sample transfer: Samples in buckets 1 & 3 (a) are poured into empty buckets 2 & 4 (b) causing the samples to move from left to right (c).

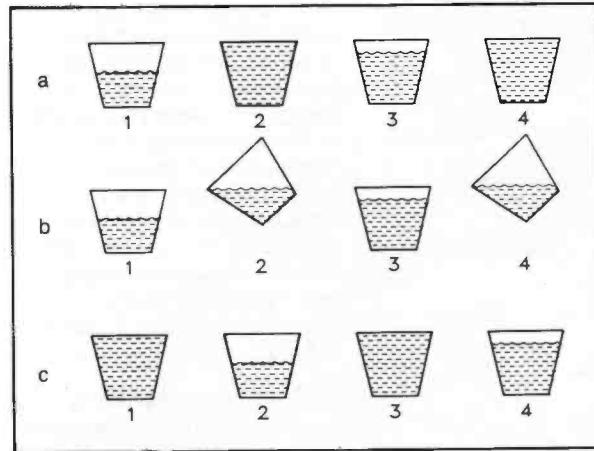
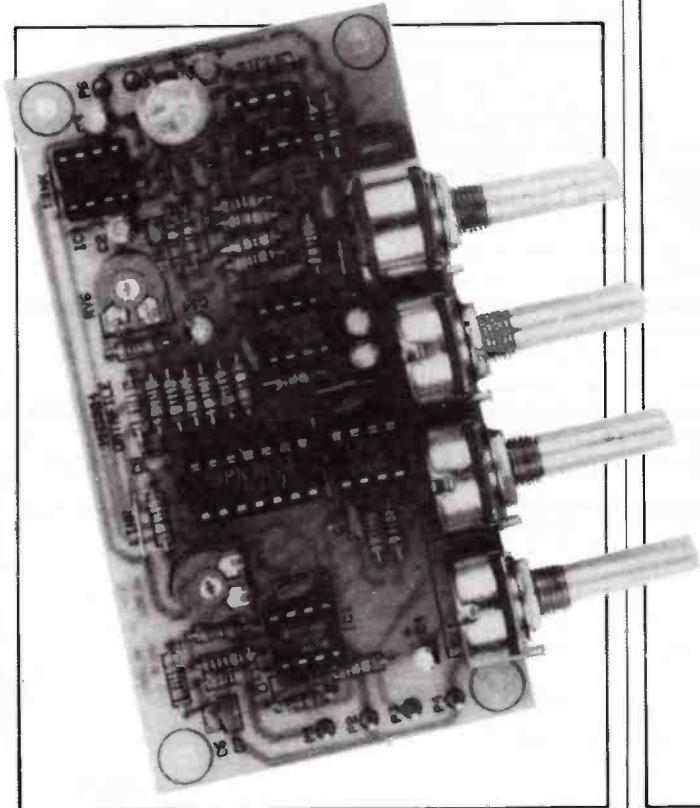


Figure 5. Practical scheme of sample transfer: Buckets 1 & 3 contain samples (a) and, when full buckets 2 & 4 are poured into them (b), the samples move from left to right (c).



The assembled PCB.

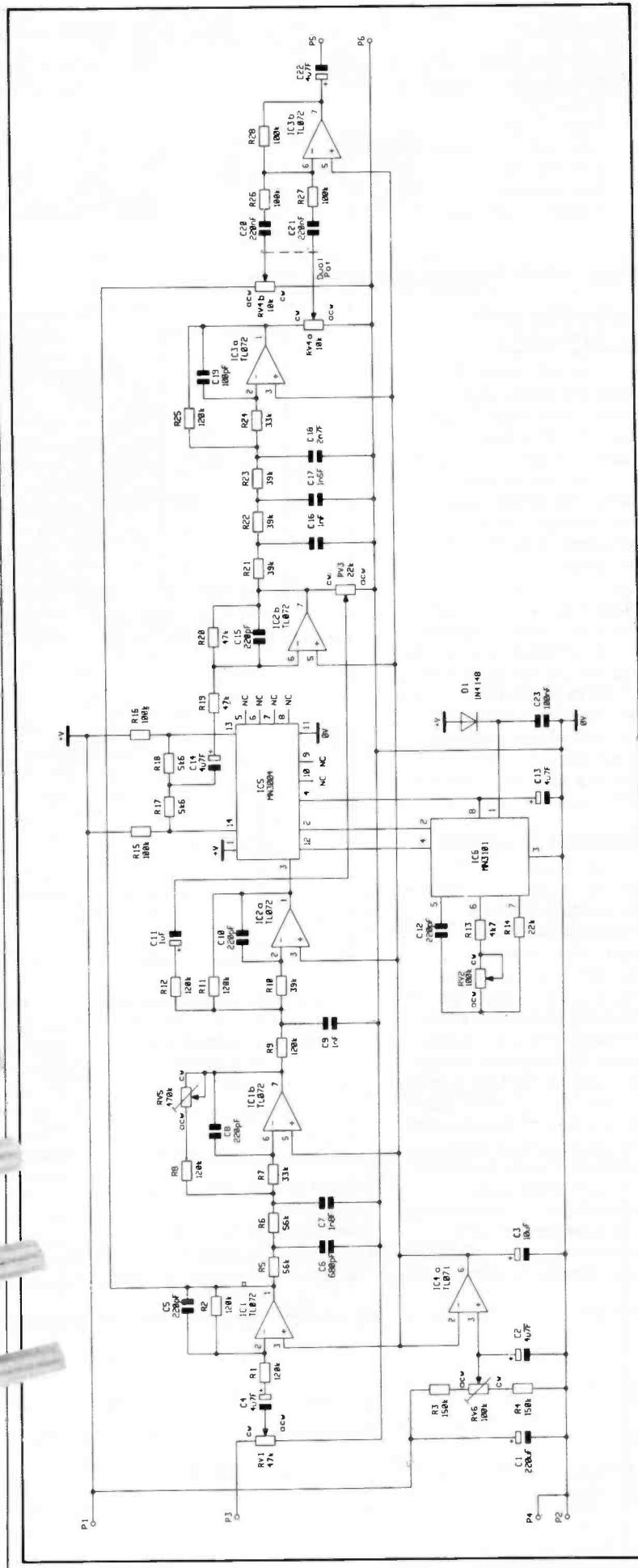


Figure 6. Circuit diagram.

Delay Line Loop Gain

With RV2 (Delay) set to mid-range and RV3 (Feedback) fully anti-clockwise connect an input signal of about 1V peak-to-peak and monitor the output signal. Adjust RV5 so that equal output levels are obtained with RV4 (Mix) fully clockwise and fully anti-clockwise. This can be done with test equipment or simply 'by ear' using a tape or digital signal source.

Applications

The module may be used in many different applications requiring a signal delay time of up to 25·6ms including musical instruments, communications systems and time compression.

As audio signals enter the module they split into two paths, which are re-united again near the output. One of these paths is a direct link from the input of the module to the mixer stage (RV4 & IC3b); the other path is via the MN3004 delay line. Note that, as the MN3004 clock frequency must be at least 3 times the maximum input signal frequency, the delayed signal has a limited bandwidth of 3·1kHz. In practice, this restricted bandwidth is hardly a problem since higher frequencies are also attenuated with natural echoes and reverberation. By varying the signal delay and the

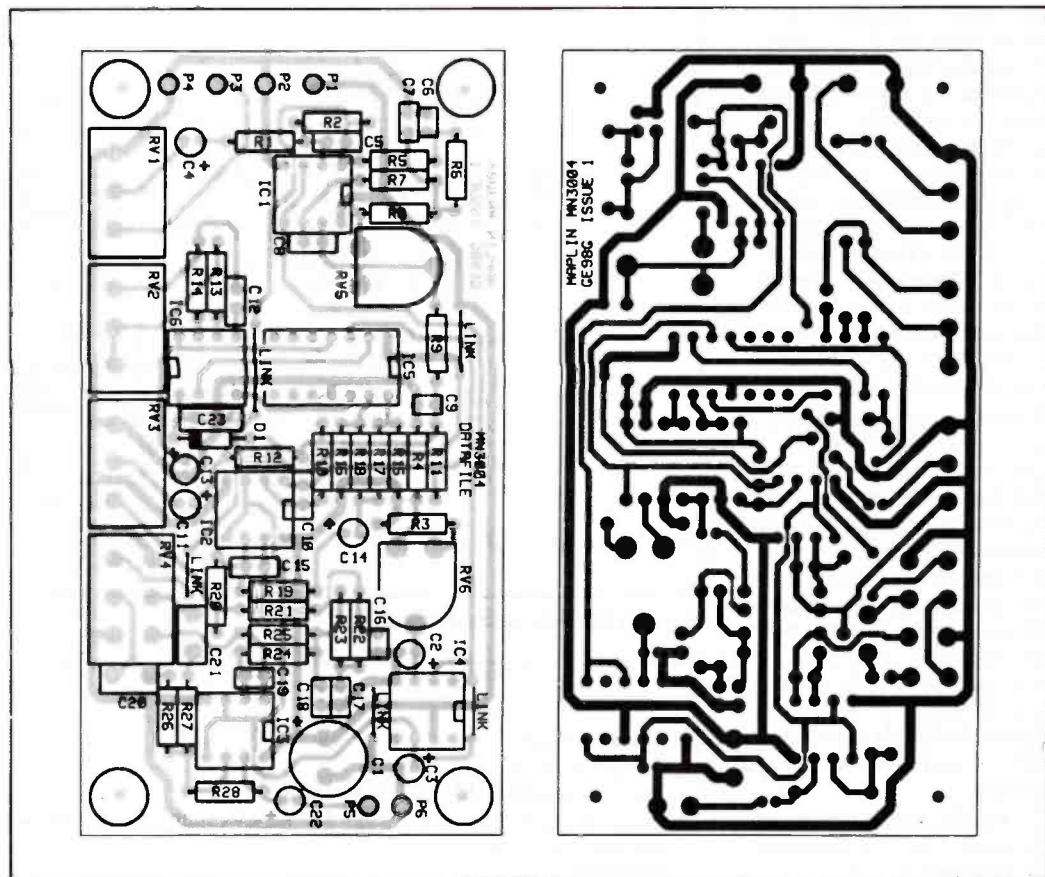


Figure 7. PCB legend and track.

mixture of direct and delayed signals, a variety of interesting effects can be obtained. Here are a few ideas to try:

With equal levels of direct and delayed signals, and a few milliseconds of delay, a 'double-tracking' effect is produced. This makes a single

input sound like a pair of independent, but time-synchronised, outputs. Using this effect a single voice sound can be made to sound like a duet, and a duet made to sound like a quartet.

With a reduced level of delayed signal in the mix, and

a reasonable length delay time, a simple echo effect is obtained. The audio sounds as if it were being played in a softly furnished room with a single hard wall facing the sound source.

When equal levels of direct and delayed signals are used

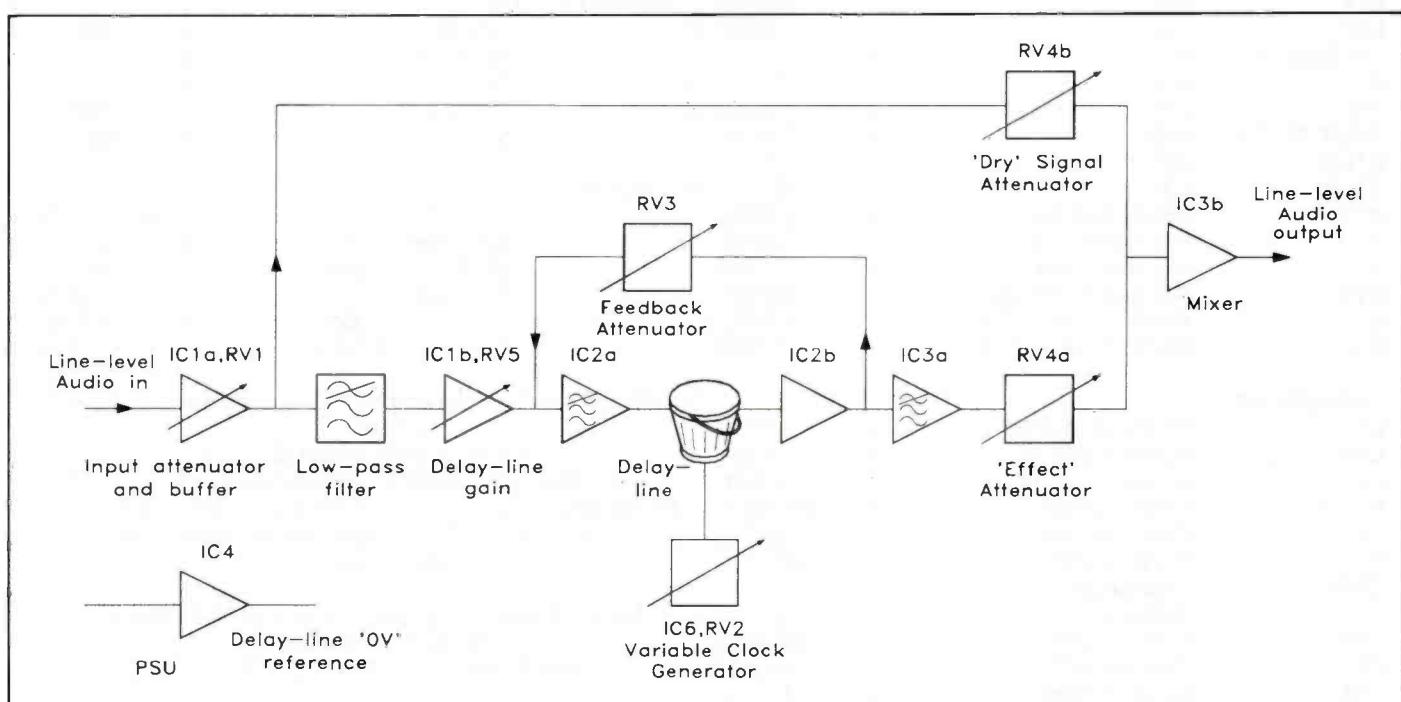


Figure 8. Module block diagram.

with a long delay time and almost maximum feed-back, the sounds seem as if they are being played in a hard-faced cave. The apparent dimensions of this 'chamber' can be varied through the delay-time control, while the 'hardness' of the chamber can be altered by the feed-back control. The apparent sounds can be varied from those of a hard cave, to a small church, or even down to a large but well furnished lounge.

When equal levels of mixing are used with a short delay time and a large amount of feed-back, all sounds give the impression that they are being played inside a small-diameter, hard-faced pipe.

The dimensions of the 'pipe' can be varied with the delay-time control, and the hardness of the pipe is variable through the feed-back control. This allows the sounds to be varied from those of a sewer pipe to a bucket.

Finally, Table 2 shows the specification of the prototype MN3004 module.

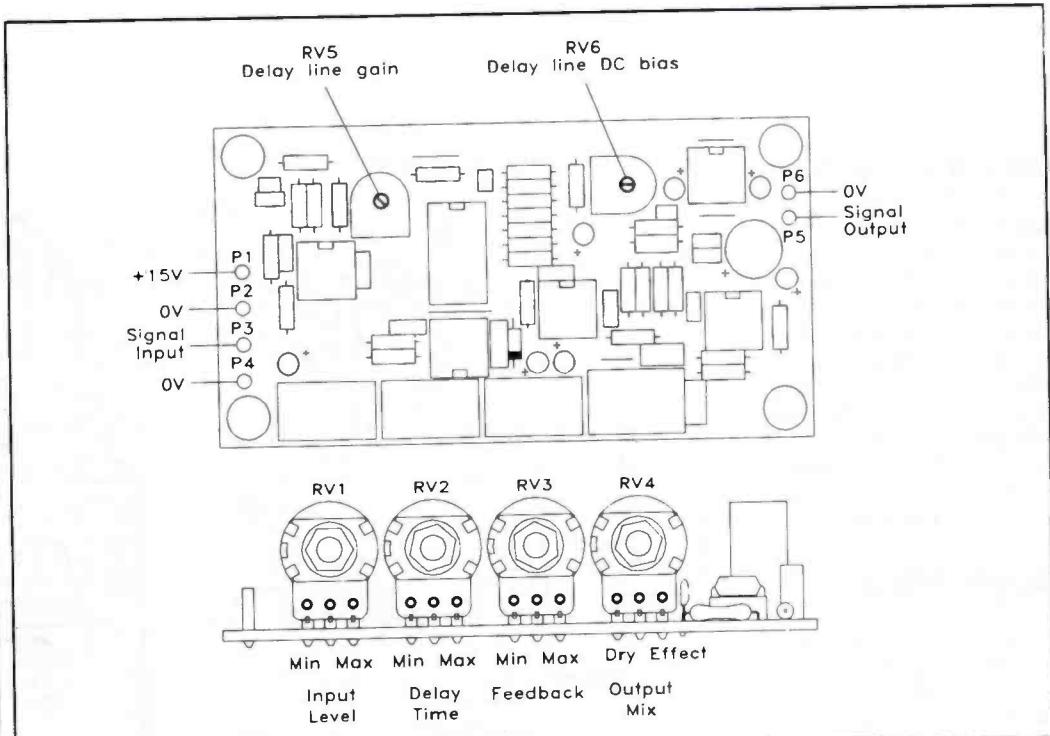


Figure 9. Module wiring diagram.

Parameter	Min	Typ	Max	Unit
Supply voltage	14	15	16	V
Supply current		36		mA
Input signal level (RV1 & RV4 fully clockwise)	1	3		Vrms
Input signal level (RV1 fully clockwise, RV4 fully anti-clockwise)	1	8		Vrms
Input impedance		47		kΩ
Delay time	2	24		ms
Dry signal path frequency response	4	15k		Hz
Delay signal path frequency response	4	3.1k		Hz
Output signal level		1		Vrms
Output impedance		600		Ω

Table 2. Specification of prototype ($V_{CC} = 15V$).

MN3004 PARTS LIST

RESISTORS: All 0.6W 1% Metal Film (Unless specified)

R1,2,8,9,11,12,25	120k	7	(M120K)	C20,21 C23	Monores Cap 220nF Minidisc 100nF 16V	2	(RA50E) (YR75S)
R3,4	150k	2	(M150K)			1	
R5,6	56k	2	(M56K)	SEMICONDATORS			
R7,24	33k	2	(M33K)	D1	1N4148	1	(QL80B)
R10,21,22,23	39k	4	(M39K)	IC1,2,3	TL072CP	3	(RA68Y)
R13	4k7	1	(M4K7)	IC4	TL071CP	1	(RA67X)
R14	22k	1	(M22K)	IC5	MN3004	1	(UM64U)
R15,16,26,27,28	100k	5	(M100K)	IC6	MN3101	1	(UM66W)
R17,18	5k6	2	(M5K6)				
R19,20	47k	2	(M47K)	MISCELLANEOUS			
RV1	Min Pot Log 47k	1	(JM78K)	P1-6	Pins 2145	6 pins	(FL24B)*
RV2	Min Pot Lin 100k	1	(JM74R)		DIL Socket 8-pin	5	(BL17T)
RV3	Min Pot Lin 22k	1	(JM72P)		DIL Socket 14-pin	1	(BL18U)
RV4	Min Dual Pot Lin 10k	1	(JM81C)		PC Board	1	(GE98G)
RV5	Hor Encl Preset 470k	1	(UH08J)		Instruction Leaflet	1	(XT24B)
RV6	Hor Encl Preset 100k	1	(UH06G)		Constructors' Guide	1	(XH79L)

CAPACITORS

C1	PC Elect 220μF 35V	1	(JL22Y)
C2,4,13,14,22	Minelect 4μF 35V	5	(YY33L)
C3	Minelect 10μF 16V	1	(YY34M)
C5,8,10,12,15	Ceramic 220pF	5	(WX60Q)
C6	Ceramic 680pF	1	(WX66W)
C7	Ceramic 1n8F	1	(WX71N)
C9,16	Ceramic 1nF	2	(WX68Y)
C11	Minelect 1μF 63V	1	(YY31J)
C17	Ceramic 1n5F	1	(WX70M)
C18	Ceramic 2n7F	1	(WX73Q)
C19	Ceramic 100pF	1	(WX56L)

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

**The above items are available as a kit.
Order As LP89W (MN3004 Data File)**

Please Note: Order Code marked with a * is not available singly, see current Maplin Catalogue for full ordering information.

