DECEMBER 87 TO FEBRUARY 88

PRICE 85p IR £1.24

Electronics

THE MAPLIN MAGAZINE

In this issue: Party Disco Lights
Temperature Module add-on boards
Domestic Appliance Mains Tester

Build this Trackside Rapid Charger for your Ni-cad Battery Racing Packs

Construct a Mini-Metal Detector with this FREE pcb!

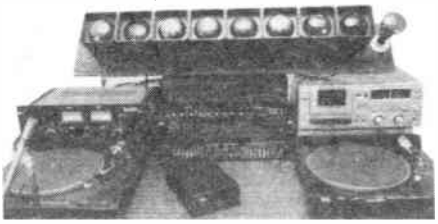
December 1987 to February 1988
Volume 7 Number 25

CONTENTS

Electronics THE MAPLIN MAGAZINE

PROJECTS

An expansion module comprising a relay switching card controlled by either of our Temperature Modules, and a serial to parallel data conversion card which will make the serial temperature output data from the Temperature Module more readily accessible. Relays can switch 3A at 24V for alarms, pumps, fans etc., whilst the converter has tri-state TTL parallel outputs for computers with 1 or 2 byte I/O availability.

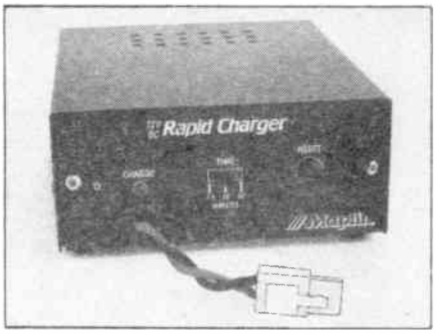


A redesigned, improved version of our popular 3 channel, sound to light Partylite project, which now includes a high quality electret microphone for its signal input directly from a loudspeaker.

With the introduction of a new range of model control racing cars now available from Maplin, there is a need to provide for the charging of the specialised, ni-cad battery packs used with these models. The Slow Charger is mains powered via a mains adaptor and is designed to slowly charge a battery pack, and if used at regular intervals will maintain maximum Ni-cad capacity.

Use your free gift on the front cover to build this useful project. A must for DIY'ers of all ages and complementary to our ever popular Live Wire Detector project. The Mini-Metal Detector can detect the presence of ferrous or some non-ferrous metals such as iron wall board nails or brass screws.

The safety of all appliances directly connected to the 240V AC mains cannot be taken too lightly and stories of serious injury and death resulting from unsafe electrical equipment abound. While it is no substitute for more sophisticated and costly test equipment, this Appliance Tester will electrically examine an appliance for most of the common faults such as open and short circuits on Line, open loop earth connection and earth leakage between the Line and/or the appliance metalwork even if this is of a fairly high resistance.



Indispensible 'Track Side' model radio control car ni-cad pack charger which uses a 12V car battery or similar for portability as a source of power. The charger includes an electronic timer to limit the fast charging time to a selected period after which the pack is maintained with a trickle charge.

Three useful, general purpose circuits which can be built on veroboard or your own PCB if you prefer. The Pulsed Speed Controller provides variable pulse width power control of a DC electric motor; the Train Controller uses the same concept specifically for a model railway layout; an Electronic Lock enables electrical equipment on insertion of a correctly wired 5-pin DIN plug.

FEATURES

That most expensive yet most useful instrument, the cathode ray oscilloscope, is described in all its various forms in this last instalment of this series. Buying an oscilloscope involves a sizeable financial outlay, and hopefully this article will be able to help you choose the right instrument for your particular requirements.

Part 1 of a brand new series which hopes to revive something of the old pioneering spirit of the early electronics hobbyists and constructors, where almost exclusively, since the technology of the time had been uniquely developed for radio applications, a typical project would consist of a build-it-yourself 'wireless set'. This article describes how to build the earliest form, the crystal set.

Where at one time DTL changed to TTL and there appeared an established range of '74' series logic ICs, there is now a fast growing and more than somewhat bewildering array of different generations of the same thing.

Part 1 of a new series which aims to teach the subject of electronics through practical experience. This first article begins with an introduction to digital devices and protocol which may initially be easier to become familiar with than analogue or linear circuitry.

REGULARS

Mail Order
P.O. Box 3, Rayleigh, Essex SS6 8LR.
Telephone: Retail Sales: (0702) 554161. Enquiries: (0702) 552911.
Trade Sales: (0702) 554171. Enquiries: (0702) 552961.
General: (0702) 554155. Cashtel: (0702) 552941.

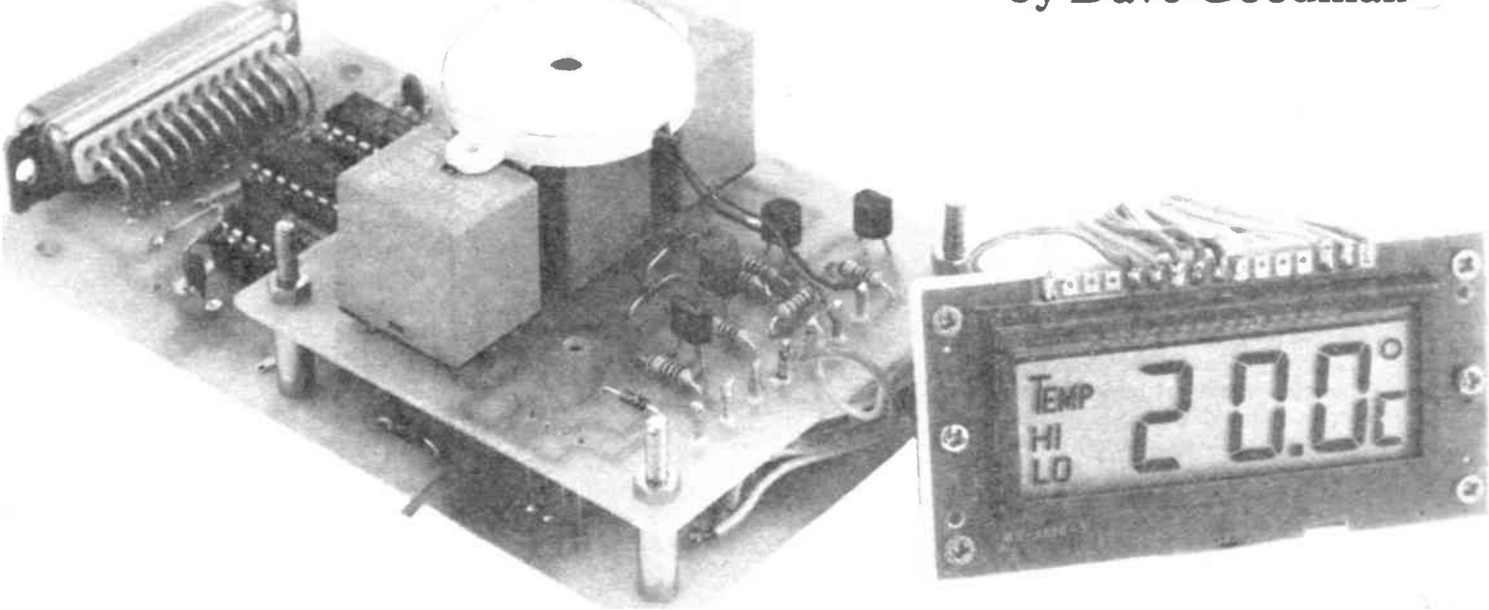
Shops: See inside front cover.

Editorial & Production
Editor Roy Smith
Production Manager Mike Holmes
Technical Editors Dave Goodman, Chris Barlow
Art Directors Peter Blackmore, Greg Buckley
Art Assistants Andy Nunn, Martin King
Technical Artists John Dudley, David Ransley, Lesley Foster

Published by Maplin Electronic Supplies Ltd.
Typesetting by Inline Design Systems Ltd. 258 London Road, Hadleigh, Benfleet, Essex.
Printed by Mayhew McCrimmon Ltd., Star Lane, Great Wakering, Essex.
Distributed by Spotlight Magazine Distribution Ltd., 1-11 Benwell Rd, London N7.

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.

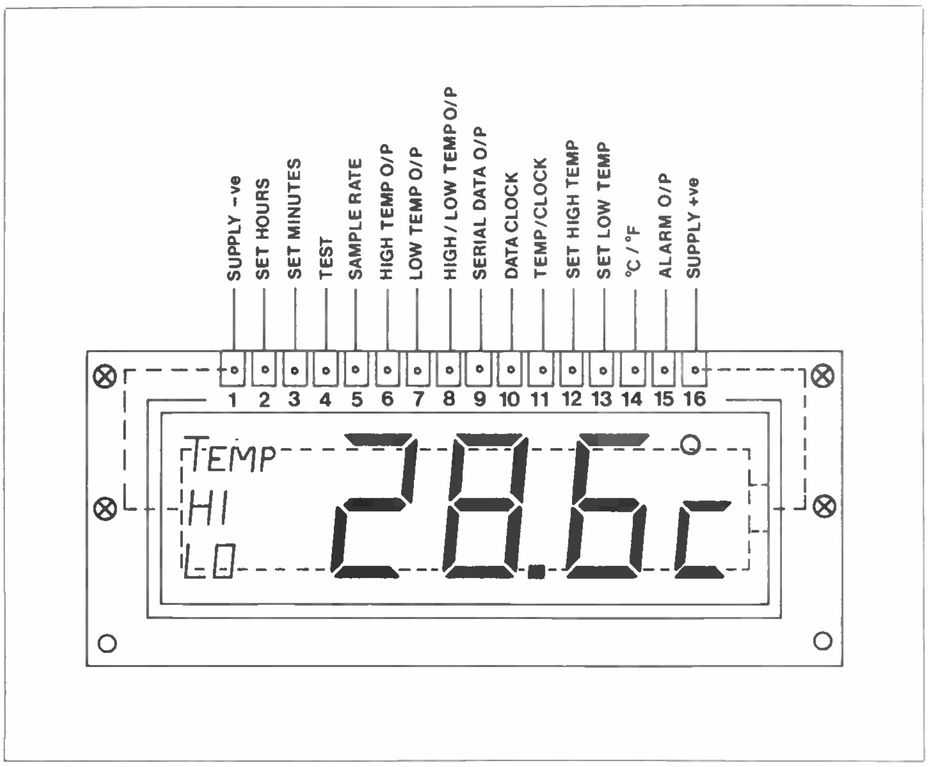


Figure 1. Temperature Module FE33L.

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.

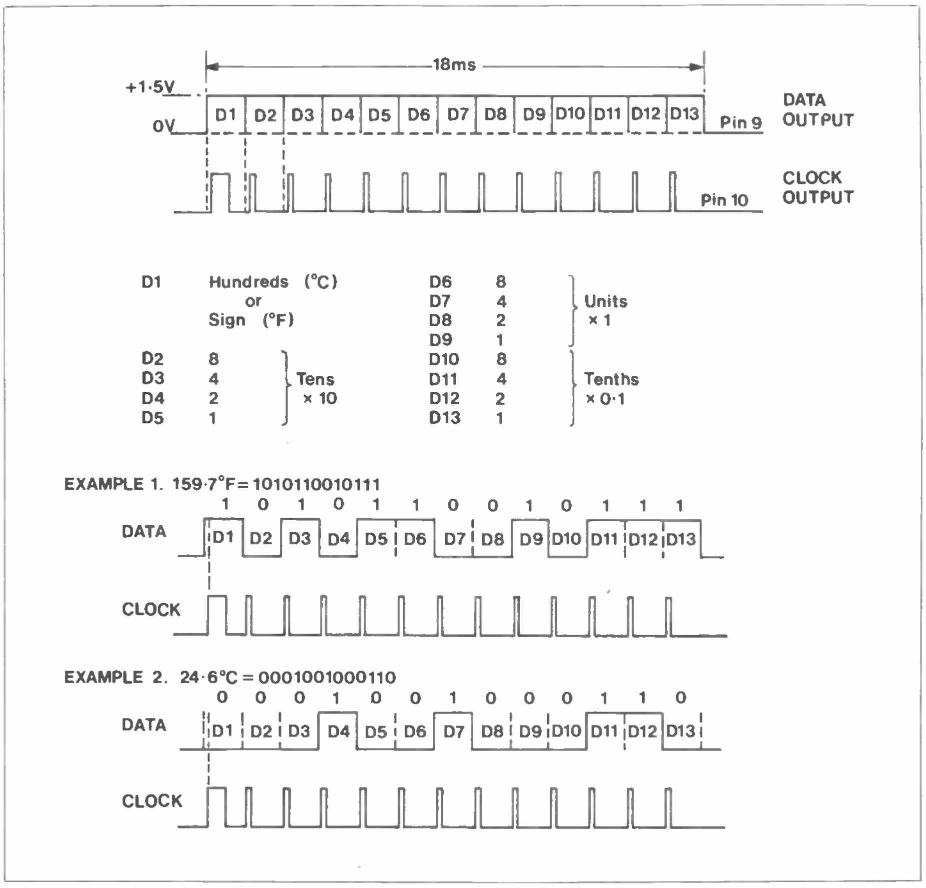


Figure 2. Data and Clock Outputs.

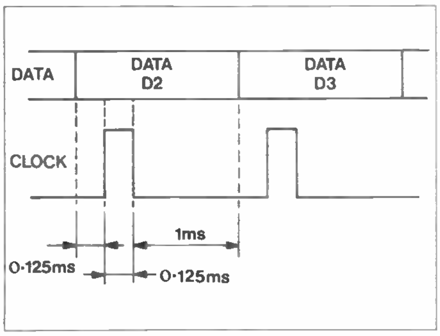


Figure 3. Clock Timing.

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 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

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.

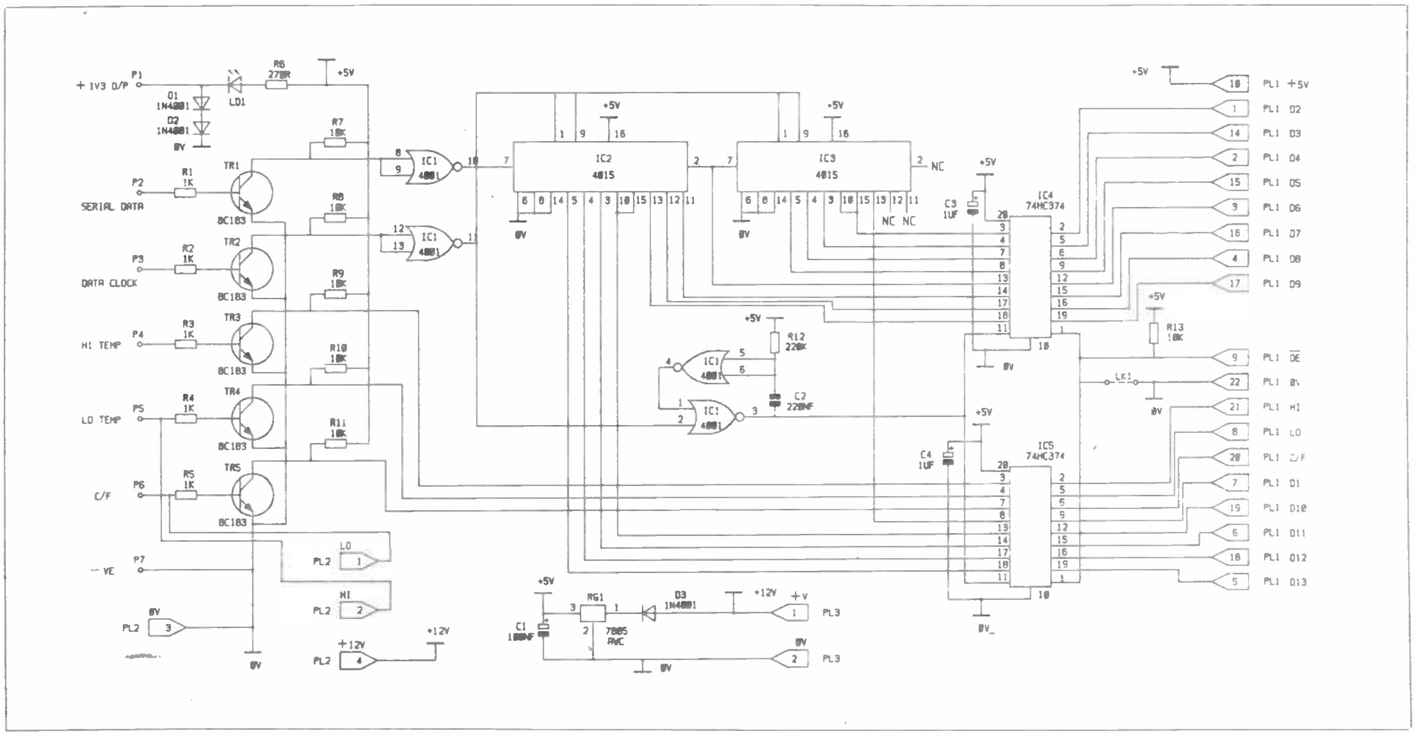


Figure 4. Serial to Parallel Converter Circuit.

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 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.

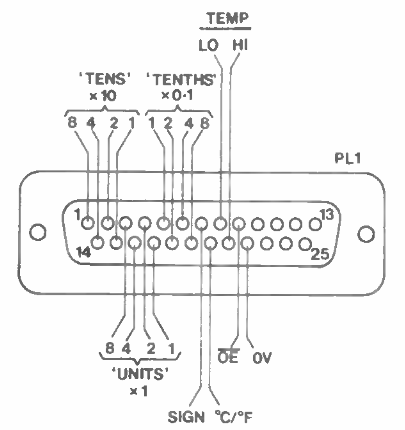


Figure 5. Parallel Bus Output Plug.

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.

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

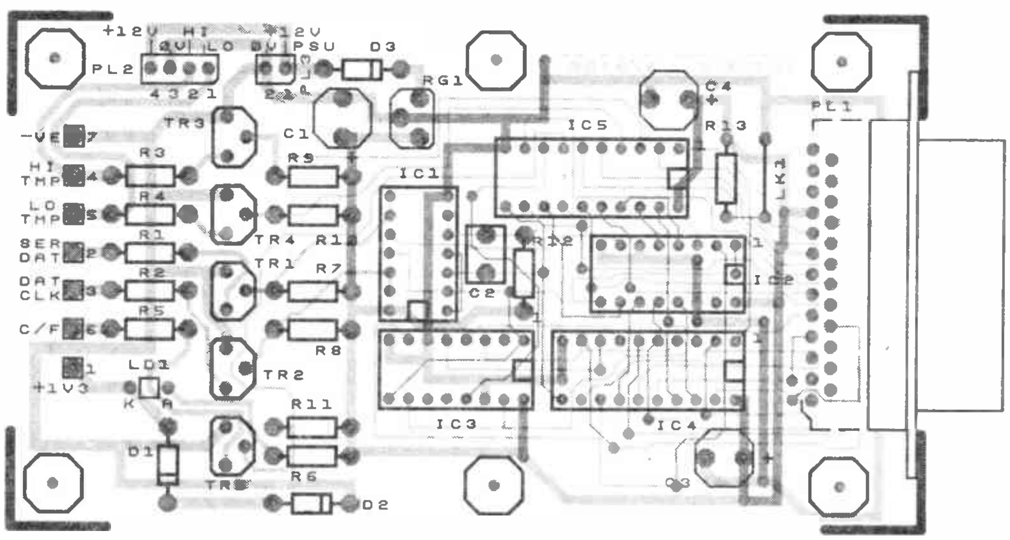
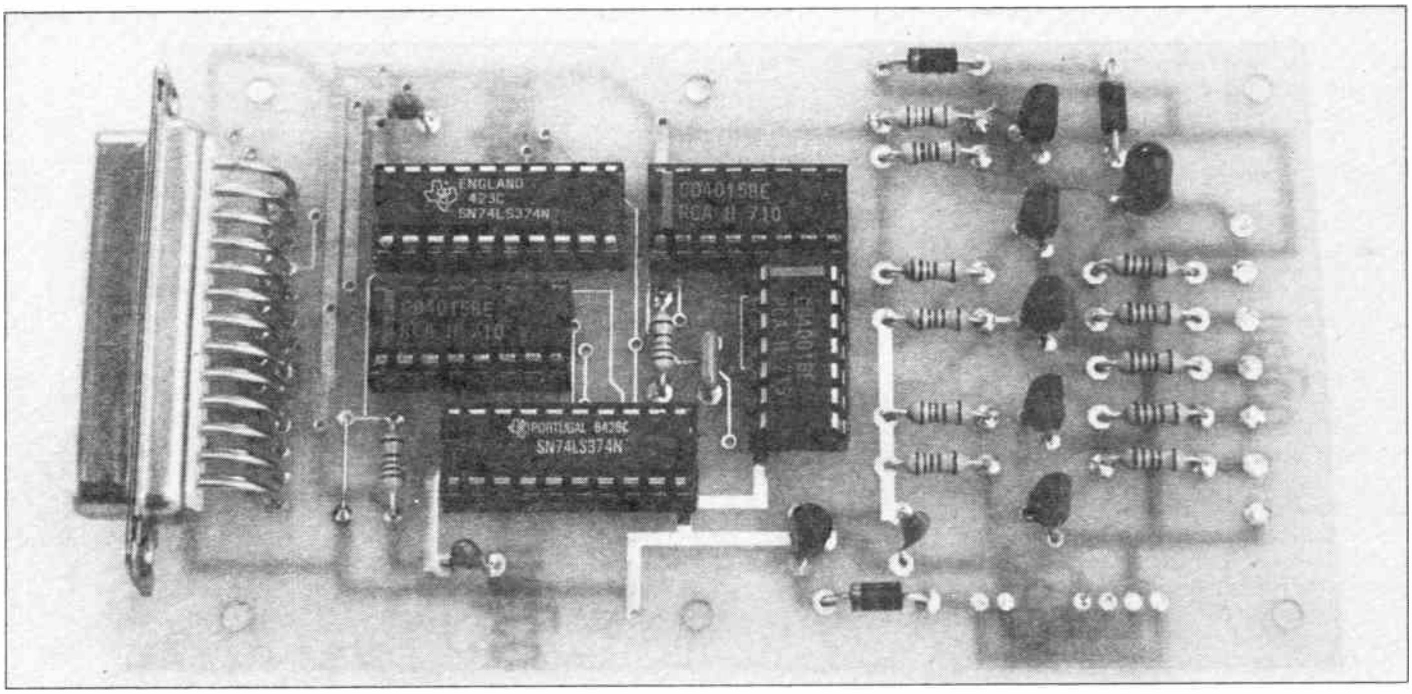


Figure 6. Converter PCB Layout.



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*

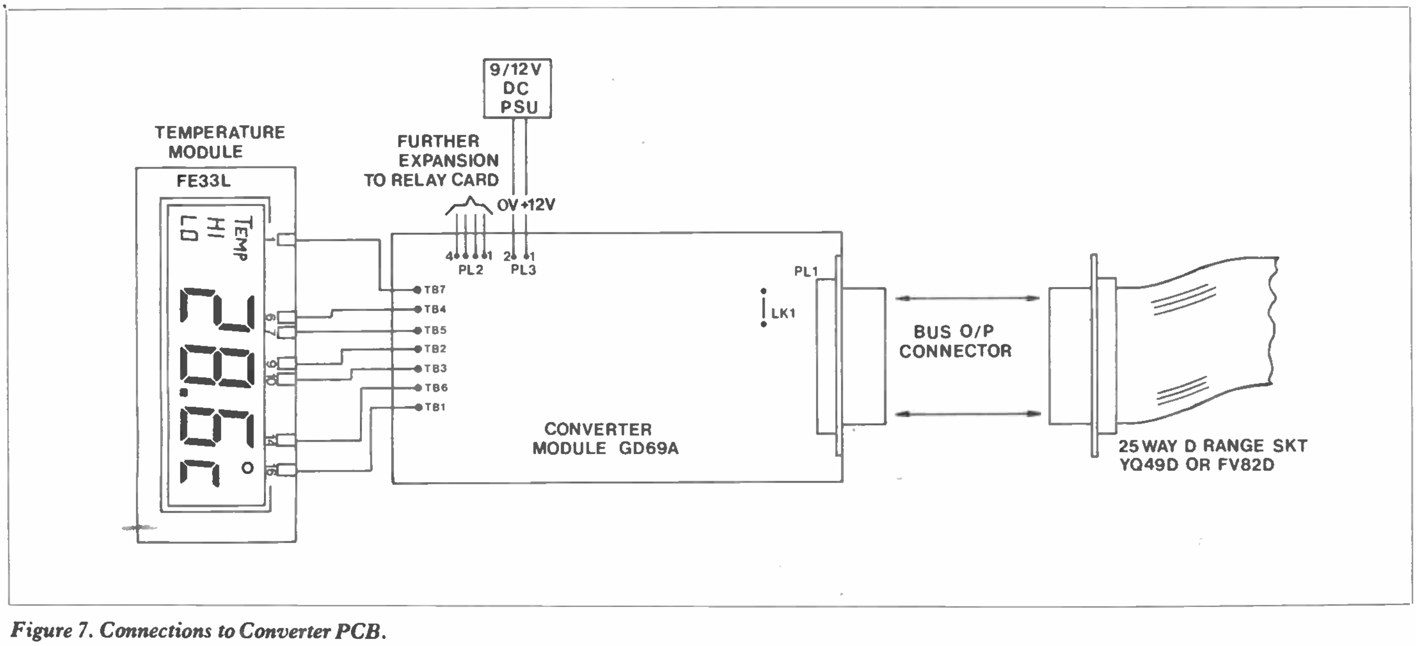


Figure 7. Connections to Converter PCB.

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)

MAPLIN'S TOP TWENTY KITS

THIS MONTH	LAST MONTH	DESCRIPTION OF KIT	ORDER CODE	KIT PRICE	DETAILS IN PROJECT BOOK
1.	(1)	Live Wire Detector	LK63T	£3.95	14 (XA14Q)
2.	(2)	U/Sonic Car Alarm	LK75S	£17.95	15 (XA15R)
3.	(3)	150W Mosfet Amplifier	LW51F	£19.95	Best of E&MM
4.	(5)	Partylite	LW93B	£9.95	Best of E&MM
5.	(9)	PWM Motor Driver	LK54J	£9.95	12 (XA12N)
6.	(6)	Car Burglar Alarm	LW78K	£7.95	4 (XA04E)
7.	(8)	Ultrasonic Intruder Detector	LW83E	£11.95	4 (XA04E)
8.	(–)	VHS Video Alarm	LM27E	£11.95	24 (XA24B)
9.	(11)	I/R Prox. Detector	LM13P	£9.95	20 (XA20W)
10.	(4)	8W Amplifier	LW36P	£5.95	Catalogue
11.	(–)	CMOS Logic Probe	LK13P	£13.95	8 (XA08J)
12.	(10)	27MHz Receiver	LK56L	£8.95	13 (XA13P)
13.	(12)	Servo and Driver	LK45Y	£13.95	11 (XA11M)
14.	(13)	27MHz Transmitter	LK55K	£7.95	13 (XA13P)
15.	(15)	15W Amplifier	YQ43W	£5.95	Catalogue
16.	(17)	Stepper Motor and Driver	LK76H	£16.95	18 (XA18U)
17.	(18)	50W Amplifier	LW35Q	£17.95	Catalogue
18.	(–)	TDA 7000 Radio	LK32K	£12.95	9 (XA09K)
19.	(19)	Xenon Tube-Driver	LK46A	£11.95	11 (XA11M)
20.	(14)	Car Digital Tacho	LK79L	£19.95	Best of E&MM

Over 150 other kits also available. All kits supplied with instructions.
The descriptions above are necessarily short. Please ensure you know exactly what the kit is and what it comprises before ordering, by checking the appropriate Project Book mentioned in the list above – see inside back cover for details.

AMENDMENTS
TO 1988 CATALOGUE

Ultrasonic Intruder Detector (Page 245). The pcb's for this kit are: GB00A (Ultrasonic Xvr PCB) Price £1.95 and GB01B (Ultrasonic IF PCB) Price £1.95.
Spectrum RS232 Interface (Page 294). The pictures for this and the VIC 20 Talkback have been transposed.
Door Guard Battery (Page 307). The order code for the recommended battery for use by 'Door Guard' should be FK67X and not FK64U.

CORRIGENDA

Vol. 4 No. 13. Gas Alarm. Please note that shortest time period set by the links will be at A to D, the medium time is A to C and the longest time period is link A to B. Also R5 is a 100Ω resistor.
Vol. 6 No. 23. Down Converter Channel Switching Unit. The case used to house the switching unit is a DCM5004, order code LH71N.
Vol. 6 No. 24. Frame Store Additional Parts. The transformer T1 should be a 30VA 9V type, order code YK09K.

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		To	Converter Module	
Pin No.	**Description**	**To**	**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.

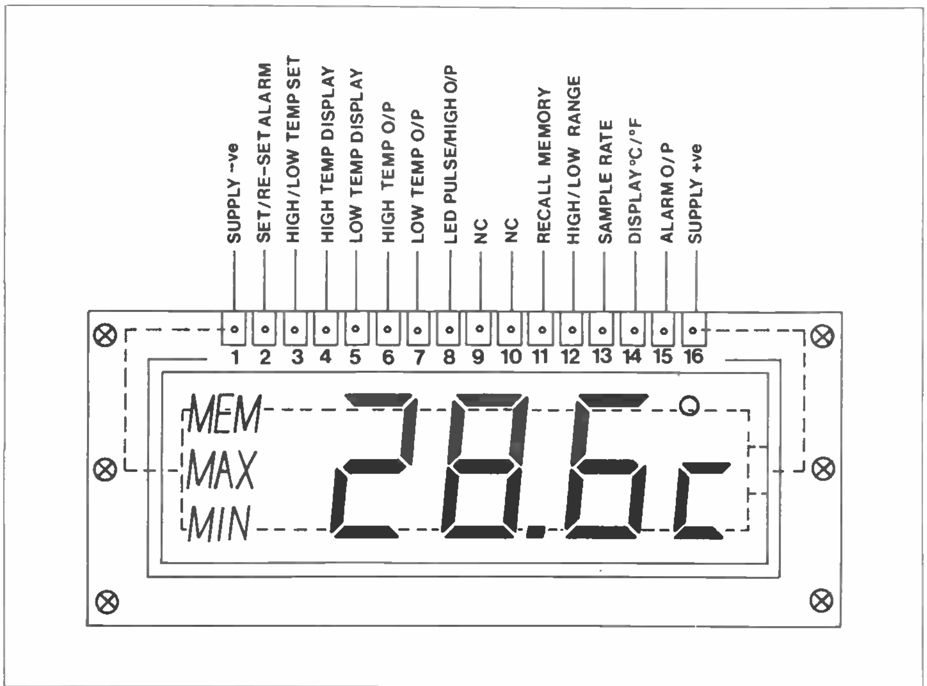
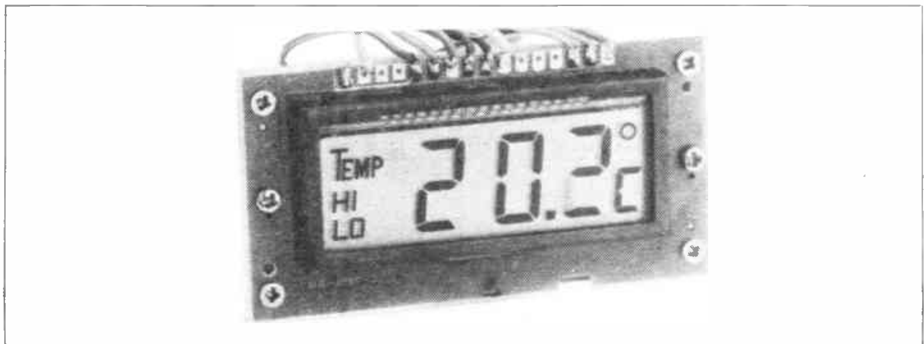


Figure 8. Min-Max Temperature Module FP64U.



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

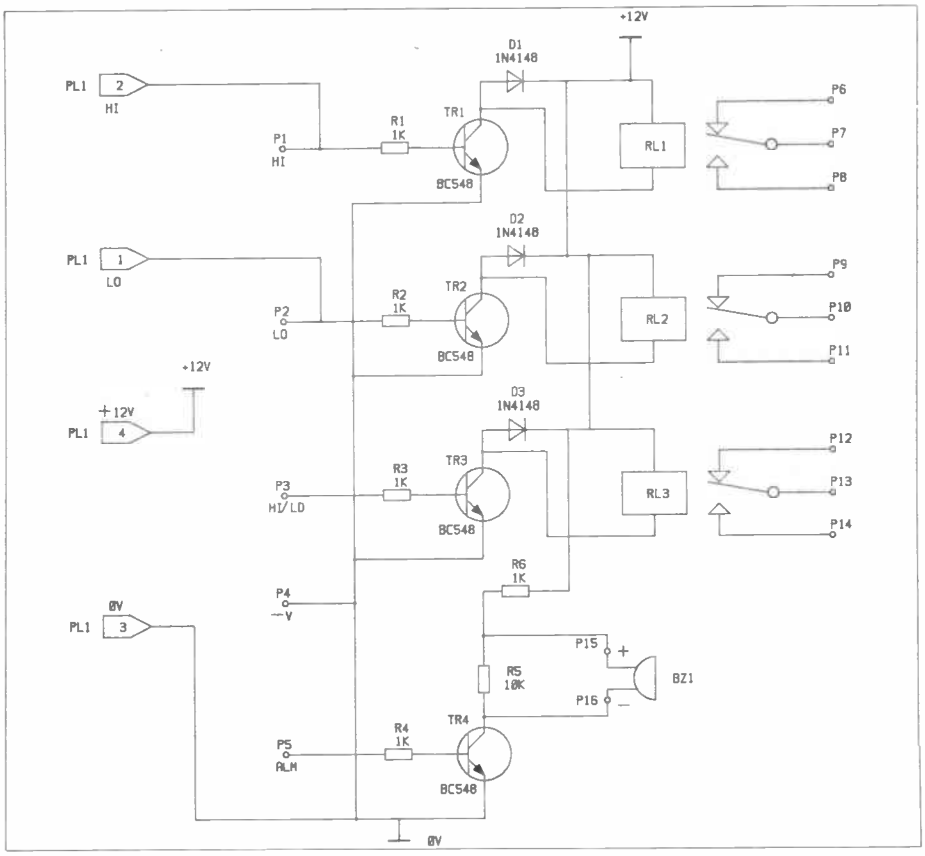


Figure 9. Relay Card Circuit.

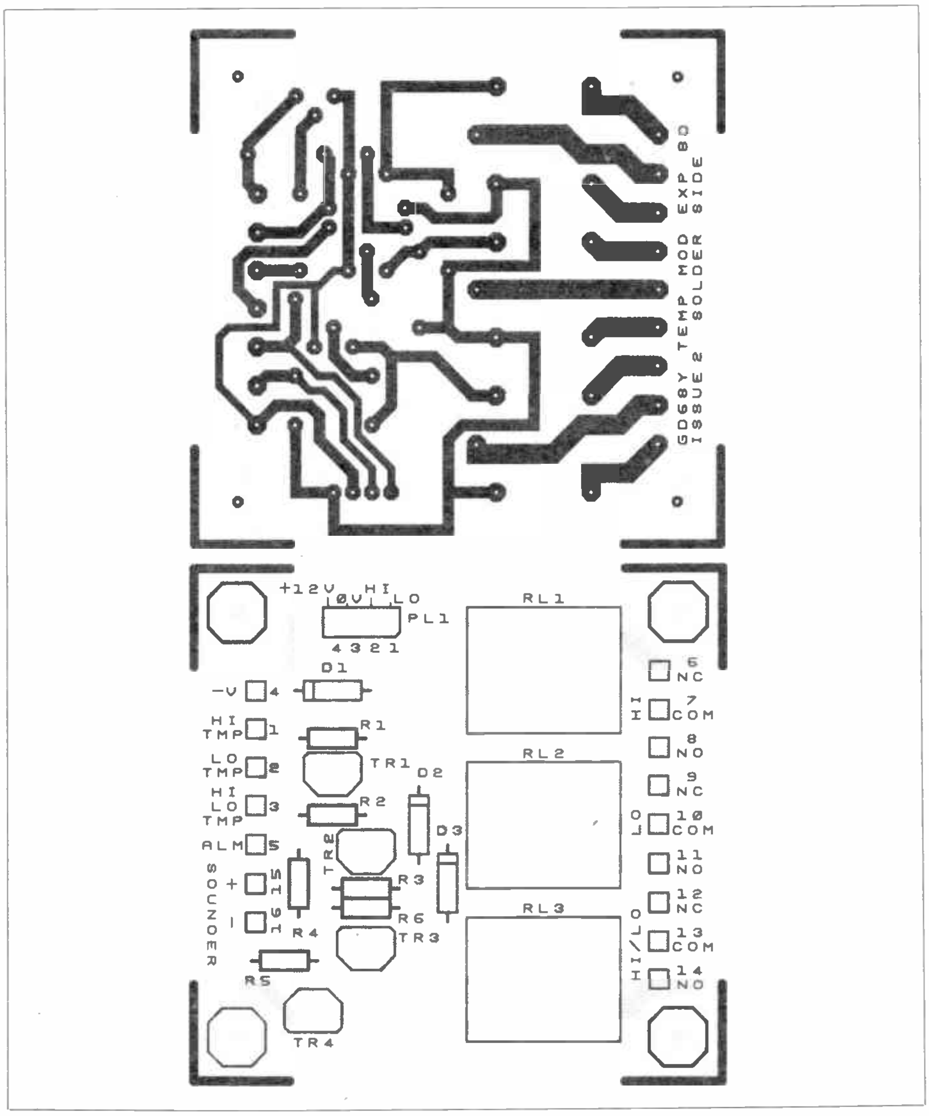
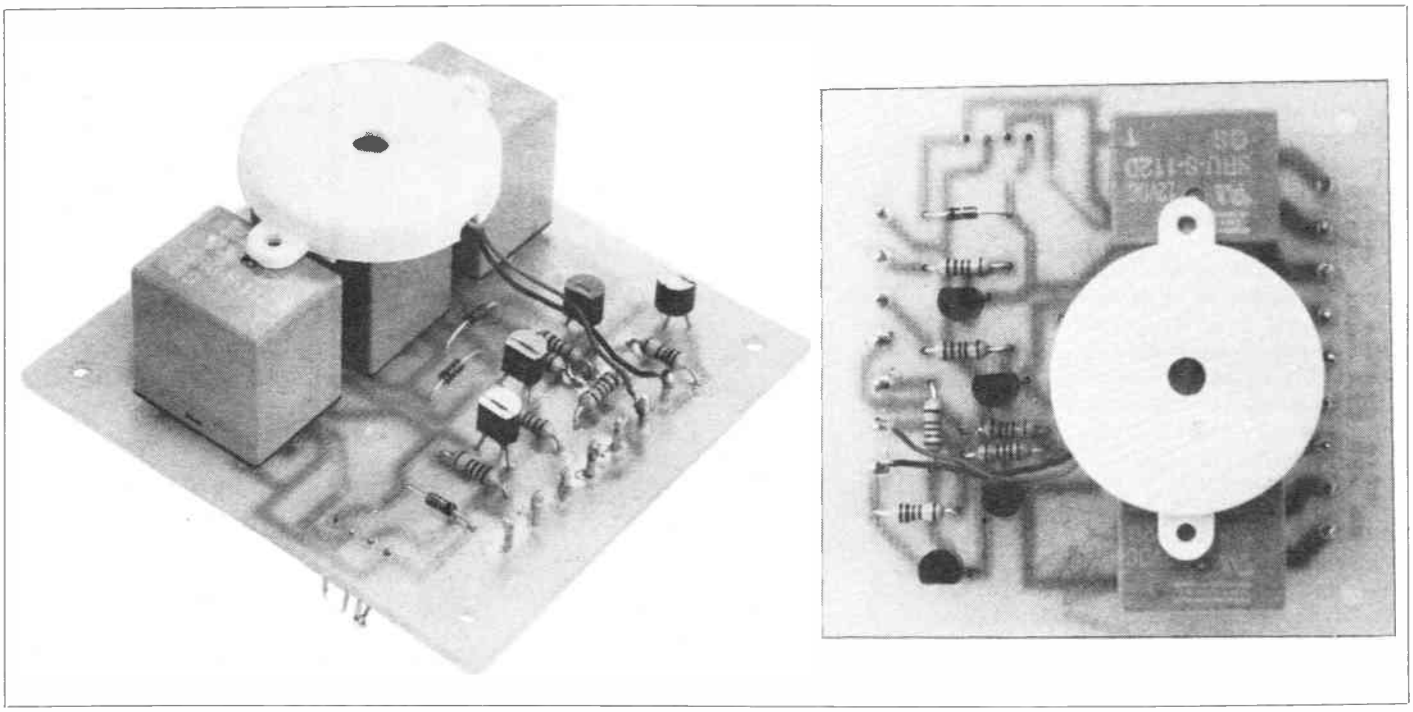


Figure 10. Relay Card Layout.



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

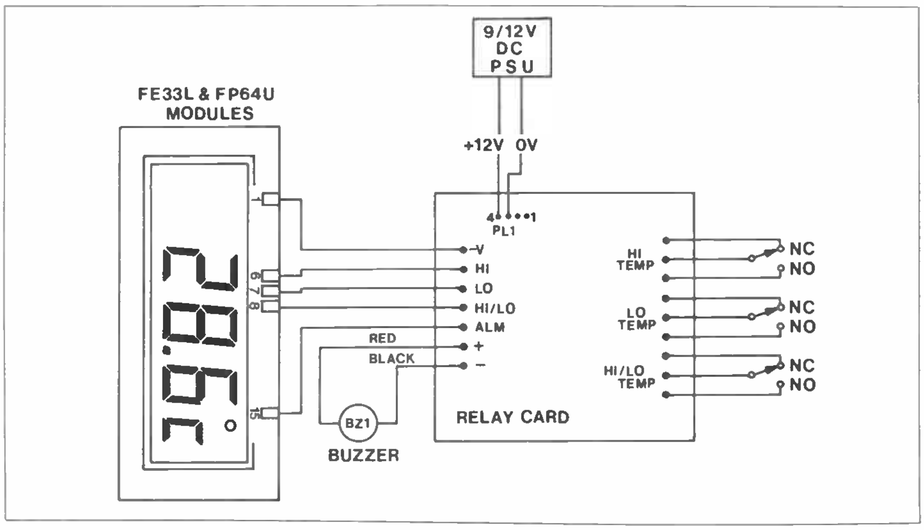


Figure 11. Connections to Relay Card.

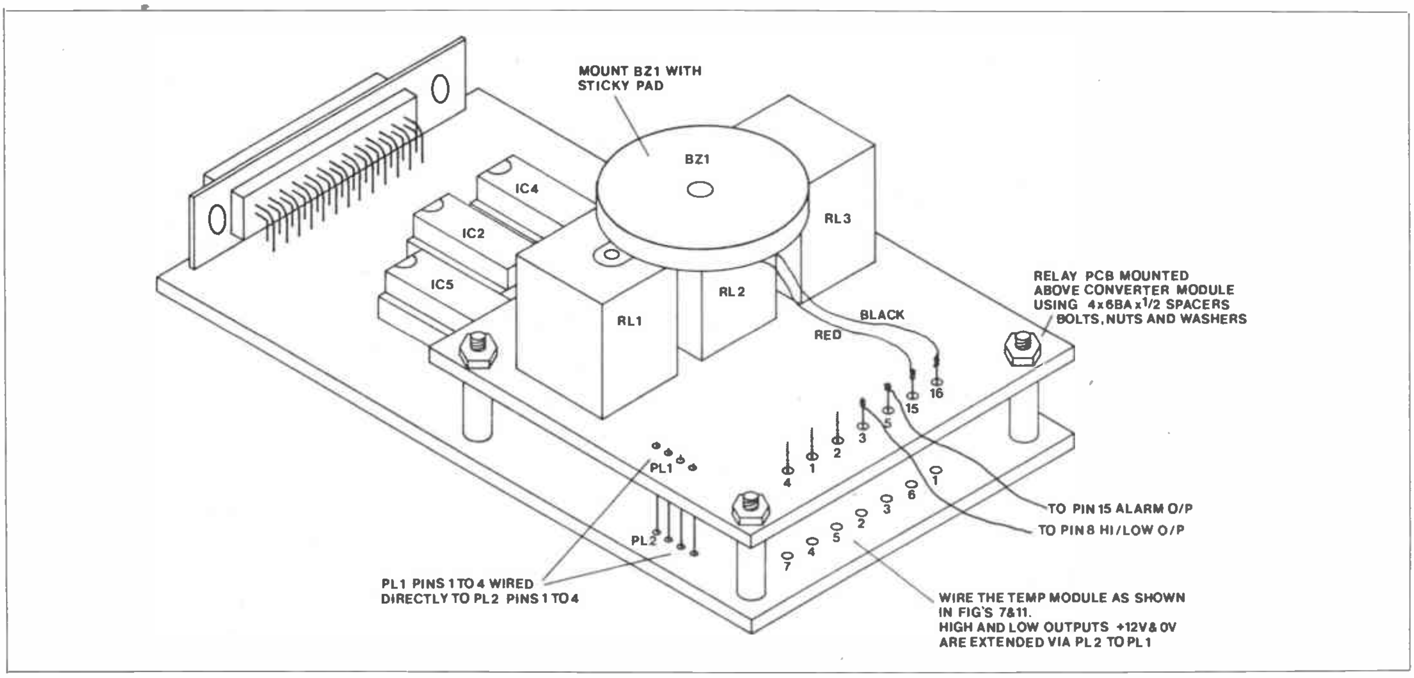


Figure 12. Connecting FE33L to both PCBs.

