PROJECTS BOOK 25

Maplin Maplin Maplin

TEMP MODULE EXPANSION
DISCO PARTYLITE
MINI-METAL DETECTOR
APPLIANCE TESTER
SLOW CHARGER
RAPID CHARGER

CONTENTS

MAPLIN PROJECTS BOOK TWENTY FIVE

EDITORIAL

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R Ball

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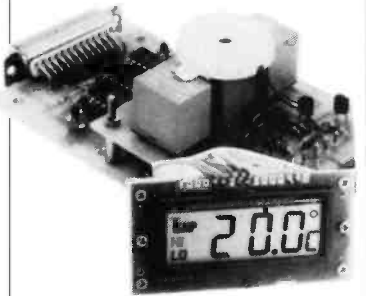
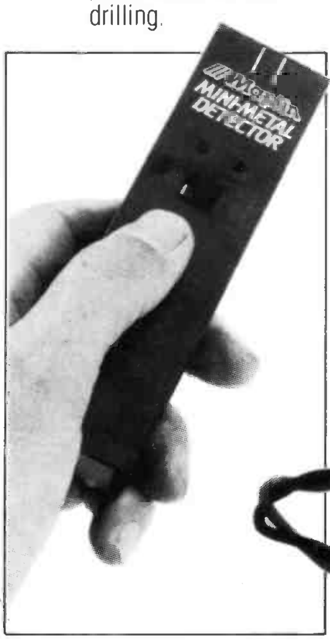
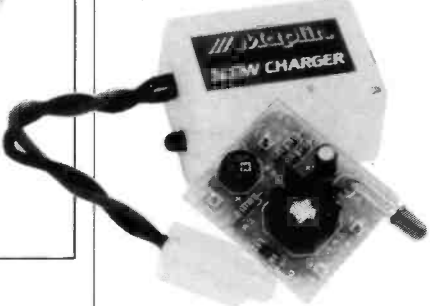
PROJECTS







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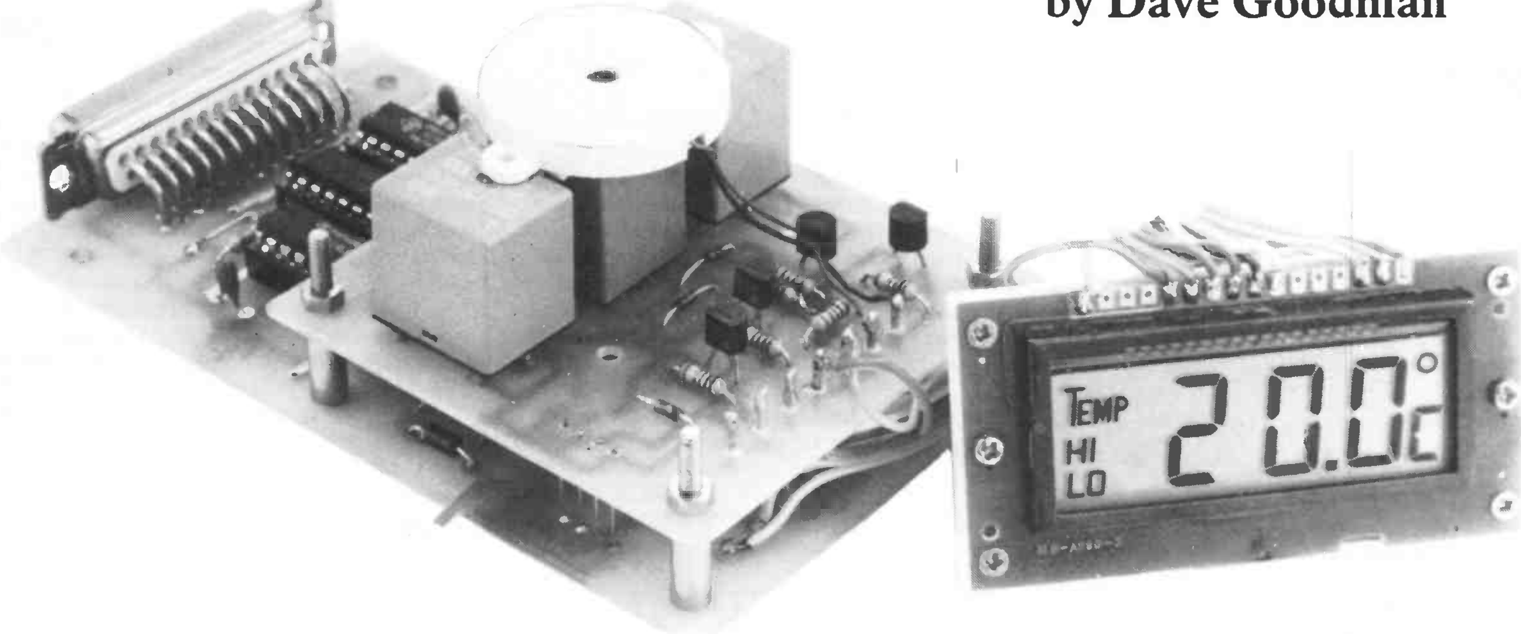
TEMPERATURE MODULE EXPANSION

by Dave Goodman



★ Serial to Parallel Conversion of Temperature Data
★ Hi-Lo Set Point, Switched Relay Outputs and Alarm Sounder
★ 1.3V DC Output Eliminates Module Battery
★ Requires 9 to 12V DC Supply

This article refers to the two versatile temperature modules currently available from Maplin known as 'Temperature Module' (FE33L) and 'Min-Max Temperature Module' (FP64U). Both of these modules, although similar in appearance, have very different specifications to each other. For example, the *Min-Max Temperature Module* version has a recall memory function which stores the highest and lowest temperature recorded. Also, there are two accessory probes for extending the operating range down to −40°C or up to +110°C. The *Temperature Module* is different by having a real time clock facility and serial data output of the temperature scale. One accessory probe (not the same as the previous probes!) can be fitted, but the operating range is fixed at −19°C to +69°C only.

The expansion system comprises two projects, a relay switching card, which may be used with both temperature modules and a serial to parallel converter card for use with the (FE33L) temperature module only. Relay contacts on the switching card are dry changeover rated at 3A 24V DC and could be used for controlling alarms, bells and buzzers or perhaps I/O interfaced to a computer. The converter is designed with tri-state TTL outputs, for use with computers that have 1 or 2 byte I/O availability. Either integer or full decimal values of temperature readings are available along with a few extra items of data explained further on in the article. Figure 1 shows the edge connections on the FE33L module, these are further explained in Table 1.

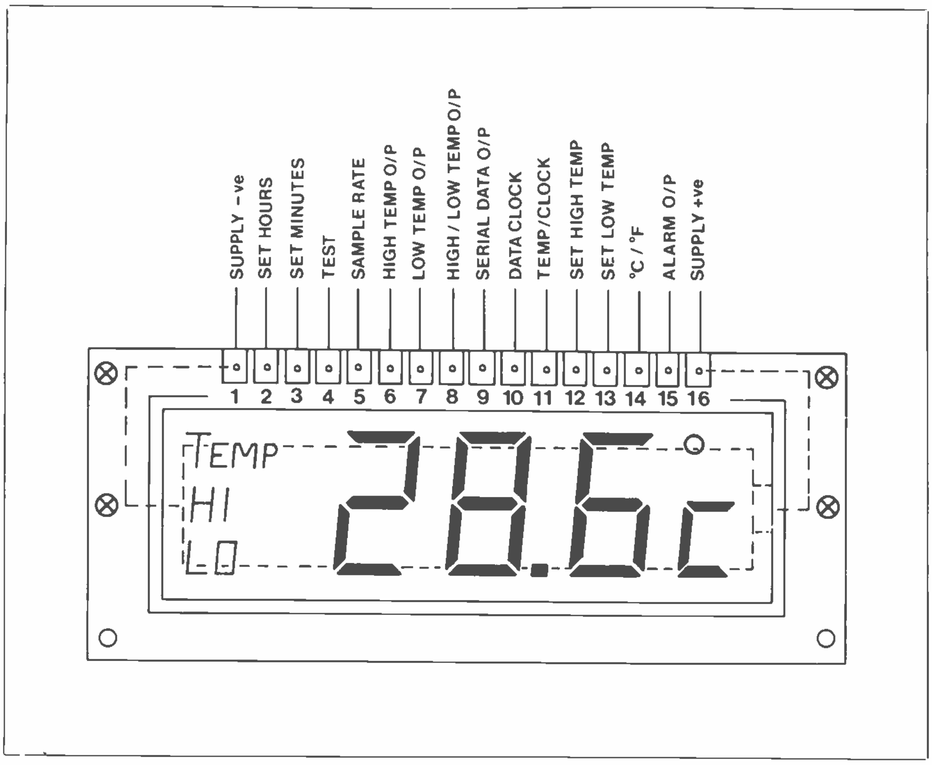


Figure 1. Temperature Module FE33L.

Edge Connections
High = positive supply rail, low = negative supply rail.

Pin

1. Supply negative.
2. High to set hours.
3. High to set minutes.
4. Test pin.
5. Sampling rate: High for 1 second sample, low or open for 10 second sample.

Note. 10 second sample rate must be selected before set points can be adjusted!

6. Higher temperature set point reached. This output goes high for at least 1 minute or remains high until the temperature falls below the set point again.
7. Lower temperature set point reached. This output goes high for at least 1 minute or remains high until the temperature climbs above the set point again.
8. Output pulses high for 1 second when either set point is reached.
9. Serial Data output. 13 bit code of temperature display only.
10. Serial Data clock output. For synchronising serial data.
11. High to display clock, low or open to display temperature.
12. Display high temperature set point.
13. Display low temperature set point.
14. Temperature scale. High for °F scale, low or open for °C.
15. Alarm output. 4kHz signal output for 6 seconds when set point temperatures are exceeded.
16. Supply positive.

Table 1. FE33L pin functions.

Serial Data Output

Figure 2 shows the data and clock serial outputs. The clock pulse train always consists of thirteen pulses, with each leading edge appearing 0.125ms into the data time slot. A complete data frame period lasts for 0.018s and is repeated at either 1 second or 10 second periods according to the sample rate selected. Each data bit, D1 to D13, has a specific meaning or value as can be seen from the list. If the temperature scale is selected to read in °C then D1 is set high for temperatures below zero (<0°C) when the negative sign is displayed, or low for temperatures above and including zero (≤ 0°C). D1 is also set high for temperatures above and including 100° when the scale is selected to read in °F. This would not occur in the Centigrade scale as the maximum specified reading is 69.8°C. Data bits D2 to D5 represent the tens digits on the scale, in binary coded decimal form for values 1 to 9. Bits D6 to D9 represent the units digit and D10 to D13 the tenths digit in the same form. The tenths digit appears after the decimal point on the display and its BCD value should be multiplied by 0.1. It follows then, that the units BCD value should be multiplied by 1 and the tens BCD value multiplied by 10 as may be seen from examples 1 & 2, see Figure 2.

Serial Clock Output

The clock output from pin 10 always begins 0.125ms after the data period and each clock pulse is 0.125ms wide with a 1.125ms space between pulses, see Figure 3. The very first pulse, significant to D1, is always much wider than the other twelve and is useful for identification purposes such as a start bit. All thirteen bits are in synchronisation with the data for both 1 or 10 second sample rates providing the module pin 11 is set to display temperature. If the module is set for 12 hour clock mode, the serial outputs cease to function and both pins 10 & 11 become inactive.

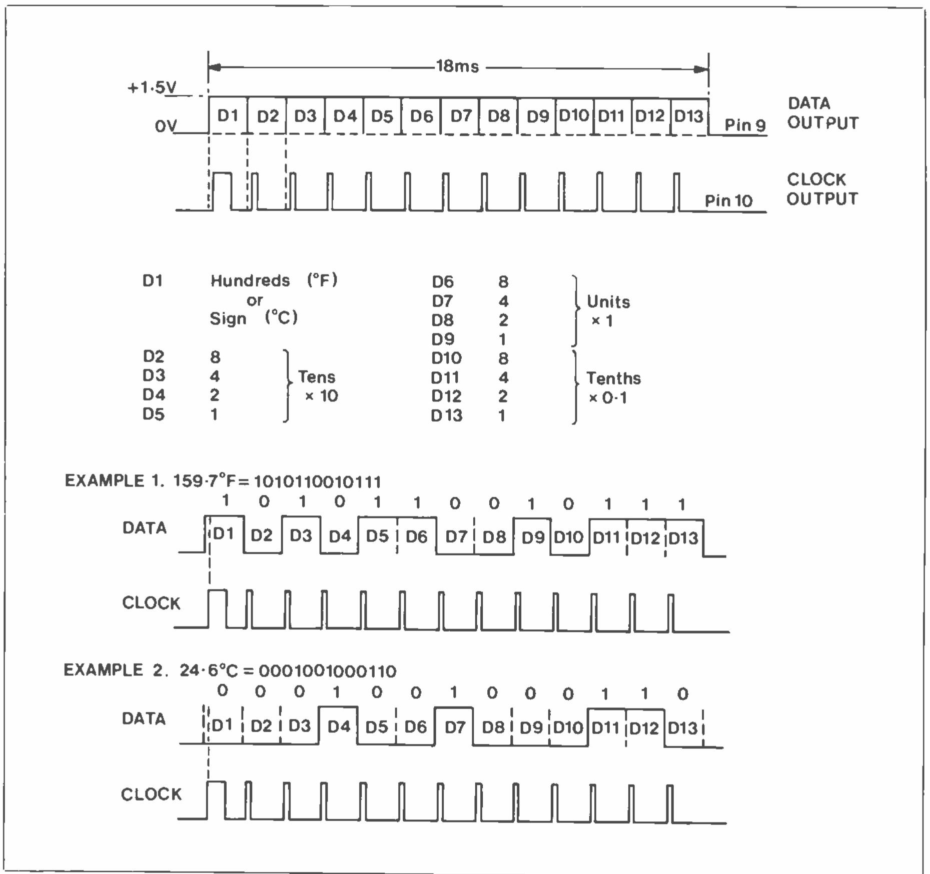


Figure 2. Data and Clock Outputs.

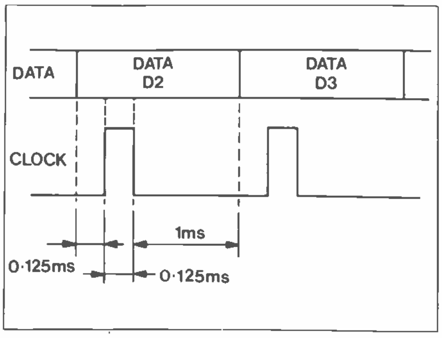


Figure 3. Clock Timing.

12 Hour Clock Mode

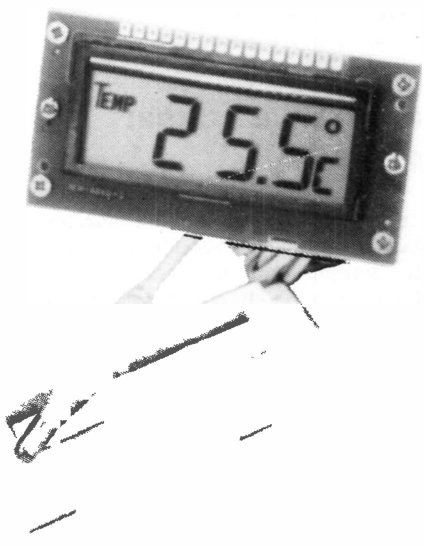
The module will also display the time in hours and minutes in twelve hour (not 24 hour) form and AM/PM indicators or alarm outputs are not available in this mode. Hours and minutes can be set independently, either single step or fast run, after a short delay.

Serial to Parallel Converter

There may be occasions where it is required to connect the temperature module to a micro computer for recording and analysing temperature measurements. To achieve this, low level buffering is necessary to match the 1.5V high impedance outputs from the module to TTL levels suitable for computer use. The converter project has front end buffer stages, 1.3V DC supply output for driving the temperature module if required, serial to parallel decoding and latched output data buffers suitable for TTL level I/O ports on a computer. Figure 4 shows the circuit diagram for the converter module. TR1 to 5 are wired directly to the corresponding outputs on the temperature module and data is input via inverter TR1 and re-inverted by IC1 to the input of shift

Technical Data

Temperature Module:	FE33L
Range:	−19.9°C to 69.8°C (0 to 159.8°F)
Resolution:	0.1°C (0.1°F)
Accuracy:	−10°C to +40°C ±1°C @ 1.5V −20°C to −10°C ±2°C @ 1.5V +40°C to +70°C ±2°C @ 1.5V
Sampling rate:	1 or 10 seconds
Alarm output:	4kHz for 6 seconds
High Temp set point reached:	Pin 6 high for 1 minute
Low Temp set point reached:	Pin 7 high for 1 minute
Either set point reached:	Pin 8 pulses high for 1 second
Temp set points:	1 ° steps
Clock:	12 hour display
Clock accuracy:	±0.5 sec/day
Working voltage:	1.5V DC (1.23 to 1.65V)



Average current: 15μA approx.

Module FE33L does not store/record any minimum or maximum temperatures measured.

register IC2. As the data bits appear, a corresponding clock pulse from TR2 and IC1 steps the data through the register. Thirteen stages of decoding are needed for this application, therefore two shift registers are used with eight outputs from IC2 and the first five outputs only used from IC3. Data bit D1 will therefore end up on IC3 pin 15 and D13 on IC2 pin 10. Because data is constantly rippling through the shift register outputs, latches must be utilised to hold the data stable. Two IC1 packages have been configured as a monostable with 30ms pulse width determined by C2 and R12. This monostable is non-retriggerable and the output pulse from pin 3 is active low during the data clock period. At the end of the monostable period, pin 3 returns to a high state thus taking the clock input, pin 11, on IC4/5 high and latching in any data present from the shift registers. This cycle is then repeated at the preselected sample rate. To assist direct connection to processor busses, IC4 & IC5 have their output enable pins brought out from pin 1 to pin 9 on the 25 way plug, PL1. All data output lines are high impedance unless the OE line is held low (0V), therefore the module could be used as a port device and selected from this

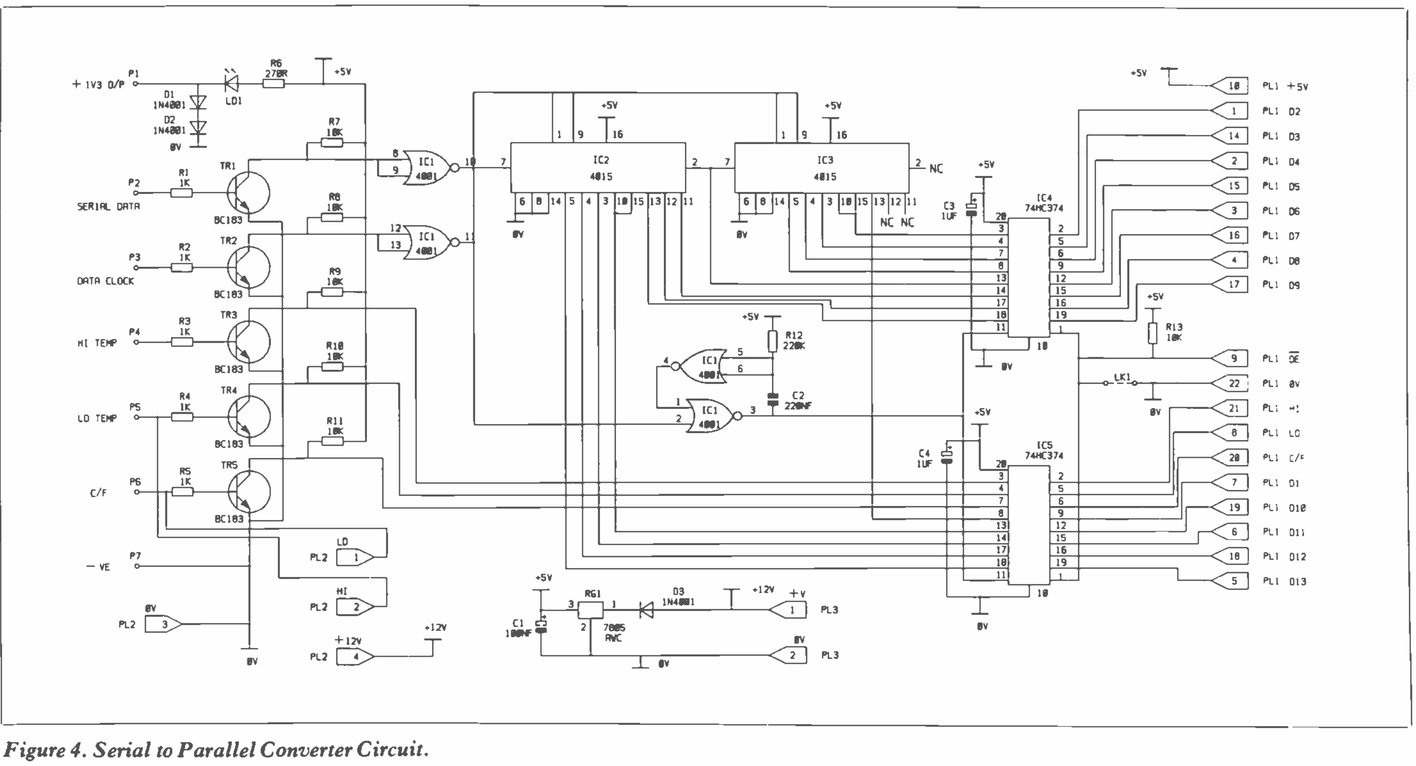


Figure 4. Serial to Parallel Converter Circuit.

pin. Alternatively, PCB link, LK1, could be fitted and doing so will permanently place the data onto the output. Note that PL1, pin 22, is the ground return (0V) connection.

Parallel Bus Output Connector

Figure 5 shows pin notations of PL1 as viewed from the front of the connector. A standard 25 way D connector is used with 7 pins not connected, pins 10 to 13 and pins 23 to 25. The connector wiring is arranged so that the first 8 pins only need be used if integer temperature values are wanted This would be the case when using a single byte (8 bit) bus. Tens and unit values represent the whole number portion only, so if full decimal readings are wanted, the tenths digit must also be read over a minimum of 12 bits. For temperature readings above 100°F or below 0°C, the SIGN bit on pin 7 is required, thus 13 bits must now be used. Three extra bits have been added to expand the module's

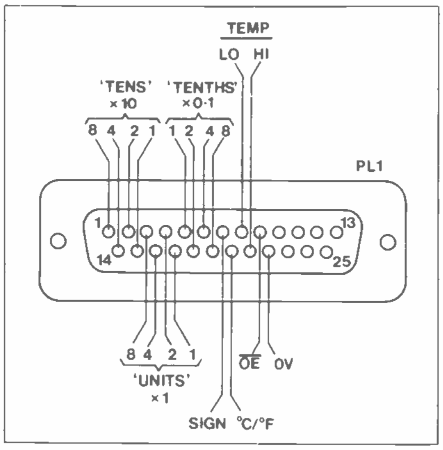


Figure 5. Parallel Bus Output Plug.

Technical Data

Min - Max Temperature module:	FP64U
Range:	−5°C to +50°C (23°F to 122°F)
Resolution:	0.1°C (0.1°F)
Accuracy:	−5°C to +30°C ±1°C @ 1.5V +31°C to +50°C ±2°C @ 1.5V
Sampling rate:	1 or 15 seconds
Alarm output:	2kHz for 1 minute
High temp set point reached:	Pin 6 high for 1 minute
Low temp set point reached:	Pin 7 high for 1 minute
Either set point reached:	Pin 8 pulses high for 1 minute then remains high
Temp set points:	1° steps
Display measuring scale:	°C or °F
Temperature memory:	Memorises both maximum and minimum temperatures reached

Working voltage:	1.5V DC (1.25 to 1.65V)
Average current:	10μA approx (at 15 second sample rate)

Module FP64U does not have serial output or real time clock.

use, but are not needed for temperature read-out's, these are: Pin 20, which sets high when °C scale is selected. Pin 8, when low (0V) indicates that the lower temperature set point has been reached and similarly, pin 21 indicates for the higher set point. These 16 bits are shown in Table 2.

Converter Module Construction

Refer to Figure 6 and the parts list; also the constructors guide (supplied in the kit) as required. Identify and insert resistors R1 to R13. The track side of the pcb can get crowded here, so it may ease

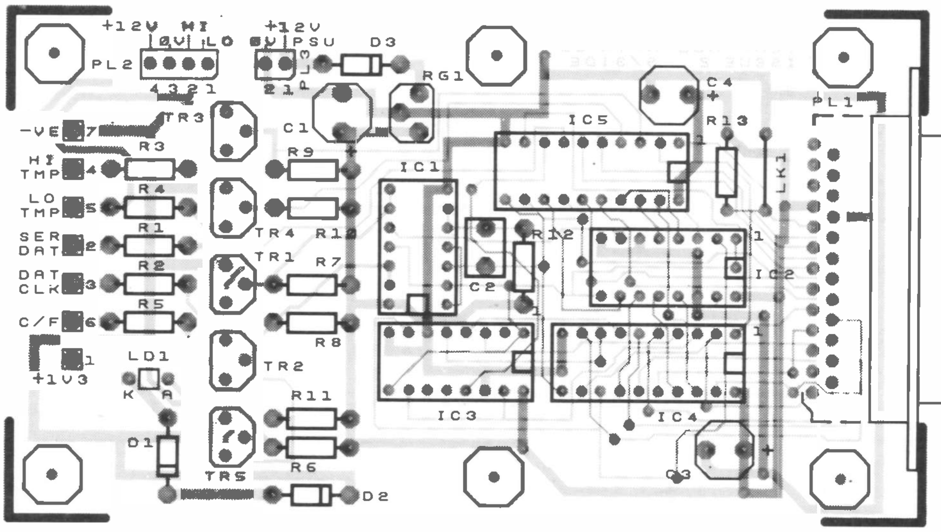
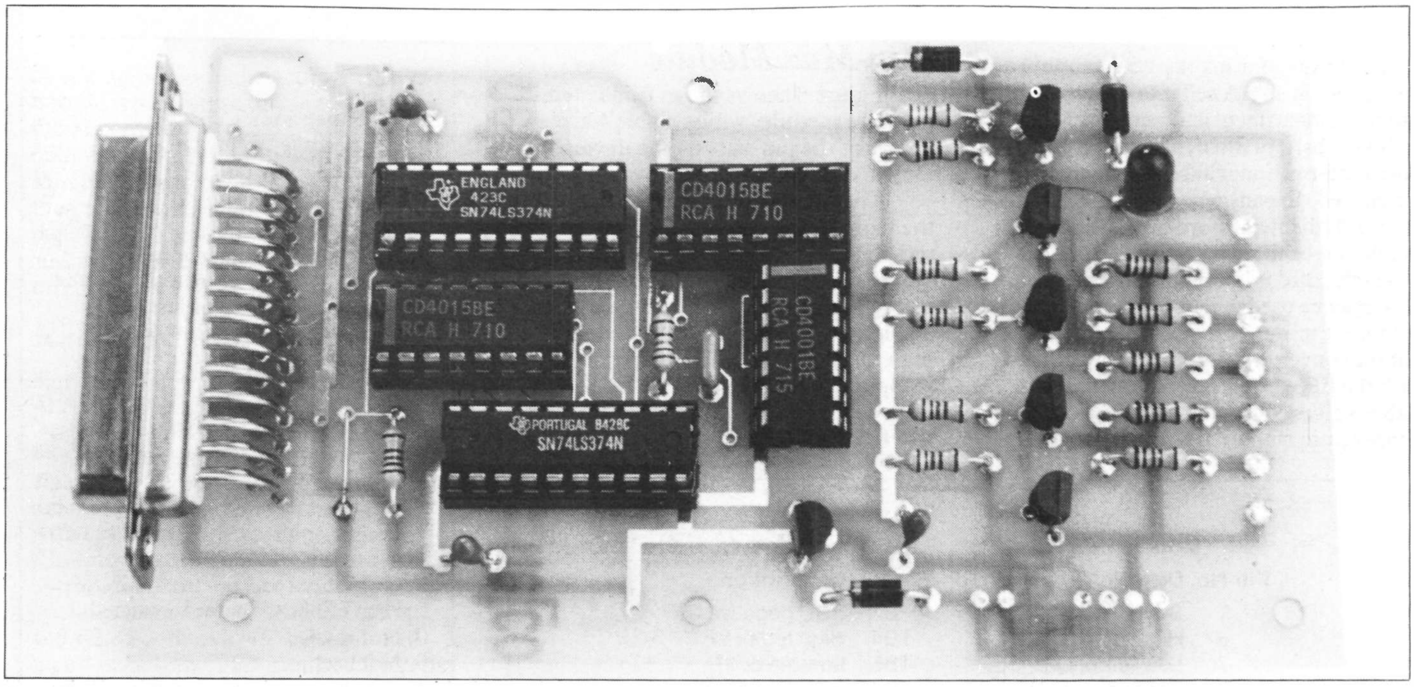


Figure 6. Converter PCB Layout.



Converter Board.

Pin	Bit		Description
1	D2	8	Tens (x10)
14	D3	4	BCD
2	D4	2	
15	D5	1	
3	D6	8	Units (x1)
16	D7	4	BCD
4	D8	2	
17	D9	1	
19	D13	8	Tenths (x0.1)
6	D12	4	BCD
18	D11	2	
5	D10	1	
7	D1		Hundred (°F)/Sign (°C)
20	°C/°F		High for °C
8	LOW		Temperature Set Points
21	HIGH		Reached (Active Low)
9	$\overline{OE}$		Output Bus Enable (Input Active Low)
22	0V		Ground Return

Table 2. D Connector pin functions.

further assembly if the resistors are soldered and trimmed now! Mount the five IC sockets and bend a few legs onto the track to prevent them from falling out. Fit capacitors C1 to C4, noting polarities where applicable, and mount diodes D1 to D3. Diodes must only be fitted with their cathode - the end marked with a bar - *in line* with the legend. Next, insert transistors TR1 to TR5 and regulator RG1, also in line with the legend. Solder all components in place and remove excess wire ends. Fit the remaining five IC's into their sockets and finally, mount the 25 way connector PL1. The connector should be soldered very carefully to prevent shorting adjacent pads together as they are closely spaced, and with this done, clean the track area with a suitable solvent and inspect all work done.