The following new item (which is included in the kit) is also available separately.

MN3004 D.File PCB Order As GE94C

LOW COST AUDIO WAVEFORM GENERATOR

FEATURES

- ★ Four Frequency Ranges
- ★ Three Output Waveforms
- ★ Push-Button Switching
- ★ High and Low Level Outputs
- ★ Minimal Wiring
- ★ Battery Powered

APPLICATIONS

- ★ Acoustic Engineering
- ★ Testing Projects
- ★ Gain and Phase Measurements
- ★ Setting Filters
- ★ Bandwidth Testing

by C S Barlow



The assembled unit.
(Box not included in kit).

Specification of prototype

DC power supply input:	$\pm 6V$ to $\pm 9V$
Current at $\pm 9V$:	$\pm 25mA$
Standby current:	$<\pm 1\mu A$
Waveforms:	Sine, Triangle, Square
Frequency ranges	
10 to 100Hz:	9Hz to 105Hz
0.1 to 1kHz:	100Hz to 1.1kHz
1 to 10kHz:	895Hz to 10kHz
10 to 100kHz:	9.2kHz to 106kHz
Output amplitude	
Full:	9V (Pk-to-Pk)
Attenuated:	400mV (Pk-to-Pk)
Output impedance:	600Ω
Sinewave distortion	
10Hz to 10kHz:	<1%
10kHz to 100kHz:	<4%
Triangle linearity	
10Hz to 40kHz:	<0.1%
40kHz to 100kHz:	<1%
Square rise/fall time:	<2 μs

Introduction

To achieve optimum audio performance from home constructed kits, or manufactured equipment, usually requires a degree of testing and alignment. The majority of these tests are of a simple nature which normally require only a small adjustment of a preset component within the circuit. However, commercially available test gear often provide a level of technical sophistication which greatly exceeds that of the unit under test, and this fact is reflected in their high cost. For the hobbyist working on a restricted budget the need for a simple LOW COST audio waveform generator is apparent, and it was for this reason that Maplin have developed this project.

Every attempt has been made in making this kit as straightforward as possible, both in construction and operation. Three of the major stumbling blocks in any project design are as follows:

1. The number of off-board components.

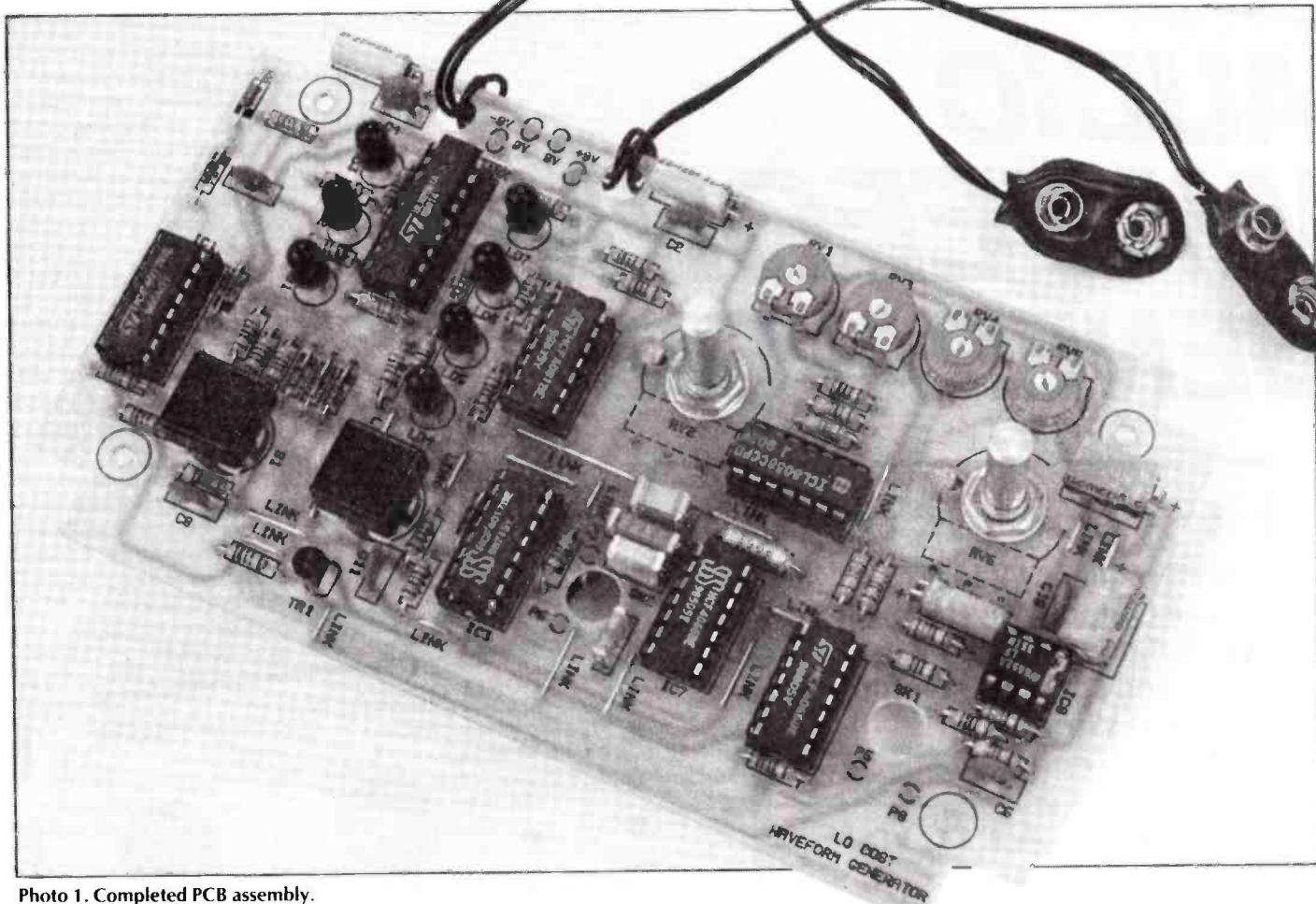


Photo 1. Completed PCB assembly.

2. The amount of wiring to and from the PCB.
3. Long term reliability.

In previous designs using standard rotary and toggle switches large amounts of messy wiring was necessary to hook everything up. Long term reliability was relatively poor owing to the number of moving parts within the switch mechanisms. However, by incorporating electronic switching all three design problems have been reduced to a minimum. This new project uses only two non-locking push-to-make PCB mounted switches to select one of four frequency ranges, one of three waveforms and power on/off.

Circuit Description

The 8038 waveform generator (IC6) is fabricated using advanced monolithic technology and only a few external components are actually required to produce a working system. However, to make it more versatile and controllable does require the following supporting ICs:

Function Control IC1 Power ON/OFF and waveform select.

Function Display IC2 LD1,2,3 Drive and -V power switch.

Function Output IC5 Sine, Triangle and Square output switch.

Range Control IC3 Selects one of four frequency ranges.

Range Display IC4 LD4, 5, 6, 7 Inhibitor.

Range Display IC2 LD4, 5, 6, 7 Drive.

Range Output IC7 Selects timing capacitor value on pin 10.

Output Buffer IC8 Provides a low impedance output.

Taking a closer look at IC6 reveals that the positive power supply is applied to pin 6, with the negative supply connecting to pin 11. The frequency of oscillation is set by two independent factors, the value of the timing capacitor on pin 10 and the sweep voltage applied to pin 7 and 8. Each timing capacitor is selected in turn by the switch action of IC7. For the lowest frequency range the largest value of capacitor is selected, which in this case is the combined values of C13 and C14. The second range switches in C15, next C16 and finally for the top range C17. To set the frequency sweep range a potential divider circuit comprising of RV1, RV2, RV3 and R31 is placed across the supply rails. Between the two preset resistors RV1, RV3 the upper and lower limits are set. Then the wiper of the main frequency control RV2 taps off the final voltage to pins 7 and 8 on IC6.

The symmetry of the three waveforms produced by IC6 is controlled by two fixed and two preset resistors. To achieve a duty cycle of 50%, R32 and R33 on pins 4 and 5 must be of identical value, the two preset

resistors RV4 and RV5 on pins 1 and 12 are used to minimise sine-wave distortion. These corrected waveforms leave the IC on pin 2 sine, 3 triangle and 9 square, the signals then pass through IC5 which is used to select the desired waveform. Setting the amplitude of the waveform is achieved by adjusting RV6, but the impedance at this point is too high for some test applications. To correct this an amplifier, IC8, provides an output that will drive into loads as low as 600Ω . To provide a clean start/stop to the signal when the power is turned on and off the output passes through IC5 before connecting to the output sockets. The maximum output level produced by the generator on SK1 is approximately 9V peak to peak and this can result in overloading the input of some highly sensitive circuits. For this reason a second attenuated output with a maximum level of approximately 400mV peak-to-peak is made available on SK2.

The function and frequency range of the generator is governed by the electronic switching circuits IC1 to 5 and IC7. When the batteries are connected up for the first time, a reset pulse is generated and applied to pin 15 of IC1 and IC3. This ensures that the unit is in its power off mode, and the lowest frequency range is selected. Every time the function push switch S1, or the frequency range switch S2 is pressed a clock signal is generated on

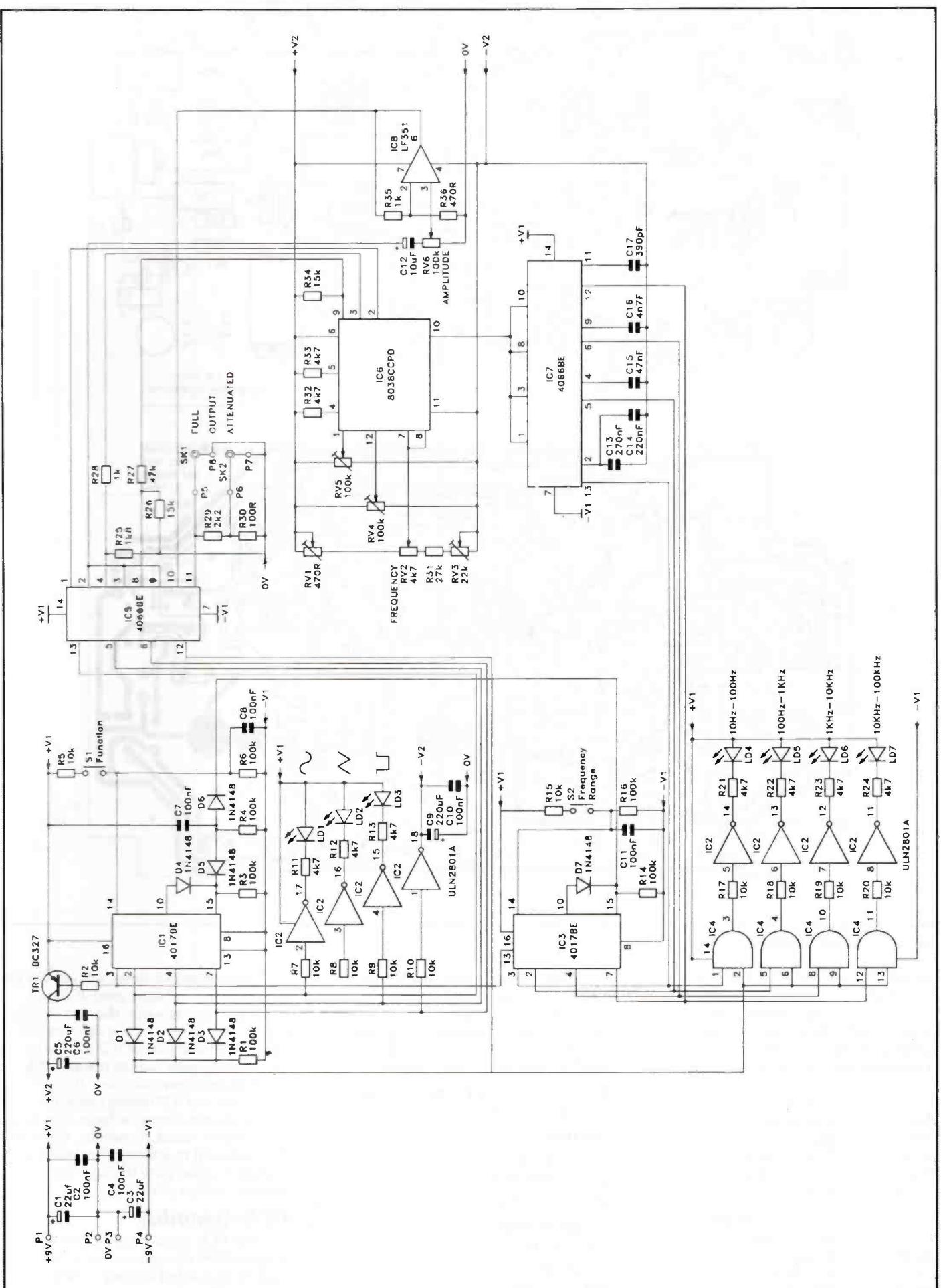


Figure 1. Circuit diagram.

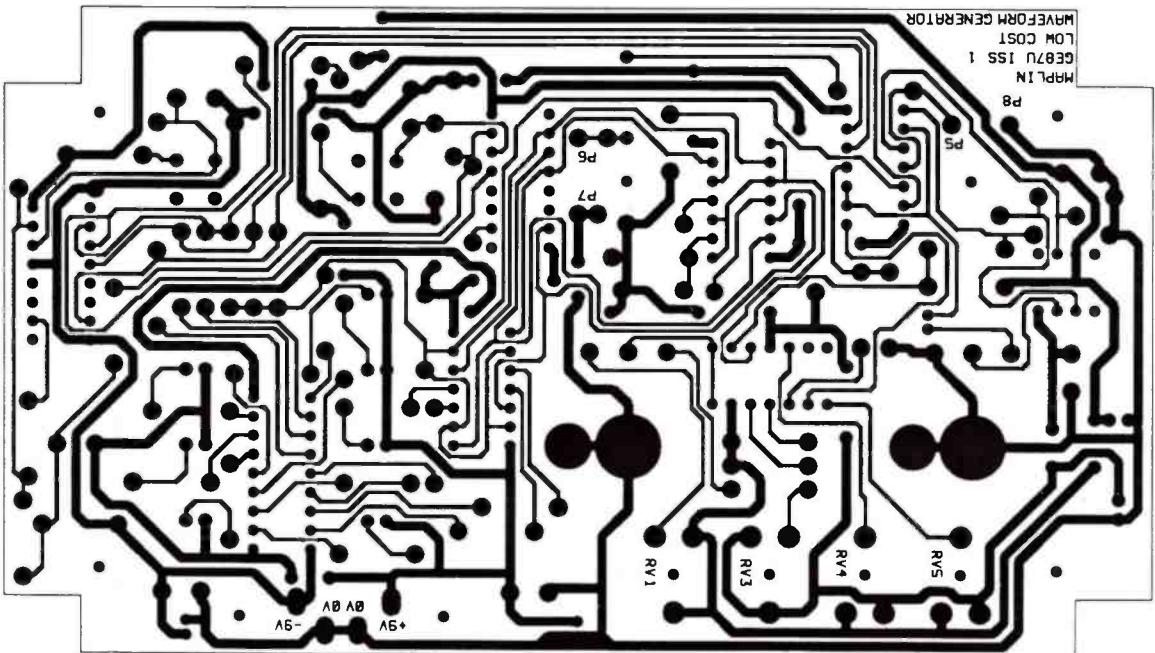
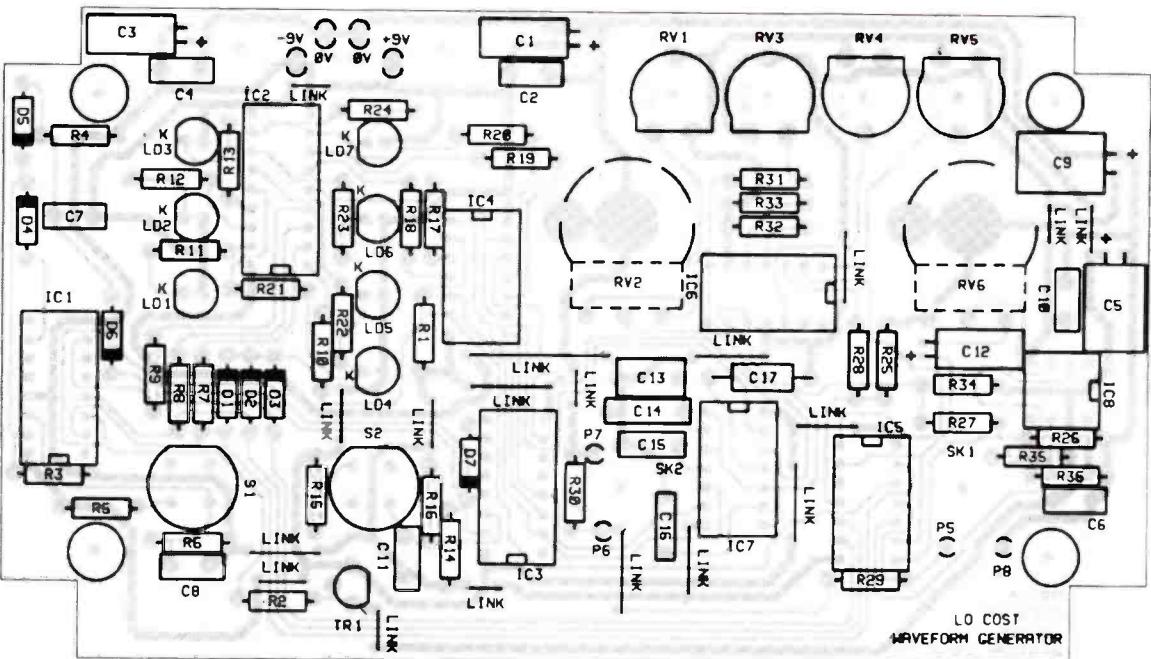


Figure 2. PCB legend and track.

pin 14 of their respective ICs (IC1 and IC3). Each IC has five outputs, the clock signal is used to step through them until the fifth one is reached which sends a reset pulse back to pin 15. The function of each IC pin is as follows:

IC1	Function
Pin 3	Power off
Pin 2	Sine-wave
Pin 4	Triangle-wave
Pin 7	Square-wave
Pin 10	Reset
IC3	Frequency Range
Pin 3	10 to 100Hz
Pin 2	0.1 to 1kHz
Pin 4	1 to 10kHz
Pin 7	10 to 100kHz
Pin 10	Reset

These outputs then control two more circuits which have similar characteristics to each other. To show which mode or frequency range you have selected each contains part of IC2 used to drive the following LEDs:

Function Control IC1 Power ON/OFF and waveform select.

Function

- LD1 Sine-Wave
- LD2 Triangle-Wave
- LD3 Square-Wave

Frequency Range

- LD4 10 to 100Hz
- LD5 0.1 to 1kHz
- LD6 1 to 10kHz
- LD7 10 to 100kHz

The frequency range display circuit has an additional logic gate, IC4, to blank the display when the unit is in its power off mode, while in the function circuit, TR1 and part of IC2 is used to switch the power rails to IC6 and IC8.

The analogue switches, IC5 waveform and IC7 timing capacitor select, receive the same logic signals as the display circuits. However, this time they are used to activate the desired analogue signal path through the relative section of each IC.

