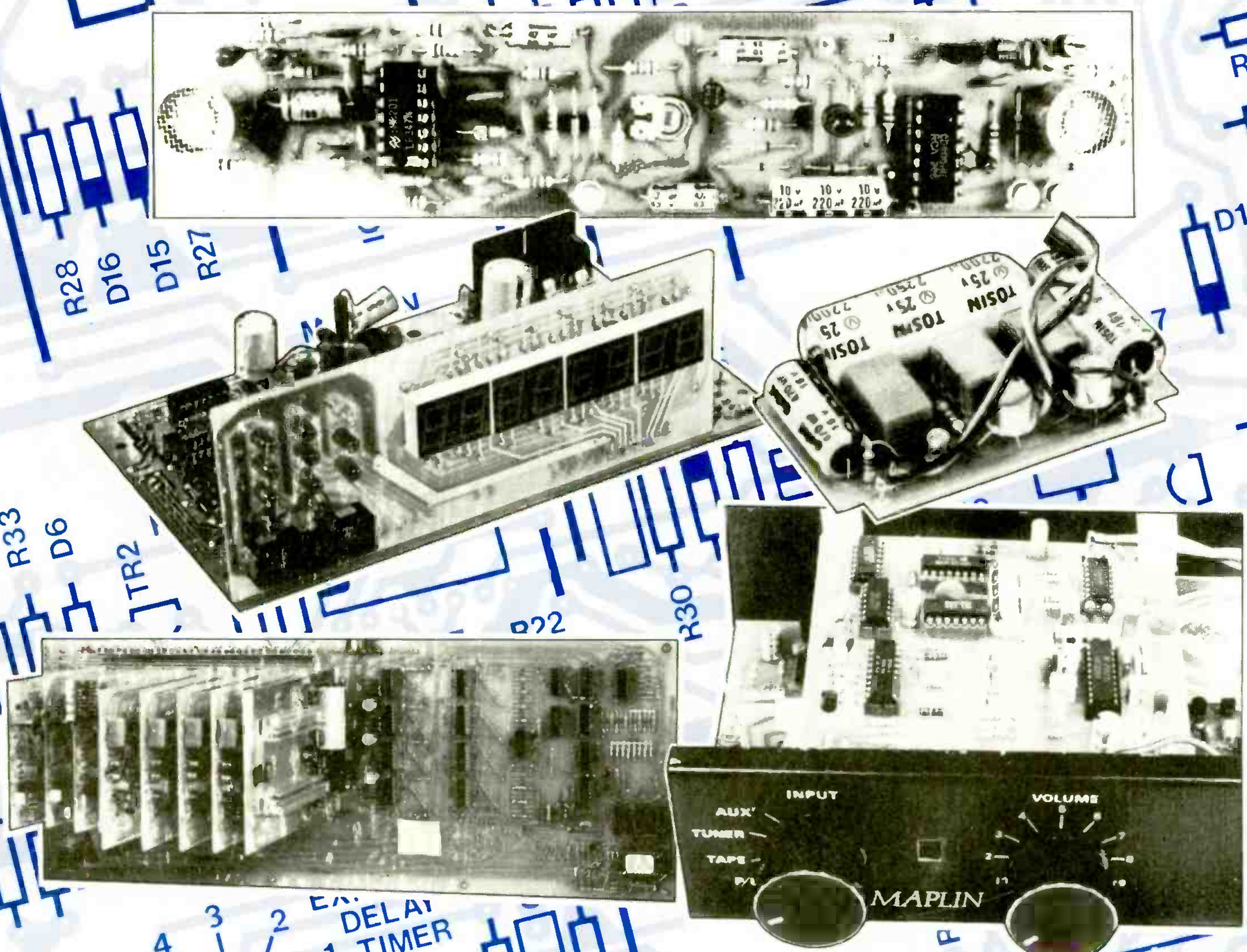
MAPLIN PROJECTS BOOK FOUR

TELEPHONE EXCHANGE
FREQUENCY COUNTER
CAR BURGLAR ALARM
REMOTE CONTROL FOR AMPLIFIERS
ULTRASONIC INTRUDER DETECTOR
I/O PORT



Electronics
THE MAPLIN MAGAZINE

This project book completely replaces issue 4 of 'Electronics', which is now out of print. Other issues of 'Electronics' will be replaced by project books as they, too, become out of print. For kit prices, please consult the latest Maplin price list. The price list also contains details of how to obtain a year's subscription to 'Electronics'.

CONTENTS

Page

Car Burglar Alarm 22
Protect your car from thieves.

Frequency Counter 28
Easy-to-use, 8-digit, battery or mains.

I/O Port 3
Let your ZX81 talk to the world.

Model Train/Computer Interface 35
Control your trains by computer.

Remote Control For Amplifiers 16
Volume changes at the touch of a button.

Telephone Exchange 6
Low cost, high reliability, and easy to instal.

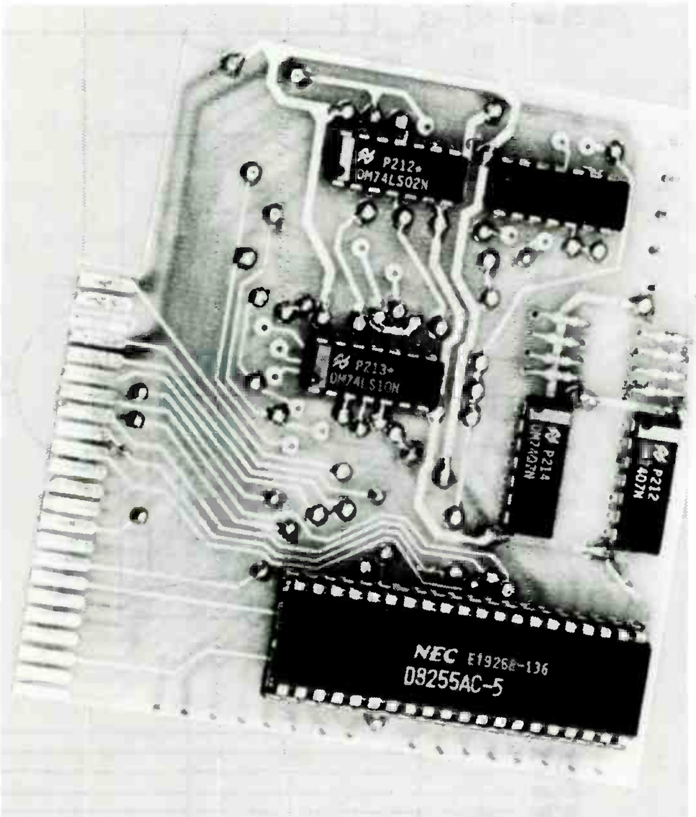
Ultrasonic Intruder Detector 24
Ultrasonic protection for your home or office.

Editor Doug Simmons
Production Manager Sue Clark
Technical Editors Robert Kirsch, Dave Goodman

Art Editor Peter Blackmore
Technical Artists Roy Smith, John Dudley
Photography Chris Barlow

Published by Maplin Electronic Supplies Ltd, P.O. Box 3, Rayleigh, Essex
Printed by Mayhew McCrimmon Ltd.
Typeset by Quillset Typesetting

ZX81 INPUT~OUTPUT PORT



by A. Daykin

- ★ **Two 'bi-directional' ports for a total of 16 input or 16 output lines**
- ★ **One buffered output port which can interface directly to CMOS**
- ★ **Able to be used with the MAPLIN digital train controller**
- ★ **On board address selection allows for expansion to 6 ports with two PCBs**

This project for the Sinclair ZX81 will give you access to the outside world with your '81'.

The I/O port, shown in figure 1, gives many possible modes of operation. For the purposes of this article examples are given for only the simplest, although the 8255 used here has a total of three programmable operations.

MODE 'O' provides 3x8bit ports, two of which can be programmed to function either as inputs or outputs, and one (port B), as a buffered output only, which can directly drive the MAPLIN DIGITAL TRAIN CONTROLLER (issue three) or, indeed, many other forms of hardware with a minimum of interfacing.

Circuit Description

Figure 1 shows a complete circuit diagram of the board, and Figure 5 shows the alternative address decoder circuitry. The MP8255 (IC4) has two address lines, pins 8 and 9, which are connected directly to the ZX81 address lines A1 and AØ. The remainder of the address decoding is performed by ICs 1,2, and 3, which enables the MP8255 with a logic Ø at pin 6 ($\overline{CS}$).

Data lines DØ to D7 are connected directly to IC4, along with write and read lines $\overline{WR}$ and $\overline{RD}$. The RESET line, P35, has been tied directly to 0v. Should an external reset be required, the track will have to be broken here, and an external reset pin fitted to P35. Two possible address groups are provided on the PCB, which can be selected at the construction stage, by inserting appropriate pins through the PCB. Addresses used are 16360 to 16363, which are designated by a square symbol on the legend, and 16380 to 16383 which are designated by a circle on the legend. All other track pins have a broken circle for designation. If two PCBs are used, they should be constructed for two different address groups.

IC5 and 6 are 7407 buffers, with open collector outputs capable of sinking up to 40mA at a maximum of 30v.

Construction

Commence by inserting all track pins into the holes marked with a broken circle. Decide which address group you require, and insert all track pins into their appropriate holes (see circuit description). Fit R1 to R8, and D1 (note polarity). Insert all 26 Vero pins and push home. Solder all pins and components, remembering that the track pins will need soldering to both sides of the PCB. Fit the 40 pin IC socket and ICs 1, 2, 3, 5, and 6. Solder these components in place and, finally, insert IC4 in the socket. Cut off any protruding leads and clean flux off the PCB with a stiff brush and thinners. Check all components and joints before connecting to your computer. If you are using a mother board the PCB will plug straight in, but if you are using the port direct into the ZX81 a 23-way socket (RK35Q) will be required. Place this socket over the edge connector, aligning pin 3 with the slot cut in the PCB, and solder all 44 pins to both sides of the board.

Testing And Using The Ports

With the power off, plug the port PCB into your ZX81. Switch on and ensure that the command cursor appears. If not, or if the screen fills with lines, switch off and re-check your assembly.

A few lines of BASIC program are now required for use. The highest address (16363 or 16383), used for the

Control Word	D7	D6	D5	D4	D3	D2	D1	DØ	Port A	Port C Upper	Port C Lower	Port B
128	1	0	0	0	0	0	0	0	Output	Output	Output	Output
129	1	0	0	0	0	0	0	1	Output	Output	Input	Output
136	1	0	0	0	1	0	0	0	Output	Input	Output	Output
137	1	0	0	0	1	0	0	1	Output	Input	Input	Output
144	1	0	0	1	0	0	0	0	Input	Output	Output	Output
145	1	0	0	1	0	0	0	1	Input	Output	Input	Output
152	1	0	0	1	1	0	0	0	Input	Input	Output	Output
153	1	0	0	1	1	0	0	1	Input	Input	Input	Output

Table 1. List of Control Words.

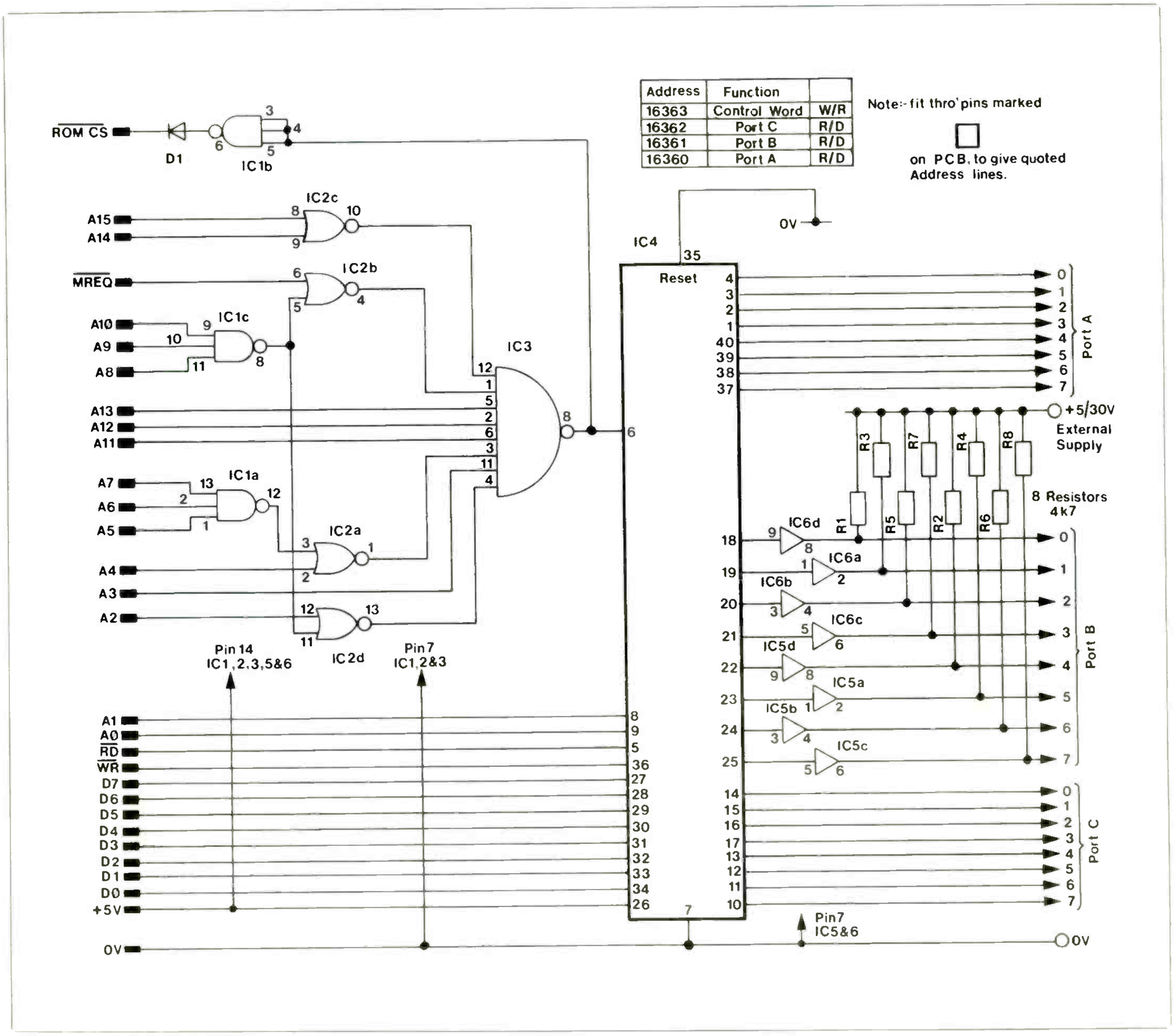


Figure 1. Circuit diagram of I/O Port.