MAPLIN'S 6 REGIONAL SHOPS

NEW SHOP IN BRISTOL

HELP SERVE YOU BETTER!

Birmingham:
Sutton New Road, Erdington. Tel: 021 384 8411.
Bristol:
302 Gloucester Road. Tel: 0272 232014.
London:
159-161 King Street, Hammersmith W6.
Tel: 01 748 0926.
Manchester:
8 Oxford Road. Tel: 061 236 0281.
Southampton:
46-48 Bevois Valley Road. Tel: 0703 225831.
Southend-on-Sea:
282-284 London Road, Westcliff-on-Sea, Essex.
Tel: Southend-on-Sea (0702) 554000.

For mail order enquiries, please *do not* call our shops as they will be unable to help you.

Before you send your next order to us by post, take a look and see if there's a Maplin shop near you. In our shops you'll find that personal service that even the best mail-order operations cannot match. And you can look at the products before you buy. If you're coming for a particular item, a quick phone call will enable you to be certain the shop has everything you want in stock.

Our shops are pleased to accept Access, Barclaycard, Connect, American Express, Mapcard and cheques up to £50 with a cheque guarantee card. We'll even accept ordinary money as well!

All our shops are close to excellent parking facilities, meters in London and Manchester, and free elsewhere.

The South
In the South our Southampton store is conveniently placed for easy access from all parts of Hampshire and surrounding counties, and is 15 minutes from Portsmouth.

London
Our London store now open 6 full days a week is situated just to the west of the pedestrian shopping centre in Hammersmith, and is just five minutes from the end of the M4 and only a short walk from the District, Piccadilly and Metropolitan lines' Hammersmith station.

The Midlands
In the Midlands, our self service Birmingham store now open 6 full days a week is just 3 minutes from the M6. Turn north at Spaghetti Junction (junction 6), onto the A5127 following the signs to Erdington. As you approach the Erdington roundabout, you'll see the store's 50 space car park directly in front of you.

South-East
Essex and Kent are served by our self-service Southend shop now open 6 full days a week which is right on the A13, just 2 minutes before you reach the centre of Southend. And we're only 30 minutes from the M25 (junction 29) as well.

West
Our West country store in Bristol is open a full 6 days per week. The self-service store can be found on the A38 Gloucester Road, midway between Bristol city centre and the airport.

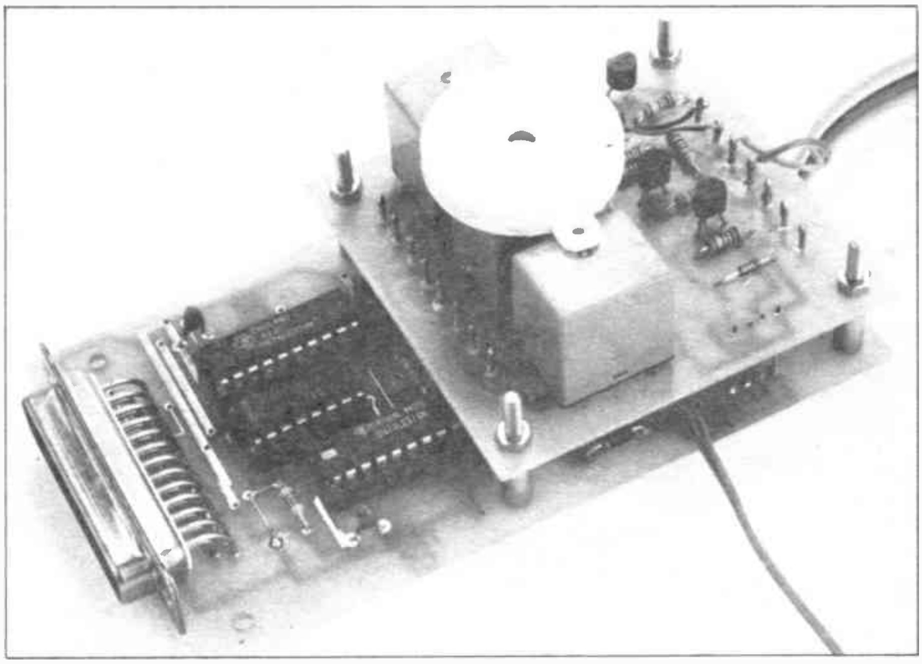
The North
Our self-service store in Manchester, now open 7 days a week, serves the North and is just off the Mancunian Way, opposite the BBC, about 5 minutes from the end of the M602 or junction 10 on the M63.

All our shops are open from 9a.m. to 5.30p.m. Monday to Saturday (9.30a.m. Wednesday) except Southampton which is closed Mondays. In addition Manchester is open Sundays. All shops are closed on Public Holidays. Shops do *not* close for lunch.

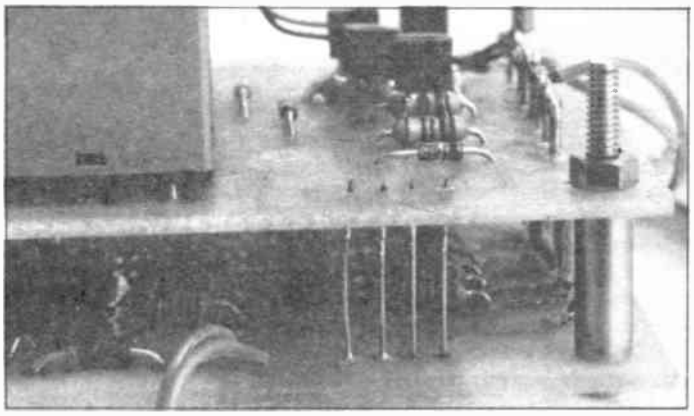
There's a friendly welcome in store for you at any Maplin shop. Our helpful staff may often be able to help with a technical problem or a constructional difficulty.

Call in at a Maplin store and get what you want today. We look forward to serving you.

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.



Connecting the two boards together.

CONVERTER BOARD 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	100nF 35V Tantalum	1	(WW54J)
C2	220nF Monores	1	(RA50E)
C3,4	1μF 35V Tantalum	2	(WW60Q)
SEMICONDUCTORS			
IC1	4001	1	(QX01B)
IC2,3	4016	2	(QW16S)
IC4,5	74HC374	2	(UB62D)
TR1-5	BC183	5	(QB56L)
D1-3	1N4001	3	(QL73Q)
MISCELLANEOUS			
RG1	78L05AWC	1	(QL26D)
LD1	Red LED	1	(WL27E)
PL1	RA D Range Plug 25-Way	1	(FG66Y)
PL2	Minicon Latch Plug 4-Way	1	(YW11M)
PL3	Minicon Latch Plug 2-Way	1	(RK65V)
	P.C. Board	1	(GD69A)
	DIL Socket 14-Pin	1	(BL18U)
	DIL Socket 16-Pin	2	(BL19V)
	DIL Socket 20-Pin	2	(HQ77J)
OPTIONAL			
	AA Battery	1	(YG00A)
	Temperature Module	1	(FE33L)
	25-Way D Range Socket	1	(YQ49D)
	25-Way D Range Socket IDC	1	(FV82D)
	Bezel	1	(FE35Q)
	External Probe	1	(FE34M)
	Min-Max Temperature Module	1	(FP64U)
	Low Temp. Probe	1	(FP65V)
	High Temp. Probe	1	(FP66W)

A complete kit of all parts, excluding optional items, is available for this project:
Order As LM36P (Converter Kit) Price £14.95
The following item included in the above kit list is also available separately, but is not shown in the 1988 catalogue:
Temp Mod Ser/Par PCB **Order As GD69A Price £5.95**

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	Minicon Latch Plug 4W	1	(YW11M)
	6BA x ½in. Threaded Spacer	1 Pkt	(LR72P)
	6BA x 1in. Bolt	1 Pkt	(BF07H)
	6BA Nuts	1 Pkt	(BF18U)
	6BA Washers	1 Pkt	(BF22Y)
	Quickstick Pads	1 Stp	(HB22Y)
	P.C. Board	1	(GD68Y)
	Veropins 2145	1 Pkt	(FL24B)

A complete kit of all parts is available for this project:
Order As LM37S (Relay Card Kit) Price £7.50
The following item in the above kit list is also available separately, but is not shown in the 1988 catalogue:
Temp Mod Relay PCB **Order As GD68Y Price £2.50**

TEST GEAR AND MEASUREMENTS

by Danny Stewart
Part 7

The cathode ray oscilloscope (CRO or 'scope for short) is not strictly a wave analyser like a harmonic analyser or spectrum analyser. These last two separate the components, e.g. fundamental wave from harmonics.

The CRO merely displays the waveform: simple or complex and leaves the viewer to form his own impression. Nevertheless, it is a most useful tool and no laboratory is ever without one. Most service departments also own one if they can afford it.

Cathode Ray Tube Features

Central to CRO operation is the tube itself, see Figure 1. The gun at the base of the tube emits electrons. The electron stream is accelerated by anodes at high potentials, (typically 1000V) and deflected horizontally and vertically by deflecting plates so that they trace the required pattern on the screen.

The screen is coated with phosphor dots which glow for a fixed period. Next to the cathode is a cylindrical control grid made of nickel. The intensity control on the CRO is connected to this grid which is negative with respect to the cathode. Turning the intensity control down makes the grid more negative hence reducing the electron beam.

The focusing anode is placed in between the two accelerating anodes and a CRO control marked focus helps produce a nice sharp trace.

CRO Operation

In order for the cathode ray tube to function it must be supplied by voltages to its gun, anodes and deflection plates, see Figure 2. The horizontal sweep is a sawtooth waveform which is applied to the horizontal deflection plates. The rate of sweep can be varied by the TIME/DIV control and alters the gradient of the sawtooth. Without any input signal, this horizontal sweep will trace a straight line across the screen. A control helps to alter its horizontal position on the screen. If the speed of the sweep is increased by varying the TIME/DIV switch then the trace will look like a permanent line since it is being swept before the phosphor glow has time to fade away.

Application of an input signal to the vertical deflection plates has the effect of lifting the horizontal line to whatever shape the input waveform is. Notice the delay in the vertical sweep to give the horizontal sweep a chance to start, or part of the input will be lost. Since the leading edge of the input signal is itself used to start the horizontal timebases generator a delay of 0.15μs is required. In practice a delay of 0.25μs is built-in.

CRO Screens

Some means is required for measuring the amplitude and period of the wave displayed on the screen. This is achieved by a square pattern called a graticule, as shown in Figure 3. The graticule may be internal to the screen which would increase the cost of the tube. Or the graticule could be inscribed on plastic and mounted externally on the screen. The advantage of an external graticule is its cheapness and the fact that it can be changed for another, say, marked in degrees. The disadvantage of the external graticule is parallax. The graticule is usually in centimetre divisions and the horizontal scale is read as so many ms or μs per centimetre, depending on the selector setting. The vertical scale is in volts or μV or mV per centimetre, again depending on the rotary knob setting.

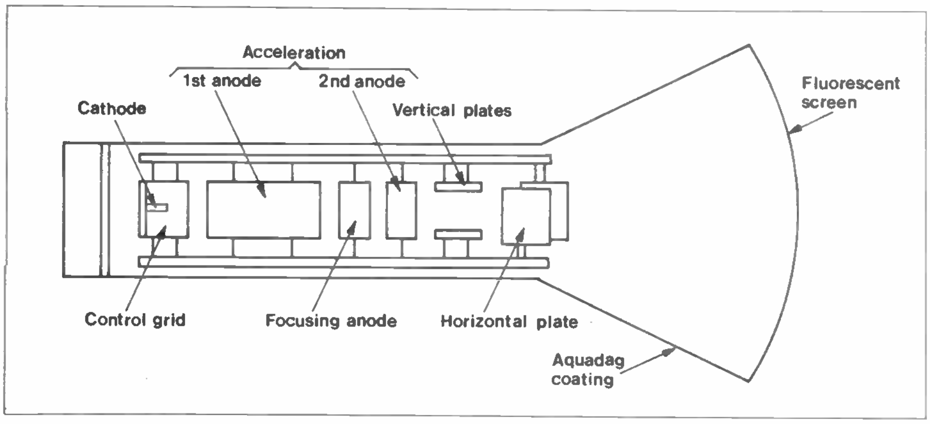


Figure 1. Cathode Ray Tube.

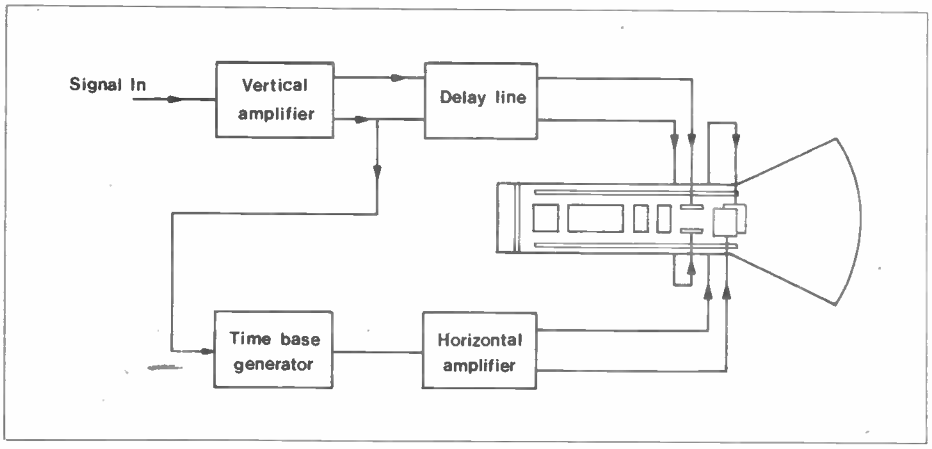


Figure 2. Cathode Ray Oscilloscope.

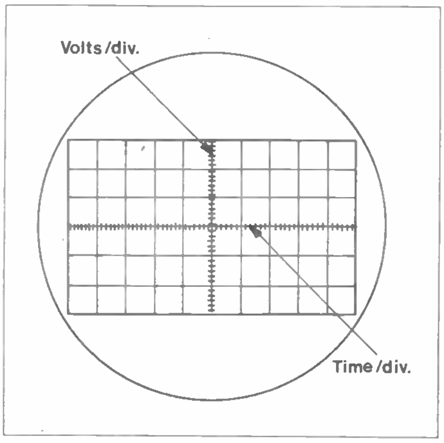


Figure 3. Graticule.

The inside of the screen is coated with phosphor which can be destroyed if the intensity control is left too high. The other controls which help obtain a neat trace are the focus and astigmatism controls. When the electron beam strikes the phosphor, secondary electrons are emitted which could cause false images. Therefore, these are conducted away by the aquadag coating inside the tube.

Figure 4 shows the characteristics of different kinds of phosphor. P31 is the brightest known phosphor and is used in most CROs since it also has medium persistence.

Type	Colour	Relative* Luminance	Time to decay to 0.1%	Remarks
P2	Blue-Green	55%	120ms	
P4	White	50%	20ms	TV application
P7	Blue	35%	1,500ms	Low speed observation
P11	Purple-Blue	15%	20ms	
P31	Yellow-Green	100%	32ms	Brightest known phosphor

*Relative to P31

Figure 4. Phosphor Characteristics.

For a display that changes very slowly P7 would be used. Materials that emit light when stimulated by light are called fluorescent. Materials which continue to emit light after the stimulating light has been turned off are called phosphorescent. Persistence of phosphors is measured as the time taken for the phosphorescent light to decay to 10% of the original stimulating light.

Delay Lines

Delay can be introduced by using LC sections in cascade. A single section arranged in a T shape is shown in Figure 5. This filter will pass all frequencies up to a cut off frequency of $f = 1/\pi\sqrt{LC}$

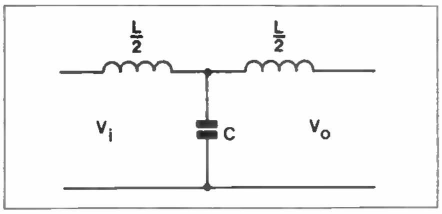
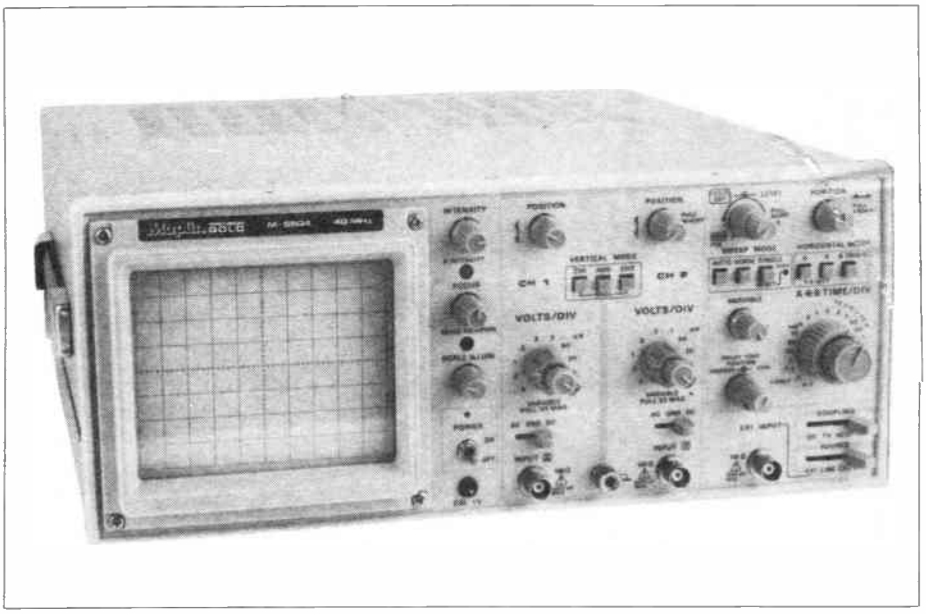


Figure 5. T Filter.

The period of delay is $= 1/f$ or $\pi\sqrt{LC}$ so several of these will give the required delay.

Mutual coupling between the arms of the T gives the popular m-derived sections. There are as many types of filters as the positions a circus contortionist can think of. Another practical type of delay line is the symmetrical type shown in Figure 6. To be effective, the L and C components must be carefully apportioned and the capacitors properly tuned.

A more rugged delay line that does not require tuning and occupies less space is shown in Figure 7. It consists of a coaxial cable with the outer made of braided wire as usual to reduce eddy currents. The inner is a helical wire on a flexible tube which gives the cable a high inductance per unit length. Capacitance is provided by the dielectric insulation.



40MHz dual beam oscilloscope.

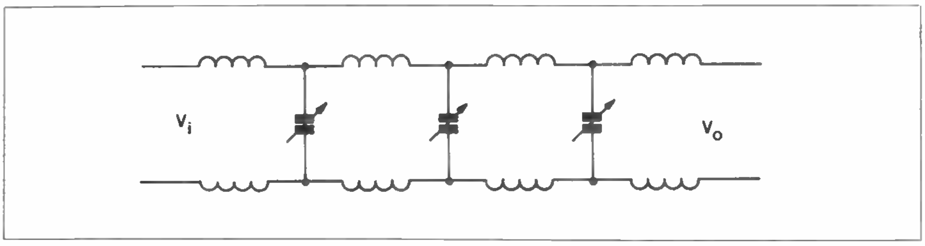


Figure 6. Symmetrical Delay Line.

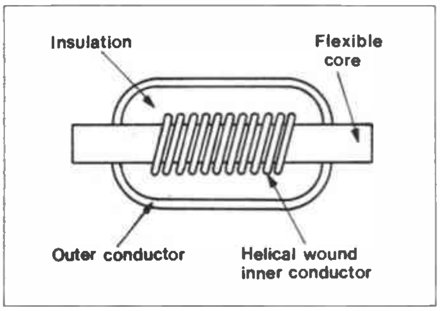


Figure 7. Coaxial Delay Line.

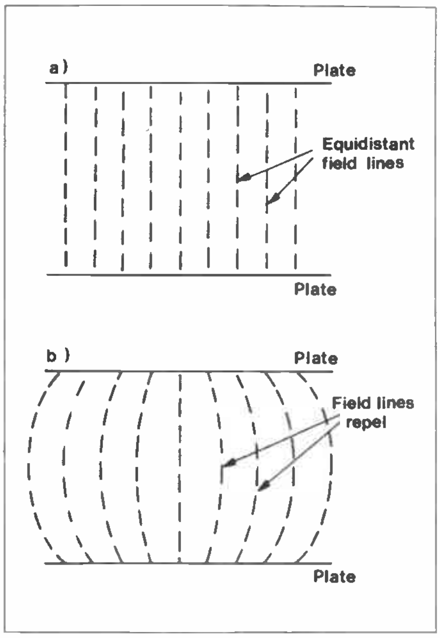


Figure 8(a). Perfect Electric Field.
8(b). Practical Electric Field.

CRO Focusing and Deflection

In a perfect world the electric field between two charged plates would be as shown in Figure 8a. In practice, the lines repel each other and cause spread and bowing, Figure 8b. If now, points on the electric field of the same potential are joined together, the equipotential lines of Figure 8b are obtained. Notice that the equipotential lines are at right angles to the electric field. If we think of an equipotential line as a lens, then an incident ray will be refracted just as in optics. Figure 9 shows the path of an electron through an equipotential line. The same equation for light applies:

$$\frac{\sin \theta_1}{\sin \theta_2} = \frac{V_2}{V_1}$$

Where V_1 is the initial velocity and V_2 is the final velocity. Since the angles are not equal, the velocities are not equal, i.e. the ray has undergone a focusing effect.

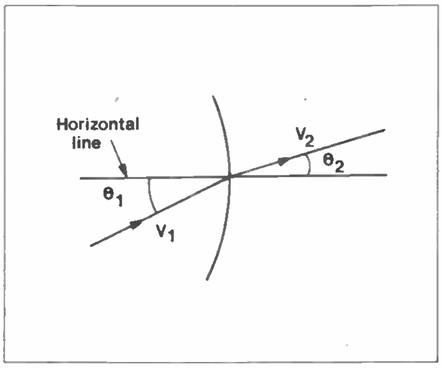


Figure 9. Electron path through an Equipotential Line.

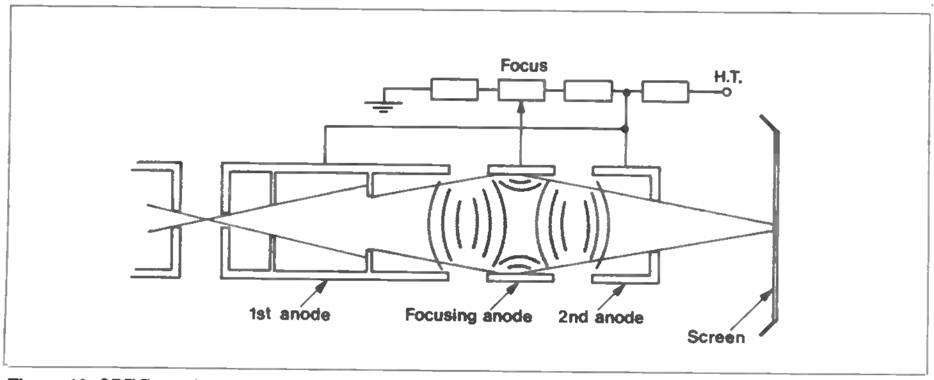


Figure 10. CRT Focusing.

The focusing and accelerating anodes in a practical CRT are not plates but cylinders, Figure 10. So instead of applying a voltage gradient between plates, a single voltage on each of the cylinders will serve to produce the equipotential lines. Usually voltages of 1500V are applied to the first and second accelerating anodes and 500V to the focusing anode. This helps form the double concave electron ›ns shown in Figure 10 whose focal length is altered by altering the voltage to it. The effect is to move the focal point of the beam along the axis of the tube. The baffles in the first accelerating anode help to collimate (gather) the light.

So much for focusing. For deflection, the electron stream traces a parabolic path as it is deflected to the edges of the screen compared to the centre, see Figure 11. The derivation of the equation is outside the scope of this article but whatever path the stream takes, it is clearly longer to the edges of the screen compared to the centre. This leads to a distorted picture and remedies are required.

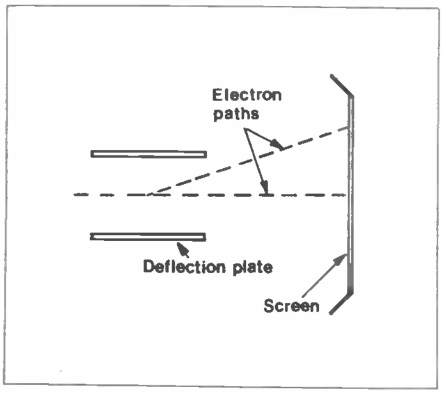


Figure 11. Parabolic path of Electron Stream.

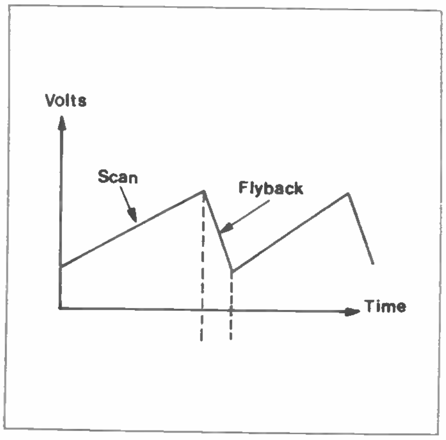


Figure 12. Horizontal Sweep.

The remedy is to use a curved screen as well as correction circuits. The higher the electron velocity, the brighter the trace, but a higher deflection voltage is also required.

Figure 12 shows the waveform required to give a horizontal sweep. Notice that the flyback time is short compared to the scan time. The electron beam is also cut off during flyback so as not to trace a line on the screen. The sawtooth required for this sweep is obtained from an RC circuit whose basic operation is shown in Figure 13a. At the start, with the switch closed, the charge across the capacitor is zero. When the switch is opened, the capacitor charges up exponentially and its instantaneous value is given by the equation:

$$e_c = V(1 - \exp{}^{-t/}RC)$$

Where t is the time to charge to the full value V and RC is called the time constant. The capacitor charges to the full voltage V in five constants. But this is an exponential curve, not a sawtooth. If the charging curve could be brought to an abrupt halt after say 0.2 of a time constant, then it is less than 10% away from linearity and has reached 0.1 of its final value. It reaches 0.63 of its final value after one time constant, see Figure 13b.

The switch could be any one of several devices: gas thyratron, thyristor, unijunction transistor or silicon controlled switch (SCS). Figure 14a shows a unijunction transistor (UJT) used as a switch. When the circuit is switched on, capacitor C starts charging up a voltage V_B, see Figure 14b. But as soon as the emitter voltage is lifted high enough, the emitter-base 1 junction conducts and offers a low resistance path to the capacitor. The capacitor discharges through this path and as its voltage decreases, the emitter voltage also drops till the junction is cut off. The cycle then repeats in a free running mode. Since R and C determine the charging rate they are called the timing circuit. If C is made to vary in steps, then R can be made to sweep the frequency range within this step. In this way a TIME/DIV selector can be built-up.

Figure 15 shows the set up of the horizontal deflection system. There is a facility for an external trigger. If an internal trigger is used then the sweep generator provides a 10V ramp. The second amplifier turns this into two ramps: a positive going ramp and a negative going ramp for application to the deflection plates via a push pull amplifier. Apart from providing two outputs, the push pull amplifier gives good linearity. Other methods of improving linearity are constant current charging or the Miller circuit. In constant current charging the timing capacitor is charged from a source of constant current or the voltage across the resistor is kept constant (and therefore the current through it - a bootstrap circuit). The Miller circuit uses operational amplifiers and integrators to convert a step input into a ramp. The horizontal position control is a DC voltage which moves the trace up or down the screen.

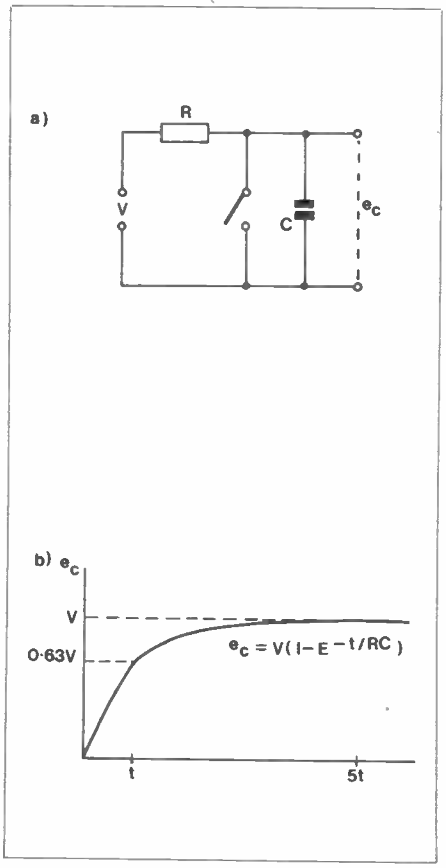


Figure 13(a). RC Sweep Circuit.
13(b). Charging Waveform.

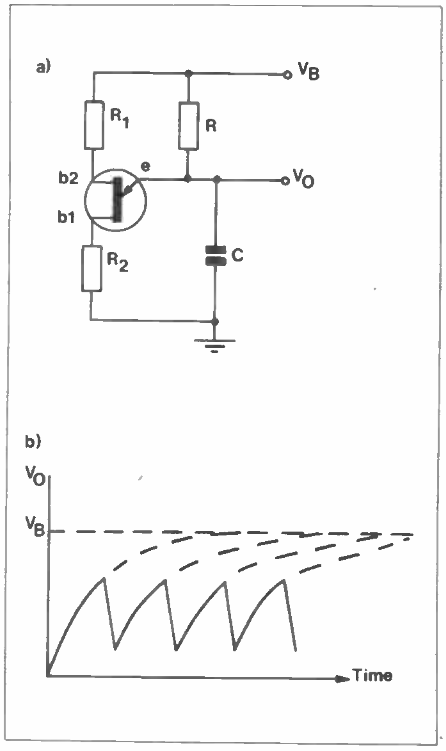


Figure 14(a). UJT Sweep Circuit.
14(b). Charging Waveform.

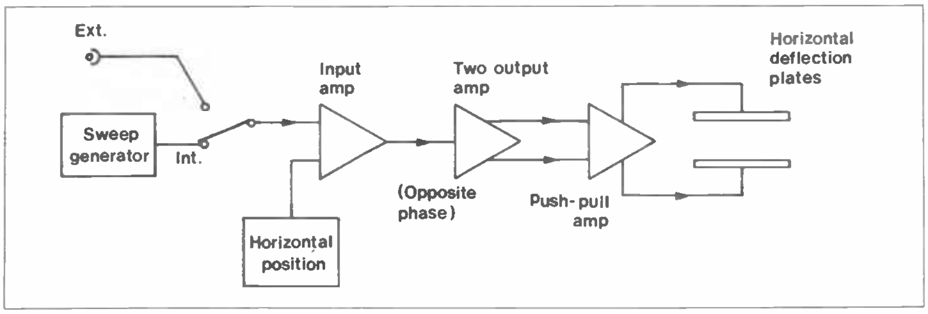


Figure 15. Horizontal Deflection System.

For vertical deflection there is no need to generate any signal, the deflection being entirely dependent on the input signal. However, there are several important considerations to avoid distorting the input. First of all, the input offers a choice of DC, AC, or ground. In the DC mode, the signal is fed directly into the input amplifier and is useful for examining DC voltages in a circuit. If the AC mode is selected then a capacitor blocks any DC and any AC signals are examined separately from any DC present. The ground position on the slider switch is between the AC and DC positions and is used to remove any charge on the internal capacitors. These internal capacitors are essential in designing the input attenuator which takes into account the gain of the vertical amplifier. Most instruments offer steps in ratios of 1:2:5. So a typical range would be 0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 50 volts per division.

Since a CRO operates from DC to 25MHz, some kind of frequency compensation is required in switching the attenuator through the ranges. The amplifier's input impedance is represented by R_2 and C_2 in Figure 16. Since this shunts the input attenuator R_1, a capacitor C_1, is required to balance the input capacitance. The equivalent circuit is shown in Figure 17 as a bridge. When the bridge is balanced, link A B can be removed and the voltage divider becomes resistive. The output voltage is then:

$$V_o = \frac{R_2}{R_1 + R_2} V_i$$

At balance $\frac{R_1}{\omega C_1} = \frac{R_2}{\omega C_1}$ or $R_1C_1 = R_2C_2$

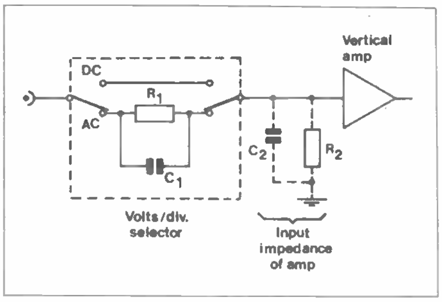


Figure 16. Input Attenuator.

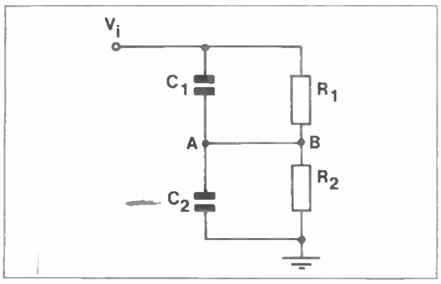


Figure 17. Equivalent Circuit.

R_1 and C_1 are chosen so that the CRO presents the same input impedance to the circuit under test, regardless of frequency or attenuator setting. A typical input impedance is 1MΩ and 33pF.

A quick practical method of setting up C_1 is to use an adjustable capacitor and a 1kHz square wave. Figure 18a shows that when C_1 is properly adjusted, the square wave out will be the same as the square wave in. Figure 18b and 18c show what happens when the waveform is overcompensated and undercompensated respectively. A sine wave could also be used but the effect is less noticeable. An overcompensated sine wave is merely a larger wave and an undercompensated sine wave is a smaller wave.

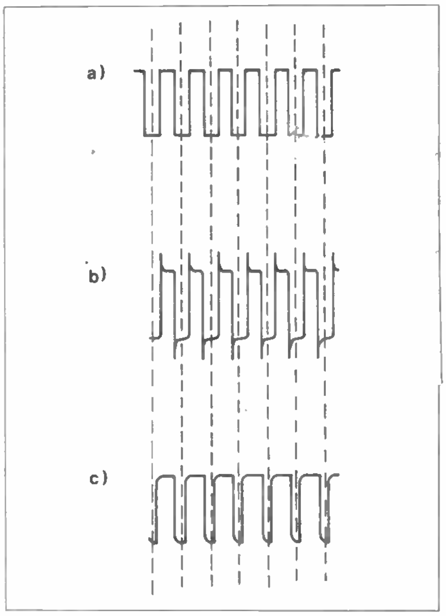


Figure 18(a). Compensated.
18(b). Overcompensated.
18(c). Undercompensated.

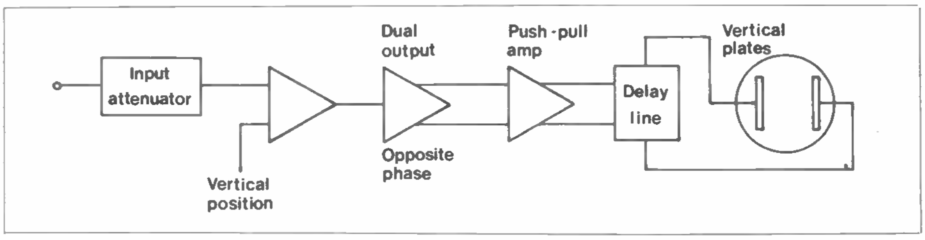


Figure 19. Vertical Deflection System.

A block diagram for the vertical deflection system is shown in Figure 19. As with the horizontal deflection system there is a DC bias to alter the vertical deflection position, a dual output to the deflection plates and a push pull amplifier to improve linearity. The difference from the horizontal deflection system is the input attenuator we have just discussed and the presence of the delay line.

Sweep Synchronisation

Since the relaxation oscillator which generates the sawtooth is free running, there is nothing to synchronise it with the input signal. The input will be in synchronisation with the ramp by accident if there are a whole number of wavelengths in the time it takes to generate a ramp, see Figure 20. Instead, if the input signal is used to provide synchronisation pulses which will control the charge/discharge cycle of the capacitor then the input will be in sync with the horizontal timebase. The input signal is used to produce sync pulses by the usual shaping techniques: amplify, truncate, differentiate to produce timing spikes, then use to trigger a multivibrator. If these sync pulses are then superimposed on the péak voltage of the UJT sweep of Figure 14a, the result is shown in Figure 21. At first, the sync pulses have no effect, but provided the period between pulses is shorter than the ramp period, a sync pulse will hit a rising ramp causing the timing capacitor to discharge through the UJT. The ramp is terminated and

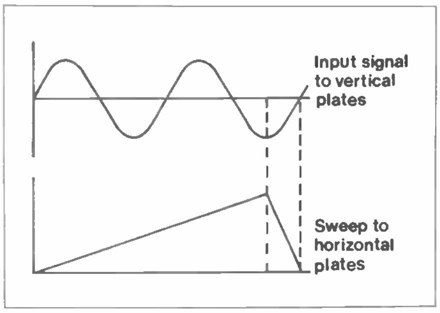


Figure 20. Input in Sync with Ramp.

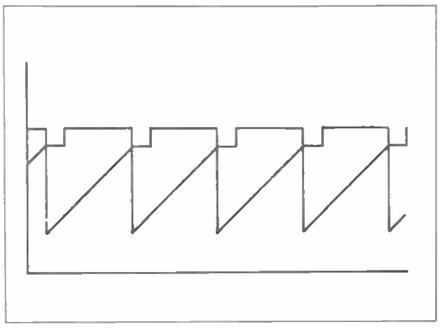


Figure 21. Sync pulses for Synchronisation.

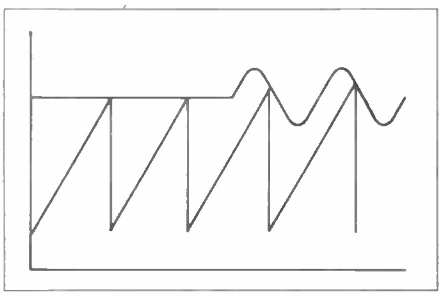


Figure 22. Sine wave for Synchronisation.

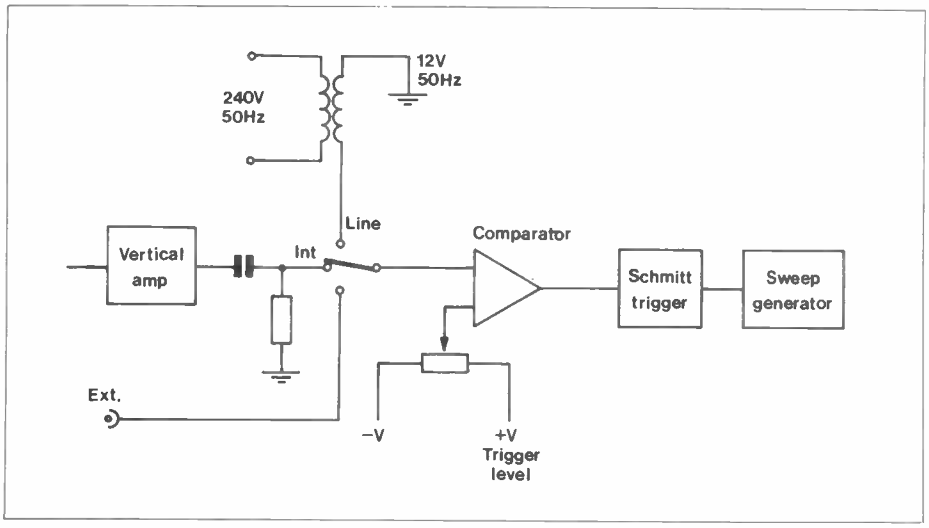


Figure 23. Triggered Sweep.

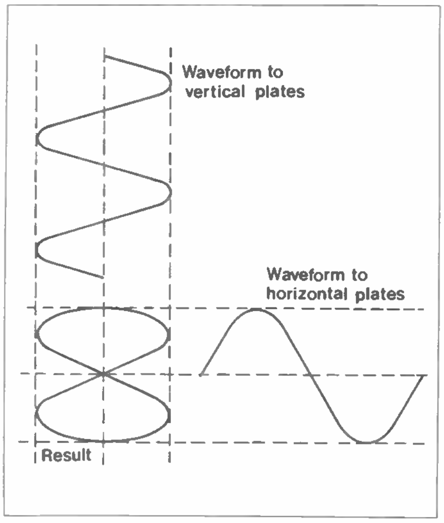


Figure 24. Frequency Ratio 2:1.

so are subsequent ramps. Pulses are not essential for synchronisation. A sine wave superimposed on the peak voltage will do just as well, Figure 22. The ramp continues to rise till it hits the sine wave.

Most CROs have a sync selector marked INT-EXT-LINE. In the INT mode, a sample of the input signal is taken and sync pulses generated by the wave shaping techniques described above. In the EXT mode, almost any signal applied externally is sufficient to undergo waveshaping. In the LINE mode a sample of the mains voltage is taken and therefore the signal is in sync with the mains. This is useful for removing mains interference or proving that a given interference is coming from the mains.

Another front panel control is TRIGGER LEVEL shown in Figure 23. When this is adjusted to the required setting, the sweep does not start till the trigger level of the input signal exceeds this setting. For this purpose a comparator is used. Figure 23 also illustrates the concept of the triggered sweep, i.e. the ramp generator does not begin to sweep until permitted by a trigger pulse. The advantage is that short duration signals can be observed stretched across the screen since the trigger is obtained from the signal itself. When the comparator produces an output, the Schmitt trigger causes the sweep generator to produce a new ramp.

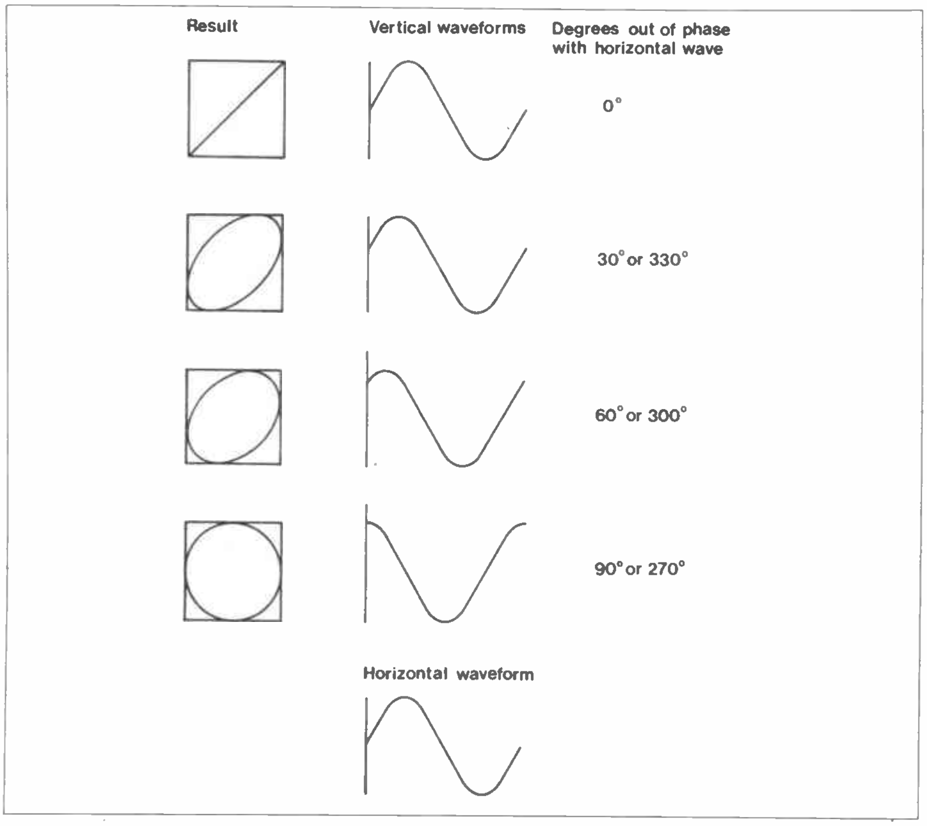


Figure 25. Lissajous Figures.

Lissajous Figures

When sine waves are applied to both horizontal and vertical deflection plates, Lissajous figures are obtained. Figure 24 shows the result of applying a sine wave to the vertical plates twice the frequency of the sine wave applied to the horizontal plates. The result is a figure of eight. If tangents are drawn against the vertical and horizontal of this figure of eight then the vertical tangent touches it in two places but only once in the horizontal plane. This shows a 2:1 frequency ratio.