Testing and Use

If intending to use the 1.3V DC supply output to drive the temperature module, then LD1 must be fitted; this also serves as a power on indicator. Connect a 12V DC power supply to PL3, either directly to the pcb or via the 2 way minicon if used, with positive to PL3 pin 1 and negative to PL3 pin 2. Turn on the power and with a multimeter, check for a voltage reading of 5V DC across tantalum C1. Also check from any 0V point to TB1, which is the low voltage temperature module supply, and note that a reading of +1.3V DC should be present. Turn off the 12V power supply and wire up to the FE33L temperature module as shown in Figure 7. *Be extremely careful when soldering to the temperature module edge connector as it is easily damaged, and easy to place short circuits*

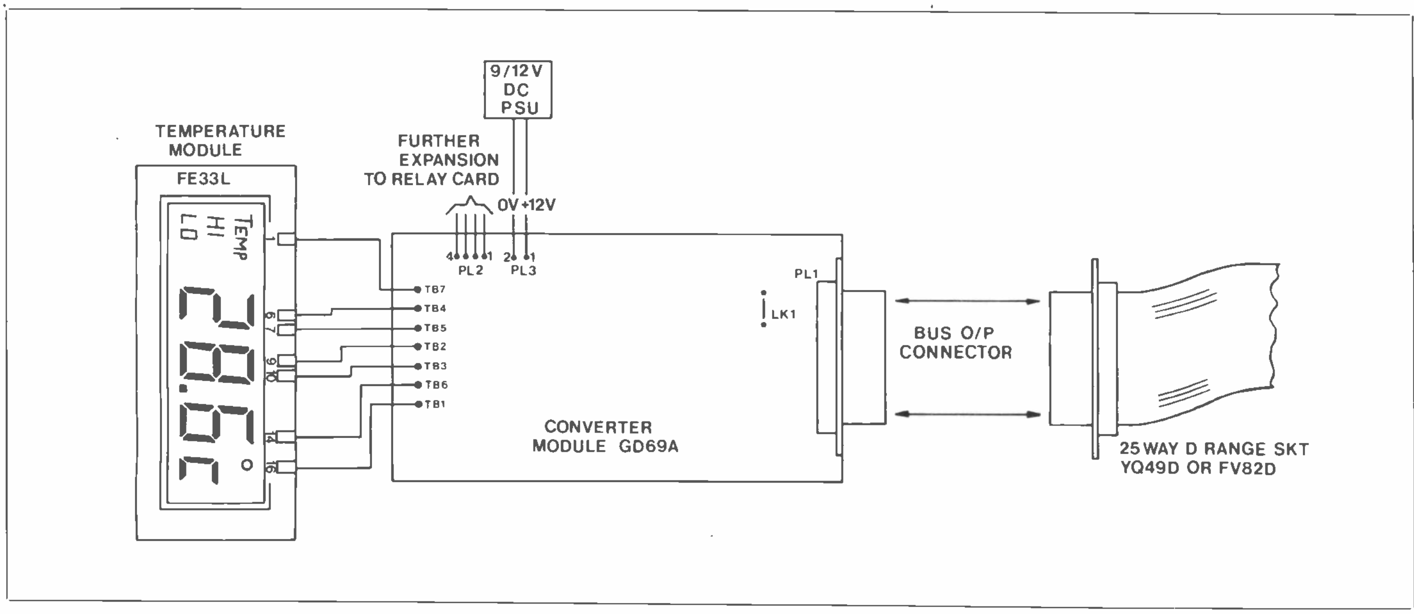


Figure 7. Connections to Converter PCB.

across the pads. If using the 1.3V supply then *do not* fit an AA cell into the module battery compartment and remember that without a battery fitted, all previously stored information will be lost when power is removed. Expansion connector PL2 is used with the Relay Card project and should not be fitted with a 4 way minicon, unless the card is not required. The Relay Card may be used with either temperature module or min-max temperature module, but the converter module can only be used with the FE33L temperature module. Table 3 gives connections between temperature module and converter pcb.

Min-Max Module

Figure 8 shows the min-max temperature module, whilst Table 4 gives details of the pin-outs on the device and information on the probes available.

The Min-Max module records both the highest (max) and the lowest (min) temperatures measured by the sensor. To recall the memory, momentarily take pin 11 high and the MEM symbol appears on the display; take either pin 4 high for MAX recorded temperature readout or pin 5 high for the MIN recorded readout. Max or Min symbols will flash on the display and momentar-

Module FE33L Pin No.	Description	To	Converter Module Pin No.	Description
1	Supply negative	"	TB7	PSU negative O/P
6	High temp. O/P	"	TB4	High temp. I/P
7	Low temp. O/P	"	TB5	Low temp. I/P
9	Serial data O/P	"	TB2	Serial data I/P
10	Data clock O/P	"	TB3	Data clock I/P
14	°C/°F	"	TB6	Scale °C/°F
16	Supply positive	"	TB1	PSU +1.3V DC

Table 3. FE33L to Converter PCB connections.

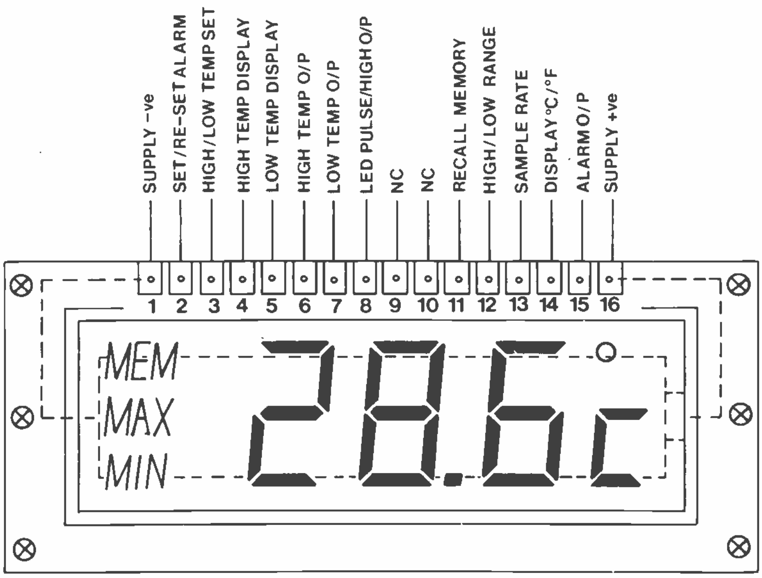
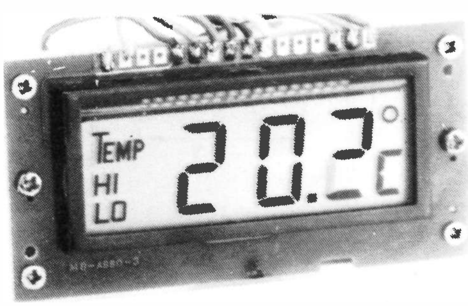


Figure 8. Min-Max Temperature Module FP64U.



Temperature Module.

Edge Connections
High = positive supply rail, low = negative supply rail.

Pin
1. Supply negative.
2. High to set or reset alarm
3. Set high or low temperature. Take high for single step or fast run.
4. Display high temperature.
5. Display low temperature.
6. High temperature output. Goes high for 1 minute when higher set point is reached and remains high until temperature falls below the set point.
7. Low temperature output. Goes high for 1 minute when lower set point is reached and remains high until temperature rises above the set point.
8. Output pulses high for 1 minute when either set point is reached.
9. Not used
10. Not used
11. Recall temperature memory. Take pin 4 high for maximum temperature or pin 5 high for minimum temperature.
12. Measure range for use with external probes. High for +20°C to +110°C range.
13. Sampling rate. High for 1 second sample, low or open for 15 second sample.
14. Temperature scale. High for °F scale, low or open for °C.
15. Alarm output. 2kHz signal output for 1 minute when set point temperatures are exceeded.
16. Supply positive.

External Probes

Low range White probe FP65V

Range:	−40°C to +50°C (−40°F to +122°F)
Resolution:	0.1°C (0.1°F)
Accuracy:	−40°C to −21°C ±2°C @ 1.5V
	−20°C to +25°C ±1°C @ 1.5V
	+26°C to +50°C ±2°C @ 1.5V

High range Grey probe FP66W

Range:	+20°C to +110°C (+68°F to +230°F)
Resolution:	0.1°C (0.1°F)
Accuracy:	+20°C to +34°C ±2°C @ 1.5V
	+35°C to +75°C ±1°C @ 1.5V
	+76°C to +110°C ±2°C @ 1.5V

Both white and grey probes are fitted with 3m of connecting cable.

Accuracy decreases with increase in length of probe cable by ±2.5°C per 3m cable and is also dependent on battery voltage.

Table 4. FP64U pin functions.

ily taking pin 11 high again will resume normal temperature display. To clear the Max memory take pin 4 high and hold then take pin 11 high or to clear Min memory take pin 5 high and hold then take pin 11 high. The display may register +50 or −40 while doing this and will then store the present temperature.

Relay Switch Card

Figure 9 shows the circuit diagram of the Relay Switch Card. The card may be used with either FE33L or FP64U modules and pin connections are the same for both (see Figure 11). Transistors TR1 to 3 are low level buffer inputs with a relay as the collector load. Relay RL1 is operated from the high set point output on a temperature module, RL2 operates from the low set point output and RL3 operates from the combined high/low output. TR4 is pulsed from the alarm signal output at either 2kHz or 4kHz, depending on which temperature module is being used, and drives the piezo transducer BZ1. The transducer being ceramic, requires a voltage source to operate it. R6 and R5 form a potential divider in the collector load and the signal voltage drop across R5 drives the transducer. The relay contacts are "dry" changeover type where the moving contact is common (C), the normally closed contact is NC and the normally open contact is NO.

Relay Switch Card Construction

Not very much can be written about constructing this module as there are very few components associated with it. However with reference to Figure 10, it is worth suggesting that the 16 vero pins are inserted into the pcb first, followed by the resistors, diodes, transistors and relays. Check the orientation of the diodes before fitting! If the module is to be used on its own, without the converter module, then fit the 4 way minicon plug, PL1. Carefully solder all components onto the board and remove any excess wire ends, then inspect for dry joints, shorts etc.

Testing and Use

Wire the card as in Figure 11 and if using the piezo buzzer, connect the black lead to pin 18, marked minus, and the red lead to pin 15 marked plus. Mount BZ1 on top of the relays using a quickstick pad. Connect a 9/12V DC power supply to PL1, with positive to PL1 pin 4 and 0V to PL1 pin 3. Switch on the supply and follow the procedure for setting the high and low set points. Have available a tin of freezer spray and also a soldering iron as they are both ideal for lowering and raising the temperature below or above the set points. Place the hot iron close to - but not on - the sensor and as the temperature reaches the high set point, RL1 and

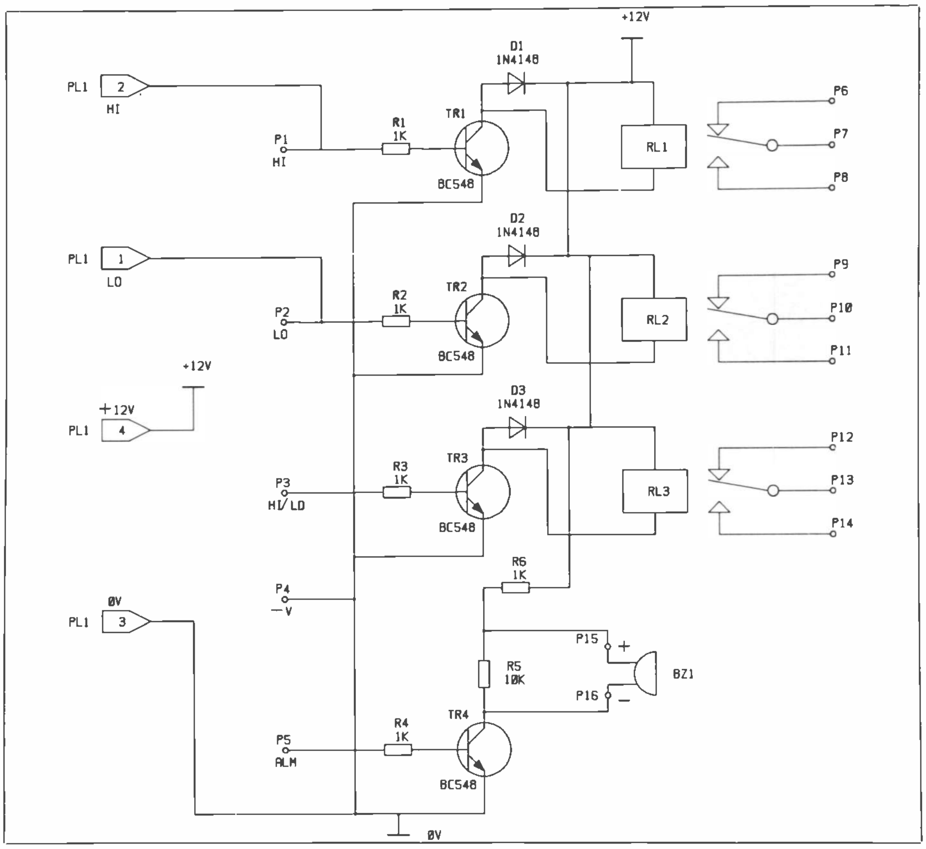


Figure 9. Relay Card Circuit.

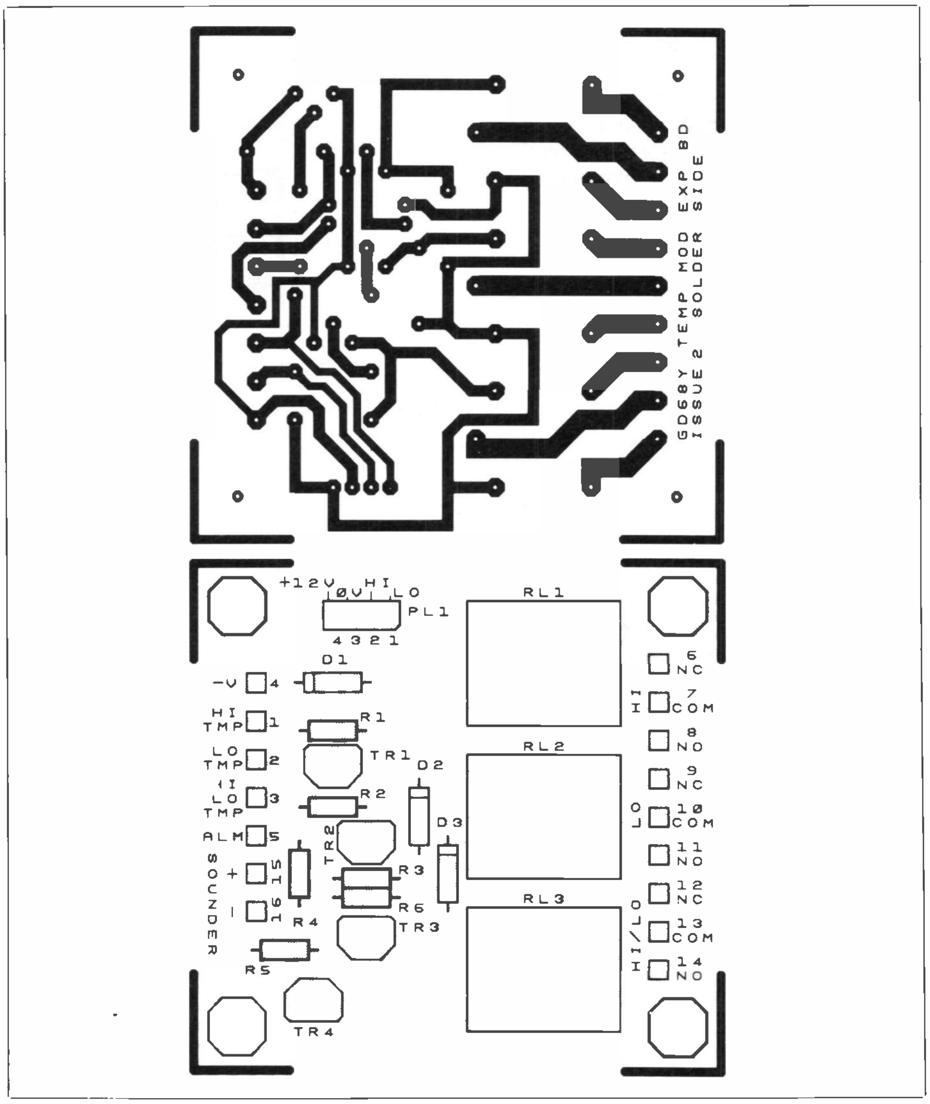
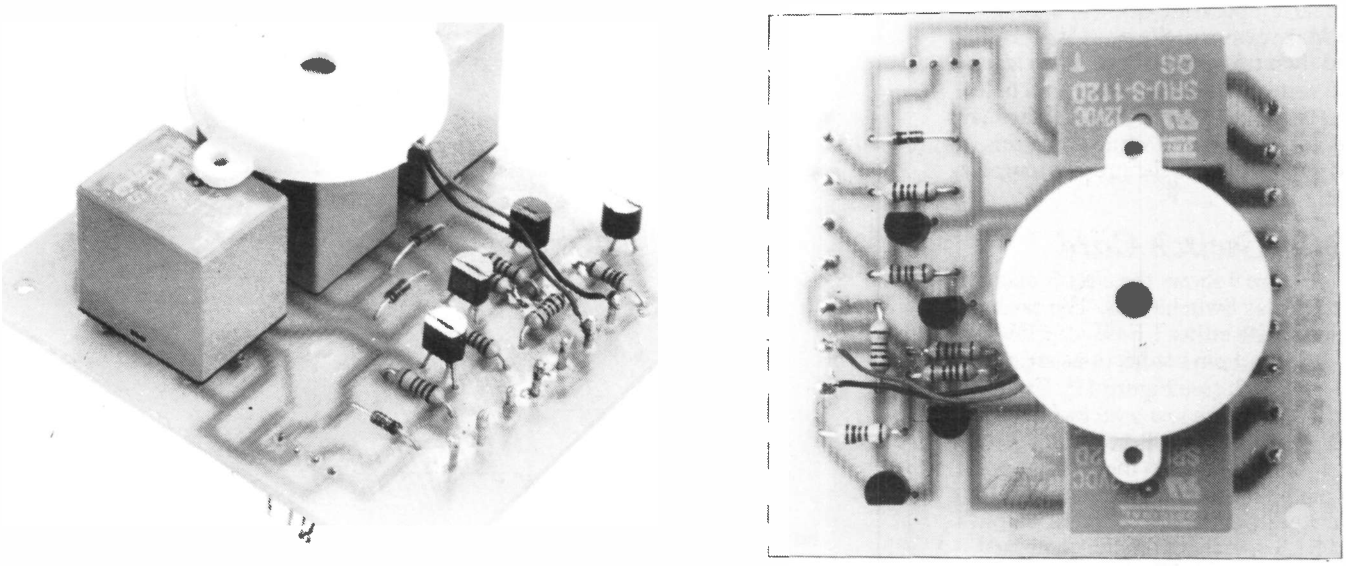


Figure 10. Relay Card Layout.



Relay card.

RL3 will both operate and BZ1 will bleep. RL3 will either release first or operate when RL1 releases. Again this depends on which temperature module is in use, therefore reference this paragraph with the leaflet supplied with each temperature module. Spraying the freezer onto the sensor will drop the temperature to the lower set point whereupon RL2 should operate as well as BZ1. Check the actual release sequence with the supplied instructions.

Using Both Modules

Figure 12 shows the assembly for use with temperature module FE33L only. The relay card can be mounted

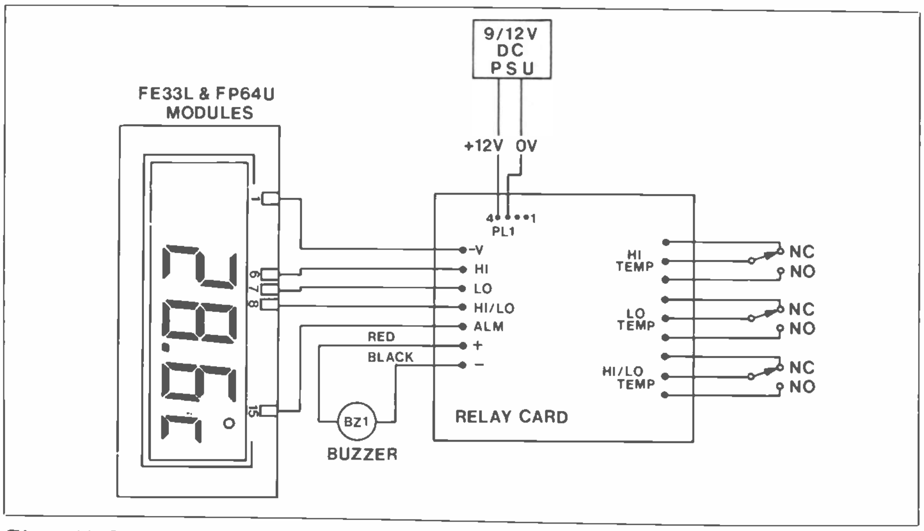


Figure 11. Connections to Relay Card.

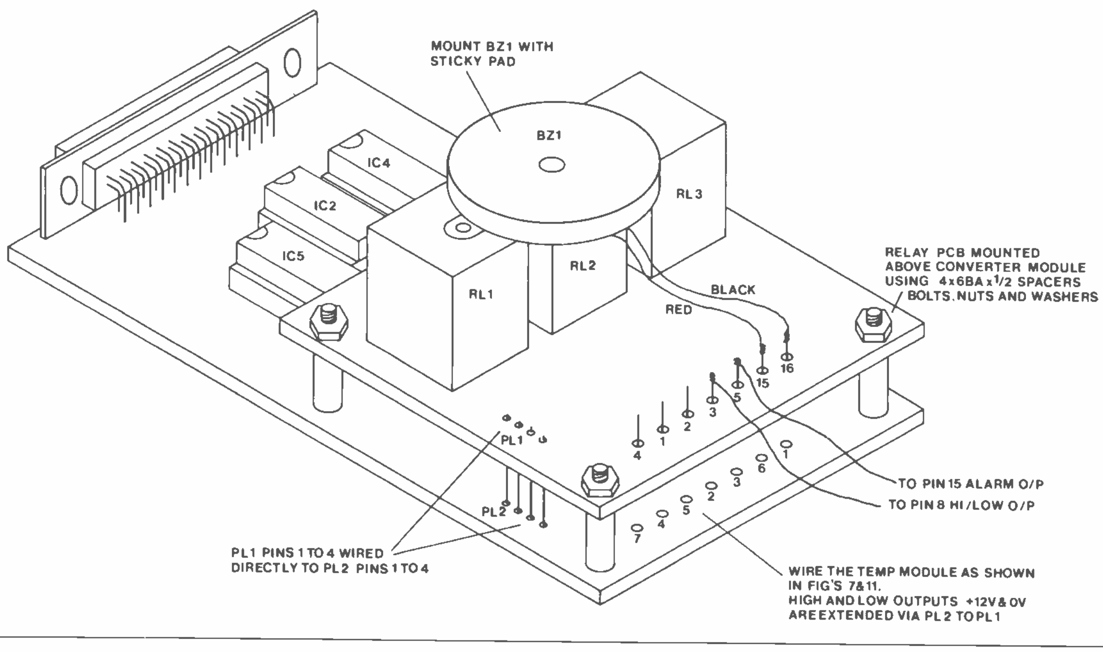
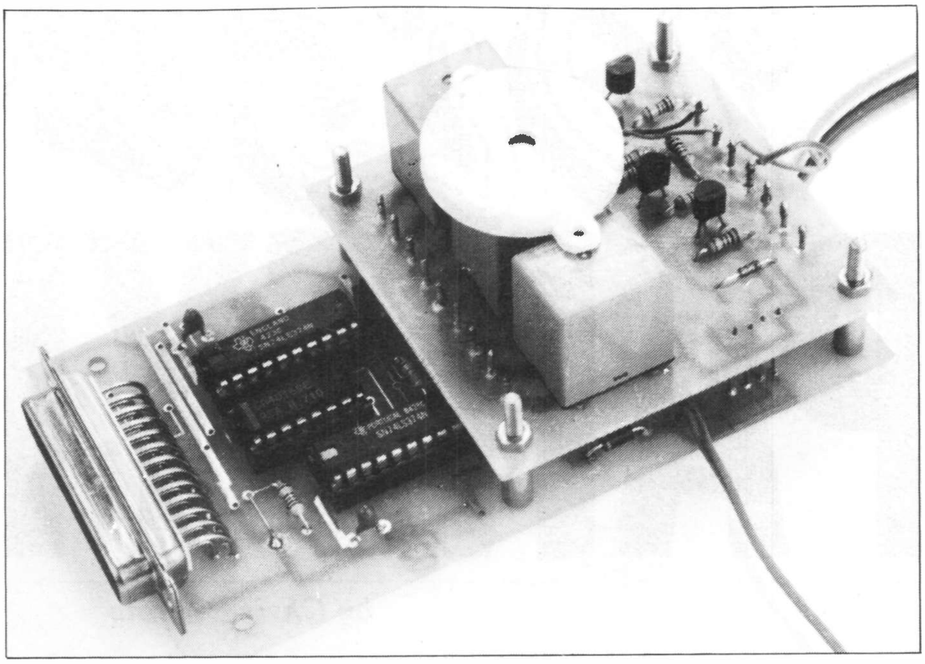


Figure 12. Connecting FE33L to both PCBs.

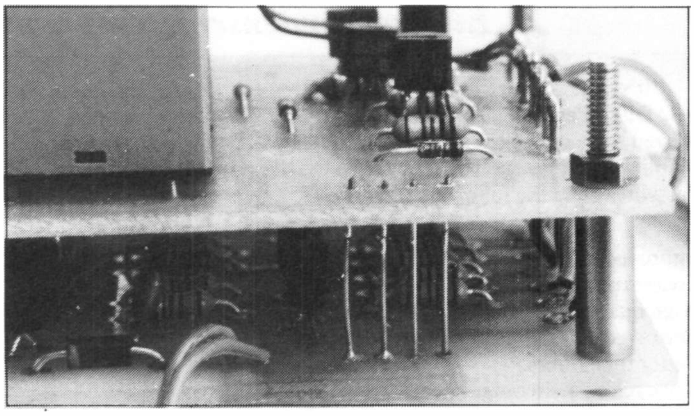
above the converter card using 4 of each; 6BA threaded spacers, 6BA 1in. bolts, 6BA nuts and washers. If 4 way minicons have previously been fitted to either module, then remove them and connect PL1 on the relay card to PL2 on the converter card by wiring directly through both PCBs and soldering in place. These connections extend the +12V and 0V onto both cards so that the PSU need only be connected onto the converter PL3. The HI and LO temperature output lines are also extended through to both cards, therefore pins 6 and 7 on a temperature module need only be fitted onto one of the cards terminal pins. Two connections only are required from the relay card, to pin 15 and pin 8 of the temperature module. The power requirement for this configuration is 9 to 12V DC @ 50mA, increasing by 30mA for each relay operating, and a maximum of 150mA.


Relay card mounted above converter board.

TEMP MODULE CONVERTER PARTS LIST

RESISTORS: All 0.6W 1% Metal Film			
R1-5	1k	5	(M1K)
R7-11,13	10k	6	(M10K)
R12	220k	1	(M220K)
R6	270Ω	1	(M270R)
CAPACITORS			
C1	Tant 100nF 35V	1	(WW54J)
C2	Monores Cap 220nF	1	(RA50E)
C3,4	Tant 1μF 35V	2	(WW60Q)
SEMICONDUCTORS			
IC1	4001BE	1	(QX01B)
IC2,3	4015BE	2	(QW16S)
IC4,5	74HC374	2	(UB82D)
TR1-5	BC183L	5	(QB56L)
D1-3	1N4001	3	(QL73Q)
RG1	μA78L05AWC	1	(QL26D)
MISCELLANEOUS			
LD1	LED Red	1	(WL27E)
PL1	RA D Range 25 Way Plg	1	(FG68Y)
PL2	PCB Latch Plug 4W	1	(YW11M)
PL3	PCB Latch Plug 2W	1	(RK65V)
	Temp Mod Ser/Par PCB	1	(GD69A)
	DIL Socket 14-pin	1	(BL18U)
	DIL Socket 16-pin	2	(BL19V)
	DIL Socket 20-pin	2	(HQ77J)
	Constructors' Guide	1	(XH79L)
	Leaflet	1	(XT35Q)
OPTIONAL			
	AA Battery	1	(FK59P)
	Temperature Module	1	(FE33L)
	25-Way D Range Socket	1	(YQ49D)
	25-Way D Range Socket IDC	1	(FV82D)
	Bezel fr Temp Module	1	(FE35Q)
	Probe fr Temp Module	1	(FE34M)
	Min/Max Temp Module	1	(FP64U)
	Low Temp Probe	1	(FP65V)
	High Temp Probe	1	(FP66W)

The above parts, excluding optional items, are available as a kit:
Order As LM36P (Temp Mod Converter Kit)
The following item is also available separately:
Temp Mod Ser/Par PCB **Order As GD69A**


Connecting the two boards together.