CONTROL WORD, will set MODE and program which ports are to be input and output (see table 1).

PORT A can be used as either input or output, but all the DATA lines will be in the same mode.

PORT B on our PCB can only be used as an output, because of the buffers.

PORT C can be either input or output, and may also be split into two parts, upper and lower halves, which can be changed independently.

Table 1 gives a complete list of the CONTROL WORDS available, along with DATA BUS state and a definition of PORT USE.

Reliable operation with PORT C in split mode can be difficult when using BASIC, and it is advisable to use only the control words 128, 137, 144, and 153. Port A is located at address 16360 or 16380, and if used as an output POKEing to this address will output data on the port pins. PEEKing at the same address will read data in from the same pins. Port B is located at address 16361 or 16381, and can only be POKEd here.

I/O PORT PARTS LIST

Resistors — all ¼W 5% carbon unless specified			
R1-8	4k7	8 off	(U4K7)
Semiconductors			
D1	1N4148		(QL80B)
IC1	74LS10		(YF08J)
IC2	74LS02		(YF02C)
IC3	74LS30		(YF20W)
IC4	8255A PIA		(YH50E)
IC5,6	7407	2 off	(QX76H)
Miscellaneous			
	40-pin DIL socket		(HQ38R)
	Veropin 2145	1 pkt	(FL24B)
	Track pin	2 pkt	(FL82D)
	PCB		(GA90X)
Test Components			
	2k2 resistors	4 off	(M2K2)
	220R resistor		(M220R)
	LED red	8 off	(WL27E)
or	Red bargraph display		(BY65V)

A complete kit is available for this project. It does NOT include the Test Components.

Order As LW76H (I/O Port Kit)

Port C is located at address 16362 or 16382, and can be POKEd or PEEKed as for port A. Printed here are two demo programs which will quickly check out your board. For demo 1 a number of discrete LEDs or a bar-graph display can be connected to 0v via a 220 ohm resistor, and then to the outputs of port B (see figure 4). Remember to connect the positive supply pin (next to port B pin 0) to a +5v/30v supply.

For the demo 2 program the LEDs can be left connected, and will give a display similar to that of the previous program. Input coding can be set up by wiring port A and C pins to either 0v or +5v, as required, but for test purposes connect the 0v and +5v via 2k2 resistors (figure 5) in case the MP8255 is set in the output mode. This should be done before running the program.

For constructors who may wish to use the I/O port with external hardware, a mother board is available for the ZX81 (GB08J) and will accept the Sinclair 16K RAM pack and up to three plug-in modules. You will need four PC edge connectors 2 x 23 way (RK35Q) and the pcb.

continued on page 35

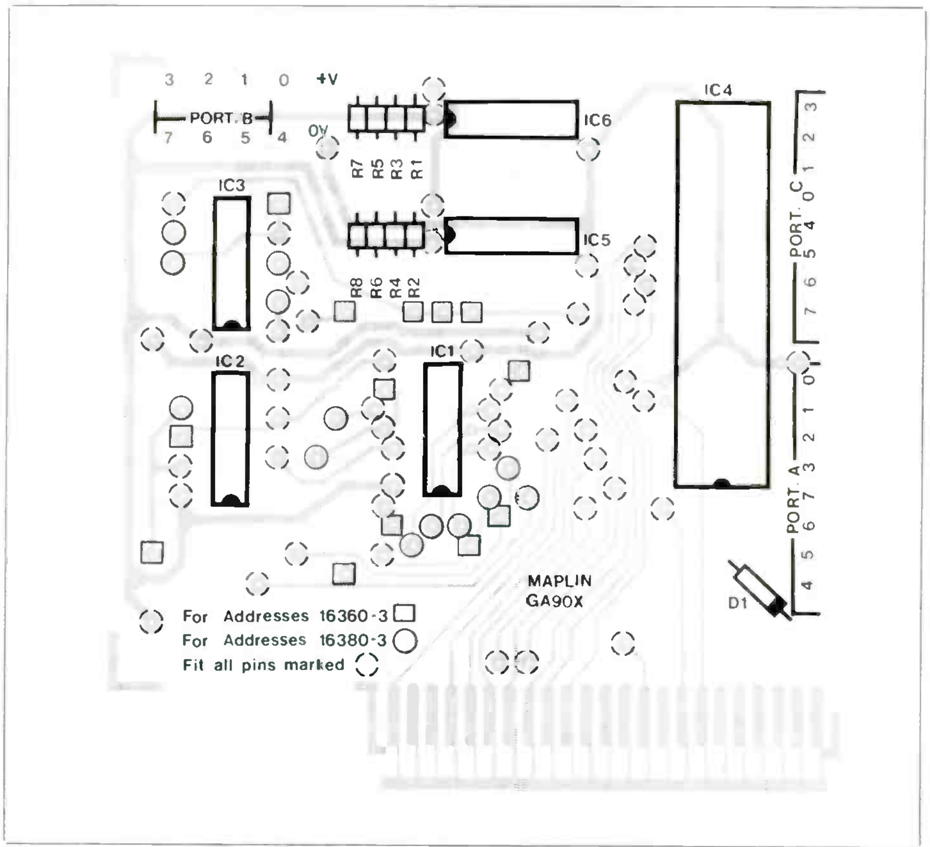


Figure 2. Component layout of I/O Port pcb.

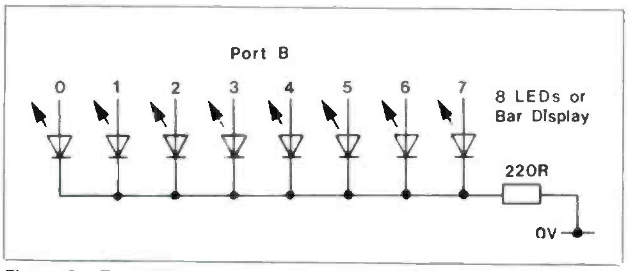


Figure 3. Test LED's.

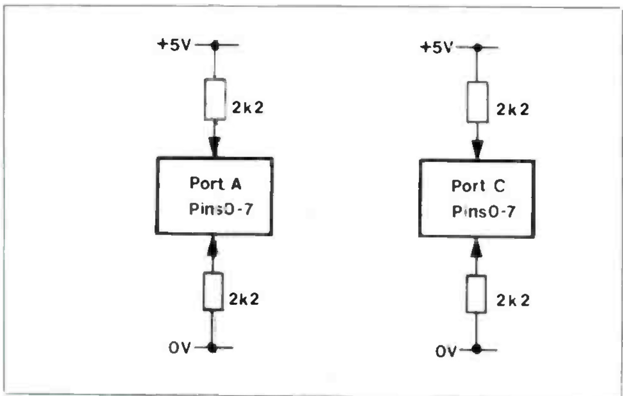
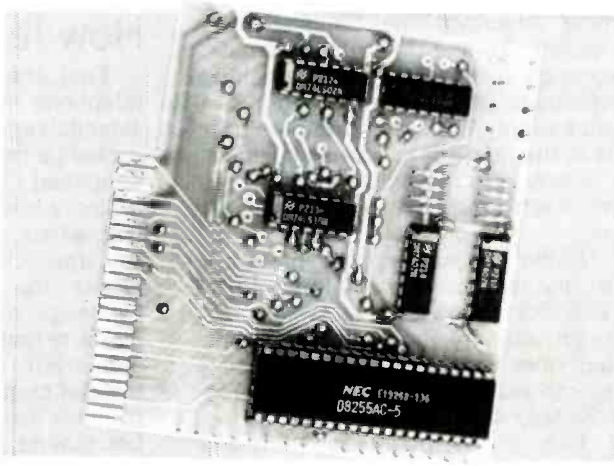


Figure 4. Test resistor connections.



DEMO 1

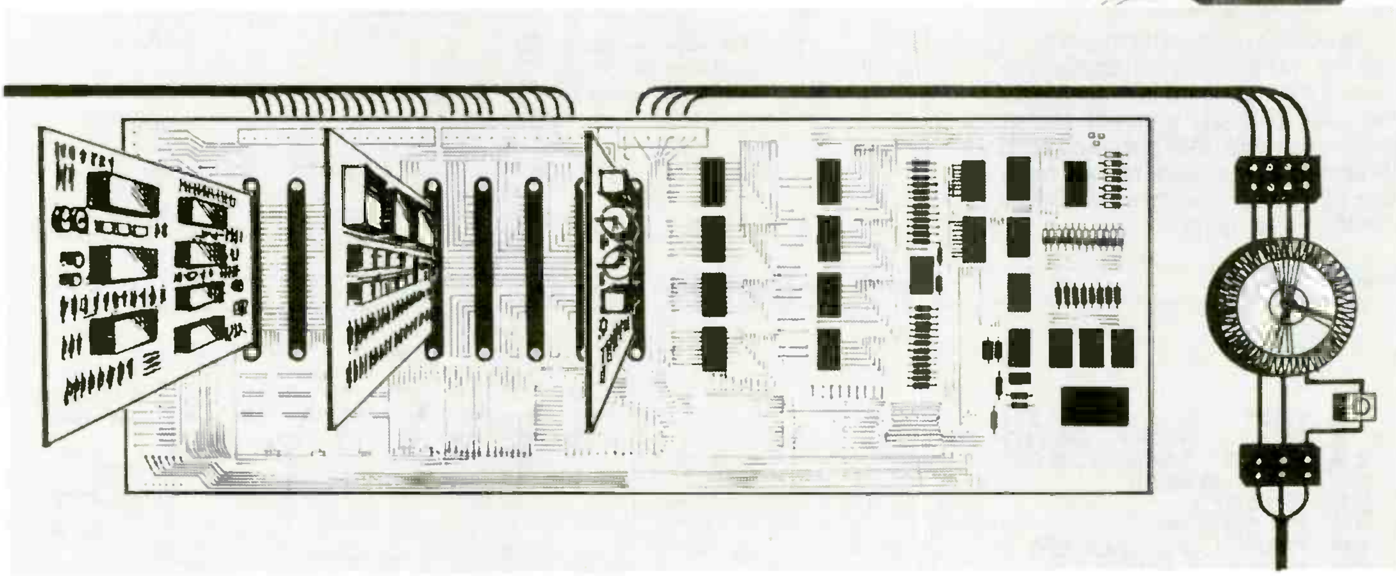
```
  1 REM  A. DAYKIN.
  5 REM  PORT DEMO NO. 1
 10 POKE 16363,128
 20 LET A=0
 25 SCROLL
 30 PRINT A
 40 FOR L=1 TO 50
 50 POKE 16361,A
 60 NEXT L
 70 LET A=A+1
 80 SCROLL
 90 IF A>=16 THEN GOTO 20
100 GOTO 30
```

DEMO 2

```
  1 REM  A. DAYKIN.
  5 REM  PORT DEMO NO. 2
 10 POKE 16363,153
 20 LET A=0
 25 SCROLL
 30 PRINT "PORT B OUTPUT IS  ";A
 35 SCROLL
 40 FOR L=1 TO 50
 50 POKE 16361,A
 60 NEXT L
 70 LET A=A+1
 80 IF A<16 THEN GOTO 25
 90 SCROLL
100 PRINT "PORTS A AND C WILL BE"
105 SCROLL
110 PRINT "TESTED AS INPUTS"
120 LET B=PEEK 16360
125 SCROLL
130 PRINT "PORT A READS  ";B
140 SCROLL
150 LET C=PEEK 16362
160 SCROLL
170 PRINT "PORT C READS  ";C
180 STOP
```

THE MAPLIN Digi~Tel TELEPHONE EXCHANGE

by Robert Kirsch



- ★ **Expandable from 4 up to 32 extensions**
- ★ **No call can be interrupted or overheard by another caller**
- ★ **Standard 2-wire connection to telephones**
- ★ **All phones powered by the 2-wire line. A mains connection is only required at the exchange**
- ★ **May be used with either our low-cost push-button telephones, or standard British Telecom phones**
- ★ **Up to sixteen telephones may be in use at any one time (in full 32 extension system)**

A telephone exchange of any capacity has not, until now, been a feasible project for the amateur constructor, due to its size, power requirements, cost, and non-availability of electro-mechanical switches. This article describes the building of a complete 16-line internal automatic exchange using solid state switching techniques, and powered from the mains supply. The system is suitable for use in the home or in a small business or factory, and requires only two wires from each extension to the exchange unit.

Maplin are making available a low cost, modern styled, push-button telephone for use with this system, although ordinary British Telecom type telephones with loop disconnect dialling and AC ringing can be used. The exchange may be equipped with as few as four or as many as thirty-two extensions (the addition of the second sixteen lines, and possible interfacing between this exchange and a switchboard and other exchanges will be described in later articles).

How It Works

First, the operation of the standard telephone should be studied to consider its' requirements in relation to the exchange being used. Figure 1 shows a simplified block schematic of an ordinary telephone, and it will be seen that when the handset is lifted the transmission circuit produces a loop across the line (indicating to the exchange that a call is about to be made, or that an incoming call has been answered). This loop is interrupted by the dial contacts, the number of interruptions being dependent on the number dialled, i.e. when 1 is dialled the circuit is interrupted once, and when 0 is dialled it is interrupted ten times. An AC bell is used for incoming calls, and this is connected across the line via a capacitor to prevent a DC loop when the handset is on its rest.