Some common Lissajous figures are shown in Figure 25. Two factors determine the shape, the amplitude as well as the phase of the two signals. A circle is formed only when the signals are equal in amplitude and 90° or 270° out of phase. To keep matters simple, let us assume both signals are equal in amplitude. Figure 25 then shows the relationship when phase is altered. If now, for each of these cases, the amplitude of the vertical

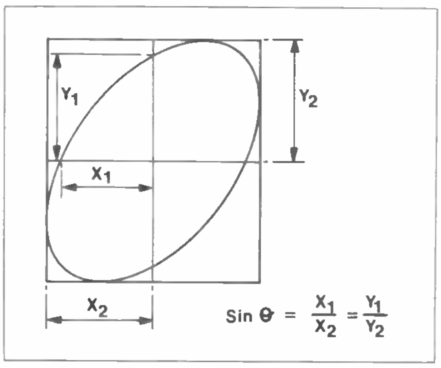


Figure 26. Phase angle from an Ellipse.

signal is increased, the straight line assumes an angle greater than 45° and the ellipse has its major axis along the vertical plane. If the amplitude of the horizontal signal is greater than that of the vertical signal then the straight line makes an angle less than 45° with the horizontal and the major axis of the ellipse lies along the horizontal plane. The ellipse in particular is useful for calculating the difference in phase between two signals of the same frequency. From Figure 26 the angle is given by:

$$\sin\theta = X_1/X_2 = Y_1/Y_2$$

For ease of reading on the graticule, the horizontal and vertical scales can be expanded so that the ellipse fills a whole square.

CRO Probes

There are many reasons for using a probe. Basically probes extend the range of the CRO. For instance a probe could measure signals higher or lower than those acceptable to a CRO by amplifying or attenuating the signals. Probes can also match the impedance of the circuit under measurement to that of the CRO to ensure that one does not

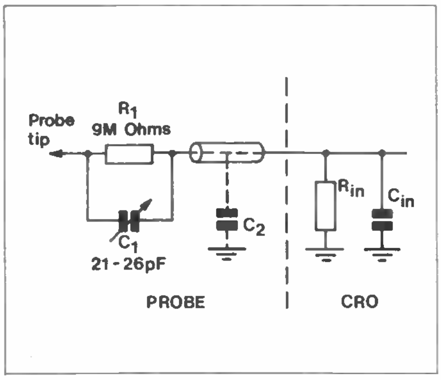


Figure 27. Times ten probe.

load the other. Probes can be either active or passive but in all cases must pass the signal undistorted.

Two of the most common passive probes are the X1 (times one) and X10 (times 10). The X1 does not provide either amplification or attenuation but can provide impedance matching. In particular, the extra six feet or so of cable has leakage capacitance of about 50pF/per foot and must be compensated. If not compensated, it will shunt high frequencies but can still be used for low frequencies, e.g. measuring mains (50Hz) interference.

Figure 27 shows a times ten probe. Most CROs have an R_{in} of 1MΩ and C_{in} of 30pF. With DC voltages, only the resistances are significant and act as a 10:1 voltage divider:

$$V_o = V_i \frac{R_{in}}{R_1 + R_{in}} = 0.1V_i$$

For AC voltage the time constant of the CRO must equal the probe time constant so as not to distort the waveform:

$$R_1C_1 = R_{in}(C_{in} + C_2)$$

For a six foot coax C_2 = 6 x 30pF and R_{in} $(C_{in} + C_2)$ = 1MΩ (180 + 20pF) = 200μs

If R_1 = 9MΩ, then C_1 = 200/9 = 22.22pF.

Now C_{in} can vary between 15pF and 50pF, therefore C_1 must be made adjustable between 21pF and 26pF.

A quick way of adjusting C_1 is to connect a 1kHz waveform and adjust it according to Figure 18.

Dual Beam, Dual Trace and Storage CROs

To get two traces on the screen, two electron guns can be used or a single gun with the beam split in two. Two sets of vertical deflection plates will also be required. This arrangement is expensive.

The alternate method of producing a dual trace when there are two inputs is to switch between the two, i.e. each scans for only a short period. The arrangement is shown in Figure 28 where A and B are the signals requiring comparison. Electronic circuits, in television say, are complex and very often it is necessary to display simultaneously, signals in different parts of a circuit, so that they can be compared in time or phase.

A mode selector on the CRO allows display of A or B only or four different combinations of A and B:

i) A and B can be used in the X-Y mode, i.e. one of them can be used to trigger the horizontal sweep.

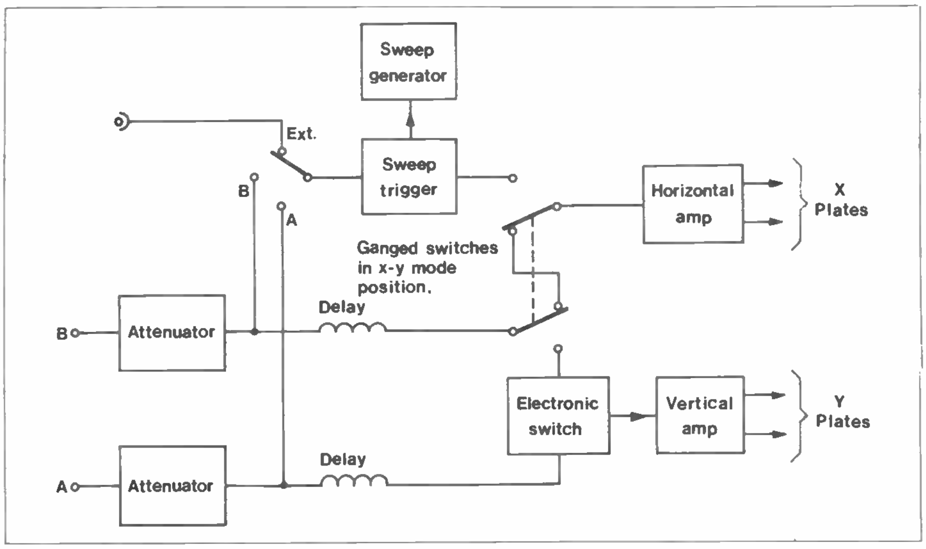


Figure 28. Dual Trace CRO.

ii) A and B can be added algebraically to give a single display. Polarity switches can be used to give all possible combinations A−B, B−A A+B, −A −B.

iii) A and B alternately, i.e. the spot traces A on the first sweep and B on the second sweep.

iv) A and B chopped. The electronic switch runs freely at between 100kHz and 500kHz independently of the sweep generator. If it runs at say 500kHz then it will display signal A for 1μs followed by signal B for 1μs. In this way each image is built up separately on a time sharing basis. Now if the chopping rate is faster than the horizontal sweep rate then nice continuous traces will appear on the screen. But if the chopping rate approaches the sweep rate then the images are not continuous. Instead they can be seen as segments being built up on the screen. In this instance it is better to use the alternate mode.

In addition, there is a delay vernier which can delay the A waveform or B waveform. This is useful in positioning the start of each sweep. Some CROs even have a facility for delaying one waveform by the time interval of the other waveform.

The display on a conventional CRO fades in a couple of seconds at most but storage CROs can hold the display on the screen for several hours in some instances. Even if several hours of storage is not required, some slow phenomenon may take several seconds which means that the start of the waveform has faded before the end is written.

Storage CROs are of two kinds: bistable or half tone. The latter has various levels of brightness, the former is at full brightness against a background of minimum brightness, there is no in-between grey scale. Both types of storage CRO use the principle of secondary emission, i.e. when the screen is bombarded, it emits electrons called secondary electrons. The secondary emission ratio is given by:

$$\frac{\text{no. of secondary electrons}}{\text{no. of primary electrons}}$$

Figure 29 shows the principle of a storage CRO. A flood gun illuminates the target at all times and the target has two stable conditions, a high and low condition. Applying a signal to the write gun lifts the targets to the higher condition so that switching off the write gun has no effect. The flood gun can maintain the targets at the higher condition on its own. To

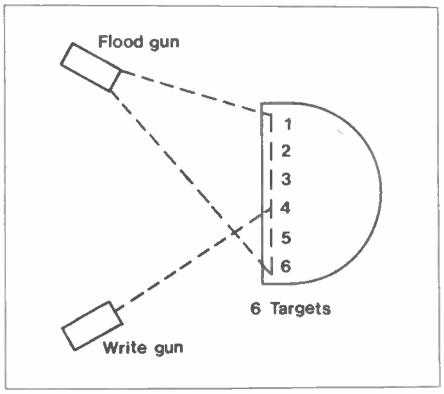


Figure 29. Storage CRO with separate targets.

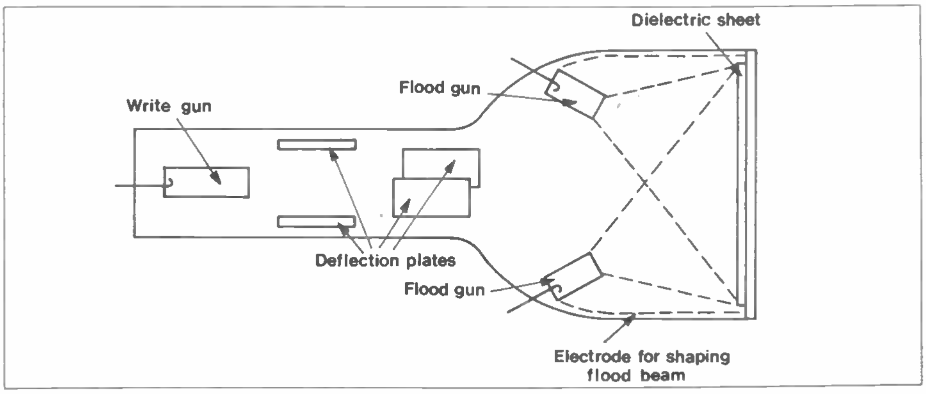


Figure 30. Storage CRO with dielectric sheet.

erase the targets a negative pulse can be applied to them. In practice these are not separate targets as in Figure 29 but a dielectric sheet which collects secondary electrons. The flood guns are mounted inside the tube as in Figure 30.

If the waveform on display is fast then there is not sufficient time for the bombarding electrons to illuminate the screens. This can be overcome by accelerating the electrons so that they hit the screen harder.

Another method of displaying high frequencies is to sample a recurring waveform over several cycles in order to build up an image of one cycle, see Figure 31. Yet another method is to strobe the waveform, i.e. sample at increasing time intervals as opposed to fixed time intervals.

Harmonic Distortion Analysers

If a sine wave is passed through an amplifier, an amplified sine wave should appear in the output. However, due to non inear characteristics in the amplifier, harmonics of the sine wave may also appear in the output. In designing amplifiers it may be necessary to measure these harmonics in terms of amplitude.

These amplitudes are with respect to that of fundamental. So the harmonic distortions would be:

$$D_2 = N2/N1,\ D_3 = N3/N1,\ Dn = Nn/N1$$

Where N_1 is the amplitude of the fundamental and N_2 etc, are the amplitudes of the harmonics.

The total harmonic distortion is given by:

$$D = \sqrt{D_2 + D_3 + \ldots\ldots D_n^2}$$

An obvious circuit to measure each frequency is an LC tuned circuit. However, large values of L and C would be required at low frequencies. The alternative is to use the heterodyning principle of converting each harmonic into a fixed frequency. This is achieved by using a variable frequency oscillator, mixing with the harmonic to produce a sum and difference frequency, then selecting one of them for measurement. There are two advantages to this method. A balanced modulator is used so that it does not introduce its own distortion. Secondly, since only one constant frequency is produced a highly selective crystal filter can be used. The amplitude of the difference frequency relative to the fundamental is read in dBm and volts. Most instruments range from + 32dBm to −90dBm.

The above method measures the distortion introduced by each harmonic. Instruments are available to suppress the fundamental, pass all the harmonics and measure the total harmonic distortion.

Spectrum Analysers

In the above study on harmonic distortion, we were only interested in multiples of the fundamental frequency. In spectrum analysis we are interested in everything within the specified bandwidth. For instance spurious frequencies may be interfering with a radio transmission. The spurious needs to be separated and identified. Spectrum analysis

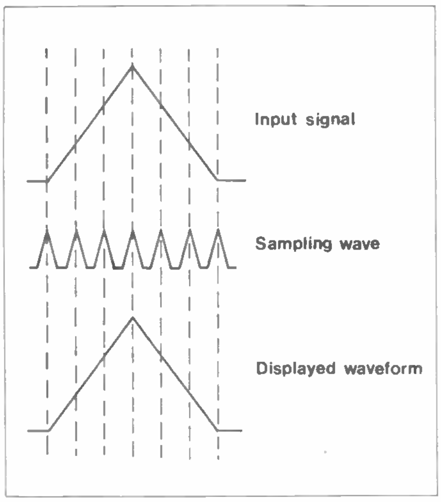


Figure 31. Sampling a wavetrain.

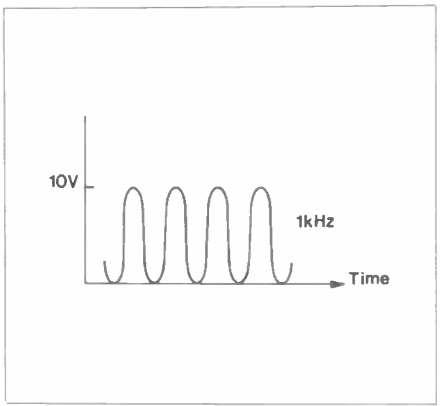


Figure 32. Amplitude verses Time.

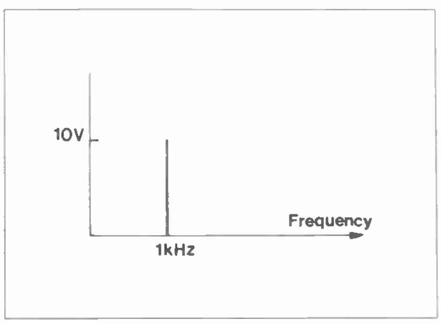


Figure 33. Amplitude verses Frequency.

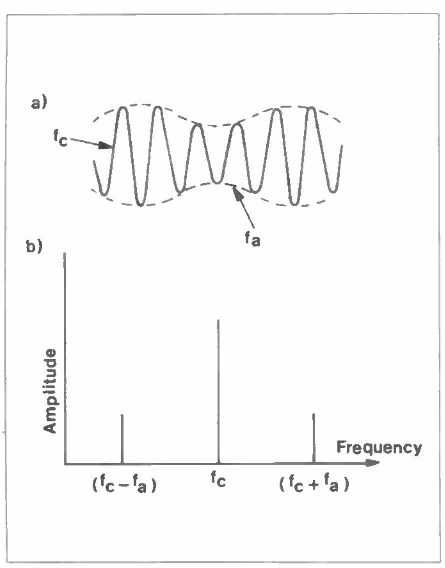


Figure 34(a). Modulated Waveform.
34(b). Spectral Display.

can also be used to study antenna radiation patterns and for examining the deviation in frequency modulation.

So what is spectrum analysis? We are used to seeing CRO displays as amplitude versus time, as in Figure 32. This tells us that the waveform is varying sinusoidally with time. The same waveform (say 1kHz) will show up on a spectrum analyser, as in Figure 33, telling us that a 1kHz wave is present but showing only one amplitude. So Figure 33 is a plot of amplitude versus frequency.

The modulated waveform in Figure 34a will show on spectrum analysis to have a carrier and sum and difference frequencies, see Figure 34b. A perfectly rectangular waveform, Figure 35a is made up of a fundamental sine wave and an infinite number of harmonics, Figure 35b. The spectral display will be as in Figure 35c with peak power in the fundamental and decreasing amounts of power in succeeding harmonics.

As with harmonic analysis, the best method of displaying the components is by the heterodyning method. An electronically tuned oscillator sweeps across the desired bandwidth picking out the spectral components, converting each to a fixed frequency for amplitude measurement but displaying it in its rightful place in the frequency band.

Trouble Shooting Tips

This is the last part of this series, so we will finish with some good advice on safety and make some conclusions.

Always check first that power is getting to all stages of the circuit. It is no use looking for the signal if some stages are 'dead'. Use the

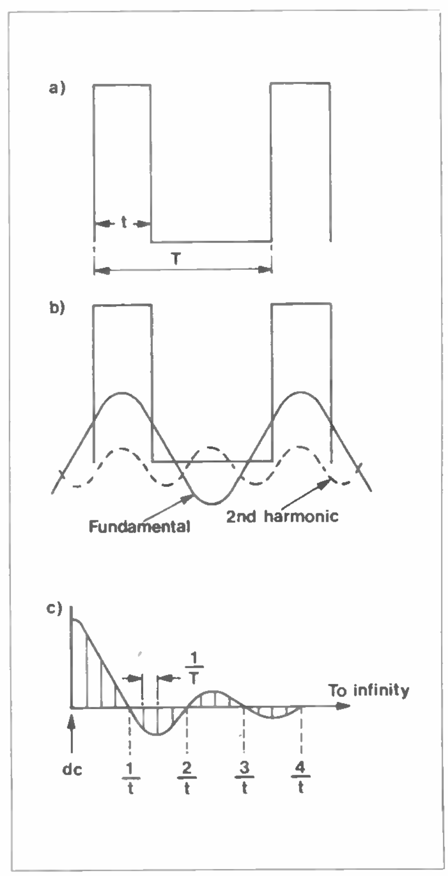


Figure 35(a). Perfect Rectangular Pulse.
35(b). Frequency Analysis.
35(c). Spectral Display.

Continued on page 35.

Disco PARTYLITE

by Chris Barlow

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

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

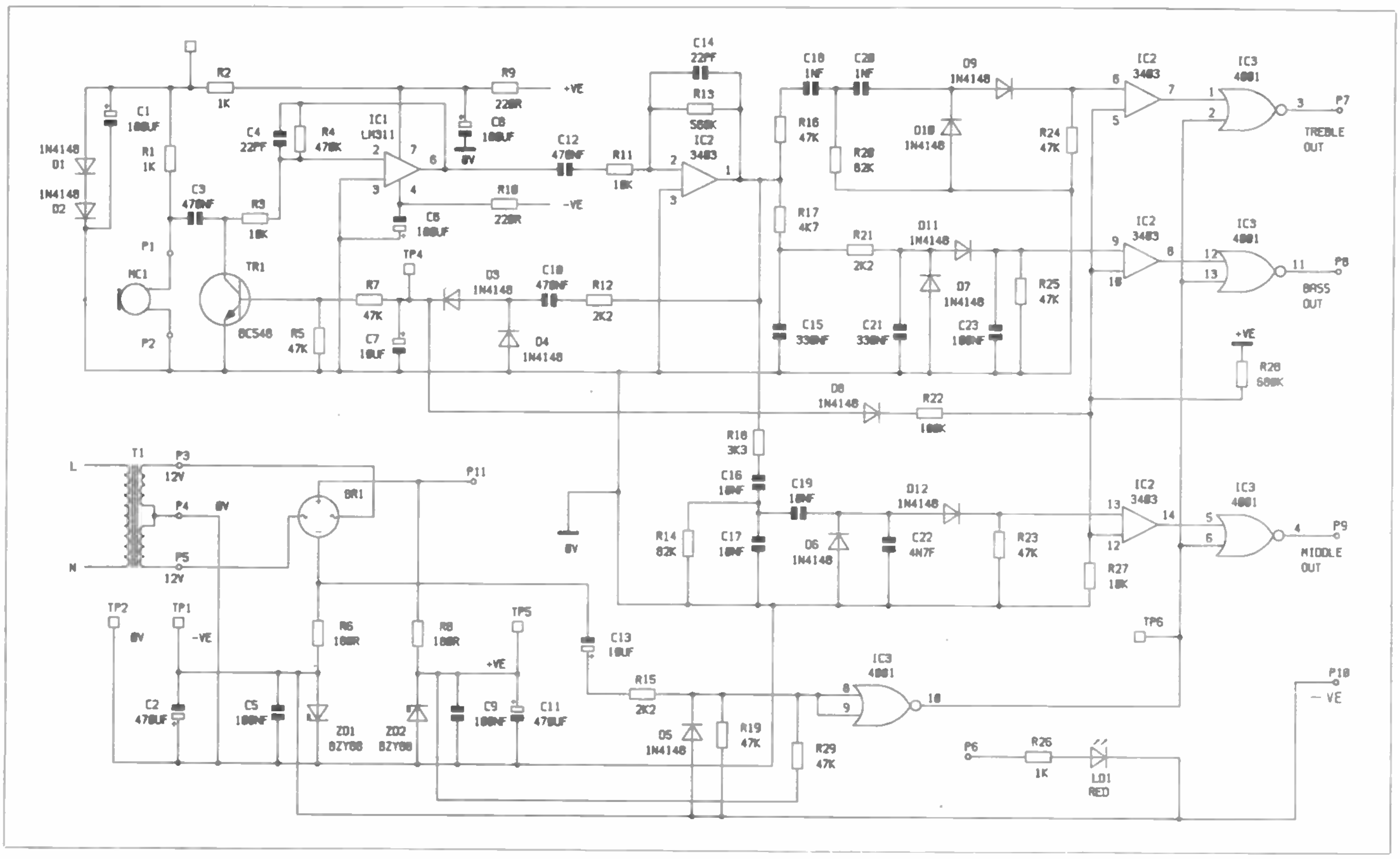


Figure 1. Controller circuit.

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

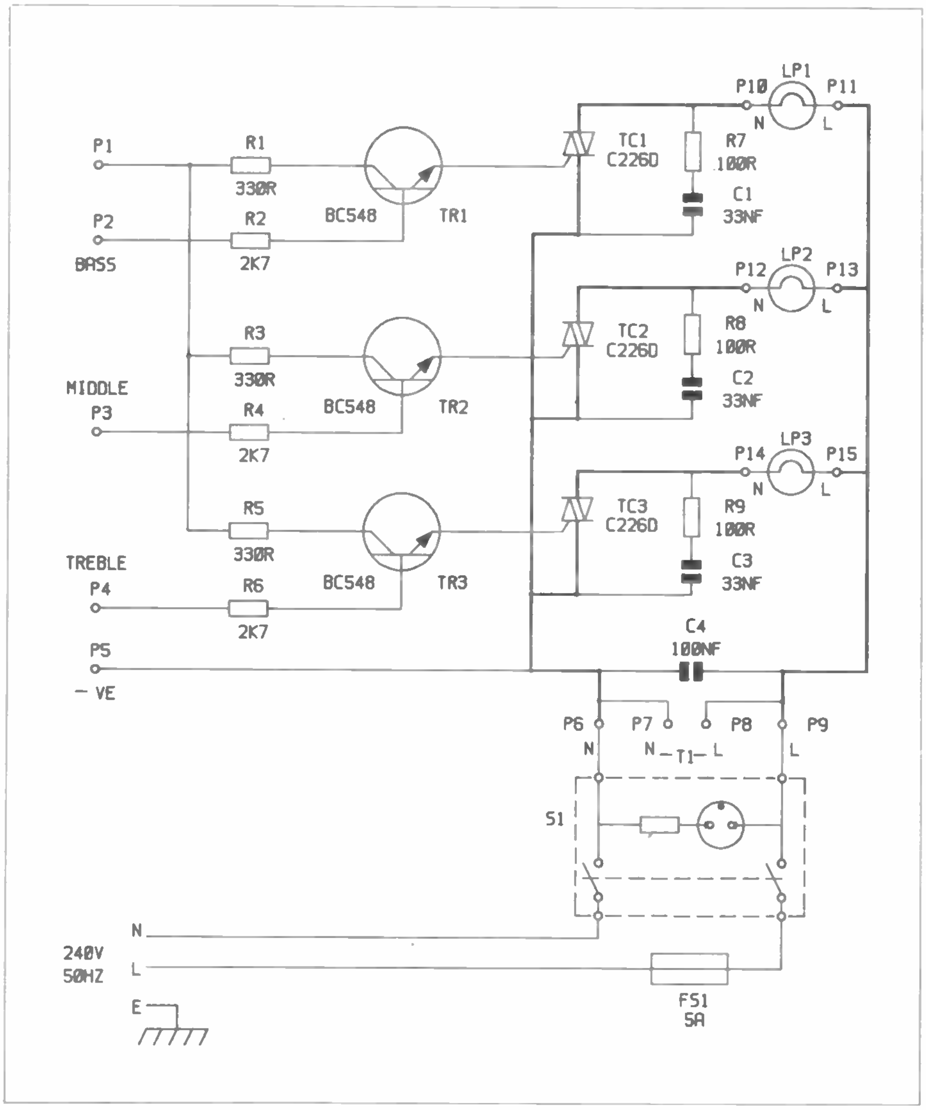


Figure 2. Triac Output circuit.

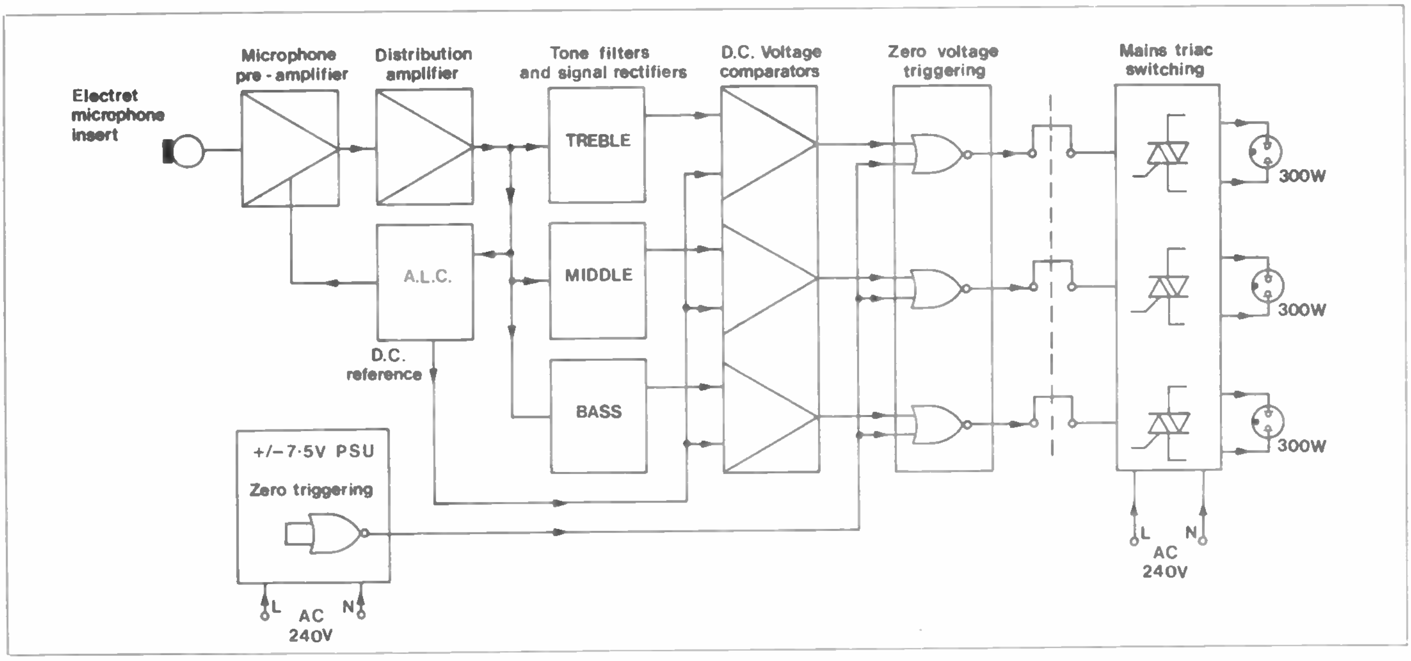


Figure 3. Block schematic.

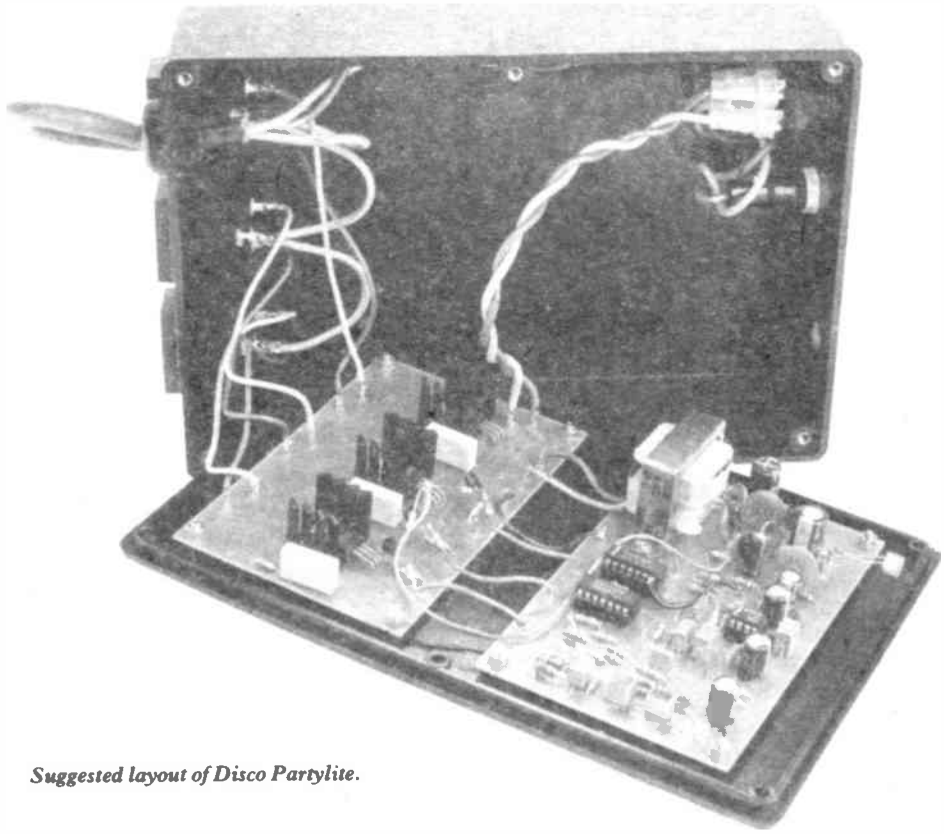
decoupled by C1, to remove any electrical noise from reaching the insert. The low level audio signal from the insert is then fed to the microphone pre-amplifier IC1, via C3 and R3.

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 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'.

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.



Suggested layout of Disco Partylite.

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

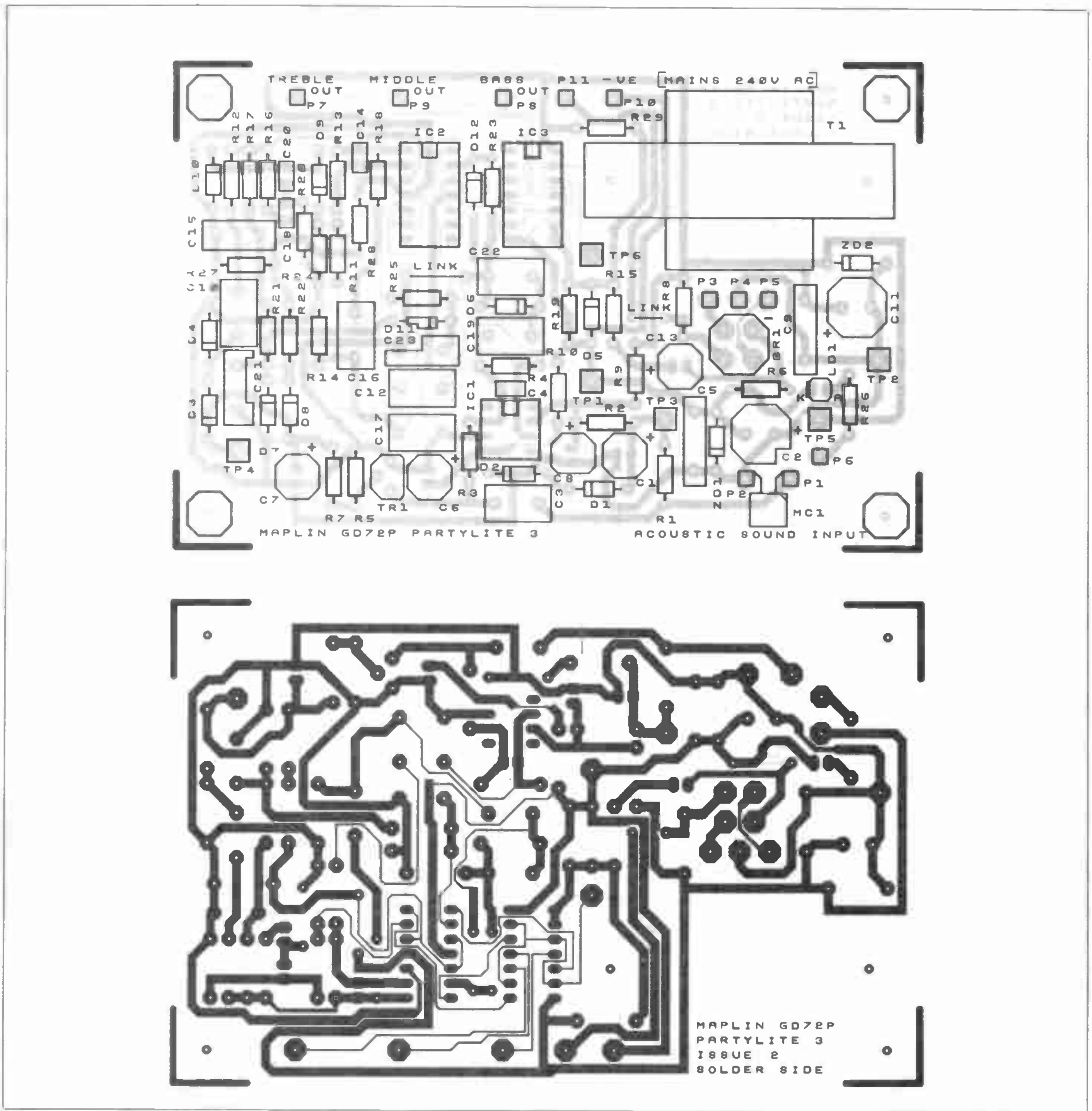


Figure 4. Controller track and overlay.

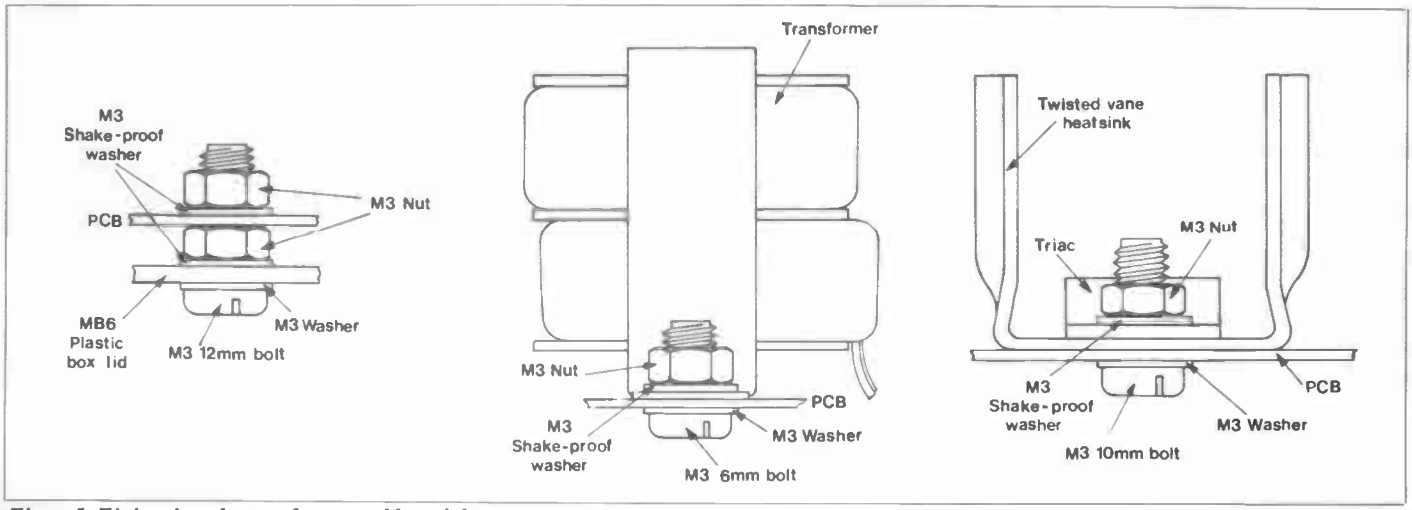


Figure 5. Fixing the pcb, transformer and heatsinks.

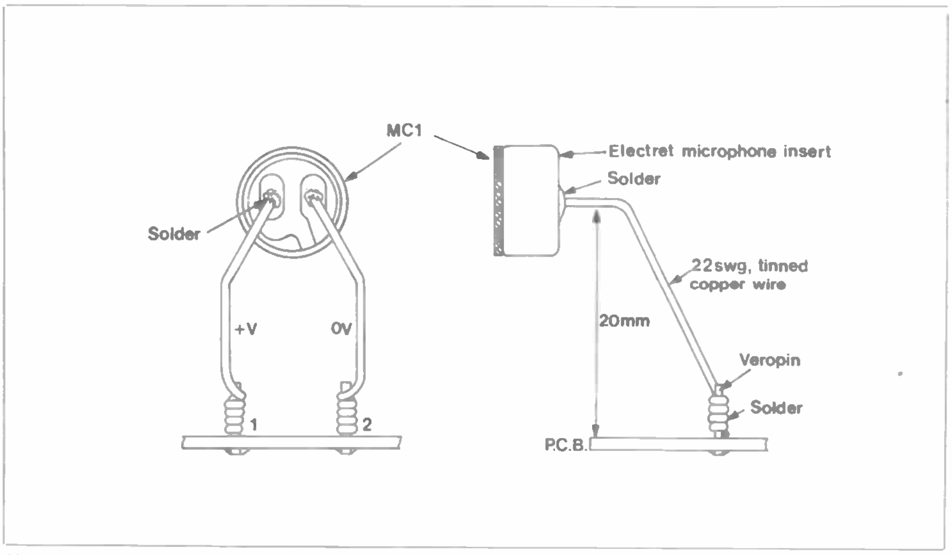


Figure 6. Mounting the microphone insert.

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

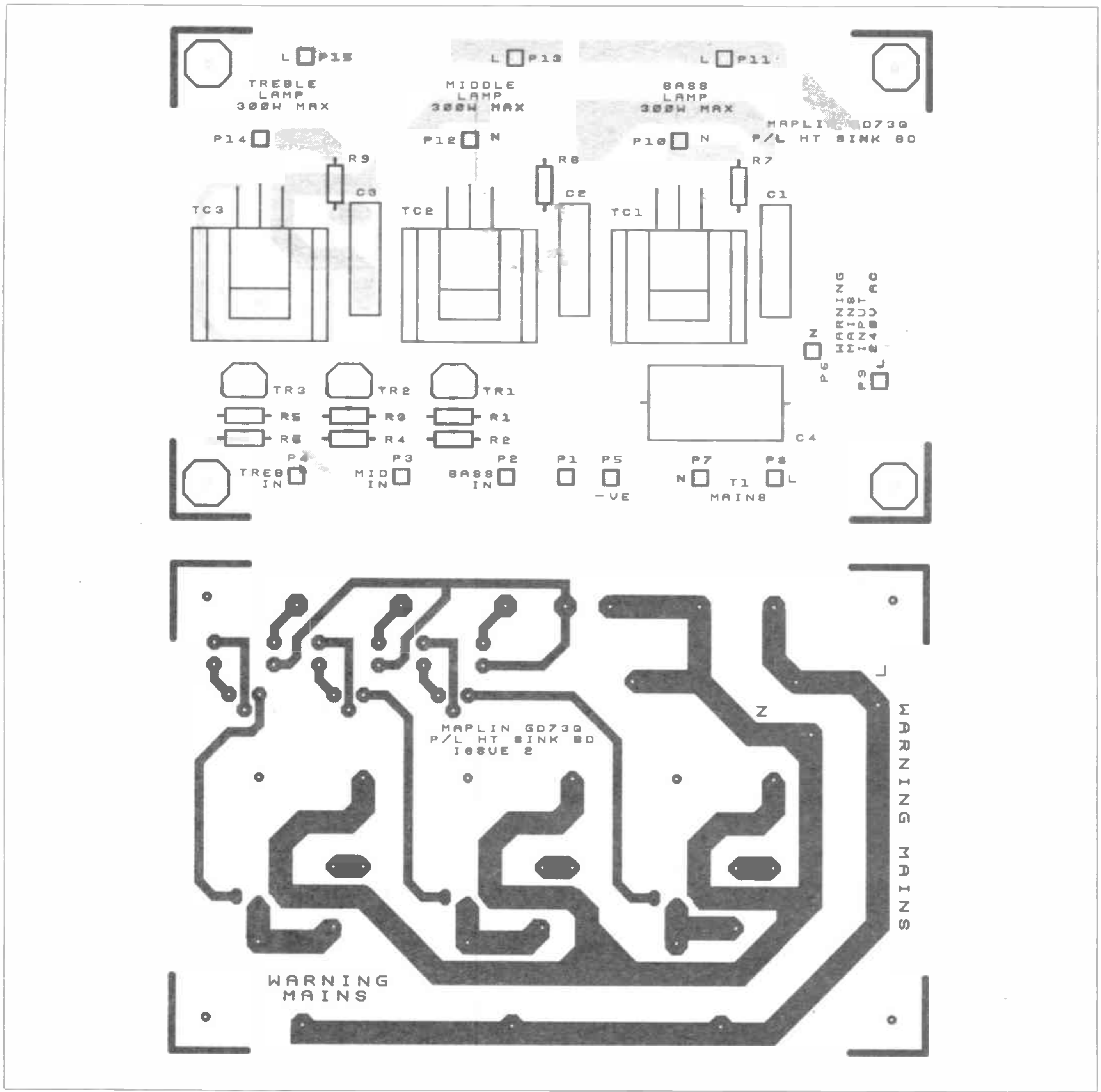


Figure 7. Triac Output track and overlay.

transformer are then connected to the board in the following way: cut the two 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.

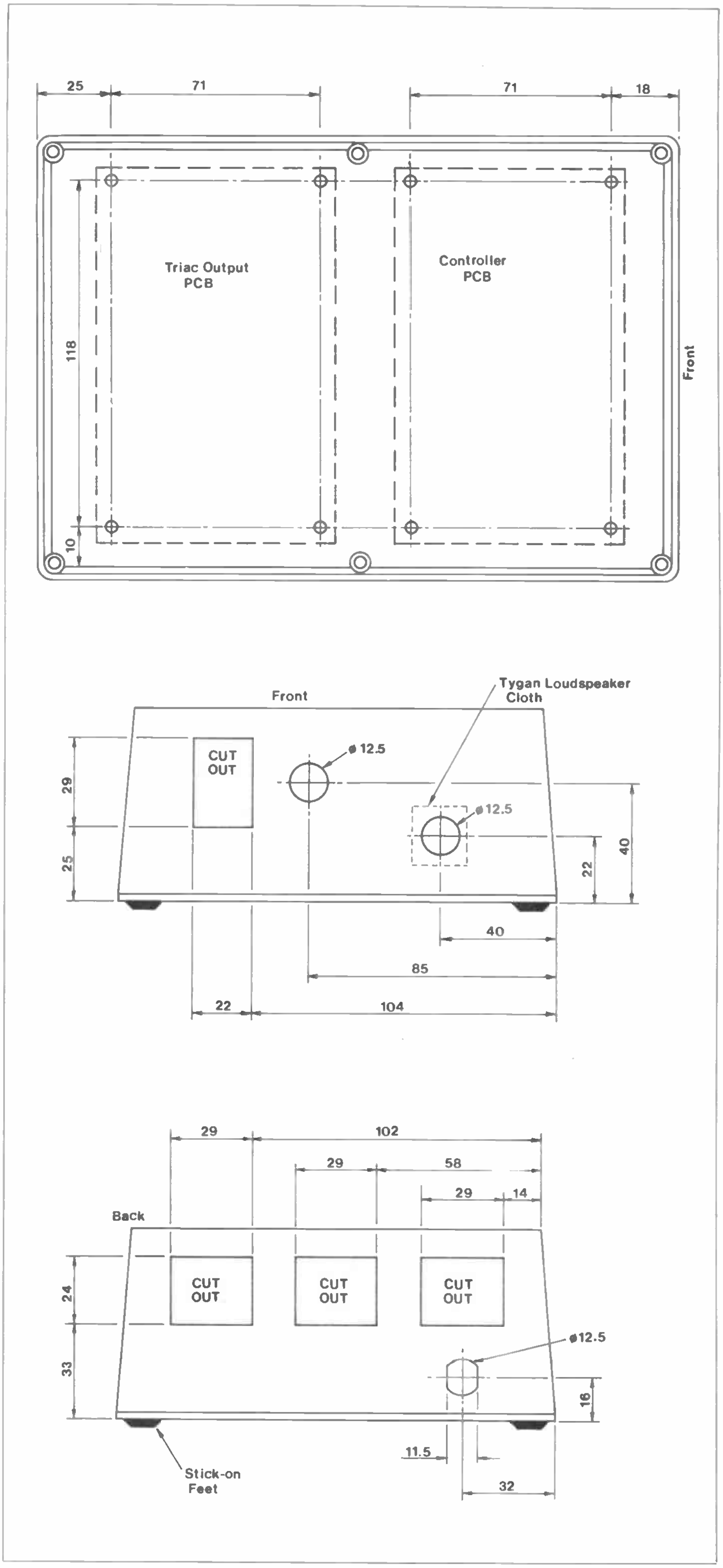


Figure 8. Suggested case drilling.