PCB Assembly

The PCB supplied in the kit is a single-sided, fibreglass type, and a copy of its printed legend is shown in Figure 2. This should assist you in correctly positioning each component,

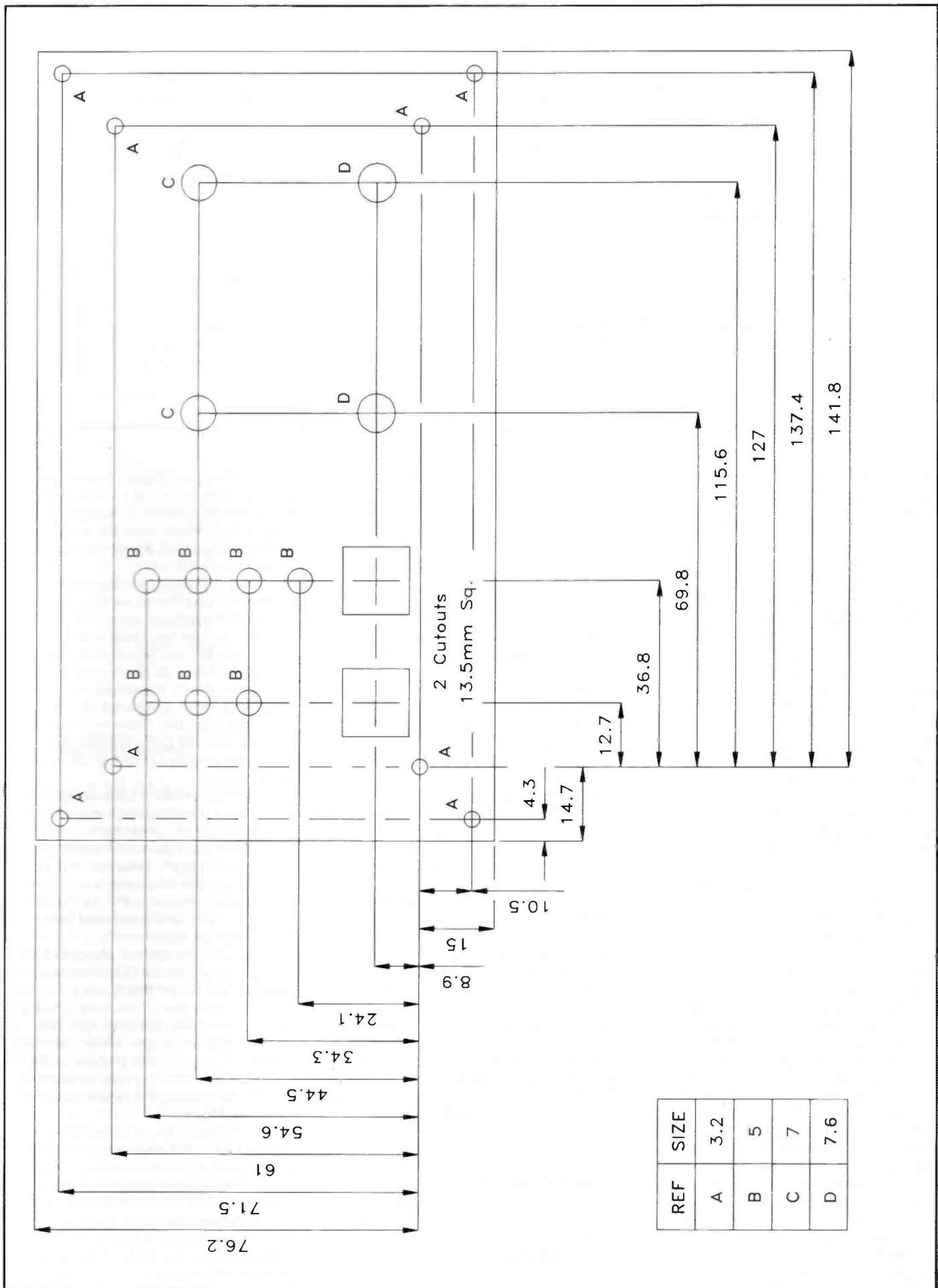


Figure 3. Front panel drilling details.

AUDIO WAVEFORM GENERATOR

Maplin

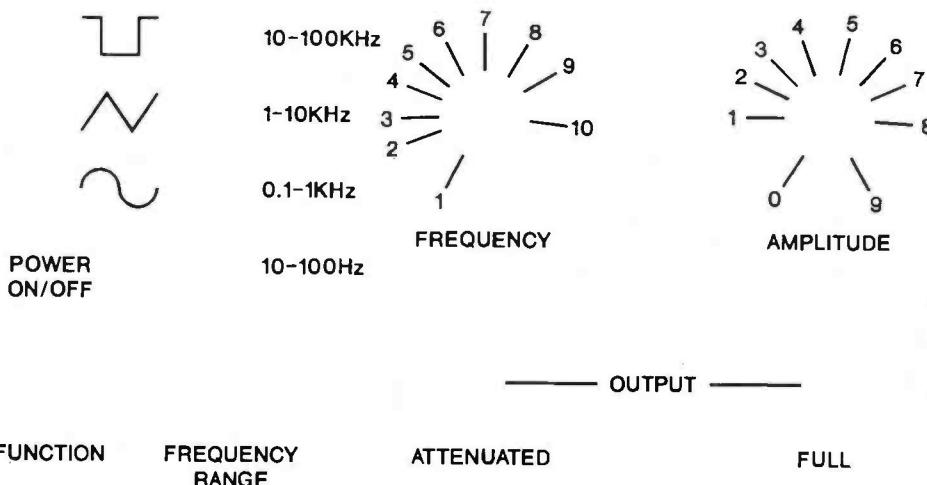


Figure 4. Front panel legend.

as removal of a misplaced item is quite difficult. Please double-check each component type, value and its polarity where appropriate, before soldering!

The sequence in which the components are fitted is not critical. However, the following instructions will be of use in making these tasks as straightforward as possible. For general information on soldering and assembly techniques please refer to the Constructors' Guide included in the Maplin kit. REMEMBER there is only a 10mm gap between the component surface of the PCB and the back of the front panel. Ensure that all the components, excluding the LEDs LD1 to LD7, are as close to the surface of the PCB as possible. Because of this restricted space the taller components must be pushed over so that they lie flat on the surface of the board. The following components have had their outlines printed on the legend to reflect this: C1 and C3, 22 μ F 25V PC Elect; C5 and C9, 220 μ F 16V PC Elect; C12, 10 μ F 50V PC Elect.

It is usually easier to start the assembly with the smaller components. Begin with the resistors R1 to R36 saving the component lead offcuts, using eighteen of these, bend them to fit the link positions on the PCB.

Next install the diodes, D1 to D7, making certain that the band on the component matches the markings on the board. When fitting the transistor TR1 ensure that its case matches the outline on the legend. The majority of the capacitors are installed and soldered in the conventional manner. However, when fitting the polarised electrolytic capacitors – C1, 3, 5, 9 & 12 – the lead nearest the negative symbol (–) on the component goes away from the positive sign on the legend, also remember to mount them as previously described.

When installing the two miniature rotary potentiometers RV2 and RV6 follow the mechanical assembly information provided in Figure 5, ensuring that you fit the correct value pot at each position. When secured, bend down the tags so that they are touching the pads on the track side of the PCB and solder them as shown. The seven LEDs LD1 to LD7 are all mounted 5mm above the surface of the board, see Figure 5. The short lead of each LED is cathode (K); this is also denoted by a flat along one side of the package, which must match up with its outline on the PCB legend.

Next mount the two click-effect push switches S1 and S2 making certain that the body of each switch matches its outline on the PCB. When fitting the IC sockets, make certain that you install the appropriate holder in each position, matching its end notch with the block on the legend.

Finally install the ICs ensuring that all the pins go into their sockets and the pin one marker is at the notched end. 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 does not have any trimmed component leads standing proud by more than 1mm, as this may result in a short circuit. The completed prototype PCB assembly is shown in Photo 1.

Final Assembly

The case in which the unit is designed to fit is the 'Metal Panel Box M4005' (WY02C). The main body of the box is moulded in black ABS plastic and does not have to be drilled or cut. In fact, the only preparation is to the aluminium top panel, see Figure 3 front

panel drilling and Figure 4 front panel legend. *Don't panic*, if you do not have the means to produce your own, Maplin have made available a pre-drilled and printed aluminium panel (Order Code KW56L).

After preparing the front panel secure the two Phono sockets SK1 and 2 using the hardware provided, see Figure 5. Solder two short wire links on to each socket and position the solder tags so the wires do not have to cross over when the PCB assembly is attached to the front panel. It is also very important that these tags should not touch any of the components on the board as either could result in a short circuit.

Next mount the PCB assembly on to the front panel, using the four 10mm insulated spacers, and check that all seven LEDs have passed through the panel, see Figure 5. Now connect up SK1 and 2 to the following solder pads: SK1 Centre terminal to P5; SK1 Solder tag to P8; SK2 Centre terminal to P6; SK2 Solder tag to P7.

The only significant amount of off board wiring is to the batteries, see Figure 6. However, this is not a problem since the wires come already prepared with the battery clips. The positive red and negative black wires both loop through a large hole in the PCB, this provides a certain amount of strain relief during the replacement of exhausted batteries.

Finally push on to S1 and 2 the square black click caps and fit the two knobs so that their pointers are at the fully-anticlockwise position. Check that they travel smoothly round to the fully-clockwise position, without scraping on the front panel. This completes the assembly of the unit. Now check your work very carefully, making sure that all the wires and solder joints are sound.

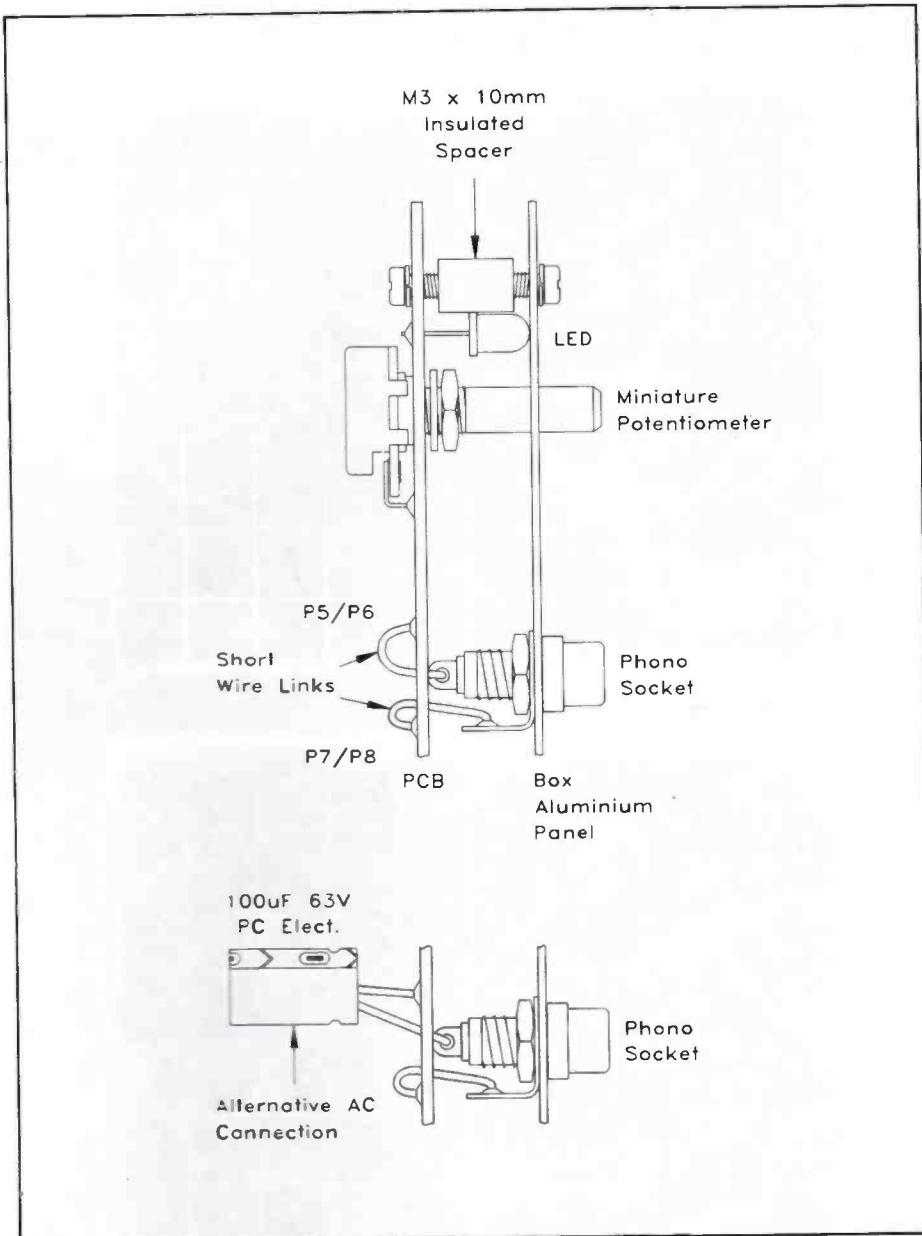


Figure 5. Mechanical assembly.

Testing and Alignment

All the DC tests are to be made using a multimeter and two PP6 nine volt batteries. 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. Before you commence testing the unit set the two rotary controls RV2 (frequency) and RV6 (amplitude) to their fully-anticlockwise positions.

The first test is to ensure that there are no short circuits on the power rails before you install the two PP6 batteries. Set your meter to read $k\Omega$ on its $20k\Omega$ resistance range, and connect the test probes to one set of battery terminals. With the probes either way round a reading greater than $4k\Omega$ should be obtained. Repeat this test on the other battery clip which should give a similar reading.

Next connect the two PP6 batteries. Although the power is now connected the generator should be in its power off mode (all LEDs off). To monitor the supply current, set your meter to read DC mA and place it in series with one of the batteries.

Ensuring that none of the LEDs are lit, observe the current reading which should be less than $1\mu A$, some multimeters may not possess sufficient resolution to read this extremely low standby current. Repeat this test on the other battery which should give a similar reading. When the function switch S1 is pressed once the generator should go to its initial power on mode, LD1 and LD4 lit. At the same time the DC current should increase to approximately $25mA$ in both batteries.

Each time the function button is pressed the waveform indicators LD1 to LD3 should step to the next position, i.e., sine, triangle, square then power off. When the frequency range button is pressed a similar stepping action should be observed on the range indicators LD4 to LD7. When the generator is in its power off mode the selected frequency range is held and can not be advanced until the unit is powered up again. The current drain previously measured should not alter significantly as different waveforms and frequency ranges are selected. This completes the DC testing of the generator, now disconnect the multimeter from the unit.

The DC tests on their own do not prove conclusively that the generator is producing an output, to do this requires some additional test equipment. A simple output test can be performed by using nothing more than a crystal earpiece, or a small audio amplifier system. However, to accurately set up the sine wave purity and frequency limits does require the use of an oscilloscope and frequency counter.

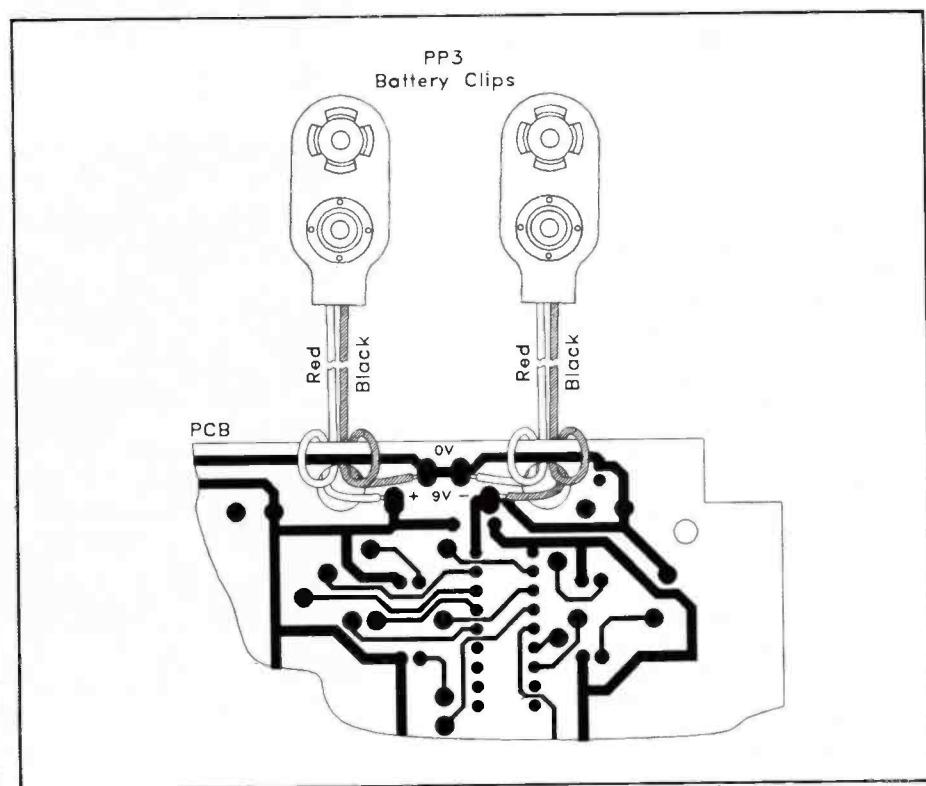


Figure 6. Battery wiring.

Before commencing the alignment set the PCB presets and the front panel controls to the following positions:

1. RV1, 3, 4 and 5 half way round.
2. Frequency control RV2 fully anticlockwise (number 1).
3. Amplitude control RV6 fully clockwise (number 9).
4. Function set to sine wave.
5. Range set to 1 – 10kHz.

Now connect the output of the generator to your oscilloscope's Y input channel. Select a suitable input sensitivity and sweep range, then observe the CRT display. If all is well, a waveform approximately corresponding to the sine wave shown in Photo 2 should appear. However, this is unlikely since the waveform purity presets RV4 and RV5 have to be critically adjusted in order to produce a sine wave with a minimum level of distortion. The effect of incorrectly adjusting these two controls can be seen in Photo 3. When the purity alignment has been successfully completed you should compare the other two waveforms against the triangle and square functions shown in Photo 2.

To set the minimum and maximum frequency control range limits a suitable frequency counter must be connected to the generators output. Some counters can give confusing results if the input signal contains too many harmonic products. For this reason it is advised that the generators sine wave function be used during the following alignment procedure. With its simple analogue dial it is not possible to obtain pinpoint accuracy over all the frequency ranges. In practice a compromise has to be made, and to achieve this the dial must have a certain amount of frequency overlap.

The two presets used to adjust the frequency limits are RV1 for the low end and RV3 for the high end. Altering either of these controls will have an affect on the other, so repeated realignment is necessary to obtain an optimised result. With the frequency control RV2 set to number one (fully anticlockwise) and the lowest range (10 – 100Hz) selected, adjust RV1 for a reading on the counter of 10Hz. Next set the frequency control to number ten and select the highest range (10 – 100kHz), adjust RV3 for a reading of 100kHz. Keep repeating this procedure while checking the other frequency ranges until your generator's calibration closely matches the specification given for the prototype unit shown in this article. Finally, using your oscilloscope check the peak to peak output levels. With the amplitude control set to maximum the full and attenuated outputs should be as follows: Full = 9V Pk-to-Pk; Attenuated = 400mV Pk-to-Pk.