Extension Line Circuit (ELC)

This circuit consists of two main parts, one for incoming and the other for outgoing cells. A block diagram of the ELC is shown in Figure 2 and a circuit diagram in Figure 3.

Outgoing Calls

When the telephone handset is lifted, the loop produced across the line is detected by TR5. This transistor is biased on by the current flowing through R11, and this current (via L1)

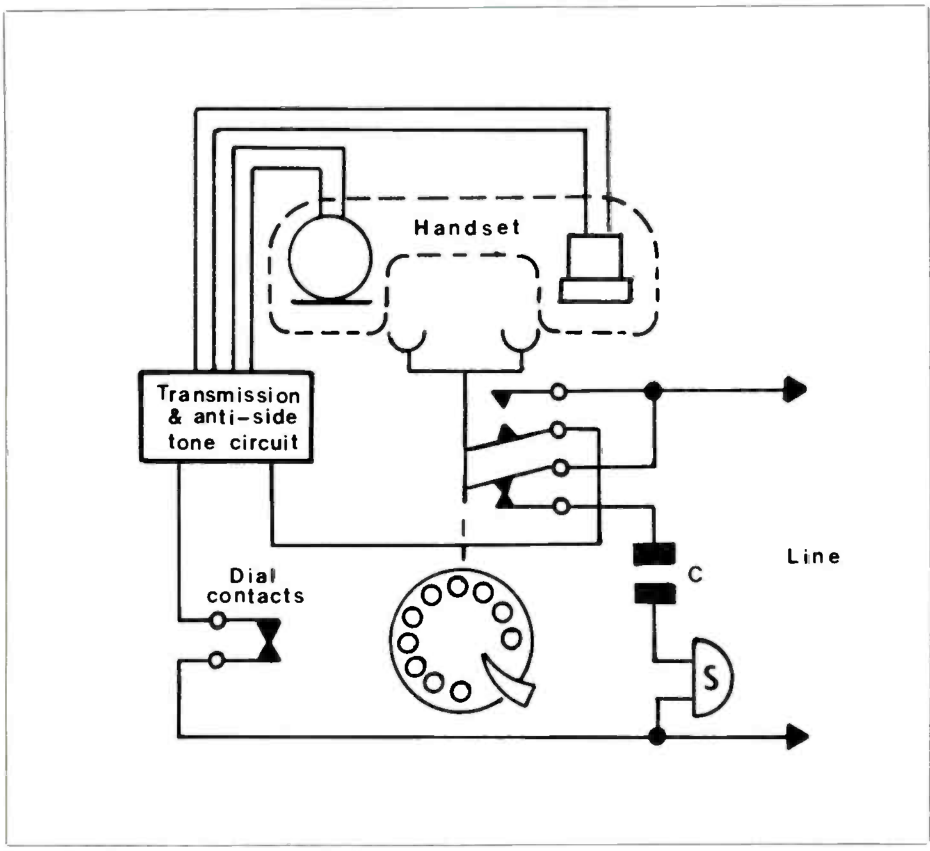


Figure 1. **Block diagram of a typical telephone.**

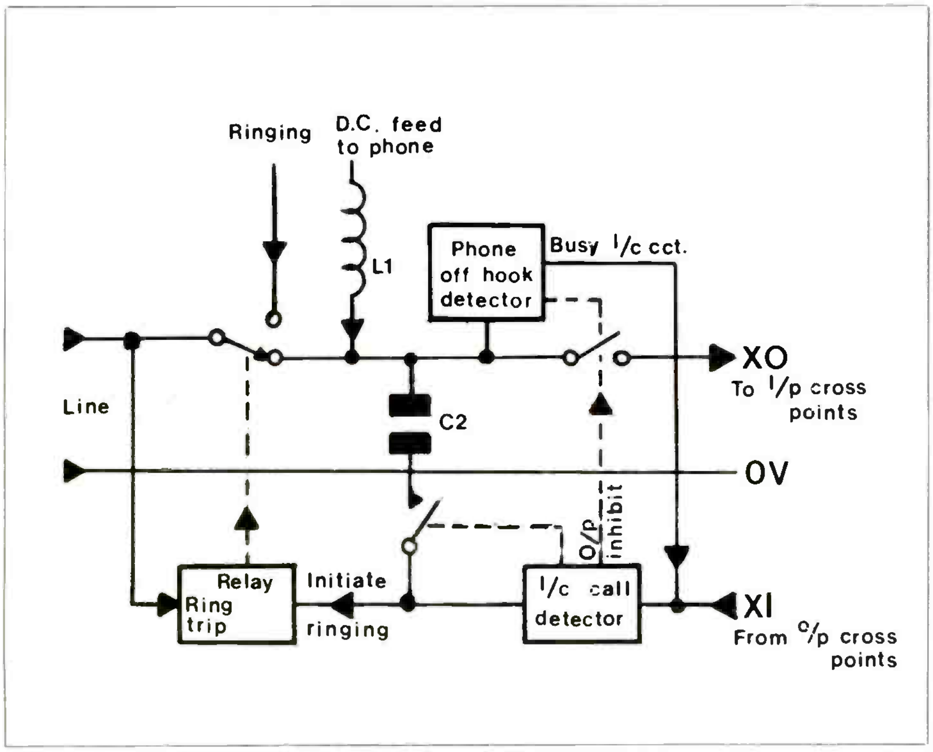


Figure 2. **Block diagram of an Extension Line Circuit (ELC).**

also provides the DC supply needed for the telephone transmitter (microphone). The operation of TR5 can be inhibited by TR4 to prevent a calling condition when the handset is lifted during an incoming call. TR5 switches the voltage present across the line through D2 to the output of the ELC. This voltage varies between 5 and 10 volts dependent on the line resistance and type of telephone in use and is modulated by audio signals. At the same time TR2 switches a high impedance 15V to the ELC output via D1 and R2, and this is used as a calling condition. When the output is terminated by a Connect Circuit the 15V is shunted, thus removing the calling voltage and preventing a second Connect Circuit (CCB) from switching to the ELC. When a call is being made a voltage is also fed to the ELC input via D4, to prevent incoming calls switching to the circuit while it is in use.

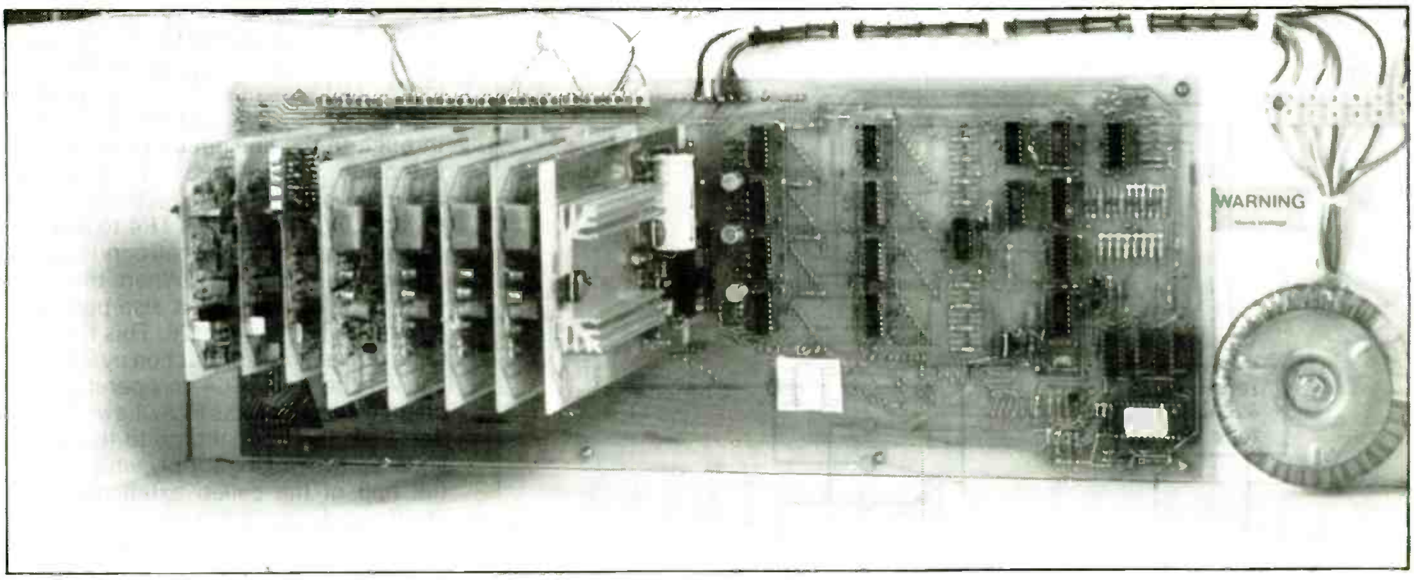
Incoming Calls

When a call is made, the voltage at the output of the calling ELC is switched through the system to the input of the ELC being called, and this voltage initiates ringing to the called extension. When a voltage is applied to the ELC input TR1 is biased on, and this connects the audio transmission path through to the line circuit of the called extension via C2. At the same time TR3 is turned on, and its collector is pulled towards 0V. This causes TR4 to turn on and inhibit an outgoing call condition as previously described. When the collector of TR3 goes low it also pulls the emitter of TR6 low via D6. This transistor is pulsed into conduction by C4, and causes the relay RLA to operate. The change over contacts RLA/1 switch the line from the normal path to the 100V square wave ringing supply, which rings the bell of the called extension. The 100V supply is also fed via R12 and R13 to the base of TR6, and holds the transistor in the conducting mode.

Ringing tone is provided for the calling extension by coupling a small amount of the ringing supply back to the input of the ELC via C1 and R1. The 100V ringing supply is fed from a fairly high impedance, and when the line is terminated by the handset of the called extension being lifted the voltage fed to the base of TR6 is reduced, and the transistor ceases to conduct, causing the relay to release, the ringing to stop, and the transmission path to be switched through. If the handset of the called extension is replaced at the end of a conversation before that of the calling extension, the ringing will not restart, as the emitter of TR6 is still low and C4 remains charged and is thus unable to pulse the transistor into conduction.

4 by 4 Crosspoint IC 45100

All the main switching in the telephone exchange is carried out by the 45100 IC, and it is important to understand how this IC works before going on to describe the connecting circuits. The 45100 is a 4 by 4 crosspoint switch that has 4X and 4Y connections. This means that there are a total of sixteen switches in each IC. Each switch is a dual direction analog transmission gate, and is turned on and off under the control of the DATA, STROBE, and ADDRESS inputs to the chip. A particular switch is controlled by setting up its code on the four ADDRESS lines A-D and applying a strobe pulse to the chip. If during the strobe pulse the DATA input is high the selected switch will turn on, and if the DATA input is low the switch is cleared. Thus it is necessary to strobe a switch on and off, as each switch has its own latch within the chip, and will remain on until it is either strobed off or the power supply to the chip is interrupted (when all switches will clear). Any number of switches (up to sixteen) can be operated at one time by strobing one on, then changing the address and strobing the next on, but in this design only four are ever operated simultaneously.



Input Cross Point Circuit (see Figures 4 & 5)

The connection between the calling and called extensions is made by one of the four connecting circuits (CCB's) provided. This means that up to four calls (using eight extensions) can be in progress at any one time. When a call is made it is first necessary for the ELC of the calling extension to be connected to one of the four CCBs, and this is done by the input crosspoint switches, ICs 11 to 14. Each of these four ICs have their X connections joined to the ELCs of the associated extensions, and the Y inputs are commoned with the other three ICs, and then connected to the four CCBs. Thus, by making one switch in any IC, an extension can be connected to one of the four CCBs. The address inputs of the crosspoint ICs are all connected in parallel, and the DATA inputs are all fed from the common pulse supply DA. Each one of the four ICs has a separate strobe input, and this input is used as a chip select.

In order to detect when a call is being made every one of the 64 crosspoint switches are made in turn, by applying a 6-bit binary count to the address and strobe lines of the crosspoint switch ICs. The four least significant bits of the address connect directly to the four address inputs of the 45100s, and the two most significant bits are connected to a decoder that enables each of the four ICs in turn.

When the high impedance 15V calling signal from the ELC is detected by one of the connecting circuits a strobe inhibit condition is initiated. This condition occurs every time a switch in the same Y row as the one in use is addressed. In the normal scan condition the pulse (SA) fed to the strobe inputs of the CP ICs is longer than the DATA pulse, so each switch is only on for the period of the DATA pulse. When a call is detected the strobe pulse is inhibited before the DATA pulse has changed back to low, and thus the switch remains made until the inhibit condition is removed at the end of a call.

The high impedance 15V is also fed from the ELCs via the data enable common, which only allows data pulses to be fed to the input CP switches when a new call is being made, thus preventing the CP switches from scanning continuously and interfering with working circuits.