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

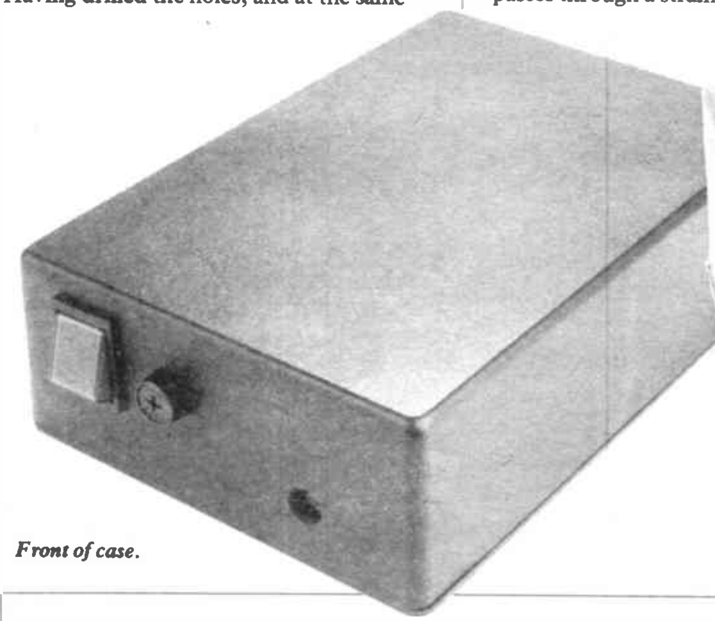
The prototype unit used a black plastic box type MB6 and the drilling instructions are shown in Figure 8. Having drilled the holes, and at the same time clearing them of any swarf, proceed to install the dual rocker switch and the 20mm fuse holder. Using impact adhesive, glue a small piece of loudspeaker 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

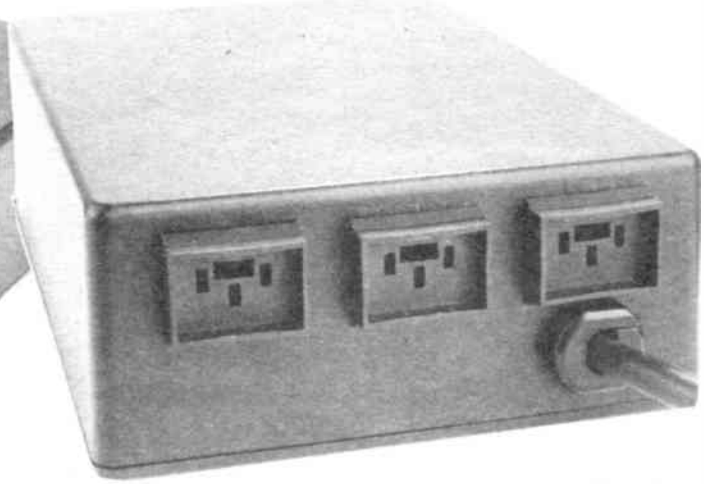
Carefully follow the wiring shown in Figure 9. Note that the 6A mains cable passes through a strain relief grommet in the back of the box. Having completed the wiring, carefully fit the lid to the box ensuring that the microphone insert is directly behind its hole. Using the countersunk screws supplied 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



Front of case.



Rear of case.

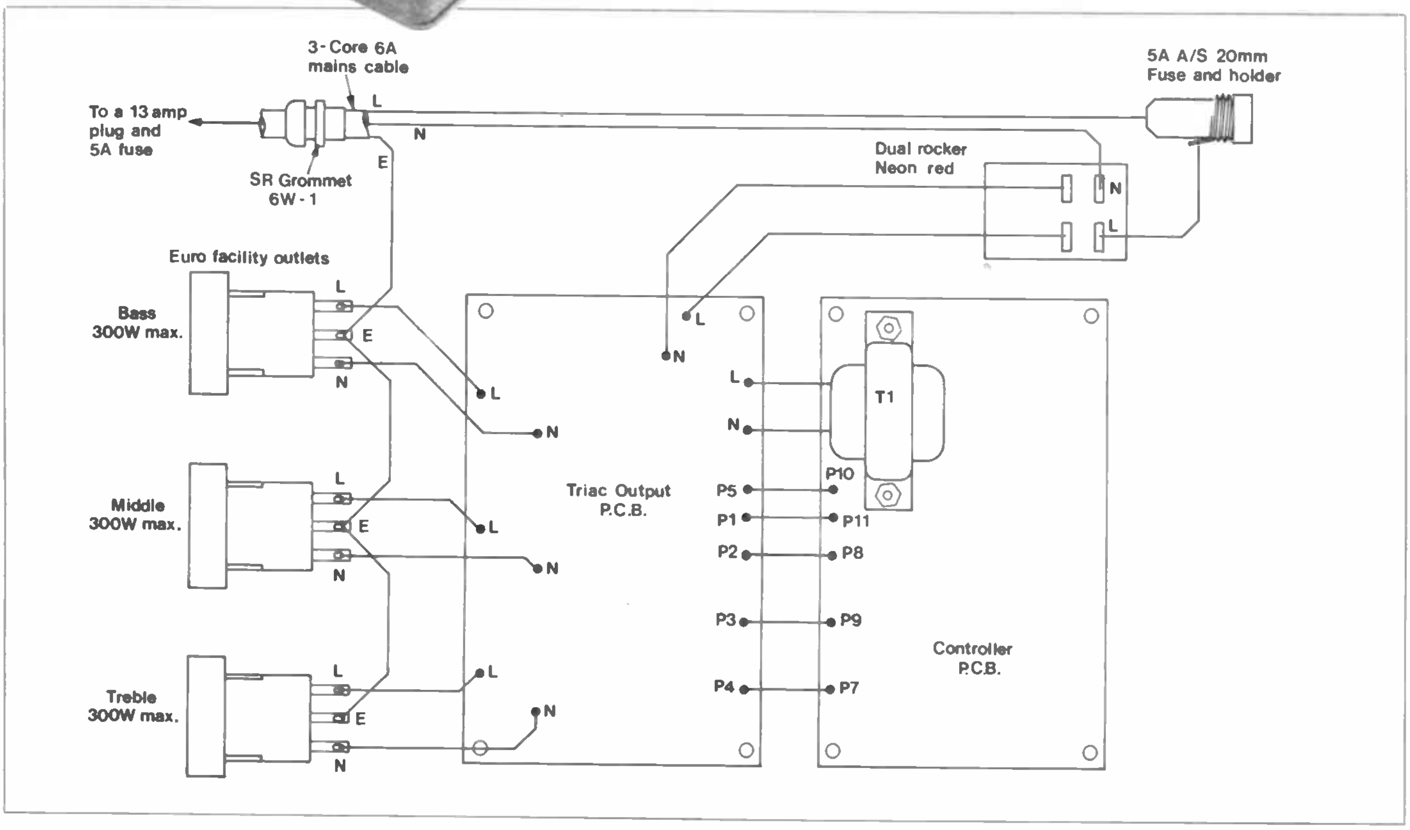


Figure 9. Interwiring.

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.

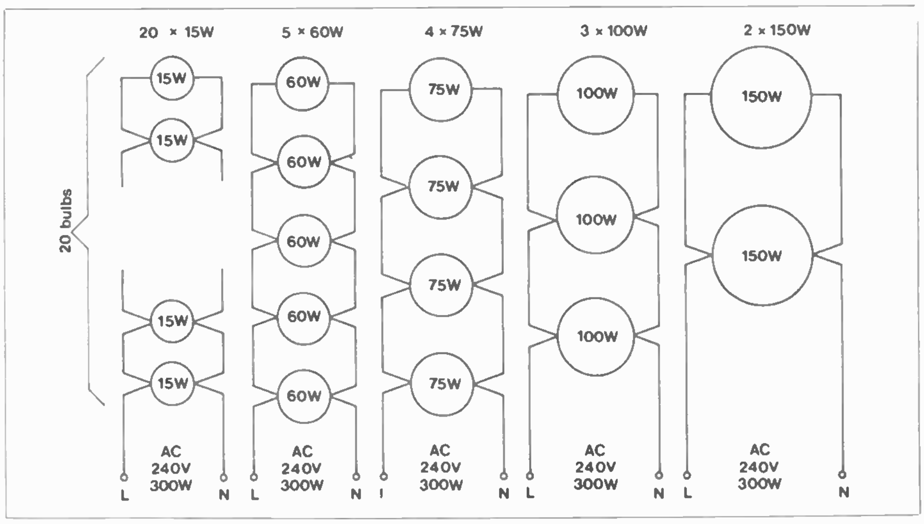


Figure 10. Bulb configurations.

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	(220R)
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	100µF 25V P.C. Electrolytic	3	(FF11M)
C2,11	470µF 16V P.C. Electrolytic	2	(FF15R)
C3,10,12	470nF Polylayer	3	(WW49D)
C4,14	22pF Ceramic	2	(WX48C)
C5,9	100nF Disc Ceramic	2	(BX03D)
C7,13	10µF 100V P.C. Electrolytic	2	(FF05F)
C15,21	330pF Polylayer	2	(WW47B)
C16,17,19	10nF Polylayer	3	(WW29G)
C18,20	1nF Ceramic	2	(WX68Y)
C22	4n7F Polylayer	1	(WW26D)
C23	100nF Polylayer	1	(WW41U)
SEMICONDUCTORS			
D1-12	1N4148	12	(QL80B)
ZD1,2	BZY88C7V5	2	(QH11M)
BR1	Bridge Rectifier 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 Transformer 12V	1	(WB02C)
MC1	Omni Insert Electret Mic.	1	(QY62S)
	P.C. Board	1	(GD72P)
	Isowasher M3	1 Pkt	(BF62S)
	Isobolt M3 x 6mm	1 Pkt	(BF51F)
	Isoshake 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			
C1,2,3	33nF IS Cap	3	(FT34M)
C4	100nF IS Cap	1	(FF56L)
SEMICONDUCTORS			
IC1,2,3	C226D	3	(WQ25C)
TR1,2,3	BC548	3	(QB73Q)
MISCELLANEOUS			
	Isobolt M3 x 10mm	1 Pkt	(HY30H)
	Isoshake M3	1 Pkt	(BF44X)
	Isonut M3	1 Pkt	(BF58N)
	Pin 2141	1 Pkt	(FL21X)
	PC Board	1	(GD73Q)
	Isowasher M3	1 Pkt	(BF62S)
	Heatsink	3	(FL58N)
OPTIONAL			
S1	Switch Dual Rocker Neon Red	1	(YR70M)
	Safuseholder 20mm	1	(RX96E)
FS1	Fuse 8A 20mm Anti-Surge	1	(RA12N)
	3-core 6A Mains Cable	3 Mtrs	(XR03D)
	Push-on Receptacle	1 Pkt	(HF10L)
	Push-on Receptacle Covers	1 Pkt	(FE65V)
	Euro-Facility Outlet	3	(HL42V)
	13 Amp Plug Nylon	1	(RW67X)
	Plug Fuse 5A	1	(HQ33L)
	SR Grommet 6W-1	1	(LR49D)
	Mains Warning Label	1	(WH49C)
	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)
	Square Cloth 0.71m	¼ Mtr	(XS10L)

A complete kit of all parts, excluding optional items, is available for this project:
Order As LM41U (Disco Partylite Kit) Price £17.95
The following items included in the above kit list are also available separately, but are not shown in the 1988 catalogue:
Controller PCB **Order As GD72P Price £2.95**
Triac Output PCB **Order As GD73Q Price £1.98**

Exploring Radio

Part 1 by Graham Dixey C.Eng., M.I.E.R.E.

Introduction

Not so very long ago, a few decades perhaps, the average 'electronics' hobbyist would most likely have been concerned more with constructing radio receivers than anything else. The most popular magazines of the day, 'Wireless World', 'Practical Wireless' and 'Radio Constructor', reflected this interest. While today there are still many amateurs who build radio equipment, the general emphasis has shifted to a very much wider field. This is to the general benefit even if it has tended to hide the 'grass roots' of a technology which owes everything to the early experimenters in 'wireless', to which my recent series 'The Story of Radio' paid tribute. This series is written for those who would like a change from projects that do all manner of clever things using 'state of the art' devices and ideas. It will introduce, in each issue, a tried and tested circuit that will allow the constructor, not only the pleasure of making something that works (always a source of satisfaction), but may even teach him a little about radio, the understanding of which is not quite so widespread as it once was. However, we are not going to take a giant backward step as some may think; there's little point in merely copying hobbyists of a former time. Furthermore, the components that would once have been used are either difficult or impossible to find, or prohibitively expensive.

For example, the 'working model' in this first article would once have used a 'cat's whisker' detector - this has been replaced by a germanium point contact diode, using the same essential principles. The original receiver would have driven a pair of high impedance head phones, but its modern counterpart uses an inexpensive crystal earpiece. The large coil, characteristic of early crystal sets, has to be made from scratch, a job easily done and costing next to nothing. It would have been nice to have used one of the traditional tuning capacitors as these had a nice solid feel to them, but the aim was to keep the cost down. The whole thing is built on a 'breadboard'. But this project is the closest we shall get to a 'time warp' in this series; later designs will be built on PCB's which will be available from Maplin.

A Little Theory

The radio wave that is propagated by the transmitter aerial is said to be an 'electromagnetic wave'. This means that it has two components, a magnetic one and an electric one, which are mutually at right angles to each other. This wave, in travelling over the surface of the Earth, will induce currents in any conducting material that intercepts it. This includes the Earth's surface itself, which causes the wave gradually to lose strength. Obviously to receive the wave all that is required is to arrange a suitable conductor in its path, this conductor being termed an aerial or antenna. There are many designs of aerial and the theory surrounding

Photo 1. That crystal sets are still made and sold commercially is evidenced by this photograph of the Aiwa AR - 100 'Germanium Radio'. As in the case of traditional receivers of this type, it needs a good aerial and earth and the output drives a high impedance earphone (of the crystal type).

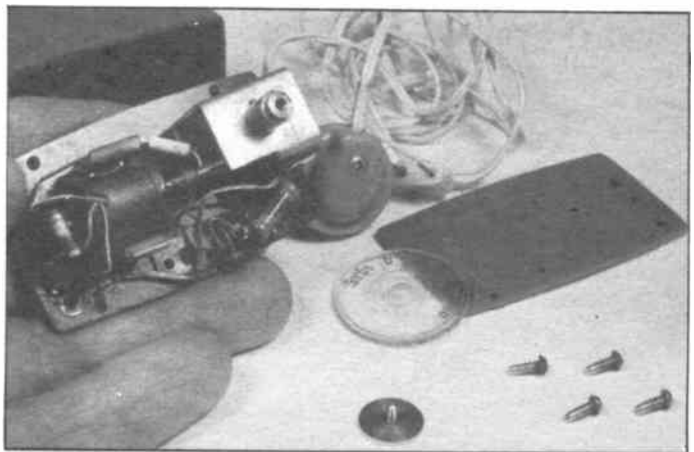


Photo 2. Taking the Aiwa set to pieces reveals the interesting fact that it is tuned by variable inductance and not variable capacitance. The magnetic core of the coil is driven in and out by a worm and gear arrangement. The fixed ceramic tube tuning capacitor can be seen at the extreme left and the germanium diode detector is at centre. A high value resistor, bottom right, provides a DC path for the detector output.

them is complex, but the fundamental object is just that stated, to derive the largest possible signal from the radio wave. In the early days of radio, and in certain circumstances today also, a good 'earth' was used as well in order to make the reception as efficient as possible. With aerials of the 'ferrite rod' type, that will be used with some of the designs presented here, a separate earth is not necessary.

Not only is it necessary to obtain the best possible signal, it should also be the right one! This means that there must be some provision for selecting one station from another. The basis of this is to allocate a 'carrier frequency' to each station and incorporate in the receiver some circuit that can distinguish one carrier frequency from another. The simplest circuit to do this consists of only two components, a coil and a capacitor. It is known as a 'tuned' or 'resonant' circuit. Figure 1 shows such a circuit together with its response curve.

Depending upon how the circuit is used, the two components, L and C, may be considered to be either in series or parallel. To avoid getting too involved with the circuit theory, one can say that the 'resonant frequency' is essentially the same in both cases, this frequency being that of maximum response, shown in Figure 1 as f_0. In the series case, the current flowing through the circuit is a maximum at the frequency f_0 while, in the parallel case, the 'impedance' of the circuit is a maximum. Both types of resonant circuit may be found in receivers, each having its own use. The frequency at which 'resonance' occurs is given by the formula:

$$f_0 = \frac{1}{2\pi\sqrt{LC}}$$

As might be expected, the resonant frequency depends upon the values of L and C in the circuit, which means it can be varied (tuned) by varying either of these components. Although both methods have been used in receivers at one time or another, the variation of capacitance is usually easier to achieve. However, what happens in practice, in most cases, is that the inductance is varied, in large, discrete steps, by switching, in order to change 'wavebands', while capacitive tuning is used within each waveband (Figure 2).

It is now necessary to explain what is meant by modulation. This takes many forms, but the most common are the methods known as 'amplitude modulation' and 'frequency modulation'.

The two methods are shown in Figure 3. The process of modulation, in general terms, means impressing the radio frequency carrier with the audio frequency signal that it is desired to transmit. This latter is usually quite complex because it represents speech or music but, to make the explanation simpler to follow, it has to be imagined that it is just a single audio tone, shown in Figure 3 as having a frequency f_m. The carrier, by contrast, has a frequency f_c, which is much higher. To take an arbitrary example, f_c may have a frequency of 1MHz and f_m a frequency of only 1kHz. Since it is impossible to draw two frequencies that differ by such a large amount to a common scale, Figure 3 simply shows that one is higher in frequency than the other.

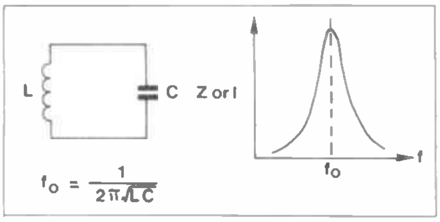


Figure 1. Simple tuning circuit.

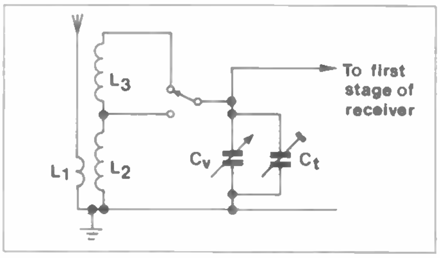


Figure 2. Practical tuning circuit.

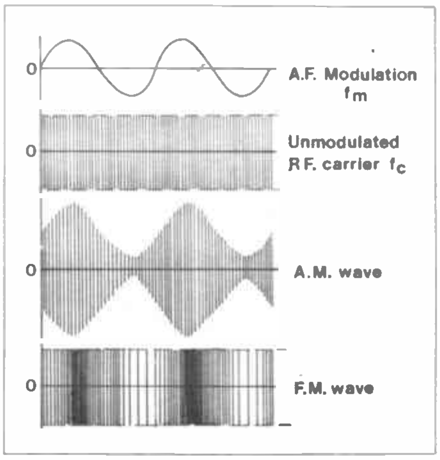


Figure 3. Amplitude and frequency modulation.

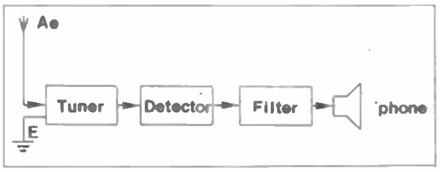


Figure 4. Crystal set block schematic.

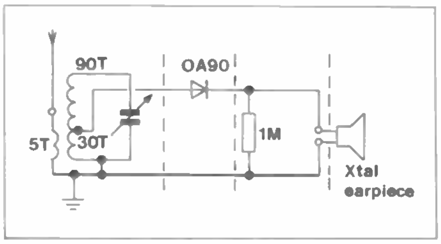


Figure 5. Crystal set circuit.

In the case of amplitude modulation, the 'amplitude' of the carrier is made to vary at the audio rate; the greater this variation in amplitude, the stronger is the audio signal. In the case of frequency modulation, the amplitude of the carrier remains constant but its frequency 'deviates' above and below the nominal carrier frequency at the audio rate. The more the carrier frequency deviates, the stronger is the audio signal.

The process of separating the audio information from the radio frequency carrier, in the receiver, is known as 'detection' or 'demodulation'. There must, therefore, be some component or stage in the receiver that takes care of this. The simplest way of doing it is to use a diode. Today a semiconductor diode, say a germanium type, would be used. In the earlier days of radio, the diode action was obtained by a 'cat's whisker' making contact with a piece of 'galena crystal', the basis of the 'crystal set'.

The process of 'diode detection' is combined with a filtering action to eliminate the residual carrier. This implies a time constant, i.e. an RC combination, that will be long for the r.f. but short for the a.f. When high impedance phones were used, a 0.1μF (100nF) capacitor was usually connected across them to form the time constant with the resistance of the phones. With a crystal earpiece, which acts capacitively, the resistance of the time constant must be supplied externally, a 1MΩ resistance being suitable.

Having obtained the audio output it must be used to drive some device that changes it into an audible form. Unless the audio signal has been boosted up to a reasonable power level, which would need an amplifier stage to effect it, the output device must be sensitive enough to operate directly from the output of the detector. This is the earpiece or phones referred to previously.

The receiver is now complete, from the aerial to the earpiece. It is shown in block diagram form in Figure 4 while Figure 5 shows the actual circuit of this simplest type of receiver. The relation ship between the two should be obvious.

The Crystal Set

The construction of the crystal set shown in Figure 5 and in the photographs is simplicity itself. The only area where any real care needs to be taken is in the construction of the coil, which is carried out as follows.

The coil former is the cardboard tube found at the centre of a toilet

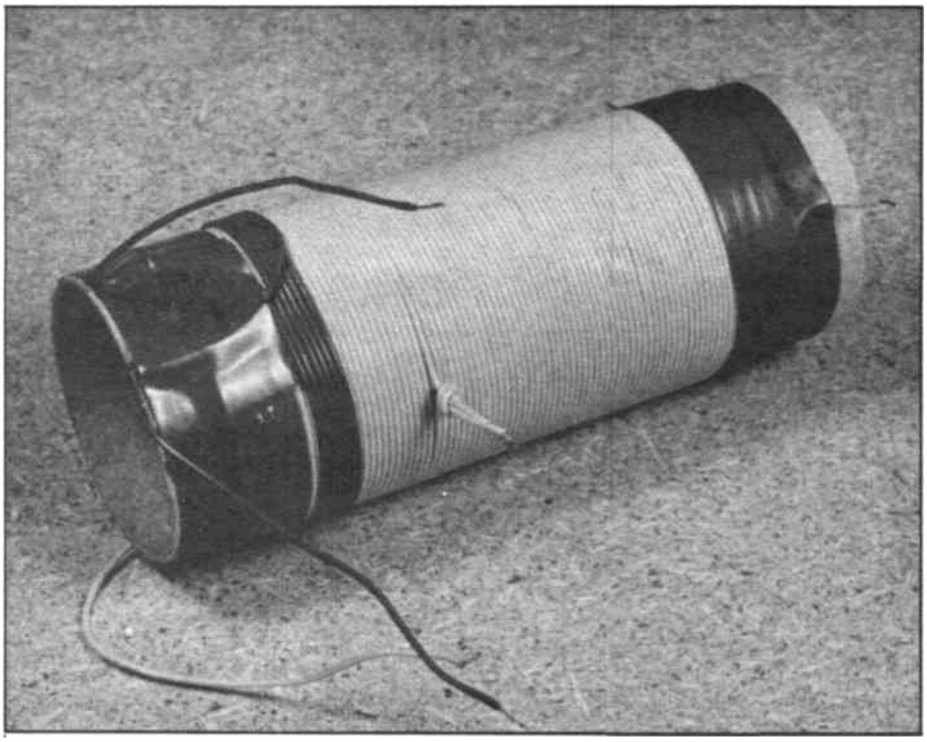


Photo 3. The coil is used in the set described in the text. The ends of the tuning coil are secured with tape and both the tap and the aerial coupling coil can be clearly identified.

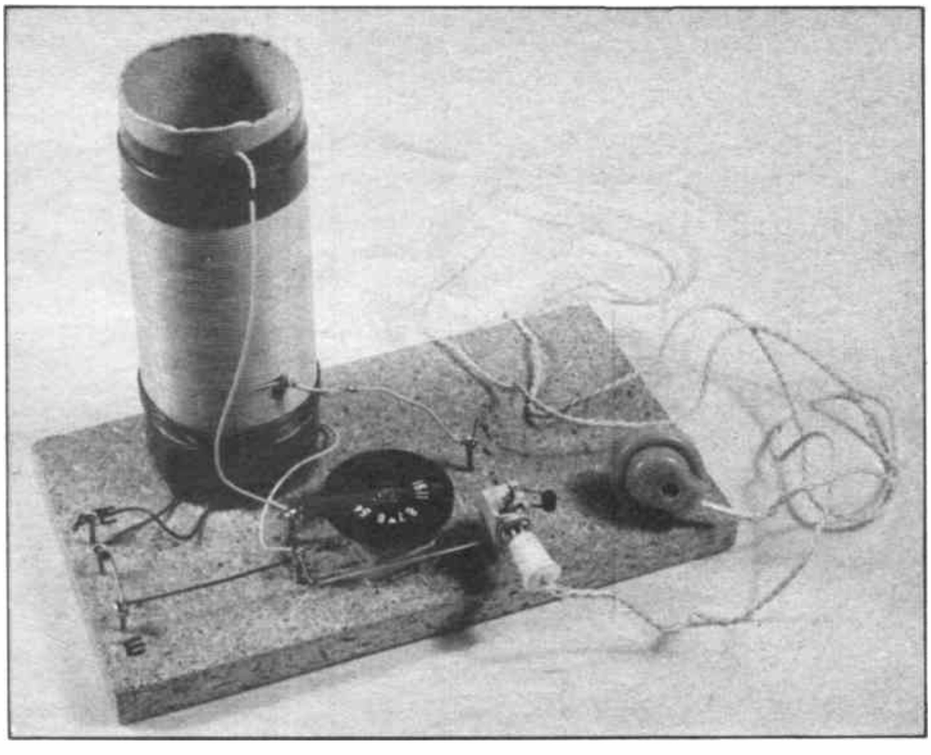


Photo 4. The completed crystal set mounted on a chipboard offcut, true 'breadboard' fashion! No claim is made for elegance but it does work.

roll, or the similar tube, but cut down, used with paper kitchen towels. (Editors Note: A fibreglass tube suitable for this application is available from Maplin, order code YM61R.) The tuning coil is wound first and consists of 90 turns close wound from fine insulated wire. Secure one end first, with tape or by a couple of holes near the start, and rotate the tube keeping the wire tight as it comes off its spool. At 30 turns knot or twist a loop of wire to act as a tapping and then carry on for the rest of the 90 turns. Secure the end. A length of PVC tape around each end of the coil should stop it falling apart. The aerial coupling coil consists of 5 turns wound over the tuning coil near the 'earthy' end. This is secured with tape. If you wish the whole thing can be given a few coats of varnish both to stiffen it and protect it.

The so called 'breadboard' is actually a chipboard offcut but any piece of wood would obviously do. This could be stained and varnished if you wished to make it more attractive. The components are mounted by soldering them to brass nails driven into the board, except for the coil which is secured with a few spots of epoxy adhesive (Araldite rapid). There is nothing the least bit critical about the layout although it is a good idea to get used to good r.f. practice and keep all leads short and use a good earth bus bar of heavy tinned copper wire.

Aerial and Earth

The signal obtained will be as good as the aerial and earth used. Taking the latter first, a connection to copper plumbing will do nicely, having scraped off the paint where the connection is to be made. Do not use 'gas' pipes for earths, water pipes only! The rule with aerials is, 'the longer and higher the better'. A length of wire from an upstairs window down the garden to a clothes post, or whatever can be found to secure it, should bring in a good signal. Suitable indoor aerials, used in my youth and less abundant now, were a length of wire around the picture rail (who remembers picture rails?), secured with drawing pins, and an iron framed bed!

Experiments

Even a simple circuit like this lends itself to some experimentation, mostly in the matter of the coil. For example, try other tapping points than the one given at 30 turns, or try a different overall number of turns to give a higher or lower frequency range. If you're not happy with the low level of sound, try adding an audio amplifier and a small speaker. There are any number of IC designs about these days, including some in the Maplin catalogue.

Note: The variable capacitor has a short shaft tapped with a metric M2.5 thread to take the type of tuning knob shown in the photograph. This latter does not appear to be available from Maplin at the present time and may have to be contrived.

Parts List

Variable Capacitor, Miniature AM type	FT78K
Germanium point contact diode OA90	QH71N
Resistor 1M 0.6W 1%	M1M
Crystal earpiece	LB25C
Jack socket 3.5mm	HF82D
Fibreglass Tube	YM61R

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

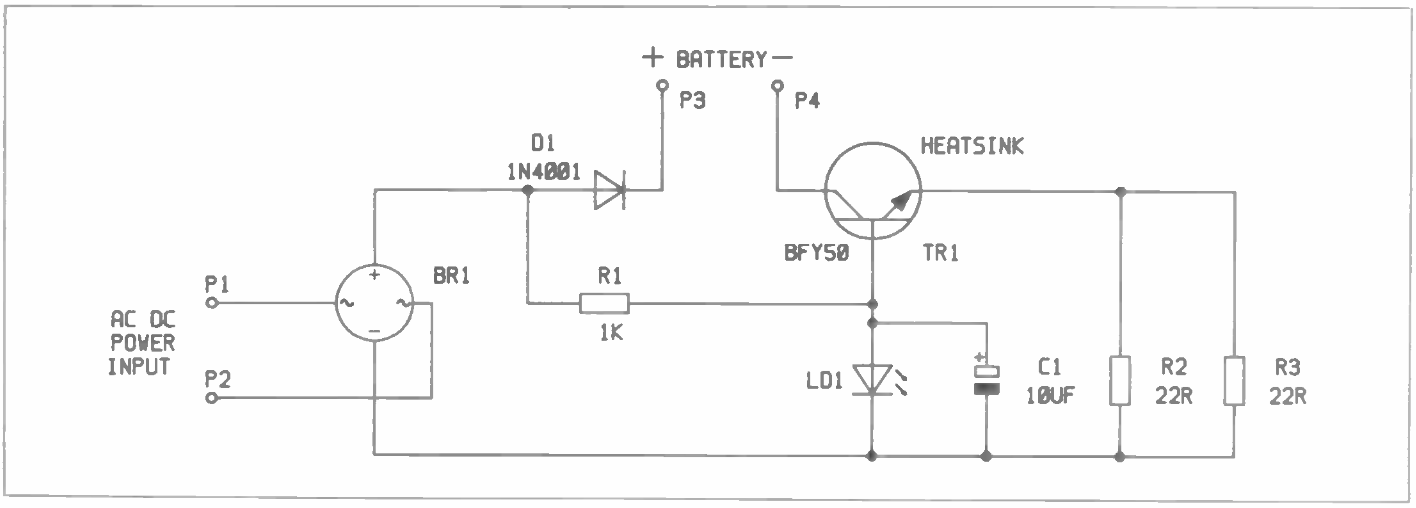


Figure 1. Circuit.

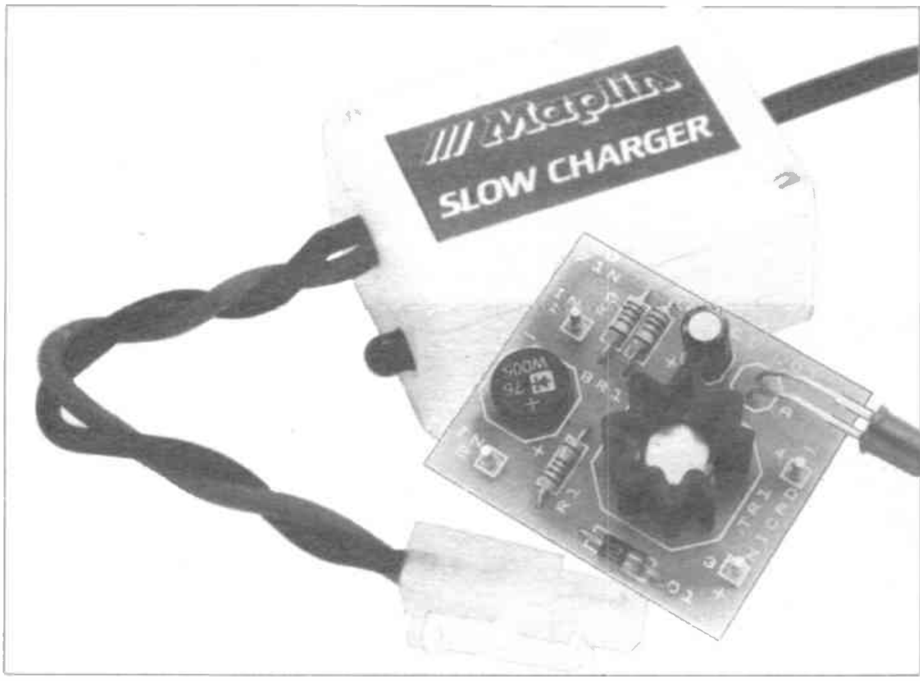
11Ω, the voltage drop across LD1 is 0.75V; the LED requires approximately 2V to conduct, therefore D1 does not illuminate. With a battery connected in the collector of TR1, current flows from the bridge through R2/R3 parallel pair. A voltage drop of 1.35V appears across these resistors at TR1 emitter 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.

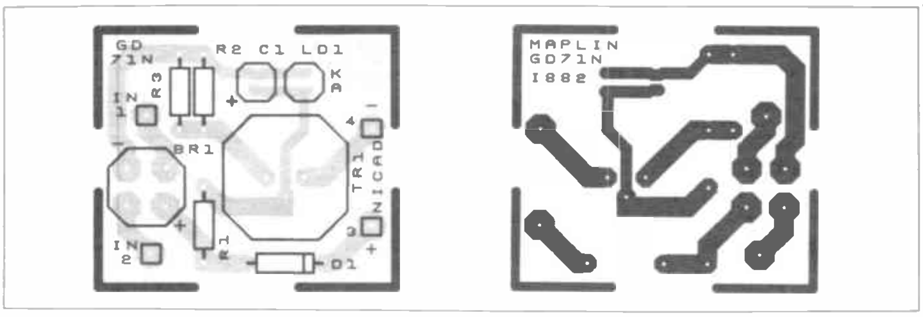


Figure 2. PCB track and layout.

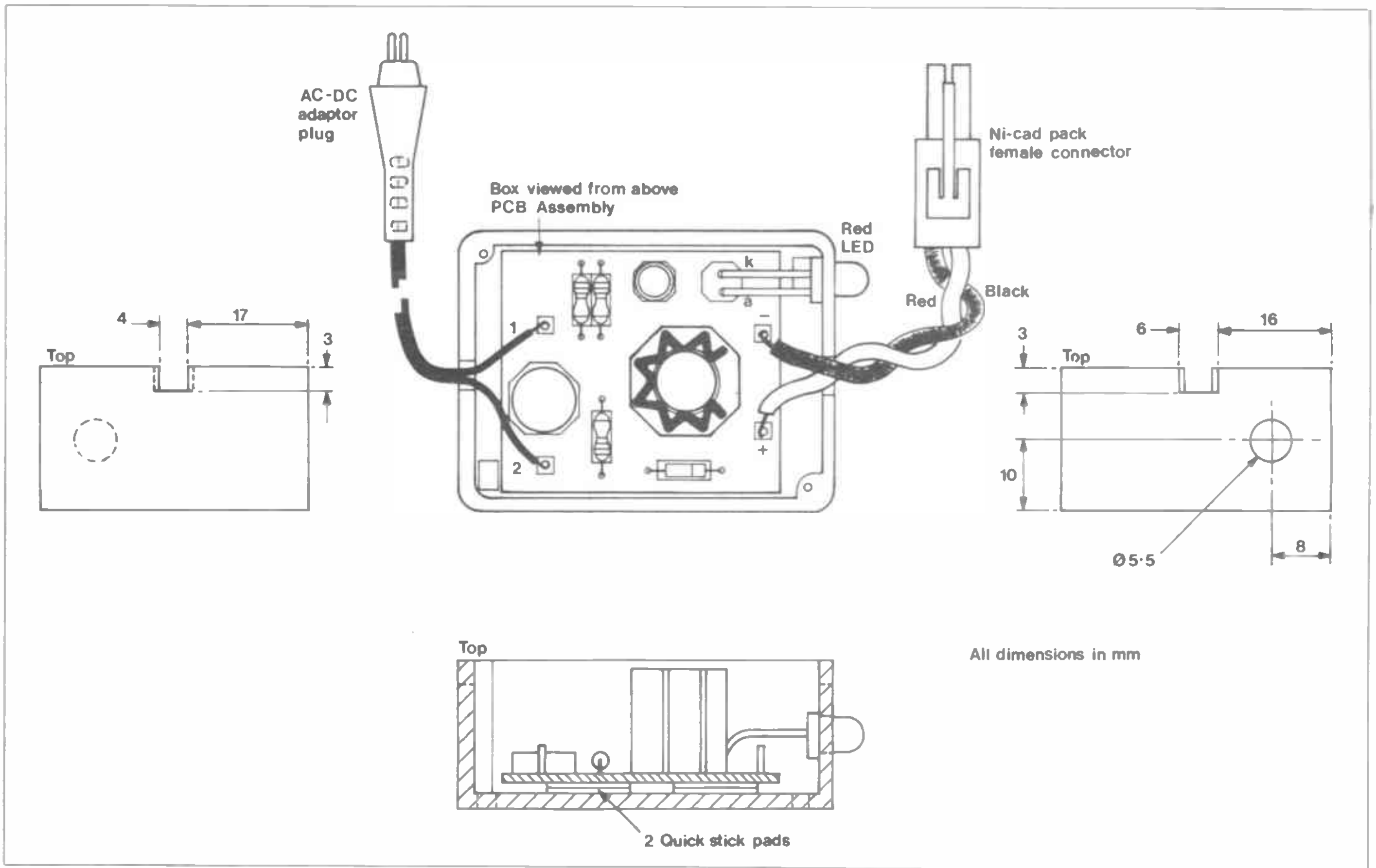


Figure 3. Final assembly and box cut-out details.

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.

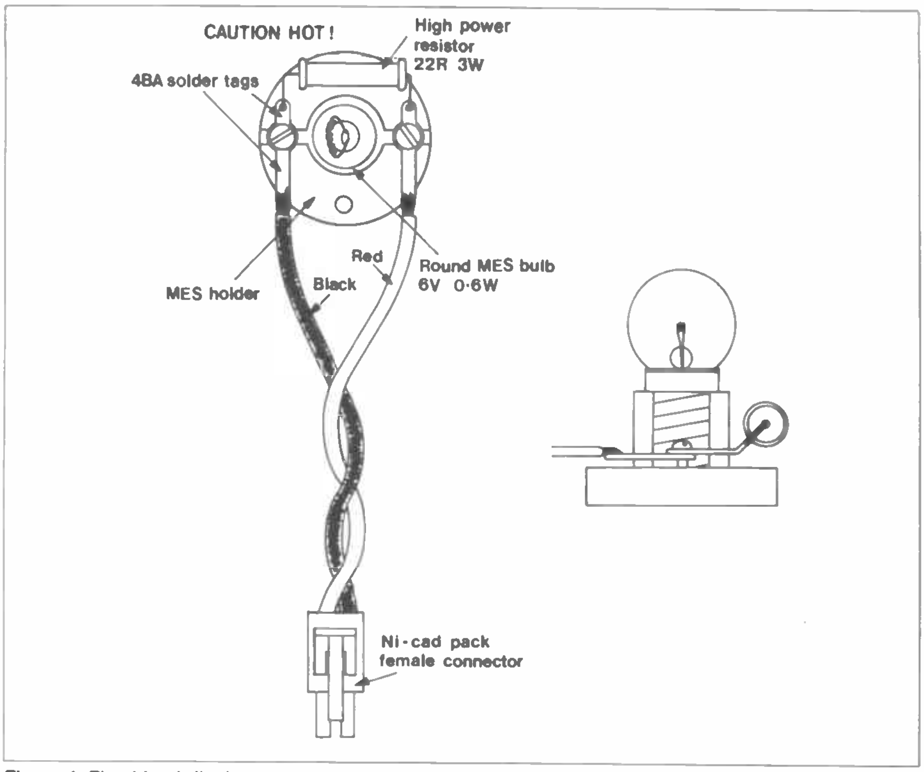
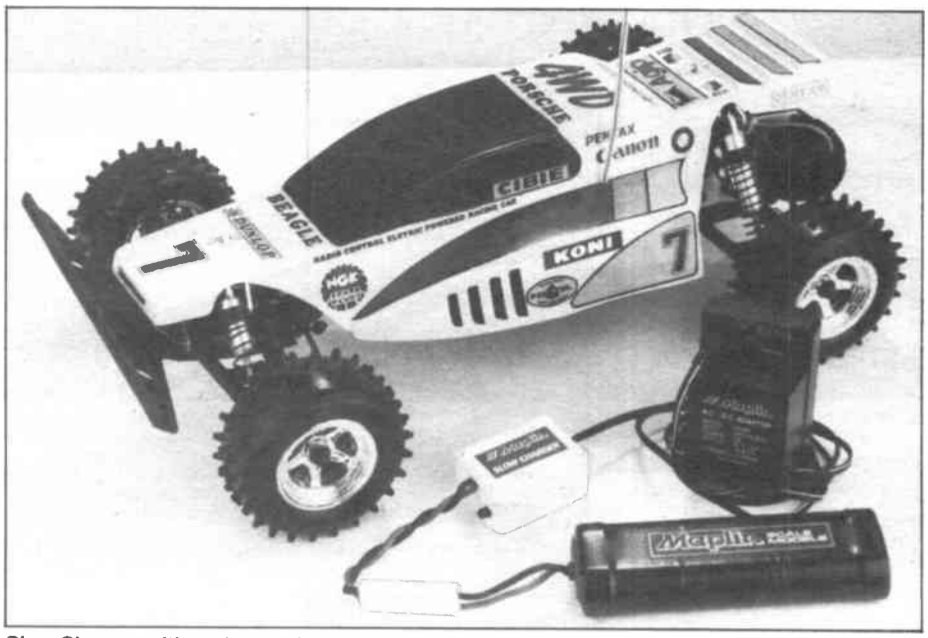


Figure 4. Fixed load discharger.



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	2	(M22R)
CAPACITORS			
C1	10μF 16V Minelect	1	(YY34M)
SEMICONDUCTORS			
D1	1N4001	1	(QL73Q)
LD1	LED Red	1	(WL27E)
TR1	BFY50	1	(QF27E)
BR1	W005	1	(QL37S)
MISCELLANEOUS			
	P.C. Board	1	(GD71N)
	Veropin 2141	1 Pkt	(FL21X)
	Quickstick Pads	1 Stp	(HB22Y)
	Heatsink	1	(FL78K)
	Box 1521	1	(FK72P)
	Race Pack Lead Female	1	(JG05F)
	DC Power Mains Adaptor Unregulated	1	(XX09K)
OPTIONAL			
	Bulb MES 6V 0.6W	1	(WL78K)
	MES Batten Holder	1	(RX86T)
	Tag 4BA	1 Pkt	(BF28F)
	Race Pack Lead Female	1	(JG05F)
	High Power Resistor 22Ω 3W	1	(W22R)

A complete kit of all parts, excluding optional items, is available for this project:
Order As LM39N (Slow Charger Kit) Price £5.95
The following item included in the above kit list is also available separately, but is not shown in the 1988 catalogue:
Slow Charger PCB **Order As GD71N Price 98p**

Mini-Metal Detector

FREE GIFT PROJECT

by Dave Goodman

- ★ **25mm search range dependent upon size of object.**
- ★ **Finds partition studs from nailheads or screws.**
- ★ **Compliments 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

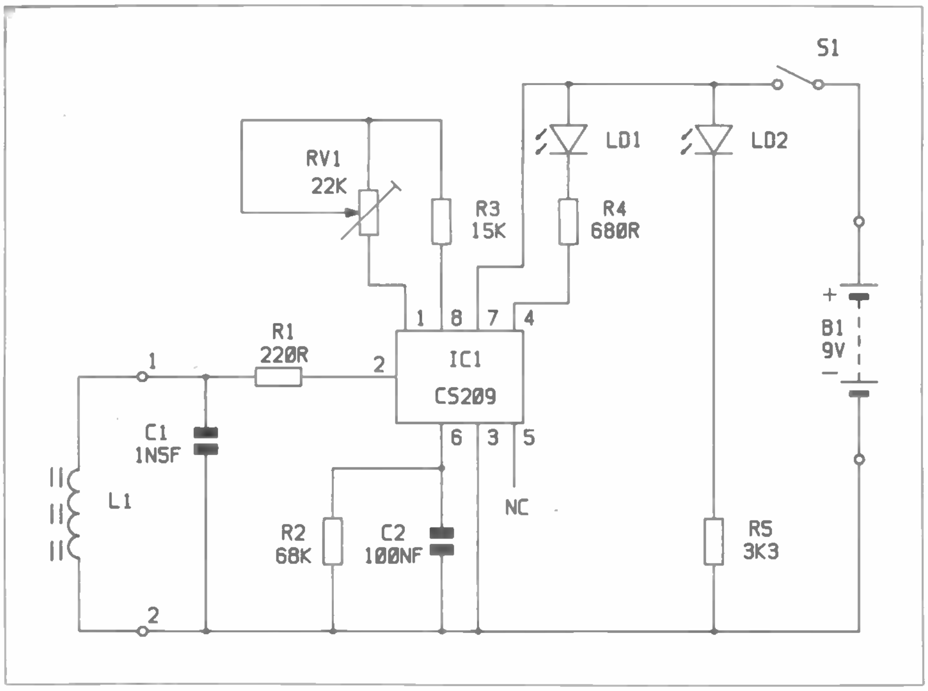
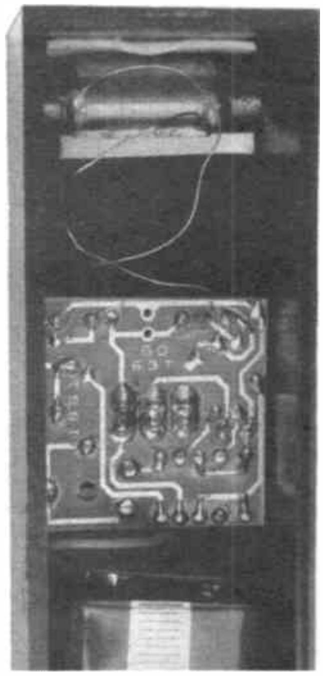


Figure 1. Circuit.