Now carefully position the two PP6 batteries into the left-hand side of the

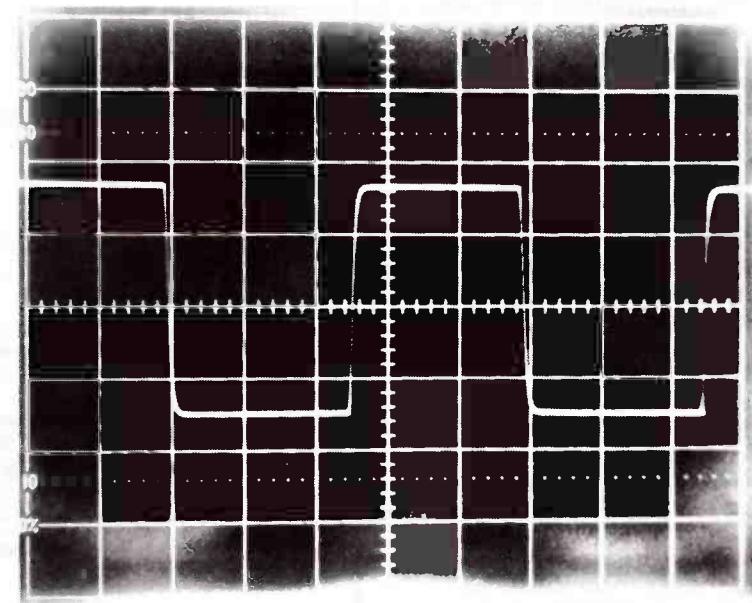
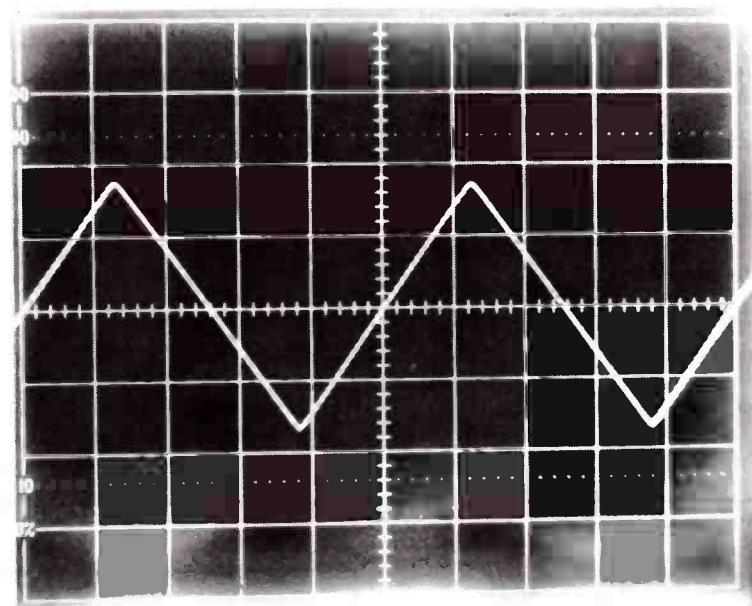
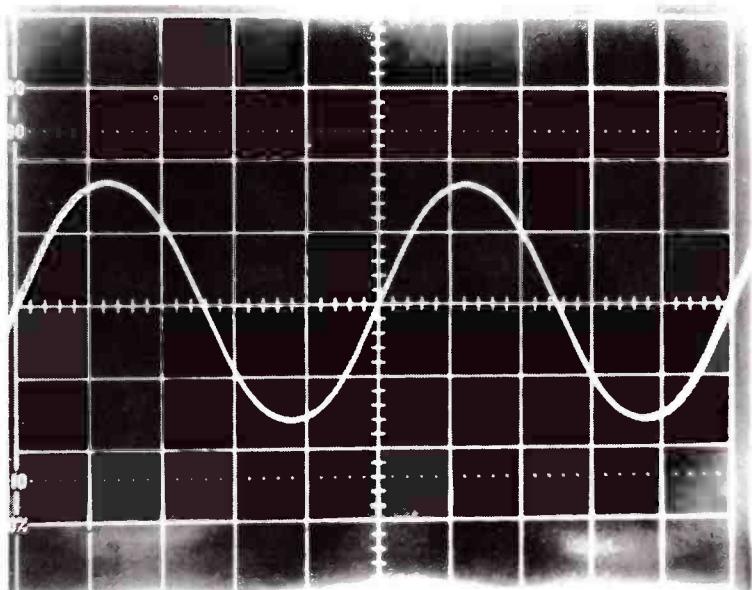


Photo 2. Correct sine, triangle and square waveforms.

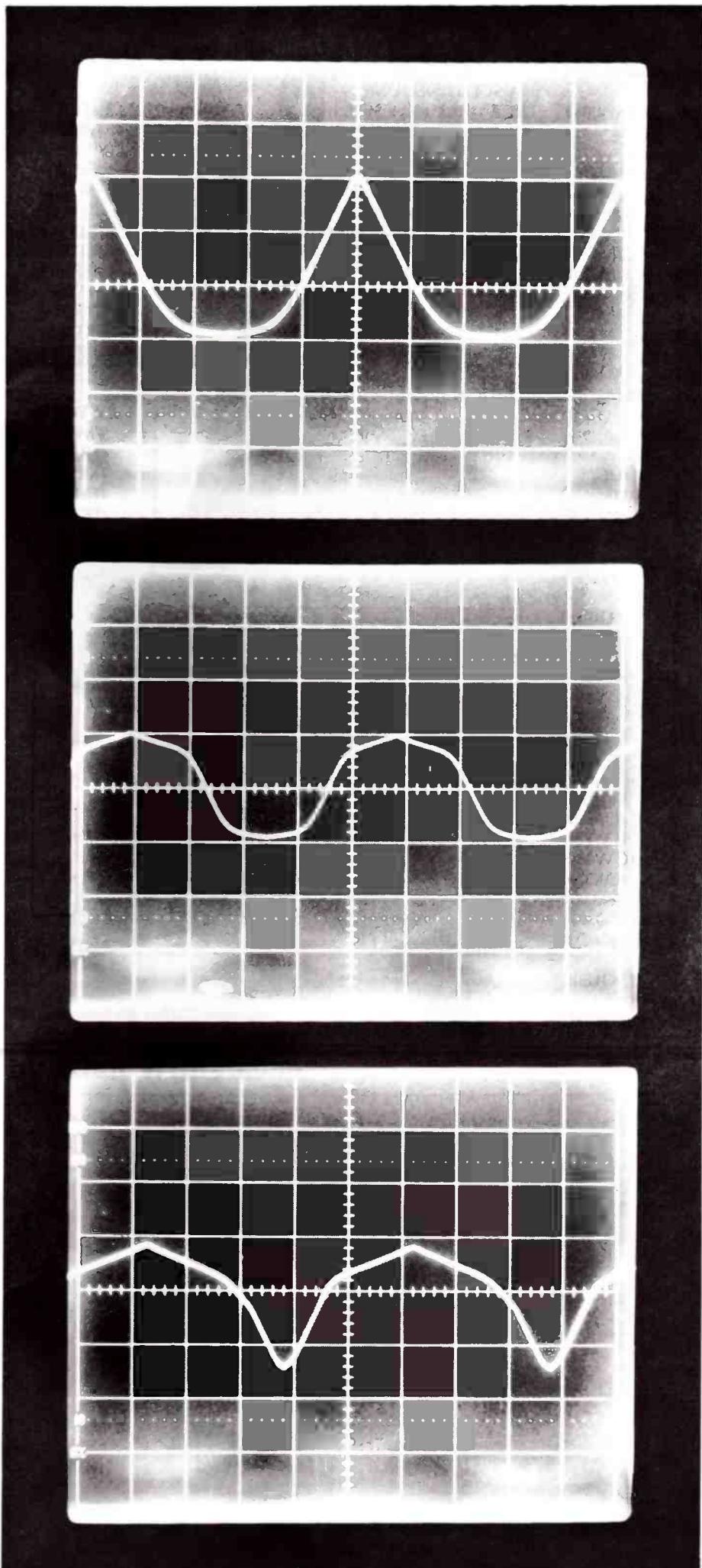


Photo 3. Incorrect sine wave.

box, so that when the front panel is in place they are behind the push buttons and LED indicators. To prevent the batteries from moving around almost any type of non-conductive packing material can be used to restrain them.

Using the Generator

There are many uses to which an audio waveform generator can be applied. In educational establishments they are often used to demonstrate the fundamentals of AC electronic theory. At a more practical level they become vital when applied to testing and fault finding on home constructed projects, or ready built pieces of electronic equipment.

IMPORTANT! THE OUTPUT OF THE GENERATOR IS DC COUPLED. When connected to an established signal input there is unlikely to be any DC voltage present as AC coupling is normally provided within the equipment under test. However, if you intend to probe around inside circuits you *must* use a suitable DC blocking capacitor placed in series with the output of the generator. To ensure good low frequency coupling when injecting the signal in to an unknown, possibly low impedance circuit, it is normal practice to use a high value capacitor, typically 100 μ F or higher. In order to keep its physical size as small as possible a polarised electrolytic type is often used. To operate correctly you must ensure that it is placed the right way round and its voltage rating is high enough to accommodate the piece of equipment under test. Because the polarity and DC voltage level can change from circuit to circuit this component is normally kept as a temporary feature at the end of the test lead. However, if the type of circuits under test have a known maximum voltage and fixed polarity a suitable capacitor may be placed inside the generator, see Figure 5.

A simple audio output lead can be quickly put together by using a phono plug, a length of screened cable and two insulated crocodile clips. To prevent any loss of signal, or stray electrical noise pick up, this lead should be kept as short as possible, i.e., up to one metre for normal practical use.

The overall performance of the generator is governed by the state of its two PP6 batteries. As these run down the peak output level will drop and the frequency control range will change slightly. Assuming that you start with a good set of full capacity batteries you can expect several hours of continuous use before any appreciable sign of waveform deterioration occurs. When the batteries are exhausted it is strongly recommended that you remove them from the unit as any chemical leakage can result in permanent circuit damage.

AUDIO GENERATOR PARTS LIST

RESISTORS: All 0.6W 1% Metal film (Unless specified)

R1,3,4, 6,14,16	100k	6	(M100K)
R2,5,7,8, 9,10,15, 17,18,19, 20	10k	11	(M10K)
R11,12,13, 21,22,23, 24,32,33	4k7	9	(M4K7)
R29	2k2	1	(M2K2)
R25	1k8	1	(M1K8)
R26,34	15k	2	(M15K)
R27	47k	1	(M47K)
R28,35	1k	2	(M1K)
R30	100Ω	1	(M100R)
R31	27k	1	(M27K)
R36	470Ω	1	(M470R)
RV1	470Ω Horizontal Encl Preset	1	(UF99H)
RV2	4k7 Min Pot Lin	1	(JM70M)
RV3	22k Horizontal Encl Preset	1	(UH04E)
RV4,5	100k Horizontal Encl Preset	2	(UH06G)
RV6	100k Min Pot Lin	1	(JM74R)

CAPACITORS

C1,3	22μF 25V PC Elect	2	(FF06G)
C2,4,6,7, 8,10,11	100nF 16V Minidisc	7	(YR75S)
C5,9	220μF 16V PC Elect	2	(FF13P)
C12	10μF 50V PC Elect	1	(FF04E)
C13	270nF Poly Layer	1	(WW46A)
C14	220nF Poly Layer	1	(WW45Y)
C15	47nF Poly Layer	1	(WW37S)
C16	4n7F Poly Layer	1	(WW26D)
C17	390pF 1% Polystyrene	1	(BX52G)

SEMICONDUCTORS

IC1,3	4017BE	2	(QX09K)
IC2	ULN2801A	1	(QY78K)
IC4	4081BE	1	(QW48C)
IC5,7	4066BE	2	(QX23A)
IC6	ICL8038CCPD	1	(YH38R)
IC8	LF351N	1	(WQ30H)
TR1	BC327	1	(QB66W)
D1,2,3,4, 5,6,7	1N4148	7	(QL80B)
LD1,2,3, 4,5,6,7	Red LED 5mm 2mA	7	(UK48C)

MISCELLANEOUS

S1,2	Click Switch	2	(FF87U)
SK1,2	Click Cap Black	2	(FF88V)
	Chassis Phono Skt	2	(YW06G)
	Knob K14A	2	(FK38R)
	DIL Socket 8-pin	1	(BL17T)
	DIL Socket 14-pin	4	(BL18U)
	DIL Socket 16-pin	2	(BL19V)
	DIL Socket 18-pin	1	(HQ76H)
	PP3 Clip	2	(HF28F)
	M3 Insulated Spacer 10mm	4	(FS36P)*
	PCB	1	(GE87U)
	Instruction Leaflet	1	(XT16S)
	Constructors' Guide	1	(XH79L)

OPTIONAL (Not in kit)

Metal Panel Box M4005	1	(WY02C)
PP6 9V Battery	2	(FM03D)
Screw-Cap Phono Black	1	(HQ54J)
Cable Single Black	1m	(XR12N)
Red Croc Clip	1	(FM37S)
Black Croc Clip	1	(FK34M)
100μF 63V PC Elect	2	(FF12N)
Front Panel	1	(KW56L)

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

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

Order As LP01B (Low Cost Sig Gen Kit)

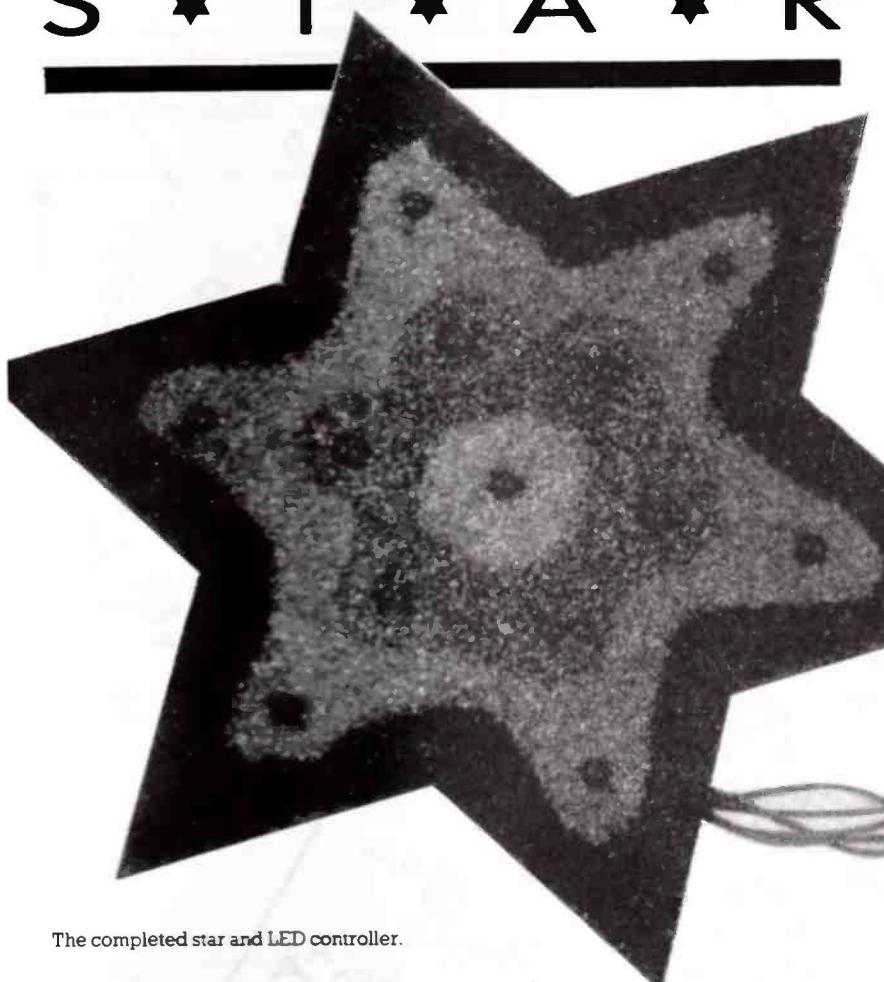
Please Note: Order Code marked with a * is not available singly, see current Maplin Catalogue for full ordering information.

The following new item (which is included in the kit) is also available separately.

Low Cost Sig Gen PCB Order As GE87U

XMAS

S * T * A * R



The completed star and LED controller.

by Alan Williamson

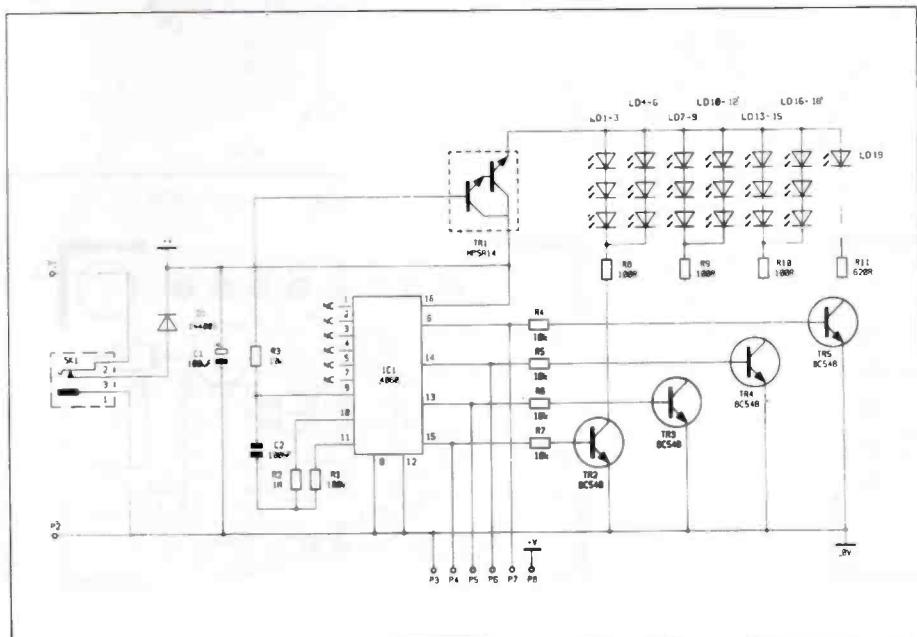


Figure 1. Circuit diagram.

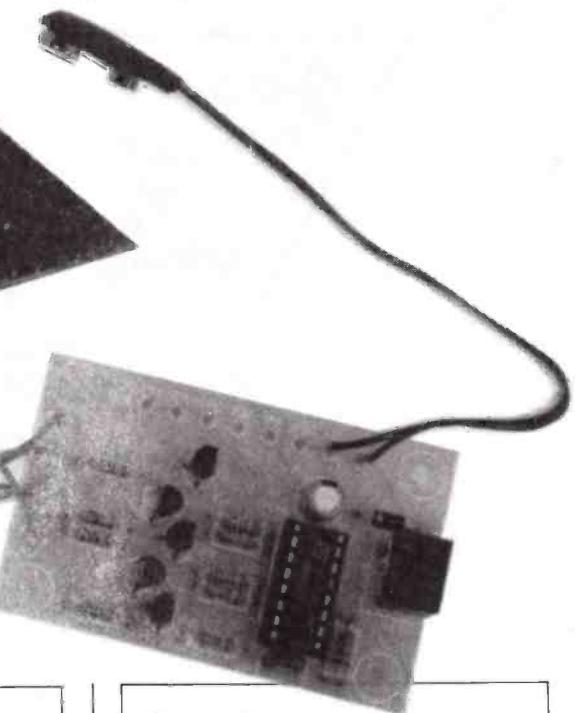


This novelty project is a festive star with lots of flashing LED's to sit upon your Christmas tree. The LED's are switched on and off at different rates by an LED controller.

The controller has two sets of 4-bit binary outputs, one set originating directly from the chip and the other set via open collector transistors. See Table 1. The controller also has a pulsed supply (switching on and off); this helps to conserve power when the controller is operating from a battery.

Circuit Description

Looking at the circuit diagram Figure 1, you will see that the heart of the controller is a CMOS 4060 IC, which contains an oscillator and a 14-stage divider, with an output at most stages of



Pin	Description
Pin 1.	+ V Battery
Pin 2.	0V Battery
Pin 3.	0V
Pin 4.	Direct output D1 (MSB)
Pin 5.	" " D2
Pin 6.	" " D3
Pin 7.	" " D4 (LSB)
Pin 8.	+ V
Pin 9.	Pulsed supply output
Pin 10.	Open collector D1 (MSB)
Pin 11.	" " D2
Pin 12.	" " D3
Pin 13.	" " D4 (LSB)

Table 1. Pin description.



division. Stages 7, 8, 9 and 10 (IC pins 6, 14, 13 and 15 respectively) are used to drive transistors TR2 - TR5 via $10\text{k}\Omega$ resistors, the LED's being the collector load of each transistor. A direct output of stages 7 through 10 is available at pins 7, 6, 5 and 4. The switching transistor TR1 is connected to the oscillator, using the highest available frequency and therefore avoiding visible flicker in the LED's. The oscillator frequency is determined by the components R2 and C2, and the frequency can be calculated using the formula:

$$f_{osc} = 1 / 2 \cdot 3 \times R_2 \times C_2$$

Battery Life

The peak current consumption of the LED controller with all the LED's lit is approximately 70mA, but due to the switching transistor this figure is reduced by half, making the expected life from a PP6 battery around 20 hours. It is therefore

recommended that a 6 to 9V DC mains adaptor is used for prolonged use, and a 300mA unregulated supply would be ideal for this application, for example Maplin stock code XX09K.

Construction

Please refer to the Constructors' Guide for hints and tips on soldering and constructional techniques.

Referring to the PCB component legend, Figure 2, assemble the PCB as follows.

Begin by finding the MPSA14 transistor and put it to one side so that it will not be placed into the wrong position.

Insert, solder and crop each component starting with the resistors. The veropins are fitted from the track side, remember that C1 and D1 are polarised devices and must be correctly fitted.