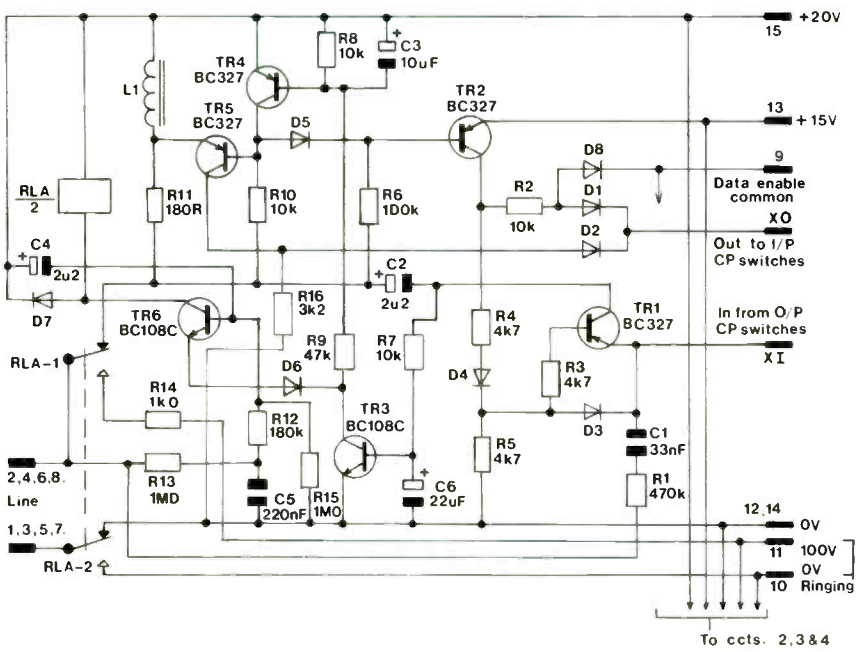
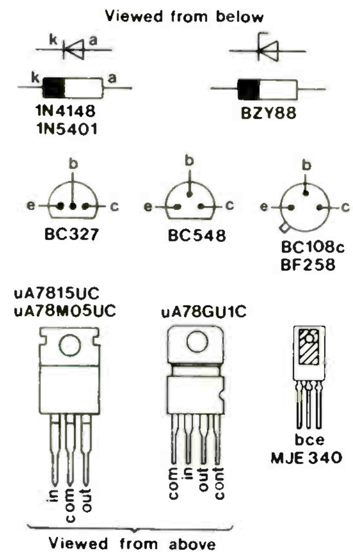


Figure 3. Circuit diagram of an ELC.



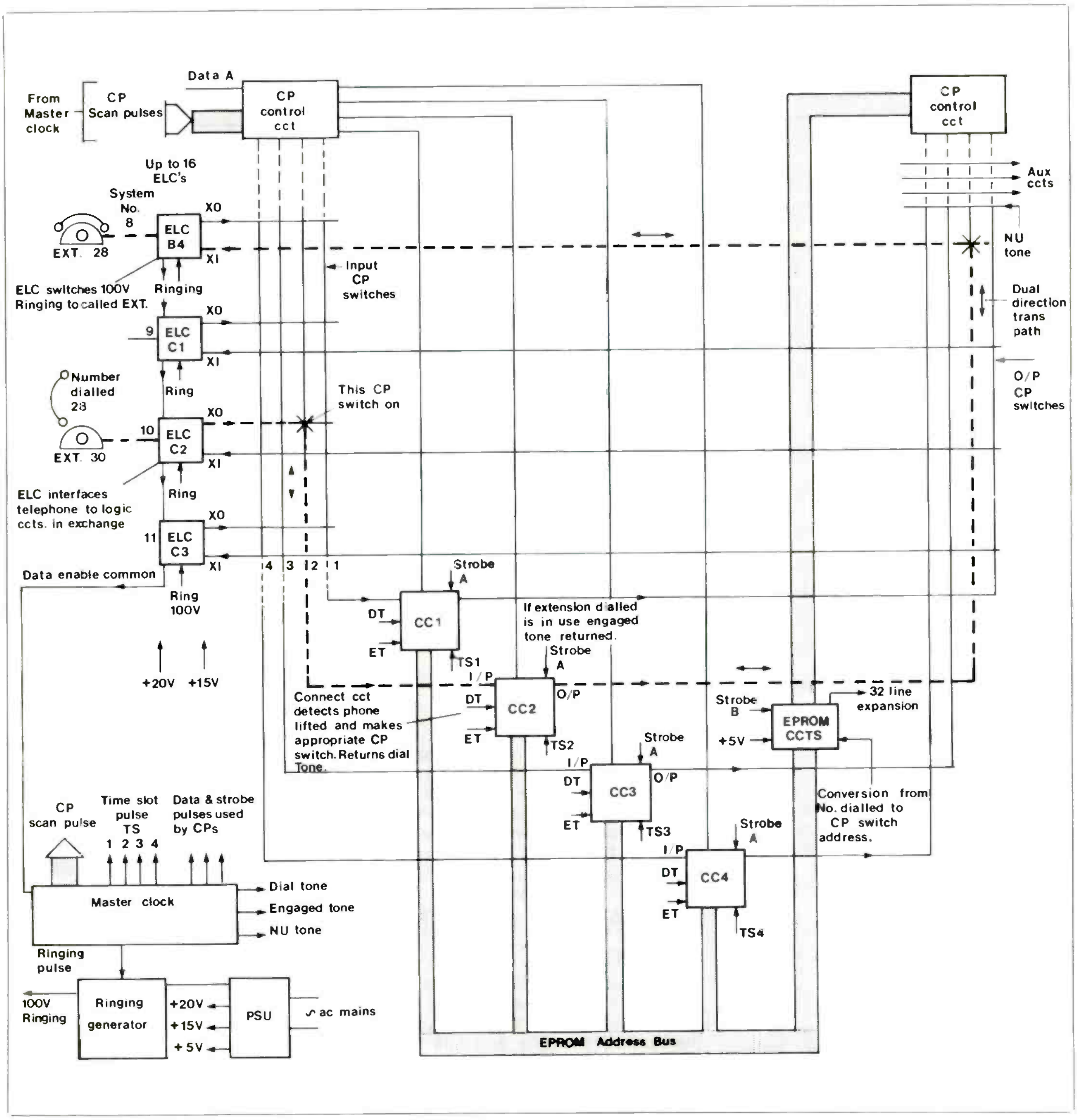


Figure 4a. Block diagram of the complete system.

Connect Circuit Board (CCB) Figure 6

The main function of this part of the system is to receive and store the number dialled by the calling extension, and to apply this data to the EPROM (IC1 Figure 5) at the appropriate time. The CCB controls the input crosspoint switches, and also tests the called line to see if it is already in use, sending engaged tone back to the calling extension when necessary.

The incoming line, from one of the Y connections of the input crosspoint switch, is monitored by TR1 and TR2. TR1 is arranged to turn on only when an ELC is calling and has not yet been found by a CCB. The calling condition, when detected, causes the latch formed by IC3d & e to change state, and this latch controls the bilateral switch (IC2a), which terminates the incoming line with D3, thus causing the calling voltage to be reduced and preventing a second CCB from connecting to the calling ELC.

Strobe inhibit pulses, corresponding to the Y connection of the CCB in use, are gated by IC1d and are fed back to the CP control on the main board, preventing the CCB from switching off, as previously described.

When the latch changes state it causes a reset pulse to be generated. This pulse is used to clear all registers and counters of any previous data. IC8 is a status counter, and in its first position it enables dial pulses to be applied to the first binary counter (IC4b). Dial tone is connected to the calling extension via IC2c. Dialling causes the input to the CCB to be pulsed to 0V at the rate of 10 pulses per second, the number of pulses depending on the number dialled. The latch has a slow reset time so it remains on during dial pulses. IC3f forms a dialling present detector and this is used to step the status counter to its next position after the first digit has been dialled. When the status counter is in position 2 the dial pulses are fed to the second binary counter (IC4a), and thus both digits dialled are stored by the two counters. After the second digit is dialled the status counter steps to its third position, which connects the call, and tests to see if the called line is already in use.

The call is connected to the required extension by a second set of CP

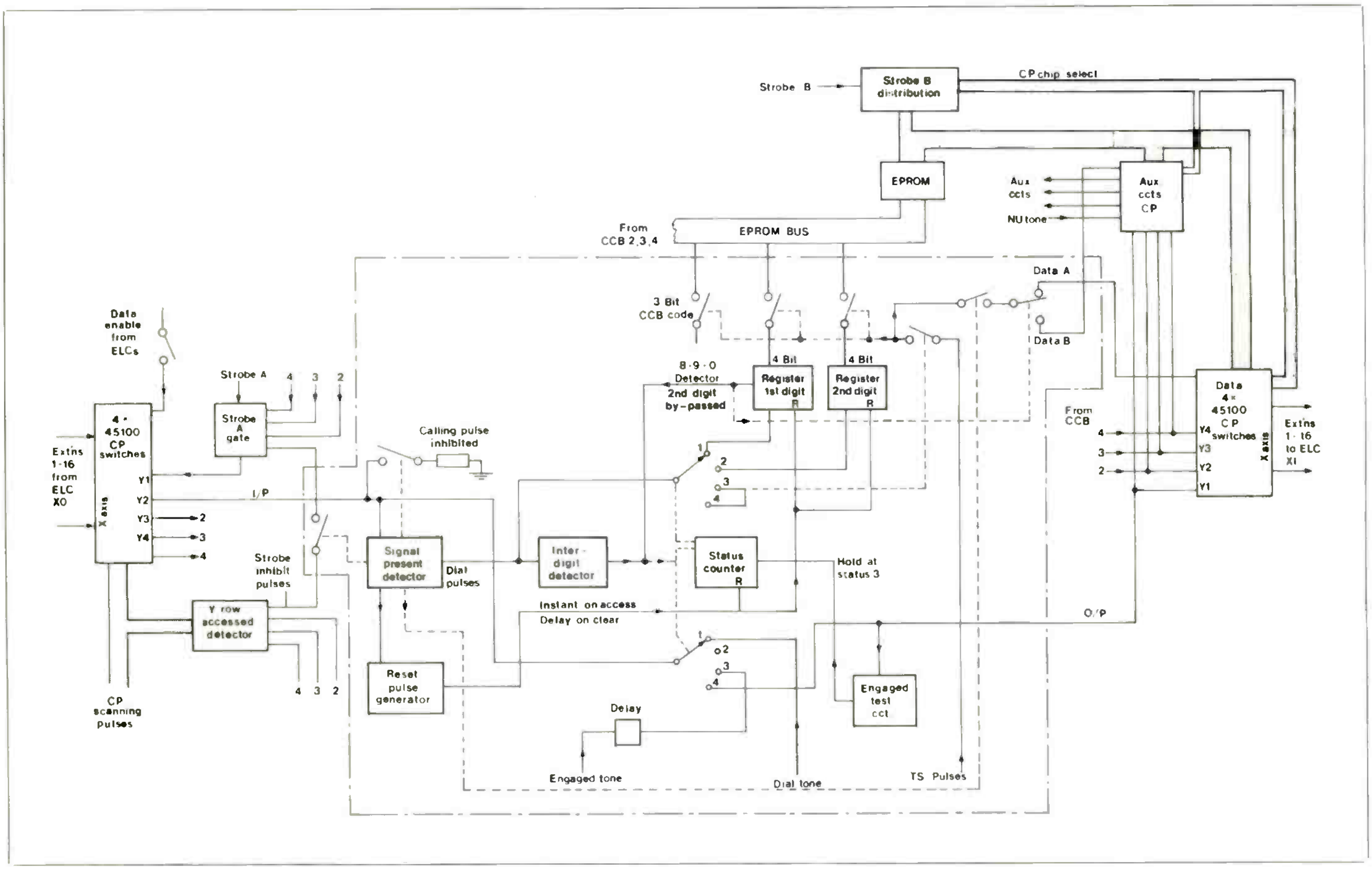


Figure 4b. Block diagram of a CCB.

switches (IC7 to 10), and these are controlled by data fed from the EPROM, which converts the data held in the binary counters of the CCB to the address needed to make the required CP switch. As there are up to eight CCBs in the system, each one is connected to the EPROM for only a short period (called a time slot) controlled by one of the eight TS pulses.

The status counter in position three enables the associated TS pulse to open the gates IC5 and IC6, and to apply the data in the counters, as well as a code indicating the CCB, to the EPROM address bus. The TS pulse is also used as a strobe inhibit and data pulse for the output CP switches. This is directly under the control of the incoming line condition to the CCB.

The required output CP switch is now made, and connected to the detector formed by TR4. When the circuit is already in use a potential will exist on the line, and this will cause TR4 to turn on, preventing the status counter from stepping to its final position and also connecting engaged tone back to the calling extension via IC2d. If no potential is detected by TR4 the status counter is allowed to step to its fourth position after a short delay, and this connects the line through from the input to the output of the CCB via IC2b.

Auxiliary Circuits

(Figure 5)

Auxiliary circuits may be connected to this exchange, and these are obtained by dialling a single digit, i.e. 8, 9 or 0. When any of these numbers are dialled, the fourth binary bit of the first digit counter goes high, and this causes the status counter to be stepped on twice, thus bypassing the second counter. An additional CP switch (IC6) is used to connect the auxiliary circuits, and in order to access this the data pulse to the output CP switches is inhibited, and a data pulse is fed to the auxiliary CP switch instead.

EPROM and Output Crosspoint Circuit

The output CP switches are connected in a similar manner to the input switches, with their X axis connected to the inputs of the ELCs, and their Y axis commoned between all chips, and connected to the four CCBs. When a call is made an address appears on the EPROM bus, at the same time a data pulse is fed to all the output CP switches via the data common. The EPROM translates the dialled code to the 8-bit address required to make the appropriate CP switch. Four bits are connected to the address inputs of the CP switches, two bits are fed to a decoder which forms a chip select, controlling a strobe pulse that is fed to any one IC at a time. The remaining two bits are used for system expansion.

The DATA pulse in this case is longer than the strobe pulse, so when both are present the CP switch addressed will be turned on and remain on during the period when other switches are being addressed.

When a call is terminated the DATA pulse stops immediately, but there is a delay before the STROBE and ADDRESS are cleared, this causes the selected switch to turn off.

Number Unobtainable Tone (NU)

The unused outlets from the output CP switches are strapped to the NU tone supply, so when one of these numbers is dialled NU tone is fed back to the calling extension. If the number dialled is one not used by the system the EPROM causes the call to be connected to the NU tone supply via the fourth part of the auxiliary circuit CP switch.