TEMP MODULE RELAY CARD PARTS LIST

RESISTORS: All 0.6W 1% Metal Film			
R1-4,6	1k	5	(M1K)
R5	10k	1	(M10K)
SEMICONDUCTORS			
TR1-4	BC548	4	(QB73Q)
D1-3	1N4148	3	(QL80B)
MISCELLANEOUS			
RL1-3	3A Min Relay	3	(YX96E)
BZ1	Min Piezo Sounder	1	(FM59P)
PL1	PCB Latch Plug 4W	1	(YW11M)
	Threaded Spacer 6BA	1 Pkt	(LR72P)
	Bolt 6BA 1in.	1 Pkt	(BF07H)
	Nut 6BA	1 Pkt	(BF18U)
	Washer 6BA	1 Pkt	(BF22Y)
	Quickstick Pads	1 Stp	(HB22Y)
	Temp Mod Relay Board	1	(GD68Y)
	Pin 2145	1 Pkt	(FL24B)
	Constructors' Guide	1	(XH79L)

The above parts are available as a kit:
Order As LM37S (Temp Module Relay Card Kit)
The following item is also available separately:
Temp Module Relay Board **Order As GD68Y**

Disco PARTYLITE

by Chris Barlow

★ *No direct connection to your sound system required*
★ *Automatic level adjustment* ★ *3-channel operation*
★ *Electret condenser microphone insert* ★ *Zero voltage triggering*

It's time to party again, with the all new Disco Partylite. The original Partylite proved to be one of the best selling kits in Maplin's top twenty. The new Disco Partylite offers the following improvements:

Improved electrical safety.
Cooler running circuitry.
High quality microphone insert.
Improved ALC circuitry.
Better tone filters.
Triac mains switching.

Specification of Prototype

Supply voltage:	240V AC 50Hz.
Supply current:	5A Maximum.
Power handling:	300W per channel maximum.
Number of channels:	3: Bass, Middle, Treble.
Frequency response:	10Hz to 20kHz.
Suggested case dimensions:	Width 150mm, length 220mm, height 64mm.

Introduction

The concept of a three channel sound to light modulator can be traced back to the early days of disco entertainment. These early units had to be under the manual control of the DJ, to ensure the correct display was produced. The audio connection was made by wiring the unit across the loudspeaker terminals of the sound system.

The Disco Partylite has a built-in microphone eliminating the need for a

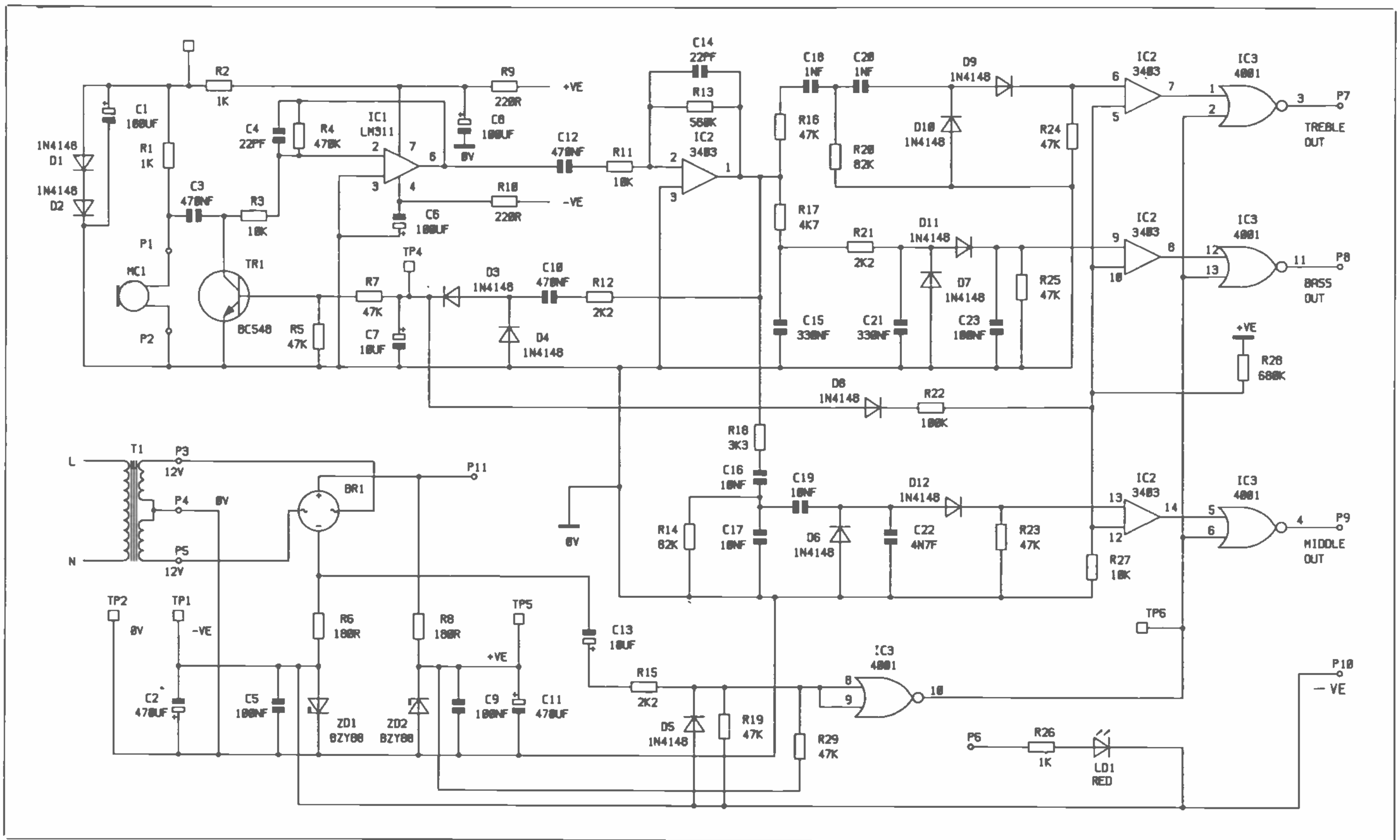


Figure 1. Controller circuit.

direct audio connection, making a completely free-standing unit. This removes the possibility of damaging your hi-fi sound system. Its automatic level control (ALC) circuit follows the volume of the music over a wide range, eliminating the need for a manual level control. The Disco Partylite employs zero voltage triggering of the triacs, minimising any interference generated by the unit.

In addition to the circuits shown in Figures 1 and 2, a block diagram of the complete system giving the signal paths are detailed in Figure 3. This should assist you when following the circuit description or fault finding in the completed unit.

Controller Circuit

The power supply for the sound to light controller is comprised of the mains transformer T1 and the bridge rectifier BR1. This provides a positive and negative output, which is then regulated by the zener diodes ZD1 and ZD2, providing a ±7.5V supply. These supplies are then decoupled by C2 and C5, and C9 and C11 to remove any electrical noise from reaching the IC's. The zero voltage triggering pulses are generated by sampling the 100Hz ripple at the negative output of BR1. These pulses are then inverted by IC3, a quad NOR gate. The power supply also provides a rough positive output at P11, used by the current driver transistors in the triac output circuit.

The electret microphone insert MC1 is powered by a low voltage supply of approximately 1.4V, provided by D1 and D2 with R1 and R2. This supply is then

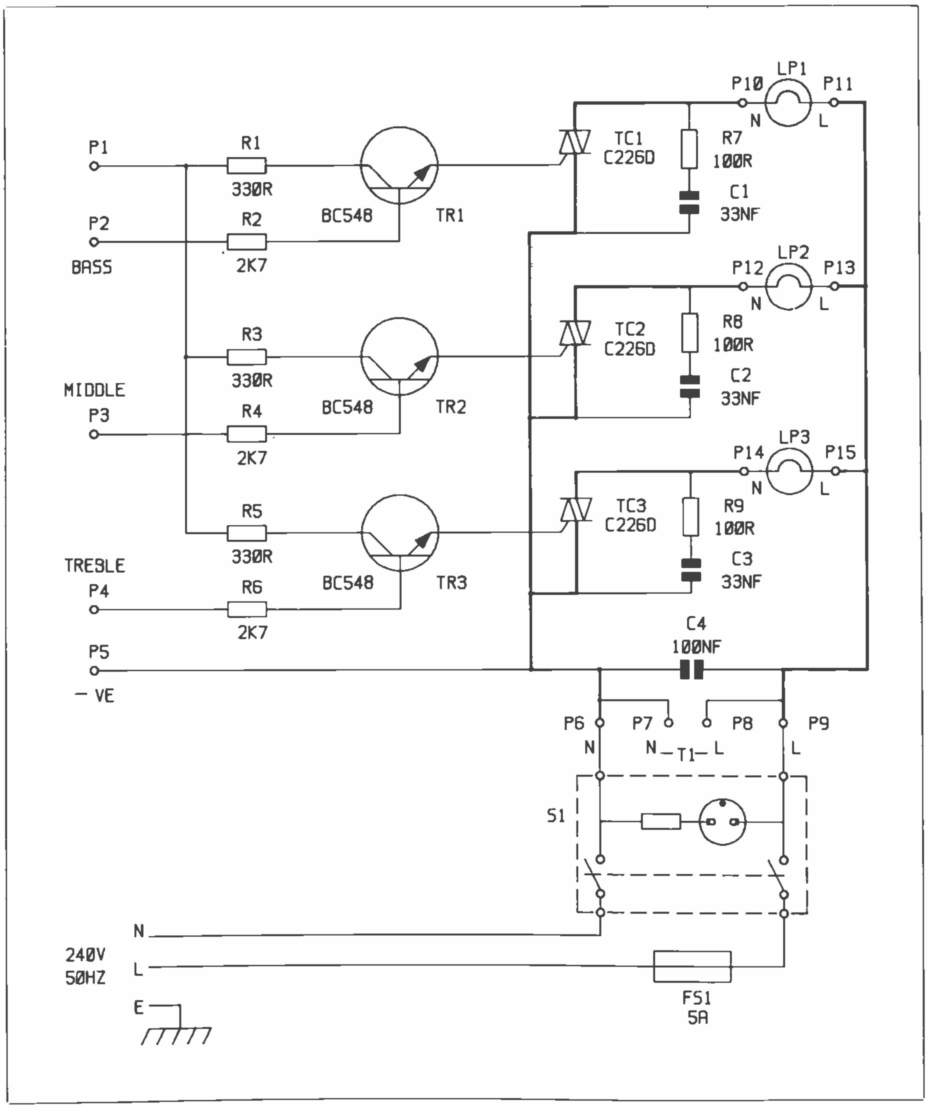


Figure 2. Triac Output circuit.

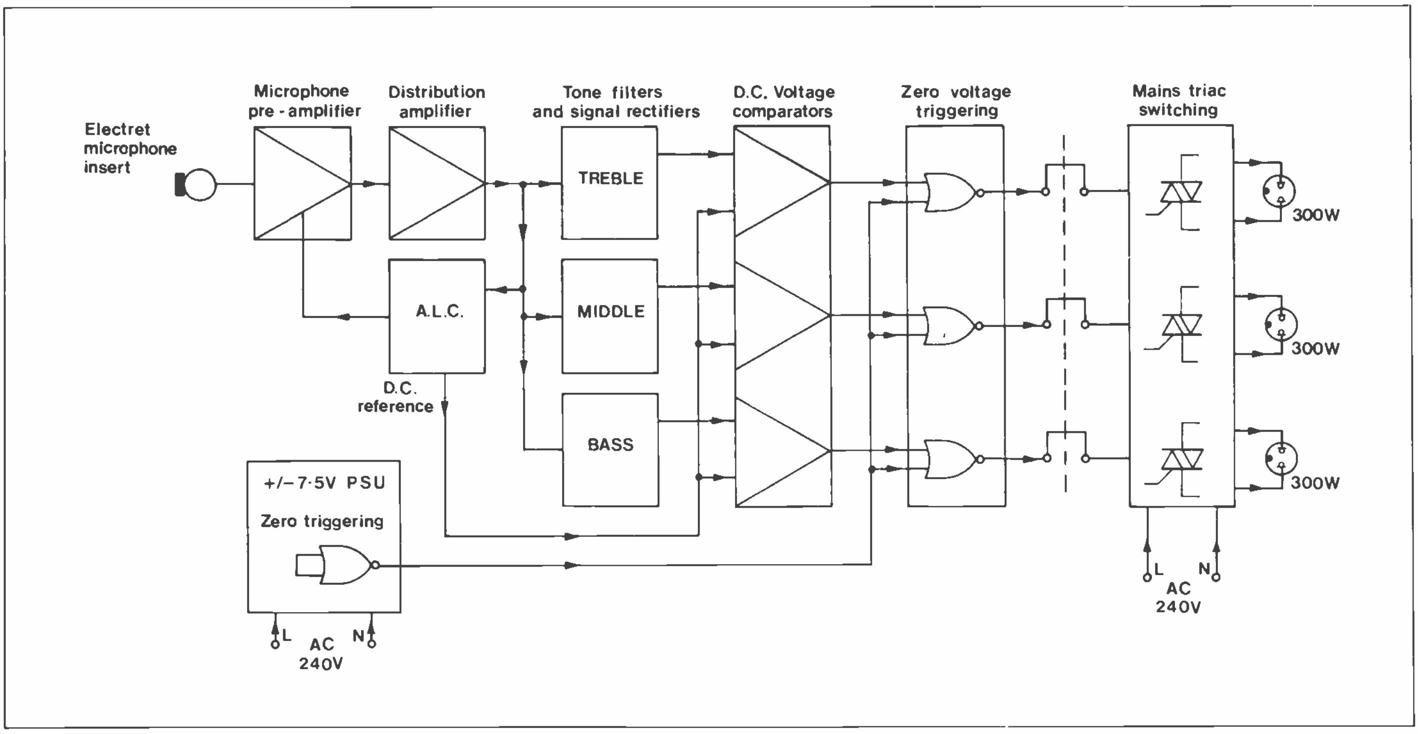


Figure 3. Block schematic.

decoupled by C1, to remove any electrical noise from reaching the insert. The low level audio signal from the insert is then fed to the microphone pre-amplifier IC1, via C3 and R3.

The supply rails to IC1 have additional decoupling, comprising C6 and C8 and R9 and R10. The output from IC1 is then fed via C12 and R11 to the input of the distribution amplifier, IC2. Its output then feeds the tone filters and ALC circuit. The ALC circuit produces a DC voltage dependent upon the level of signal fed via C10 and R12 to the diode pump D3, D4 and C7. This voltage is used to

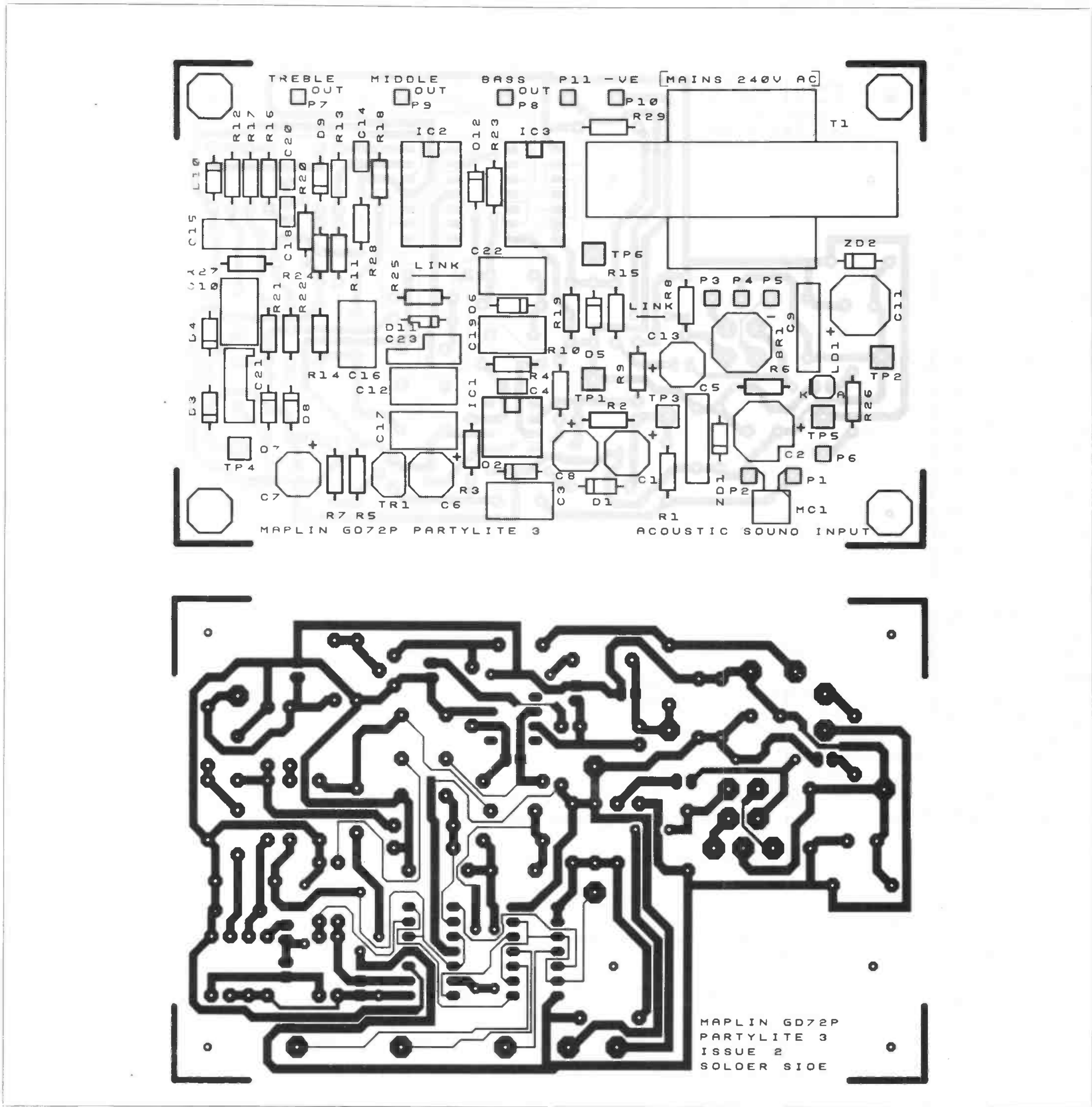


Figure 4. Controller track and overlay.

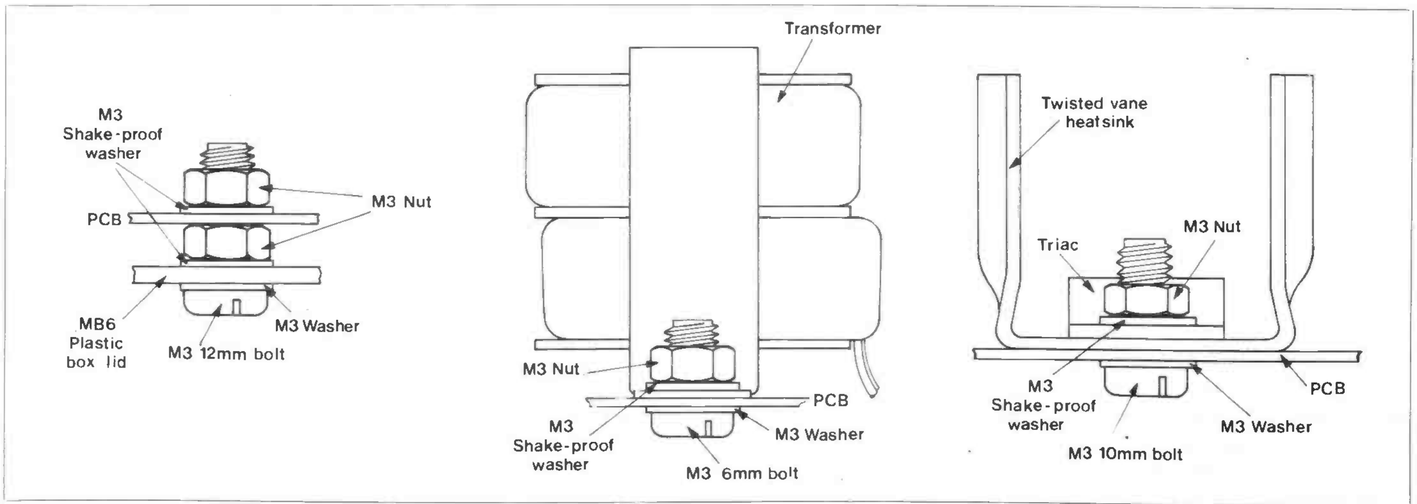


Figure 5. Fixing the pcb, transformer and heatsinks.

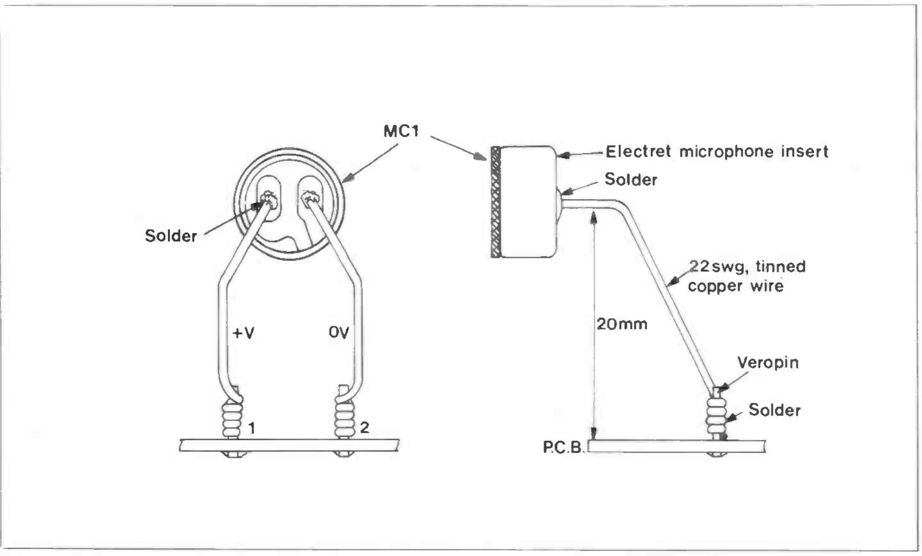


Figure 6. Mounting the microphone insert.

bias TR1 and supply the reference voltage to the comparators. As TR1 is progressively biased on it pulls the audio signal to ground at the junction of C3 and R3.

The three filter networks split the signal into the bass, middle and treble frequencies. The bass filter comprising C15, C21, C23, R17 and R21. The middle filter, comprising C16, C17, C19, C22, R14 and R18, and the treble filter comprising C18, C20, R16 and R20. Each filter has two diodes to rectify the signal into positive DC voltage pulses, which feeds one input of a voltage comparator IC2. The output of the comparators are normally high (logical '1'). However, when the voltage level from the filter exceeds the reference level the output goes low (logical '0'). When the zero voltage triggering stage IC3 receives a '0' from the comparator and a '0' from the pulse generator, its output will go to '1'.

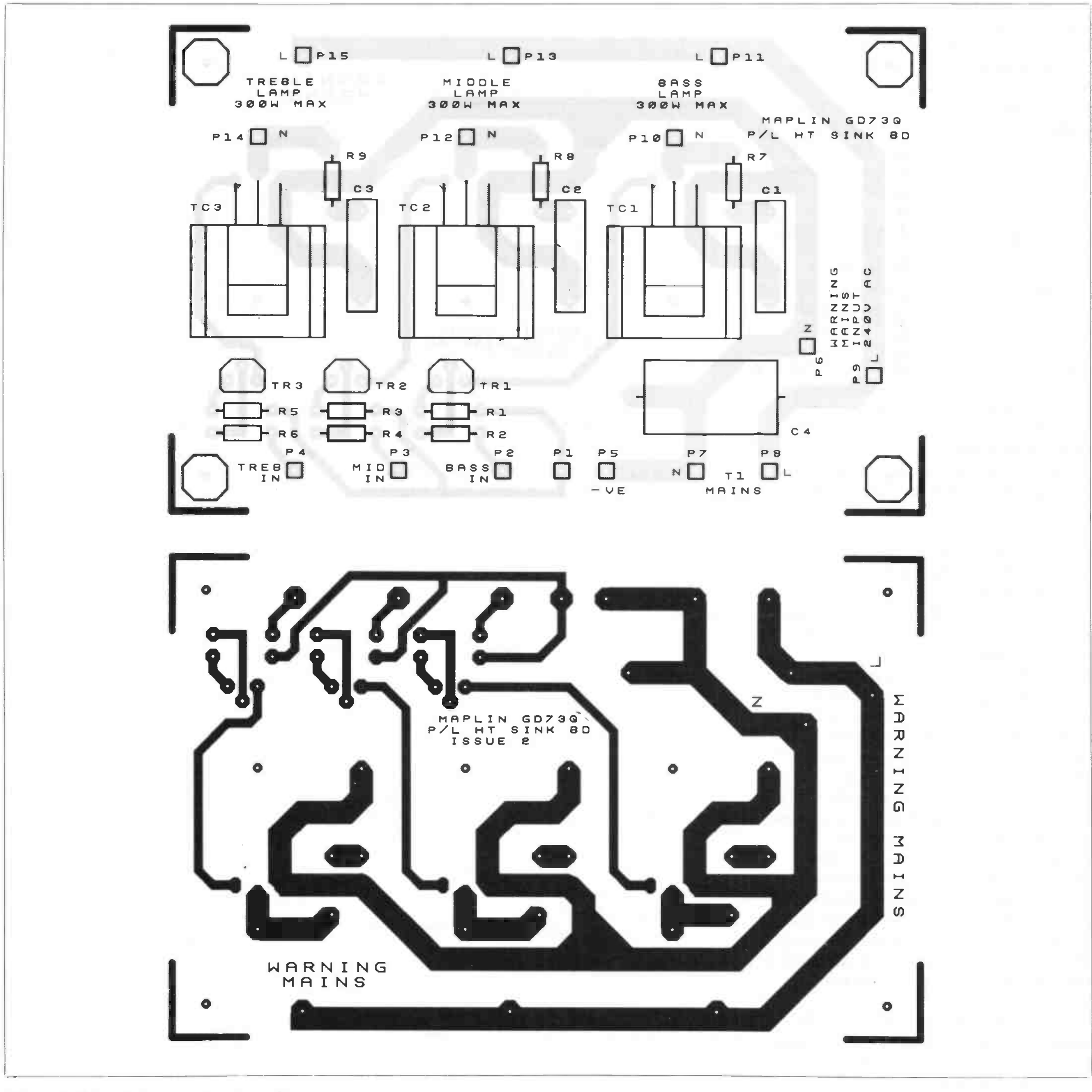


Figure 7. Triac Output track and overlay.

Triac Output Circuit

The output from IC3 cannot provide sufficient current to drive the gate of the triac directly, so a driver transistor is required. Each channel has one of these, the bass TR1, the middle TR2, and the treble TR3. When the current is flowing in the gate circuit of a triac it will turn on, allowing the 240V AC mains current to flow through the lamp LP1 to LP3. Suppression components C1, C2, C3, R7, R8 and R9, are fitted across each triac to reduce the electrical interference to a minimum. Additional interference suppression is provided across the mains supply by C4. For safety reasons, the mains entering the circuit must first pass through FS1, the 5A 20mm anti-surge fuse and S1, the dual rocker switch.

PCB Assembly

The PCB's are of single-sided fibre glass type, chosen for maximum durability and heat resistance. Removal of a misplaced component is quite difficult, so please double-check each component type, value and its polarity where appropriate, before soldering! For further information on component identification and soldering techniques please refer to the constructor's guide which is included in the kit.

Controller PCB Assembly

The PCB has a printed legend to assist you in correctly positioning each item, see Figure 4. The sequence in which the components are fitted is not critical. However, it is easier to start with the smaller components. Begin with the two wire links and then fit the pins at the positions indicated by the white squares on the PCB. Mount the appropriate IC holder in each position, matching the notch with the block on the legend. *Do not* fit the ICs until the initial testing stage!!

Next install the metal film 0.6W resistors, then mount the disc ceramic capacitors C5, C9, C4 and C14. Install all of the polyester layer capacitors and position them accordingly. The polarity of the electrolytic capacitors is shown by a plus sign matching that on the PCB legend. However on some capacitors the polarity is designated by a negative symbol, in which case the lead nearest this symbol goes away from the positive sign on the legend. When fitting the transistor TR1 you must carefully match the case to the outline shown. The diodes, D1 to D12 and ZD1 and ZD2, have a band at one end to identify the cathode connection. The bridge rectifier, BR1 has a plus sign to identify the positive output. However, on the PCB legend the negative is shown, position the plus sign of BR1 diagonally opposite to this symbol. When mounting the red LED LD1 it must be 6 millimetres above the board and the flat indicates the cathode.