Inside the box.

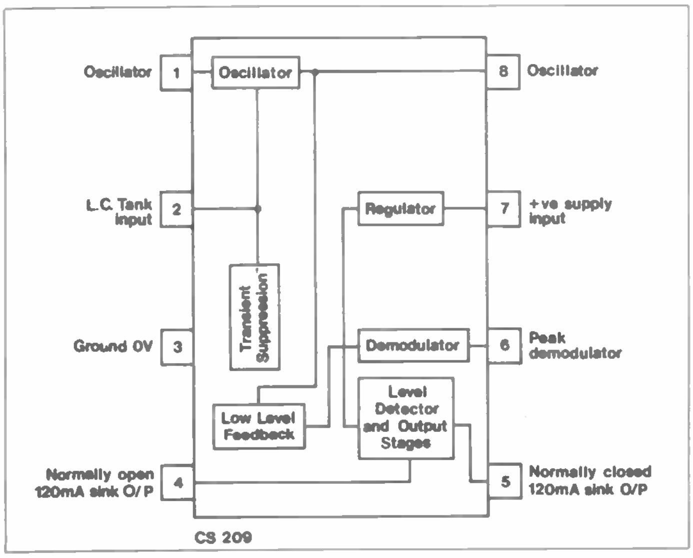


Figure 2. IC Block Schematic.

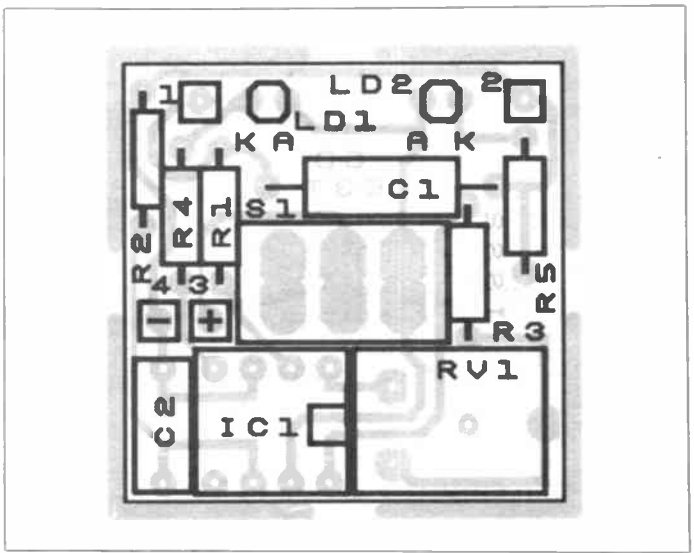


Figure 3. Board Overlay.

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.

PCB Construction

With reference to Figure 3 and the parts list, locate and insert the five resistors R1 to R5. It is important to make sure these resistors are pushed down onto the pcb, otherwise they will foul the slide switch, when fitted. Insert capacitor C1 and mount the eight pin package IC1. Do ensure all eight legs of this device

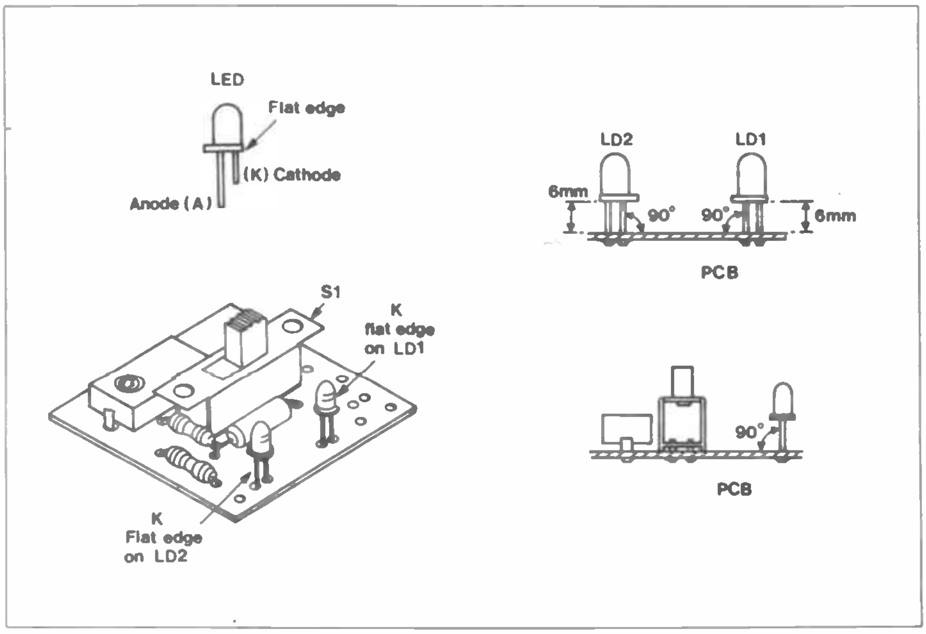


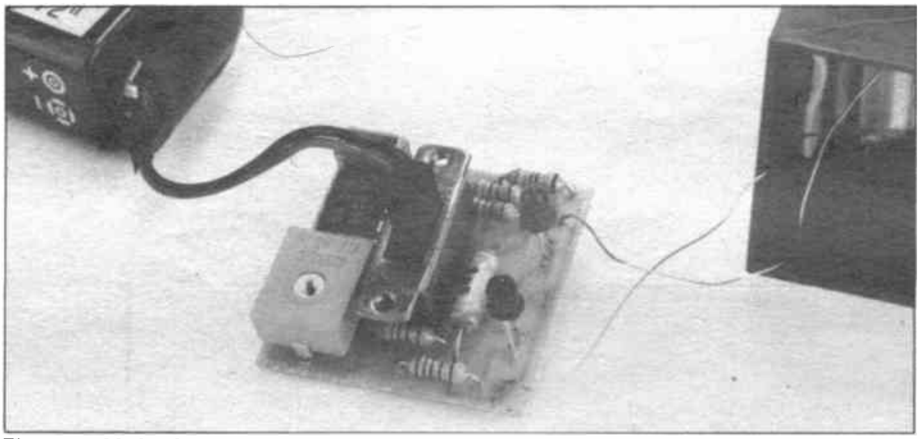
Figure 4. Mounting LD1 and LD2.

protrude through the board before soldering! Next fit C2 and preset RV1; C2 is easily broken so be extra careful with the legs when fitting. Now solder all components carefully to the pcb and watch out for short circuited tracks during this operation. Cut off all excess wire ends and leads and insert the battery clip wires. The black wire goes into the position marked negative (−) and the red wire to the position marked positive (+) on Figure 3, also solder both of these wires. Fit the slide switch S1 close down onto the pcb and straighten up the housing before soldering. Now refer to Figure 4 for mounting the LED's; 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 are due to the quality of soldering, therefore time is well spent on close inspection in this area.

Final Assembly

Figures 5 and 6 show the final assembly details. Before mounting the final components into the box, two of the lid mounting pillars must be removed so that search coil L1 can be fitted. Figure 6 shows which two of the four pillars to cut out and they are situated at the legended front end of the box, nearest to LD1 and LD2. A small pair of wire nippers or a craft knife could be used for cutting through the soft plastic and this should be done as close to the bottom of the pillar as possible. Any protruding plastic left intact can be melted and smoothed over with a hot soldering iron. Fit a sticky pad onto the inside front edge of the box and another pad adjacent to it on the inside top edge. Remove the backing strips and carefully press L1 onto both pads. Cut the two connecting wires on L1 to about 50mm in length, tin each end then fit into pcb pins 1 and 2 and solder in place.

Place the completed module, component side first, into the box and align the two threaded holes in S1 housing with the holes in the box. Gently push the module home, making sure LD1 and LD2 slightly protrude through to the outside and insert an M2 x 6mm screw into each hole and tighten them both up.



The assembled pcb.

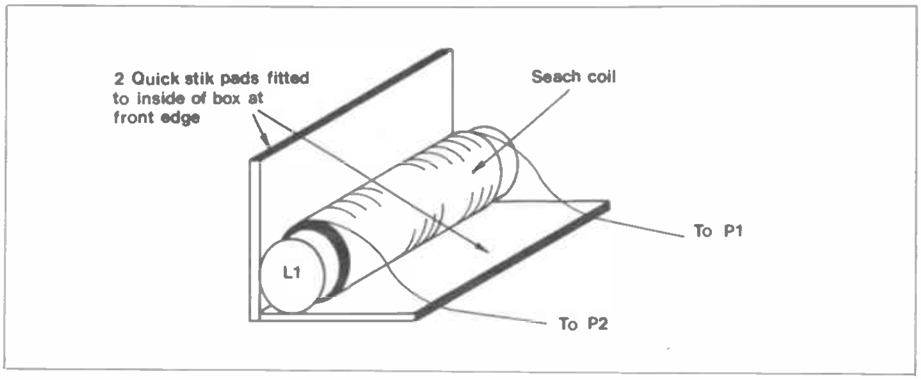
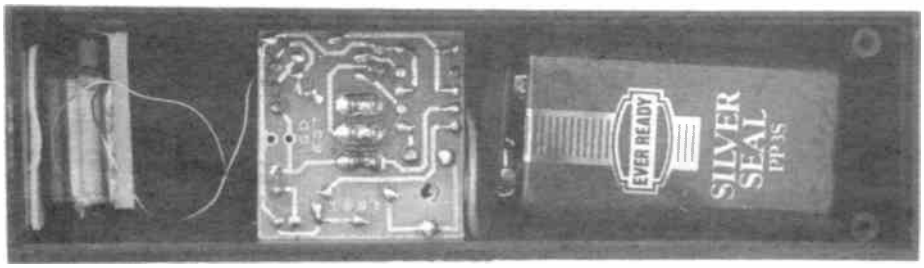


Figure 5. Mounting Search Coil L1.



Search coil, pcb and battery all fit inside the box.

Testing and Use

Fit the battery clip onto a working PP3 battery and operate the slide switch so that either LD2 or both LED's turn on. Insert a trimming tool or small screwdriver into the hole above RV1 and turn

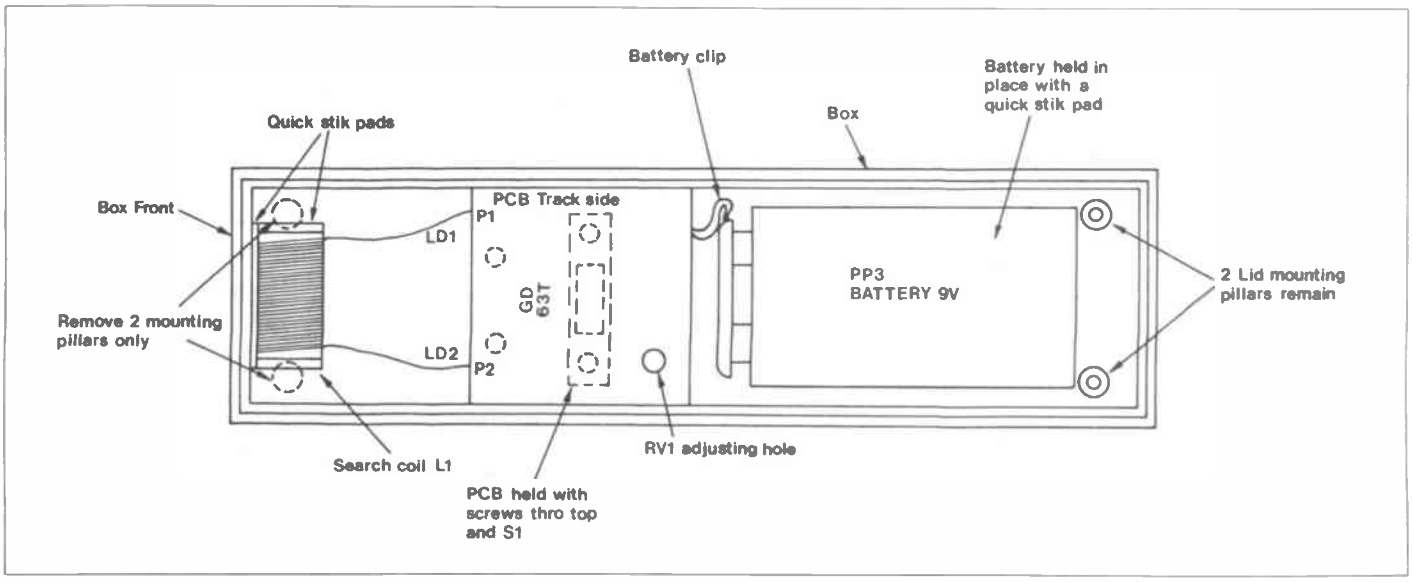


Figure 6. Final Assembly.

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.

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.

Enjoy your Free Gift!

MINI-METAL DETECTOR PARTS LIST

RESISTORS: All 0.6W 1% Metal Film unless stated			
R1	220Ω	1	(M220R)
R2	68k	1	(M68K)
R3	15k	1	(M15K)
R4	680Ω	1	(M680R)
R5	3k3	1	(M3K3)
RV1	22k Hor Encl Preset	1	(UH04E)
CAPACITORS			
C1	1500pF 1% Polystyrene	1	(BX58N)
C2	100nF Polylayer	1	(WW41U)
SEMICONDUCTORS			
IC1	CS209	1	(UH59P)
LD1,2	High Bright Red Min LED	2	(WL83E)
MISCELLANEOUS			
S1	Sub Min Slide	1	(FH35Q)
L1	100μH Search Coil	1	(JC25C)
	Detector Box	1	(JC24B)
	Battery Clip	1	(HF28F)
	M2 x 6mm C/Sk Screw	1 Pkt	(BF41U)
	Quickstik Pads	1 Strip	(HB22Y)
	Constructor's Guide	1	(XH79L)
OPTIONAL			
	Mini-Metal Detector PCB	1	(GD63T)
	Battery PP3 9V	1	(FK58N)

A complete kit of all parts, excluding optional items, is available for this project:
Order As LM35Q (Mini Metal Detector Kit) Price £4.95
The following items included in the above kit list are also available separately, but are not shown in the 1988 catalogue:
Mini Metal Detector Box **Order As JC24B Price £1.20**
100μH Search Coil **Order As JC25C Price 45p**

Continued from page 17.

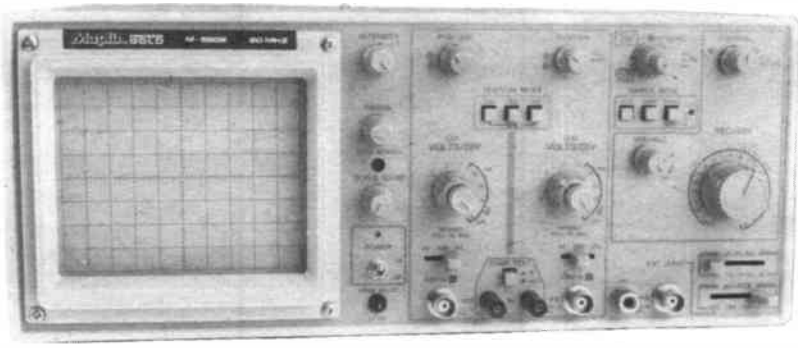
recognised manual or circuit diagram and work methodically. Hopping around only leads to confusion. Have the correct equipment. Trying to desolder a double-sided board without a solder sucker could damage the printed circuit. Or using crocodile clips when thin probes are required makes life unnecessarily difficult.

While troubleshooting be aware of surrounding circuitry, e.g. applying a signal generator to the IF coils of a radio could detune the IF giving a wrong reading. Or while looking for short circuits beware of coils or low value resistors in parallel before jumping to conclusions - it may be necessary to desolder components.

Safety

It seems strange to have left an important subject like this till last but remember the old adage: a little knowledge is a dangerous thing. One needs to know what one is doing before handling electrical circuits. Safety has two aspects: safety to equipment and safety to personnel. Modern circuits use integrated circuits (ICs) increasingly and these are sensitive to static from human fingers. Another example of safety to equipment is the use of the highest measuring range of an instrument when measuring unknown voltages.

A clean work bench goes a long way towards safety to equipment and personnel. Otherwise printed circuit boards get damaged and people get burned by soldering irons.



20MHz dual beam oscilloscope.

Safety to personnel is the more important of the two. For instance large value electrolytic capacitors store a substantial charge and should not be touched unless safely discharged. A dirty trick is to short the terminals with an insulated screwdriver. The correct method is to discharge to earth via a low value resistor of sufficient wattage.

And what if you test the mains with a mains tester? Just because the neon did not light does it mean it is safe to touch the mains? Could the neon light in the screwdriver itself be faulty? Did you first check it in a socket that is known to be working? Remember, survival is the name of the game!

Conclusions

This short series has explored measurement standards, and transducers for converting non-electrical quantities into electrical quantities so that they can be measured electrically. Instruments for measuring capacitors and inductors were discussed. Both analogue and digital meters were explored for measuring the electrical fundamentals: voltage, current and resistance - both DC and AC.

Apart from measuring current, voltage and resistance, electronics engineers are obsessed with signal processing, and the remaining parts were devoted to electronic counters, signal generators and wave analysers.

This concludes the series on test gear. However, the best piece of equipment for analysing a problem or measurement results is still the human brain. Not even the most powerful computers have approached its power. However, that is a different subject and although neurology makes fascinating reading, we must regretfully bring this series to a close.

WHICH NAND GATE?

by J.K. Hearfield

Unlike analogue circuits, digital circuits operate in a world which recognises only two different signal voltages: close to earth, and close to the supply rail. The two levels are known as 0 and 1 for convenience, where 0 almost always means the state nearer to 0 volts. Since 0 and 1 are the only possible levels, it follows that if a signal is not 0 it must therefore be 1. This simple truth can be written as $\overline{0} = 1$.

The bar over the 0 means that the level is inverted - that is, converted into its opposite. Inverting a signal is actually very easy, as Figure 1 shows. When the input signal is high (a 1) the transistor is turned ON; its collector current is limited only by its load resistor, and the output voltage is low (a 0). Conversely, an input signal of 0 produces an output of 1.

The inverter's behaviour can be expressed as a 'truth table', which defines in a straightforward and compact way what its output will be for all possible inputs. See Figure 2.

There are in fact only two other fundamental types of gate. AND gates are used to detect the condition of ALL inputs being simultaneously 1, whilst OR gates respond if ANY input is 1. Their truth tables are given in Figure 3.

NAND and NOR gates are just AND and OR gates with inverted outputs. So the output of a NAND gate is 0 only when all its inputs are simultaneously 1; any other combination of inputs gives a 1 at the output. Any logic circuit, no matter how complex, can be built by interconnecting AND gates, OR gates and inverters. Why, then, should manufacturers of logic circuits bother to produce NAND and NOR gates? The reason, not surprisingly, is because NAND and NOR gates are simpler to make and also have better performance, as Table 1 illustrates.

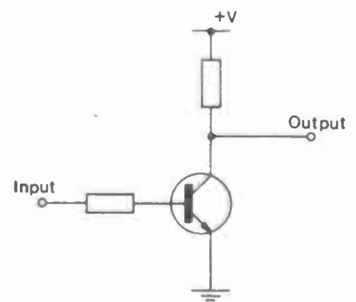


Figure 1. The simplest single-transistor inverter.

A	X
0	1
1	0

Figure 2. Simple truth table.

A	B	X
0	0	0
0	1	0
1	0	0
1	1	1

(a) AND Gate

A	B	X
0	0	0
0	1	1
1	0	1
1	1	1

(b) OR Gate

Figure 3. AND and OR gate truth tables.

	NAND gate (7400)	AND gate (7408)
Transistors	4	6
Diodes	1	2
Resistors	4	6
Propagation delay time (ns)	9	15
Average power dissipation (mW)	2	4

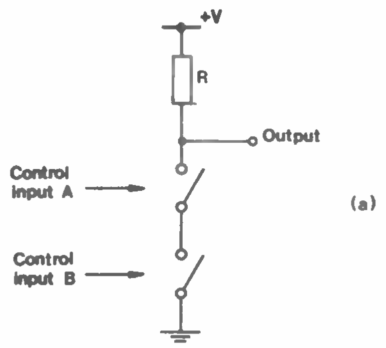
Table 1. NAND better than AND?

NAND Gates

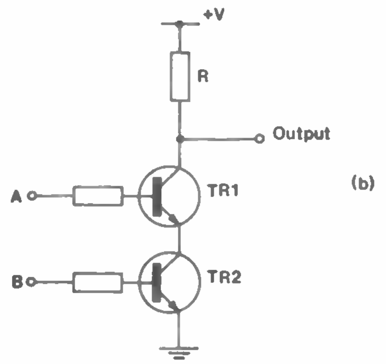
A NAND gate is a logic element in which the output is LOW only when both the inputs are HIGH. It behaves like a NOT gate (inverter) preceded by an AND gate: hence the name.

It is quite possible to make a NAND gate from switches, as Figure 4(a) shows: the output voltage is low only when both the switches are closed. More usually, transistors replace the switches, and a possible discrete-component NAND gate is shown in Figure 4(b). The behaviour of each circuit is conveniently expressed in truth-table form, as shown.

Figure 5(d) shows the truth table expressed in the more usual way: the output is 0 only when both inputs are 1. An AND gate output is 1 only when both inputs are 1, so it is easy to see that Figure 5(a) and 5(b) are equivalent. It may not be quite so obvious that Figure 5(c) is also equivalent, though it is. Inverting the inputs and then OR-ing them generates the same outputs. This

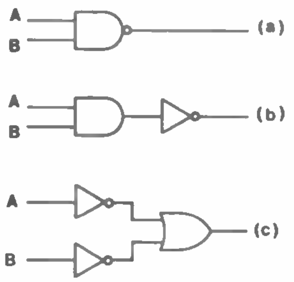


CONTROL INPUT A	CONTROL INPUT B	OUTPUT
Open	Open	+V
Open	Closed	+V
Closed	Open	+V
Closed	Closed	0V



INPUT A	INPUT B	OUTPUT
0V	0V	+V
0V	+V	+V
+V	0V	+V
+V	+V	0V

Figure 4. NAND gates made from (a) switches, and (b) transistors.



A	B	OUTPUT
0	0	1
0	1	1
1	0	1
1	1	0

(d)

Figure 5. Three circuits which perform the NAND function.

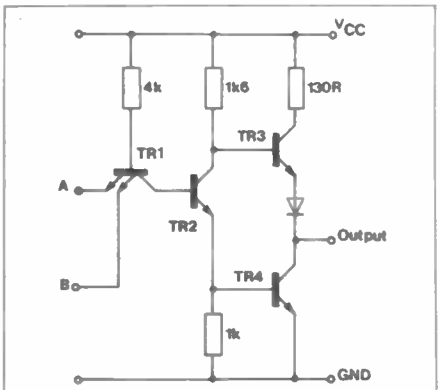


Figure 6. 7400: internal circuit of each gate.

can be written mathematically as:

$\overline{A} + \overline{B} = \overline{A.B}$

Which together with its dual:

$\overline{A} . \overline{B} = \overline{A+B}$

Is an extremely useful logic design ool; the two equations are known collectively as de Morgan's theorem.

TTL NAND Gate

The internal circuit of a 7400 (shown in Figure 6) is at first glance misleadingly similar to that of a straightforward amplifier. Its operation is however quite different. Part of the reason for this is that it (normally) only ever sees input signals that are near earth (logic 0) or near the positive supply rail (logic 1). As a result, its transistors are intended to be either saturated (ON) or deprived of base current (OFF).

To understand how it works, imagine first that either of the inputs is connected to earth. TR1 is then ON, and tries to draw its collector current from TR2 base. It can only get leakage current, of course; TR2 under these conditions must be OFF. So TR3 can draw base current down through the 1k6 resistor and turn ON, and TR4 is deprived of any base current (which must flow through TR2) and so is turned OFF. The net result is that the output is at 1 when either (or both) the inputs is at 0.

Now suppose instead that both inputs are connected to the positive supply rail. TR1's emitter is now more positive than its base, so one might suppose that TR1 is still off. But TR1 is just an npn transistor: it doesn't 'know' that current is supposed to flow in at its collector and out of its emitter. It will work quite happily the other way round (provided it can get base current), though with a much lower gain. So with both inputs positive, current flows INTO them, out of the collector, and onwards into TR2 base. TR1 and TR2 are thus both ON, as is TR4. TR3 cannot turn on, because the voltage at its base (the 0.7V of TR3's base-emitter drop plus the 0.1V or so saturation voltage of TR2) is about the same as the voltage at its emitter (the 0.1V to 0.4V saturation voltage of TR4 plus 0.7V from the diode). The diode is included to ensure that TR3 is always off when TR4 is on, even under worst-case conditions. So the output is at 0 only when both inputs are at 1.

Schottky TTL

There is a significant disadvantage in allowing switching transistors to enter saturation (in which any increase in base current hardly increases the collector current at all). Saturated transistors are slow to turn off, because of the excess charge stored in the base region.

To get round the problem it is necessary only to arrange that the collector voltage does not fall too far below the base voltage. This is done by connecting a diode between base and collector, so that the collector voltage is always one diode drop above the base. But an ordinary silicon diode cannot be used here; it would in fact probably make matters worse. The diode must itself turn on and off faster than the transistor to be useful. In practice, special diodes (known as Schottky diodes) are used. They exploit the properties of a metal-to-semiconductor junction (as opposed to semiconductor-to-semiconductor) and can effectively be built-in to the transistor as it is manufactured by arranging that the base contact metallisation overlaps the collector surface. A Schottky transistor can be identified on a circuit diagram by the stylised 'S' of its base.

Schottky TTL is a good deal faster than ordinary TTL: the propagation delay of a 74S00 is only about 3ns, compared to a 7400's 11ns. But since most systems need not operate as fast as this, manufacturers took the opportunity to trade some of the speed for a reduction in power consumption. The result was Low Power Schottky (LSTTL).

Low-power Schottky TTL

LSTTL has become in recent years the industry standard logic family. It offers a huge range of functions, is widely second sourced, and costs very little. The internal circuit diagram of a 74LS00 is

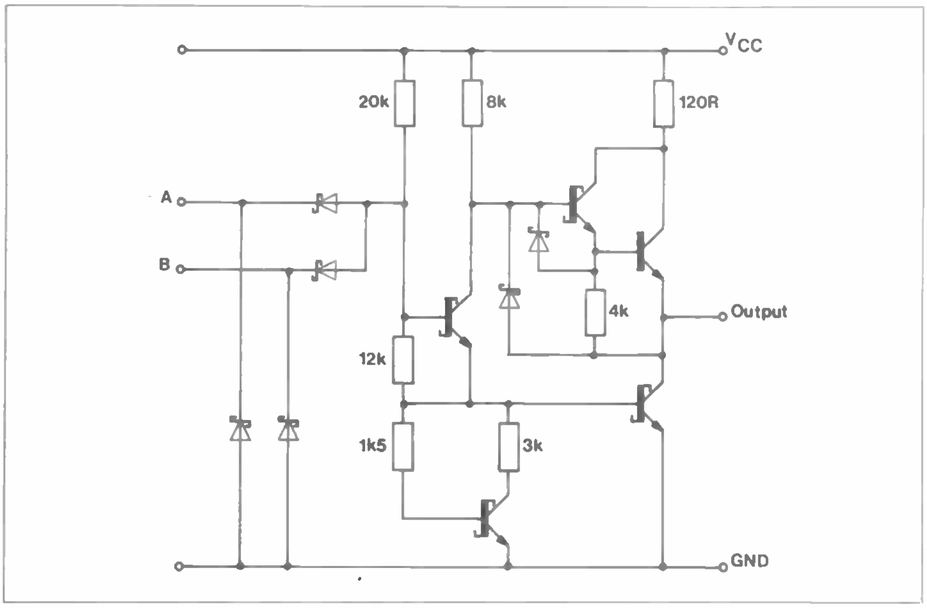


Figure 7. 74LS00: internal circuit of each gate. The low-power Schottky NAND gate beats the standard 7400 on both speed and power by using faster transistors in a more complex circuit.

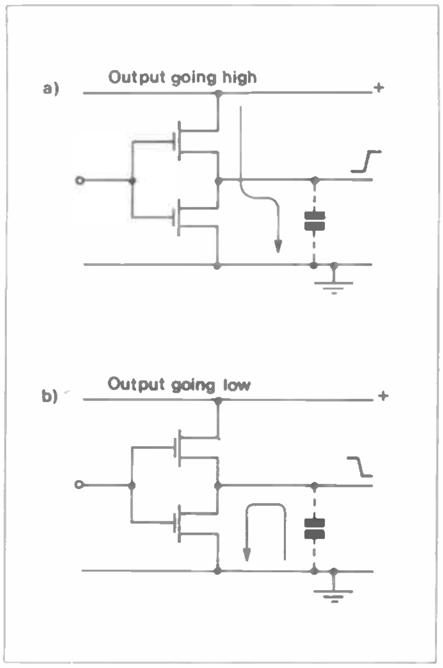


Figure 10. CMOS gates dissipate power when they charge and discharge stray capacitance.

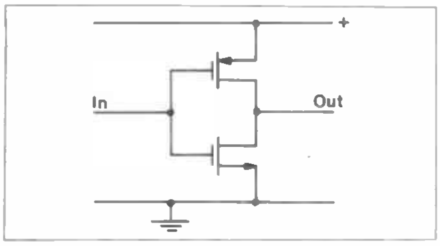


Figure 8. The output stage of a CMOS gate consists of an n-channel device in series with a p-channel device.

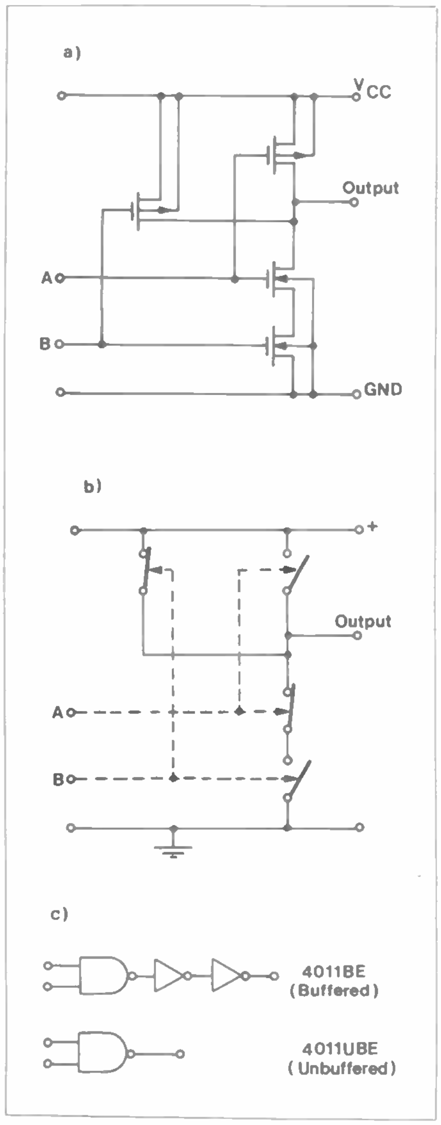


Figure 9(a). The internal circuit of a simple CMOS NAND gate is very straightforward; it uses just n-channel and p-channel MOSFETs.
(b). The MOSFETs can be thought of as switches.
(c). Buffered gates are also available in some cases.

shown in Figure 7. Comparing this circuit with that of an ordinary TTL gate (Figure 6) the basic similarity of the two is apparent, and apart from the use of a diode AND gate in place of the multi-emitter input transistor, the LSTTL gate works in much the same way as its TTL ancestor.

CMOS Gates

In CMOS (Complementary Metal Oxide Silicon) logic, MOS transistors replace bipolar transistors as the switching elements. The ingenious twist that makes CMOS much easier to use than TTL however lies in the way n-channel and p-channel devices are arranged so that each type acts as a load for the other. The output stage of a typical CMOS gate (Figure 8) consists of an n-channel MOSFET connected in series with a p-channel device. Both are enhancement-mode types, so a large positive voltage at the input turns ON the n-channel (lower) transistor. At the same time, it ensures the p-channel (upper) transistor is turned OFF though, so the n-channel transistor cannot draw any current. Conversely, an input signal near earth turns the upper transistor ON but leaves the lower one OFF; still no current can flow. And although the output is usually connected to the gates of other MOS devices, they take no current either. In other words, a CMOS gate draws practically no current at all, no matter what state its output is in. As an added bonus, the gate doesn't much care what supply voltage it gets. Ordinary metal-gate CMOS is specified to work at a positive rail voltage anywhere between 3V and 18V. High-speed CMOS (sometimes known as silicon-gate CMOS) is a little more choosy: its supply rail should be kept between 2V and 6V.

The internal circuitry of a metal-gate CMOS NAND gate is illustrated in Figure 9(a) and redrawn in Figure 9(b) with the MOSFETs replaced by switches.

Power Dissipation

One of the most striking differences between the logic families is the amount of power they consume. The current demand of the TTL families is more or less constant (and quite large), regardless of whether the gate is handling a signal or not. By contrast, CMOS gates use practically no power when they are idle, but their current demand rises linearly with signal frequency.

The explanation for this effect lies in the stray capacitance at the gate's output (Figure 10). When the output switches to a high level, this capacitance must gain charge to support the new, higher voltage. The charging current flows through the upper transistor, dissipating power as it does so. Conversely, the lower transistor dissipates power as the capacitance discharges through it when the output goes low. The more frequently the capacitor is charged and discharged, the higher the power dissipation.

The relationship can be expressed as:

$$P = f C V^2 + I V$$

Where P is the power dissipation, f is the signal frequency, C is the gate's 'power dissipation capacitance', V is the supply voltage, and I is the quiescent current drain. Typically C = 20pF and I = 1μA for a 74HC00, so with a 5 volt

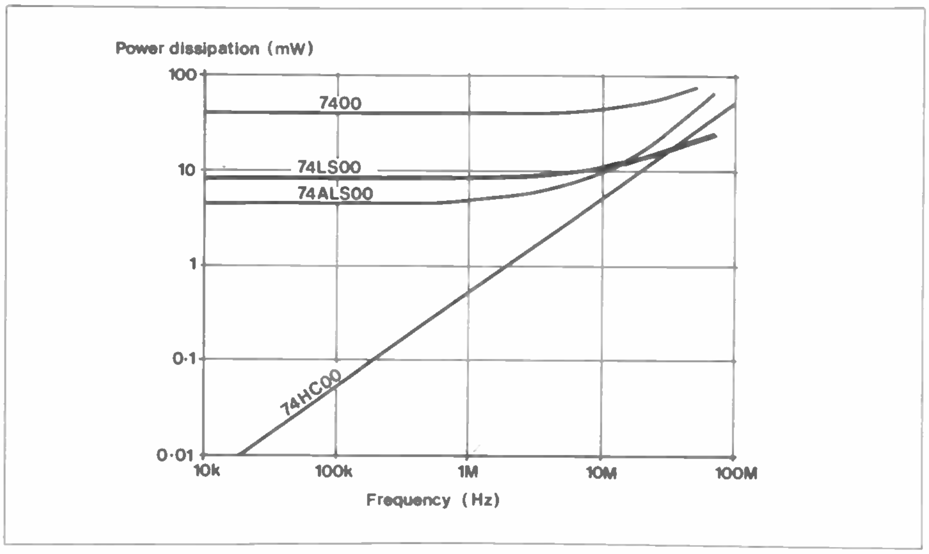


Figure 11. CMOS devices use much less power than TTL at low frequencies.

supply rail, the equation predicts that the gate will dissipate 50mW at 1MHz, but only about 5μW at 1kHz. In practice, this means that HCMOS gates use less power than TTL gates at all but the highest clock frequencies, as Figure 11 illustrates, and the current demand of CMOS systems operating at low speeds is usually negligibly small.

Noise Immunity

Defining a logic 0 as 'near earth' and a logic 1 as 'near the supply rail' may be an adequate shorthand for system designers, but the manufacturers of logic gates need a more precise specification. Figure 12 shows the worst-case definitions for the major TTL and CMOS families.

The levels shown relate directly to the amount of output current a gate can deliver: in other words, to its maximum fanout. For example, a 74LS00 can drive up to 20 LSTTL inputs in the 0 state without its output voltage exceeding 0.5 volts. But the inputs it is driving will accept any level up to 0.8V as a valid logic 0. The difference of 0.3V is the gate's 0 state noise margin. An unwanted glitch (or pulse) riding on top of the 0.5V level would be ignored provided its amplitude were less than 0.3V. If the 74LS00 were driving only one input, its output voltage would of course be much lower than 0.5V, since its output transistor would be sinking a much smaller current, so its noise margin would then be correspondingly greater.

Variants

Many digital systems need to interface directly with the outside world, in which input signal levels change relatively slowly. Unfortunately, the TTL logic families cannot handle signals whose risetime (or falltime) is greater than a microsecond or so. A TTL gate is really just a wideband amplifier which is intended to work in saturation. Its inputs normally swing from one extreme to the other so quickly that the gate spends hardly any time in its linear region. But if the input signal changes slowly enough, the gate is quite likely to spring into oscillation somewhere along the way from one level to the other generating a burst of unwanted pulses. The usual solution is to arrange for all slow input signals to pass first through Schmitt triggers, which provide TTL-compatible DC levels and edge speeds. The Schmitt trigger function is often incorporated directly into the gate design. TTL types 74132 and 74LS132 are examples of quad 2-input NAND Schmitt trigger gates. And

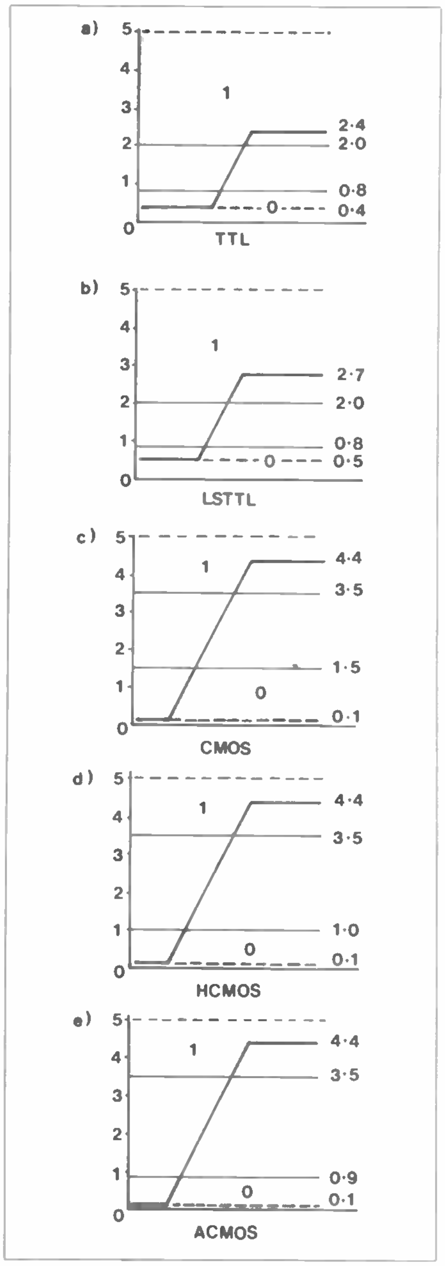


Figure 12. The worst case output voltage swing for CMOS is much greater than for TTL, so the input voltage thresholds for CMOS can be further apart, giving better noise immunity. (Supply voltage = 4.5V).

		TTL		CMOS		
		7400	74LS00	4011BE	74HC00	74AC00
Temp range		0 to 70		−40 to +85		
Supply	V_{CC}	4.5 to 5.5		3 to 18	2 to 6	
Output voltage	V_{OH} / V_{OL}	2.4 / 0.4	2.7 / 0.5	4.4 / 0.1		
Input voltage	V_{IH} / V_{IL}	2.0 / 0.8		3.5 / 1.5	3.5 / 1.0	3.5 / 0.9
Noise margin		0.4 / 0.4	0.7 / 0.3	1.4 / 0.9		
Output current (mA)	I_{OH} / I_{OL}	−0.4 / +16	−0.4 / +8	−0.5 / +0.5	−4 / +4	−24 / +24
Input current (μA)	I_{IH} / I_{IL}	40 / −1600	20 / −400	0.1		
Fanout		10	20	50	50 (10)	100 (20)
Power/gate (μW)		10,000	2,000	1		
Propagation delay (ns)		11	9	28	8	5

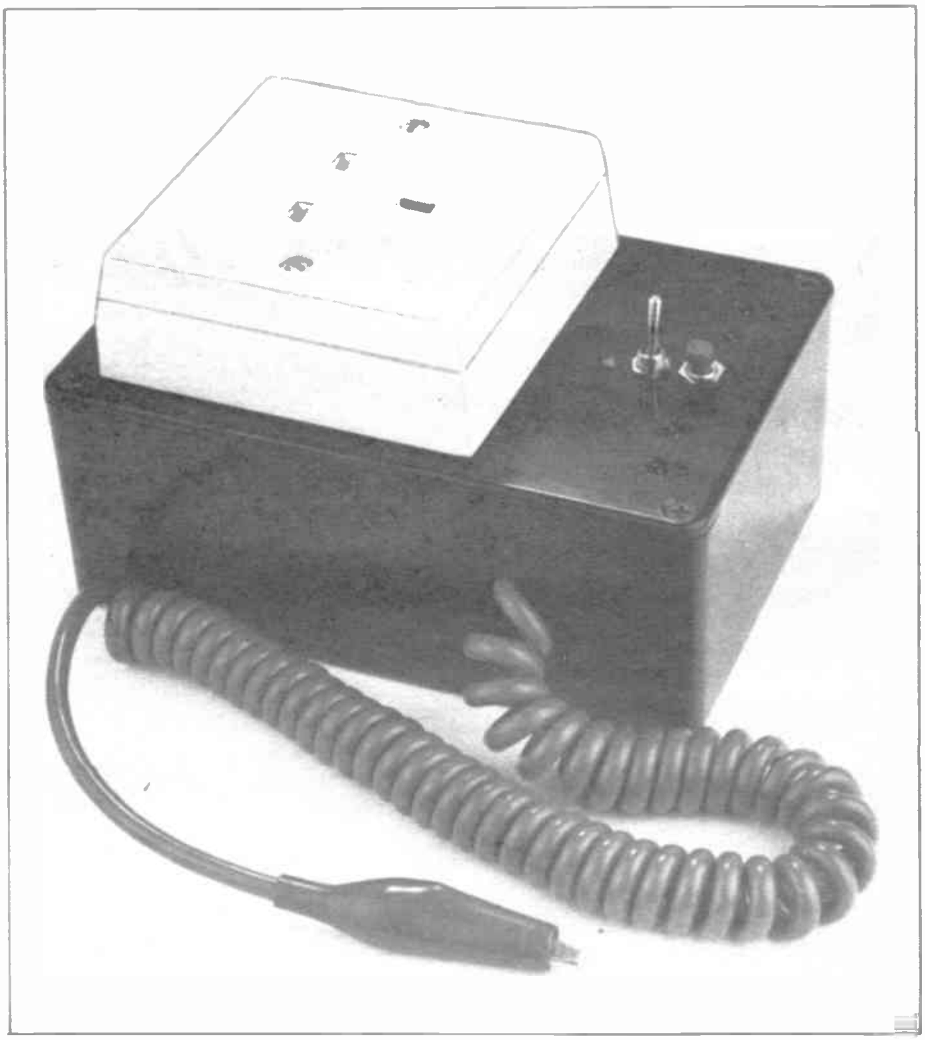
Table 2. TTL and CMOS differences.

Continued on page 56.

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



The tester.

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 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.

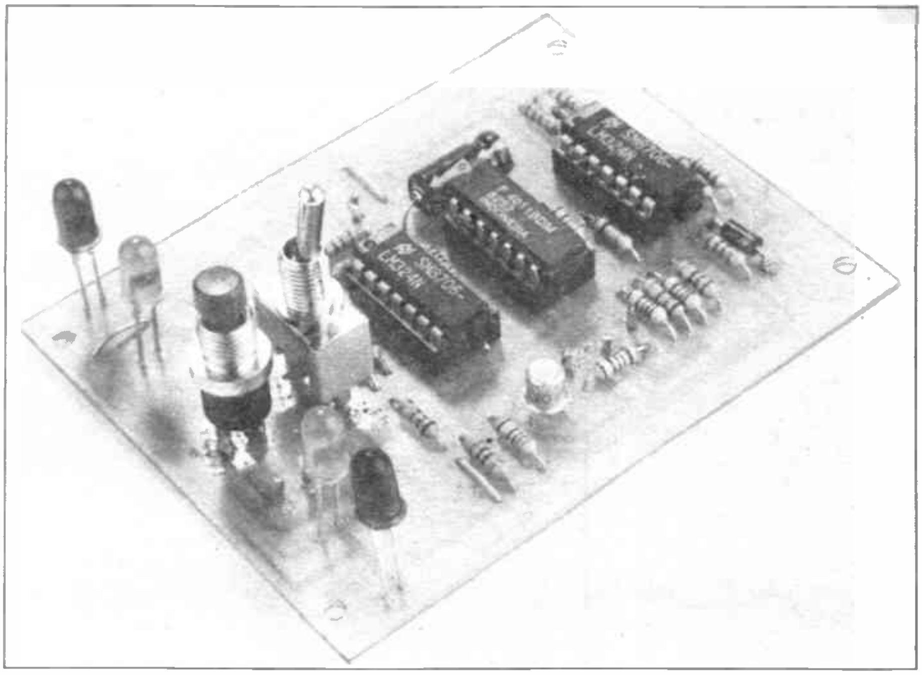
What Can Go Wrong?