Master Clock

(Figure 5)

All pulses and tones used by the system are produced by the master clock circuit (Figure 5), controlled by an oscillator running at about 500Hz formed by IC15a and its surrounding circuitry. The mark/space ratio of the oscillator is set to give the correct pulse timing for the various strobe and data inputs of the CP switches. The DATA pulse for the input CP switches is fed from the oscillator through an inverter, and this signal is also used to clock the octal counter (IC16). The eight consecutive output pulses from IC16 are used as the TS pulses, and one is fed to each CCB. The output pulse from the oscillator is delayed by the monostable (IC15b), and this signal is used as STROBE A, and when inverted produces STROBE B output. The oscillator also feeds the two binary counters (ICs 17 and 18), whose first six outputs are used to scan the input CP switches, and the remaining outputs control the timing of the engaged and ringing

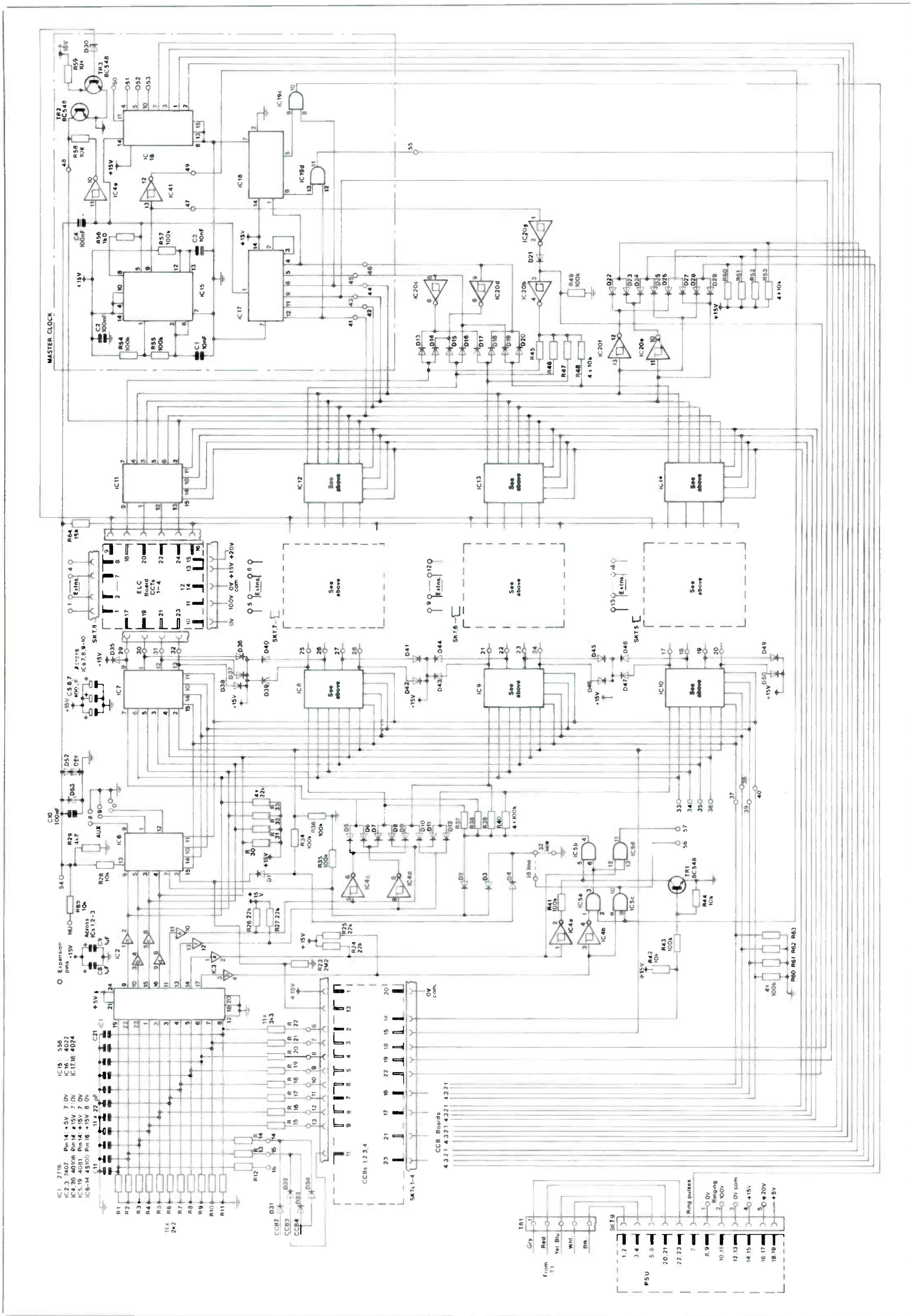


Figure 5. Motherboard circuit.

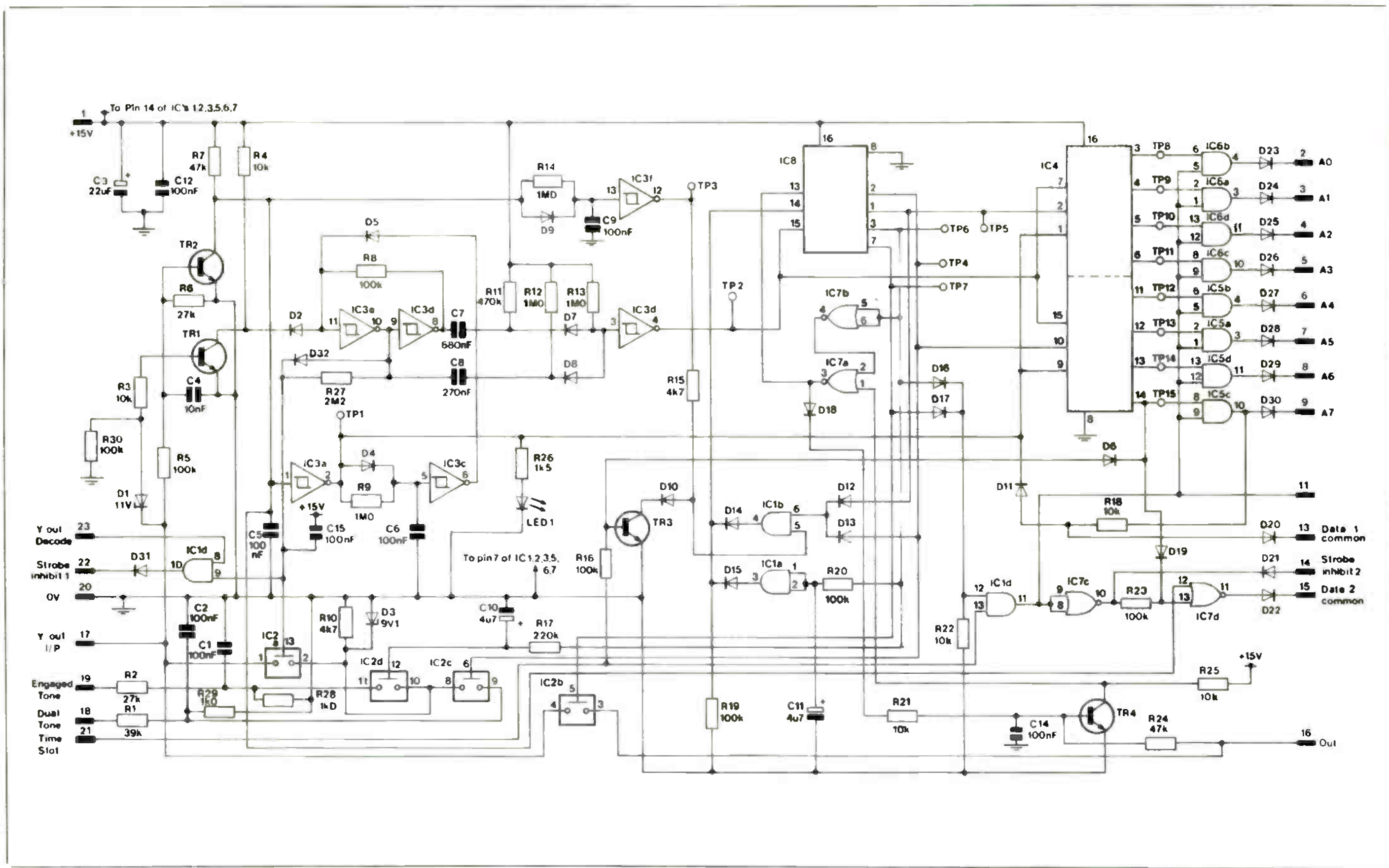


Figure 6. CCB circuit.

signals. The actual tones are produced by using various outputs from the binary counters, which are filtered on the individual CCBs.

The relationship between the STROBE, DATA, SCAN and TS pulses are shown in Figure 8.

Power Supplies

(Figure 9)

AC mains is fed to the transformer T1, which has two secondary windings. The low voltage winding is rectified by D1 and D2 and fed to the three regulators. IC1 is set to give an output of about 20V, which is fed to the ELC units to provide the line current for the extensions. IC2 is a fixed 15V regulator, and is used to supply all the logic and switching circuits. The EPROM requires TTL voltage, and this is provided by IC3, which is fed from the 15V line. The ADDRESS inputs to the EPROM are reduced to the required 5V by potential divider circuits, while the DATA outputs are converted back to 15V logic levels by the open collector non-inverting buffers IC2 and IC3 on Figure 5. An AC supply of about 100V at 16Hz is required to ring the telephone bell, and the signal needed to produce this is generated by the master clock. The ringing signal is interrupted approximately every 4 seconds, and during this break the ringing voltage must remain high, in order to hold the relays operated in the ELCs until the call has been answered. The required 100V square wave is produced by alter-nately turning TR1 and TR2 on, thus switching the ringing supply output between 0V and 100V. The ringing supply has its own 0V line, and this is fed to the ELCs independently of normal 0V path. This is to prevent ringing currents inducing interference in working circuits.

System Extension Number	Number Dialled	System Extension Number	Number Dialled
1	21	19	39
2	22	20	30
3	23	21	41
4	24	22	42
5	25	23	43
6	26	24	44
7	27	25	45
8	28	26	46
9	29	27	47
10	20	28	48
11	31	29	49
12	32	30	40
13	33	31	51
14	34	32	52
15	35	Aux 1	8
16	36	Aux 2	9
17	37	Aux 3	0
18	38		

Figure 7. Number conversion table.

Putting the System Together

The exchange is built on a mother-board, which contains the Master Clock and all the common circuits required for a complete system. The ELCs and CCBs are plug-in modules, to enable the system to be built up as required, in multiples of four extensions.

The ELC kit contains not only the components for the ELC boards, but also the CP switch required to cater for up to 4 lines. Each CCB will enable one call to take place at a time (between 2 extensions), and from one to four CCBs may be installed, depending on the amount of extensions required, and the number of calls to be made simultaneously.

Construct all boards referring to the appropriate parts list and PCB legend. IC holders need only be inserted for the CP switches (ICs 6 to 14) and the EPROM. The output CP ICs 6 to 10 are provided with the mother board kit, and should all be inserted when building the mother board, but the input CP switch ICs are provided with the ELC kit, and are inserted as necessary. Observe the usual CMOS precautions when handling these ICs (see relevant page of our catalogue), and always turn off the power when making any circuit changes or additions.

It should be noted that the voltage required to ring the telephone bells can give an unpleasant shock should it be touched, so it is always advisable to switch off the mains supply before working on the exchange, extension, or a line to an extension.

Testing

Insert the PSU into the motherboard and connect mains supply. The following readings should be obtained relative to 0V (TP5).

PSU test points	Voltages
1	+18.5V to +22V
2	+14V to +16V
3	+4.8V to +5.2V
4	120V to 160V, falling to approx. 80V every 2-4 seconds.

Switch off the mains, and insert one ELC board in position A, and one CCB in any position. Connect two telephones to 1 and 4 on the block marked extensions 1 to 4, and switch the mains on. Lift the handset on the telephone con-

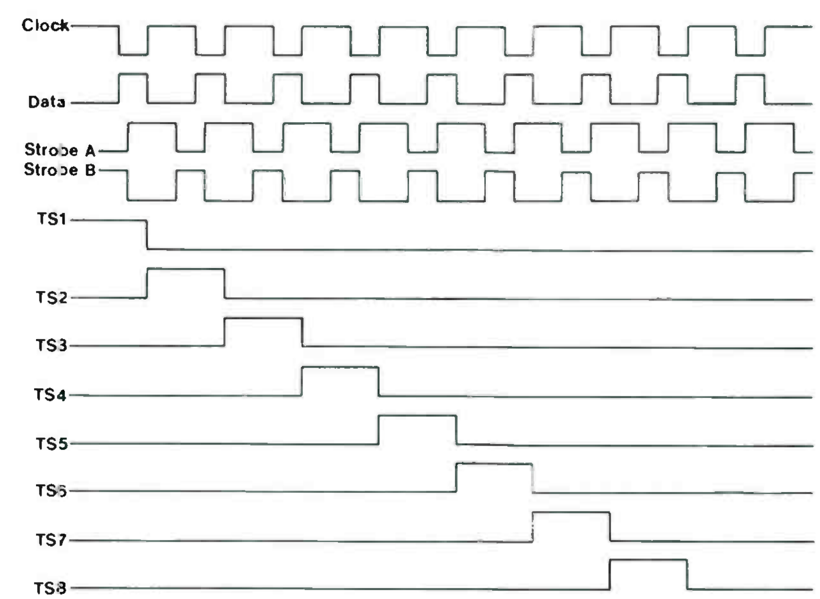
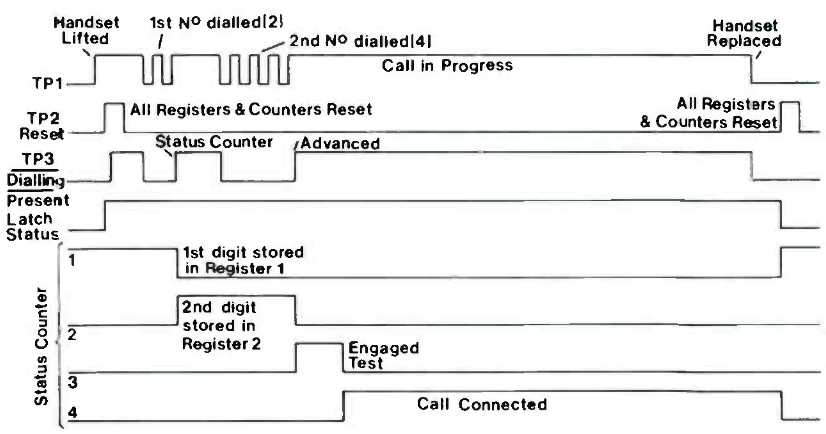


Figure 8. Pulse timing diagrams.



nected to 1 and dial tone should be heard as the CCB picks up the calling circuit. Lift the handset of the second telephone before replacing that of the first, this time NO dial tone should be heard. Replace the second telephone handset, and dial 24 on the first. The bell should now ring, and when the handset is lifted it should be possible to communicate in both directions between the two extensions. Now repeat this test, but this time with the handset of the second telephone raised. Engaged tone should now be heard. Repeat the above tests with another CCB and ELC until all the boards have been tested, remembering to switch the power off whilst changing boards.