Next fit the mains transformer T1 using the M3 hardware as shown in Figure 5. The secondary outputs from the transformer are then connected to the board in the following way: cut the two

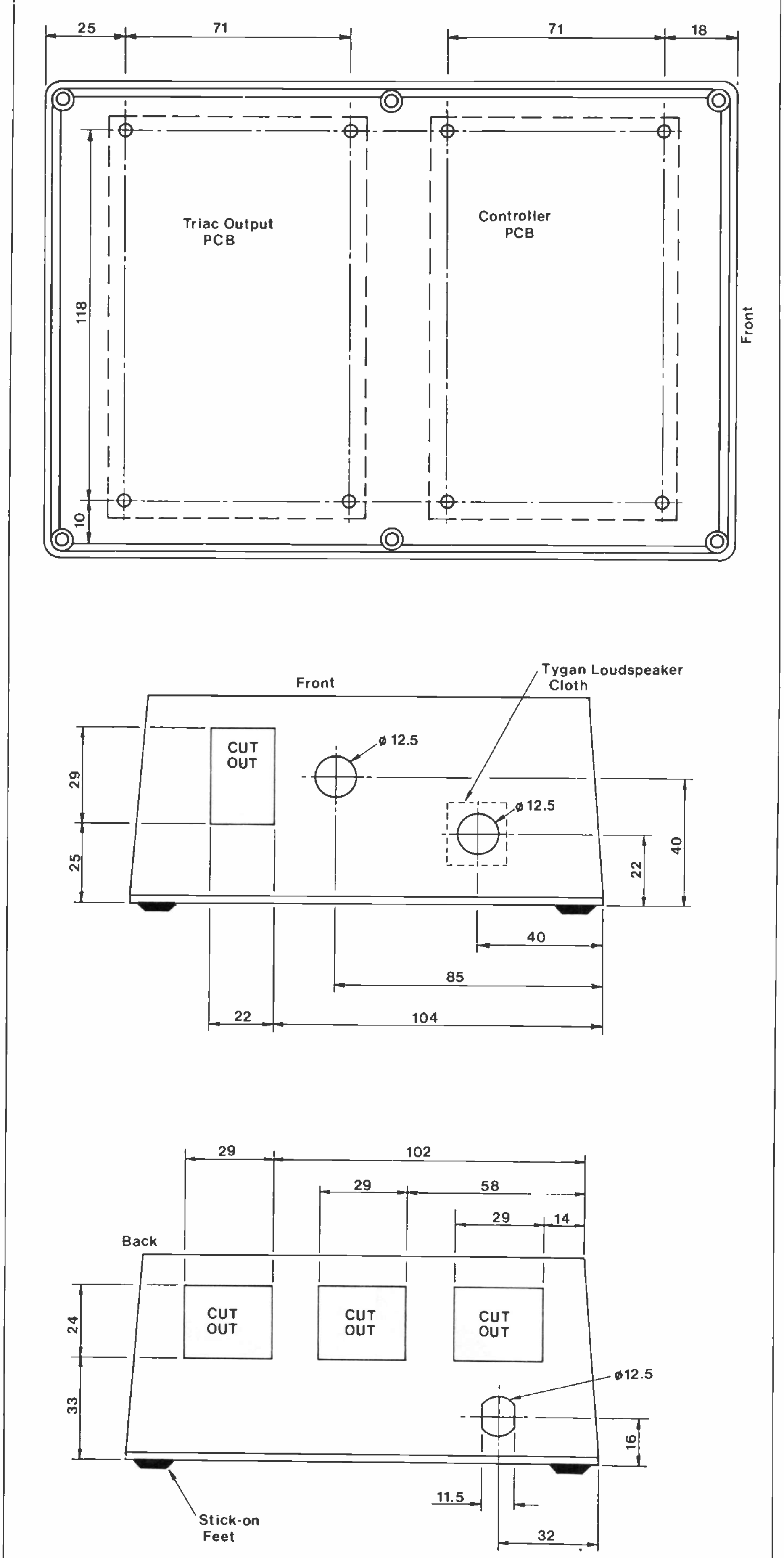


Figure 8. Suggested case drilling.

red and remaining black wires to a length of approximately 30mm and remove 3mm of insulation from each. Solder each wire to the pin nearest to it, first red to P3, black to P4, and the remaining red to P5. The brown and blue primary mains wires will be connected at a later stage.

Mount the electret microphone insert as shown in Figure 6. This completes the assembly of the controller PCB and you should now check your work very carefully ensuring that all the solder joints are sound. It is also very important that the bottom, track side, of the circuit board does not have any trimmed component leads standing proud by more than 1mm.

Triac Output PCB Assembly

Begin by fitting the pins at the positions indicated by the white squares on the PCB, see Figure 7. Next install the metal film 0.6W resistors, then mount the three 33nF IS capacitors C1, C2 and C3 and the 100nF IS capacitor C4. When fitting the transistors TR1, TR2 and TR3 you must carefully match the shape of the case to the outline shown. Finally mount the three triacs TC1, TC2 and TC3, and their heatsinks, using the M3 hardware as shown in Figure 5. This completes the assembly of the triac output PCB and you should now check your work very carefully ensuring that all the solder joints are sound. It is also very important that the bottom, track side, of the circuit board does not have any trimmed component leads standing proud by more than 1mm.

Controller Unit Testing

All the tests can be made with a minimum of equipment. You will need an electronic digital, or analogue moving coil, multimeter. Carefully lay the PCB assembly on a non-conductive surface, such as a piece of dry paper or plastic. Make a temporary, but *safe*, connection to the 240V AC mains supply, Live to the brown wire and Neutral to the blue wire from the primary of transformer T1. Set your meter to read DC volts and place its negative lead on TP2, the 0V ground, and the positive to TP5. You should observe a reading of 7.5V and approximately 11V on P11, 1.4V on TP3. Then place the positive lead on TP2, and the negative on TP1, where again you should observe a reading of 7.5V.

Remove the mains supply and carefully install the ICs. Be sure to position them properly according to the legend. Reconnect the mains supply and place the negative lead of the meter on TP2. The positive voltage at TP4 will vary according to the sound level present at electret microphone insert MC1. For a loud whistle a voltage reading of approximately 7V should be seen. If an oscilloscope, or frequency counter, is available then the 100Hz positive pulses should be observed at TP6.

The final test makes use of the red LED LD1 on the PCB. Place the unit with the microphone insert facing one of your hi-fi speakers, at a distance of approximately one metre. Play some disco party type music, set the volume and tone controls to suit. When P6 is connected to P8 the LED should respond to the bass frequencies. When connected to P9 it should respond to the middle and when on P7 to the treble frequencies. Remove any connection to P6 and the temporary mains connection to the transformer T1. This completes the testing of the controller PCB assembly.

Box Assembly

The prototype unit used a black plastic box type MB6 and the drilling instructions are shown in Figure 8. Having drilled the holes, and at the same time clearing them of any swarf, proceed to install the dual rocker switch and the 20mm fuse holder. Using impact adhesive, glue a small piece of loudspeaker cloth inside the box over the microphone insert's hole. Mount the three euro-facility outlet sockets to the back of the box and the two PCBs to the lid at the positions shown in Figure 8. Use the M3 hardware as shown in Figure 5 and ensure that the PCB interconnecting pins are facing each other, see Figure 9. Fit the square stick-on feet to the lid, ensuring not to cover any of the fixing holes. This completes the assembly of the box and you should now check your work very carefully before proceeding to the wiring stage.

Wiring

Carefully follow the wiring shown in Figure 9. Note that the 6A mains cable passes through a strain relief grommet in the back of the box. Having completed the wiring, carefully fit the lid to the box ensuring that the microphone insert is directly behind its hole. Using the countersunk screws supplied with the box, secure the lid and fit a 5A 20mm anti-surge fuse in the holder. Finally, fit a 13A plug with a 5A fuse to the mains cable. **Warning:** Once the two PCBs are wired up the entire circuit is at live mains potential. Do not operate the unit out of its box!! Only connect the mains lamps to the euro facility outlets and DO NOT make any other connection to the unit.

Final Testing

After the unit has been completed and the lamps, not exceeding 300W per channel, are connected, it can then be plugged into the mains for testing. Should it not function correctly, disconnect the unit from the mains supply before making

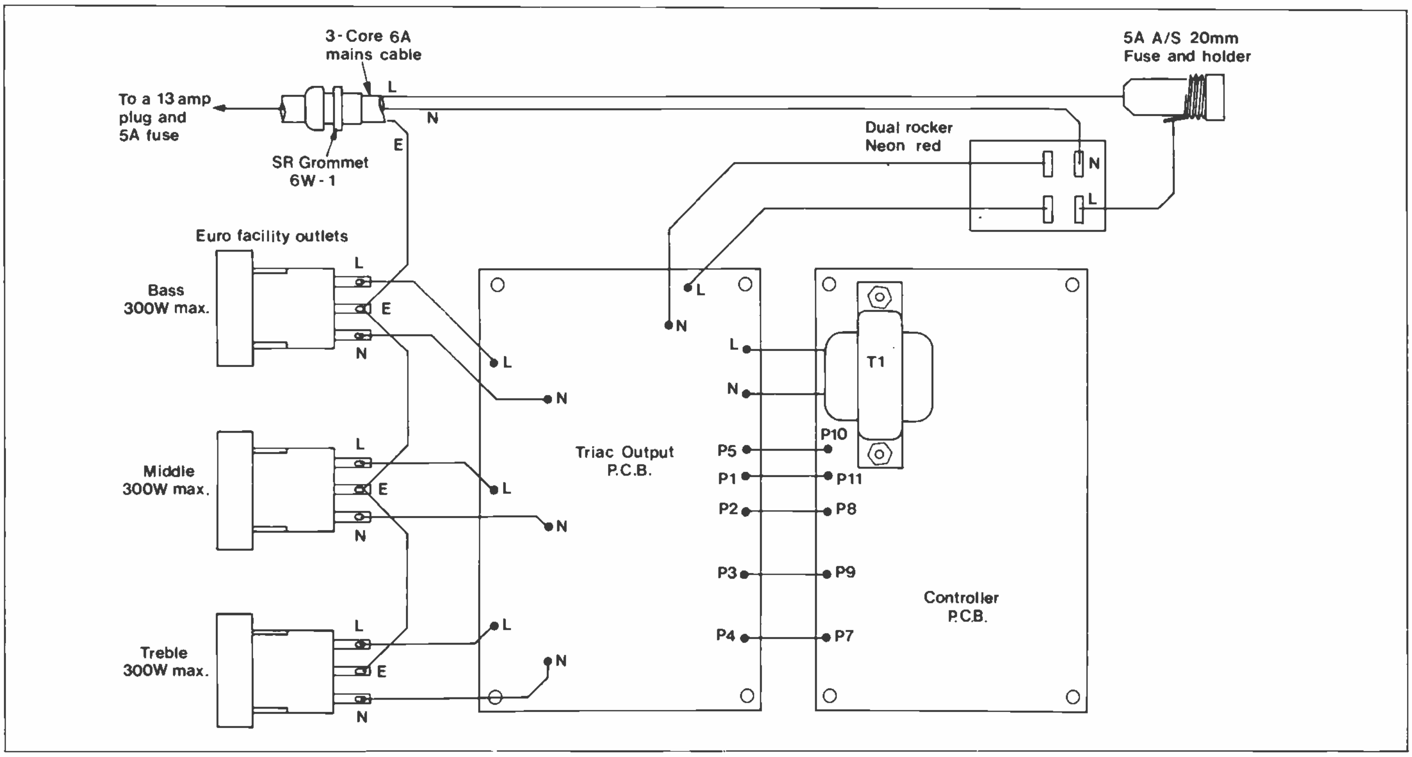


Figure 9. Interwiring.

any checks. Repeat the sound test by playing some disco party music on your hi-fi. If all is well the lamps should flash in sympathy with the music. This completes the testing of the unit and it is now ready for use.

Using the Disco Partylite

The unit can handle a total power loading of 300W per channel. This can be made up from a number of different combinations of lamps, see Figure 10. Bulbs and holders are not available from Maplin, but are readily available from many high street electrical retailers. The best operating position for the unit will depend on room size and the power output of your hi-fi system. Once set up the Disco Partylite should give added atmosphere to your party.

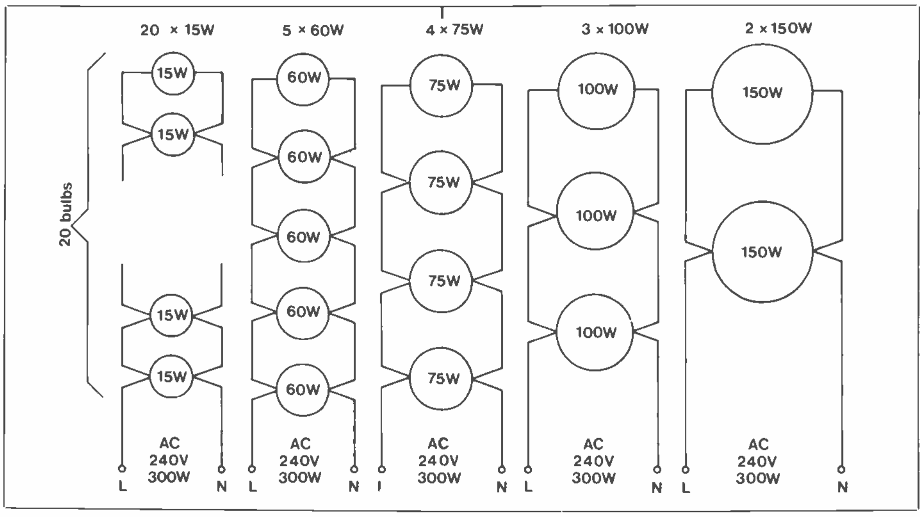


Figure 10. Bulb configurations.

DISCO PARTYLITE CONTROLLER PARTS LIST

RESISTORS: All 0.6W 1% Metal Film			
R1,2,26	1k	3	(M1K)
R3,11,27	10k	3	(M10K)
R4	470k	1	(M470K)
R5,7,16,19,23,24,25,29	47k	8	(M47K)
R6,8	180Ω	2	(M180R)
R9,10	220Ω	2	(M220R)
R12,15,21	2k2	3	(M2K2)
R13	560k	1	(M560K)
R14,20	82k	2	(M82K)
R17	4k7	1	(M4K7)
R18	3k3	1	(M3K3)
R22	100k	1	(M100K)
R28	680k	1	(M680K)
CAPACITORS			
C1,6,8	PC Elect 100µF 25V	3	(FF11M)
C2,11	PC Elect 470µF 16V	2	(FF15R)
C3,10,12	Poly Layer 47nF	3	(WW49D)
C4,14	Ceramic 22pF	2	(WX48C)
C5,9	Disc 100nF 50V	2	(BX03D)
C7,13	PC Elect 10µF 100V	2	(FF05F)
C15,21	Poly Layer 330nF	2	(WW47B)
C16,17,19	Poly Layer 10nF	3	(WW29G)
C18,20	Ceramic 1000pF	2	(WX68Y)
C22	Poly Layer 47nF	1	(WW26D)
SEMICONDUCTORS			
D1-12	1N4148	12	(QL80B)
ZD1,2	BZY88C7V5/BZX55C7V5	2	(QH11M)
BR1	W005	1	(QL37S)
TR1	BC548	1	(QB73Q)
LD1	LED Red	1	(WL27E)
IC1	LF351	1	(WQ30H)
IC2	3403	1	(QH51F)
IC3	4001BE	1	(QX01B)
MISCELLANEOUS			
T1	Sub-Min Tr 12V	1	(WB02C)
MC1	Ultramin Omni Insert	1	(QY62S)
	D/Party Contrllr PCB	1	(GD72P)
	Isowasher M3	1 Pkt	(BF62S)
	Isobolt M3 6mm	1 Pkt	(BF51F)
	Shake Washer M3	1 Pkt	(BF44X)
	Isonut M3	1 Pkt	(BF58N)
	Pin 2141	1 Pkt	(FL21X)
	DIL Socket 8-pin	1	(BL17T)
	DIL Socket 14-pin	2	(BL18U)

DISCO PARTYLITE TRIAC OUTPUT PARTS LIST

RESISTORS: All 0.6W 1% Metal Film			
R1,3,5	330Ω	3	(M330R)
R2,4,6	2k7	3	(M2K7)
R7,8,9	100Ω	3	(M100R)
CAPACITORS			
C1-3	IS Cap 33nF	3	(FT34M)
C4	IS Cap 100nF	1	(FF56L)
SEMICONDUCTORS			
TI1-3	C226D	3	(WQ25C)
TR1-3	BC548	3	(QB73Q)
	Isobolt M3 10mm	1 Pkt	(HY30H)
	D/Party Triac PCB	1	(GD73Q)
	Vaned Htsnk Plas Pwr	3	(FL58N)
	Constructors' Guide	1	(XH79L)
	Leaflet	1	(XT36P)
OPTIONAL			
S1	Dual Rocker Neon Red	1	(YR70M)
	Safuseholder 20	1	(RX96E)
	C 6A Mains Black	3 Mtrs	(XR03D)
	Push-on Receptacle	1 Pkt	(HF10L)
	Push-on Recep Covers	1 Pkt	(FE65V)
	Euro-Facility Outlet	3	(HL42V)
	13 Amp Plug Nylon	1	(RW67X)
	Plug Fuse 5A	1	(HQ33L)
	SR Grommet 6W-2	1	(LR49D)
	Mains Warning Label	1	(WH48C)
	ABS Box MB6	1	(YN39N)
	Isobolt M3 x 12mm	1 Pkt	(BF52G)
	Isoshake M3	2 Pkts	(BF44X)
	Isonut M3	2 Pkts	(BF58N)
	Isowasher M3	1 Pkt	(BF62S)
	Stick-on Feet Square	1 Pkt	(FD75S)
	Euro-Facility Plug	3	(HL43W)

The above parts, excluding optional items, are available as a kit:
Order As LM41U (Disco Partylite Kit)
The following items are also available separately:
DP Controller PCB **Order As GD72P**
DP Triac Output PCB **Order As GD73Q**

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

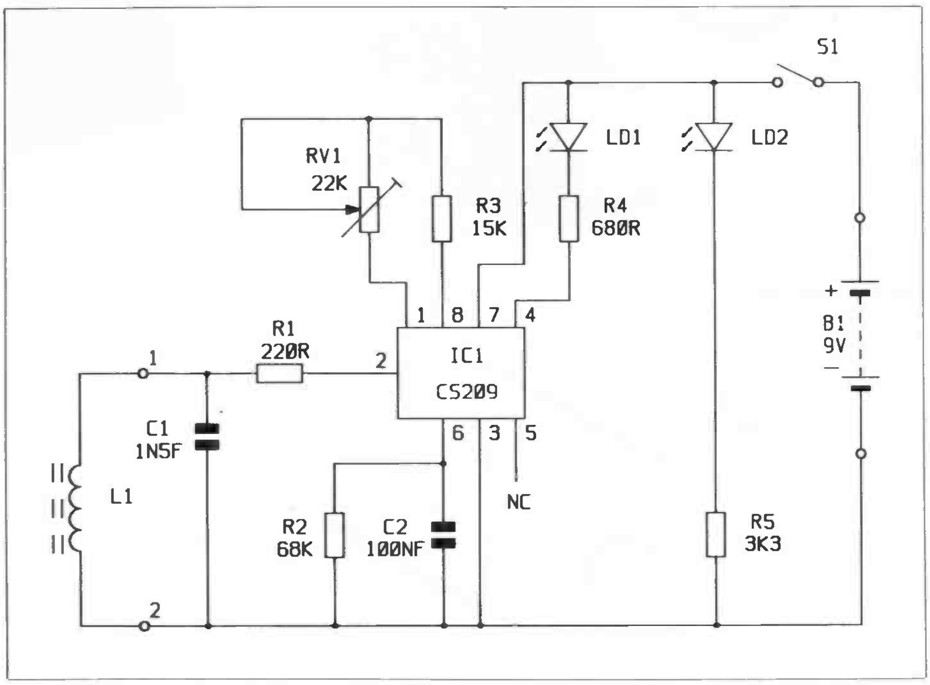
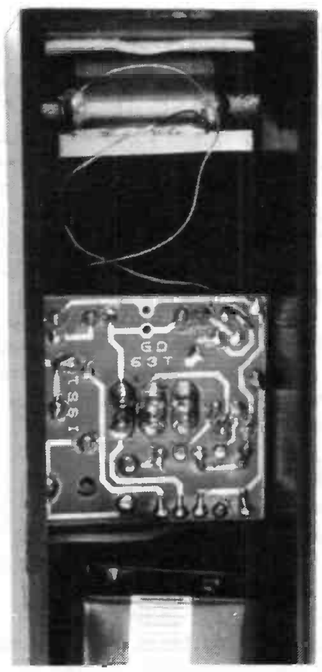


Figure 1. Circuit.



Inside the box.

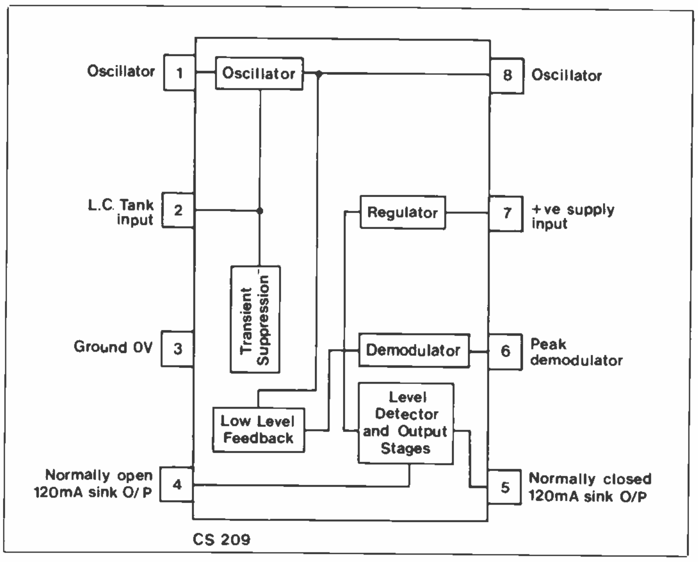


Figure 2. IC Block Schematic.

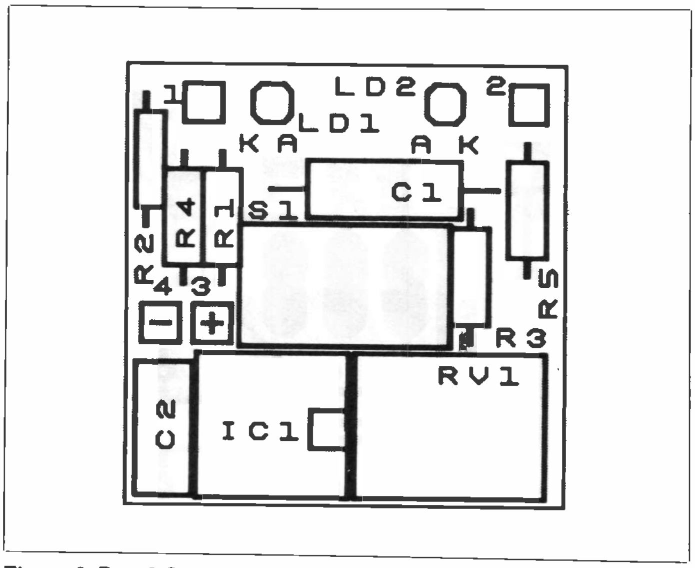


Figure 3. Board Overlay.

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, than 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

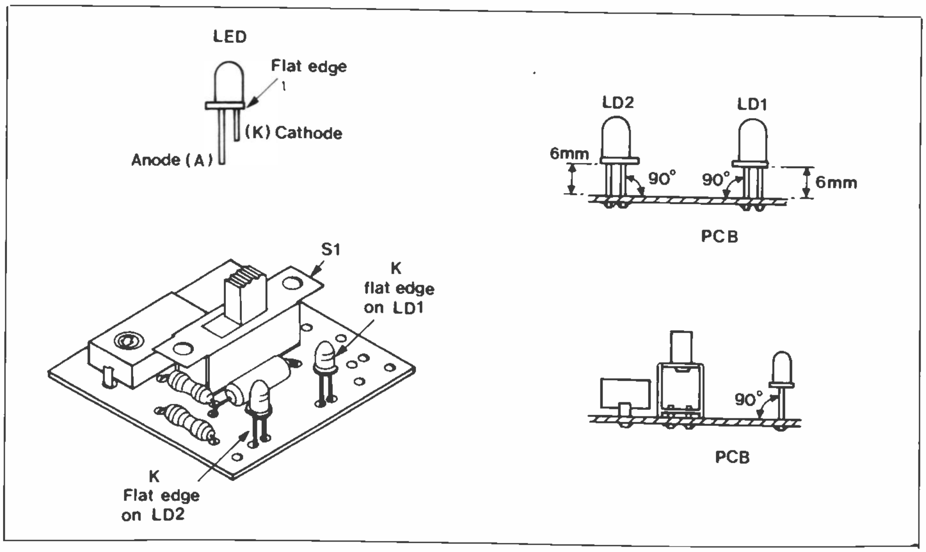
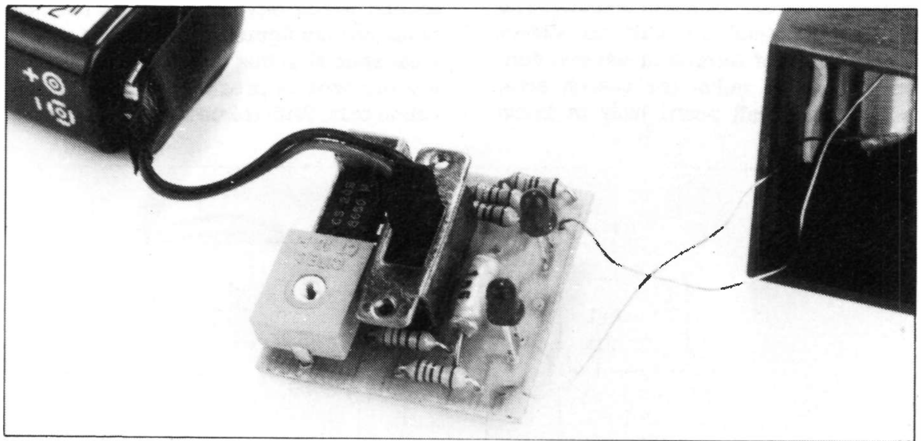


Figure 4. Mounting LD1 and LD2.



The assembled pcb.

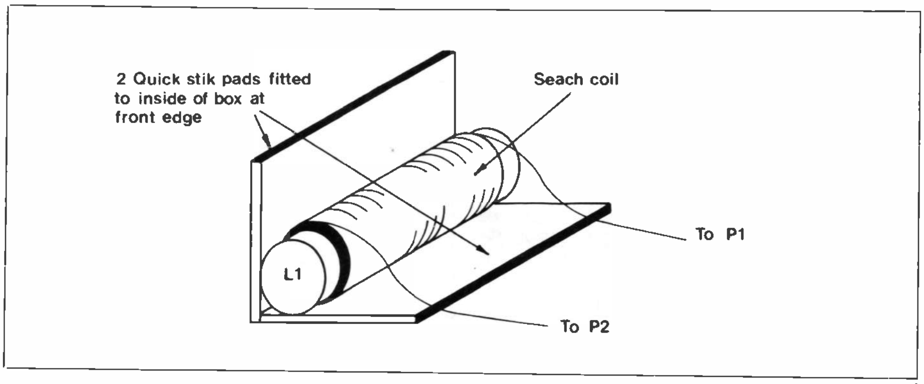


Figure 5. Mounting Search Coil L1.

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 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 screw-driver 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 according to the size of the object being monitored.

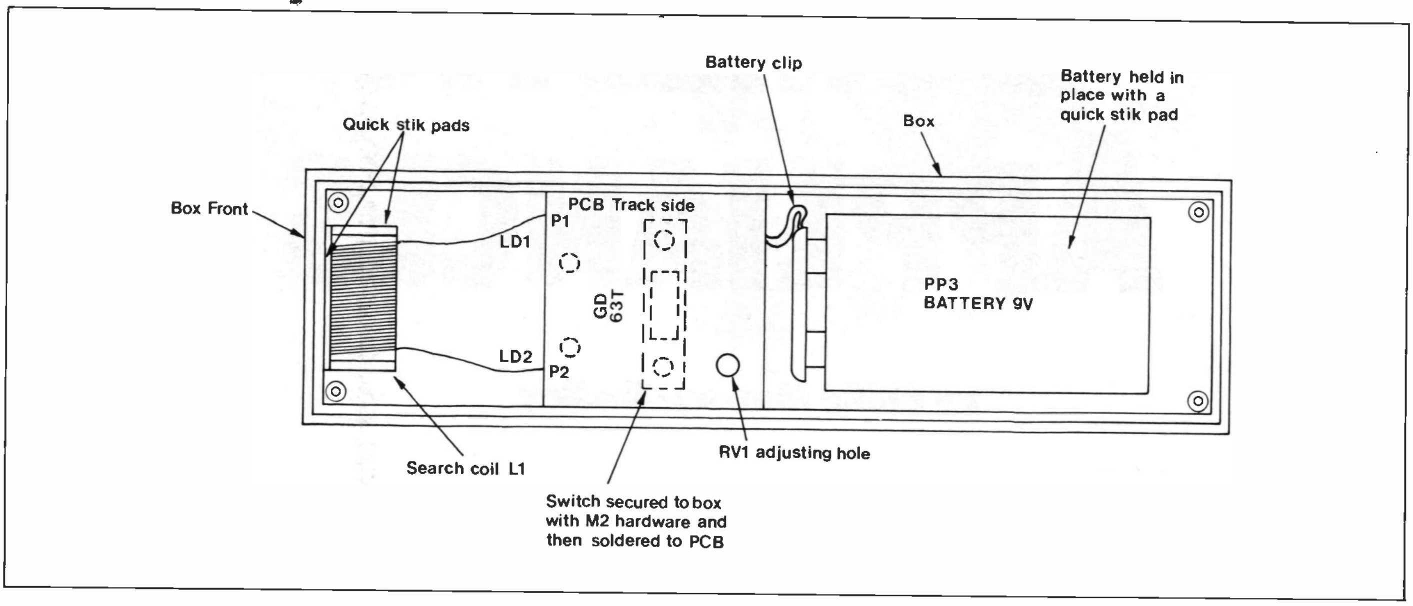


Figure 6. Final Assembly.

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 details of which are found in our Projects Book 14.