Having completed the PCB it should be now cleaned with alcohol, Ultraclene or PCB cleaner (Maplin stock code

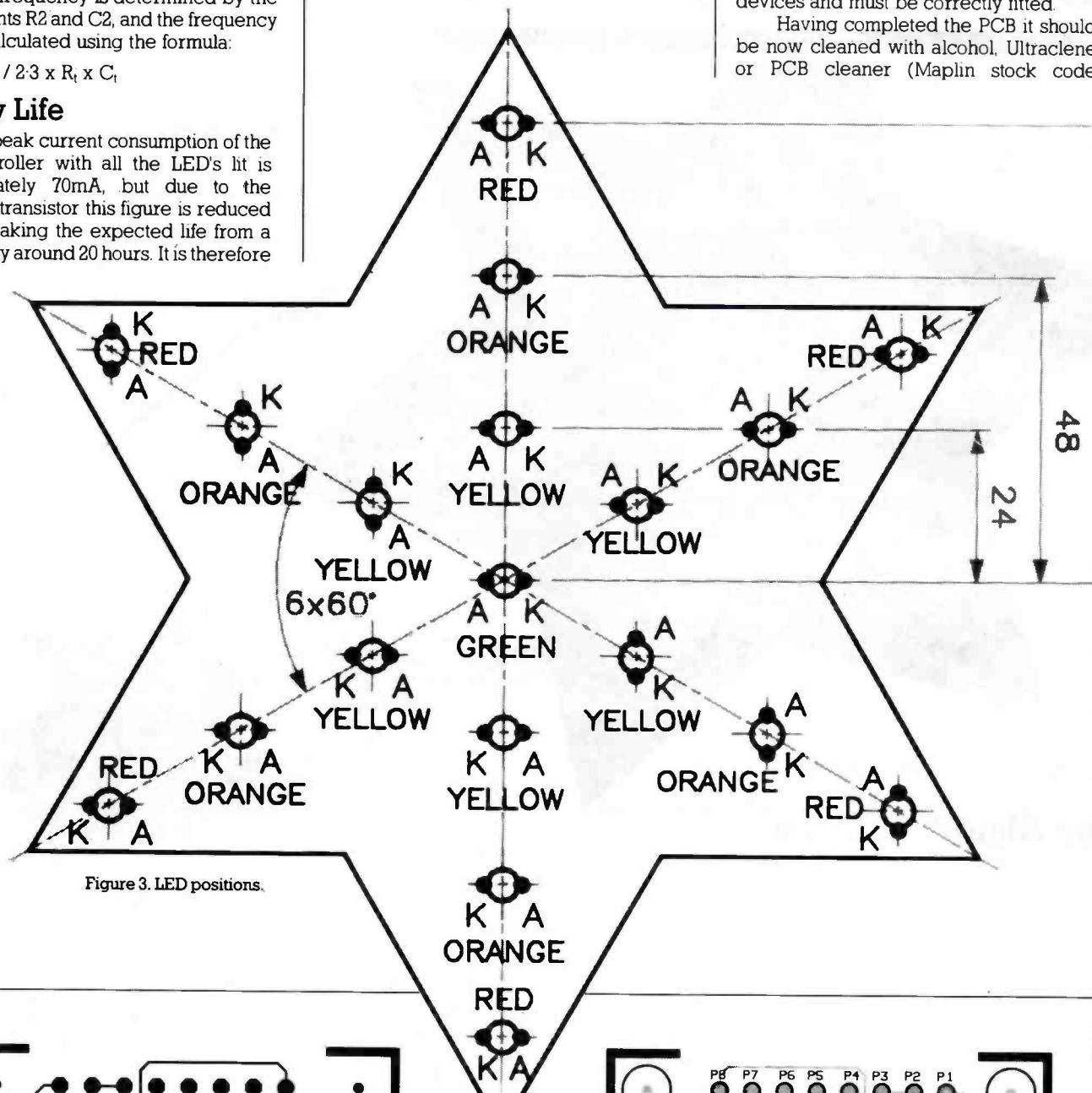


Figure 3. LED positions.

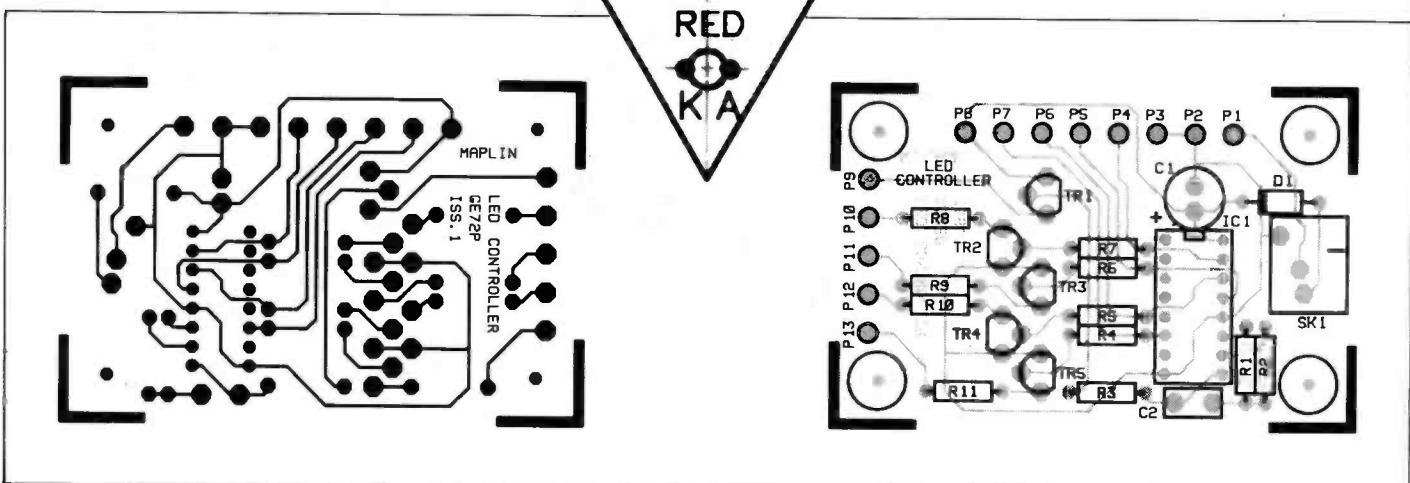


Figure 2. Component legend.

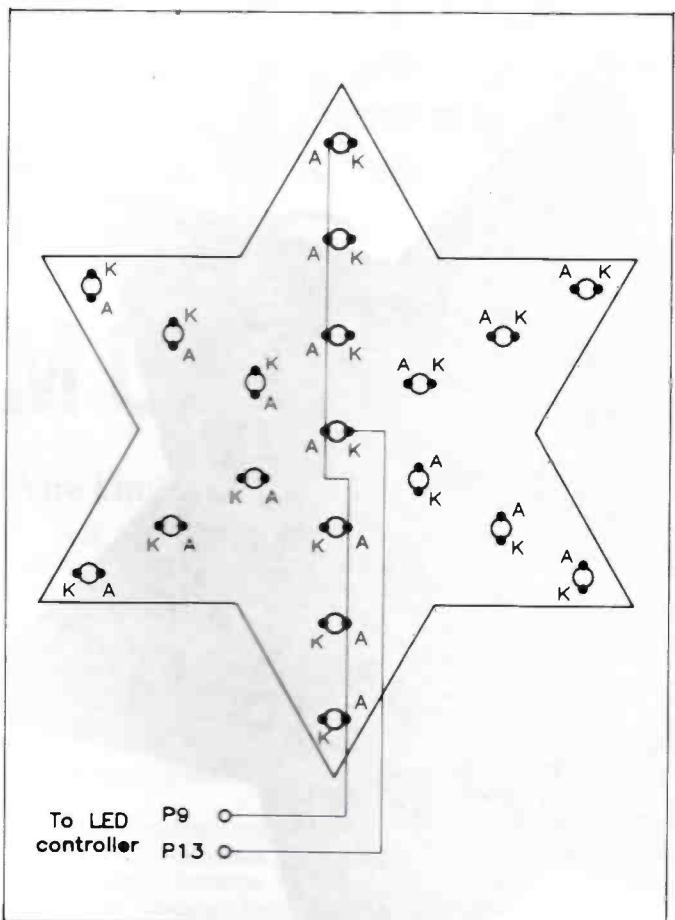


Figure 4. Common supply and centre LED.

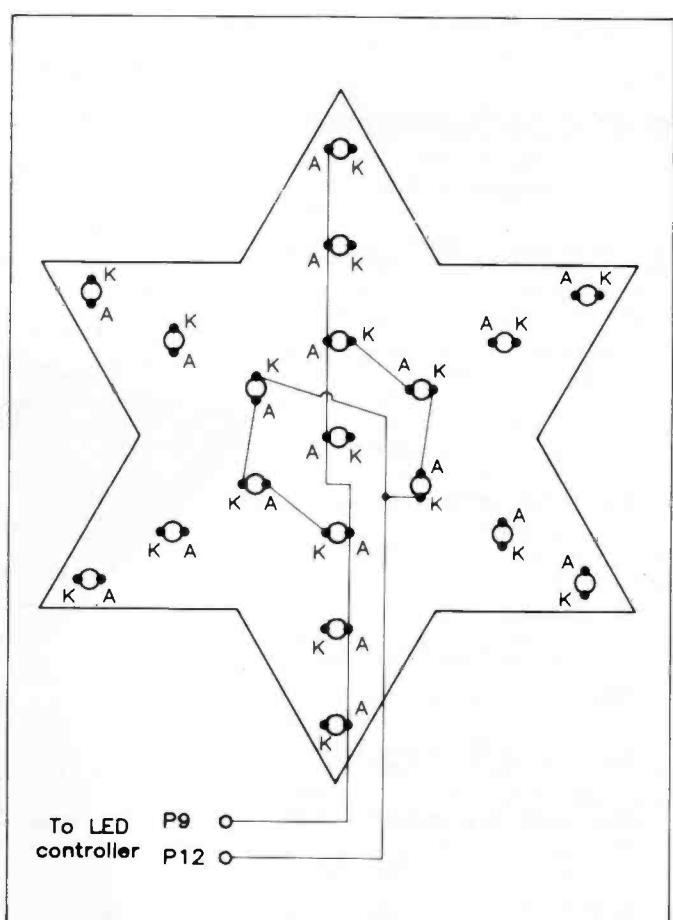


Figure 5. Inner LED group wiring.

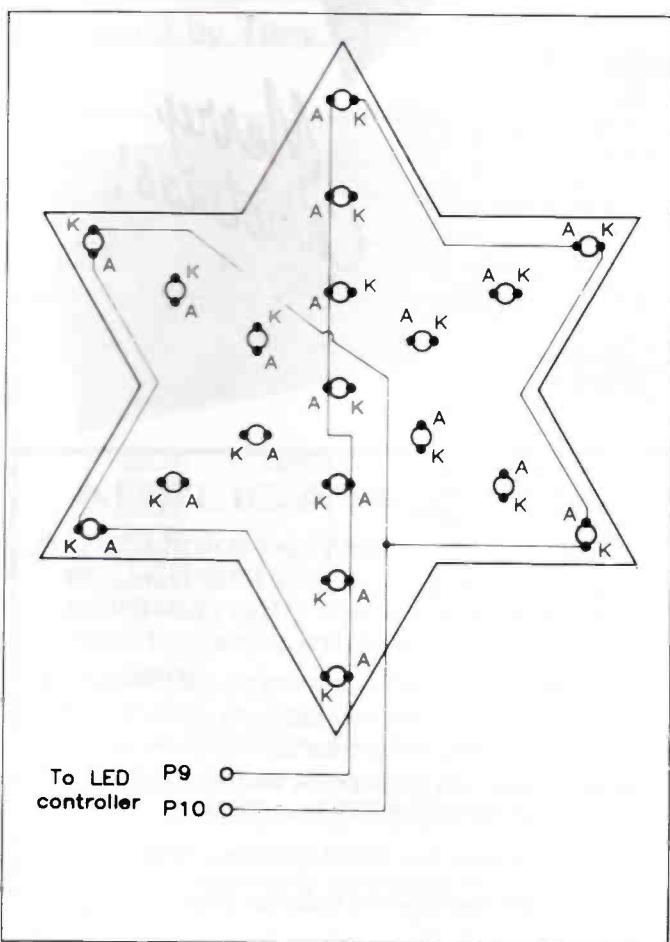


Figure 6. Outer LED group wiring.

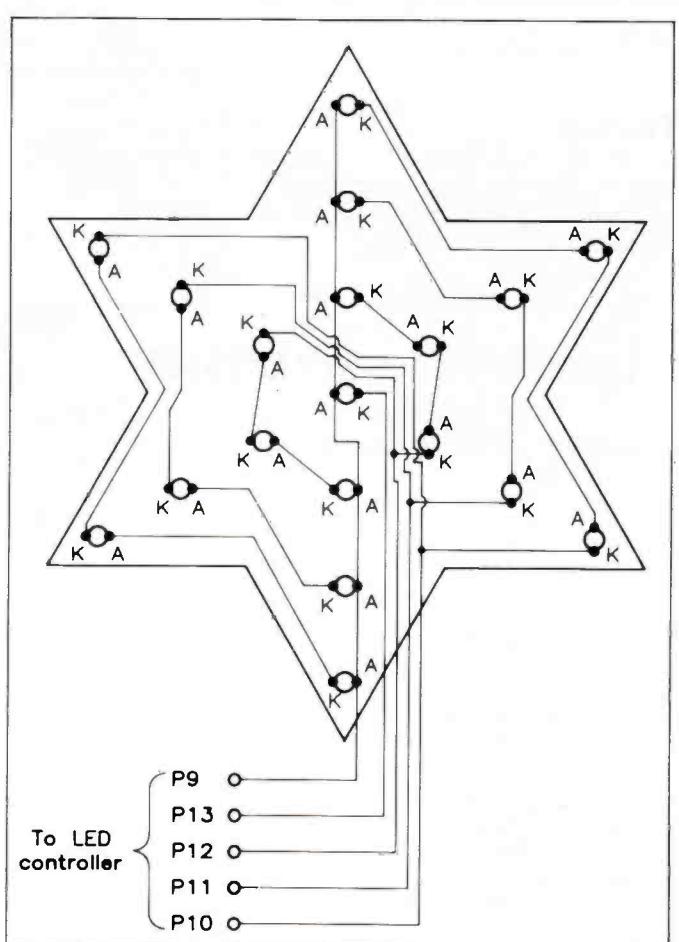


Figure 7. Completed LED wiring.



YT66W and YJ45Y), then put it to one side so as not to damage it while you are building the festive star.

Building the Festive Star

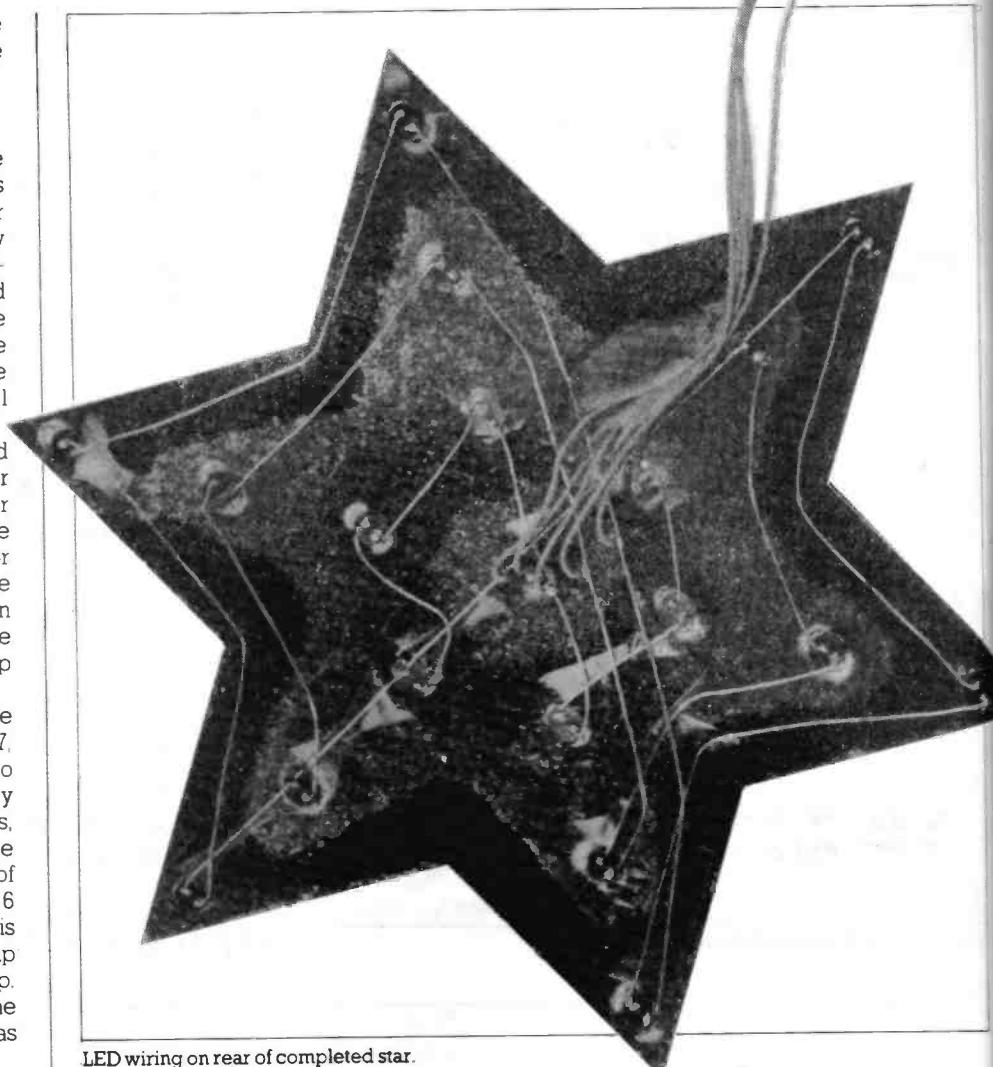
Begin by taking a photostat or trace around the star printed on the previous page to use as a template, make a star (or any other shape you may fancy) from any material handy e.g. thin plywood, hardboard, perspex or thick card. Metal and other conductive materials should not be used, otherwise the LED's could become short circuited. Alternatively a decorative star could be purchased from your local Christmas decoration supplier.

Once the star has been cut out and the 5mm holes drilled for the LED's, cover the face of the star with baking foil or aluminium laminate (Maplin stock code XY19V), or alternatively some silver or coloured glitter to make it look pretty. The next job is to glue the LED's into the star in the positions shown in Figure 3. Allow the glue to set before attempting to wire up the LED's.

Connect the LED's using the cable supplied as shown in Figures 4, 5, 6 and 7, the cathode being the shorter of the two leads. Figure 4 shows the common supply to the top anode of each group of LED's, and the lead to the cathode of the centre LED. Figure 5 shows the first group of LED's away from the centre, Figure 6 shows the outer group of LED's which is wired in the same way as the inner group and Figure 7 shows all the LED's wired up. Having now completed the wiring, the LED legs should be trimmed as short as possible.

Testing

To test the controller, connect the leads from the star as shown in Figure 1, and connect a PP6 battery to the battery clip or apply 6 to 9 volts DC to the power



LED wiring on rear of completed star.

socket, the pin of the socket being 0V. The LED's will start to flash, if any group of LED's fail to light; check to see if one of the LED's has been inadvertently fitted the wrong way round.

*Merry
Christmas!*

LED CONTROLLER PARTS LIST

RESISTORS: All 0.6W 1% Metal Film

R1	1M	1	(M1M)
R2	100k	1	(M100K)
R3-7	10k	5	(M10K)
R8-10	100Ω	3	(M100R)
R11	620Ω	1	(M620R)

CAPACITORS

C1	100μF 16V Minelect	1	(RA55K)
C2	68nF Monores	1	(RA48C)

SEMICONDUCTORS

D1	1N4001	1	(QL73Q)
LD1-6	LED Red	6	(WL27E)
LD7-12	LED Orange	6	(WL29G)
LD13-18	LED Yellow	6	(WL30H)
LD19	LED Green	1	(WL28F)
TR1	MPSA14	1	(QH60Q)
TR2-5	BC548	4	(QB73Q)
IC1	4060BE	1	(QW40T)

MISCELLANEOUS

P1-13	Pin 2145	13 Pins	(FL24B)
	DIL Socket 16-Pin	1	(BL19V)
	PC Mtg Power Socket	1	(RK37S)
	PP3 Battery Clip	1	(HF28F)
	PC Board	1	(GE72P)
	Constructors' Guide	1	(XH79L)
	Instruction Leaflet	1	(XK37S)

OPTIONAL (not in kit)

PP6 Battery	1	(FM03D)
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The above items, excluding Optional, are available as a kit:
Order As LP54J (LED Xmas Star Kit)

The following item is also available separately
but is not shown in our 1991 catalogue:
LED Controller PCB Order As GE72P

10 Channel FIBRE-OPTIC DIGITAL MULTIPLEXER

Wire Limitations

Until recently, electronic designers were restricted in their choice of interconnections between systems. Wire cables have traditionally been the only cost-effective choice until the arrival of inexpensive fibre-optic devices. The designer now has the choice of using conventional wire or advanced fibre-optic communications.