All the boards can now be inserted, and the system should be fully working. In order to provide NU tone on spare extensions the appropriate SL pins should be linked to the NU pin (these are located between the ELC connectors on the mother board).

Numbering Scheme

The relationship between the extension system number, and the number dialled to obtain that extension are shown in Figure 7. The auxiliary circuits are selected by dialling 8, 9, or 0, and connections to these will be described in a later article.

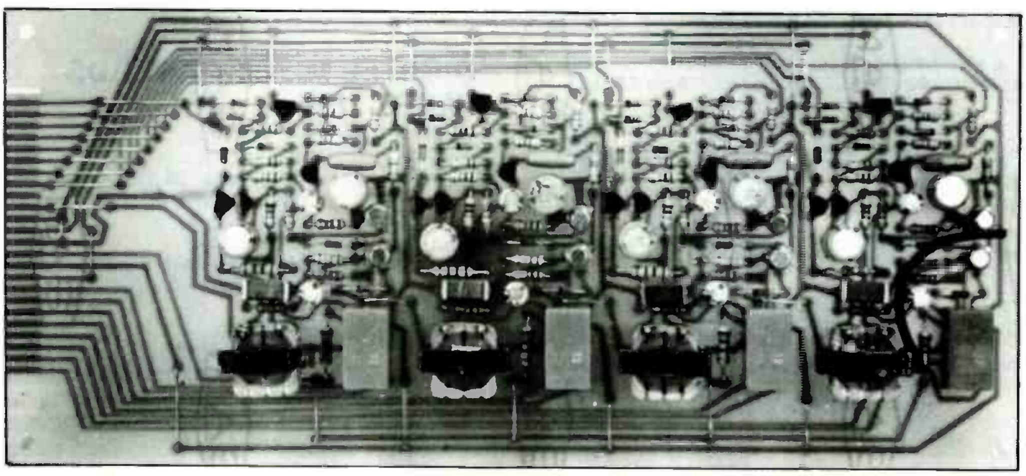
Expansion

System expansion, up to the full 32 lines, is accomplished by connecting a second mother board to the pins provided for this purpose on the left side of the main mother board. The expansion board has positions for a further four ELC and CCB boards, but has no master clock or EPROM, as the main board provides these.

The expansion board, interfacing to external lines, and a possible switchboard will be described in later articles.

Installing the System

The exchange should be placed in a convenient position near a mains supply, and at a point where wiring to the extensions will be as easy as possible. The connection to each extension may be made with any two-core cable, but Maplin supply British Telecom type four-core cable specially for



PARTS LIST FOR DIGI-TEL CONNECT CIRCUIT

Resistors — all 0.4W 1% metal film unless specified.

R1	39k		(M39K)
R2,6	27k	2 off	(M27K)
R3,4,18,21,22,25	10k	6 off	(M10K)
R5,8,16,19,20, 23,30	100k	7 off	(M100K)
R7,24	47k	2 off	(M47K)
R9,12,13,14	1M0	1 off	(M1M0)
R10,15	4k7	2 off	(M4K7)
R11	470k		(M470K)
R17	220k		(M220K)
R26	1k5		(M1K5)
R27	2M2		(B2M2)
R28,29	1k0	2 off	(M1K0)
Capacitors			
C1,2,12,14,15	100nF Polyester	5 off	(BX76H)
C3	22uF 63V PC elect		(FF07H)
C4	10nF polycarbonate		(WW29G)
C5,6,9	100nF polycarbonate	3 off	(WW41U)
C7	680nF polycarbonate		(WW51F)
C8	270nF polycarbonate		(WW46A)
C10,11	4u7 63V PC elect	2 off	(FF03D)
Semiconductors			
D1	BZY88C11		(QH15R)
D2,4-32	1N4148	30 off	(QL80B)
D3	BZY88C9V1		(QH13P)
TR1-4	BC548	4 off	(QB73Q)
IC1,5,6	4081BE	3 off	(QW48C)
IC2	4066BE		(QX23A)
IC3	40106BE		(QW64U)
IC4	4520BE		(QX33L)
IC7	4001BE		(QX01B)
IC8	4022BE		(QW19V)
LED 1	Red		(WL27E)
Miscellaneous	Veropin 2141	1 Pkt	(FL21X)
	PC Board		(GB05F)

A complete kit of all parts listed above is available.
Order As LW81C (Digi-Tel Connect Kit).

PARTS LIST FOR DIGI-TEL EXTENSION LINE CIRCUIT

Resistors — All 0.4W metal film unless specified.

R1	470k		(M470K)
R2,7,8,10	10k	4 off	(M10K)
R3,4,5	4k7	3 off	(M4K7)
R6	100K		(M100K)
R9	47K		(M47K)
R11	180R (½W)		(S180R)
R12	180k		(M180K)
R13,15	1M0	2 off	(M1M0)
R14	1k0 (½w)		(S1K0)
R16	3k2		(M3K2)
Capacitors			
C1	33nF polycarbonate		(WW35Q)
C2,4	2u2 63V PC elect	2 off	(FF02C)
C3	10uF 63V PC elect		(FF05F)
C5	220nF polycarbonate		(WW45Y)
C6	22uF 63V PC elect		(FF07H)
Semiconductors			
D1-8 incl.	1N4148	8 off	(QL80B)
TR1,2,4,5	BC327	4 off	(QB66W)
TR3,6	BC108C	2 off	(QB32K)
Miscellaneous			
L1	Choke 10H		(HW27E)
RLA	Relay DPDT		(YX95D)

* All above items to be multiplied by 4 for use on 1 PCB.

	PC board		(GB04E)
	Track Pin	1 Pkt	(FL82D)
	Veropin 2141	1 Pkt	(FL21X)

A complete kit for 4 circuits on 1 pcb is available.
Order As LW80B (Digi-Tel ELC Kit). **Price £24.95**

PARTS LIST FOR DIGI-TEL POWER SUPPLY

Resistors — All ½W 5% carbon unless specified.

R1	8k2		(S8K2)
R2	13k		(S13K)
R3	4k3		(S4K3)
R4,R7,10	1k0	3 off	(S1K0)
R5	2k7		(S2K7)
R6	4k7		(S4K7)
R8	3k3		(S3K3)
R9	10k		(S10K)
Capacitors			
C1	100uF, 250V axial electrolytic		(FB53H)
C2	2200uF 40V axial electrolytic		(FB91Y)
C3,4,5	100nF polyester	3 off	(BX76H)
Semiconductors			
BR1	S04		(QL10L)
D1,2	IN5401	2 off	(QL82D)
TR1,2	MJE340	2 off	(QH54J)
TR3	BF258		(QF17T)
TR4	BC548		(QB73Q)
IC1	uA 78GU1C		(WQ79L)
IC2	uA 7815UC		(QL33L)
IC3	uA 78M05UC		(QL28F)
Miscellaneous			
	PC board		(GB07H)
	Heatsink 4Y		(FL41U)
	Bolt 6BA ½"	2 off	(BF06G)
	Nut 6BA	2 off	(BF18U)
	Washer 6BA	2 off	(BF22Y)

PARTS LIST FOR DIGI-TEL MOTHERBOARD

Resistors — All 0.4W 1% metal film unless specified.

R1-11	2k2	11 off	(M2K2)
R12-22	3k3	11 off	(M3K3)
R23	2M2 ¼W 5% carbon		(B2M2)
R24-27, R30-33	22k	8 off	(M22K)
R34-36,41,43,49, 54,55,57,60-63	100k	13 off	(M100K)
R28,37-40,42, 44-48,50-53,58, 59,65	10k	18 off	(M10K)
R29	4k7		(M4K7)
R56	1k0		(M1K0)
R64	15k		(M15K)
Capacitors			
C1,3	10nF polycarbonate	2 off	(WW29G)
C2,4,10	100nF polyester	3 off	(BX76H)
C5-7	100uF 25V PC Elect.	3 off	(FF11M)
C8,9	1uF 35V tant	2 off	(WW60Q)
C11-21	22pF ceramic	11 off	(WX48C)
Semiconductors			
D1-29,31-53	IN4148	52 off	(QL80B)
D30	BZY88C12		(QH16S)
TR1-3	BC548	3 off	(QB73Q)
IC1	2716/M4		(QY25C)
IC2,3	7407	2 off	(QX76H)
IC4,20	40106	2 off	(QW64U)
IC5,19	4081	2 off	(QW48C)
IC6-14	45100	9 off	(QQ51F)
IC15	556		(QH67X)
IC16	4022		(QW19V)
IC17,18	4024		(QX13P)
Miscellaneous			
	PC board		(GB06G)
	8way PC terminal	5 off	(RK38R)
	Edge conn. 124	9 off	(FL85G)
	Edge conn. foot G	9 off	(FL91Y)
	Edge conn. foot H	9 off	(FL92A)
	Dil socket 16 pin	9 off	(BL19V)
	Dil socket 24 pin		(BL20W)
	Track pin	7 Pkts	(FL82D)
	Veropin 2141	1 Pkt	(FL21X)
	Bolt 6BAx½"	18 off	(BF06G)
	Nut 6BA	18 off	(BF18U)
	Washer 6BA	18 off	(BF22Y)

DIGI-TEL MISCELLANEOUS PARTS LIST

Toroidal transformer			
	24/100V		(YK33L)
	SA fuseholder 20		(RX96E)
	Fuse A/S 2A		(WR20W)
	P.B. telephone	Set of 4	(XG19V)
	P.B. telephone		(XG18U)
	Cable (4 wire phone cable)	As req	(XR66W)
	Terminal block 5A		(HF01B)
	Tag 2BA		(BF27E)
	Mains lead	As req	(XR04E)
	Wire 3202 white	2m	(XR37S)

See next page for details of Digi-Tel Main Kit.

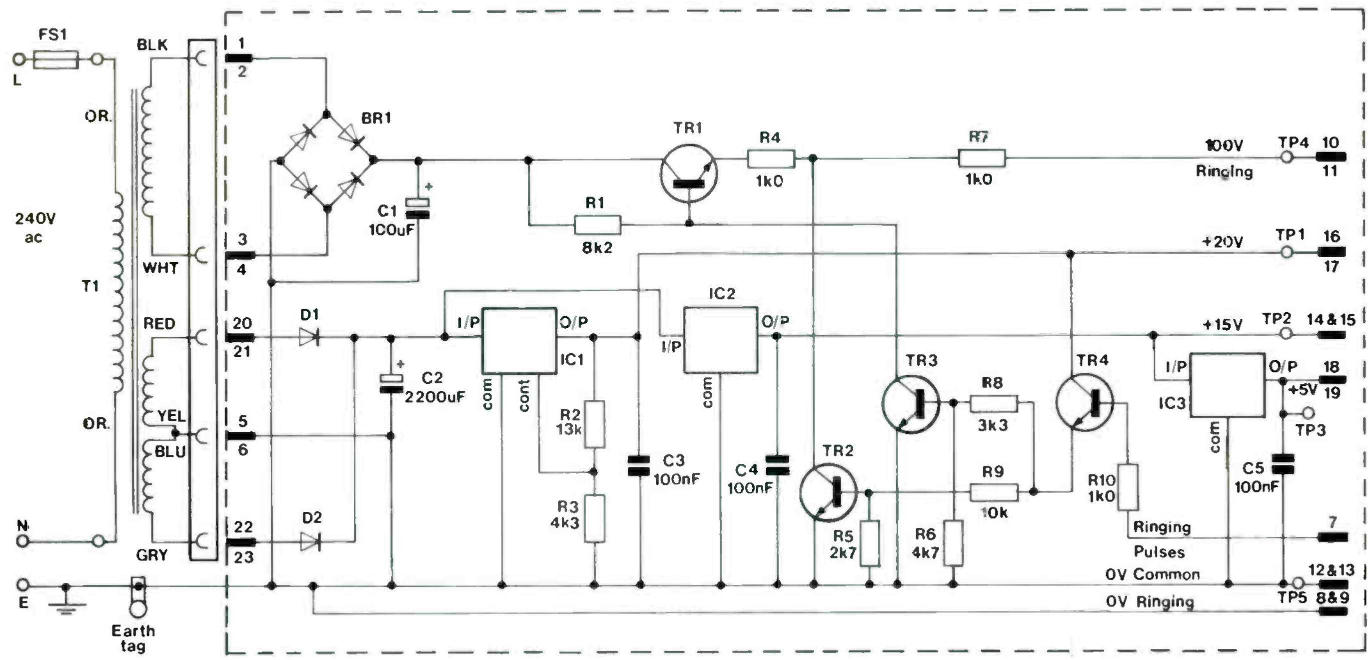


Figure 9. PSU circuit.