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 Dtctr PCB	1	(GD63T)
	Mini Metal Dtctr 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 Dtctr PCB **Order As GD63T**
100μH Search Coil **Order As JC25C**

TESTER FOR ELECTRICAL DOMESTIC APPLIANCES

by Philip Murray-Shelley

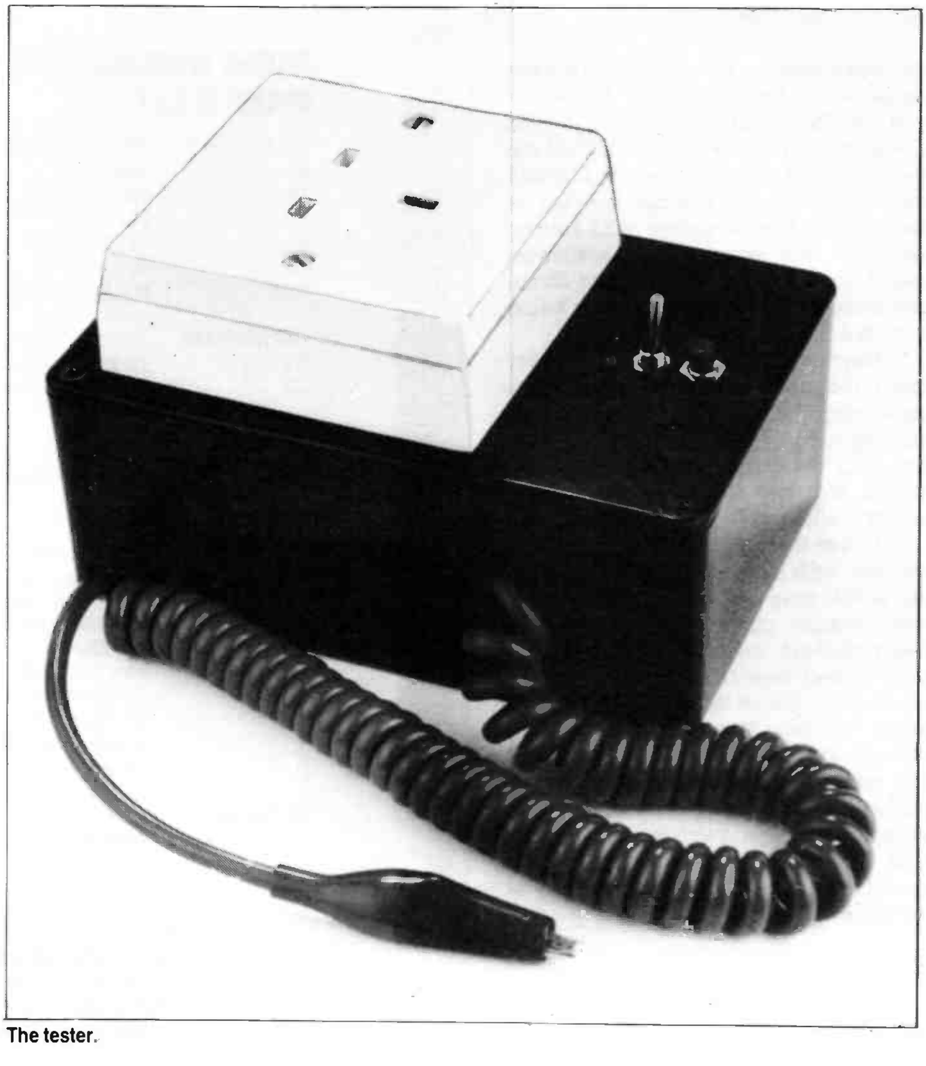
★ Checks for earthing continuity between appliance and plug
★ Indicates when Life/Neutral shorting to appliance case
★ Plug/Appliance fuse test
★ Low battery indicator

Introduction

It is easy to under-estimate the importance of regularly testing the safety of all appliances which are connected directly to the mains electricity supply. Stories of serious injury and even death resulting from unsafe electrical equipment abound, and this appliance tester provides a means of quickly and easily checking for most of the common faults likely to be encountered.

Whilst it cannot replace more sophisticated and very much more costly test equipment, the appliance tester nevertheless provides a front line defence against possible faulty equipment. Naturally any faults identified by this tester should be investigated and rectified by a competent electrician.

Mains driven electrical appliances are of two main types. Perhaps the most common, certainly until a few years ago, were what are now called 'Class 1' appliances (see BS 2754 : 1976 "construction of electrical equipment for protection against electric shock", and BS 3456 Part 1, "safety of household electrical appliances. General requirements"). Equipment of this type is provided with a mains cable having three conductors. Two of these, the line conductors, are the ones that actually carry power to the unit whilst the third conductor is now always coded with green and yellow stripes and provides the essential protective earth for the system. Within the line



The tester.

circuit a fuse provides a safety link so that if a fault should occur between the line conductor and the metal work of the appliance to which the protective earth is connected, a very large current will flow and this should burn out the fuse and thus make the equipment safe. Clearly if there are any faults in the protective circuit so that its resistance has gone high due to a poor connection (perhaps it has even become open-circuit) then this important safety feature is totally lost. The appliance tester has a number of safety features which enables the security of the earthing system to be thoroughly checked. Examples of class 1 appliances include: electric kettles, electric fires, soldering irons and a whole host of other important appliances such as washing machines, dryers and so on.

The second group of appliances found commonly in the home are those which are said to be double insulated. Double insulated products rely on having two completely separate sets of insulation, separating the user from the line terminals and consequently these do not require a protective earth conductor. Double earthed appliances include some vacuum cleaners, radios, tape recorders and so on. Whilst the appliance tester is intended for use with class 1 appliances (which generally present the greatest hazards if they are not properly maintained) the fuse test facility will also be valuable when trying to identify problems with double insulated equipment.

What Can Go Wrong?

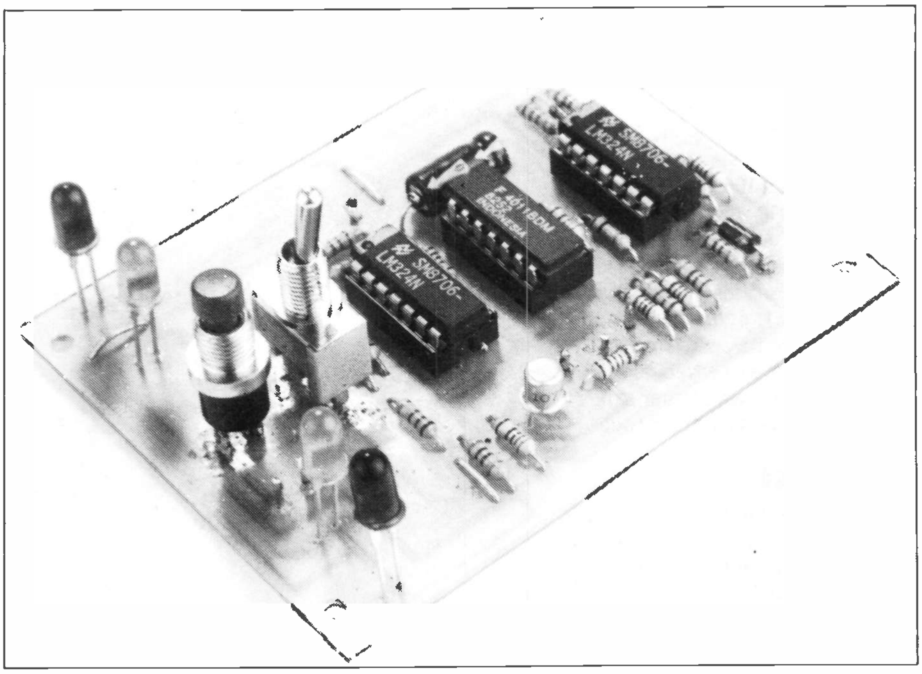
With three conductors between the mains supply and any class 1 appliance, there is potential for a large number of different faults. Obviously there is always the possibility of a short circuit between either of the supply conductors and the metal case of the unit. There is also a very real possibility that the protective conductor may have become disconnected in the plug or in the appliance. Water or a partial electrical breakdown may mean that the resistance between either of the supply conductors and the metal work of the appliance may be lower than it should be and there is always the possibility that the fuse in the plug may have blown for some reason - either because of a fault or it has simply aged.

The appliance tester consequently aims to test for these conditions and report in a visual manner the exact cause of the fault, so it can be consequently rectified.

Safety Test

The circuit diagram of the appliance tester is shown in Figure 1a, and switch functions are shown in Figure 1b. The basis of the safety test are three continuity checkers using LM324 op-amps. The continuity check between both Live/Neutral and Earth is done with two op-amps, IC1a and IC1b. The Live and Neutral are not connected together because the fuse test measures the resistance between the Live and Neutral. R1 and R2 provide a potential divider for half the supply voltage at the inverting input of the op-amp. This op-amp is used as a comparator such that if the non-inverting input of the op-amp should go above or below half of the supply voltage a logic 0 or 1 will be given respectively at the output. If the resistance is more than 1MΩ (open circuit) the appliance can be considered safe as regards a short between the L/N and Earth. The output of both the continuity checkers are fed into a NAND gate, IC3d, so that if both are OK then the safe LED D4 will be illuminated in conjunction with the result of the Earth check. Since the appliance tester uses a 4011'B' series IC for the NAND gates a current limiting resistor is not needed. The 4011B as opposed to the 'A' series incorporates a current limiting facility, thus the tester must use a 'B' series and not an 'A' series IC.

If a fault condition occurs between Live/ Neutral and Earth a logic level '0' illuminates the RED fault LED, D1, continuously through



Switch and LED mounting.

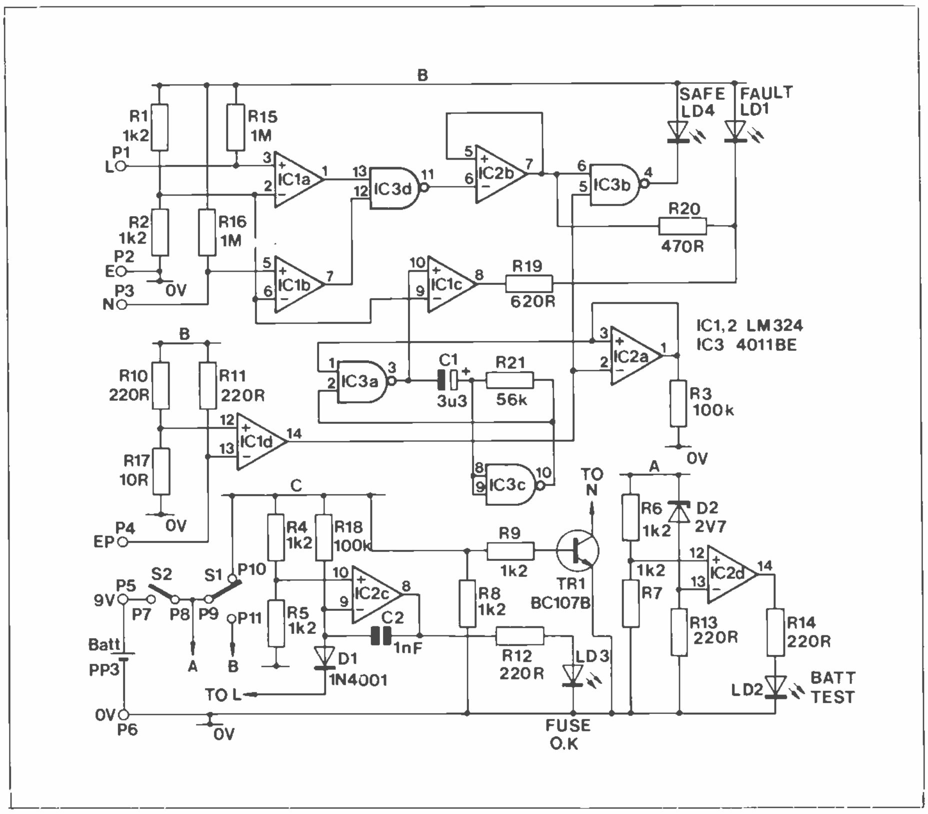


Figure 1a. Appliance Tester circuit.

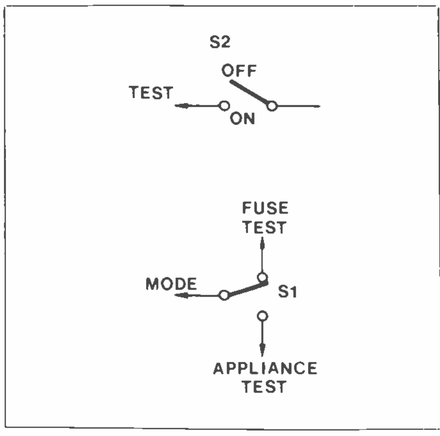


Figure 1b. Switch functions.

IC2b and R20.

The Earth continuity check between the appliance case and the earth pin uses again an op-amp (IC1d) as a comparator. If the resistance between the earth pin and the probe is less than 10Ω a wire must be connected from the plug earth pin to the metal appliance case. If the result of this test is OK then a logic 1 in conjunction with the Live/Neutral to the Earth test will illuminate the 'safe' LED. With logic 0, a fault condition triggers the oscillator, which in turn flashes the fault LED D1. If the Live/Neutral to Earth test is also faulty the LED will be seen to be modulating, giving a third fault code.

Fuse Test

The fuse test works as a continuity checker measuring the resistance between Live and Neutral. When the mode switch is positioned for the fuse test, the power for the appliance safety test is switched off. This enables the resistance to be checked between the Live/Neutral by grounding the Neutral. With S1 placed in the fuse test position, the supply rail 'C' is energised and transistor TR1 is turned on, therefore the Neutral is pulled down to ground. Another op-amp (IC2c) is then used as a continuity checker; if the resistance between Live/Neutral is below 100kΩ the fuse can be said to be 'not blown.' A logic 1 is then used to drive the 'fuse good' LED D3. The diode D5, incorporated between the non-inverting input and Live, stops the path to ground via R18, R4 and R5 when the 'C' power rail is turned off.

Low Battery

When the supply voltage drops below a fixed voltage determined by the zener diode D6, R13 and potential divider R6 and R7, 'low battery' LED D2 is illuminated. The op-amp (IC2d) compares the fixed voltage generated by the zener diode and the resistor in series to the battery voltage. If the battery voltage is lower than the fixed voltage of 5.8 volts then the 'low battery' LED will be illuminated.

Construction

Refer to the parts list and constructors guide. All resistors, capacitors and semiconductors are mounted on the printed circuit board, see Figure 2, in that order, taking care as always with the orientation of the electrolytic capacitor, IC's, diodes and the transistor. When all the components are in place it is a good idea to fit veropins 1 to 6 for the leads which come from the board. Veropins are put in from the track side for the various wires to be connected onto them. Veropins 7 to 11 must also be used for S1 and S2. S1 and S2 are consequently soldered directly to the veropins on the board as can be seen in Figure 3. There are also four wire links to be inserted into the board, all of which are clearly indicated. When mounting the LED's and switches, refer to Figure 3 for lead lengths and spacing.

The next stage is to connect a battery clip to +9V (pin 5) and 0V (pin 6) ensuring that the red wire goes to +9V and the black wire to 0V. Three wires must be connected to the Live/Neutral and Earth pins 1, 2 and 3, the length being left at about 8 inches for connecting to the 13A outlet socket. The pcb assembly is

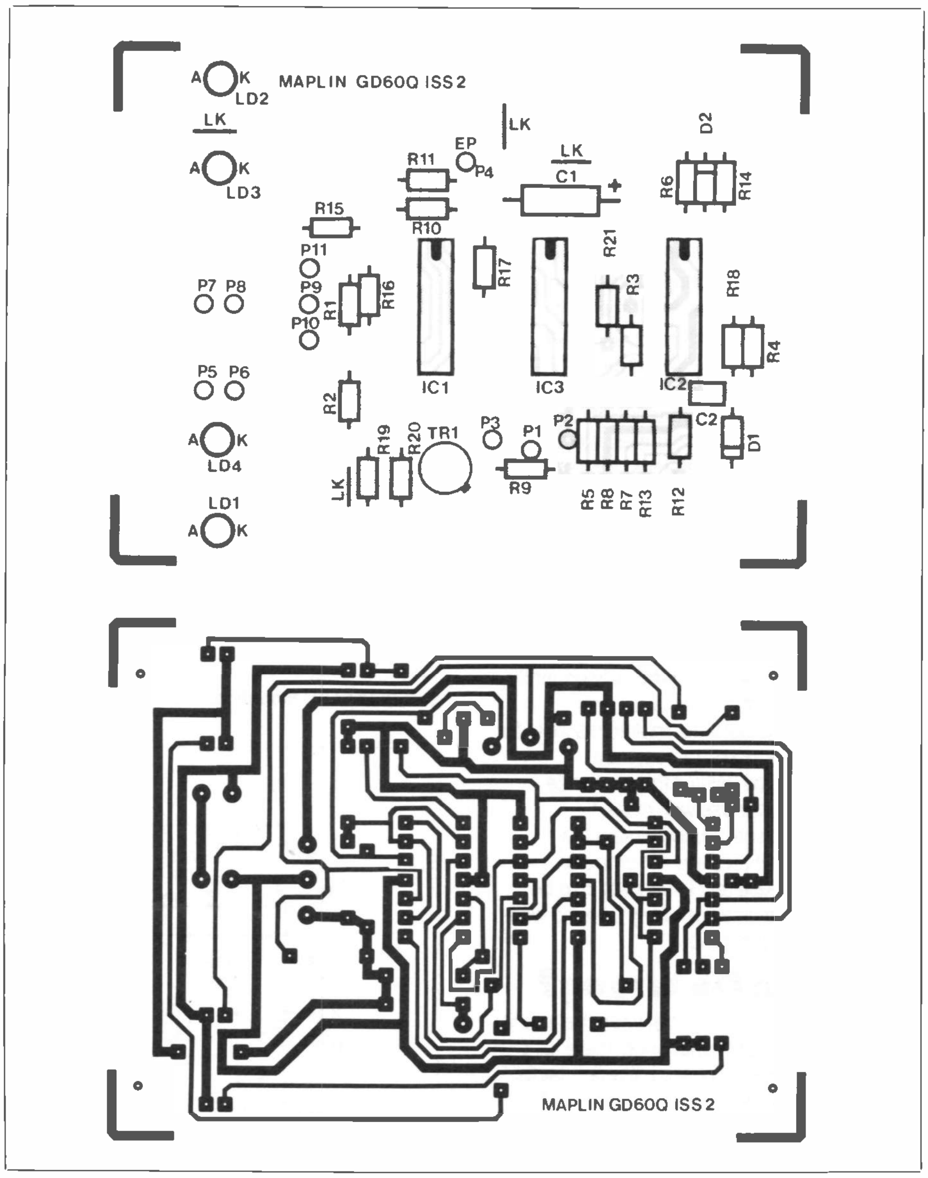


Figure 2. PCB layout and track.

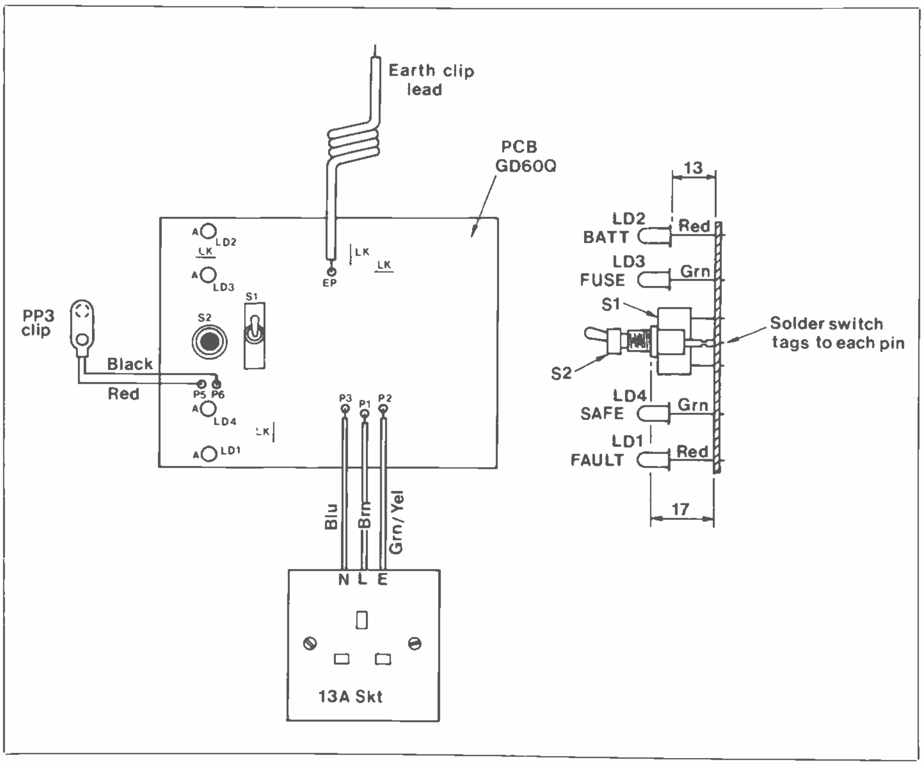


Figure 3. LED and switch mounting.

now complete with the exception of the earth probe, which is not connected until the pcb is just about to be put into place in the box.

Box Drilling

The next stage is to drill the box lid to the dimensions shown in Figure 4. Figure 5 shows the dimensions of the battery case cut-outs and also the probe cable hole.

The next stage is to fix the pcb into place in the box on the pillar arrangement as seen in Figure 6. It is important that the pcb is fixed in place before the socket since the socket covers two of the pillar screws. When the pcb is in place make up the Earth lead from the 'curly cable' and the crocodile clip and place one end through the hole in the box side and solder it to the pcb at the point labelled 'EP' (pin 4).

Screw down the patress of the mains socket and pass through it the Live, Neutral and Earth leads and connect them to the socket.

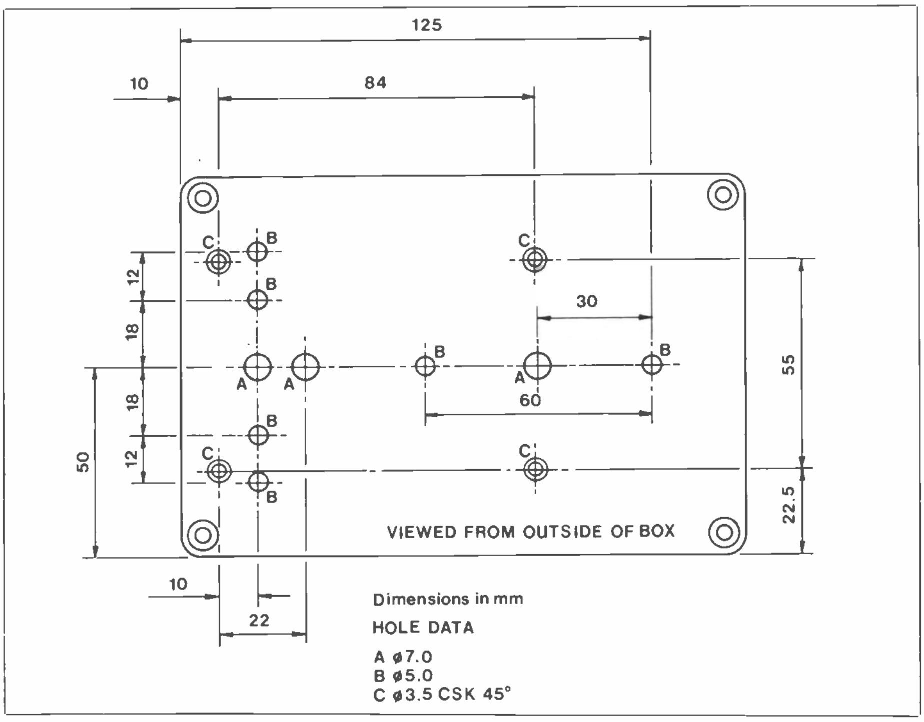
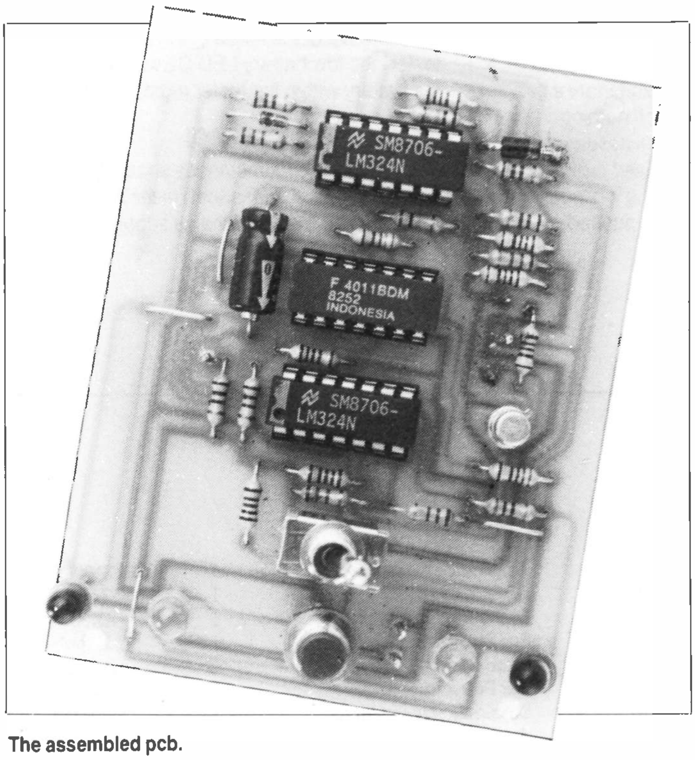


Figure 4. Lid of box drilling.



The assembled pcb.

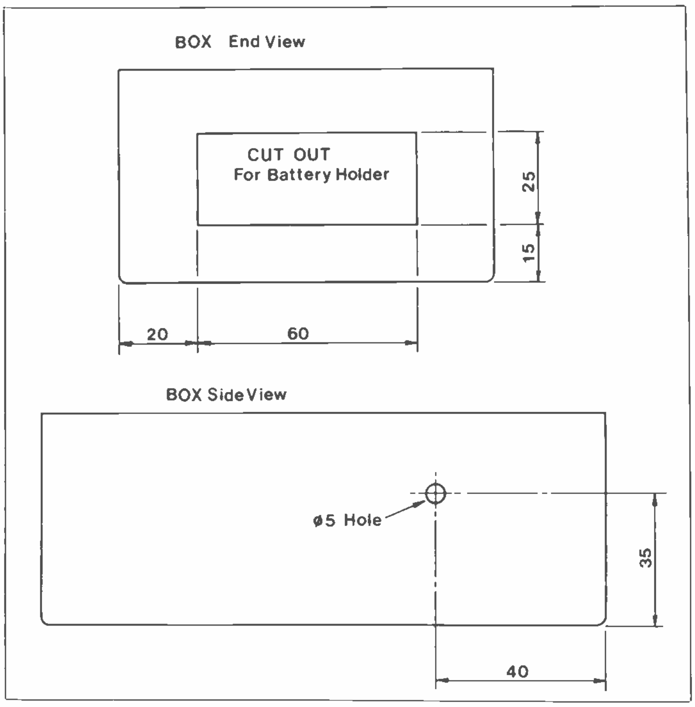


Figure 5. Box cut out details.

Testing

You will need to fit a PP3 battery in the tester and also a short length of wire bared at both ends, then unscrew the socket from the patress. Move the toggle switch S1 to the appliance 'test' position and press test switch S2. The bottom fault LED D1 should flash - indicating an earthing fault - release the test switch S1.

Connect the earth probe to the Earth pin on the socket and when the test switch is pressed again the green LED D4 should illuminate - thus there is no fault. The test switch S2 should now be released.

Disconnect the earth clip and place the piece of wire between the Live and Earth pins press S2 and the LED should modulate - S2 should now be released. The earth clip should now be reconnected to the Earth pin - when S2 is pressed the LED should remain constantly illuminated. Repeat the previous process but short the Neutral and Earth together - the results should be the same.

To test the fuse test facility move the toggle switch S1 to the 'fuse test' position and short the Live and Neutral together. When the test switch S2 is depressed the top green LED D3 should illuminate - indicating that the fuse is OK. If the short is removed the green LED will not be illuminated.

The low battery test can only be really tested with the use of a power supply or a 'run down' battery. When the voltage is less than 5.8 volts the low battery LED D2 will be illuminated.

Use of the Tester

The tester has two modes - safety test and fuse test - determined by the position of S1. With the correct mode selected the appliance to be tested must be plugged into the test socket on top of the device via a 13A plug. Don't forget to switch on the appliance as if it was connected to the mains. The earth clip on the flying lead coming from the tester must then be clipped onto a metallic part (if any) of the appliance - the earth clip does not have to be connected to the appliance for the fuse test. It must also be noted that the appliance test and the fuse test are two separate tests and the push switch (S2) must be released before moving the toggle switch from one test to another.

Appliance Test

Position the toggle switch S1 to the appliance test position, press S2, after viewing the fault code on either LED D1 or D4 release the switch S2. The various fault codes are described below.

Green LED D4

When this LED illuminates no fault condition was found.

Flashing Red LED D1

Earth pin on the plug is not connected to the product case. A flashing red LED will be seen when a double insulated appliance is being tested. This is because double insulated products do not have an earth lead. Most double insulated products use the symbol ⧈, so determining whether or not it is double insulated can be done without removing the plug cover to see if an earth lead is connected.

Steady Red LED D1

This means that the Live or Neutral is shorting to Earth (appliance case). This is potentially a very dangerous situation since the case of the appliance will be live and could cause an electric shock if it is touched.

Modulating Red LED D1

This occurs when both the above faults are present on the appliance.

Fuse Test

Position the toggle switch S1 to the fuse test mode, press switch S2, release switch S2 after viewing the fault on LED D3.

It must be ensured that if a power switch is present on the appliance it is turned to the 'on' position.

The green LED (D3) will illuminate if the fuse in the appliance is blown; if nothing happens to LED (D3) it must be assumed that the fuse is either blown or a power switch on the appliance is not turned to the 'on' position.

When the test button S2 is pushed (irrespective of the mode of the appliance tester) the low battery LED D2 will illuminate if the battery within the tester must be changed.

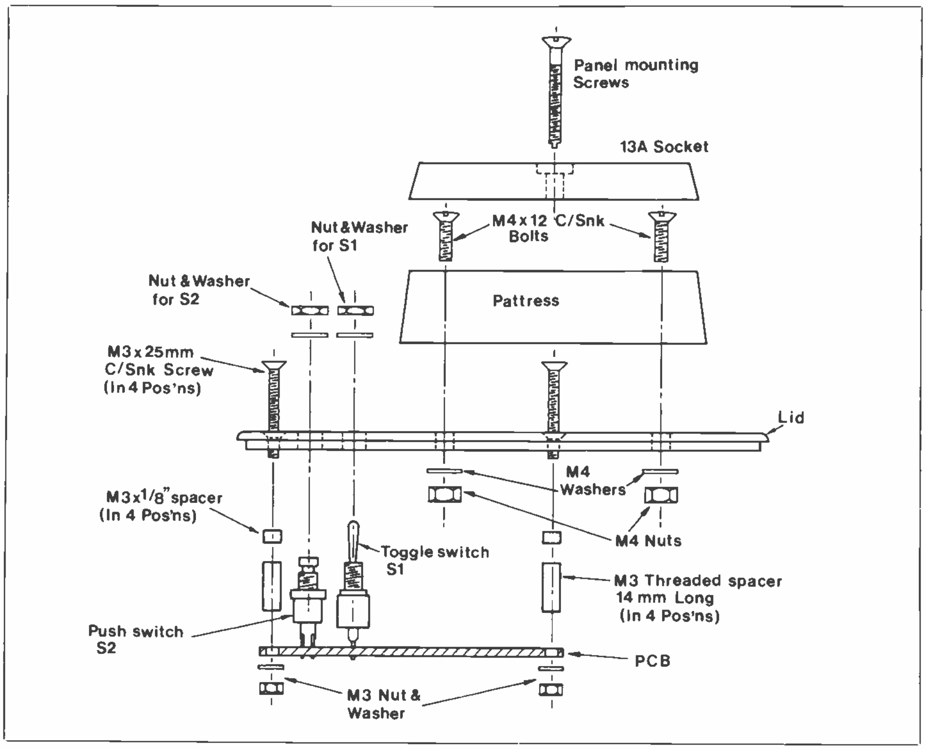


Figure 6. Final assembly.