The use of wire cable has several disadvantages, some of which are listed below:

Interconnecting wires act as antennas, funnelling the destructive voltage caused by electrostatic discharge (ESD) to sensitive circuits. Common forms of ESD are: lightning; discharge of a spark by a person,

due to static voltage accumulation; high voltage discharge of a xenon lamp firing; etc.

Radio frequency interference (RFI) from radio, TV stations, computers, etc. can cause errors in data communications. Again, the interconnecting wire acts as an antenna, picking up the RF signals.

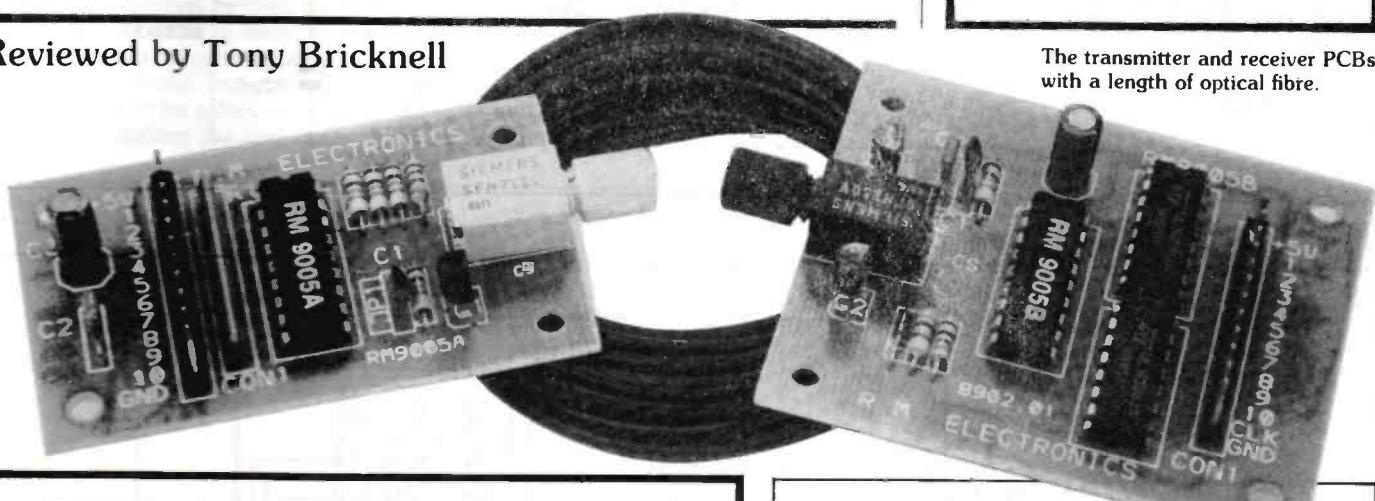
Electromagnetic interference (EMI) in wire systems can be caused by inductive pick-up of power line current or interference from industrial machinery. Traditional methods of solving these problems have been to use expensive balanced lines, with differential drivers and receivers, or heavy twisted shielded cables.

Capacitance between wire cables can cause coupling between data lines and, if

FEATURES

- ★ 100% galvanic isolation
- ★ 10 independent digital channels
- ★ Excellent EMI, RFI and crosstalk immunity
- ★ Transmitter compatible with TTL and CMOS logic
- ★ Open collector receiver outputs
- ★ STROBE output for interface with computer systems
- ★ 5V DC power supply required for both transmitter and receiver
- ★ Immune to ambient light
- ★ Extremely high isolation voltage
- ★ Absence of ground loops

Reviewed by Tony Bricknell



The transmitter and receiver PCBs with a length of optical fibre.

APPLICATIONS

- ★ Data links between electronic equipment requiring galvanic isolation with excellent noise and interference immunity
- ★ Remote connections of switches, tacho's, pulse devices and detectors which demand reliable operation in hostile environmental conditions
- ★ Replacement of shielded cables in digital applications
- ★ Replacement of complex wiring by one single fibre-optic cable

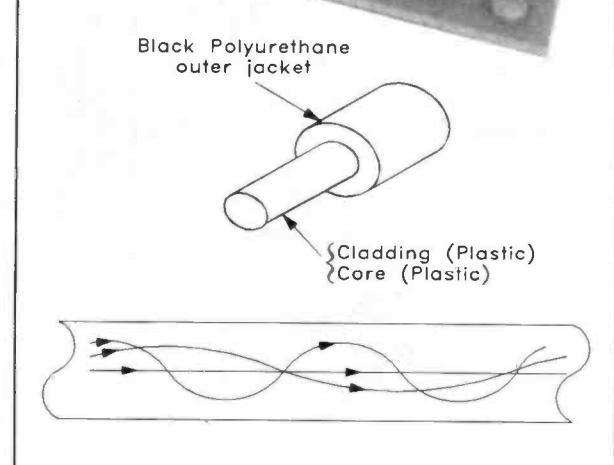


Figure 1. Graded index plastic fibre propagation and cable construction.

the interference is great enough, the data will be corrupted.

Also, the data driving the wire cable can be radiated with the interconnecting wire cable acting as a transmitting antenna, causing interference to neighbouring circuits. Basically, every time a logic level changes in a wire, there is an *overshoot* or *undershoot*, followed by *ringing*. Although the switching frequency may be only a few kilohertz, the ringing frequency depends on the resonance of the wire and may cover a bandwidth of several megahertz.

The Optical Answer

The advantages of using fibre-optics lies in the non-metallic, dielectric nature of fibre-optic cable. Data is conveyed through an optical waveguide by packets of photons, which have no electrical charge and, are therefore, not affected by radio frequencies or other forms of electromagnetic interference.

There are no crosstalk problems as the small leakage of flux, which may occur at the fibre boundary, is retained by the

opaque jacket ensuring that optical signals cannot interfere with each other when fibres are in close proximity. This factor also guarantees security of transmission, for the signal is unable to be externally detected throughout the entire length of the fibre.

In the event of a damaged or broken cable, the escaping flux is harmless in environments where a spark or short circuit from a broken wire could be disastrous. This enables hazardous areas with volatile chemicals to use fibre-optics for control and data gathering.

Plastic fibre is generally of the 'graded index' type, whose refractive index changes gradually from a high refractive index at the centre, to a lower index towards the perimeter. This causes the rays to propagate as shown in Figure 1.

The RM9005 Modules

The 10-channel fibre-optic digital multiplexer is sold as a pair of 'ready-to-use' modules and they are supplied with a

comprehensive instruction leaflet.

The multiplexer consists of two ready-built modules (1 × transmitter, 1 × receiver), and a 3 metre length of plastic optical fibre. Figures 2 and 3 show the circuit diagrams of the transmitter and receiver respectively; note that both circuits use an 18-pin mask-programmed microcontroller (IC1, PIC16C54).

Both transmitter and receiver require a regulated DC power supply of 5V. The inputs of the transmitter have $10k\Omega$ pull-up resistors, and are compatible with signals from TTL and CMOS logic or switches, see Figure 4. The receiver's outputs (including STROBE or CLK) are open-collector which can be connected directly to relays, LEDs etc. For connection to digital logic or microprocessors, external pull-up resistors will have to be employed, see Figure 5.

Connection to the fibre-optic cable is achieved by couplers on the Tx and Rx PCBs. These packages maximise the electro-optical conversion efficiency, by maintaining the axial optical alignment of the emitter and detector with the mating fibre

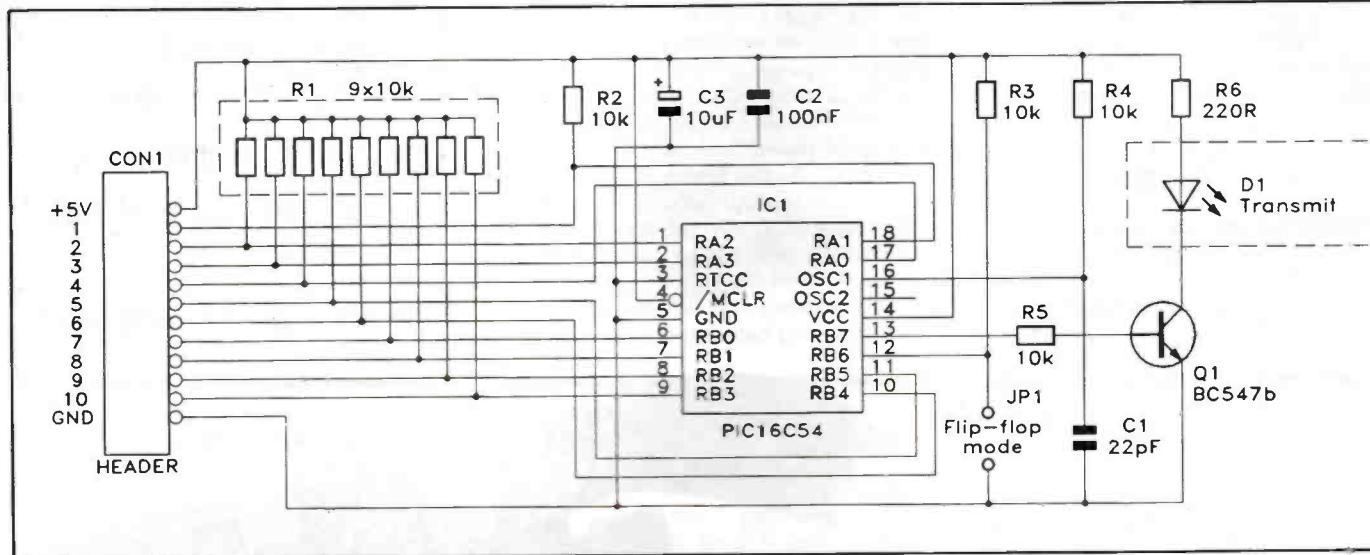


Figure 2. Transmitter circuit diagram.

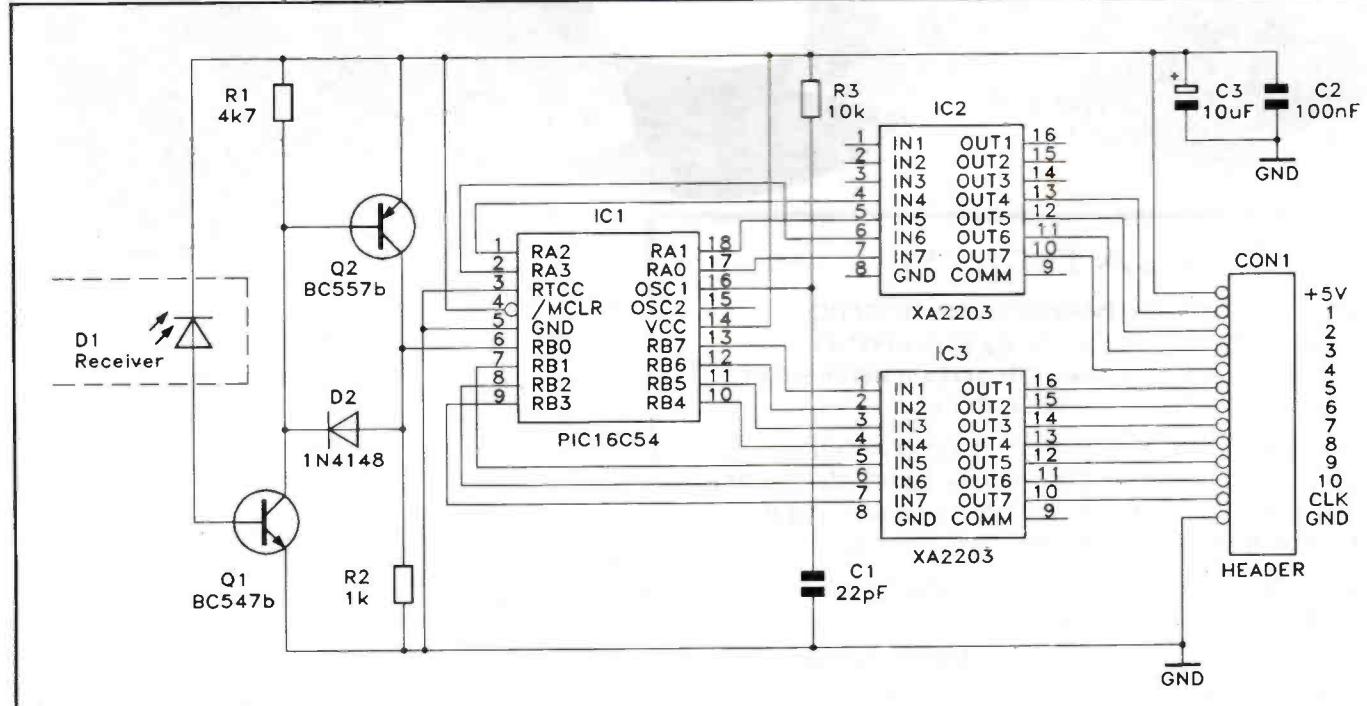


Figure 3. Receiver circuit diagram.

Preparation of the Optical Fibre

Both couplers are designed to be used with 1000 micron (1mm) core plastic fibre, providing an excellent transmission medium for short distance communication. A 3m length is supplied with the RM9005 modules. However, note that the transmitter module can reliably drive up to 20 metres of light guide; additional lengths can be ordered under stock code XR56L.

When cutting the light guide, great care should be taken to avoid scoring the fibre core. Try to make a single, straight cut thus keeping the end as smooth as possible, this being important for maximum light transfer to the couplers. Use a very sharp knife for this. Fine emery paper, or the striking edge of a matchbox (but not glasspaper types!) can be gently rubbed squarely across the cut fibre end to polish the surface. Liquid metal polish also helps to develop a smooth finish, and could also be used to finish-off with.

Alternatively, the cut fibre end could be placed close to a naked flame for a few seconds, until the end begins to round off. Excessive heat should be avoided as it will melt the fibre completely. This method has the advantage of producing a near perfect finish and develops a 'lens' in the fibre – ideal for good light transfer. Whichever method is employed, aim for a mirror-like finish on the fibre end if maximum range is required.

Push the prepared end of the light guide, through the fluted cap and into the coupler. Tighten the cap with your fingers only – do not use any tools! Repeat this procedure on the opposite end, so that the light guide is secured to both transmitter and receiver modules. It must be emphasised that careful preparation of the optical fibre ends is of vital importance, if maximum range is to be achieved.

When installing the light guide in a

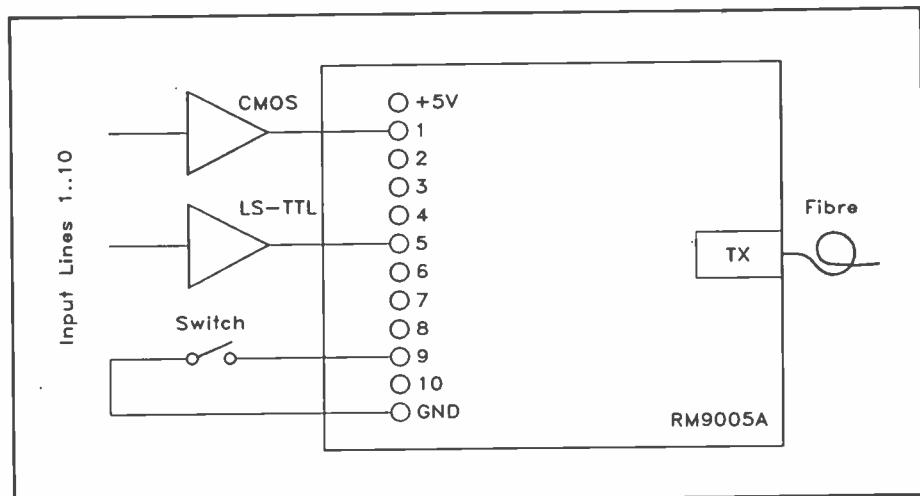
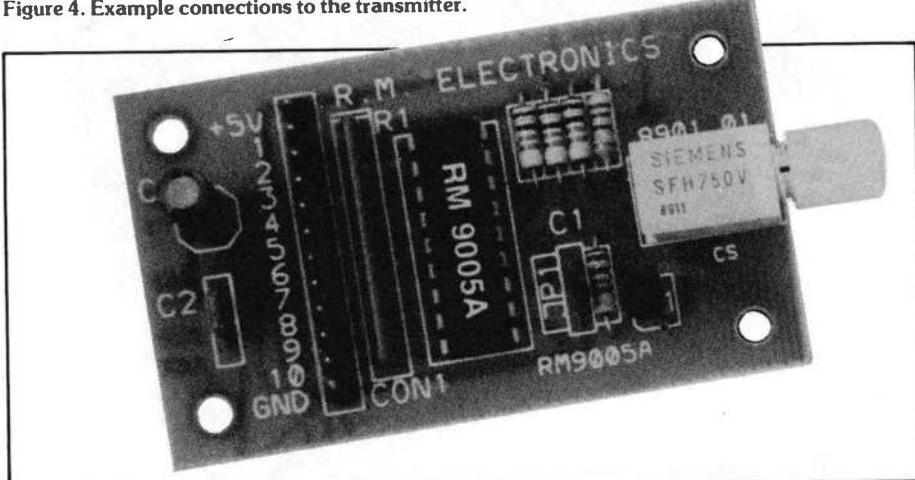


Figure 4. Example connections to the transmitter.



The transmitter PCB.

permanent position, be careful with bends. With reference to Figure 6, the absolute minimum radius of any bend in the fibre should not be less than 20mm. Exceeding the limit could result in cracking of the fibre, which will completely refract light and result in zero throughput. If using clips

to hold the guide in position, be careful not to pinch or damage the outer sheath in any way. Light will escape from and/or enter through pierced sheathing which may give poor results. Excessive heat and some chemical solvents will also damage the guide and should be avoided.

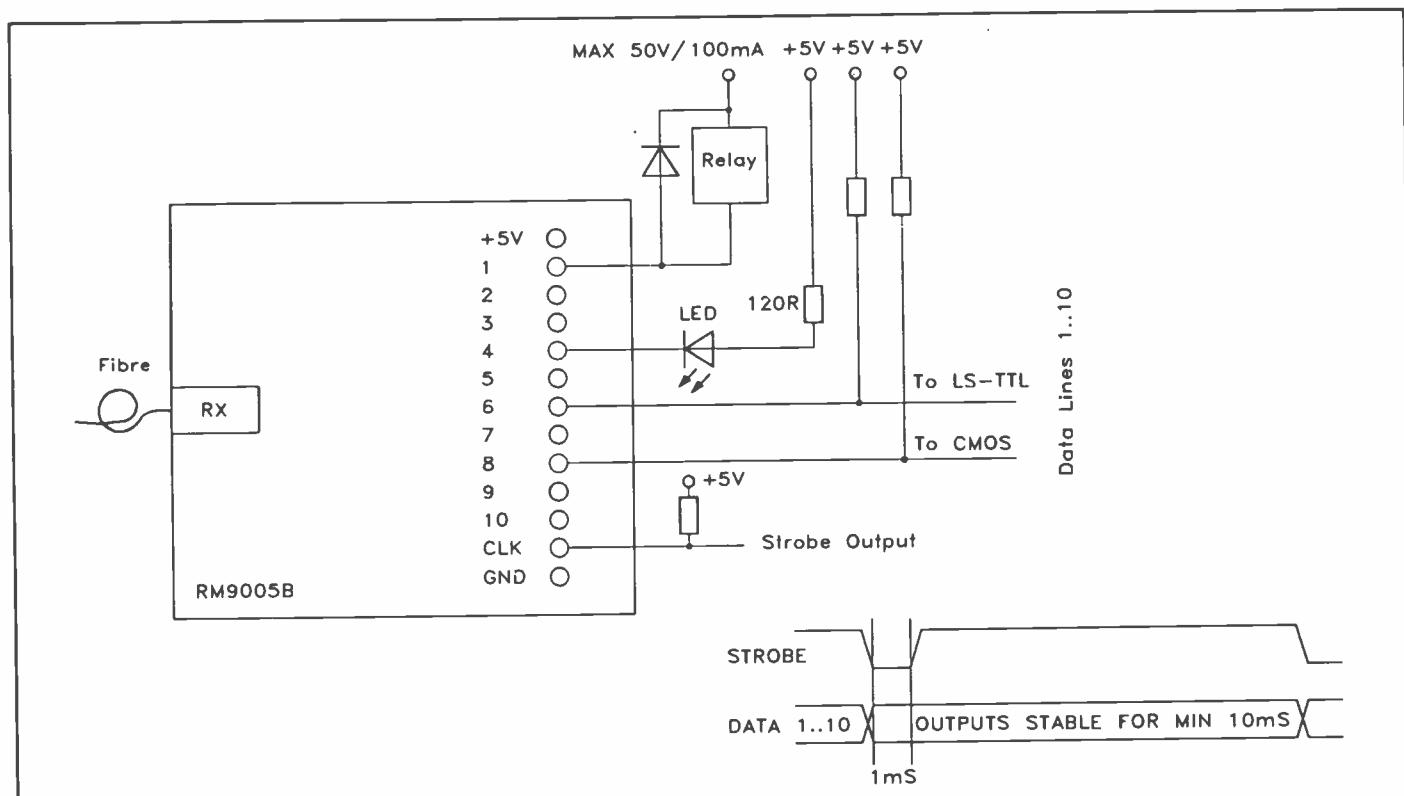


Figure 5. Example connections to the receiver.