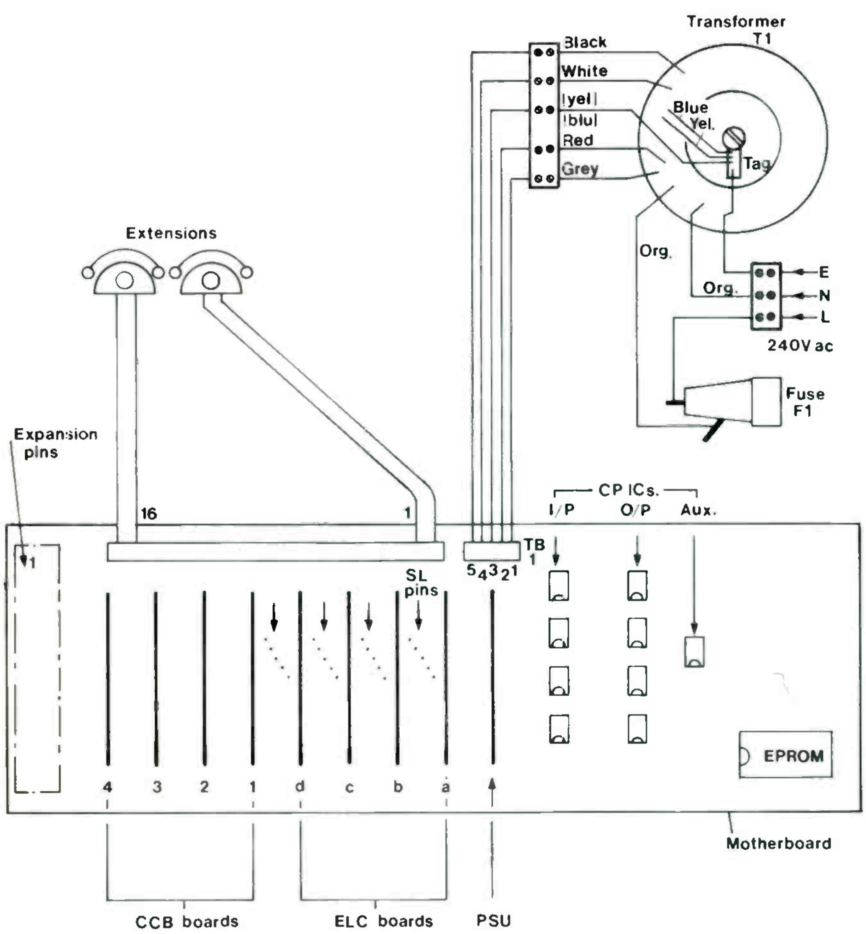


Figure 10. Wiring diagram.

this purpose (XR66W). This cable may, of course, be used to feed two extensions, one on each pair.

No case is shown for the exchange, but this may be simply constructed as a wooden box, with the mother board mounted either vertically or horizontally. If the mother board is mounted vertically the plug-in cards may need some support on their lower edges, and this can be accomplished by using a piece of wood with shallow slots cut in it for the cards to slide along. Adequate ventilation should be provided, particularly near the PSU card and transformer. Provision should be made in the case for system expansion, allowing room for a second mother board of the same dimensions as the first, and mounting adjoining the pins provided.

DIGI-TEL MAIN KIT

A complete kit is available of all the parts shown for the Power Supply, Mother Board and Miscellaneous except telephones.

Order As LW82D (Digi-Tel Main Kit).

REMOTE CONTROLLER FOR 25W STEREO MOS~FET AMPLIFIER

by Dave Goodman

★ **Remote control over Volume, Bass, Treble and Balance**
★ **Switched loudness (contour) compensation**
★ **Local or remote select**
★ **Flat response select**
★ **Can be incorporated into our MOSFET amplifier**

Over recent years infra-red control has greatly increased in popularity, as is evident by the plethora of televisions and video cassette recorders fitted with this facility. Some hi-fi systems do incorporate remote control, but not very many, which is regrettable because sound level and balance settings are dictated by listening position in relation to the loudspeakers.

This hi-fi controller project gives the user total control over adjustment of volume and speaker balance settings, also bass and treble cut and boost. All operations are performed by pressing an appropriate button on the hand-held control transmitter. The selected parameter can then be either stepped by single shot or automatically swept by holding the button down. Two further controls allow for return from remote to local (or vice versa), and an instant flat setting of speaker balance and tone response.

A Pulse Position Modulation (PPM) dedicated integrated circuit is used in this design, based on the SL490 IC (see figure 2).

IC 1 is an encoder-oscillator and pulse train generator, producing a series of five pulses of fixed amplitude. Each pulse can vary in width, either 6ms or 9ms, according to whether a digital '1' or '0' is required (see figure 1).

Each one of the six 'spaces' between every pulse is of a consistent 1.25ms duration, and the pulse train repeats for as long as an encoding key is held operating.

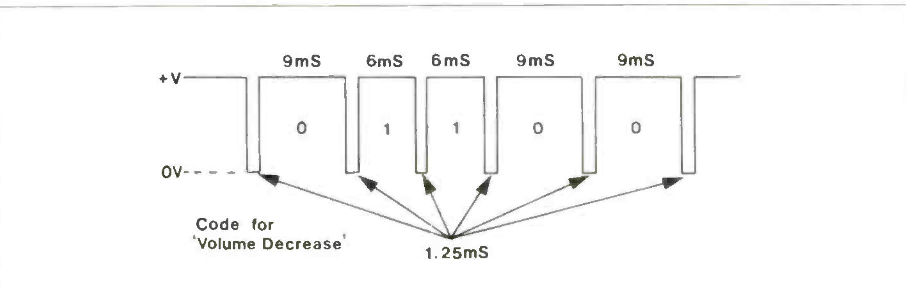


Figure 1. P.P.M. Pulse Train.

Switches S1 to S10 are PCB 'pads', and a ten-way bubble contact strip is used to join the appropriate pads together within the encoding matrix, pins 1, 4, 5, 8, and 10 to 13. Each bubble on the strip has an internal carbon contact of low electrical resistance, and applying pressure to the bubble flexes the contact down across the two pads. Table 1 lists each key, command, symbol, and pulse code used here and present on pin 2 of IC1.

TABLE 1

Key	Command	Symbol	Pulse Code
S1	Volume Down	∨	01100
S2	Volume Up	∧	00010
S3	Balance Left	>	11100
S4	Balance Right	<	10100
S5	Bass Cut	—	11110
S6	Bass Boost	+	10110
S7	Treble Cut	-	11111
S8	Treble Boost	+	10111
S9	Local-Remote	LOC/REM	11000
S10	Flat Response	Flat	11011

C2 and R3 produce a differentiated signal of narrow width, and this is applied to the base of TR2. D1 prevents TR2 from becoming reverse biased. TR1 is a MOSFET device capable of switching large current pulses for only a small loading on the drive stages. Pulses from TR2 turn TR1 on and off, effectively forward biasing D2, 3, and 4. These three diodes are infra-red devices, and transmit light in the infra-red band (940nM). When TR1 is turned on these diodes appear connected between the supply rails, C1 discharges, and the current drawn from the battery would be high damaging the diodes and battery. To prevent this happening TR1 is turned on then off very fast, so that the 'on' time is far smaller than the 'off' time, producing a duty cycle of only a few per cent. The mean current drawn from the battery is therefore low, being approximately 15mA, and well within the 100mA rating of the TIL38 diodes.

C3 and RV1 set the transmission rate/internal clock of IC1 at approxi-

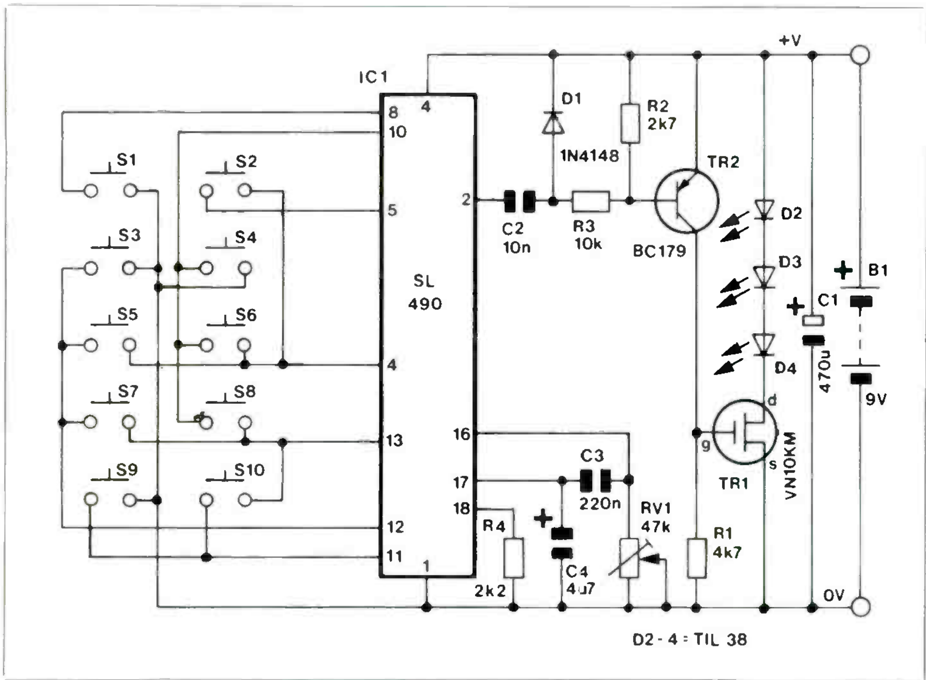


Figure 2. Circuit diagram of Transmitter.

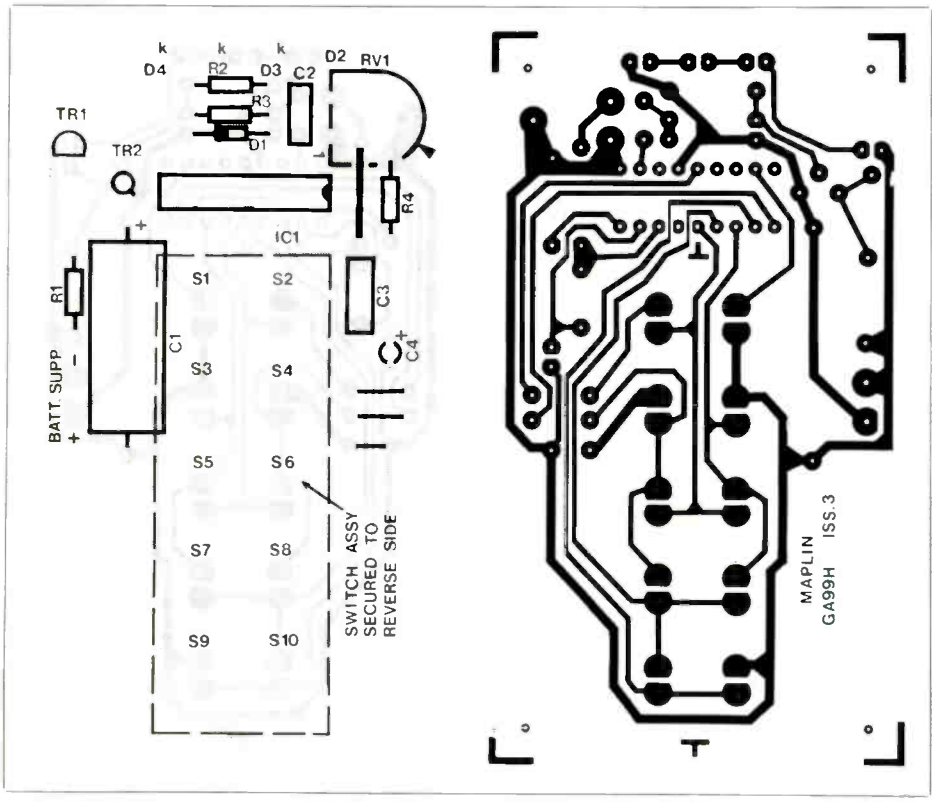
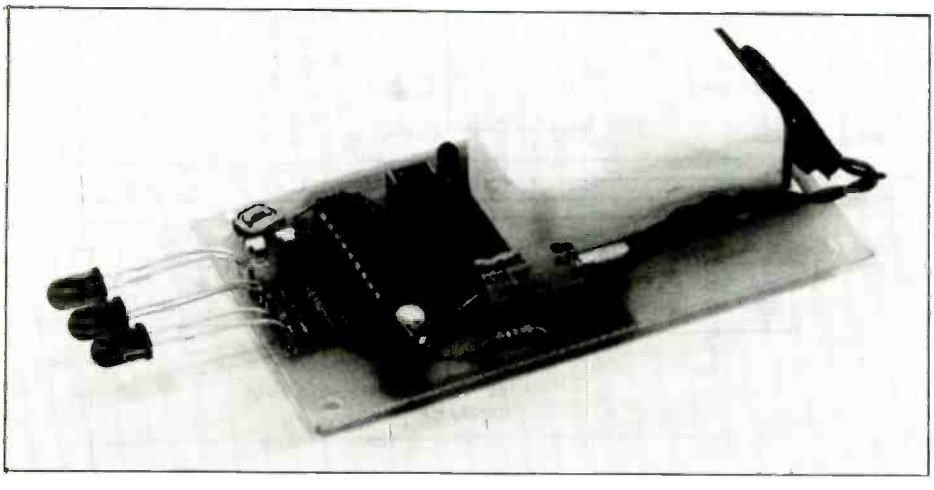


Figure 3. Component Overlay for Transmitter PCB.



mately 150Hz. Scope measurements can be made on pin 2 of IC1 with the 'treble cut' key S7 operated.

Transmitter Assembly And Construction

Cut four pieces of wire for links, bend to shape and insert. Fit diode D1, followed by R1 to R4 and RV1. Mount all four capacitors. Note that C1 and C4 are polarised, and must be fitted one way only. C1 is marked with a negative sign on the case, whilst C4 is marked with a positive. Insert TR2, and ensure the 'pip' on the metal case aligns with the symbol on the legend (figure 3). Next mount TR1, also noting correct positioning. Fit the DIL socket for IC1, and proceed with soldering and trimming all component leads. Do NOT fit infra-red diodes D2-4 at this stage. Clean the track with a suitable spirit and check for bad joints and short circuits.