Final Warning

Under no circumstances should the appliance or the Appliance Tester be connected to the 240V mains supply.

MAINS APPLIANCE TESTER PARTS LIST

RESISTORS: All 0.6W 1% Metal Film

R1,2,4-9	1k2	8	(M1K2)
R10-14	220Ω	5	(M220R)
R15,16	1M	2	(M1M)
R17	10Ω	1	(M10R)
R3,18	100k	2	(M100K)
R19	620Ω	1	(M620R)
R20	470Ω	1	(M470R)
R21	56k	1	(M56K)

CAPACITORS

C1	Axial 3µ3F 100V	1	(FB17T)
C2	Ceramic 1nF	1	(WX68Y)

SEMICONDUCTORS

IC1,2	LM324	2	(UF26D)
IC3	4011BE	1	(QX05F)
D1	1N4001	1	(QL73Q)
D2	BZY88C2V7/BZX55C2V7	1	(QH00A)
LD1,2	LED Red	2	(WL27E)
LD3,4	LED Green	2	(WL28F)
TR1	BC107B	1	(QB31J)

MISCELLANEOUS

	14-Pin DIL Socket	3	(BL18U)
S1	Sub-Min Toggle A	1	(FH00A)
S2	Push Switch	1	(FH59P)
	Pin 2145	1 Pkt	(FL24B)
	Appliance Tester PCB	1	(GD60Q)
	ABS Box MB25C	1	(YN40T)
	PP3 Battery Holder	1	(XX33L)
	Scr Stretchflex Red	1 Mtr	(BH34M)
	4mm Croc Clip Red	1	(HF24B)
	Sur Patt 20mm Sngl	1	(YB14Q)
	Single Skt Unswtched	1	(HL68Y)
	Appliance Tstr F/Pnl	1	(JG18U)
	Threaded Spacer M3	1 Pkt	(FG38R)
	Screw M3 25mm	1 Pkt	(BF53H)
	Isowasher M3	1 Pkt	(BF62S)
	Isonut M3	1 Pkt	(BF58N)
	M3 Spacer ⅛in.	1 Pkt	(FG32K)
	Poziscrew M4 12mm	1 Pkt	(BF34M)
	Isowasher	1 Pkt	(BF61R)
	Isonut M4	1 Pkt	(BF57M)
	Min Mains White	1 Mtr	(XR02C)
	Constructors' Guide	1	(XH79L)
	Leaflet	1	(XT38R)

OPTIONAL

Battery PP9	1	(FK62S)

A complete kit of all parts, excluding optional, is available:
Order As LM38R (Appliance Tstr Kit)
The following items are also available separately:
Appliance Tester PCB **Order As GD60Q**
Appliance Tester Fr/Pnl **Order As JG18U**

SLOW CHARGER

- ★ Reverse Polarity Protected
- ★ LED Charging Indicator
- ★ Can be used with 7.2V or 8.4V Packs
- ★ Simple to Construct

by Chris Barlow

High performance model racing cars and electric powered model aircraft make huge demands on their nicad battery racing packs. For optimum model performance, nicad's must be able to deliver extremely high currents whilst maintaining the rated terminal voltages for long periods of use. Because regular rapid charging techniques are employed out in the field, nicad packs tend to 'memorise' or suffer from reduced capacity, thus preventing the full charge/discharge parameters from being reached. Early warning signs of this effect become apparent when running models; racing cars tend to become less lively and top/lap speeds drop off, aircraft lack height or exhibit a reduced rate of climb and perhaps more noticeably, the model's running time becomes increasingly shorter. Under rapid charging conditions, older battery packs may heat up after just a few minutes whereas previously they remained cool – although this could also signify excessive abuse or cell breakdown!

To maintain maximum nicad capacity, it is necessary to regularly slow charge/discharge the pack at regular intervals and for reduced capacity nicads, a sequential cycle of slow charge/discharging over several days can restore much of the original capacity.

How it Works

The Slow Charger is a very simple project to build and is based on the well known constant current principle. Both 7.2V and 8.4V nicad packs can be used on this system and charged at 120mA (±5mA) which is safe for most packs available with charging periods up to 15 hours. In fact Maplin racing packs may be overcharged up to 20,000 hours without problem on this system! With reference to Figure 1, the charger requires a separate supply of 15VDC provided by the *unregulated* mains adaptor type XX09K, and this connection is reverse polarity protected by full wave bridge rectifier, BR1. The battery pack connected between pins 3 & 4 is prevented from discharging back through the charger by diode D1. With the battery out of circuit, base current via R1 is 12mA (15V supply) and allowing for $0.62V_{be}$ and an emitter load of

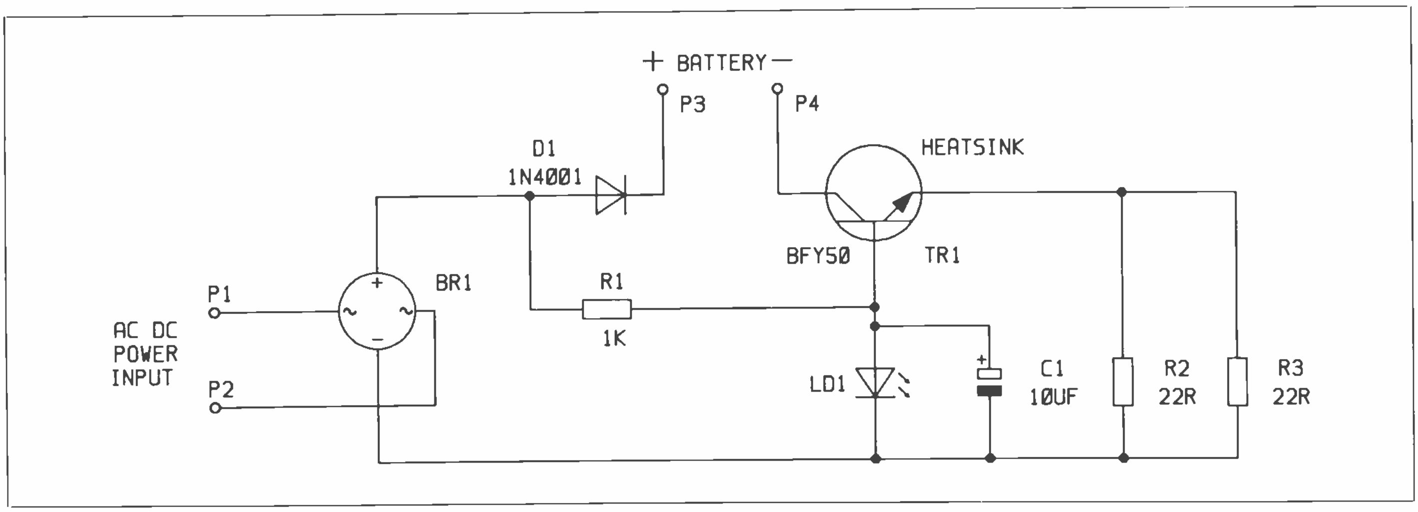


Figure 1. Circuit.

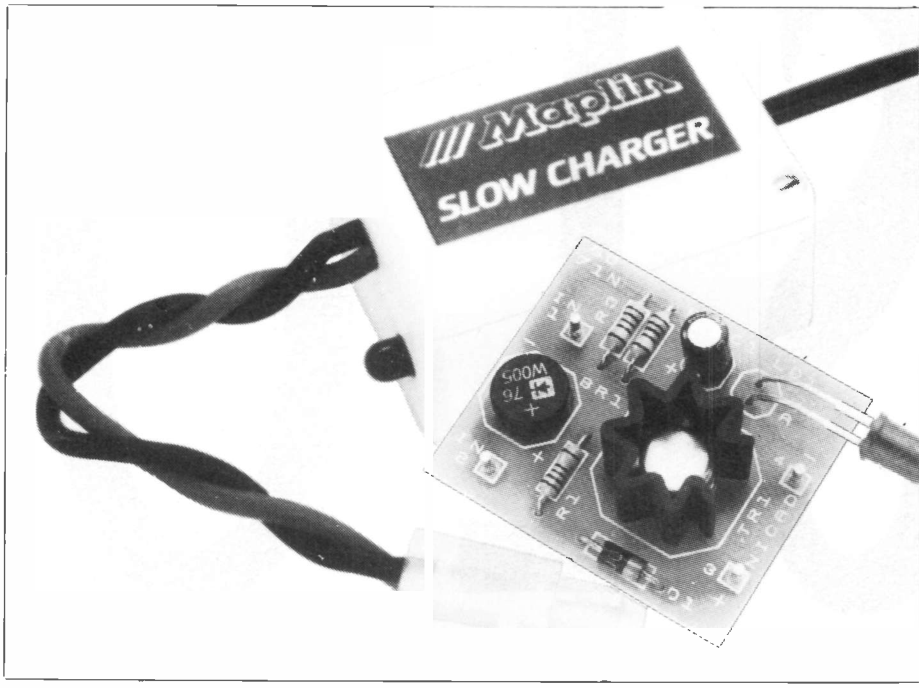
11Ω, the voltage drop across LD1 is 0.75V; the LED requires approximately 2V to conduct, therefore D1 does not illuminate. With a battery connected in the collector of TR1, current flows from the bridge through R2/R3 parallel pair. A voltage drop of 1.35V appears across these resistors at TR1 emitter and is clamped 0.65V higher at TR1 base by the LED. As the voltage across LD1 is now 1.35 + 0.65 = 2V, the LED conducts and collector current through the nicad is defined as 1.35 volts/11Ω = 123mA. Capacitor C1 reduces any ripple present from the external PSU, thus maintaining the DC constant current characteristics of the charger.

Construction

Figure 2 shows the very simple layout of the circuit board. Refer to the parts list and constructors guide for assembly techniques if in doubt and ensure that the + symbol on BR1 aligns with the + symbol on the pcb. TR1 must be fitted with the metal case flat down onto the pcb and the clip-on heatsink attached. When fitting LD1, place the leads so they are just protruding through their track pads and solder in place. This will allow the LED to stand approximately 18mm above the pcb, leaving enough room for fitting into the box (Figure 3). Solder all components and clip off excess wire ends. Insert four pins from the track side and push their heads down onto the pcb with a soldering iron prior to soldering.

Assembly

The completed module is fitted into a plastic box and held in place with double sided stick pads as shown in Figure 3. A 5mm hole



The Slow Charger board.

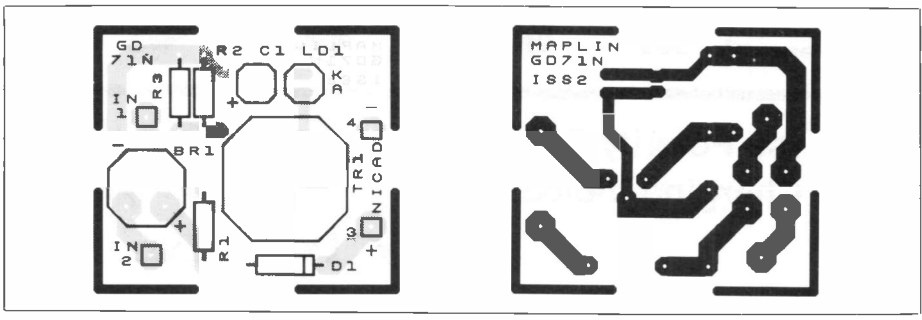


Figure 2. PCB track and layout.

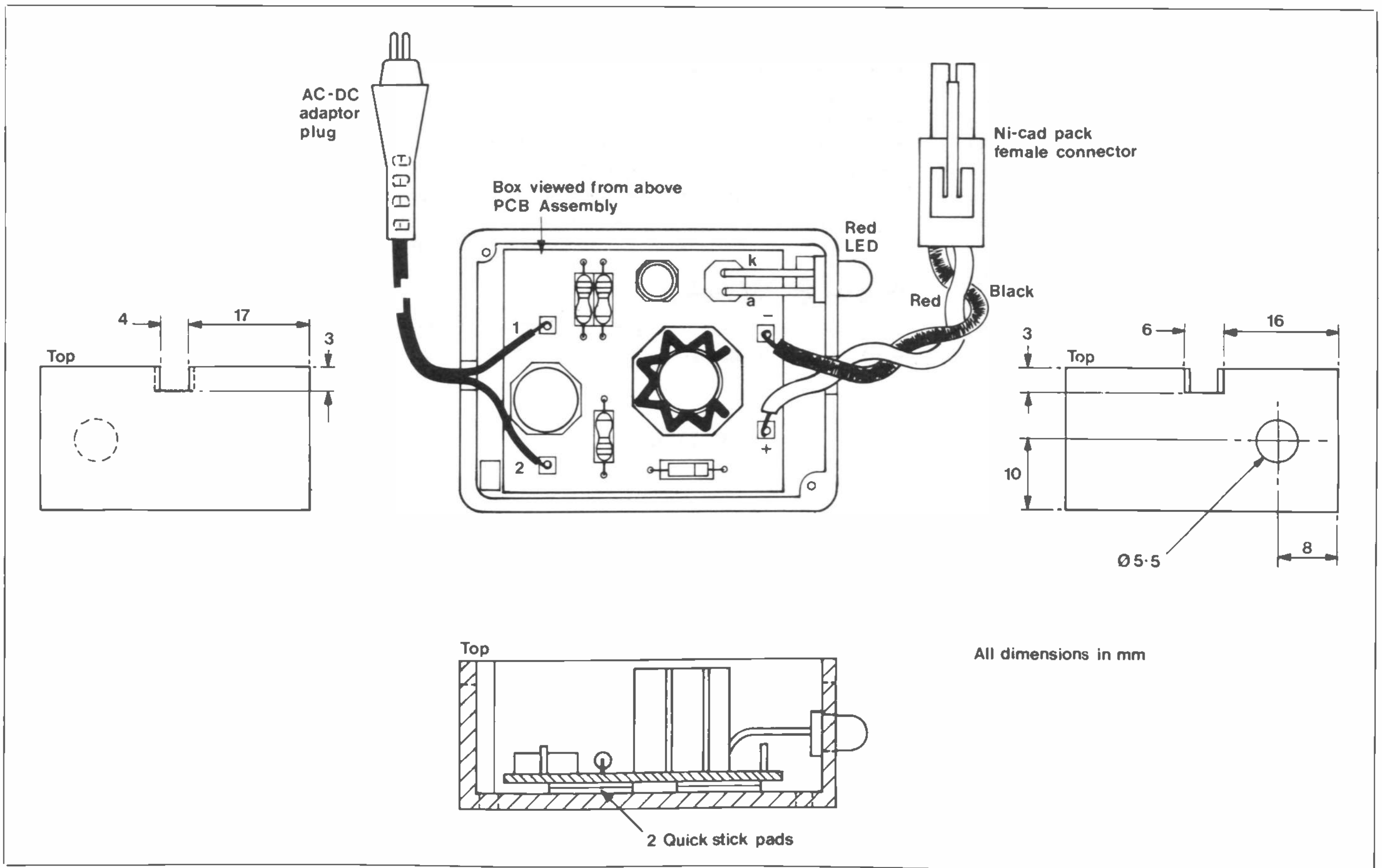


Figure 3. Final assembly and box cut-out details.

will need to be drilled in one end of the box for LD1 and slots filed out at both ends to take the PSU and battery cables. Connect the adaptor plug wires to input pins 1 and 2 – do not worry which way around – and solder the female connector positive (red) lead to pin 3 and the negative (black) lead to pin 4. Mount two quickstick pads at each end of the PCB, on the track side only and place another row of pads on top of them so that they are two high. Remove any remaining paper strips and place the module into the box, LD1 end first, inserting the LED through the previously drilled hole in the box end. Twist the module round into the box and push firmly down so the pads have a good purchase on the box bottom. If the end panel slots have been filed correctly then the cables should fit into them without standing proud, otherwise the box lid will not be a flush fit.

Using the Charger

The most common nicad racing packs used in models are either 1.2Ah, 1.4Ah or 1.8Ah versions. At a charging rate of 0.12Ah it will take 10 to 15 hours for these batteries to reach full capacity. Always check the manufacturers recommendations for charging first in case variations are encountered. Of course it is almost impossible to know the state of charge of a battery at any one time, so that charge times can be calculated, therefore it is advisable to discharge the battery first. The diagram in Figure 4 shows a 6V, 0.6W (100mA) torch type lamp connected in parallel with a 22Ω resistor. For 1.2Ah packs the discharge rate will average 0.425A, falling as the nicads near discharge, and the lamp will gradually become dimmer. It will take about 3 hours to discharge a racing pack and power dissipated by the resistor is approximately 2.5W, which means it becomes very hot to the touch! 8.4V and 1.8Ah packs will require just over 4 hours to discharge with this system. Always slow charge the racing pack before use whenever possible as doing so will ensure the maximum charge capacity being available. After a heavy session of rapid charging, allow the battery to slow discharge into the fixed load shown and then slow charge for 15 hours. Repeat this for two or three cycles over a few days to keep the battery in good working order.

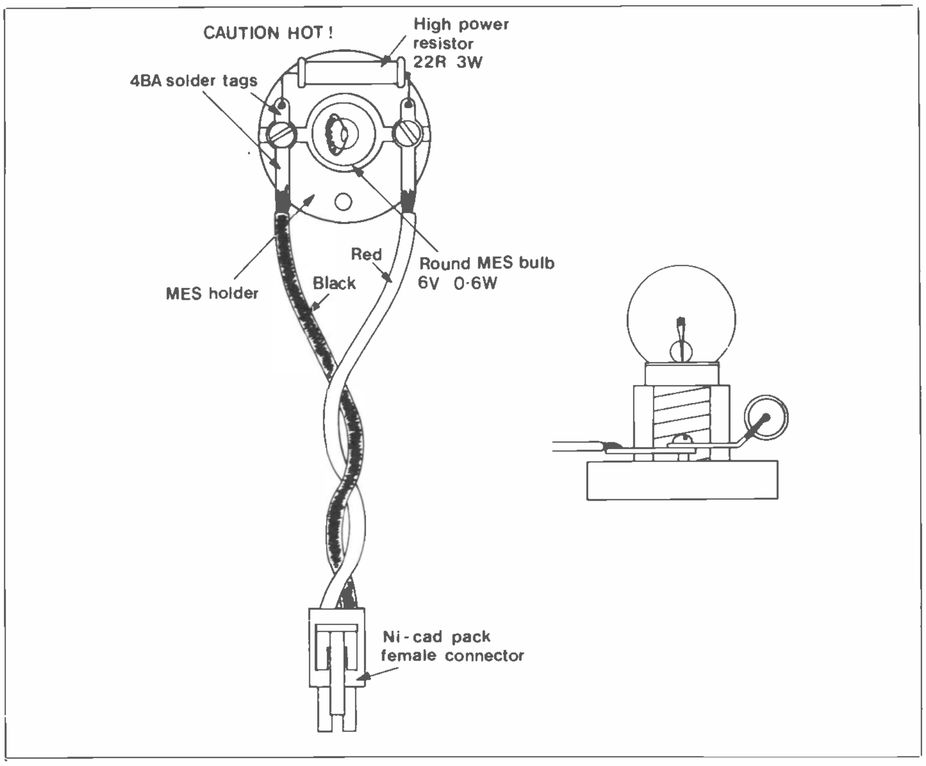
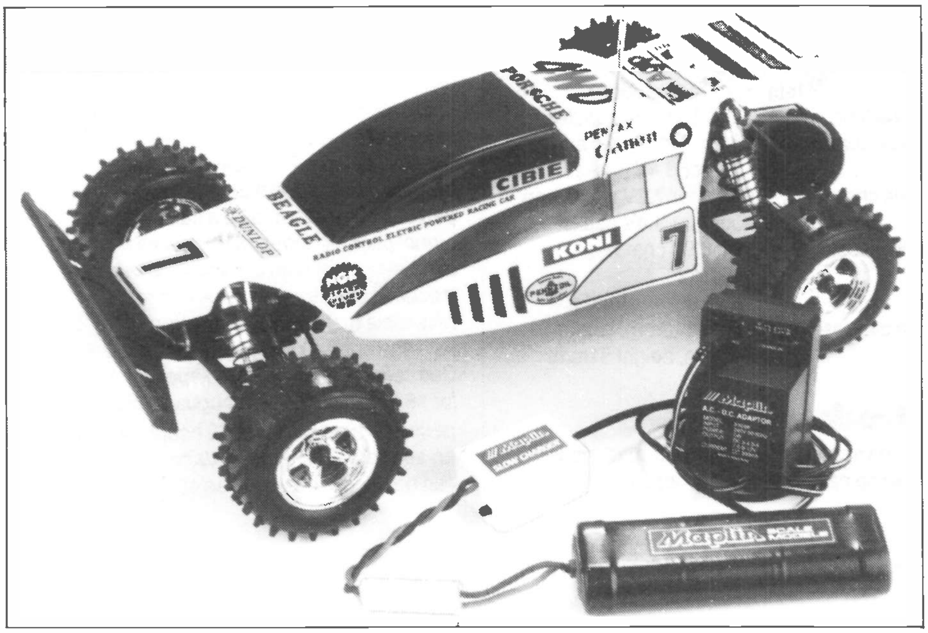


Figure 4. Fixed load discharger.



Slow Charger with racing pack and unregulated supply.

SLOW CHARGER PARTS LIST

RESISTORS: All 0.6W 1% Metal Film			
R1	1k	1	(M1K)
R2,3	22Ω	1	(M22R)
CAPACITORS			
C1	Minelect 10µF 16V	1	(YY34M)
SEMICONDUCTORS			
D1	1N4001	1	(QL73Q)
LD1	LED Red	1	(WL27E)
TR1	BFY50	1	(QF27E)
BR1	W005	1	(QL37S)
MISCELLANEOUS			
	Slow Charger PCB	1	(GD71N)
	Pin 2141	1 Pkt	(FL21X)
	Quickstick Pads	1 Stp	(HB22Y)
	Heatsink Clip-on	1	(FL78K)
	Box 1521	1	(FK72P)
	Race Pk Lead Female	1	(JG05F)
	AC Adaptor Unreg 300mA	1	(XX09K)
	Constructors' Guide	1	(XH79L)
	Slow Charger Leaflet	1	(XT37S)
OPTIONAL			
	Bulb MES 6V 0.6W	1	(WL78K)
	MES Batten Holder	1	(RX86T)
	Tag 4BA	1 Pkt	(BF28F)
	Race Pk Lead Female	1	(JG05F)
	W/W Min 22R	1	(W22R)

A complete kit of all parts, excluding optional items, is available:
Order As LM39N (Slow Charger Kit)
The following item is also available separately:
Slow Charger PCB **Order As GD71N**

RAPID CHARGER

TRACK SIDE CHARGER FOR NI-CAD RACING PACKS

by Chris Barlow

Build this Ni-Cad Rapid Charger and put real power into your radio control model car. The unit is powered from a conventional 12 volt lead acid car battery, which can be left in your vehicle or removed for track side use. Housed in a tough steel case the Rapid Charger is ideally suited for use at outdoor off-road race meetings.

Specification of Prototype

Supply voltage:	12V lead-acid car battery.
Supply current:	5A maximum.
Batteries charged:	6 cell 7.2V and 7 cell 8.4V racing packs.
Charge time:	7.5, 15 and 30 minutes.
Charge current:	3A for 7.2V packs and 1.8A for 8.4V packs.
Trickle charge:	60mA for 7.2V packs and 40mA for 8.4V packs.
Audio/visual:	Red LED charging indicator. Piezo ticker sounder.
Case dimensions:	Width 118mm, length 143mm, height 51mm.

Introduction

The sport of competitive off-road model car racing has become very popular over the past few years. The success of this hobby is mainly due to the increasing technical sophistication of the models. Four wheel independent suspension and four wheel drive cars have now become commonplace. The majority of models use small yet powerful electric motors in preference to the model internal combustion engine.

These electric motors, when in a race, draw several amps of current from the battery, rapidly draining the power from the cells. With present battery technology the re-chargeable nickel cadmium cell is most suited for this application. There are two main configurations of cells used at present, the 6 cell providing 7.2 volts and the 7 cell giving 8.4 volts. The physical arrangement of cells used in any particular model could be a flat, hump or tunnel pack. All these racing packs have two short lengths of high current silicone rubber insulated wire, terminated with a non-reversible male power connector.

The normal charge rate for the 1.2 Ah Ni-Cad cells used on the prototype was 120mA for 16 hours, with a continuous overcharge period of more than 20,000 hours. However, an accelerated charge of 480mA for 3.5 hours can be used in complete safety, with a continuous overcharge period of more than 10 days. When rapid charging at currents in excess of 1 amp for 15 to 30 minutes, care must be taken not to overcharge the cells as damage will occur. It is for this reason an electronic timer is used to shut off the high current at the end of the selected period and put a trickle charge on the cells.

Circuit Description

Refering to Figure 1, the positive DC voltage from the lead acid car battery is first applied to FS1, the 5A, 20mm anti-surge fuse. This protects the circuit from burning out if a faulty short circuit racing pack is connected to the unit. The DC supply entering the circuit must have the correct polarity, otherwise damage will occur to the semiconductors and polarised components. To prevent this, a diode, D2, has to have the positive supply voltage applied to its anode before the DC power can pass to the relay control and timer circuits. D1 is a high current diode which prevents the ni-cad racing pack, B1, from receiving a reverse polarity charge or discharging back into the circuit if the supply is removed.

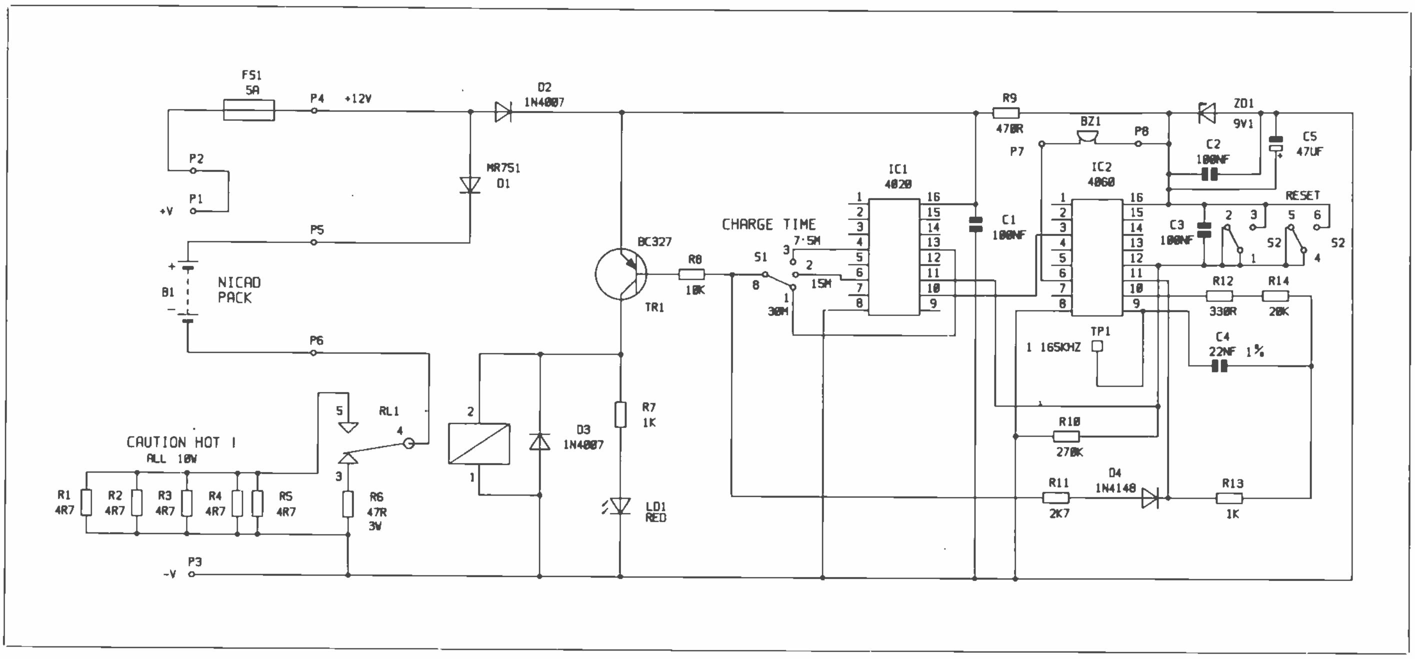


Figure 1. Circuit.

The timer circuit comprises CMOS integrated circuits IC1, a 4020BE, and IC2, a 4060BE. IC1 is a 14 stage ripple counter whereas IC2 is a 14 stage ripple counter and oscillator. It is the frequency and stability of this oscillator that will determine the accuracy of the selected charge period. There are two main influences on oscillator stability, supply voltage and ambient temperature. To minimise the effect of supply voltage fluctuations a 9.1V zener diode, ZD1, limits the voltage fed to pin 16 of IC2. This supply is then decoupled by capacitors C2 and C4 to remove any electrical noise. To maintain frequency accuracy over a range of temperatures, high stability components are used in the oscillator circuit. The frequency of which is set by the values of C5 a 1% close tolerance polystyrene capacitor and 1% resistors R12, R14.