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



Switch and LED mounting.

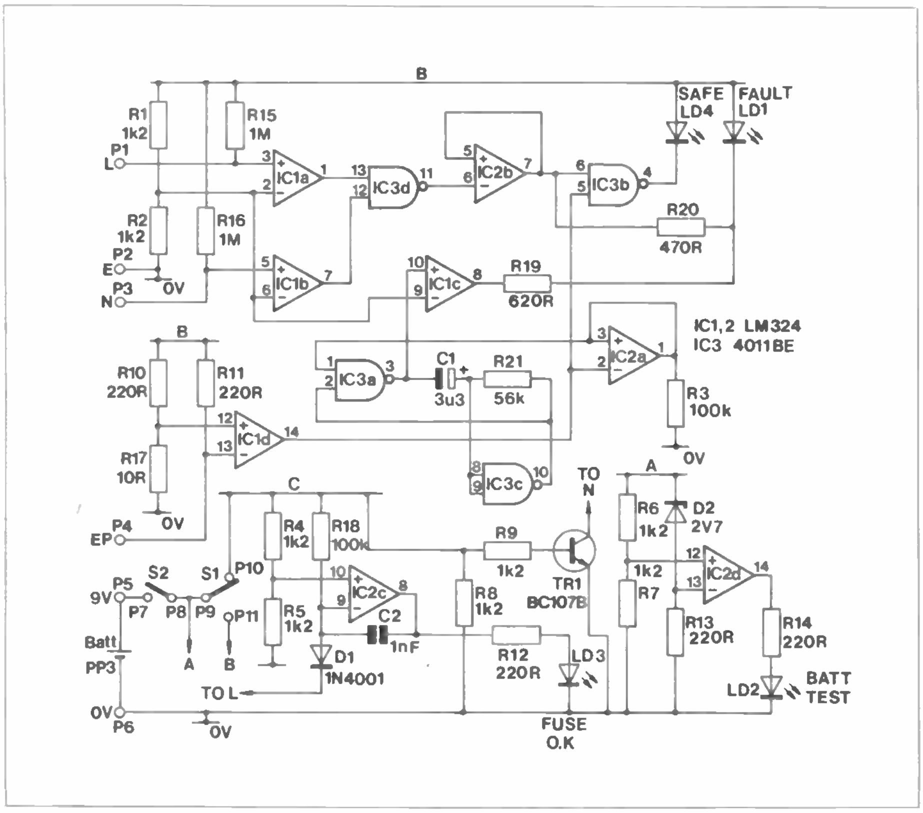


Figure 1a. Appliance Tester circuit.

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

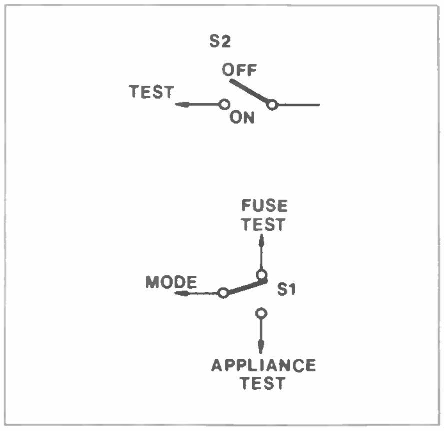


Figure 1b. Switch functions.

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

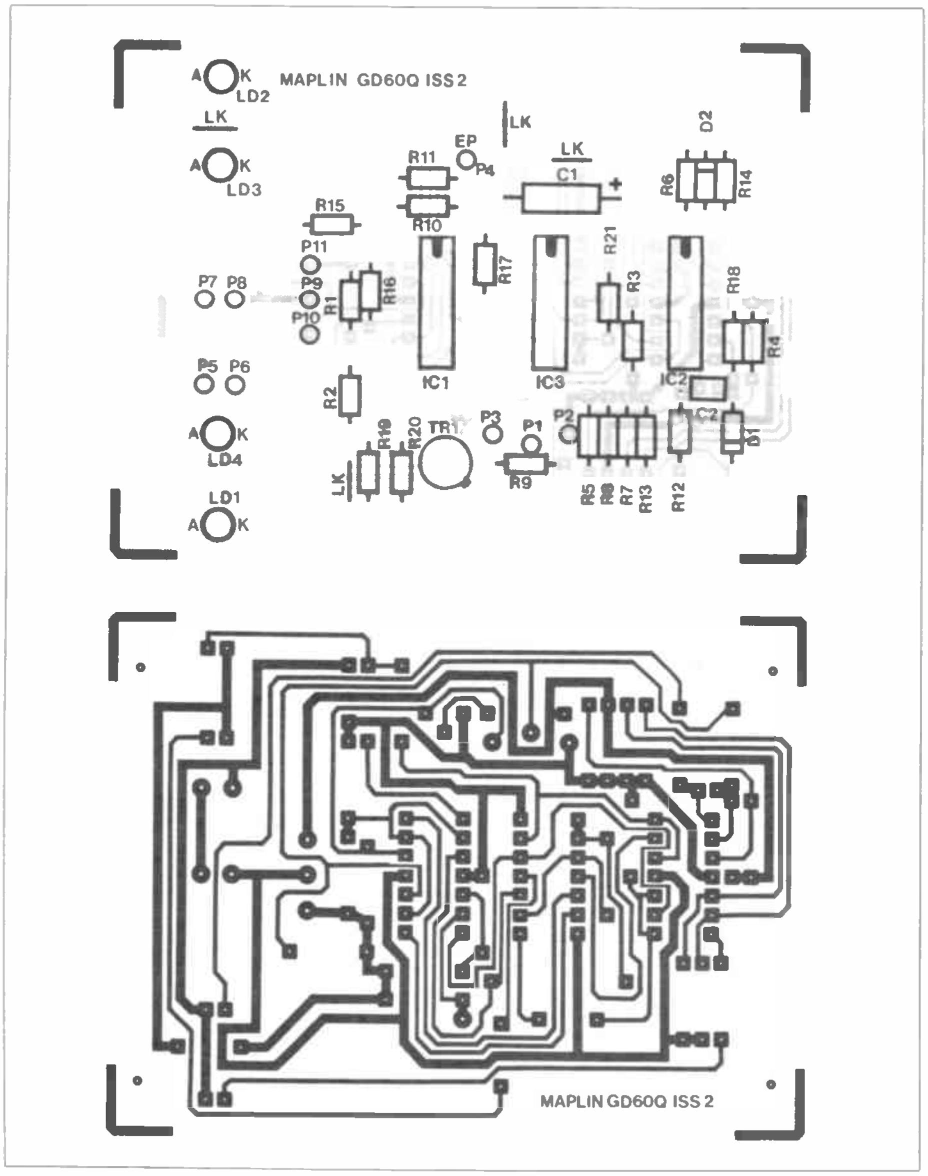


Figure 2. PCB layout and track.

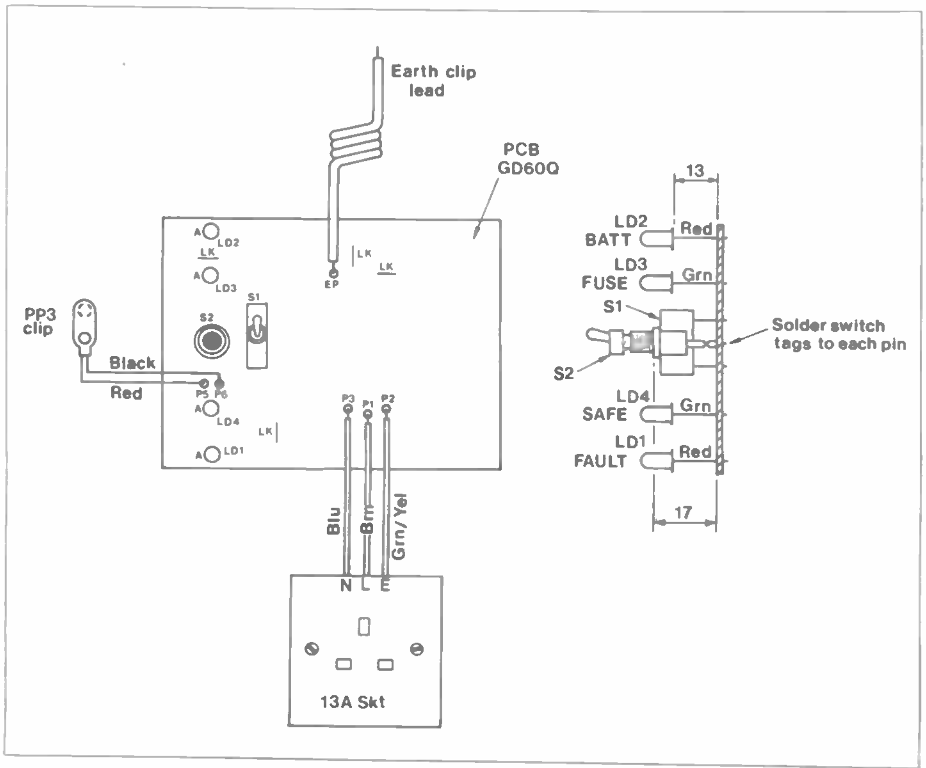


Figure 3. LED and switch mounting.

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.

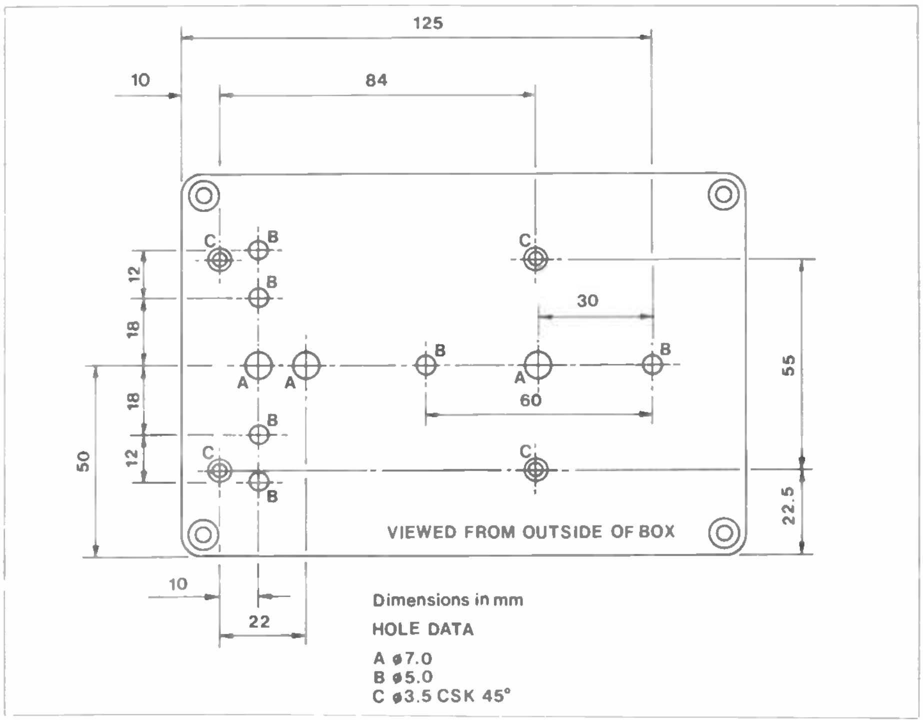
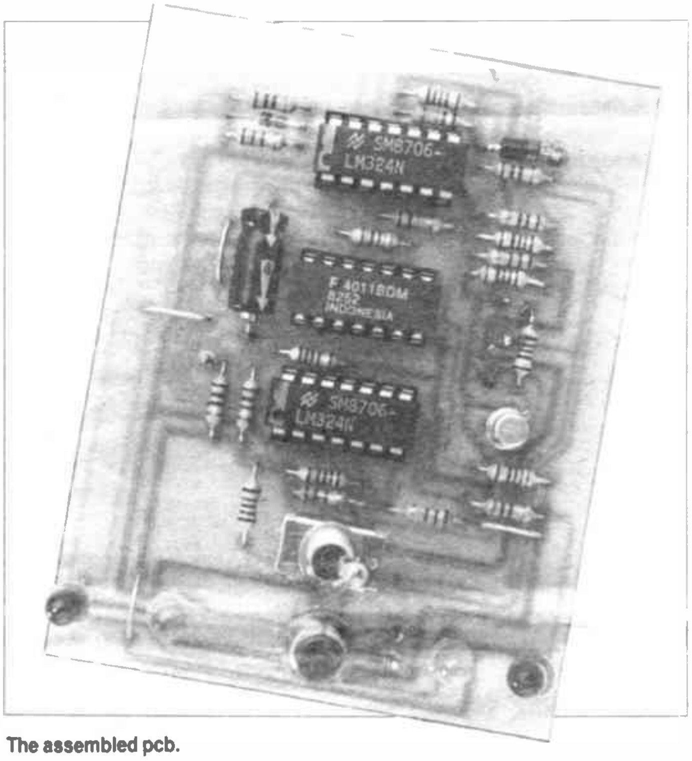


Figure 4. Lid of box drilling.


The assembled pcb.

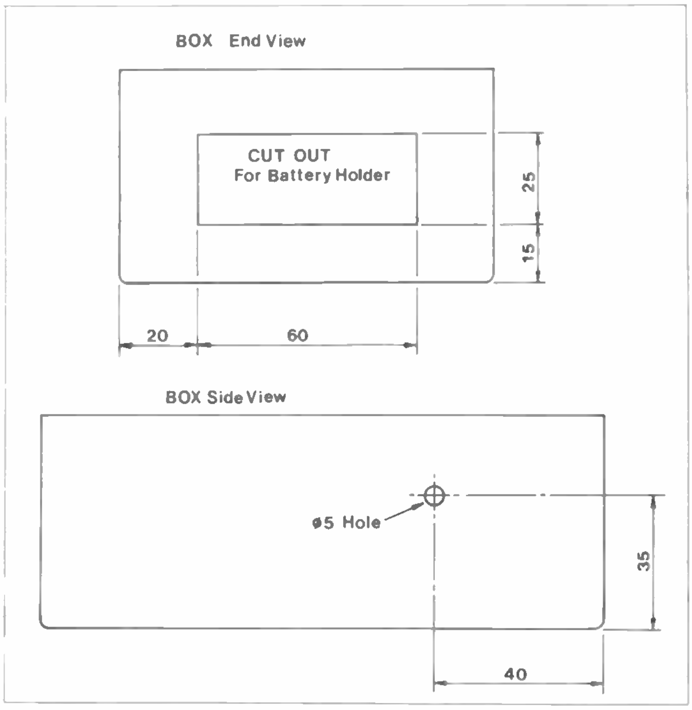


Figure 5. Box cut out details.

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.

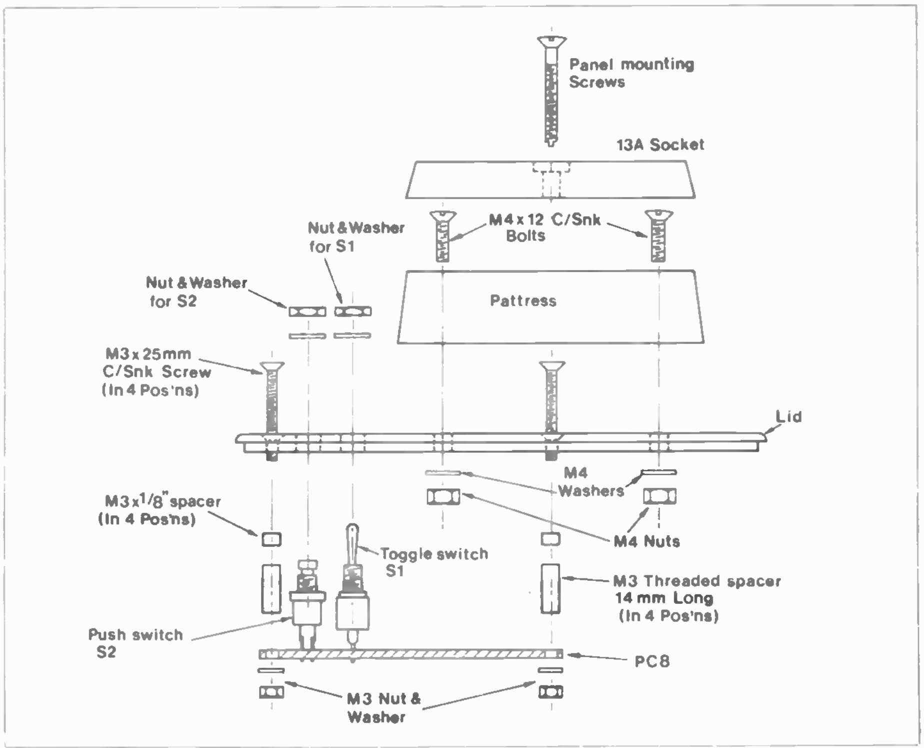


Figure 6. Final assembly.

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,R18	100k	2	(M100K)
R19	620Ω	1	(M620R)
R20	470Ω	1	(M470R)
R21	56k	1	(M56K)
CAPACITORS			
C1	3μ3F 100V Electrolytic	1	(FB17T)
C2	1nF Ceramic	1	(WX68Y)
SEMICONDUCTORS			
IC1,2	LM324	2	(UF26D)
IC3	4011BE	1	(QX05F)
D1	1N4001	1	(QL73Q)
D2	BZY88C2V7	1	(QH00A)
LD1,2	LED Red	2	(WL27E)
LD3,4	LED Green	2	(WL28F)
TR1	BC107B	1	(QB31J)
MISCELLANEOUS			
S1	Toggle Switch SPDT	1	(FH00A)
S2	Push Switch	1	(FH59P)
	Veropin 2145	1 Pkt	(FL24B)
	P.C. Board	1	(GD60Q)
	Box ABS MB5	1	(YN40T)
	Battery holder	1	(XX33L)
	Coiled Screened Cable Red	1	(BH34M)
	Crocodile Clip Red	1	(HF24B)
	Patress 20mm Surface Mounting	1	(YB14Q)
	13 Amp Socket, Single unswitched	1	(HL68Y)
	Front Panel	1	(JG18U)
	Threaded Spacer M3 x 14mm	1 Pkt	(FG38R)
	Screw M3 x 25mm C/Snk	1 Pkt	(BF38R)
	Washer M3	1 Pkt	(BF62S)
	Nut M3	1 Pkt	(BF58N)
	Spacer M3 x ⅛in.	1 Pkt	(FG32K)
	Screw M4 x 12mm C/Snk	1 Pkt	(BF34M)
	Washer M4	1 Pkt	(BF61R)
	Nut M4	1 Pkt	(BF57M)
	3-Core Mains Cable	1	(XR02C)
OPTIONAL			
	PP3 Battery	1	(FK62S)

A complete kit of all parts, excluding optional item, is available for this project:
Order As LM38R (Appliance Tester Kit) Price £15.95
The following items included in the above kit list are also available separately, but are not shown in the 1988 catalogue:
Appliance Tester PCB **Order As GD60Q Price £1.98**
Stick-on Front Panel **Order As JG18U Price £2.95**

RAPID

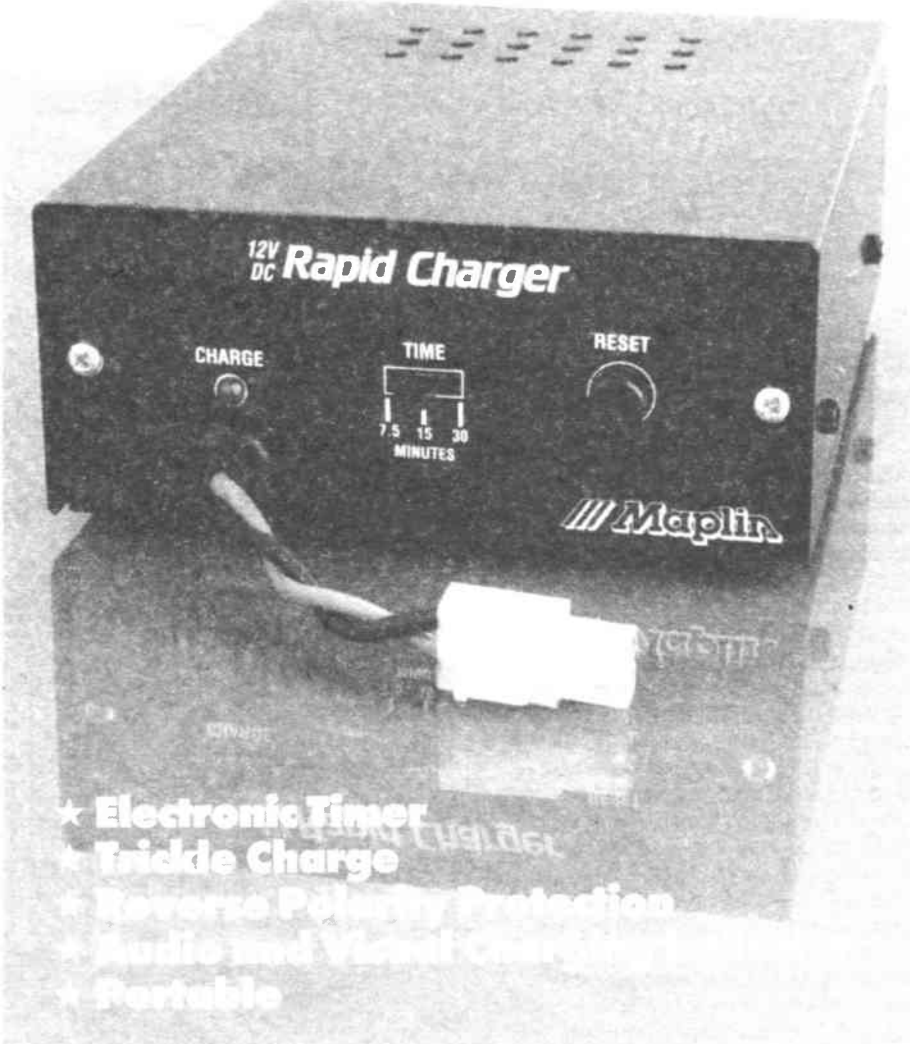
TRACK SIDE CHARGER FOR NI-CAD RACING PACKS

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.

CHARGER

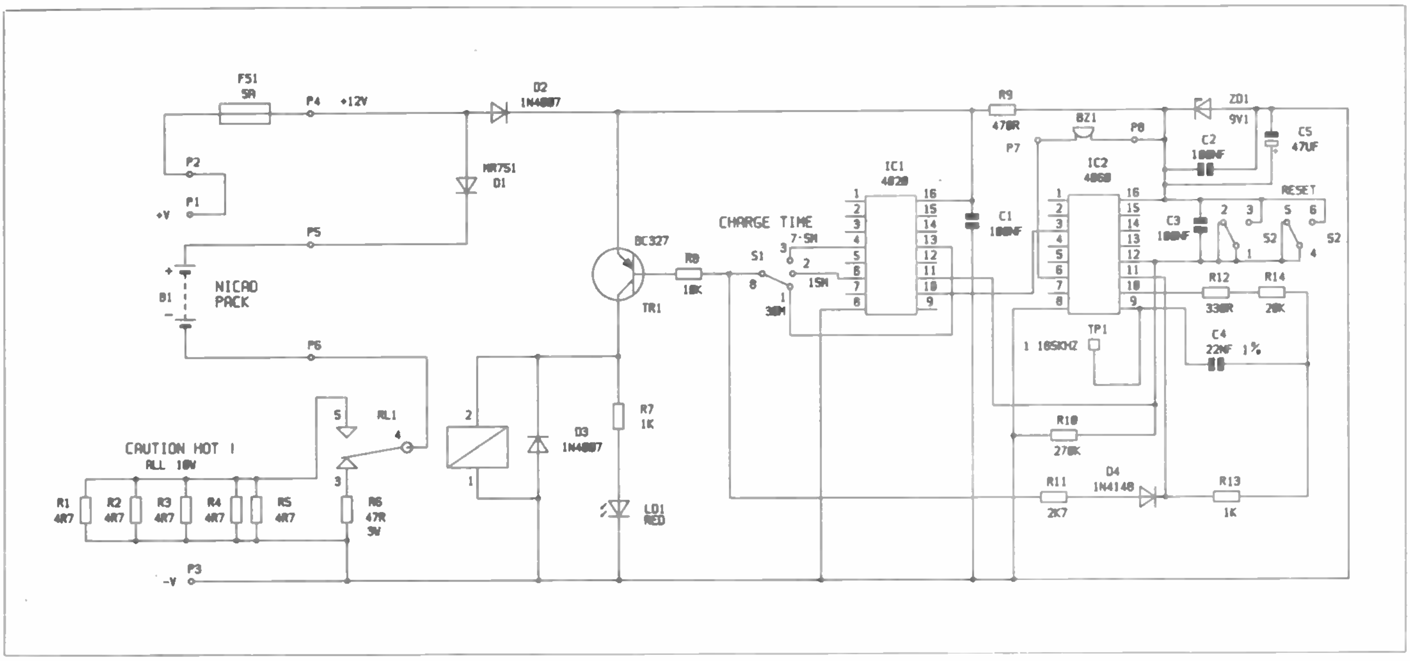


Figure 1. Circuit.

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

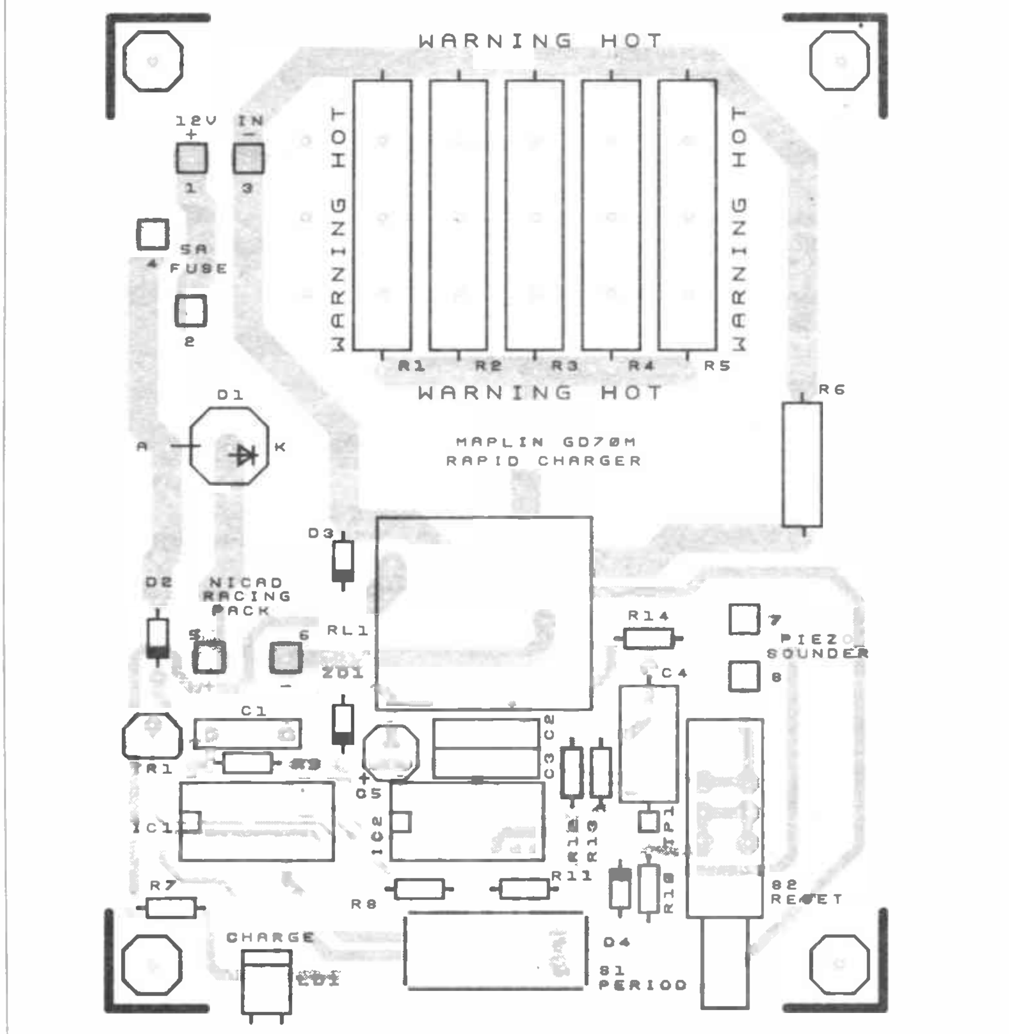
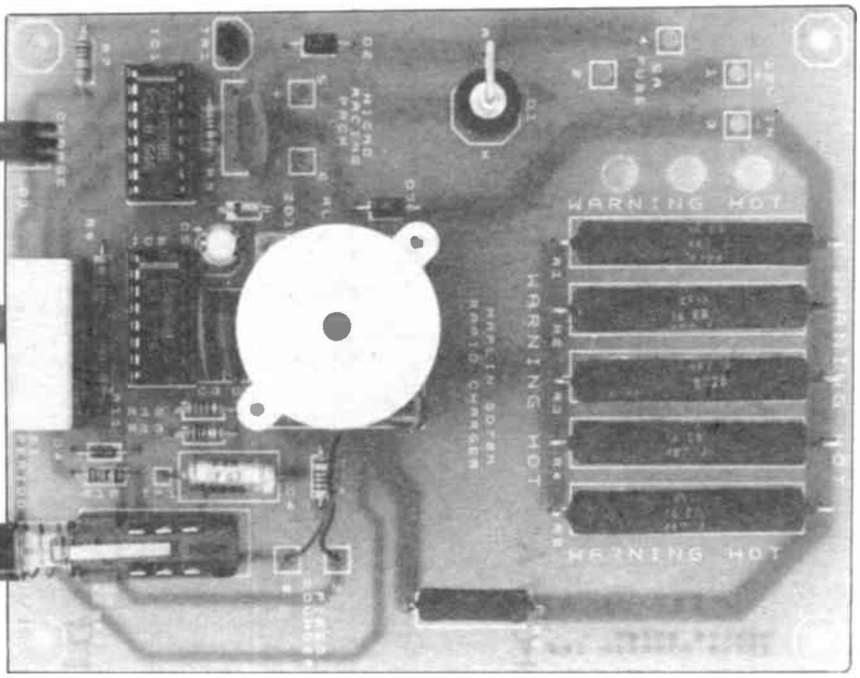
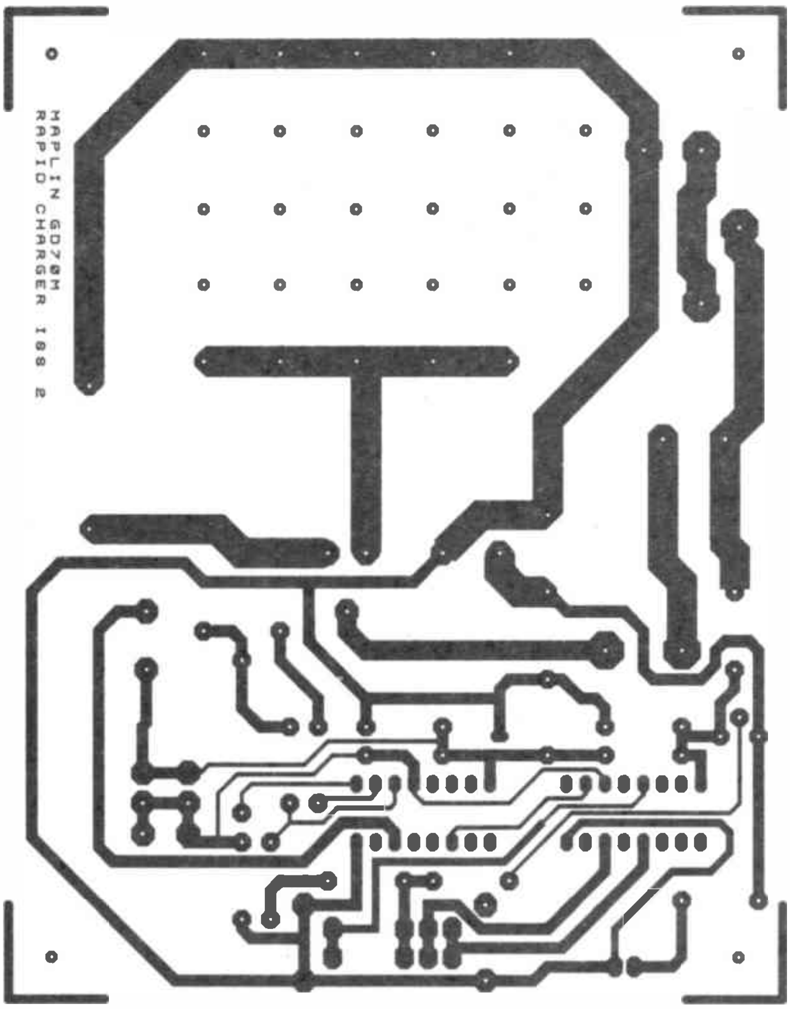


Figure 2. Track and layout of the pcb.



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 black painted top from

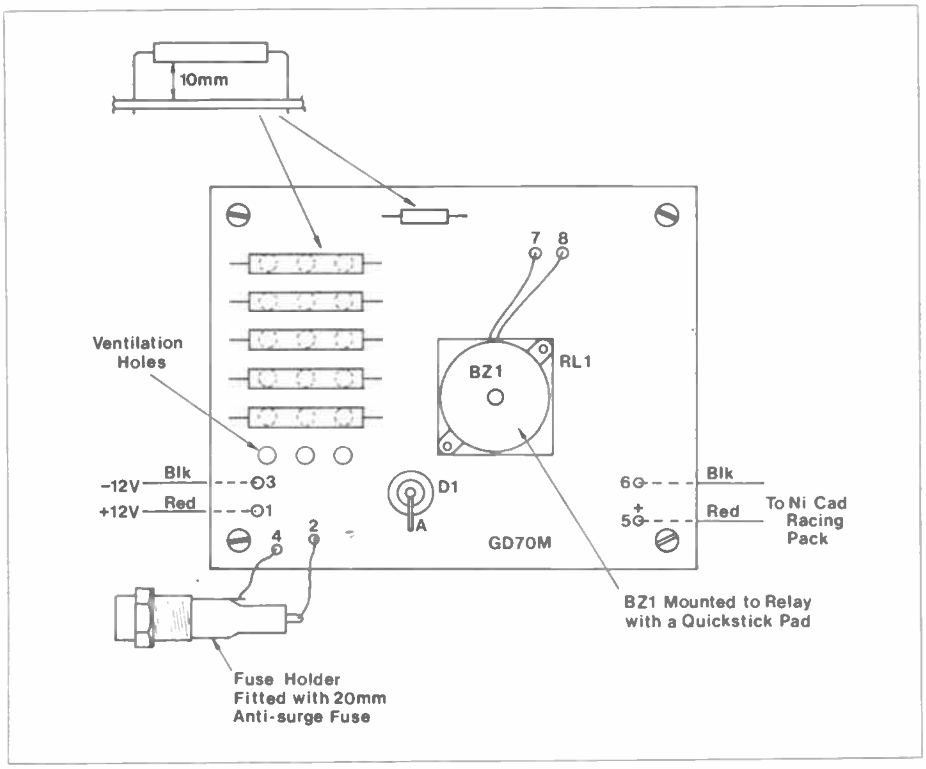


Figure 3. Component mounting on the pcb.

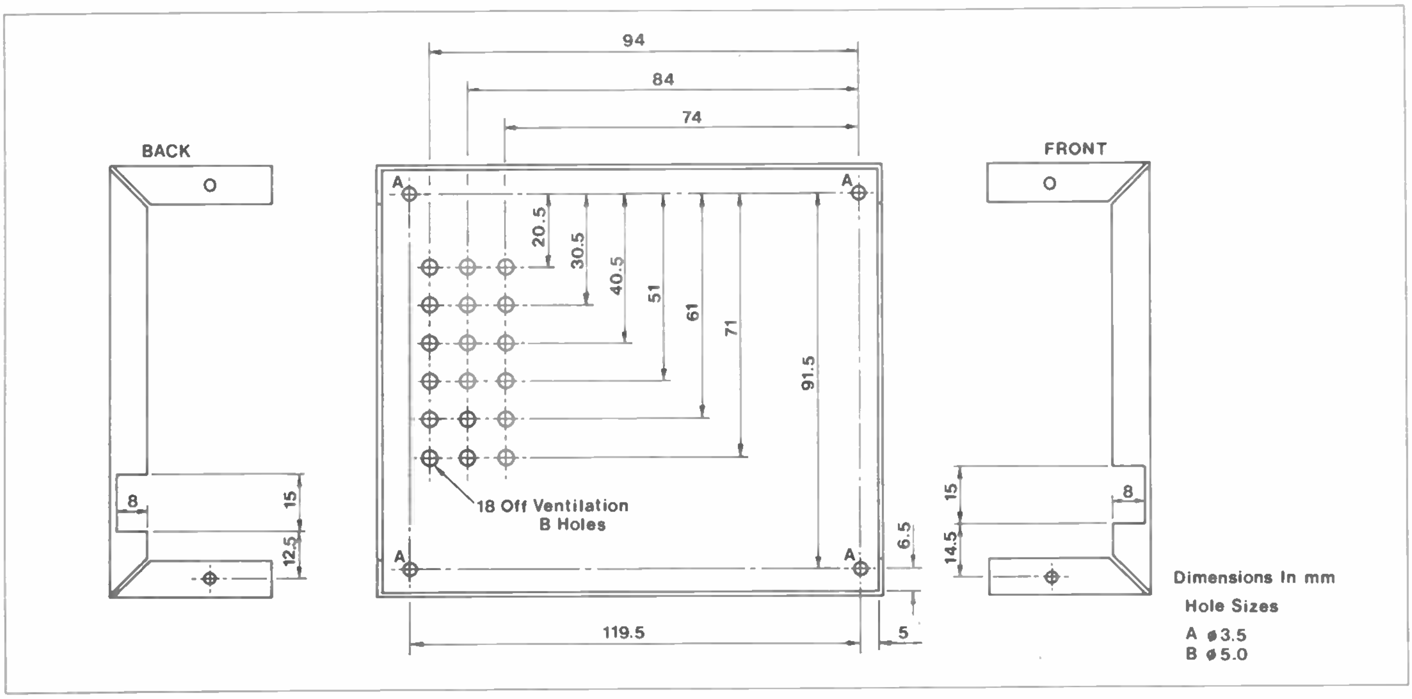


Figure 4. Case drilling.

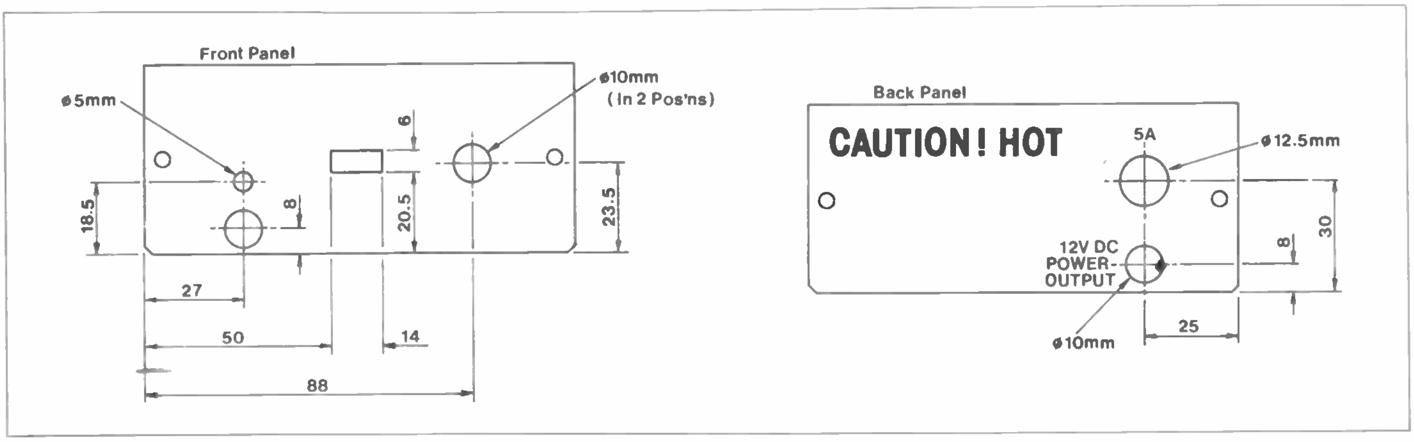


Figure 5. Front and rear panel drilling.

the case and follow the drilling instructions in Figure 4 when preparing the base. It has to have a number of holes drilled in to it for ventilation and PCB fixing. The top cover has ventilation holes already punched and this can be used as a guide for checking the positioning of the base ventilation holes.

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. The self-adhesive front trim can be used as a guide for checking the positioning of the holes in the front panel. Having drilled the holes at the same time clearing them of any swarf, clean the front panel and remove the protective backing from the self-adhesive front trim. Carefully position and firmly push down using a dry, clean cloth until it is securely in place. 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 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.

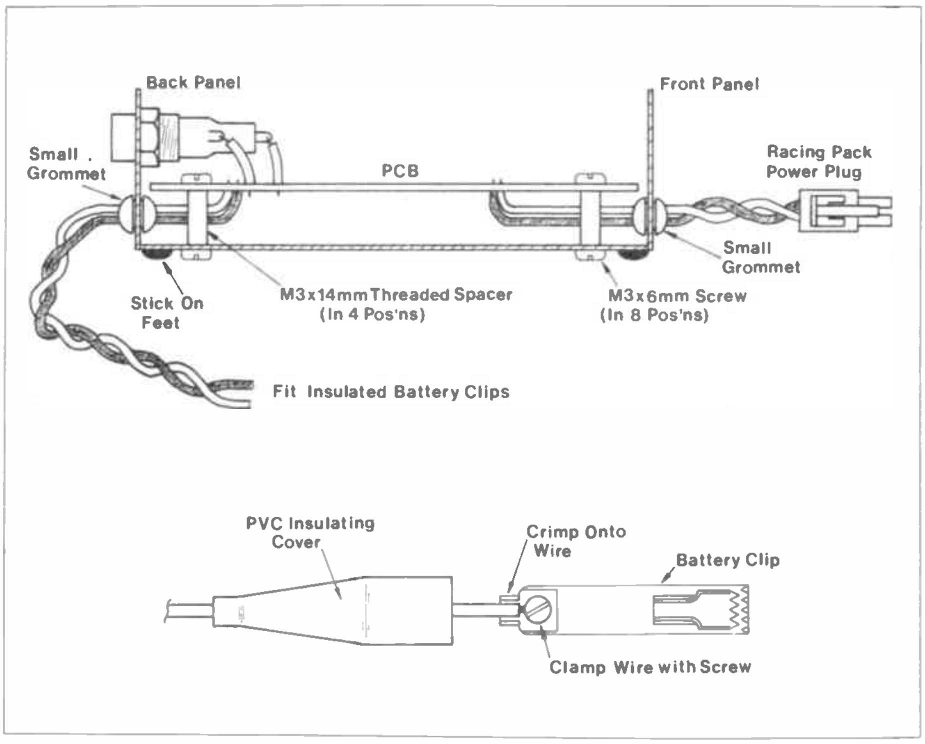
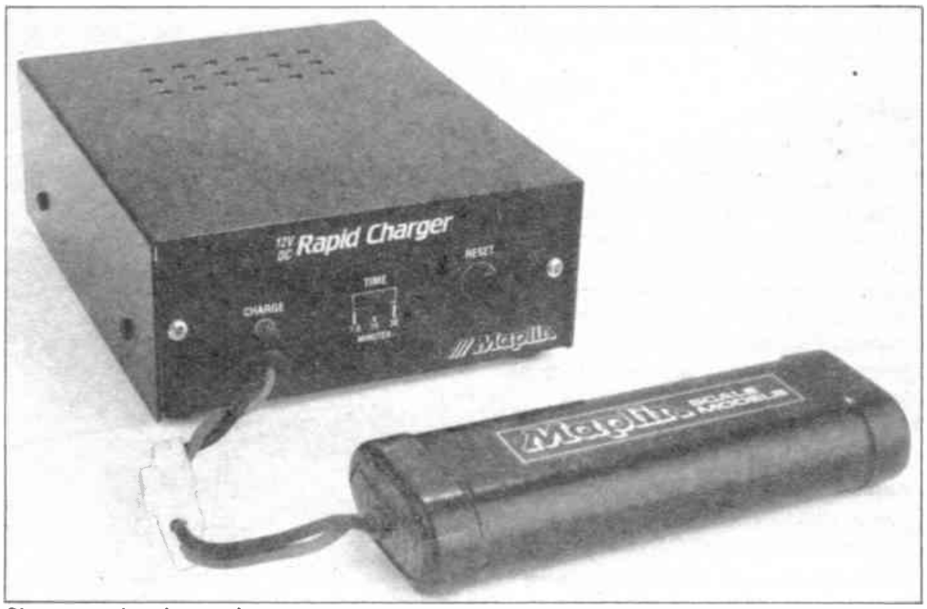


Figure 6a. Mounting assembly in case.
6b. Fitting battery clips.