In Use

All ten channels are completely independent of each other and are multiplexed on the transmitter. The data is then transmitted in a serial format to the receiver, where it is latched to the outputs after being demultiplexed. The transmission of this information takes 10ms, and new information is only transmitted to the receiver after the status of one or more inputs has changed. The STROBE (CLK) inputs has changed. The STROBE (CLK)

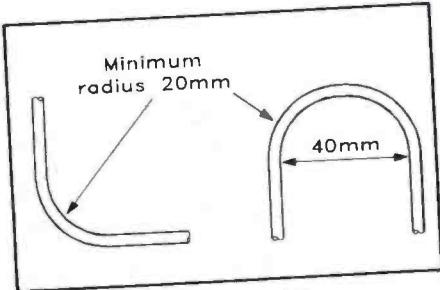
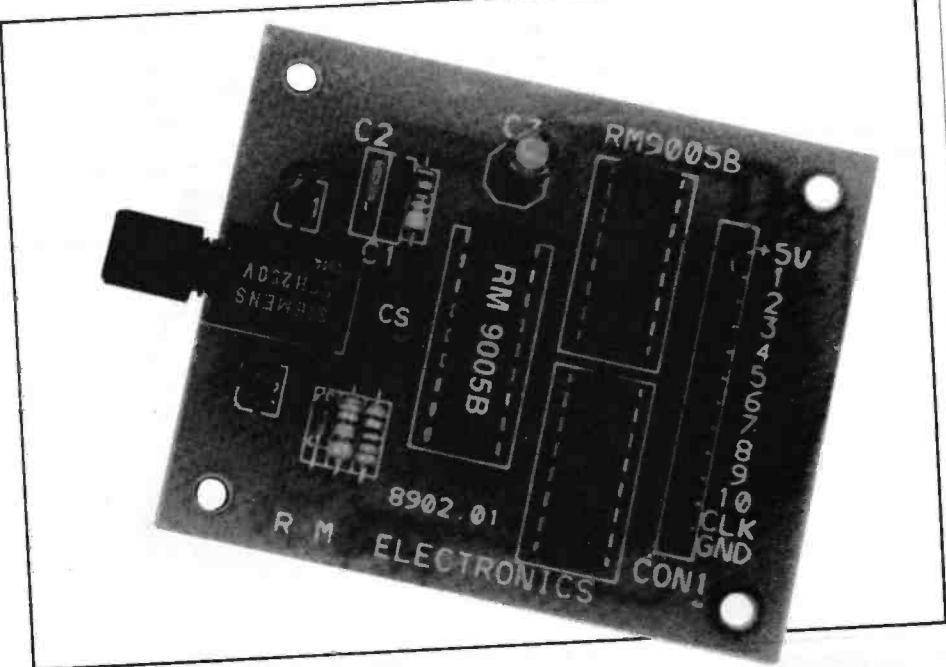


Figure 6. Bending the optical fibre.



The receiver PCB.

output is activated on any new incoming data for 1ms and is active low.

Two modes of operation are available:

With link JP1 not installed on the transmitter, the outputs are an exact copy of the inputs. This means that if an input is pulled down for 5 seconds, then the identical output will simultaneously be down for 5 seconds.

With link JP1 installed on the transmitter, the module will enter 'flip-flop' mode. This means that, for instance, when input 4 is activated once, output 4 will switch on and, when input 4 is activated a second time, output 4 will switch off. This makes it very easy to remotely control, say, relays by push-buttons.

Availability

The 10 Channel fibre-optic digital multiplexer is obtainable from Maplin Electronics by mail-order or through their numerous regional stores. The order code is LP84F.

Reference

Finally, for additional information on fibre-optic techniques, reference is made to 'Opto-Electronic Line Transmission' by R.L. Tricker (Stock code WS74R).

Mini-Metal Detector

by Dave Goodman

- ★ 25mm search range dependent upon size of object.
- ★ Finds nails, water and gas pipes in walls and plasterboard.
- ★ Complements the Live Wire Detector.
- ★ Simple to build and use.

If you have ever had to fit cupboards or shelving to partition walls then you will know how "hit and miss" it can be when trying to find the studding. Several methods of assisting with the task exist, such as elaborate relative density measurement systems or the much simpler proximity detector or metal detector. The Maplin Mini-Metal Detector can detect the presence of ferrous or various non-ferrous metals within the search area, such as iron wall board nails or brass

screw heads or it could even detect the absence of metal in seemingly solid door sills on a car!

Along with the Live Wire Detector project, the Mini-Metal Detector is a must for DIY'ers of all ages or just for the fun of having built a very simple project with a multitude of uses.

How it Works

In the circuit diagram of Figure 1, it can be seen that IC1 is the main device, around which most of the other components are configured. The chip is somewhat special in that it was developed for just this type of proximity sensing application only. With reference now to Figure

2 block schematic, L1 and C1 form a tank circuit at the oscillator input pin 2. Preset RV1 in the oscillator feedback path determines the operating frequency of this stage, which is close to 400kHz at an amplitude dependent upon the 'Q' of the tank network. If the tank 'Q' drops then the signal reduces in amplitude, although the frequency remains the same. Spurious oscillations and spikes could cause the system to 'lock up', but this is prevented by a transient suppression stage at the input. Metallic objects placed in close proximity to the tank coil produces a change in 'Q' thus causing the peak signal level to drop. The amplitude level could drop too far to allow oscillation to

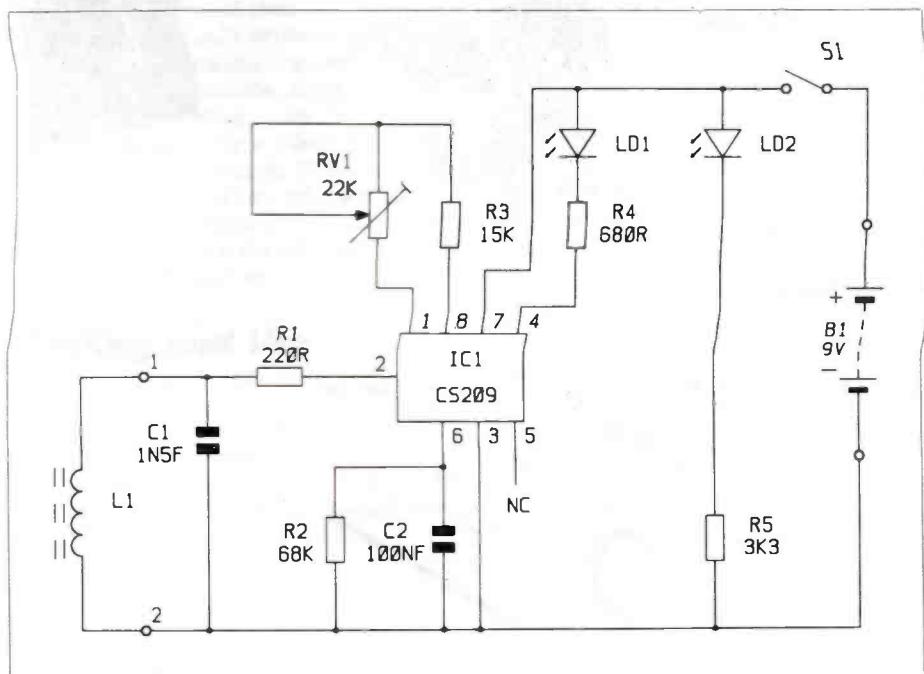
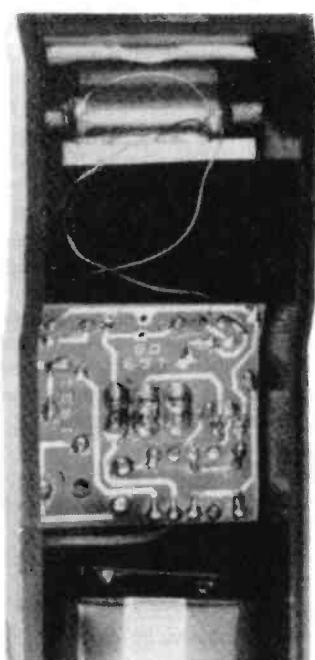


Figure 1. Circuit.



Inside the box.

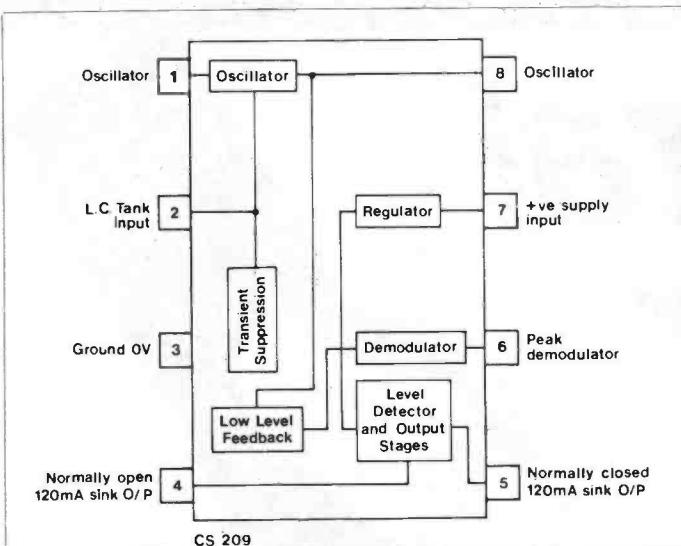


Figure 2. IC Block Schematic.

continue, therefore during low 'Q' conditions, a variable low level feedback is applied to maintain oscillation. The peak signal 'envelope' has its negative half detected by a peak demodulator which charges C2. R2 acts as a discharge path for C2 and the resulting DC level is compared with a level detector at the output stage. Pin 4 is an open collector output which can be likened to a relay Normally Open contact. When this stage trips, LD1 comes on via R4 and remains on while detection continues. LD2 and R5 indicate power on when on/off switch S1 is operated.

Construction

With reference to Figure 3 and the Parts List, fit the components, with the exception of the slide switch and the coil, as follows: start by fitting each of the resistors, it is important that each of the resistors lies flat on the PCB, otherwise they will foul the slide switch when the PCB is fitted into the box. Solder the components in place and cut off the excess lead-lengths.

Insert capacitors C1 and IC1, then C2 and RV1; C2 is easily broken so be extra careful with the legs when fitting. Now solder all components carefully to the PCB and cut off the excess lead-lengths. Cut the battery clip wires to a length of 50mm (2in.), tin them, and solder them to the PCB (black = $-V_e$; red = $+V_e$) at the positions marked '-' and '+' in Figure 3. Refer to Figure 4 when mounting the LEDs; both LD1 and LD2 are positioned vertically at 90° from the PCB and at a distance of 6mm from board to LED base. Finally, inspect the completed assembly looking for wrong components and poor soldering. It is worth pointing out that most project failures can be attributed to poor quality soldering, and therefore thorough checking of your work is recommended.

Final Assembly

Figures 5 and 6 show the final assembly details. Before mounting the PCB and coil in the box, the switch will need to be fitted into position.

Referring to Figure 6, place the switch in the box so that its lever protrudes through the rectangular cut-out in the case. Insert the M2 bolts through the two

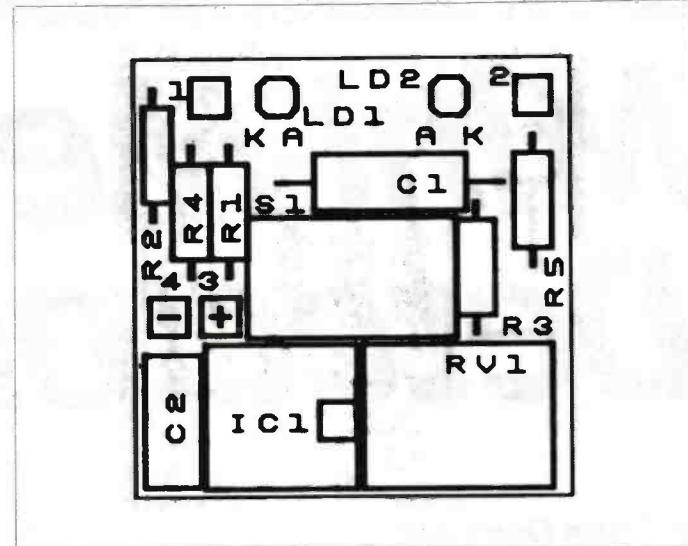


Figure 3. Board Overlay.

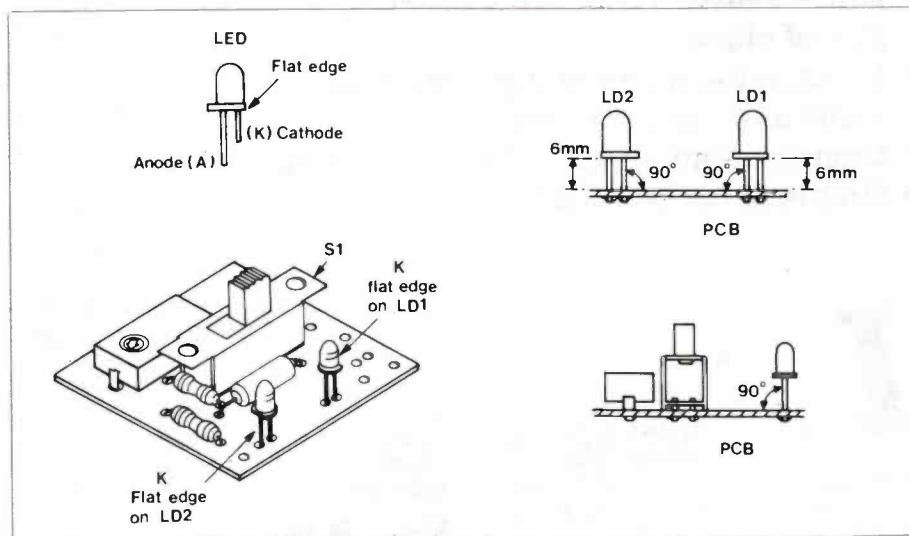
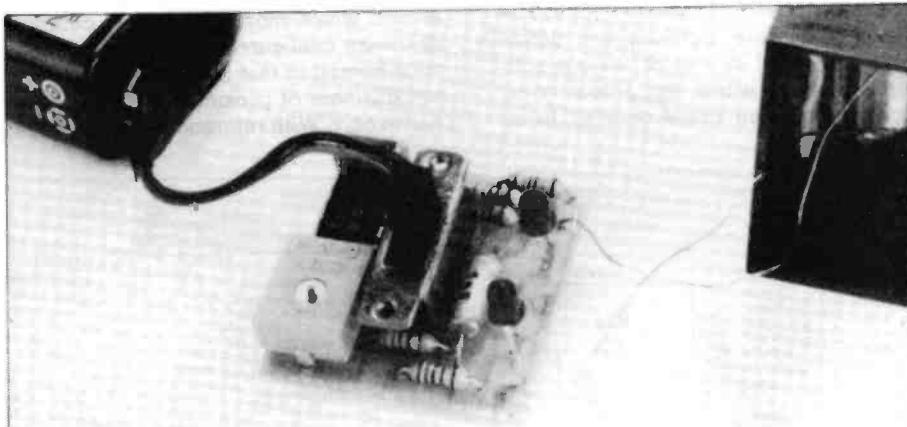


Figure 4. Mounting LD1 and LD2.



The assembled pcb.

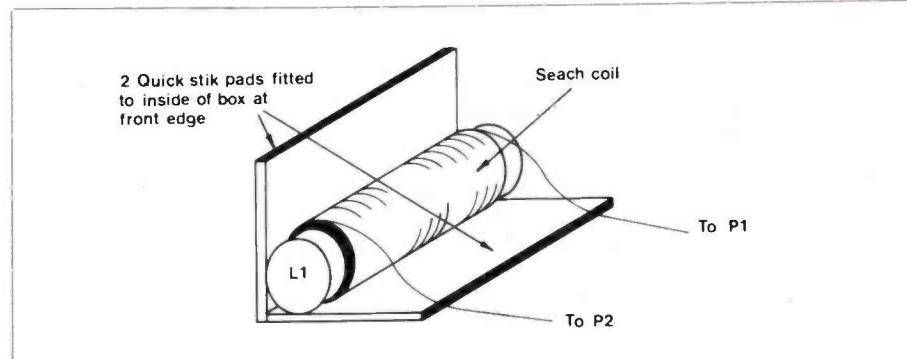


Figure 5. Mounting Search Coil L1.

holes on either side of the switch cut-out, pass them through the mounting holes of the switch and secure the assembly with the M2 nuts. Carefully position the PCB over the exposed switch terminals and locate the LEDs through their respective holes within the case, now push the PCB onto the switch terminals. It must be checked that the board is mounted flush against the switch prior to soldering, otherwise undue strain could be placed on the PCB tracks - the switch effectively holds the PCB in place. Now solder the switch terminal to the PCB.

To allow the coil to be fitted, two of the box pillars must be removed, see

according to the size of the object being monitored.

The third sticky pad may be used for fixing the battery inside the box thus preventing it from bouncing about and causing damage. To complete the project, clip the back panel in place and secure with two screws, at the bottom end of the box only.

To use the Mini-Metal Detector, hold the case with the small front edge pointing at the area to be searched. If very small metallic objects are suspected as being present, such as wire nails and pins in wall boards, then the case will need to be placed directly onto the wall

panel. The Mini-Metal Detector will only indicate for metal objects being present and will not identify whether wire and cables are 'live' or connected to mains voltages. For this purpose a matching 'Live Wire Detector' project LK63T is available.

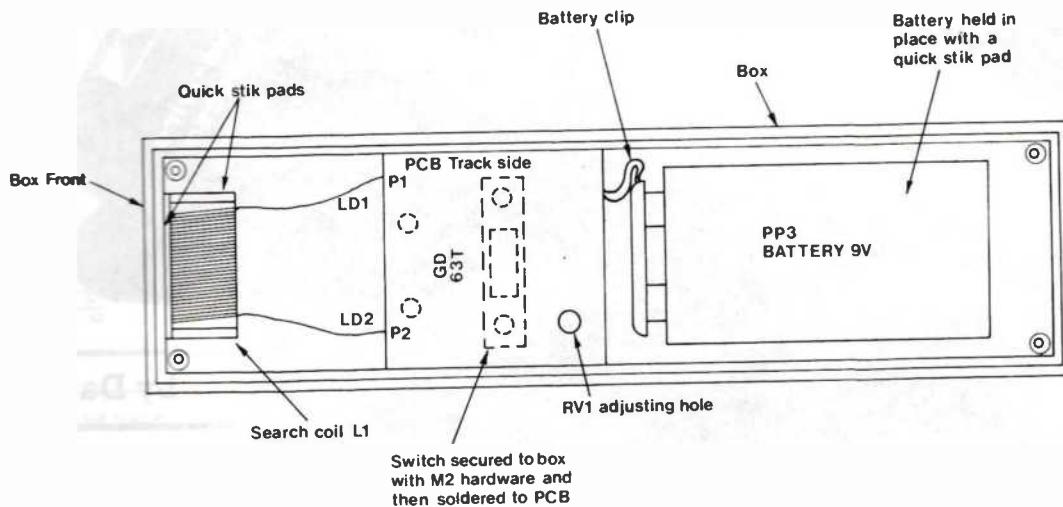


Figure 6. Final Assembly.