To obtain the desired charging period times of 7.5, 15 and 30 minutes the oscillator must run at a frequency of 1.165kHz (858.3μs). This frequency may vary slightly due to component tolerance and ambient temperature, it can be measured using a frequency counter at TP1. The output from the oscillator stage of IC2 is then divided by its binary counters to produce two much longer time periods, one of 54.93ms at pin 6 and 7.031 seconds at pin 3. The output on pin 6 is used to drive the piezo sounder BZ1. This produces an authentic ticking clock sound while the Ni-Cad pack is charging and stops at the end of the charge period. The output on pin 3 is connected to pin 10, the clock input of IC1 for further division.

The full supply voltage is connected to pin 16 of IC1 and is decoupled by C1 to remove any electrical noise. The three outputs used for the relay control circuit are pin 4 the divide by 64, pin 6 the divide by 128 and pin 13 the divide by 256 outputs. This corresponds to the 7.5, 15 and 30 minute time periods. The desired period having been selected by S1 then feeds the normally low signal to R8 in the base of TR1 and through R11 and D4 to the oscillator stage of IC2. When the signal goes high at the end of the time period D4 is forward biased and pulls up pin 11 of IC2 stopping the oscillator. The system can be set going again

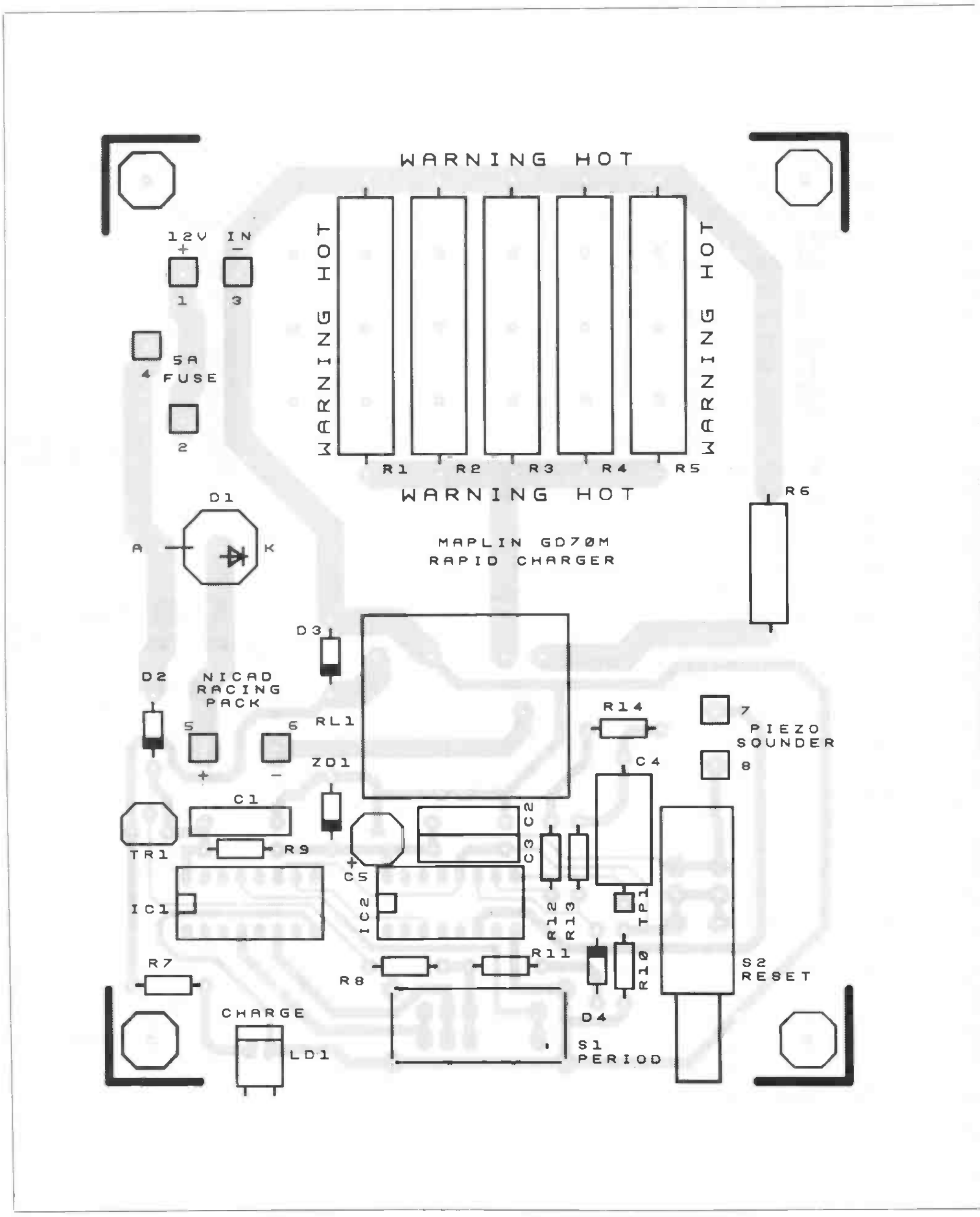
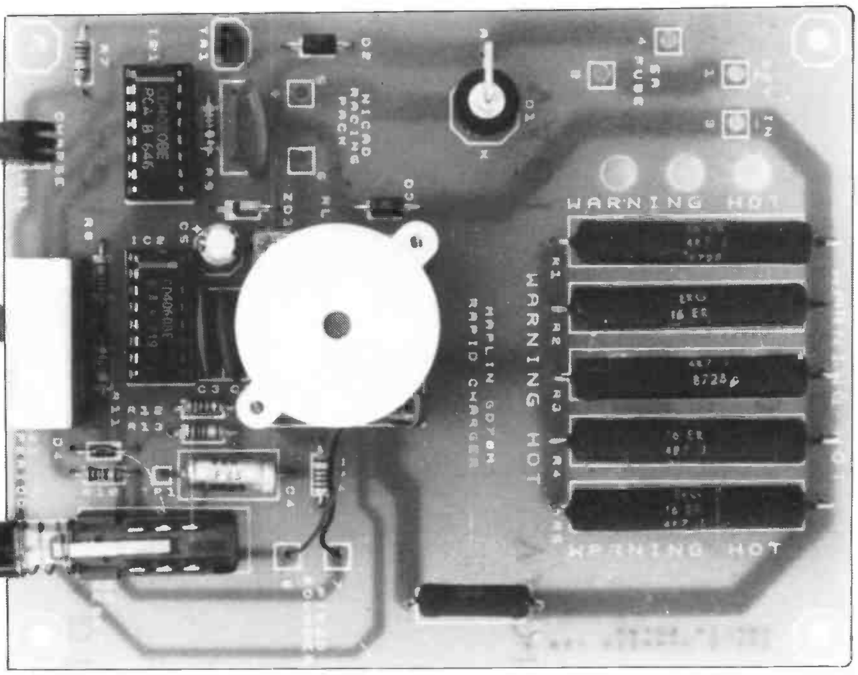


Figure 2. Track and layout of the pcb.



Rapid Charger board.

by pressing the reset switch, S2. This takes pin 11 of IC1 and pin 12 of IC2 high, thus resetting their binary counters.

While the timer is running TR1 is biased on and current will flow in its collector circuit. This results in the relay, RL1, becoming energised and the red LED indicator, LD1, to light. RL1 is used to select the full charge current or the much lower trickle charge for B1. When energised RL1 selects the resistor network comprising of five 4.7Ω ten watt resistors, R1 to R5. The total resistance of the network is 0.94Ω and the power dissipation capacity is fifty watts. This high power dissipation is necessary when high current rapid charging is occurring. When not energised RL1 selects R6 the 47Ω three watt resistor, allowing less than 100mA to flow into the ni-cad pack. TR1 is biased off at the end of the selected time period by the voltage applied via R8 to its base. The diode, D3, across the coil in RL1 is there to suppress the high voltage pulse which is generated when the current stops flowing.

PCB Assembly

The PCB is a single-sided fibre glass type, chosen for maximum durability and heat resistance. Removal of a misplaced component is quite difficult, so please double-check each component type, value and its polarity where appropriate, before soldering! For further information on component identification and soldering techniques please refer to the constructors guide included in the kit.

The PCB has a printed legend to assist you in correctly positioning each item, see Figure 2. The sequence in which the components are fitted is not critical. However, it is easier to start with the smaller components. Begin with the metal film 0.6W resistors, then mount the disc ceramic capacitors, C1, C2, C3 and C4 the close tolerance polystyrene capacitor. The polarity of the electrolytic capacitor, C5, is shown by a plus sign (+) matching that on the PCB legend. However on some capacitors the polarity is designated by a negative symbol (−) in which case the lead nearest this symbol goes away from the positive sign on the legend.

When fitting the transistor, TR1, you must carefully match the case to the outline shown. The diodes, D2, D3, D4 and ZD3, have a band at one end to identify the cathode connection. The high current diode, D1, has a ring at one end to identify its cathode. Be sure to position them accordingly.

Next, install the slide switch, S1, making certain that it is pushed down firmly on to the surface of the PCB. Before fitting the reset switch, S2, you must first convert it from locking to momentary push non-locking operation. A special nylon retainer clip is supplied with the switch, which replaces the wire retainer, converting it to momentary action. With either removed the plunger will be forced out by the spring, so keep it firmly held in. When fitting the switch make certain that it is pushed down firmly on to the surface of the PCB.

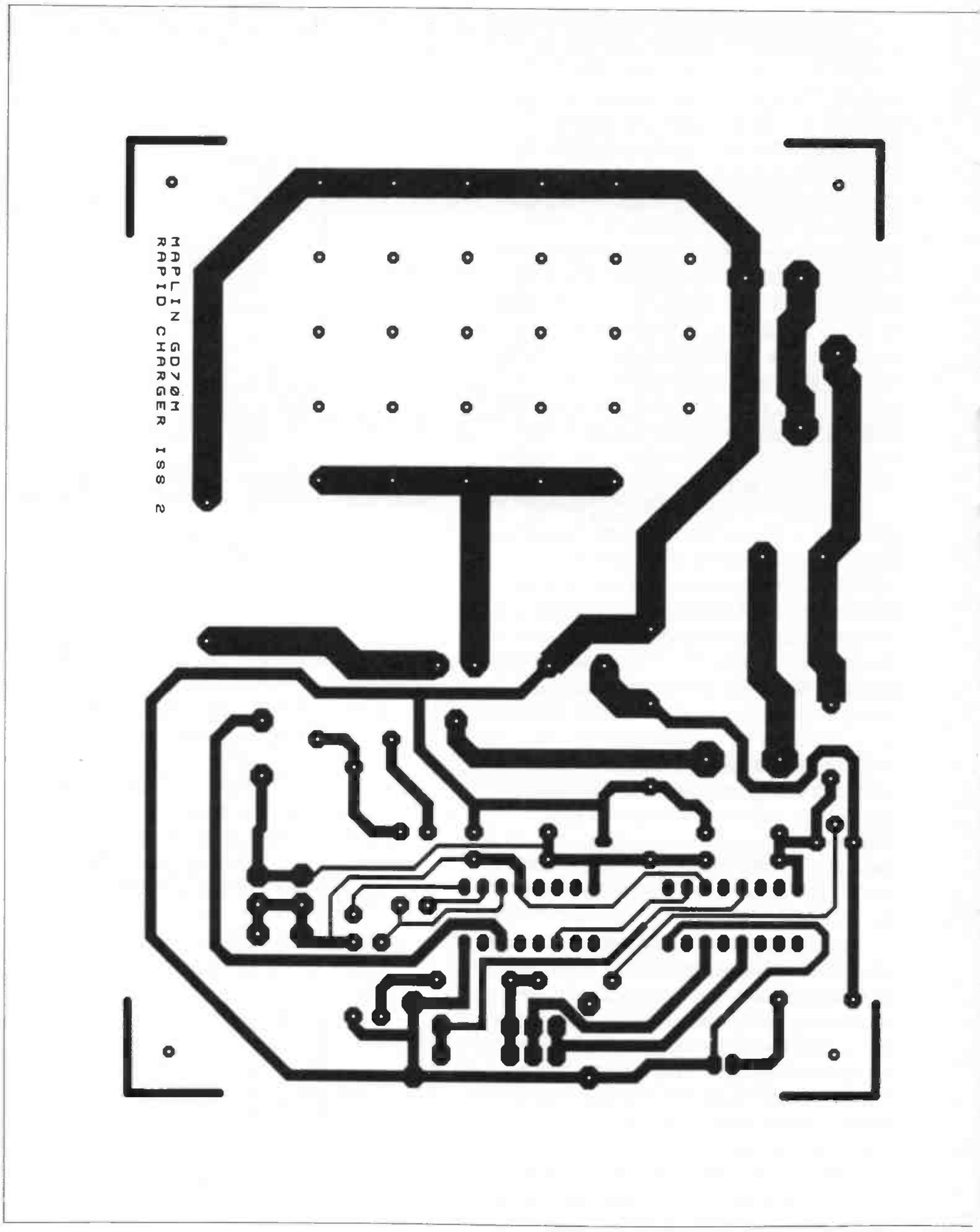
When fitting the 16 pin IC sockets ensure that you match the notch with the block on the legend. Now carefully install, IC1, and, IC2, into their appropriate sockets. Next, install the red PCB mounted LED and relay making certain that they are pushed down firmly on to the surface of the PCB. The piezo sounder, BZ1, is mounted using a self-adhesive pad to the top of the relay. The sounder may have different coloured leads but either can be taken to P7 or P8.

The remaining components to be fitted are the 3W and 10W high power resistors. The five 10W, 4.7Ω resistors, R1 to R5 are mounted 10mm above the surface of the PCB, over the ventilation holes, see Figure 3. Finally install R6, the 3W, 47Ω resistor making certain that it is also mounted 10mm above the PCB.

This completes the assembly of the PCB and you should now check your work very carefully ensuring that all the solder joints are sound. It is also very important that the bottom, track side of the circuit board does not have any trimmed component leads standing proud by more than 3mm.

Final Assembly

The case which the unit is designed to fit is the 'Steel Instrument Case type 1105' (XJ25C). Remove the top cover from the case and follow the drilling instructions in Figure 4 when preparing the base for mounting the



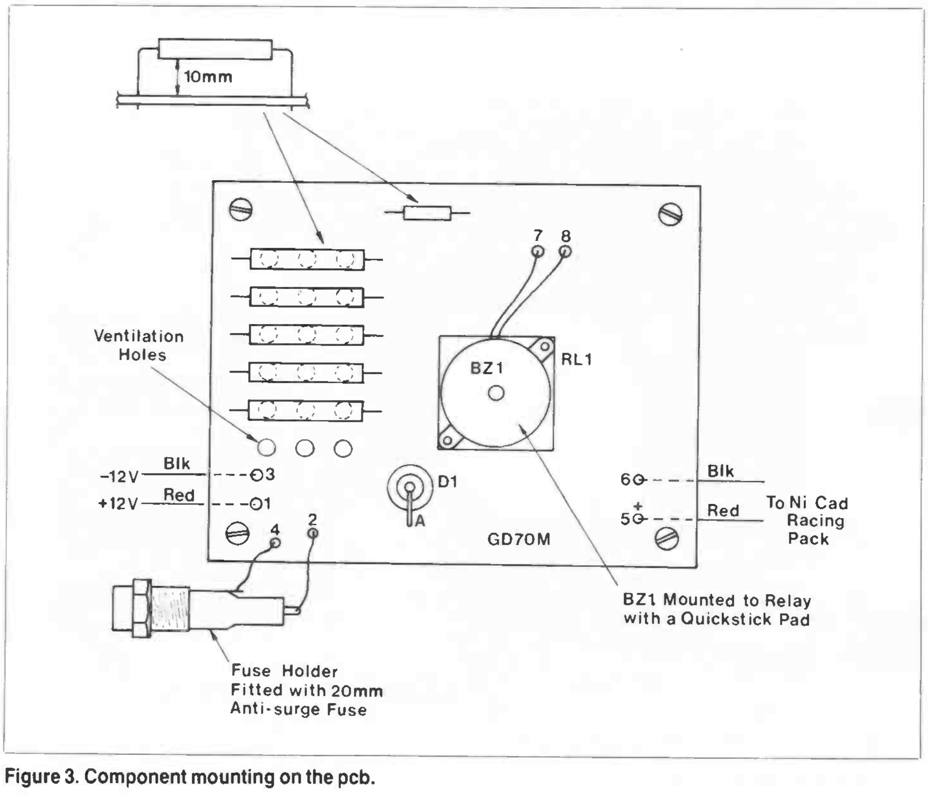


Figure 3. Component mounting on the pcb.

pillars. The top and bottom cover have ventilation slots already punched.

Remove the front and back panels from the case and follow the drilling instructions in Figure 5 when preparing them. The back panel has two holes drilled into it, one for the fuse holder and the other for the grommet at the power input. Having drilled the holes at the same time clearing them of any swarf. Install the small grommets in to the panels as shown in Figure 6a. Then using the self-tapping screws supplied with the case refit the front and back panels. Install the four threaded spacers at the PCB fixing holes using M3 bolts.

Next prepare two 30mm lengths of red high current wire. Remove 5mm of insulation from each and solder them to the PCB at P2 and P4, see Figure 3. Note that they are inserted from the component side and the other ends are connected to the fuse holder at a later stage. The two, metre long, power input cables have the appropriate large insulated battery clip fitted at one end and 7mm of insulation removed from the other, see Figure 6b. The female ni-cad power connector is

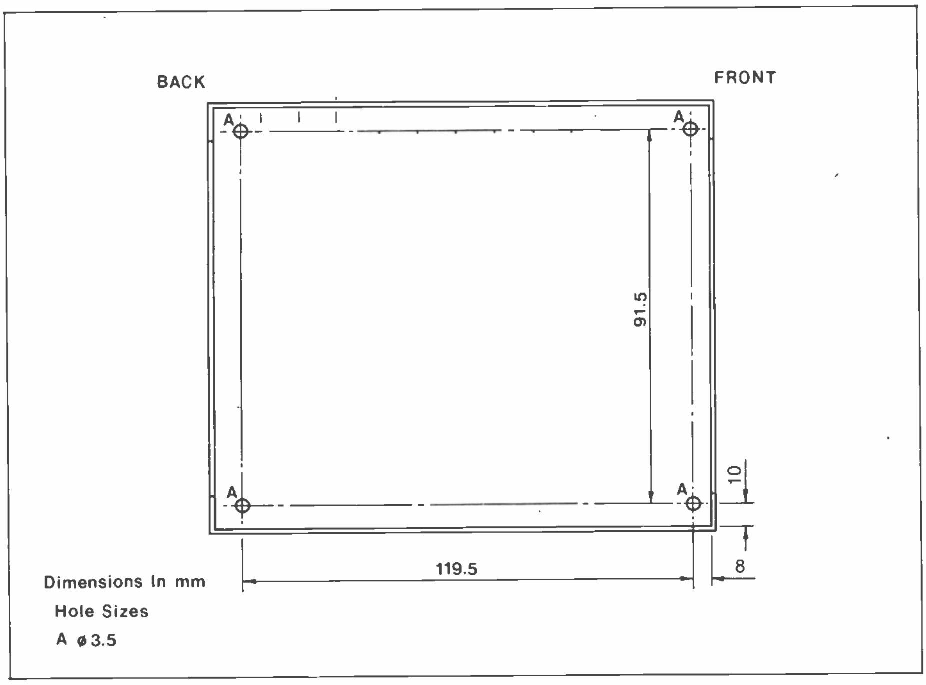


Figure 4. Case driling.

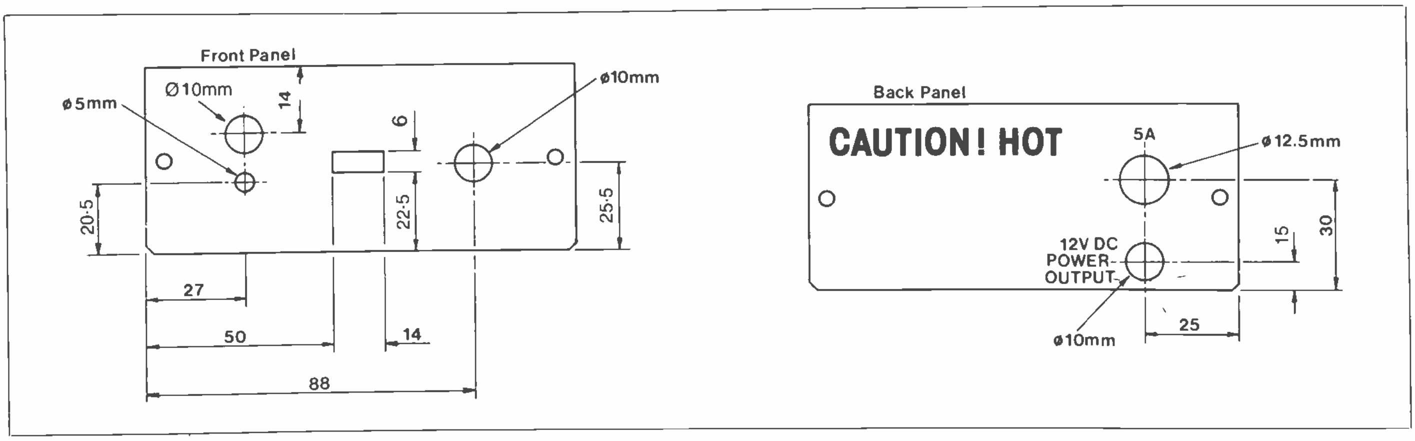


Figure 5. Front and rear panel drilling.

supplied with a 150mm length of red and black high current wire already fitted. Ensure that 7mm of insulation is removed from the free ends of the cable. Both power cables are then fed through its appropriate grommet in to the case, see Figure 6a.

In the next stage the high current cables are inserted in to the PCB from the copper track side. The red power input cable goes to P1, and the black to P3. The red ni-cad power cable goes to P5, and the black to P6, see Figure 3. Next secure the PCB assembly onto the threaded spacers using four M3 bolts. Install the 20mm fuse holder on to the back panel and solder its terminals to the red wires from P2, P4. Finally, fit the 5A 20mm anti-surge fuse and push the black round button on to the reset switch, S2. Do not fit the black case top until the testing stage is successfully completed.

Testing the Unit

All the tests can be made with a minimum of equipment. You will need an electronic digital, or analogue, moving coil multimeter, preferably with a 10A DC current range. The power source can be a 12V lead acid car battery, or a 12V to 14V DC high power regulated supply, capable of up to at least 5A. To check the timing accuracy of the unit you will require a watch or clock.

The following test results were obtained from the prototype using a digital multimeter

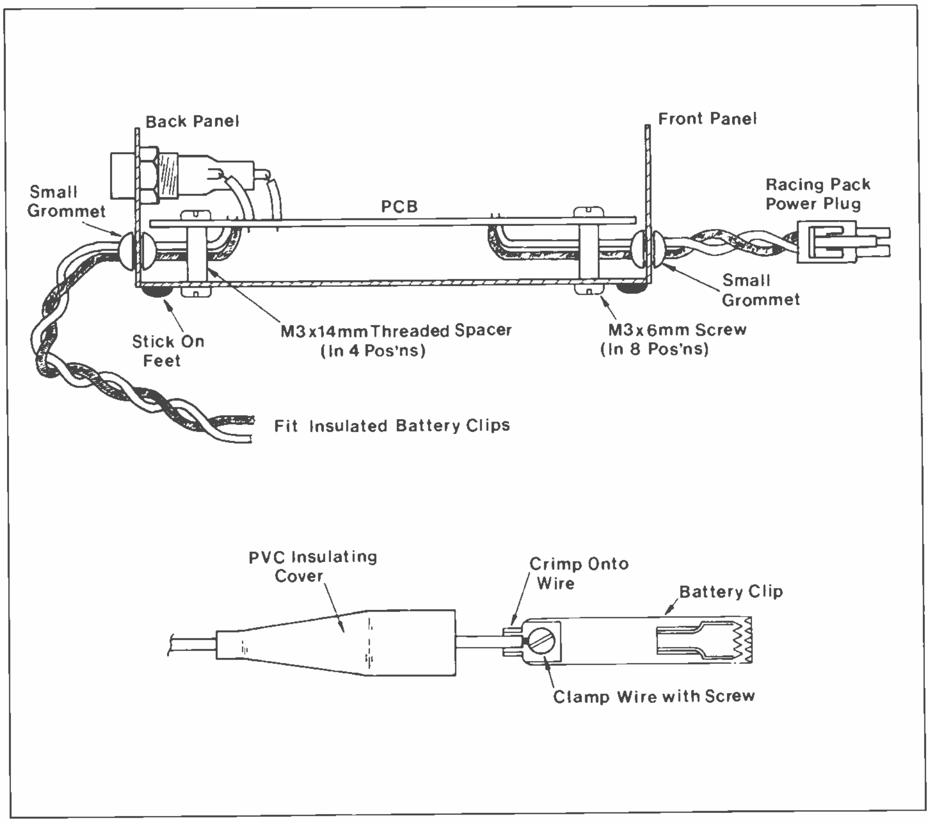


Figure 6a. Mounting assembly in case.
6b. Fitting battery clips.

and a 12V DC power supply. Two 1200mAh ni-cad racing packs were used for the charging tests, a 6 cell 7.2V and a 7 cell 8.4V. Note that before a racing pack can be rapid charged *it must first be in its discharged state*, of less than 1V per cell.

The first test is to ensure that there are no short circuits before you connect the supply. Set your multimeter to read OHMS on its resistance range and connect the probes to the large battery clips on the power input cable. The reading obtained with the probes either way round should be greater than 1000Ω. This test procedure is then applied to the terminals in the female power output connector and should give similar readings.

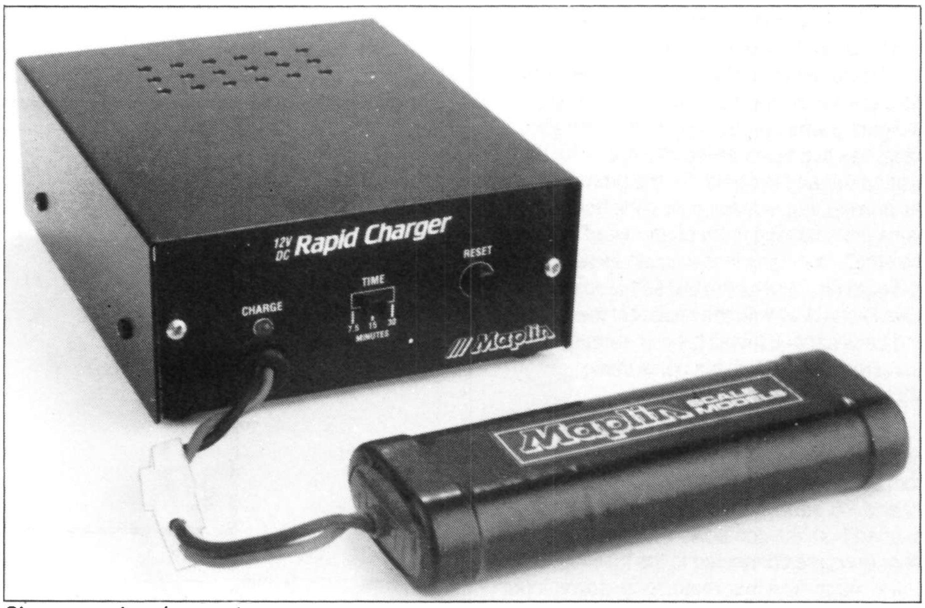
Next position the charge time switch S1, to its 7.5 minute setting and connect the large black battery clip to the negative DC supply. *Do not* fit a ni-cad racing pack to the female power connector at this time! To monitor the supply current set your meter to read mA and place it in the positive line to the large red battery clip. The unit may start up on its own, disregard this and push the reset switch, S2. Start timing the unit with your watch or clock. When the unit is in its full charge mode the red LED, LD1, should be illuminated and the piezo sounder, BZ1, should produce a clock like ticking sound. The current reading should be approximately 50mA. At the end of the full charge period the LED will go out and the sounder should stop ticking. The current reading should drop to approximately 5mA. Repeat this procedure for the 15 and 30 minute settings of the time switch and when successfully completed proceed to the final testing stage.

Charging Times for 6 and 7 cell Racing Packs		
Lead-acid car battery voltage	Initial charge current 6 cell 7.2V 1.2Ah	Initial charge current 7 cell 8.4V 1.2Ah
Low 11V	1.9A for 30 minutes	
Normal 12V	2.9A for 15 minutes	1.7A for 30 minutes
High 13V	3.8A for 15 minutes	2.5A for 30 minutes
Maximum 14V	4.4A for 7.5 minutes	3.4A for 15 minutes

Table 1. Charge times.

Final Testing

Set your meter to its 10A DC range. If a high current range of more than 5A is not available, then remove the meter from the positive line and connect the large red battery clip, directly to the supply. Using the 12V information provided in Table 1, set the time switch for 15 minutes for a 7.2V ni-cad pack and 30 minutes for an 8.4V pack. Plug the ni-cad pack on to the female connector and press the reset button. **WARNING!** The 10W high power resistors, R1 to R5, will become very hot during the full charge period. The currents shown in Table 1 and Figure 7a and 7b are dependent upon the individual condition of the racing pack being charged. At the end of the full charge period the unit will automatically switch over to a trickle charge of approximately 70mA for a 7.2V pack and 40mA for a 8.4V pack. This completes the testing of the rapid charger. Finally secure the case top with the four self-tapping screws. The rapid charger is now ready for use.



Charger and racing pack.