Charger and racing pack.

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 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.

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-

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.

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.

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.

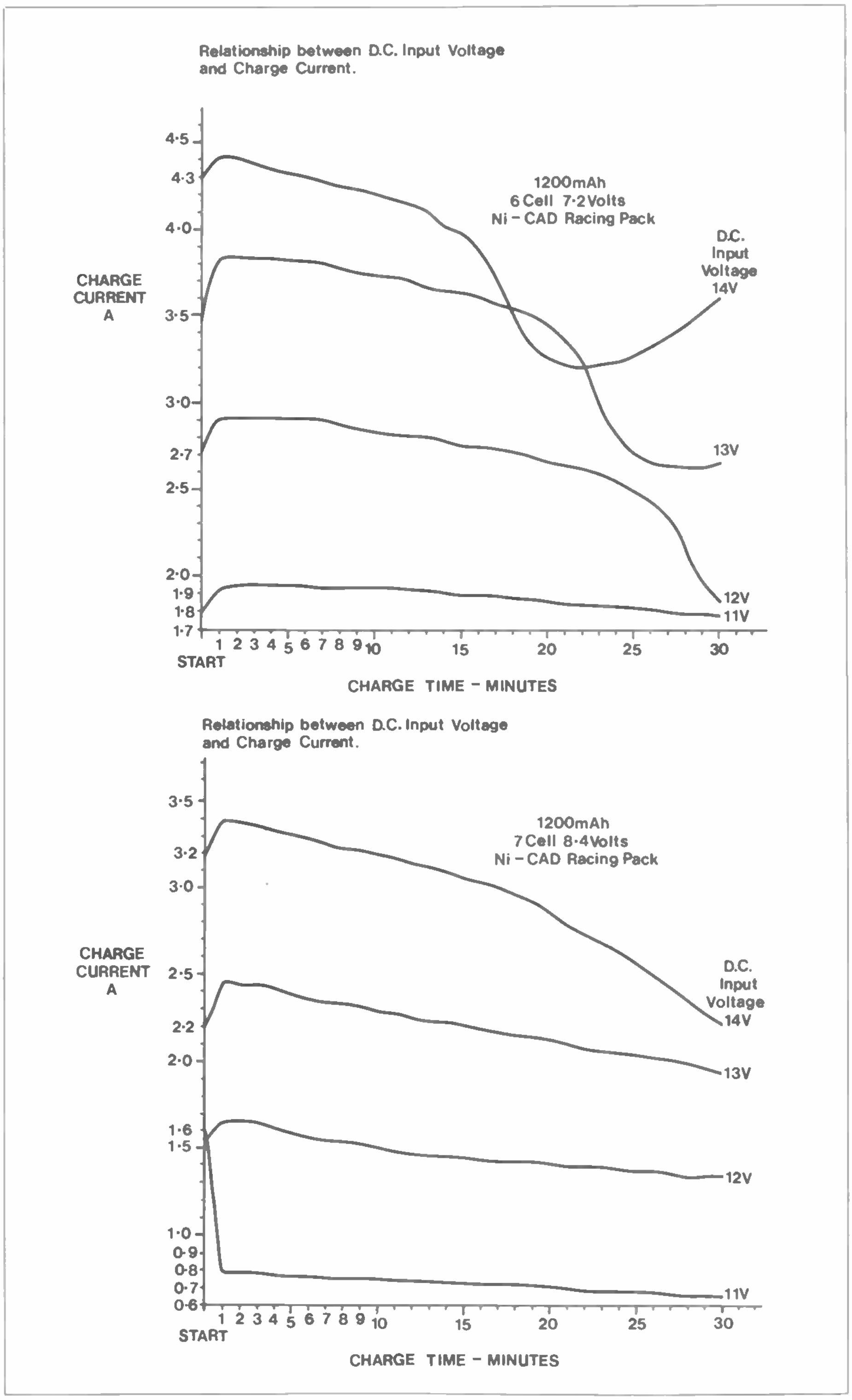
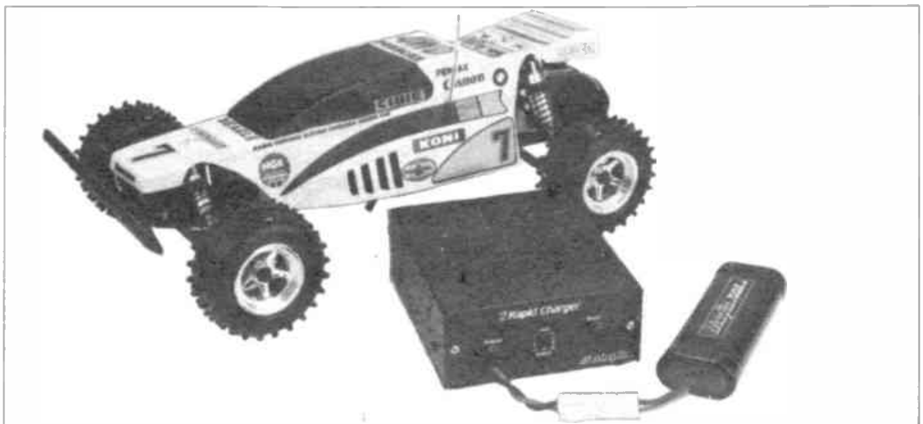


Figure 7a. 6 cell current charging graph.
7b. 7 cell current charging graph.



Trackside charger with Beagle racing car.

RAPID CHARGER PARTS LIST

RESISTORS: All 0.6W 1% Metal Film unless stated			
R1-5	4Ω7 10W WW	5	(H4R7)
R6	47Ω 3W WW	1	(W47R)
R7,13	1k	2	(M1K)
R8	10k	1	(M10K)
R9	470Ω	1	(M470R)
R10	270k	1	(M270K)
R11	2k7	1	(M2K7)
R12	330R	1	(M330R)
R14	20k	1	(M20K)
CAPACITORS			
C1,2,3	100nF Disc Ceramic	3	(BX03D)
C4	47μF 16V Minelect	1	(YY37S)
C5	22nF Polystyrene 1%	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	LED Red	1	(QY86T)
ZD1	BZY88C9V1	1	(QH13P)
TR1	BC327	1	(QB66W)

MISCELLANEOUS			
S1	Switch 2-Way Momentary	1	(FH67X)
S2	R/A 2-Pole 3 Position Switch	1	(FV02C)
	Safuseholder 20mm	1	(RX96E)
	Fuse 5A 20mm Anti-surge	1	(RA12N)
	Grommet Small	2	(FW59P)
RL1	Relay 8A 12V Flat	1	(HY20W)
	DIL Socket 16-pin	2	(BL19V)
	Small Button Round	1	(BW13P)
	Wire Red	2 Mtrs	(XR59P)
	Wire Black	2 Mtrs	(XR57M)
	Piezo Sounder	1	(FM59P)
	M3 x 6mm Bolt	1 Pkt	(BF51F)
	M3 x 14mm Threaded Spacer	1 Pkt	(FG38R)
	Race Pack Lead Female	1	(JG05F)
	P.C. Board	1	(GD70M)
	Insulated Batt. Charger Clip Red	1	(FS86T)
	Insulated Batt. Charger Clip Black	1	(FS87U)
	Steel Instrument Case Model 11051	1	(XJ25C)
	Quickstick Pads	1 Stp	(HB22Y)
	Front Trim	1	(JG19V)

A complete kit of all parts is available for this project:
Order As LM40T (Rapid Charger kit) Price £19.95
The following items in the above kit list are also available separately, but are not shown in the 1988 catalogue:
Rapid Charger PCB **Order As GD70M Price £2.95**
Rapid Charger Front Trim **Order As JG19V Price £3.50**

TOP TWENTY BOOKS

1. (1) Loudspeaker Enclosure Design and Construction. (WM82D) Cat. P82.
2. (5) Electronic Security Devices, by R.A. Penfold. (RL43W) Cat. P79.
3. (3) Power Supply Projects, by R.A. Penfold. (XW52G) Cat. P78.
4. (10) How to Design and Make Your Own PCB's, by R.A. Penfold. (WK63T) Cat. P76.
5. (4) International Transistor Equivalents Guide, by Adrian Michaels. (WG30H) Cat. P73.
6. (7) More Advanced Electronic Music Projects, by R.A. Penfold (WP44X) Cat. P83.
7. (8) IC555 Projects, by E.A. Parr. (LY04E) Cat. P80.
8. (2) MIDI Projects, by R.A. Penfold. (WP49D) Cat. P83.
9. (13) Audio Amplifier Construction, by R. A. Penfold. (WM31J) Cat. P81.
10. (15) Introduction to Electronics, by Pam Beasant. (WP50E) Cat. P77.
11. (–) Electronic Music Projects, by R.A. Penfold (XW40T) Cat. P82.
12. (–) Projects for the Car and Garage, by Graham Bishop. (XW31J) Cat. P79.
13. (6) Mastering Electronics, by John Watson. (WM60Q) Cat. P77.

14. (–) Scanners, by Peter Rouse. (WP47B) Cat. P84.
15. (17) Audio Projects, by F.G. Rayer. (WG46A) Cat. P81.
16. (9) How to get Your Electronic Projects Working, by R.A. Penfold (WA53H) Cat. P77.
17. (19) Micro Interfacing Circuits Book 1, by R.A. Penfold. (WM79L) Cat. P86.
18. (–) Adventures with Micro-Electronics, by Tom Duncan. (XW63T) Cat. P77.
19. (–) Domestic Videocassette Recorders - A Servicing Guide, by Steve Beeching. (WP56L) Cat. P85.
20. (–) Audio Circuits and Projects, by Graham Bishop. (WP51F) Cat. P81.

These are our top twenty best selling books based on mail order and shop sales during July, August and September 1987. Our own magazines and publications are not included. The Maplin order code of each book is shown together with page numbers for our 1988 catalogue. We stock over 250 different titles, covering a wide range of electronics and computing topics.

ELECTRONICS BY EXPERIMENT

Part 1 by Graham Dixey C.Eng., M.I.E.R.E.

Introduction

Understanding of any subject is based on a combination of knowledge and practical experience. This idea is what has been borne in mind in designing this series. If each part of the series consists of a little theory (the knowledge) and the remainder of the space is devoted to practical work: experiments, constructional work and projects, then the reader will acquire, quickly and easily, a broad base of understanding of electronics. This will be especially true as both digital and linear (analogue) electronics will be covered. It is intended that the reader will learn largely from 'doing', from carrying out simply explained procedures to investigate how a variety of circuits work and from making up circuits, some of which will also contribute to his store of experimental equipment and not just be made up for the sake of it.

Although the word 'course' sounds rather dry and academic, this series is in essence a course because it has a 'structure', which simply means that it is designed to build up both knowledge and practical ability in a logical manner and not be a series of disjointed articles that leap about from one topic to another at the whim of the author. It is hoped that readers will agree that the presentation is neither dry nor academic.

One thing has to be accepted and that is that it is almost impossible to learn very much without access to certain items of test equipment. Of these the oscilloscope is often going to be the most important but unfortunately also the most expensive. It is a fact that most work on analogue circuits will require the use of this instrument and some work on digital circuits will also, although much useful work can be done in the latter case without it. Power supplies will be needed as well but these can be made up quite easily and inexpensively using chip regulators and circuits will be given for these. Signal generators for various waveforms will be needed to provide inputs for circuits. But it is possible to generate a limited range of signals from fairly simple oscillators and circuits for these will also be presented. Naturally the possession of a multimeter (whether analogue or digital) is highly desirable; indeed it is difficult to imagine a serious experimenter without one and they at least are not that expensive these days. For these and other items of test gear you have only to look at the current catalogue to see that many are available at quite affordable prices. Incidentally, this catalogue is one item you will find indispensable. Not only will it put you in touch with a vast range of components but it will also often tell you a great deal about them. It isn't just a catalogue but a data book as well! See outside back cover.

Getting Started

As a starting point, one could do worse than become acquainted with some of the ideas and devices found in 'digital electronics'. The trend has been, for many years now, to go towards digital operation where before analogue was the order of the day. Commonplace examples are digital watches and digital multimeters. But there are many other areas which have become, are becoming or will soon become 'digitised'. Anyone who turns his or her back on digital work is doing so to the mainstream of electronics.

A further advantage of learning about digital devices and circuits is that the cost is quite low. For someone who is just making a start this is a very real factor. Why should it be less expensive to study digital techniques than analogue? Very simply, it is because of the fundamental way in which digital circuits work - by handling signals that, for practical purposes, have only one of two possible values. This makes it a lot easier to determine the value of the signal, because it will always be just 'one or the other'. More of what that means soon. For the moment, consider that all that is needed is a power supply - a low current one will do, a way of simulating digital inputs and a way of monitoring the signals throughout the circuit.

A Power Supply for Digital Circuits

Whereas the supply rail of an analogue circuit can be any one of a variety of values (even negative at times!), this supply to the majority of digital circuits is just +5 volts, no more, no less. In fact, it has to be quite close to this value, so a stabilised supply is always used. With the advent of chip regulators it is simplicity itself to make up such a supply, and at minimal cost. The major expenditure, as always, will be on the transformer. For this reason it is a good idea to select one that will allow expansion later, so that other outputs can be obtained. The transformer specified at the end of this article has been chosen with this in mind. There are three chip regulators that are likely to

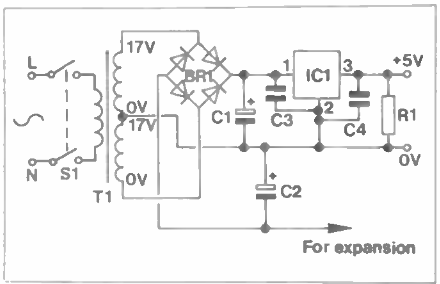


Figure 1. Power supply circuit.

be used, the 7805 (giving up to 1A), the 78M05 (giving up to 500mA) and the 78L05, a much smaller chip that gives only 100mA. For all of the circuits that will be met in this series the 78M05 will be more than adequate; the average logic chip takes only a few mA. However, the 7805 can be fitted instead if desired, since it is pin compatible with the 78M05. In either case a heatsink should be fitted to the regulator, a few square inches of 16SWG aluminium being adequate. In addition to the above, there will be a bridge rectifier and a few capacitors. The complete circuit, with layout, is shown in Figure 1 with an assembled circuit shown in Photo 1.

Inputs and Outputs

The theory follows shortly but, for now, appreciate that the devices to be described are all what are termed 'two-state'. This means that, in theory at least, the signal level will always be exactly one state or the other. If one state was represented by 'zero volts' (0V) and the other by +5V, then all one has to do is determine whether the signal at any point in a circuit is either 0V or +5V; an easy enough task. It's rather like a lamp that is either on or off, or a switch that is open or closed. There's no doubt of the sensor because it's all or nothing. In fact the two-state signal inputs can be provided by switches and the outputs can be determined by noting whether a lamp is on or off. It happens to be more convenient to use a light emitting diode (LED) rather than a lamp, but the principle is the same. Circuits for switched inputs and a logic detector are shown in Figure 2 and Photos 2 and 3. Note that the switch is associated with a 'pull-up' resistor, so called because when it is in the 'logic 1' position it 'pulls' the output terminal up towards +5V; otherwise this point is at 0V (logic 0). The logic level detector uses a transistor to drive the LED. It is not desirable to draw the LED current (10-20mA) directly from the circuit being tested, so the transistor acts as a current amplifier, the logic level at the input being used to switch it on or off, so driving the LED on or off.

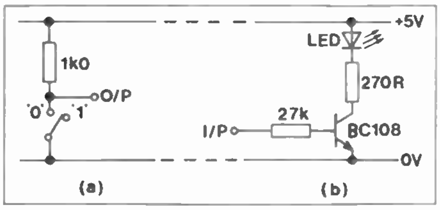


Figure 2. Switched inputs and logic detector.

The Logic Probe

The circuits of Figure 2 will, by themselves, allow certain digital circuits to be investigated but this is a suitable point at which to introduce something a little more sophisticated. The logic probe, see Photo 4, is the basic test-tool of digital circuits and will determine not only the logic level at a point in a circuit but will often tell the user something about 'waveforms' in the circuit. Obviously at any given point, the level may not be steady but may vary in some way between the two possible levels, as is the case with pulses. The logic probe may also be able to 'memorise' a single, rapid pulse or change of logic level, an event that may be too fast for the eye to register. Indications are by means of LED's, often of different colours. Versatile logic probes will be able to work on both TTL and CMOS logic circuits. A probe that meets all of these requirements can be obtained from Maplin

Parts List

5 Volt Power Supply

S1	Switch	FH39N
T1	Transformer 0-17, 0-17, 1A	WB07H
BR1	Bridge Rectifier W01 100V 1.5A	QL38R
C1,2	1000µF 25V Axial Electrolytic	FB83E
C3	220nF Polyester	BX78K
C4	470nF Polyester	BX80B
R1	4k7 0.6W 1%	M4K7
IC1	7805 5V 1A regulator	QL31J

TTL Switches and Logic Level Indicators

	Sub-miniature toggle switch	FH00A
	LED red	WL27E
	LED clip	YY40T
	BC108	QB32K
	270Ω 0.6W 1%	M270R
	1kΩ 0.6W 1%	M1K
	27kΩ 0.6W 1%	M27K

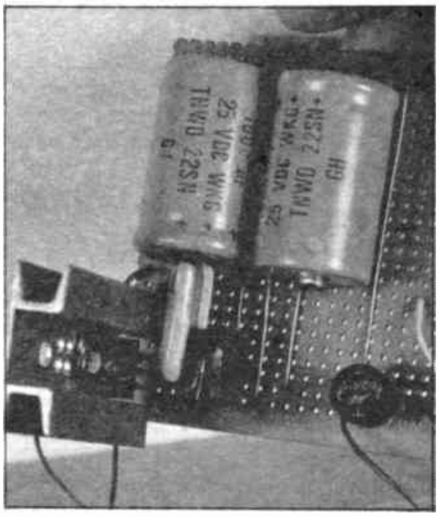


Photo 1. The 5V power supply assembled on a piece of Veroboard. The simplicity of the design is evident.

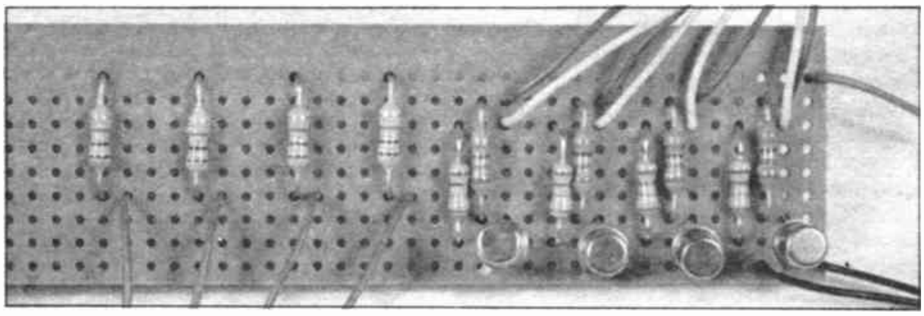


Photo 2. Component side view of the board for the TTL switches and indicators, as mentioned in the text.

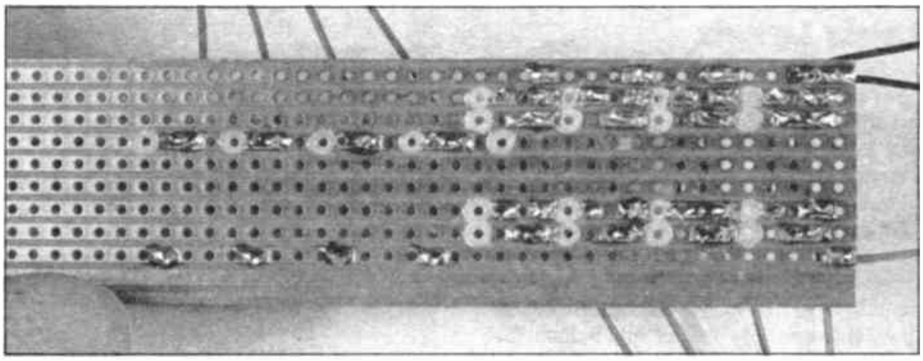


Photo 3. The copper side view of the TTL switch board (0.1in. pitch Veroboard).

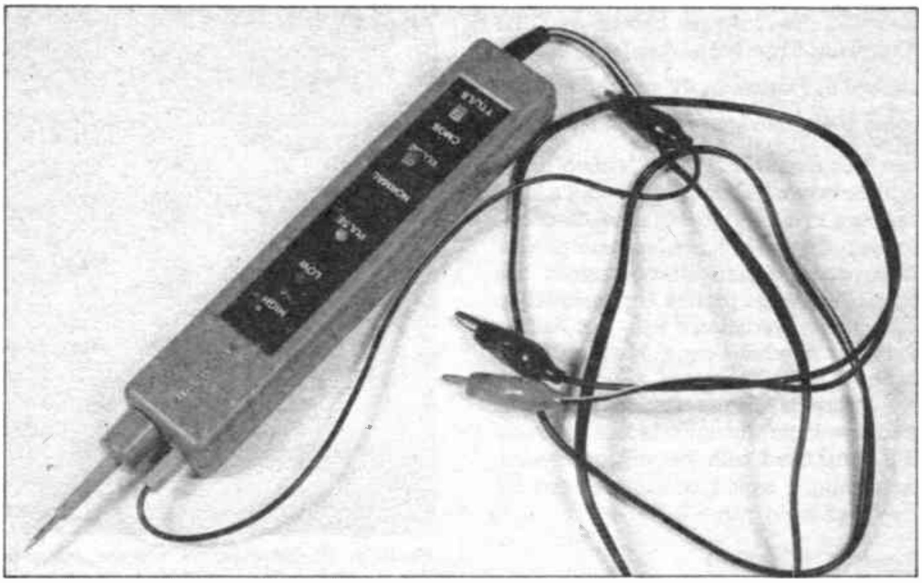


Photo 4. A typical logic probe. The mode selector switches and LED indicators can be seen. Though inexpensive, such test tools are capable of very good work.

(Order Code FY73Q). A photograph of a typical logic probe in use is shown in Photo 5. The probe connects to the supply rails of the test circuit in order to get its power.

Breadboarding Experimental Circuits

To use a rather old-fashioned term that is still current, this describes how a circuit is connected up for investigation or development. Once it meant soldering components in and out of circuit as development proceeded, but 'solderless' pin-boards have made this unnecessary. Spring-loaded sockets hold the component leads firmly in place yet allow them to be removed and replaced at will. In use any IC's in the circuit straddle the central trench and the pin spacing between the rows on either side of this trench is exactly 0.3in. to allow this. There is another type of board in which this spacing is 0.6in.; this is used for the larger chips associated with microprocessors. These boards are not cheap but are worth every penny in the convenience that they bring to circuit experimentation. Each of these types of board is shown, screwed to a piece of spare chipboard, together with power supplies and various other facilities, in Photo 6.

Two-state Systems, Binary Numbers and Logic Levels

First it is necessary to distinguish between theoretical logic levels and practical ones. The idea of using +5V as one level (known as 'logic 1') and 0V as the other (known as 'logic 0') has already been mentioned. This is known as 'positive' logic.

In practice, because the presence of components results in voltage drops, the actual levels in a circuit may differ a little or a lot from these theoretical values. To accommodate this fact it is necessary to let each logic level lie between upper and lower limits. Those commonly accepted for what is known as 'TTL' (Transistor-Transistor-Logic) are:

Logic 0 lies between 0V and +0.8V.

Logic 1 lies between +2.0V and +5.0V.

This means that there is a 'no man's land' between 0.8V and 2.0V and if a level happens to fall within this zone, there is a danger that it will be misinterpreted. Thus, good design always avoids this possibility. Logic probes are designed to take these variations into account in deciding whether a signal is a logic 0 or a logic 1.

There is also a system known as 'negative logic', though it is less common. If it were used with the voltages stated, then logic 0 would be represented by +5V and logic 1 by 0V.

Logic Gates

The logic gate may be said to be the basic 'building block' of digital electronics. The sub-division that uses gates only to perform various logical functions is termed 'combinational logic'. The gates have two or more inputs and a single output. A 'chip' will usually have two, three or four gates on it, each being able to be used quite independently of the others. The function of a gate is defined solely by what level the output takes for each of the possible combinations of input levels. How many input combinations are there? Since there are two possible levels, the number of combinations equals 2^n, where 'n' is the number of inputs. Thus, a 2-input gate yields $2^2 = 4$ combinations, a 3-input gate yields $2^3 = 8$ combinations and so on. Figure 3 shows the following gates: AND, OR, NOT, NAND, NOR, which may be said to be the basic gates; anyway they will do for now. Each one is shown with its circuit symbol, its 'truth table' and its 'Boolean expression'.

Let us take the truth table first. This is a simple way of stating what the output logic level (right-hand column) will be for each of the possible input combinations (left-hand columns). Thus, to take the example of the AND gate, the truth table says that the output Z = 1 when both A and B are 1. Otherwise Z = 0.

Now take the Boolean expression. This, as you may have guessed, is to do with Boolean algebra. It's quite easy to interpret simple Boolean statements like these without having a deep knowledge of the algebra itself. All that has to be remembered is that the dot . means AND and the plus sign + means OR. Look now at these expressions.

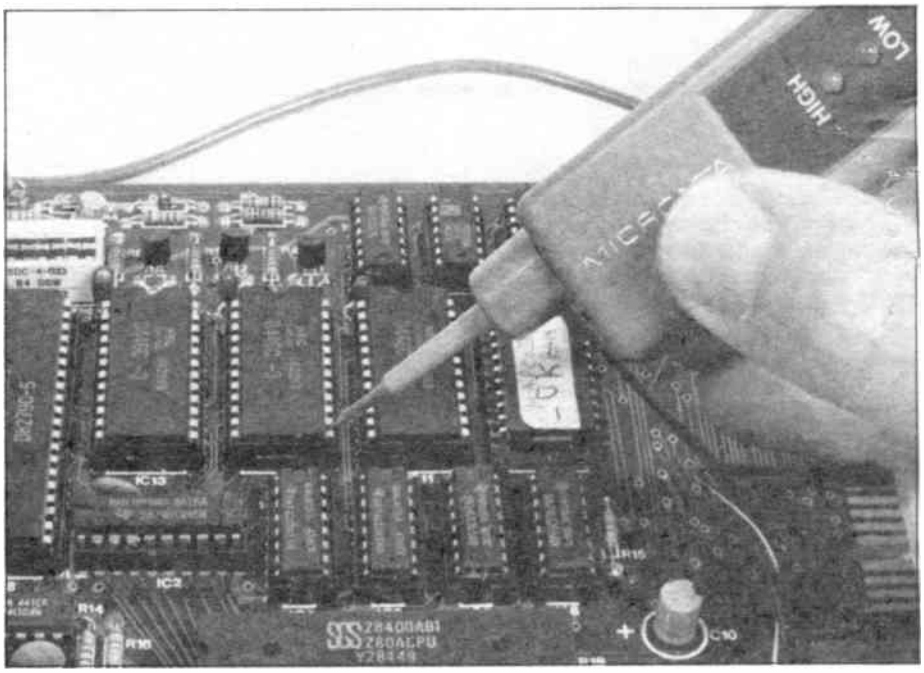


Photo 5. A logic probe being used to check a microprocessor circuit board.

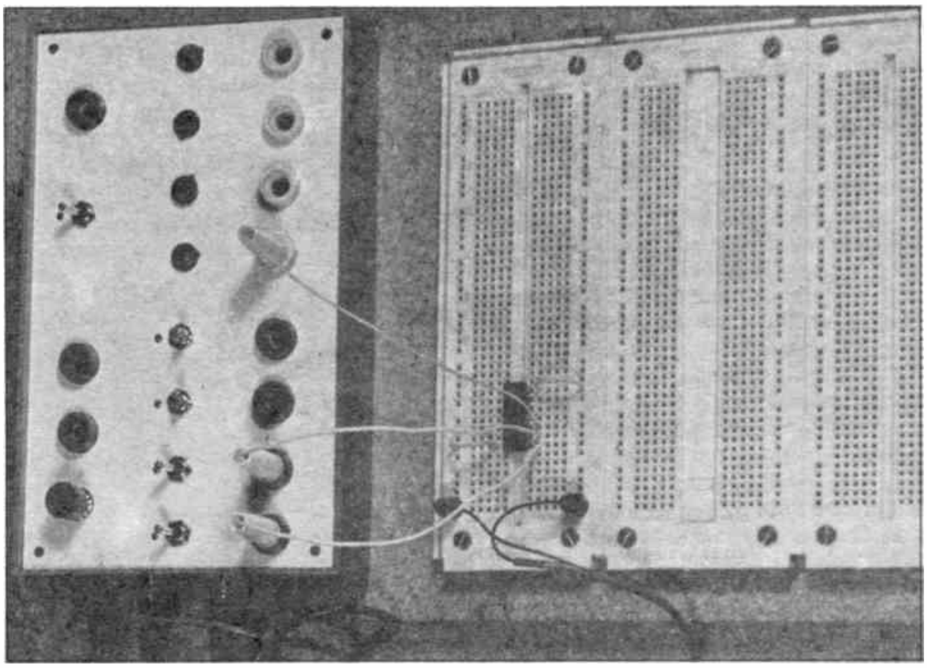


Photo 6. A development system using the two types of pin-board described in the text. The power supply is out of photo, but the unit at the top houses four TTL switches and LED indicators, as well as a 'debounced' switch and TTL 1Hz/1kHz oscillator (both to be described later). A two-input gate is shown being tested.

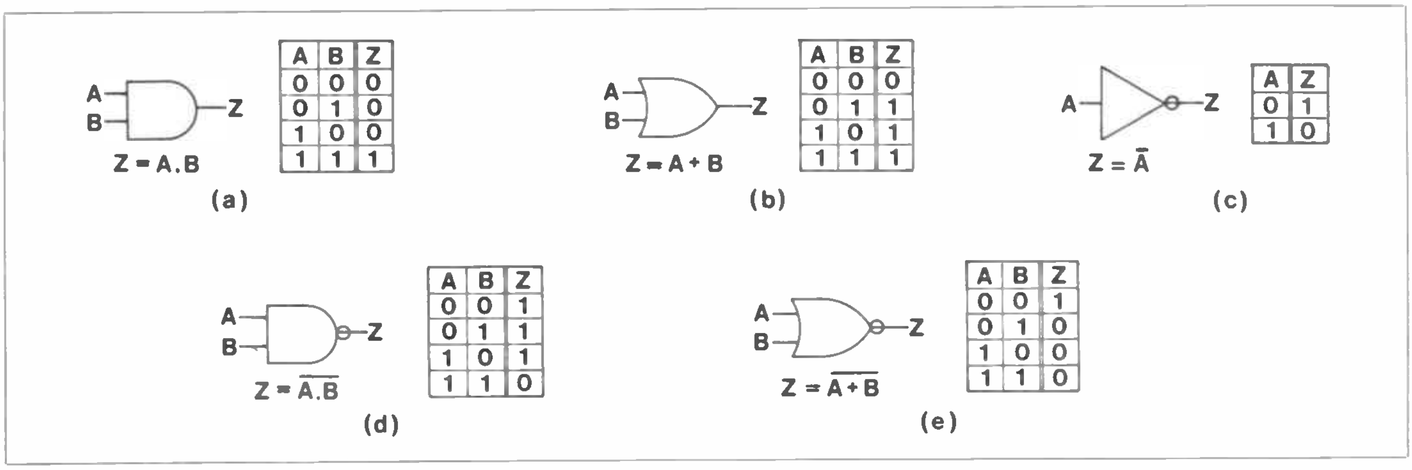


Figure 3. The 5 standard logic gates.

1. A.B means A AND B which itself is merely a way of stating what has already been seen from the truth table, namely that Z = 1 only when A AND B are both 1.
2. A+B means A OR B which also describes what can be seen from the truth table, namely that Z = 1 when A = 1 OR B = 1 OR both A and B = 1. Look at the truth table for the OR gate to see that this is true, because it shows for the three cases stated that Z = 1. When A and B are both zero, Z is zero also.

Obviously the Boolean expressions are shorthand ways of telling us what we could see from the truth tables. The added advantage that they have occurs in the case of more complex expressions, which usually is the case with circuit design, when their algebraic nature allows the designer to manipulate them and perhaps simplify the circuit.

The next gate hardly qualifies as a gate as such since it has only one input. Nonetheless, the inverter or NOT gate is a very important device. It changes a logic level so that a 0 at its input becomes a 1 at the output and vice-versa. When an input, such as A, is inverted it is written with a bar over it as shown in Figure 3(c) in which A becomes $\overline{A}$ by the process of 'inverting', 'complementing' or 'negating' as it is alternatively known.

This argument leads nicely to the NAND gate because this word is made up of the words NOT and AND. Therefore, a NAND gate is a combination of these two types of gate. As one may expect, the output column Z is the exact opposite of the same column for the AND gate. Note the Boolean expression in which the term A.B now has a bar over it, that is it has become $\overline{A.B}$, (A NAND B).

The last gate, the NOR gate, is also a combination of two functions, this time the NOT and OR functions. Therefore, the Z column of the truth table is the 'inverse' (as the opposite is known) of that column for the OR gate. The expression A + B now has a bar over it, becoming $\overline{A+B}$, (A NOR B).

The 7400 Series of TTL Gates

The fact that TTL stands for Transistor-Transistor-Logic has already been stated. This describes the internal arrangement of the chip, which uses 'bipolar transistors'. It is actually of little real benefit to dive into the chip itself to examine its inner workings. It is far better to adopt what is known as a 'systems' approach and regard the chip as a 'black box' which performs a specific function, provided that one keeps to certain guidelines, such as giving it the correct supply and knowing what its operational limitations are. There are two other main classes of logic, known as Emitter-Coupled Logic (ECL) and CMOS (L) which stands for Complementary-Metal-Oxide-Semiconductor Logic. We shall be concerned with the TTL and CMOS logic only.

In the largest TTL logic family, all the chip designations contain a number that starts with '74', the very first being 7400. Many of them are four digit numbers following this sequence, but there are five digit codes as well. Many of them will be met in the series. Sometimes there will be a prefix, such as SN, used by Texas Instruments, so we get SN7400. One shouldn't be thrown by this prefix; it is merely tagged on by the manufacturer to identify it as his product.

What will also often be found, that is much more significant, is a letter or letters within the 7400 code, e.g. SN74LS00, which identifies it as a 7400 chip (a quad two-input NAND gate in fact), made by Texas Instruments, but using 'Low Power Schottky Logic', a form of design optimising economy of current consumption with speed. If a faulty chip is being replaced such variations must be observed; it is wrong to replace a 74LS00 with a plain 7400. Other variants are as follows.

74L00: a Low power version of the 7400

74H00: a High power version of the 7400

74S00: a Schottky version of the 7400

(Schottky refers to a design using the special Schottky diodes to increase the speed of response).

Practical Work

This first part of the series has been concerned with introductory ideas and

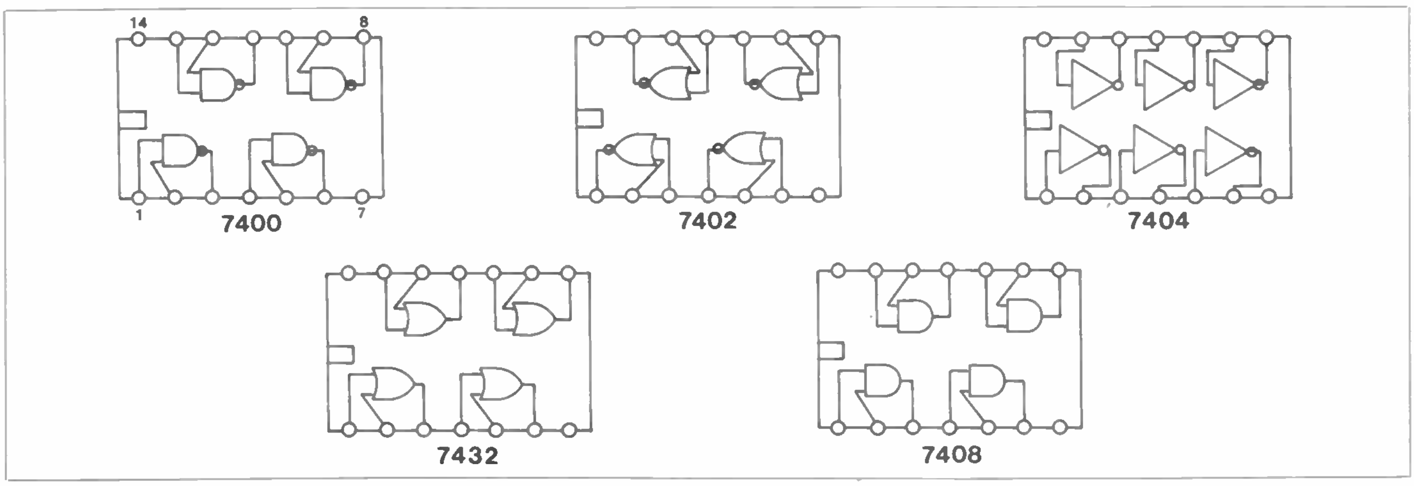


Figure 4. Some different chip internals.

some circuits to build for the future. It is suggested that something is made up along the lines of that shown in Photo 6, with the +5V power supply and four of each, switches and LED indicators. Terminals of some sort will be needed, 4mm sockets or screw-type terminals being suitable. To wire up the more complex circuits that will be discussed next time, leads of various lengths, perhaps colour-coded according to length, need to be made up. For these 'solid conductor' type equipment wire should be used, not the stranded variety. The mains transformer 'must' be hidden under a cover, or put in a case, to keep the mains connections out of harms way, but the low voltage connections, whether for power or signals can be mounted on open panels, according to the wishes of the experimenter.

Having got that far, it would then be useful to prove the truth tables by taking each gate type in turn (Figure 4 shows the pin-outs for two-input versions of each) and supplying the required input combinations through the switches while using a LED detector (or logic probe) to determine the output level. In case there is any doubt, Figure 5 shows the connections for testing a gate.

To finish off this introduction here is a little practice in wiring up several gates, in fact two arrangements of three gates,

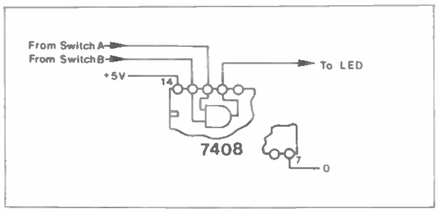


Figure 5. Gate connections.

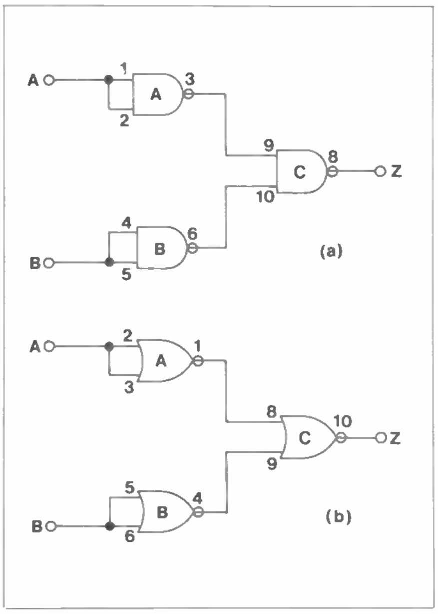


Figure 6. Practice gate configurations.

using NAND gates and NOR gates respectively. These circuits are shown in Figure 6. The circuits are identical in form, which does not mean that they will be so in function. Having wired them up, a truth table should be compiled for each arrangement, using the four possible combinations of inputs, A and B. The column for Z should then be compared with that for the truth tables obtained from Figure 5, to see if there is a match in each case. The result is a very useful one.

It should be noted that each gate has been given a letter and that all pin connections (except those for power) are marked against the inputs and outputs on the circuit diagram. It is a good idea to get in the habit of doing this, rather than attempting to wire up a circuit from a 'bare' diagram. The gate designations themselves are arbitrary; from the pin-out diagram for, say, the 7400 quad two-input NAND gate, one can allocate a letter (or number) to each gate on the chip, purely for one's own convenience. Working systematically in this way makes it easier to wire up the circuit in the first place as well as easier to trouble-shoot when things won't work (as will sometimes be the case). Although the power pins are not shown they will have to be wired up, pin 14 usually being +5V and pin 7, 0V.

Although a kit is not provided, a list of parts that you may require is shown.

Continued from page 39.

although CMOS gates are more tolerant of edge speed, the 74HC132 is also available to do the same job if required.

It sometimes happens in TTL system design that a gate must drive many inputs in parallel, or must interface to a short transmission line. An ordinary 74LS00 cannot be called upon to sink more than a few milliamps, though, without seriously eroding its noise immunity margin. One solution is to use a discrete transistor to supply the higher current, but a better one is to replace the gate by a buffer which performs the same logical function but has a lower effective output resistance. The 74LS37, for example, is designed to handle 24mA: three times as much as the 74LS00. An open-collector version (74LS38) also exists. This problem too is less severe in CMOS systems, because CMOS gates have inherently small input currents. The latest generation of CMOS parts virtually abolishes it: a 74AC00 can deliver up to 24mA of output current.

The major differences between TTL and CMOS logic families are summarised in Table 2, whilst their speed-power performance is shown in its true perspective in Figure 13. Advanced CMOS represents the current state of the art; HCMOS is becoming the new standard logic family.

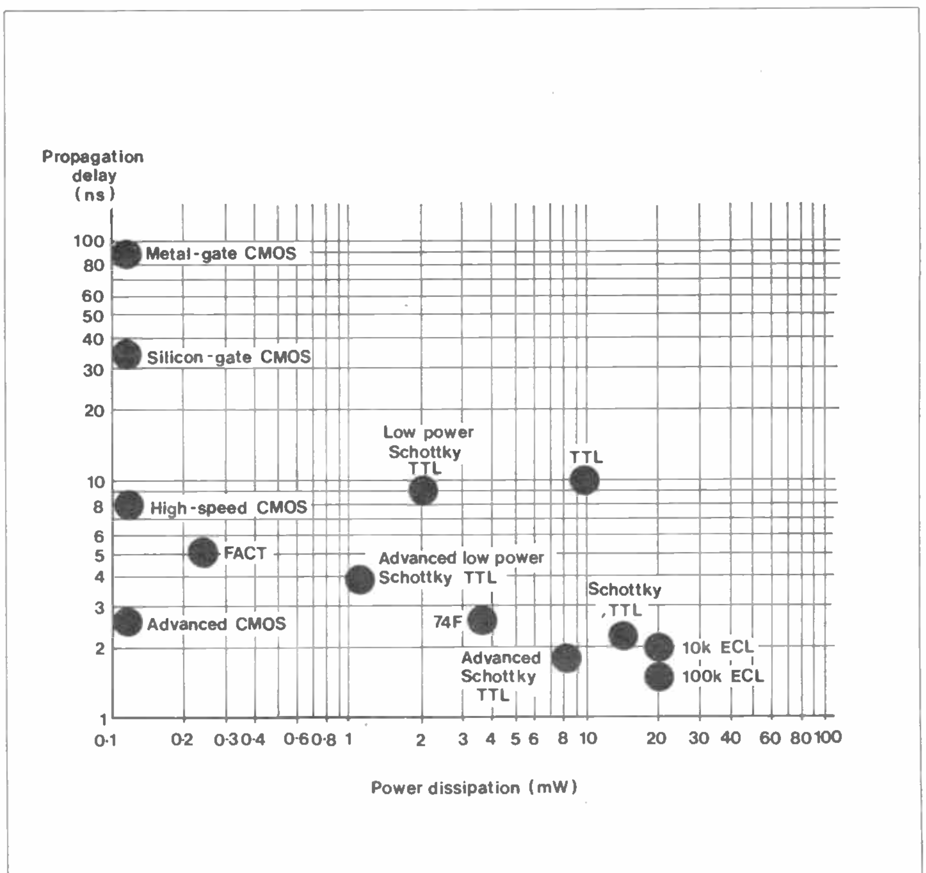


Figure 13. The different logic families offer a variety of speedpower trade-offs.