Figure 6. To secure the search coil, first fit sticky pads onto the inside front and inside top edges of the box. Remove the backing strips and carefully press L1 onto both pads, as shown in Figure 5. Cut the two connecting wires on L1 to about 50mm (2in.) in length, remove the enamel coating and tin each end. Thread the wires through the holes marked '1' and '2' in Figure 6 and solder into place.

The PCB should then be fitted over the switch terminals exposed within the case, making sure that the two LEDs line up with, and protrude slightly through, their corresponding holes in the case. Solder the assembly in place, once it has been ascertained that the PCB is mounted flush against the switch, otherwise undue strain could be placed on the PCB tracks - bearing in mind that the switch effectively holds the PCB in place.

Testing and Use

Fit the battery clip onto a working PP3 battery and operate the slide switch so that either LD2 or both LED's turn on. Insert a trimming tool or small screwdriver into the hole above RV1 and turn the wiper fully anti-clockwise. LD2 only should be on. Now slowly turn RV1 wiper in a clockwise direction until LD1 just comes on and at this point, back off the wiper until LD1 is just turned off. LD2 will stay on all the time while the unit is switched on. Precise setting of RV1 wiper and LD1 will improve the maximum search range, which can be up to 25mm

MINI METAL DETECTOR PARTS LIST

RESISTORS: All 0.6W 1% Metal Film (Unless Specified)			
R1	220Ω	1	(M220R)
R2	68k	1	(M68K)
R3	15k	1	(M15K)
R4	680Ω	1	(M680R)
R5	3k3	1	(M3K3)
RV1	Hor Encl Preset 22k	1	(UH04E)
CAPACITORS			
C1	1% Polystyrene 1n5F	1	(BX58N)
C2	Poly Layer 100nF	1	(WW41U)
SEMICONDUCTORS			
IC1	CS209	1	(UH59P)
LD1,2	Hi-Bright LED Red Min	2	(WL83E)
MISCELLANEOUS			
S1	Sub-Min Slide	1	(FH35Q)
L1	100μH Search Coil	1	(JC25C)
	Mini Metal Dctr PCB	1	(GD63T)
	Mini Metal Dctr Box	1	(JC24B)
	PP3 Clip	1	(HF28F)
	Pozi Screw M2 6mm	1 Pkt	(BF41U)
	M2 Steel Nut	1 Pkt	(JD63T)
	Quickstick Pads	1 Stp	(HB22Y)
	Constructors' Guide	1	(XH79L)
	Leaflet	1	(XT34M)
OPTIONAL			
	Alkaline PP3	1	(FK67X)

A complete Kit of all parts, excluding optional, is available:

Order As LM35Q (Mini Metal Detector Kit)

The following items are also available separately:

Mini Metal Dctr PCB Order As GD63T

100μH Search Coil Order As JC25C

LIVE WIRE DETECTOR

by Dave Goodman

the fuses and mains present on the wires leaving every fuse except the dead one. If you're wallpapering and need to remove a switch plate, first check that you get a positive reading with the mains on, then switch off or remove the fuse from the circuit you think is the right one. With Live-Wire in the same position as before, it will no longer sound if you've found the right circuit. There are probably hundreds of other uses and one or two we've thought of include detecting ringing on telephone lines, detecting the EHT in TV sets (though Live-Wire will probably need to be desensitised).

Live-Wire will also detect static electricity but in this case, it must be moved into or through the static field and only while it is moving will the instrument sound.

Circuit Description

An AC electro-magnetic field is detected at IC1 pin 1. The 4069 inverter is connected in a linear by placing a feed-

The Maplin Live-Wire Detector is a fascinating and novel device which will detect the presence of mains electricity whether there's a current flowing or not. It's better than neon screwdrivers or multimeters because you do not have to make contact with the wire – it signals the presence of mains up to two inches (5cm) away and better than metal detectors, because it only indicates if the wire is live; also it's considerably cheaper.

that wall, then you can hammer the nail home with confidence anywhere else. The message then is: beware of negative readings.

Other uses of Live-Wire include detecting breaks in cables or appliance leads. If you have a suspect mains lead, plug it into the mains; run Live-Wire along the cable and at the point where the live wire is broken, Live-Wire will cease to sound and flash. If a fuse blows, Live Wire will indicate mains present up to all

A Most Useful Instrument

It's the sort of device every household should own and anyone can use it because you don't have to actually touch dangerous points with any part of the Live-Wire Detector. Even if the wires are not connected to anything at one end, Live-Wire will tell you if they're live. You could use it to find buried wires in dry plaster or plastic conduit or under floor or ceiling boards, though keep in mind that its sensitivity is only about two inches, so don't put a four inch nail where there was a negative reading! However, if you get a positive reading of a wire in a wall and there's nothing else electrical on

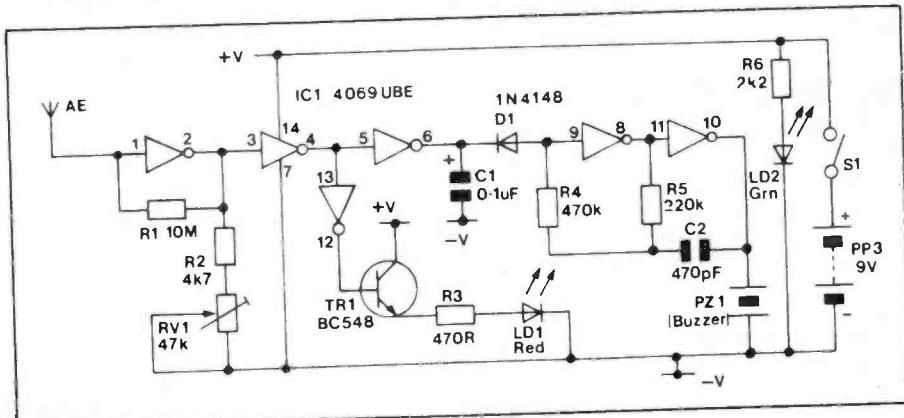
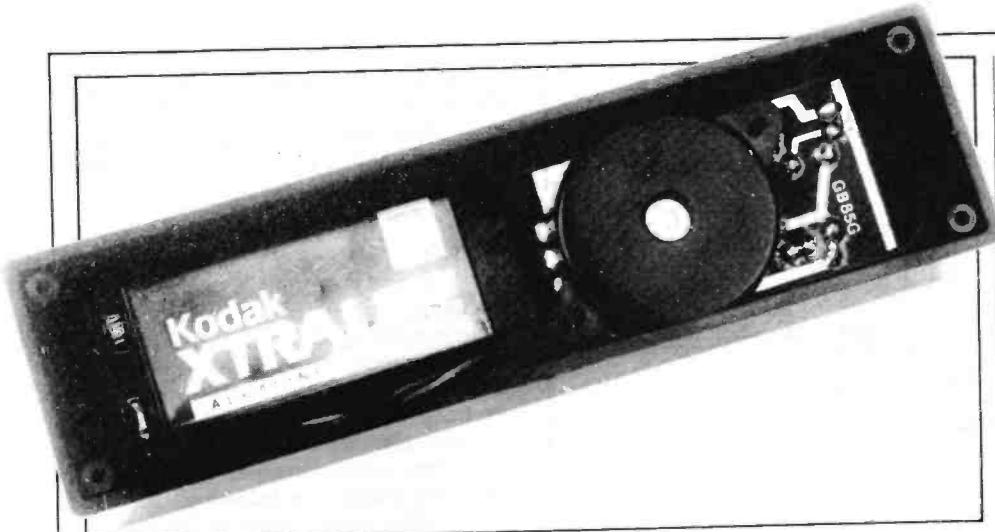


Figure 1. Circuit diagram of the Live-Wire Detector.



Inside view of the Live-Wire Detector prior to fitting the back panel.

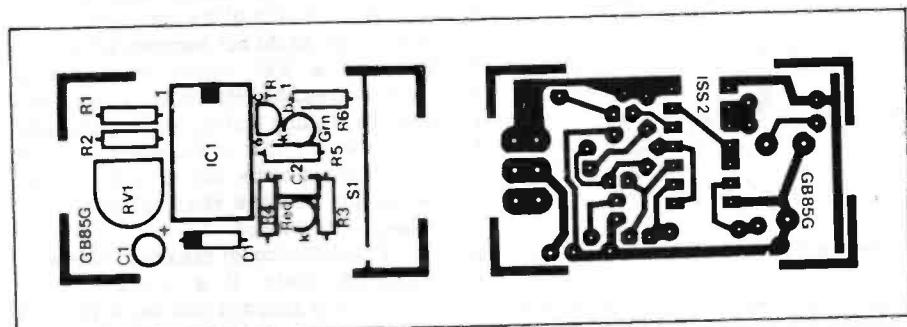


Figure 2. PCB legend and track.

back resistor between pins 1 and 2. The value chosen for R1 keeps the characteristics high CMOS input impedance so that changes in the surrounding electro-magnetic field produce a minute voltage change on the aerial track which are massively amplified in this stage.

RV1 sets the point at which the output from IC1 pin 4 will trigger the next two stages. This is necessary since the quiescent voltage at pin 2 will be different from one chip to another. Being a digital chip, this usually makes no difference but in linear mode, it is significant and RV1 has to be present to ensure that every Live-Wire can meet the specification. RV1, therefore, is adjusted to keep pin 4 high when not triggered.

Turning S1 on, lights LED2 which indicates that the circuit is active. If no electro-magnetic field is detected, then pin 4 will be high and the rest of the circuit is inactive. When an electro-magnetic field is detected, pin 4 goes low and pin 12 then goes high causing the emitter-follower TR1 to conduct, operating LED1.

At the same time, IC1 pin 6 goes high. D1 will now be reverse-biased which removes the continuous low 'hold-off' condition from pin 9 and allows the oscillator to run. The oscillator comprises the final stages of the 4069 and resistors R4, R5 and C2. The approximate frequency is 3.5kHz. The output of the oscillator drives the high impedance piezo-ceramic buzzer directly.

The circuit runs from a 9V PP3 battery. The current drain is approximately 10mA when the circuit is switched on and 17mA when it is detecting electricity.

lies flat to the PCB as shown in the photographs.

Fit the two capacitors in their respective positions, noting that C2 is a polarised device which needs to be installed the correct way round. Carefully solder all these components in place and clip off the excess lead ends. Now insert IC1 and TR1 (so that their orientation matches up with that shown in the corresponding board legends), and fit preset RV1 in the position indicated. Carefully solder all the leads of these three components and cut off the excess leads of the lead-lengths.

The red LED (LD1) is inserted into the position marked on the PCB as 'Red' in Figure 2. Likewise, the green LED (LD2) is placed in the 'Grn' position. Correct positioning of these items is also critical, and the cathode (marked as 'k' in Figure 2) is the shorter lead of the LED. Adjust the two LEDs until the base of each coloured package is 6mm above the top surface of the board. Holding the LEDs absolutely vertical in that position, solder the four leads and clip off the excess lead-lengths.

Cut the two wires from the battery connector (black = -Ve; red = +Ve) so that they are 50mm (2in.) long, tin them, and referring to Figure 3, insert each in the appropriate hole and solder in place. Cut the wires from the buzzer so that about 25mm (1in.) of each remains, tin them, insert in the two remaining holes on the PCB and solder them in position. Note that buzzer polarity is uncritical. With a small screwdriver or trim tool, adjust RV1 until its wiper points to C1 as arrow in Figure 2, and finally check that all components have been inserted and soldered correctly.

Final Assembly and Testing

Referring to Figure 4, place the switch in the box so that its lever protrudes through the rectangular cut-out in the case. Ensuring that the two LEDs protrude through the appropriate round holes, insert the M2 bolts through the two holes on either side of the switch cut-out, pass them through the mounting holes of the switch and terminate with M2 nuts. When the bolts have been sufficiently tightened, position the PCB on the switch

Construction

With reference to Figure 2 and the Parts List, fit the components, with the exception of the slide switch, as follows: start by fitting each of the resistors into the positions shown. Next, insert the diode in position D1 ensuring that the device is correctly orientated. It is important that each of these components

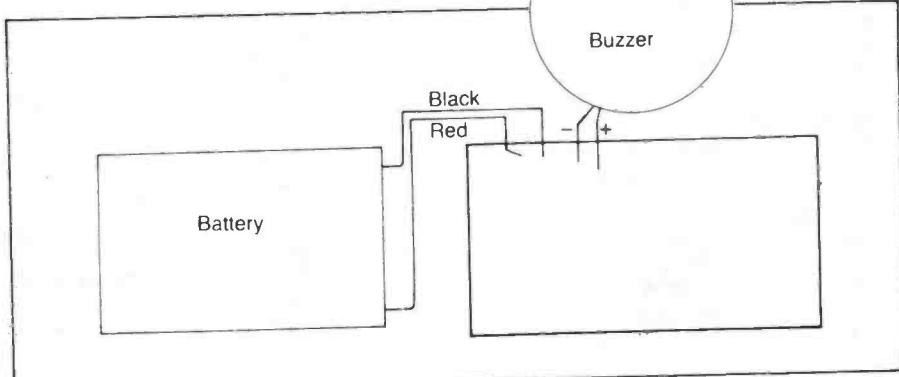


Figure 3. Live-Wire Detector wiring diagram.

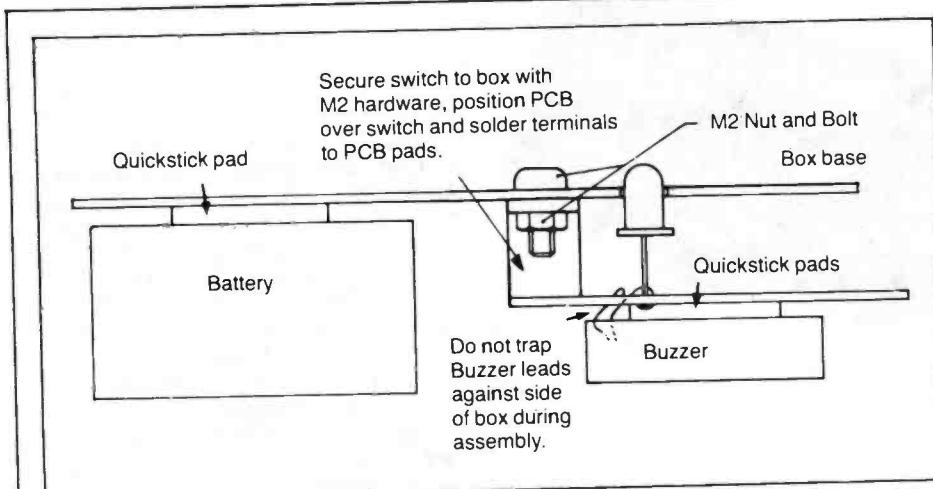


Figure 4. Overall assembly of the Live-Wire Detector.

terminals exposed within the case and solder in place. It must be checked that the board is mounted flush against the switch prior to soldering, otherwise undue strain could be placed on the PCB tracks. Please bear in mind that the switch effectively holds the PCB in place. Now solder the switch terminals to the PCB.

Stick the buzzer centrally onto the soldered side of the PCB using a quick-stick adhesive pad, as shown in Figure 5, so that the mounting ears of the buzzer point to the corners of the PCB and the buzzer lead-out wires are nearest the edge of the board. Ensure that the adhesive pad is fixed to the base of the buzzer, and not the top (which has a large central hole on it, from which the sound is emitted). Please note that the diameter of the buzzer may vary slightly. If it is found that it is too large to fit into the box, carefully remove some of the plastic casing of the buzzer with a sharp knife.

Install a new PP3 battery, preferably of the alkaline type, ensuring that it is fitted to the battery clip the right way round, even a momentary incorrect connection could cause damage. Depending on the position of the on/off switch the Live-Wire Detector may already be switched on, indicated by the green LED

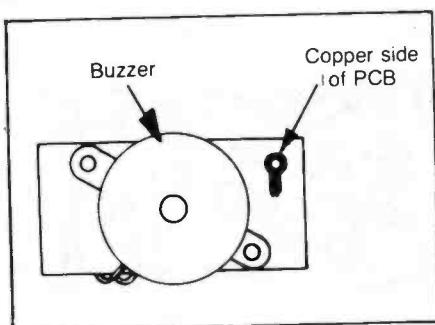


Figure 5. Buzzer mounting.

glowing, if this is the case, switch the unit off.

Plug an appliance into a mains socket and switch it on. Bring the assembly up to the cable, holding the battery end of the box. Switch the Live-Wire Detector on. The green LED should light and stay on. As you approach the appliance's cable, the red LED should light and the buzzer should sound.

RV1 must now be adjusted so that the unit starts to operate about 2 inches (5cm) from the cable. To increase the sensitivity, turn RV1 clockwise; vice versa to decrease the sensitivity. Do not try to make the unit too sensitive or you will find that it is occasionally triggered by your body, or for no apparent reason.

When RV1 is correctly adjusted, fix the battery into the box using the other sticky-pad, see Figure 4. Finally, screw the box lid on using the four screws provided.

Uses

This unit is extremely useful around the home, and because the user does not have to make actual contact with any part of a live circuit, it is perfectly safe to use. Even if the wires are not connected to anything at one end (i.e. no current is flowing), Live-Wire will reveal if they are live. Some of the many uses that we have identified include the following:

Finding wires concealed by plaster, plastic conduit, floor boards or ceiling panels. However, please bear in mind that the sensitivity of the unit is only about two inches, so do not hammer a four inch nail into a wall where there was a negative reading! However, if you get a positive reading and there is nothing else electrical on that wall, then you can confidently fix the nail anywhere else. Generally, negative readings should be treated with caution.

The detection of breaks in cables or appliance leads. If a mains lead is suspect, it is plugged into the mains and Live-Wire is run along its length. At the point where the live wire is broken, Live Wire will cease to sound and flash.

If a particular mains circuit needs to be isolated, for example, when a switch plate needs to be removed (e.g. for wallpapering a wall), first check that you get a positive reading with the Live-Wire Detector when the mains is switched on, then remove the lighting fuse and use Live-Wire Detector, *in the same position*, to verify that the correct fuse has been removed.

Detecting ringing on telephone lines.

Detecting the presence of EHT within a TV set (in this case, Live-Wire will probably need to be desensitised).

Live-Wire will also detect static electricity, but only when it is being moved into, or through, the static field.

LIVE-WIRE DETECTOR PARTS LIST

RESISTORS: All 0.6W 1% Metal Film (Unless Specified)

R1	Econ Res 10M	1	(B10M)
R2	4k7	1	(M4K7)
R3	470Ω	1	(M470R)
R4	470k	1	(M470K)
R5	220k	1	(M220K)
R6	2k2	1	(M2K2)
RV1	Hor Encl Preset 47k	1	(UH05F)

CAPACITORS

C1	Tant 100nF 35V	1	(WW54J)
C2	Ceramic 470pF	1	(WX64U)

SEMICONDUCTORS

TR1	BC548	1	(QB73Q)
D1	IN4148	1	(QL80B)
IC1	4069UBE	1	(QX25C)
LD1	Mini LED Red	1	(WL32K)
LD2	Mini LED Green	1	(WL33L)

MISCELLANEOUS

S1	Sub-Min Slide	1	(FH35Q)
	PP3 Clip	1	(HF28F)
	Min Piezo Sounder	1	(FMS9P)
	Poziscrew M2 6mm	1 Pkt	(BF41U)
	Steel Nut M2	1 Pkt	(JD63T)
	Live Wire Det Case	1	(FT39N)
	Quickstick Pad	1 Strip	(HB22Y)
	PCB	1	(GB85G)
	Instruction Leaflet	1	(XK07H)
	Constructors' Guide	1	(XH79L)

OPTIONAL

B1	Battery PP3	1	(FK62S)
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The above items (excluding Optional) are available as a kit.

Order As LK63T (Live Wire Detector Kit)

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