Using the Rapid Charger

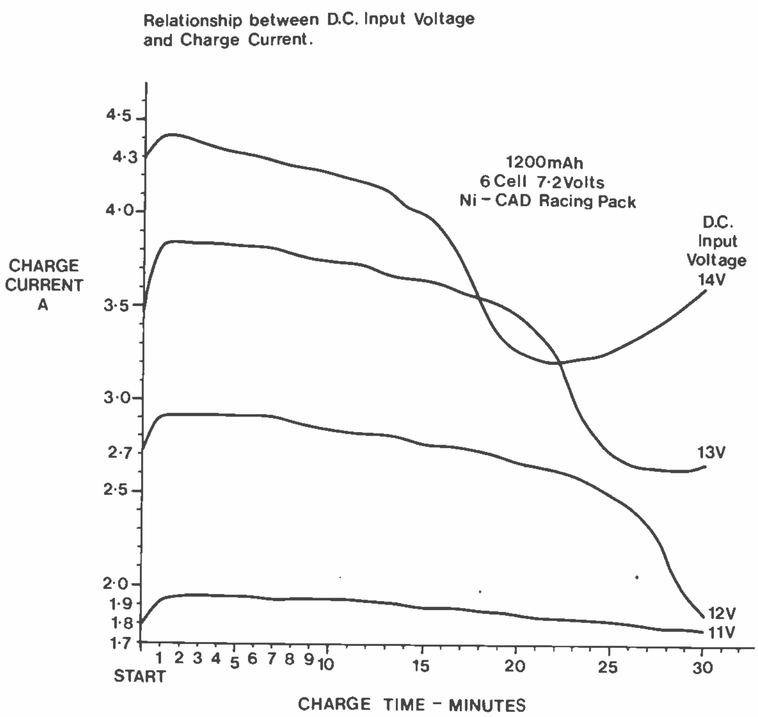
When using the charger with a lead acid battery in your car, it is possible to increase the voltage supplied to the unit. If the engine in your vehicle is left running, the voltage across the terminals will increase as the alternator charges the battery. You must follow the charging times given in Table 1 for the different supply voltages. In addition to this the following operating procedure should be observed:

1 Connect the large black battery clip to the negative terminal of the 12V power source.
2 Connect the large red battery clip to the positive terminal of the 12V power source.
3 Select the necessary charging time for the type of ni-cad pack and supply voltage, see Table 1.
4 Connect the ni-cad pack to the female power connector.
5 Press the reset button.
6 At the end of the charge period the ni-cad pack can be removed when required.

WARNING!
Do not attempt to charge a *hot* ni-cad pack.
Do not attempt to charge a ni-cad pack unless in its discharged state.
Do not over charge a ni-cad pack.
Do not obstruct the ventilation holes in the case of the rapid charger.

Operating Tips

Always carry some spare 20mm 5A anti-surge fuses. Use a digital, or analogue, moving coil meter to measure the supply voltage. Have one ni-cad pack charging and another ready for use. Occasionally use a slow charger to maintain the condition of the ni-cad pack.



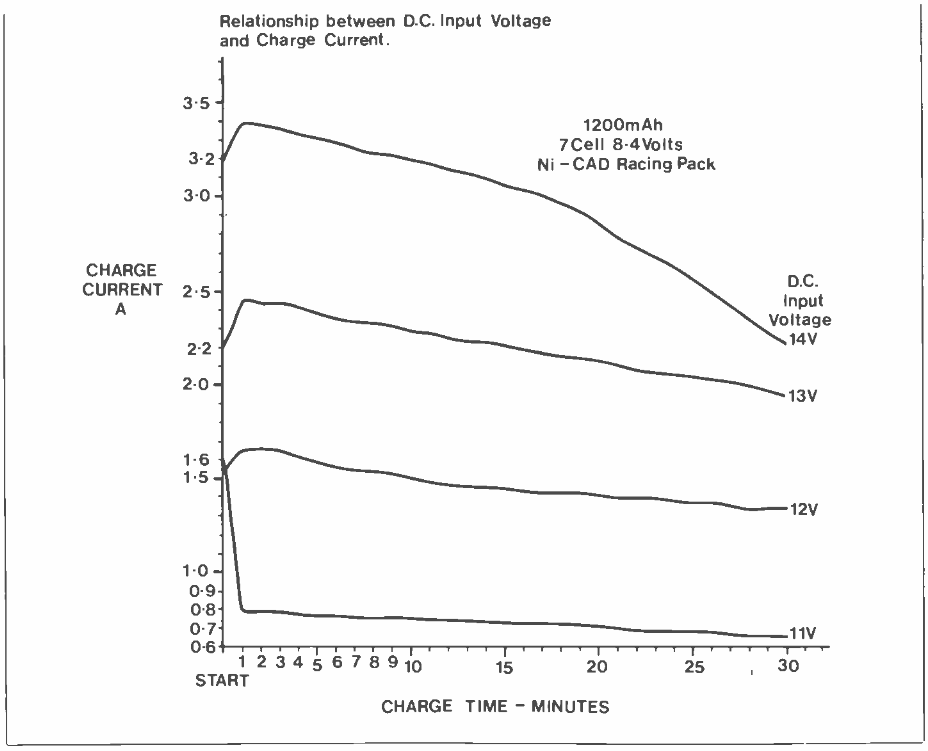
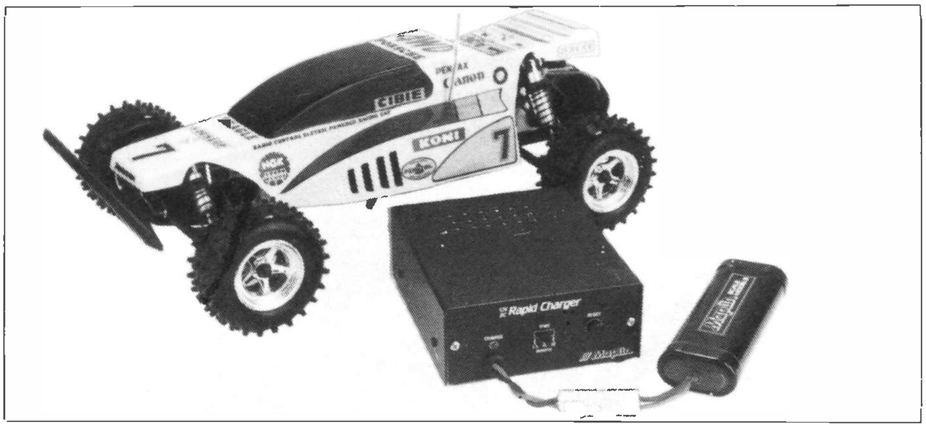


Figure 7a. 6 cell current charging graph.
7b. 7 cell current charging graph.



Trackside charger with Beagle racing car.

RAPID CHARGER PARTS LIST

RESISTORS: All 0.6W 1% Metal Film (Unless Specified)			
R1-5	4·7Ω 10W Round Type	5	*Kit only**
R6	47Ω 3W Round Type	1	*Kit only**
R7,13	1k	2	(M1K)
R8	10k	1	(M10K)
R9	470Ω	1	(M470R)
R10	270k	1	(M270K)
R11	2k7	1	(M2K7)
R12	330Ω	1	(M330R)
R14	20k	1	(M20K)
** Not available separately*			
CAPACITORS			
C1-3	Disc 100nF 50V	3	(BX03D)
C4	Minelect 47μF 16V	1	(YY37S)
C5	1% Polysty 22nF	1	(BX87U)
SEMICONDUCTORS			
IC1	4020BE	1	(QX11M)
IC2	4060BE	1	(QW40T)
D1	MR751	1	(YH96E)
D2,3	1N4007	2	(QL79L)
D4	1N4148	1	(QL80B)
LD1	PCB LED Red	1	(QY86T)
ZD1	BZY88C9V1/BZX55C9V1	1	(QH13P)
TR1	BC327	1	(QB66W)
MISCELLANEOUS			
S2	Latchswitch 2-Pole	1	(FH67X)
S1	R/A DT3T Slide	1	(FV02C)

	Safuseholder 20	1	(RX96E)
	Fuse A/S 5A	1	(RA12N)
RL1	Relay Flat 12V	1	(HY20W)
	DIL Socket 16-pin	2	(BL19V)
	HC Wire Red	2	(XR59P)
	HC Wire Black	2	(XR57M)
	Min Piezo Sounder	1	(FM59P)
	Race Pk Lead Female	1	(JG05F)
	Rapid Charger PCB	1	(GD70M)
	Large Batt Clip Red	1	(FS86T)
	Large Batt Clip Blk	1	(FS87U)
	Constructors' Guide	1	(XH79L)
	Leaflet	1	(XT39N)
	Quickstick Pads	1 Stp	(HB22Y)
OPTIONAL			
	Steel Case 1105	1	(XJ25C)
	Round Latchbutton Black	1	(FL31J)
	Thk Grommet 6.4mm	2	(FW59P)
	M3 x 6mm Bolt	1 Pkt	(BF51F)
	M3 x 14 Threaded Spacer	1 Pkt	(FG38R)

A complete kit of all parts is available for this project:
Order As LM40T (Rapid Charger Kit)
The following items are also available separately:
Rapid Charger PCB **Order As GD70M**

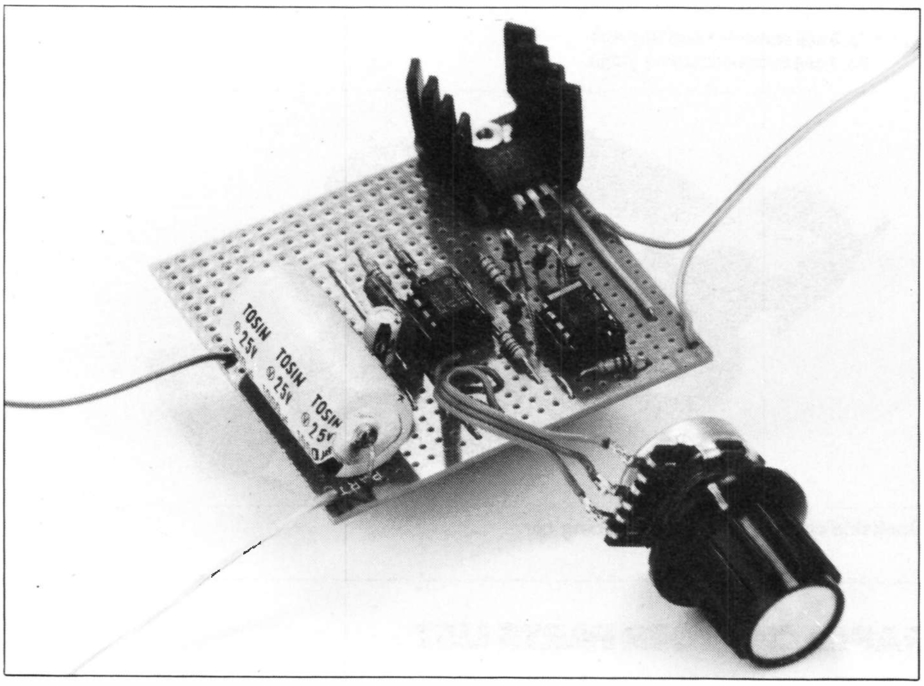
Bob's MINI-CIRCUITS

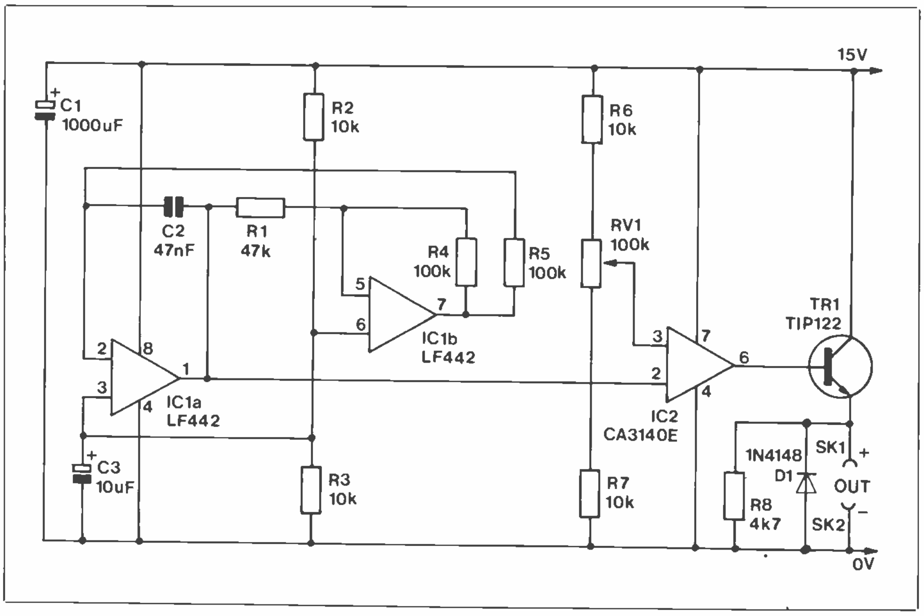
Pulsed Speed Controller

Simple variable voltage controllers are often used for small DC electric motors, but they have the disadvantage of providing relatively low torque at low speeds. Whether the application is a drill speed controller or a model train controller, this usually results in very poor low speed performance with a marked tendency for the motor to stall. In a train controller application the motor can also have a definite reluctance to start, giving the so-called 'jump' start effect.

There are several types of improved motor speed controllers, but these basically boil down to the over-compensated voltage regulator and pulsed types. The former can give extremely good results and is much used in such things as cassette recorders, but it is perhaps best suited to applications where only one or two preset speeds are required, and the characteristics of the controller can be closely matched to those of the motor. The pulsed type controller is well suited to general use, and it operates by feeding a pulsed signal to the motor with the mark-space ratio being varied in order to control the average output potential (and the motor's speed).

A good quality pulsed controller does not need to be particularly complex, and the circuit shown here provides excellent performance but requires only a handful of components. The basis of the unit is a clock oscillator based on IC1, and a voltage comparator stage which uses IC2. The clock oscillator is of the Miller Integrator/Schmitt Trigger type, and in this case it is the triangular waveform from IC1a that is required and not the squarewave signal from IC1b. The output frequency of the controller is, of course, equal to the operating frequency of the clock oscillator, and it is important that this frequency is not too low or the motor may tend to stutter. On the other hand, if the output frequency is set too high the motor will have a high impedance at the signal frequency and little power will be driven through it. A





Speed Controller Circuit.

but realistic acceleration from the model train, and provides the simulated inertia. When PB2 is released, the voltage on C4 slowly decays as it discharges through R10, and the model train very slowly decelerates and stops, giving a simulated momentum effect. The train can be brought to a more rapid halt by operating the 'brake' control (PB1), which shunts the lower resistance of R9 across R10 and increases the discharge rate. PB3 is the 'stop', or emergency brake control, and this can be used to very rapidly discharge C4 and bring the train to a halt if necessary. The values for R9, R10, R11, and R13 give what I felt to be the best response times, but they can easily be altered to suit individual requirements. The response times are proportional to the values of these components.

The only other modification needed for operation as a train controller is to add a forward/reverse switch at the output of the unit. All this requires is the addition of a DPDT switch connected as shown in (b). Note that the switch should be a break before make type as it will otherwise momentarily short circuit the output of the controller each time it is operated!

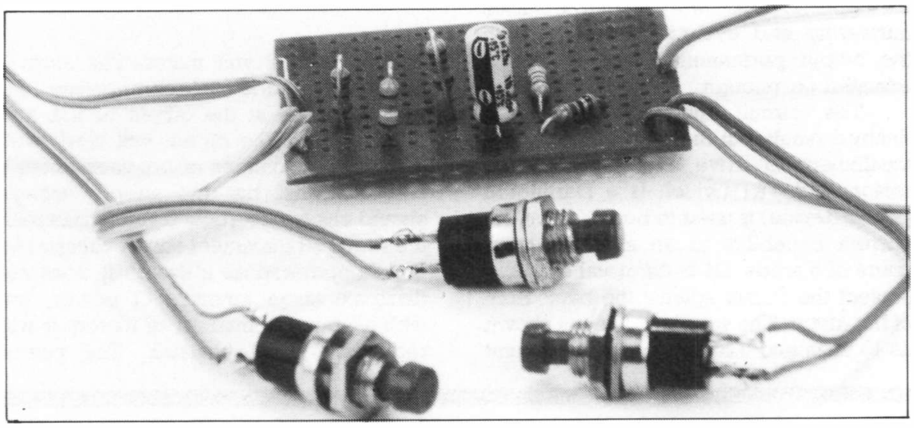
TRAIN CONTROLLER PARTS LIST

RESISTORS: All 0.6W 1% Metal Film			
R9	390k	1	(M390K)
R10	10M	1	(M10M)
R11	820k	1	(M820K)
R12	10k	1	(M10K)
R13	33k	1	(M33K)
CAPACITORS			
C4	10μF 50V PC Electrolytic	1	(FF04E)
MISCELLANEOUS			
PB1,2,3	Push to Make Switch	3	(FH60Q)
S1	DPDT Sub-min Toggle	1	(FH04E)

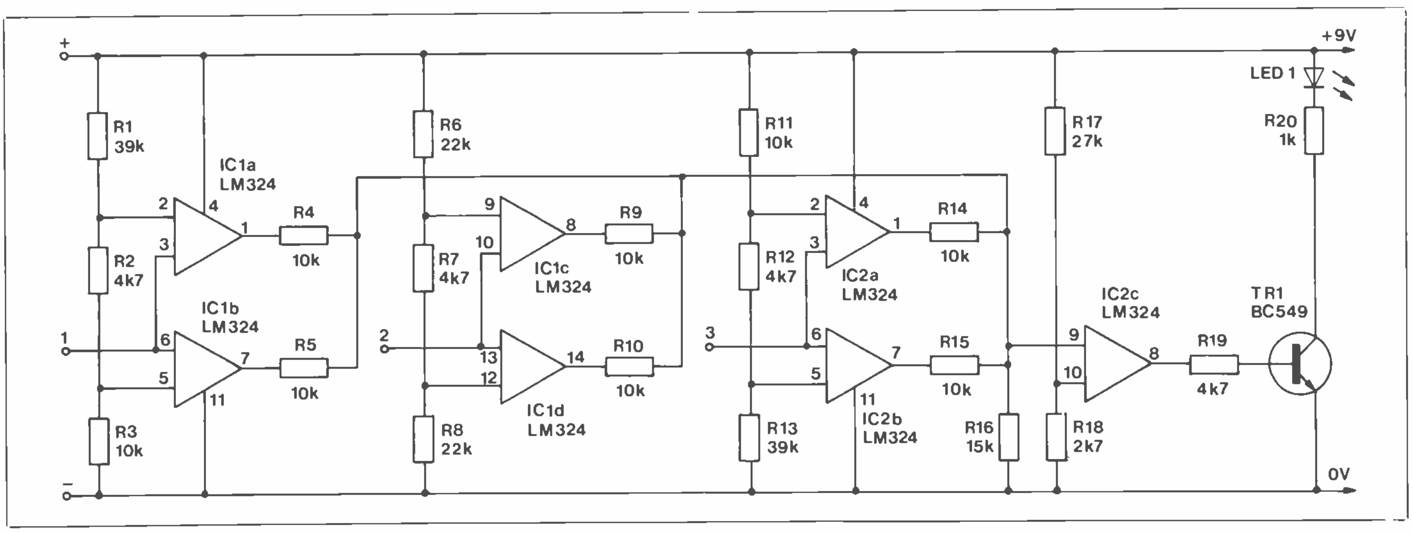
Electronic Lock

There has been no shortage of electronic lock designs over the years, and in recent times they have virtually all been of the electronic combination lock variety. There are numerous types of electronic lock, and there are plenty of practical alternatives to combination types. These alternatives are mostly electronic equivalents to a conventional key and lock, rather than akin to a tumbler style combination lock. There must be an almost infinite range of possibilities, with resistance, capacitance, modulated infra-red beams, audio tones, or virtually anything related to electronics being usable as the 'key'. This makes electronic locks very secure, since it becomes necessary to have quite precise knowledge about how a lock operates before any realistic attempt at 'picking' it can be made. Even with this knowledge, 'picking' the lock is likely to be a very slow and difficult process which will often be unsuccessful.

This electronic lock is very simple, but is virtually 'crack-proof'. In the form in which it is presented here it is really only suitable for experimental and demonstration purposes, but it could easily be used to drive a relay if it is to be used in earnest. Apart from driving the solenoid of an electronic lock mechanism, a useful application for any form of electronic lock is to hinder the unauthorised use of computer equipment, radio transmitters, etc.



Operation of the unit is probably easiest to understand if the 'key' circuit is considered first. This is just four resistors which connect across the supply rails of the 'lock' circuit, and provide three output voltages. These are nominally 25%, 50%, and 75% of the supply voltage.



Electronic Lock Circuit.

frequency of about 200Hz is used in this case, which seems to be a good compromise. Unlike some simple pulsed speed controller circuits, with this one the output frequency is constant and is totally unaffected by changes in the speed setting control.

The speed control is RV1, and with this set at a central position the clock signal swings symmetrically either side of the bias level that it feeds to the non-inverting input of IC2. The clock signal is fed to the inverting input, and the output from IC2 is therefore a squarewave signal having an average voltage of half the supply voltage. Moving the wiper of RV1 towards the R6 end of its track results in the clock signal going above the bias level for a smaller percentage of the time, and the output is high for longer periods than it is low. If RV1 is adjusted far enough, the clock signal will fail to exceed the bias level even on signal peaks, and the output will stay permanently high. Taking the wiper of RV1 down the track towards the R7 end has the opposite effect, with the output pulses narrowing and eventually ceasing with the output permanently low, if RV1 is adjusted far enough.

The circuit therefore gives the desired result, but the output from IC2 is insufficient to drive even a small DC motor, and TR1 (which is a Darlington power device) is used to boost the output current capability to an absolute maximum of 5 amps. D1 is the usual diode to protect the circuit against the back EMF of the motor. The supply voltage is shown as 15 volts and it is assumed that the unit will drive a 12 volt motor. The extra 3 volts is needed to compensate for voltage drops at the output of IC2 and through TR1. The circuit will work well with supply voltages of between about 9 and 30 volts, but the supply voltage should always be about 3 volts more than the required maximum output voltage. As TR1 is operated as a switch it does not dissipate large amounts of power, but with all but the smallest of motors it will require a small heatsink. The power source should ideally be regulated and reasonably well smoothed, and should incorporate current limiting to protect the controller in the event of a short circuit on the output.

As a model train controller, a DPDT switch should be added at the output to give direction control, and as the unit is controlled by a voltage fed to pin 3 of IC2, refinements such as simulated breaking and inertia could easily be added to the unit.

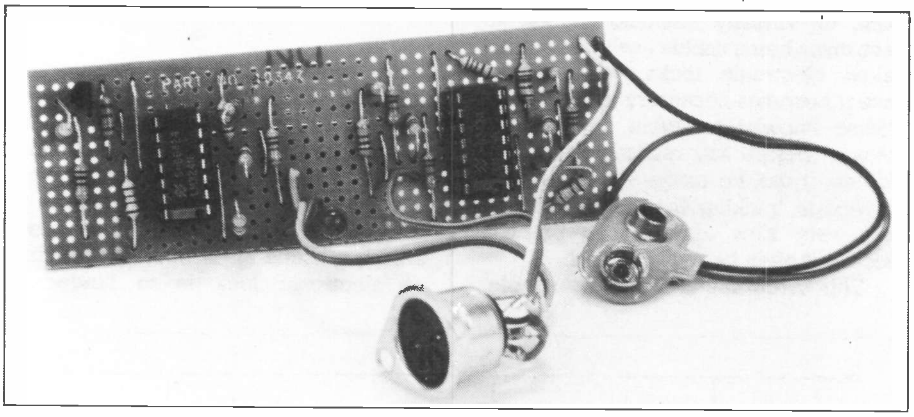
PULSED SPEED CONTROLLER PARTS LIST

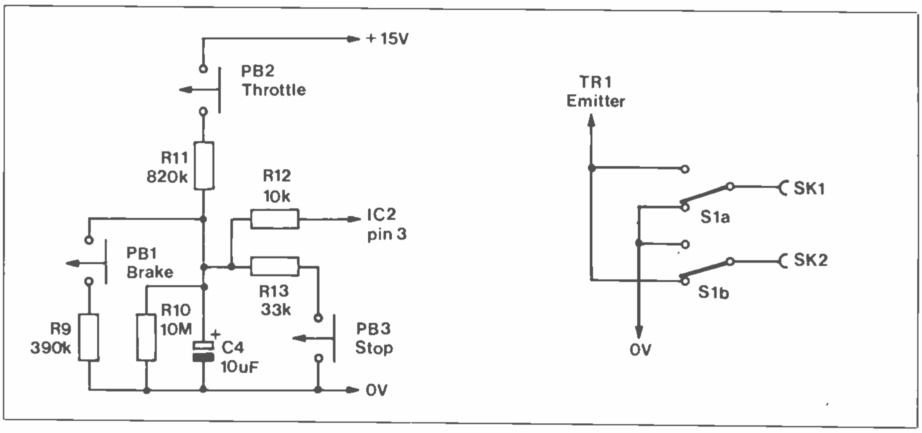
RESISTORS: All 0.6W 1% Metal Film			
R1	47k	1	(M47K)
R2,3,6,7	10k	4	(M10K)
R4,5	100k	2	(M100K)
R8	4k7	1	(M4K7)
RV1	100k lin pot	1	(FW05F)
CAPACITORS			
C1	1000μF 16V Axial Electrolytic	1	(FB82D)
C2	47nF Poly Layer	1	(WW37S)
C3	10μF 50V PC Electrolytic	1	(FF04E)
SEMICONDUCTORS			
TR1	TIP122	1	(WQ73Q)
IC1	LF442	1	(QY30H)
IC2	CA3140E	1	(QH28F)
D1	1N4148	1	(QL80B)
MISCELLANEOUS			
SK1	Terminal Post (Red)	1	(FD72P)
SK2	Terminal Post (Black)	1	(FD69A)
	8 pin DIL Socket	2	(BD17T)

Train Controller

The motor speed controller described elsewhere in this feature can operate very well as a model train controller, but the unit really needs some additional circuitry in order to get the best results from it. The simple potentiometer speed control may be considered quite adequate by some users, but most will prefer a slightly more realistic method of control. It is quite easy to add simulated braking and inertia to the controller, which is voltage controlled and has a very high input resistance at the control input (pin 3 of IC2). The circuit of (a) shows a simple method of obtaining improved control, and this circuit is connected in place of R6, R7, and RV1 on the original design.

Capacitor C4 is at the heart of this circuit, and it is the charge voltage on this component that constitutes the control voltage. The output voltage from the controller is almost identical to the charge potential on C4. The voltage on C4 is coupled to IC2 via protection resistor R12, and the input resistance of IC2 is so high that it has no significant affect on the operation of the circuit. PB2 is the 'throttle' control, and by closing this switch, C4 is slowly charged from the supply rails via R11. This gives quite slow





Train Controller Circuits.

The lock must be designed so that it is only activated if these three voltages are supplied to its three inputs, and in the correct order.

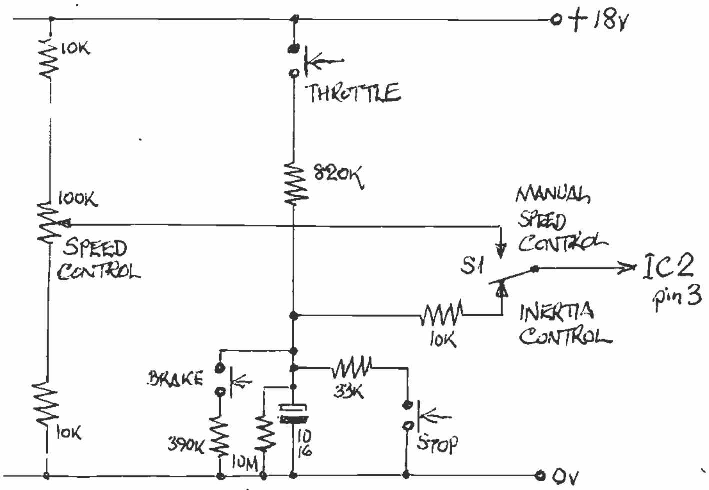
The 'lock' circuit is basically just three window discriminators. If we consider IC1a and IC1b for example, R1 to R3 form a potential divider across the supply rails. These provide a bias voltage of something over 25% of the supply voltage to the inverting input of IC1a, and just under 25% of the supply potential to the non-inverting input of IC1b. Both amplifiers function here as voltage comparators, with the input voltage being compared to these reference levels. With the input voltage within the window (i.e. between the reference voltages) both outputs will go low. If the input voltage is taken outside the window voltage limits, then one or other of the outputs will go high.

IC1c and IC1d are used to detect the 50% of V+ voltage, while IC2a and IC2b are used to detect the 75% of V+ voltage level. All six comparator outputs are mixed by a simple passive mixer circuit, and their combined output is fed to a simple level detector circuit based on IC2c. This simply detects the slightly higher output voltage when one or more of the outputs goes high. This circuit is designed so that TR1 and indicator LED1 are switched off when an output or outputs are high, and switched on when they are all low (which only occurs when the correct 'key' is connected to the unit). Of course, LED1 and current limiting resistor R20 could be replaced with some other small 9 volt d.c. load if necessary, or a suitable relay plus protection diode could be connected here.

Construction of the unit is quite straightforward. I took the three inputs plus the two supply rails to a 5 way DIN socket, and mounted the 'key' resistors in a matching DIN plug. You do not have to use the voltage levels suggested here, and by changing the values in the 'key' desired voltage levels can be produced. Obviously the window discriminators would have to be modified to match the key, and security could be increased by narrowing the window voltage limits. Do not take this to excess though, as this could compromise the reliability of the 'key'.

ELECTRONIC LOCK PARTS LIST

RESISTORS: All 0.6W 1% Metal Film			
R1,13	39k	2	(M39K)
R2,7,12,19	4k7	4	(M4K7)
R3,4,5,9, 10,11,14,1	10k	7	(M10K)
R6,8	22k	2	(M22K)
R16	15k	1	(M15K)
R17	27k	1	(M27K)
R18	2k7	1	(M2M7)
R20	1k	1	(M1K)
R21,22,23,24	5k6	4	(M5K6)
SEMICONDUCTORS			
TR1	BC549	1	(QQ15R)
IC1,2	LM324	2	(UF26D)
LED1	5mm Red LED	1	(WL27E)
MISCELLANEOUS			
	14 pin DIL Socket	2	(BL18U)
	5 pin DIN Socket	1	(HH34M)
	5 pin DIN Plug	1	(HH27E)



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