Bob's MINI-CIRCUITS

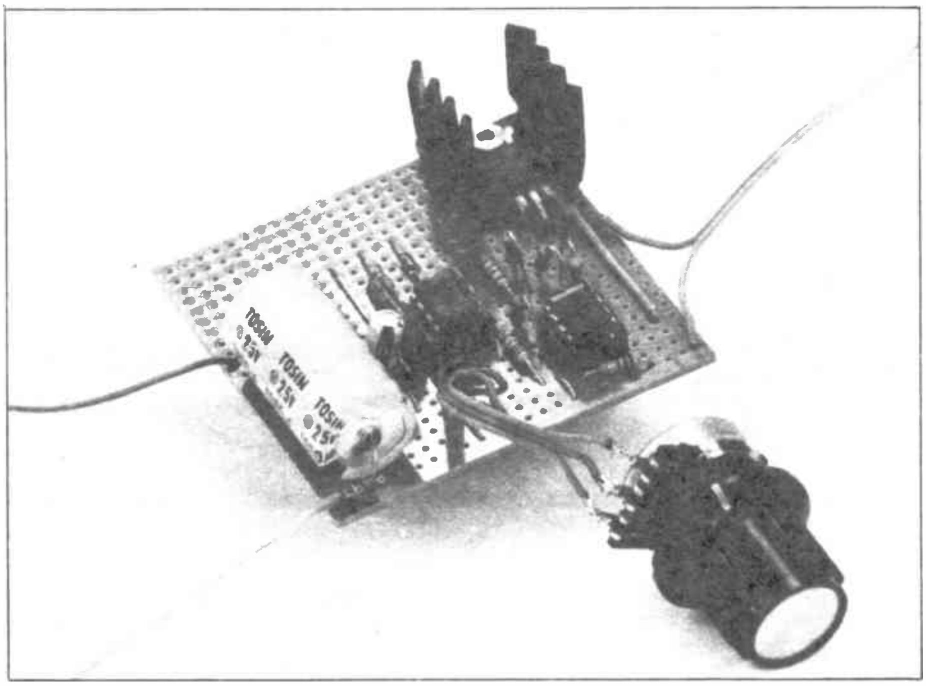
From Robert Penfold

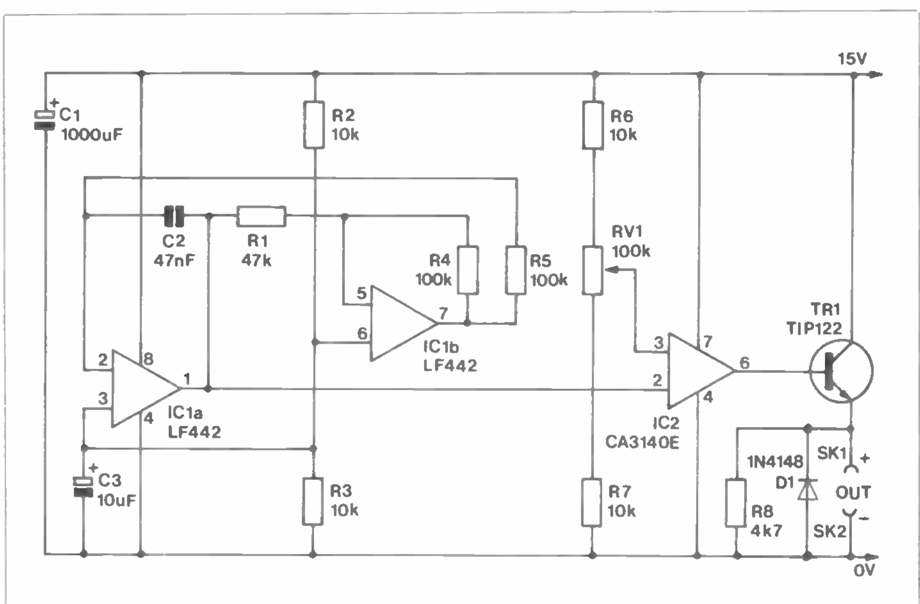
Pulsed Speed Controller

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.

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.

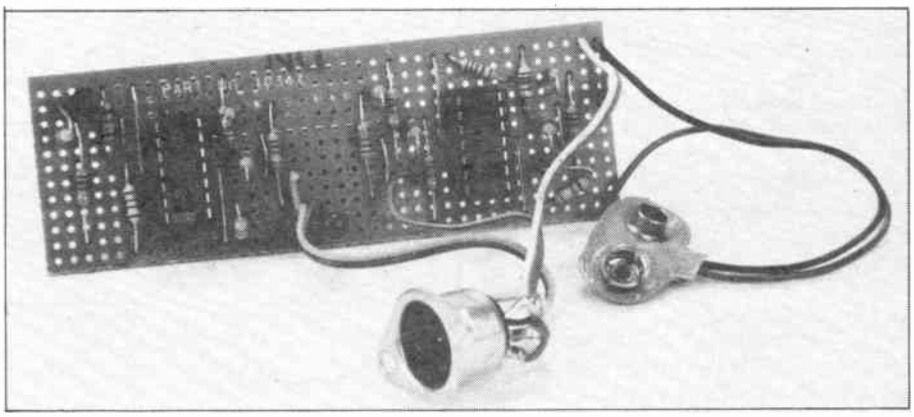
PULSED SPEED CONTROLLER PARTS LIST

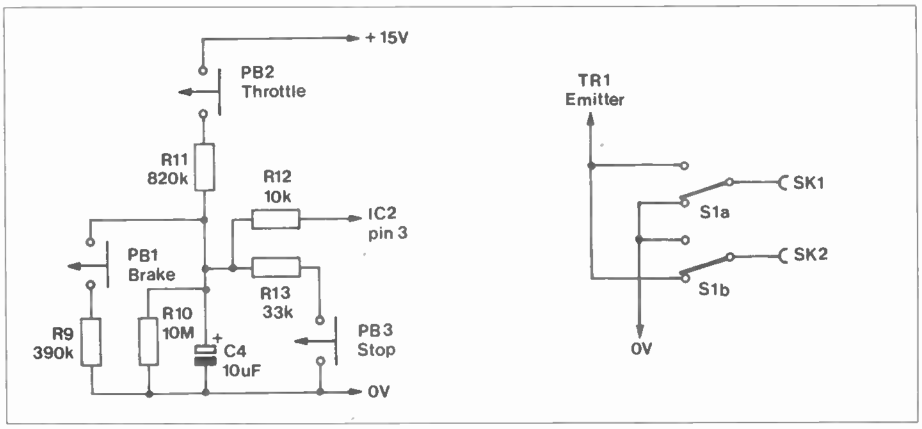
RESISTORS: All 0.6W 1% Metal Film			
R1	47k	1	(M47K)
R2,3,6,7	10k	4	(M10K)
R4,5	100k	2	(M100K)
R8	4k7	1	(M4K7)
RV1	100k lin pot	1	(FW05F)
CAPACITORS			
C1	1000μF 16V Axial Electrolytic	1	(FB82D)
C2	47nF Poly Layer	1	(WW37S)
C3	10μF 50V PC Electrolytic	1	(FF04E)
SEMICONDUCTORS			
TR1	TIP122	1	(WQ73Q)
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.

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!

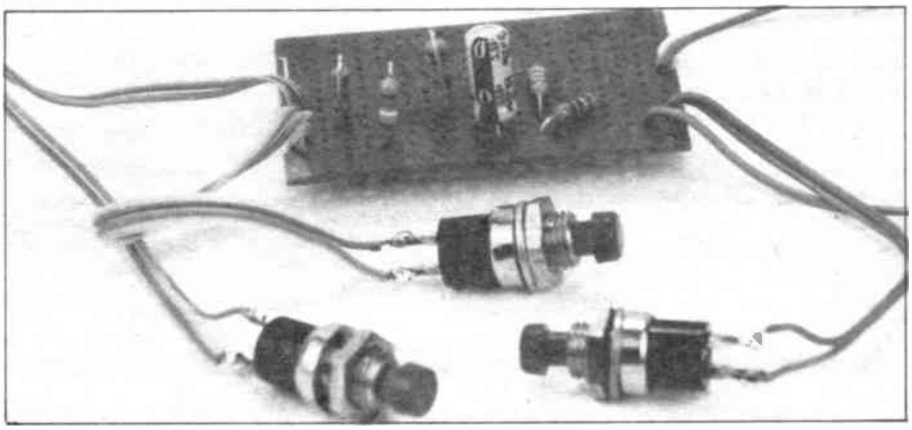
TRAIN CONTROLLER PARTS LIST

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

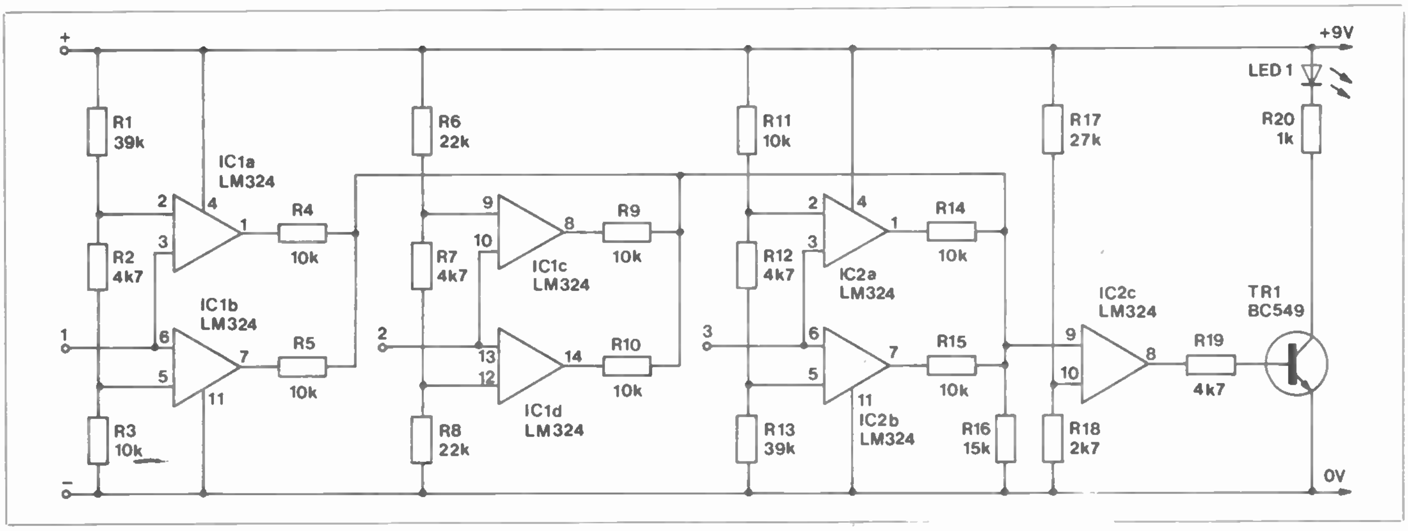
There has been no shortage of electronic lock designs over the years, and in recent times they have virtually all been of the electronic combination lock variety. There are numerous types of electronic lock, and there are plenty of practical alternatives to combination types. These alternatives are mostly 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.

ORDER COUPON

Maplin

ELECTRONIC SUPPLIES LTD.
P.O. Box 3, Rayleigh, Essex SS6 8LR.
Telephone, Credit Card Sales (0702) 554161; Enquiries (0702) 552911.
A different postal code is correctly shown on the reply paid envelopes.

In any correspondence please quote your customer number. *Date* ....

Customer No ....

Name ....

Address ....

....

.... *Post Code* ....

IT IS MOST IMPORTANT THAT YOU INCLUDE YOUR POSTCODE

Block capital letters please. ***Keep a copy of your order.***

Description (for your information only)	**Order Code**					**Quantity**	**Price Each**	**£ Total**	**p**
Current Price List (Please write 1 in quantity, if required)	X	F	0	8	J		FREE	0	00
Price Change Leaflet (Please write 1 in quantity, if required)	C	A	9	9	H		FREE	0	00

Total this sheet £		
Total other sheet(s) £		
Total for goods £		
Handling Charge. If total for goods between £4.50 and £5, make total here up to £5. If less than £4.50, add 50p.		
Deduct value of Credit Note No .... Enclose the numbered Credit Note with this order.		
Please add 50p Carriage and Packing This amount must be added to each order placed.	0	50
Total £		

VISA

Phone before 5pm for same day despatch.

Overseas customers including Channel Isles and Eire, please deduct VAT where applicable and tick this box.

Export Order ☐

Office Use Only			
DOR	CQ	CA	PO
CNC	Total		
CNM			

I authorise you to debit my credit card account for the cost of goods despatched.

Credit Card Number ☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐

Access/American Express/Mapcard/Visa/ .... Delete as required.
Note. Goods will be despatched only if the address above is the cardholder's address.
If ordering by Credit Card please sign:

....

Expiry date of Credit Card ....

ONLY £3.40

FOR A WHOLE YEAR'S SUBSCRIPTION TO 'ELECTRONICS - THE MAPLIN MAGAZINE'

- ★ Every issue sent to you as soon as it's printed, post free.
- ★ Packed with interesting and novel projects that you can build with all components easily obtainable.
- ★ Many features on electronics subjects to keep you up-to-date with latest developments.
- ★ More pages to read than monthly magazines.
- ★ And much, much cheaper too. Many of the monthlies are now £1.30 or more per issue!

BUYING A SUBSCRIPTION IS THE BEST WAY TO BUY 'ELECTRONICS'

'Electronics' is different from any other electronics magazine for two reasons:

1. It's quarterly, so it's hard to remember when a new issue is due out both for you and your newsagent.

2. We don't carry any advertising, which means that having lots of copies sitting on the newstands waiting for casual sales is of no advantage to us. The newsagent will normally have plenty in stock of those magazines which advertise because in almost all cases, he can return them if they are not sold - so he doesn't pay for them.

'Electronics' has no advertisers to pay for unsold copies, nor does it need to have an impressively large circulation, so the newsagent must buy all of his delivery of 'Electronics' and cannot return those he doesn't sell. Therefore, he may not want to take stock of too many. Before you know where you are, 'Electronics' has sold out!

That's why you'll need to place a firm order with your newsagent to be sure of obtaining each new issue. Better still, place the order directly with us by sending £3.40 now and we will send you every issue for a year, post free.

Despite having very few casual sales, 'Electronics' sells more copies in the U.K. than any other electronics magazine!

BIGGEST CIRCULATION IN THE U.K.

Publication dates as follows:

XA26D Issue 26 12th February 1988	Price 85p *NV*
XA27E Issue 27 13th May 1988	Price 85p *NV*
XA28F Issue 28 12th August 1988	Price 85p *NV*
XA29G Issue 29 11th November 1988	Price 85p *NV*

New Books

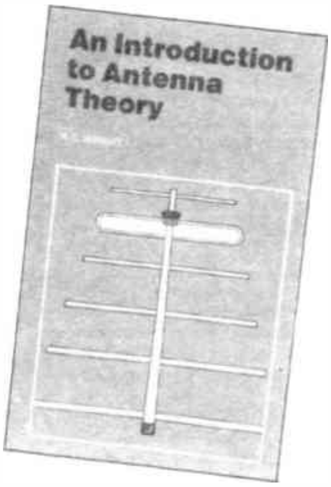
An Introduction to Antenna Theory

by H.C. Wright

Any conducting body exposed to radio waves will have electric currents induced in it and, conversely, any conductor carrying varying electric currents will radiate energy in the form of radio waves. Thus an antenna can take any form from a bedstead to a tin-tack and, while these particular items are seldom encountered in practice, the experimenter can test ideas and innovations with little more than bent copper wire, particularly when it comes to TV and CB wavelengths. This book illustrates the basic concepts relevant to receiving and transmitting antennæ in a manner which emphasises the mechanism involved, supported by copious diagrams and illustrations which help to reduce mathematics to a minimum.

1987. 110 x 178mm, 86 pages, illustrated.

Order As WP78K (An Introduction to Antenna Theory) ***Price £2.95NV***



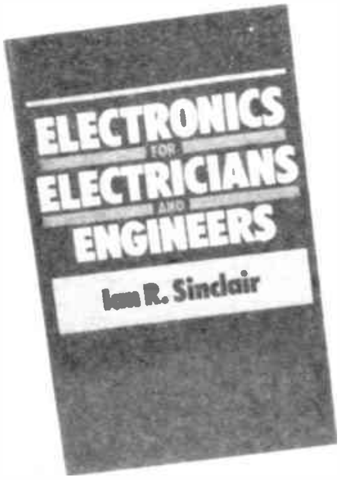
Electronics for Electricians and Engineers

by Ian R. Sinclair

The rapidly changing technology of electronics has left many technicians requiring an urgent updating of their skills. The same problems have faced other engineers, who now require a knowledge of electronics to understand new developments in their own subjects. Hardly any part of modern life is untouched by electronics, and almost everyone working in engineering or science needs some understanding of it. This book has been written in response to that need and explains principles and devices in clear terms and without assuming a high level of prior knowledge. This is in the assumption that the reader is most likely to have some elementary knowledge of electricity, more often from practical experience rather than theory. The early chapters contain a revision of electrical principles for those who are not too sure. The remainder deals with electronic devices and principles with circuit diagrams where necessary to show how components are used. An invaluable introduction to electronics for the electrician or newly qualified technician.

1987. 158 x 206mm, 272 pages, illustrated.

Order As WP80B (Electronics for Electricians and Engineers) ***Price £9.95NV***



Electronics

by G.E. Foxcroft, J.L. Lewis & M.K. Summers

A course intended for those studying GCSE physics or other subjects which may also require knowledge of electronic principles or components. It will also be of considerable use to those studying GCSE Electronics. The material is based on that developed by the Independent Schools' Microelectronics Centre and modified as a result of school trials. A systems approach to electronics is adopted, with familiar ideas about simple circuits leading to the NAND gate, then bistables and further logic theory including coding and decoding, astables and counters, concluding with a simple introduction to memory. Ideal beginner's introduction to electronics with many self-learning exercises.

1986. 239 x 185mm, 184 pages, illustrated.

Order As WP82D (Electronics) ***Price £4.95NV***

Video Handbook

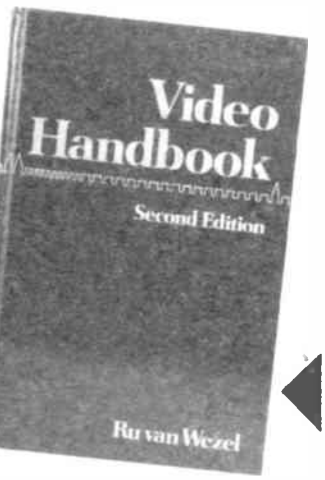
Second Edition

by Ru Van Wezel

Video is a fast expanding communications medium, which is not only replacing film and film cameras, but is also developing in directions in which it is difficult for film to follow, such as special effects and instant viewing, for example. The *Video Handbook* presents in one volume most of the information needed to understand video. A practical book on all aspects of the subject intended for the serious enthusiast. Early chapters cover television standards, transmission, structure of the video signal, cameras and tubes, and includes a build-it-yourself monochrome camera project. Principles of a 'master control desk' are described including special effects in detail, and a simple control desk project is described. Later chapters cover transmission and reception systems, cables, video recording and editing, reel-to-reel and cassette and audio recording and playback. Also included are some guides to the basic skills of stage lighting, composition and make-up to give an idea of how the professionals achieve the required results. This second edition takes into account the current modern state-of-the-art of video recording equipment now available.

1987. 240 x 160mm, hard cover. 455 pages, illustrated.

Order As WP81C (Video Handbook) ***Price £30.00NV***



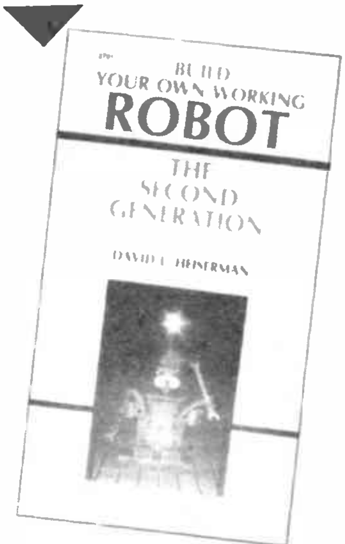
Build Your Own Working Robot - The Second Generation

by David L. Heiserman

Offering a project called 'Buster', a personal robot which can be built from scratch by employing a 'modular' construction where the robot can become increasingly more complex as further stages are added. By using this step-by-step approach, the author breaks down the construction of a complex robot system into easy and logical sub-systems that you will enjoy building – these comprise the moving platform assembly, the drive/steering mechanism, the operator's control panel, the power supply and clock circuitry, system mode control, and the 'blunder response' system. When Buster is complete, you will find instructions on all the test protocols necessary to check out each circuit. The author is an industrial process control/robotics software consultant and a former college professor.

American book, 1987. 200 x 130mm, 130 pages, illustrated.

Order As WP79L (Build Your Own Working Robot) ***Price 10.35NV***



CLASSIFIED

VARIOUS FOR SALE

'ELECTRONICS' MAGAZINES issues 10, 11, 21, 22, 23, 24. All in excellent condition. Any offers including p&p to Mr. Hudson, 71 Knight Avenue, Canterbury, Kent CT2 8PY.

APPROX. 200 COPIES of 'Practical Electronics', 'Practical Wireless' and 'Everyday Electronics', £40. 'Micro User's' from 1st issue to mid-'86, £20. 'Beebug' magazine, 1st issue to mid-'86, £25. Tel: Michael Stout, 01-723 5190.

EX-GOVERNMENT Royal Electric Inc. inverter CLA-2500VA P/N X3516-1. Input: 27.5V 150A. Output: 1PH 115V 400CY, 2500VA 0.90 PF. Manufacturer's serial No. 8220. Contact E.G. Priestly F.B.I.S., 6 Lynden Avenue, Windhill, Shipley, West Yorkshire BD18 1HF. Tel: 0274 593382.

DUE TO ILLNESS MUST SELL hobby items; electronics, photography, woodworking, etc. Send SAE for lists of many bargains. BBC/Electron computer software, several hundred radio, TV, audio valves, books. Many interesting items. Hopwood,54, Water Lane, Middlestown, Wakefield, West Yorkshire WF4 4PX. Tel: 0924 263503.

PHILIPS PM3230 10MHz Dual Beam oscilloscope with manual and probe kit, £100. Fisher digital tuner with 12 presets, £40. Wanted, Quad FM2 tuner. Tel: 0209 820066.

SINCLAIR TV data fault-finding, setting up, circuit diagram, operation, address for parts and modules. Maues oscilloscope, monitor, timebase amp and more. £1.50. Van Hamlin, 10 Speldhurst Road, Southborough, Kent.

MAPLIN 40W AMP built in 1980 and given trouble free service ever since, also pair Wharfedale XP2 speakers, will sell amp or speakers separately. Offers to C. Hart, Flat 4, 12 Caearau Crescent, Newport, Gwent.

FOR SALE IBM 'GOLFBALL' typewriter, perfect working order plus photocopy of Maplin instructions, £10. Buyer collects. Redway, 3 Felixstowe Road, Abbey Wood, London SE2 9QW.

OSCILLOSCOPE with flat LED screen (unmade kit) £29.99. Also casekit £9.99 and 'scope lead, £3.95. Brand new unused ZX81, £29.99. J.E. Ellis, The Flat, 18, Butter Hill, Wallington, SM6 2JD.

CORDLESS TELEPHONE 700ft range, local paging facility, last number re-dial etc. First class operation, brand new, boxed. Ideal Christmas present, £70. Tel: Brentwood (0277) 224581 after 6pm.

ANTI-STATIC FOAM 250 x 160 x 15 (13p each). Anti-static bags, different sizes, from 1.5p each. Resistors E12 and E24 values, 2%, 2p each. Tel: (0978) 758202.

RECORD SLEEVES FOR SALE PVC record sleeves in single and L.P. sizes. Ex-shop use. Also other record protection sleeves for sale. Write for lists to D. Bush (Audio), 19 Addelam Road, Deal, Kent CT14 9BZ.

OSCILLOSCOPE MARCONI TF1330 12cm tube, £18. Telequipment DM64, twin trace solid state, no tube, £18. AF signal generator, £12. Tel: 0689 55965.

COMPONENTS FOR SALE new, used, transistors, capacitors, resistors, IC's, PCB's, switches, 1kg parcel for £10, includes postage! UK only. P. Fowler, 26 Octon Road, Mickleover, Derby DE3 5PL.

If you would like to place an advertisement in this section, here's your chance to tell Maplin's 200,000 customers what you want to buy or sell, or tell them about your club's activities - absolutely free of charge. We will publish as many advertisements as we have space for. To give a fair share of the limited space, we will print 30 words free of charge. Thereafter the charge is 10p per word. Please note that only private individuals will be permitted to advertise. Commercial or trade advertising is strictly prohibited in the Maplin Magazine. Please print all advertisements in bold capital letters. Box numbers are available at £1.50 each. Please send replies to Box Numbers to the address below. Please send your advertisement with any payment necessary to: Classifieds, Maplin Mag., P.O. Box 3, Rayleigh, Essex SS6 8LR.

For the next issue your advertisement must be in our hands by 15th January 1988.

DIGITAL M777 PSU outputs 5V at 32A 15-0-15 at 1A, offers. Also for sale Maplin stereo cassette deck kit (switch PCB missing, but easy to make) £25 o.n.o. Tel: 0562 755035.

ULTIMATE AUDIO AMPLIFIER components e.g. 52-0-52 (1kVA), 52-0-52 (50VA), 15-0-15 (25VA) 3% reg. split primary toroidal transformer, £45 o.n.o. Many other used and unused ex-prototype parts. SAE for full list to C. Wallace, 23 Victoria Road, Leeds, LS6 1AS.

COMPUTERS FOR SALE

DRAGON 32 COMPUTER key responses sometimes take time, leads and manual included. Games, books – will split. Offers, Grant Donovan, 17 Chipponds Drive, St Austell, Cornwall, PL25 5DE. Tel: 75233.

PRISM ACOUSTIC MODEM with software for Prestel etc., £25. Twin joysticks, wired for BBC, £7 the pair. Michael Stout, 01-723 5190.

SPECTRUM 48K COMPUTER & extras, £73. Sabatronics 2000 digital multimeter, £29. Tradiper Grid Dip meter, £25. Nombrex 32 C/R bridge, £24. Heathkit A0-1U AF generator, £29. Range doubler 50kΩV multimeter, £14. Phonosonics spring line reverb. unit, £23. Wordmaker speech synthesiser, £29. Eagle FF11 Graphic Equaliser, £29. Fidelity Sensory 8 chess challenger, £43. Tel: 0502 66026.

ORIC ATMOS 48K computer plus books and software, £32, good condition. Electronic components, miscellaneous, worth £200, complete clearout £20. Tel: 555 7519.

CBM 128 C2N, 1570, all manuals and disks. All as new, £275 o.n.o. Tel: 0373 66369.

SPECTRUM PLUS COMPUTER 5 year warranty, cords, power supply, manual, RGB interface, green monitor, two cassette machines. Would sell separately. Offers? Or all for £130. R.T. Lovelock, 14 Knightly Road, Exeter EX2 4SR. Tel: 0392 75896.

COMPUTER FOR SALE Acorn Atom fully expanded plus many spares and extras. Offers? Free to a good cause. Godfrey, G4GLM, 63 The Drive, Edgware, Middlesex HA8 8PS. Tel: 01 958 5113.

FOR BBC B's EPROM programmer and eraser, £35. 32K sideways RAM, plus software and booklet, £25. Viglen low profile cartridge system, £15. Marconi Trakball, £40. Solidisk CPU and keyboard cases, £15. Tel: 204 4838.

CLEARING OUT MY GARAGE the following items for sale, Winchesters, floppy disks, PCB's, screens, printers etc. SAE for list. 14 Garth Close, Rudry Nr Caerphilly, Mid Glamorgan CF8 3EN.

AMSTRAD CPC464 colour monitor, lightpen, joystick, 37 software titles, games and serious, M/Code assembler, magazines etc., £250. Tel: Roger 0202 433306, 105a Southwick Road, Bournemouth, Dorset, BH6 5PS.

IBM PRINTER mechanism suitable for Maplin LQ printer, £30. Also Spectrum plus Kemston Centronics 'E' and Maplin 8 bit PIO module, plus various software including Zeus monitor and disassembler, Tasword (incl. mail merge), Masterfile. Softy 1 and 2 PROM programmers/editors. All items open to offers. Tel: Worthing 200111 eves.

MUSICAL FOR SALE

OAK ORGAN CONSOLE with space for two manuals. Pedal board. R.A. Creak, tel: 0245 413725.

REVOX B77 REEL TO REEL tape deck, 3¾ - 7½ ips with remote control, excellent condition. £380. Also Integrex Dolby B noise reduction unit, £35. Tel: Merseyside, 051 734 0673.

MAPLIN PERSONAL STEREO DNL (fully built), £12. Yamaha PSS360 keyboard (digital voices, programmable drums) was £150, accept £70. Mr. Armstrong, 2 Allandale Road, Harraby, Carlisle, Cumbria or Tel: 0228 44268.

WORKSHOP CLEARANCE mainly organ parts. Tel: 0436 71181 (Helensburgh).

SEIKO DIGITAL DS-202 keyboard with DS-310 synthesiser and DS-320 sequencer units, RAM memory cassette, manuals, as new £399 (cost £800!) Or swap for very good video. Henno, 0458 34535 (Glastonbury).

SONY TC-377 stereo reel to reel tape deck in excellent working order. Cost £400 new, accept £150 o.n.o. Tel: Shanu 0695 72673 after 6pm.

MAPLIN 3800 SYNTHESISER complete and working, requires some tidying, £95. 61-note keyboard with contacts, £25. DM02(T) organ master oscillator, boxed and unused, £10. Similar but used, £7.50. Tel: 0249 650926.

WANTED

WANTED SERVICE MANUAL and/or circuit diagram for Sony TC250A reel to reel tape deck. Please contact:- Richard Clarke, 2 Northlands Street, Camberwell, London SE5 9PL. Tel: 01 737 4096.

WANTED MAPSAT WEATHER SATELLITE SYSTEM has anyone interfaced MAPSAT to an Atari ST or willing to sell Frame Store with compatible video output of MAPSAT. Please 'phone Keith on 0223 247980.

48K SPECTRUM repair manual and/or circuit diagram wanted. Please write to:- Mr. G. Prout, 33 Arnett Avenue, Finchampstead, Berkshire RG11 4EG.

WANTED JVC RC-M90L portable cassette player. Hallvard Tangeraas, 3577 Hovet, Norway.

WANTED CIRCUIT TO INTERFACE Teletext decoder panel to printer (Centronix type I/P). C. Savage, 9 Cook Road, Millom, Cumbria LA18 4JH.

WANTED SATELLITE TV dish, equipment and information for school project. 'Phone Paignton (0803) 559245 or write to 13 Hill Park Terrace, Paignton, Devon TQ4 6EX.

WANTED TO BUY copy of Vic Revealed by Nick Hampshire. Any other books or accessories for Vic or 6502 considered, especially VICMON and IEEE cartridge. Write to D. Looker, 202 Farmers Close, Witney, Oxon OX8 6NS.

NEED A U.K. ADDRESS of a manufacturer or supplier of spare parts? List of over 500 U.K. addresses for £1. Disk for BBC micro, £3.50. Mr. G. Cornes, 162 Netherton Road, Anniesland, Glasgow G13 1BJ.

WANTED 27MHz AM SSB CB radio in good working order. Gareth White, 5 Bamfords Fold. Bretherton, Preston, Lancashire PR5 7AL. Tel: 0772 601399.

WANTED MAPLIN MAGAZINES issues 1 to 16. Contact Van on 0892 28589.

WANTED RADIO CIRCUIT DIAGRAM for Zenith model H500 chassis 5H40 AC DC. Write to Francis Campos, Rua Possidonio Da Silva, 162-4E, 1300 Lisbon, Portugal. Will meet all costs involved.

WANTED TRANSFORMER AND BOARD assemblies for B1010 oscilloscope and TV transistor defects and replacement handbook. Write details and prices to Wilson Oppong, Box 59, Achimota, Ghana.

WANTED BIZTEK ELECTRONIC MEMO PAD will pay £10 + postage/packing for one that works or £5 + postage/packing for one not working, but the display *must not* be broken: 'phone Southend (0702) 206097 after 6pm, ask for David.

£5 PAID FOR THE SHORT-TERM LOAN of the service manual for Philips oscilloscope type PM3210/05. John Martin, 32 Pakenham Close, Cambridge CB4 1PW or tel: 0223 321011.

WANTED M.E.S. 53 ORGAN accompaniment circuitry, finished or not. Contact Mr. S. Ball, Doncaster (0302) 770335.

PAUL NEWMAN would appreciate correspondance with a MAPSAT user. Someone local ideal. Expenses refunded. Contact Paul Newman G4INP, 3 Red House Lane, Leiston, Suffolk IP16 4JZ.

WANTED ADAPTOR TO COPY from a Philips VR2021 (2000 flip-over system) to a Solvalox VHS (NCVR-5000) buy or rent. D. Ward, 192 Heath End Road, Nuneaton, Warwickshire CV10 7JB.

DID YOU MISS THESE ISSUES?

Project Book 1 Universal Timer. Programmable mains controller. **Combo-Amplifier.** 120W MOSFET power amp. **Temperature Gauge.** 10°C - 100°C, LED readout. **Pass The Bomb!** Pass-The-Parcel with a difference. **Six easy-to-build Projects on Veroboard.** Car batt. monitor; Colour snap game; CMOS Logic Probe; Peak Level meter; Games timer; Multi-colour pendant.
Order As XA01B (Maplin Project Book No. 1) Price 85p *NV*.

Project Book 2 Digital Multi-Train Controller. Controls up to 14 model trains. **Home Security System.** Six independant channels. **Digital MPG Meter.** With large LED display, a must for more economical motoring.
Order As XA02C (Maplin Project Book No. 2) Price 85p *NV*.

Project Book 3 ZX81 Keyboard. 43 keys, plugs directly into ZX81 with no soldering. **Stereo 25W MOSFET Amp.** 25W r.m.s per channel; Disc, Tape, Tuner & Aux. **Radar Intruder detector.** 20 metres range, may be used with our security system. **Remote Control for Train Controller.** Remote control by infra-red, radio or wire.
Order As XA03D (Maplin Project Book No. 3) Price 85p *NV*.

Project Book 4 Telephone Exchange. Up to 32 extensions on 2-wire lines. **Remote Control for Amplifier.** Volume, balance and tone controlled via infra-red link. **Frequency Counter.** 8 digit DFM, 10Hz - 600MHz range. **Ultrasonic Intruder Detector.** Areas up to 400 square feet can be covered.
Order As XA04E (Maplin Project Book No. 4) Price 85p *NV*.

Project Book 5 Modem. 300 baud transmission speed over normal telephone lines. **Inverter.** 240V AC 60W from 12V car battery. **ZX81 Sound Generator.** 3 tone generators fully controlled from BASIC. **Central Heating Controller.** Optimised performance with this advanced system. **External Horn Timer.** Exterior intruder alarm. **Panic Button.** Add on to our Home Security System. **Model Train Projects.** Add on to our Multi-Train Controller. **Interfacing Micro processors.** How to use parallel I/O ports, with circuits.
Order As XA05F (Maplin Project Book No. 5) Price 85p *NV*.

Project Book 6 VIC20 & ZX81 Talkbacks. Speech synthesis projects. **Scratch Filter.** Tunable active circuit 'reclaims' scratched records. **Bridging Module.** Converts two 75W MOSFET amps to one 400W full bridge amplifier. **Moisture Meter.** Finds damp in walls and floors. **ZX81 TV Sound and Normal/Inverse Video.** TV sound and inverse video direct. **Four Simple Veroboard Projects.** Portable Stereo Amp; Sine Generator; Headphone Enhancer and Stylus Organ.
Order As XA06G (Maplin Project Book No. 6) Price 85p *NV*.

Project Book 7 CMOS Crystal Calibrator. For amateur radio receiver calibration. **DX'er's Audio Processor.** Improved sound from Communications Receivers. **Enlarger Timer.** An accurate timer for the darkroom. **Sweep Oscillator.** Displays AF frequency response on an oscilloscope screen. **VIC20 and ZX81 Interfaces.** RS232 compatable.
Order As XA07H (Maplin Project Book No. 7) Price 85p *NV*.

Project Book 8 Spectrum Modem/RS232 Interface. 2400 baud self contained operating system. **Synchime.** Simulates bells, gongs and other chiming sounds. **Dragon 32 RS232/Modem Interface.** Plugs into ROM expansion port. **Codelock.** Programmable electronic lock. **CMOS Logic Probe.** Digital display shows logic states. **Minilab Power Supply.** Versatile unit for the test bench. **Dragon 32 I/O Ports.** Two 8-bit ports. **Doorbell for The Deaf.** Flashing lamp attracts attention.
Order As XA08J (Maplin Project Book No. 8) Price 85p *NV*.

Project Book 9 Spectrum Keyboard. 47 full travel keys. **VIC Extendiboard.** Three expansion ports, one switchable. **Oric Talkback.** Speech synthesiser for the Oric 1. **TDA7000 FM Radio.** Complete FM receiver on a chip. **ZX81 High Resolution Graphics.** 256 x 192 fine pixel display. **Nine Projects!** Personal Stereo Dynamic Noise Limiter; Logic Pulser; TTL/RS232 Converter; Pseudo Stereo AM Radio; and more.
Order As XA09K (Maplin Project Book No. 9) Price 85p *NV*.

Project Book 10 Spectrum Easyload. Helps cassette loading with the Spectrum. **80m Receiver.** Simple SSB direct conversion receiver. **Fluorescent Tube Driver.** 8W 12V for camping and caravanning. **Auto-Waa.** Automatic waa-waa effects unit. **Digi-Tel Expansion.** Expands Maplin Telephone Exchange to 32 extensions. **Oric 1 Modem Interface.** Adapts the Oric 1 to the Maplin Modem. **Dragon 32 Extendiport.** Makes the Dragon's cartridge socket more accessible.
Order As XA10L (Maplin Project Book No. 10) Price 85p *NV*.

Project Book 11 Mapmix. Six channel audio mixer. **Xenon Tube Driver.** Xenon flash tube module with strobe. **Enlarger Exposure Meter.** Simple inexpensive tool for the darkroom. **8 Channel Fluid Detector.** Check/control fluid level in up to 8 containers. **Servo & Driver Module.** Servo mechanism with driver module kit. **Mk II Noise Reduction Unit.** Improves signal/noise ratio of tape recordings. **Cautious Ni-Cad Charger.** Controlled charging of ni-cad cells. **Motherboard for The BBC Micro.** Gives easy access to ports.
Order As XA11M (Maplin Project Book No. 11) Price 85p *NV*.

Project Book 12 RTTY Unit. The TU1000 receives/transmits Radio Teletype; connects to computer via RS232. **Computadrum.** Use your computer as a drum synthesiser. **Light Pen.** Draw onto the TV screen or select menu options. **PWM Motor Drive.** Reversible model motor driver for 6V and 12V.
Order As XA12N (Maplin Project Book No. 12) Price 85p *NV*.

Project Book 13 Explosive Gas Alarm. Flammable gas detector. **Flash Meter.** Get your exposure right when using your flash gun. **Musical Announcer.** A doorbell with a difference. **Mains Controller.** An add-on for the 8-Channel Fluid detector.
Order As XA13P (Maplin Project Book No. 13) Price 85p *NV*.

Project Book 14 Live Wire Detector. Invaluable aid for the handyman. **Trundle.** The line follower robot as featured on Channel 4. **4-Channel PWM Controller.** Digital control of motors and servos. **Display Driver Module.** How to use our LED bargraph display ICs. **Control-A-Train.** Full inertia control of model trains. **Spectrum I/O Controller.** Buffered 2-way 8-bit data bus and 8 control lines.
Order As XA14Q (Maplin Project Book No. 14) Price 85p *NV*.

Project Book 15 Z80 CPU Module. Expandable CPU based controller. **Sharp MZ-80K Serial Interface.** Get into communications with this project. **Ultrasonic Car Alarm.** Stop car thieves. **Active Crossover.** Includes matched output power amplifiers. **Guitar Equaliser.** Specifically for six string electric guitatrs. **Fabulous Five.** A selection of interesting circuits.
Order As XA15R (Maplin Project Book No. 15) Price 85p *NV*.

Project Book 16 Floodlight Controller. Both power supply and mains switching unit for the Infra-red Intruder Detector Kit. **Spectrum Parallel/Serial Interface.** Provides 8-bit I/P and O/P parallel or serial transfer with programmable UART. **Mains Tx/Rx Data Communications System.** Sends or receives data via the mains wiring. **16-Channel Logic IC Tester.** Simultaneously displays logic states for any logic IC of up to 16 pin-outs on your oscilloscope.
Order As XA16S (Maplin Project Book No. 16) Price 85p *NV*.

Project Book 17 Video Digitiser. Interface a TV camera to your computer. **Mixing It.** A comprehensive range of audio amplifier modules. **Hobbyist's Temperature Controller.** General purpose electronic mains power thermostat. **ASCII Keyboard.** Professional computer keyboard with standard ASCII output. **Play Along Mixer.** Play along to your favourite records and tapes on your own instrument.
Order As XA17T (Maplin Project Book 17) Price 85p *NV*.

Project Book 18 Weather Satellite Receiver. Display regional weather systems on your TV or monitor. **Mixing It Part 2.** Mono/stereo Hi-Z mic input, mixer and line amplifiers; VU/headphone driver. **Stepper Motor Driver.** How to build and start using the Stepper Motor Kit featured in the Catalogue. **Amstrad Expansion System.** The Maplin Amstrad External ROM Card System for the CPC 464, CPC 664 and 6128. **Sealed Lead Acid Battery Charger.** Special high stability output with automatic trickle charge mode for sealed lead acid batteries. **Fantastic Five.** Veroboard projects comprising HF tremelo unit, crystal checker, clap switch, low-Z ohmmeter, snooze timer.
Order As XA18U (Maplin Project Book 18) Price 85p *NV*.

Electronics Issue 19 Active Aerial and Aerial Tuning Unit. Get more from SW. **Amstrad Expansion System.** 6 x 8-bit parallel I/O card and PSU. **ADA Digital Echo.** RAM based low cost echo machine. **Mixing It.** Mixer Modules' PSU.
Order As XA19V (Maplin Magazine Volume 5 Issue 19) Price 75p *NV*.

Project Book 20 Weather Satellite Decoder. Displays output from Satellite Receiver on TV or monitor. **Infra Red Proximity Detector.** Short range heat or movement detector. **Fibre-Optic Link.** Sends AF signals over up to 20m of fibre-optic cable. **Low-Z Microphone Pre-amp.** For 200-600Ω mics plus gain adjustment.
Order As XA20W (Maplin Project Book 20) Price 75p *NV*.

Electronics Issue 21 6 Channel Burglar Alarm. Develop a complete security system. **Six Circuits.** Bass Fuzz, Voice-Over Unit, Noise Gate, Envelope Tremolo, RTTY Decoder and Scratch & Rumble Filter on veroboard. **Notch Filter.** AF processor for communications receivers. **12V Public Address System.** 10W per channel from car battery. **Tungsten Lamp Controller.** AC phase control for mains lamps.
Order As XA21X (Maplin Magazine Volume 6 Issue 21) Price 85p *NV*.

Electronics Issue 22 MIDI Interfacing Techniques. Connect MIDI instruments to the VIC20 or CBM64. **Hi-Fi Speakers & Enclosures.** Two high quality loudspeaker cabinet designs. **Keypad for Z80 CPU.** At last a keypad I/F & ROM for the Z80 CPU kit. **4½ Digit Counter.** Versatile basic counter module to 4½ digits. **Weather Satellite Down Converter Part 1.** Aerial & freq. converter for MAPSAT Receiver to tune into the Meteosat satellite. **Mini Circuits.** Veroboard Audio Level Tester, Sound Triggered Flash, In-Circuit Resistance Meter, I/R Audio Isolator.
Order As XA22Y (Maplin Magazine Volume 6 Issue 22) Price 85p *NV*.

Electronics Issue 23 MAPSAT Frame Store #1. Z80B CPU controller. **Servo Tester.** Proportional servo tester. **Weather Satellite Down Converter Part 2.** Channel Switching Unit. **Capacitance Tester.** 5 ranges, 3 digit display. **More Mini Circuits.** Movement alarm, Stepper Motor Driver, Pink Noise Generator, Optical Port Data Link, 'Metal Pedal'.
Order As XA23A (Maplin Magazine Volume 6 Issue 23) Price 85p *NV*.

Electronics Issue 24 Nuclear Radiation Monitor. Alpha, Beta, Gamma & X-ray gieger counter. **VHF Pre-Amp Module.** MAPSAT VHF pre-amp. **External Horn Programmable Timer Update.** Modifying the module for use with other than the Maplin Home Security System. **MAPSAT Frame Store #2.** The Video Graphics Card. **VHS Video Alarm.** Battery powered portable movement alarm built into a VHS Video Cassette.
Order As XA24B (Maplin Magazine Volume 6 Issue 24) Price 85p *NV*.

GET YOUR COPY OF THE NEW MAPLIN CATALOGUE ON SALE NOW
ck up a copy from any W.H. Smith for just £1.60 or post this coupon
now to receive your copy by post for just £1.60 + 40p p & p. If you live
outside the U.K. send £2.75 or 12 International Reply Coupons. I enclose £2.00.
ame
ress
Post Code
Send to Maplin Electronic Supplies Ltd., P.O. Box 3, Rayleigh, Essex SS6 8LR.
AVAILABLE NOW IN ALL W.H.SMITH STORES GET YOUR COPY NOW!
1988 BUYER'S GUIDE TO ELECTRONIC COMPONENTS
Maplin
MAPLIN
VISIT OUR NEW SHOP IN BRISTOL NOW OPEN AT 302 GLOUCESTER ROAD Tel: (0272) 232014
UNIQUE
Make your own DIGITAL WATCH KIT
½ PRICE OFFER ONLY £1
SEE INSIDE COVER. NO SOLDERING. SUITABLE FOR AGES 10+
Maplin
10:23
Electronics
NEW! RADIO CONTROL MODELS + 100's OF NEW PRODUCTS AT LOW, LOW PRICES
£1.60