The ten-way contact strip can now be fitted over the 'pads' on the track face of the PCB. Above and below these pads are two small 'T' symbols, which should be lined up with the two grooves situated along the centre line of this strip, one at each edge. These symbols do not connect electrically, and have been added solely as a guide for assembly. Use a contact type adhesive paringly around the edges of the strip, taking care not to spill over onto the carbon contacts. Remember that the glue will spread out once the strip is placed in position and pressed home, which might cover the PCB pads, so don't be too generous!

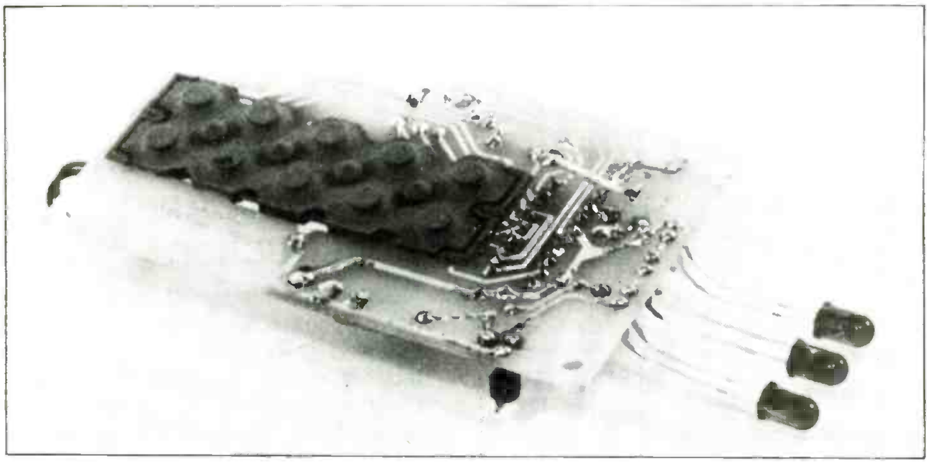
If you are satisfied with your efforts so far fit IC1 (SL490), and refer to the component lead configuration drawing for D2-4 description. All these LEDS may be fitted directly to the PCB, or connected with wires. Keep any wiring as short as possible. Finally, fit the battery clip. Check over all components and soldering once more before use.

Transmitter Use

Set RV1 wiper just past halfway, to line up with the arrow printed on the legend. Connect a 9v battery to the clip, but only on one stud contact. Place an ammeter between the other battery contact and clip, so that it is in series with the positive rail. Press each bubble contact in turn. The ammeter reading should be 15-20mA each time, and only a few uA otherwise.

If there is no reading at all, or a much higher reading, check TR1, 2 orientation, D1 and C1 polarity, and D2-4 orientation. Of course, the contact strip may also be misaligned, and should be rechecked.

Now place a voltmeter from the negative rail (C1 neg. lead) to D4 cathode. A reading of 6.9v should be



apparent. Press any one of S1 to S10 contacts, and the reading should drop 200mv to 6.7v. These readings can vary slightly, but serve to give an indication that all is well.

No particular box is recommended for this project, but a flip-lid box type 601 (LQ03D) was used for the prototype. The LEDS mount through the front, and a suitable cut-out for the switches was made in the lid. The PCB can then be screwed or taped inside the lid, with the battery suitably accommodated underneath. A screened switch panel (RK36P) is available to fit over the contacts S1-10.

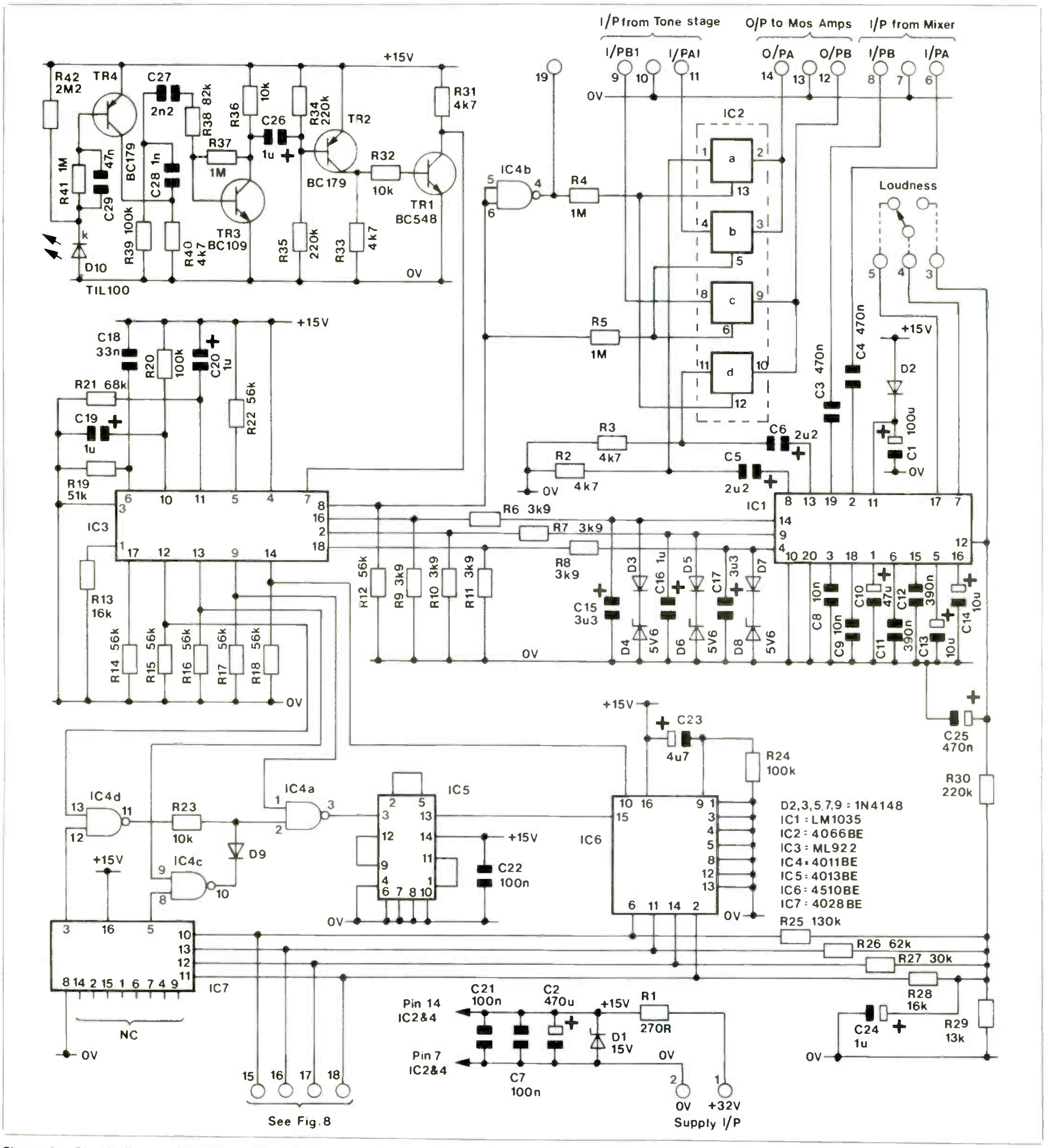
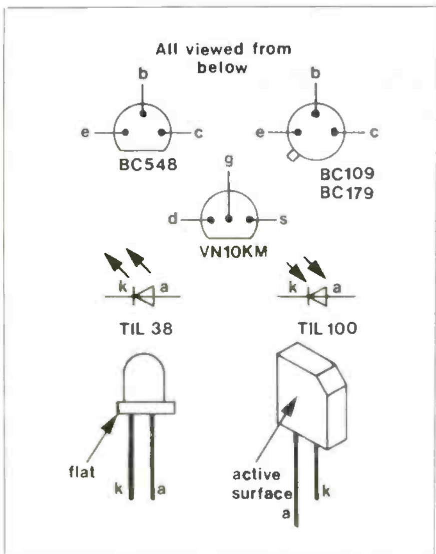


Figure 4. Circuit diagram of Infra-red Decoder.

Decoder Circuit Description

P.P.M. data transmitted by the hand controller are received by D10 (figure 4), which is an infra-fred photodiode designed to react with signals of 940nM wavelength.

It is used in reverse bias mode and R42, 41, and C29 help prevent signals generated by incandescent or fluorescent light from becoming amplified. Quite considerable gain is required, to bring the incoming signals to a level suitable for correct operation, and circuit stability can become a problem.



Therefore two gain stages, comprising TR2 and TR3, have been incorporated. TR1 inverts the recovered pulse train so that it is in the correct sense and amplitude for use by IC3. PPM principles have been explained in the text previously, and reference can be made as necessary. IC3 (ML922), is a PPM decoder with one pulse, four digital, and three analogue outputs. An internal oscillator, with a clock frequency determined by C18 and R19, enables decoding of incoming pulse trains. R20 and C19 reset the decode circuits at switch-on, and C20 and R21 set the rate at which digital output codes step on. P16 controls bass, P18 controls treble, and P2 controls speaker balance. Only these three outputs step up and down about a 2.7v centre or 'flat' point, and are analogue channels. D3-8, C15-17, and R6-8 compress positive going voltage changes, thus producing a linear control of these functions within IC1. Pin 8 has a normally high output (+15v), holding the bilateral switches IC2b and c closed. IC4b, an inverter, holds IC2a and d open. Input signals from the MOSFET amplifier tone processing stages on pins 9 and 11 are thus connected via IC2 to pins 12 and 14 and, hence, to the power amp. stages (figure 6). Pre-processed signals are connected to input pins 6-8, and direct to IC1, which is a voltage controlled stereo, volume, and tone control IC. IC3, on receipt of a VOLUME UP or DOWN incoming pulse code, places a

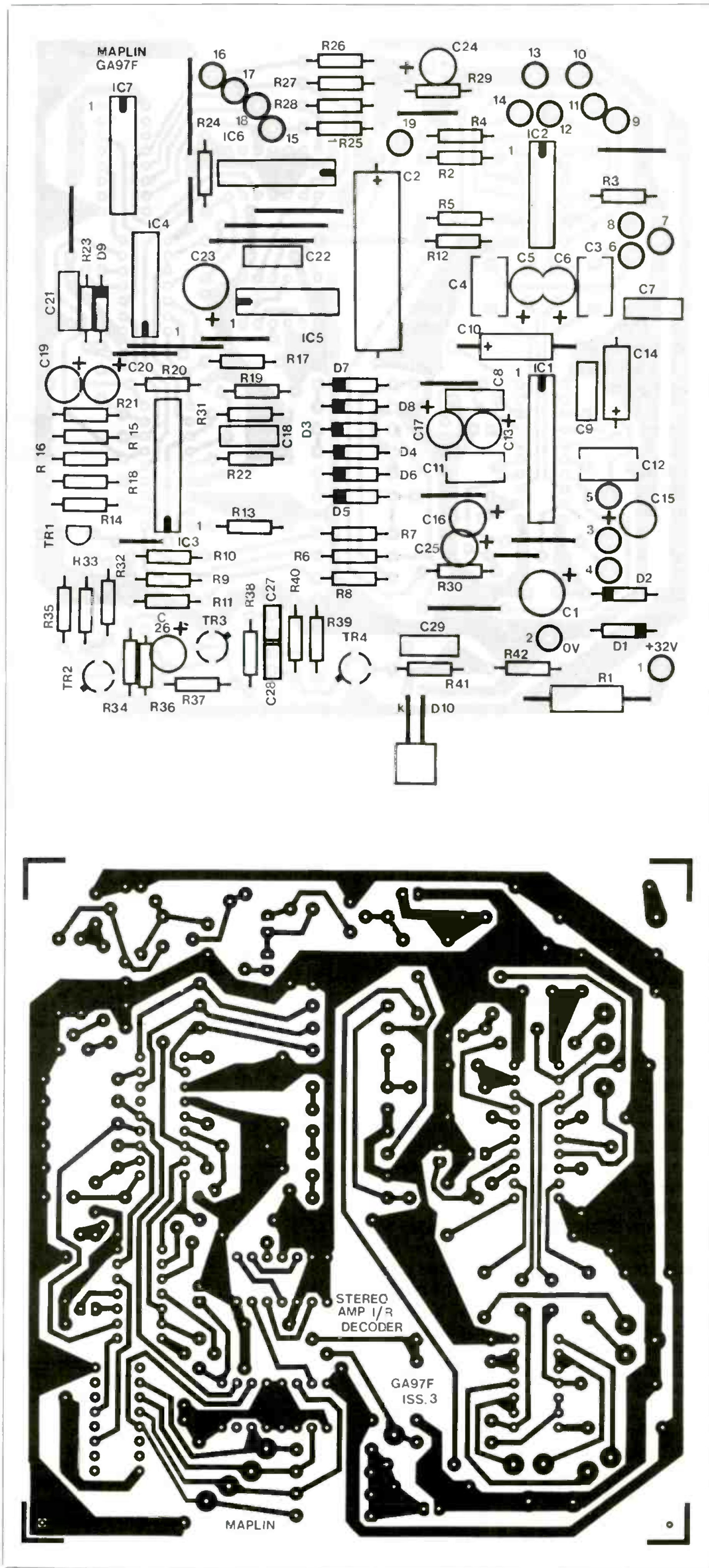


Figure 5. Component Overlay for Infra-red Decoder PCB.

low (0v) on pin 8. IC4b switches IC2a, d closed and IC2b, c open. Processed audio signals from IC1 are then transferred via C5,6, and IC2 to pins 12 and 14 and to the power amp stages.

Control of loudness (or contour) at low volume levels is achieved by connecting a change-over switch between pins 3, 4, and 5 as shown in figure 4. The action is local, and remote control of this facility has not been included. If loudness control is not required, then strap pins 4 and 5 together. C8 and 9 allow 15dB boost or cut at treble frequencies of 16kHz, whilst C12 and C13 allow 15dB boost or cut at bass frequencies of 40Hz.

ICs 4 to 7 are used to decode volume level commands. At power on, IC3 pins 12 to 14 are high (logic 1). Pin 14 determines volume 'direction', and is high for an increase or low for a decrease. Pin 9 is normally high with a negative going pulse output. Pin 13 is normally high and remains so for an up count switching low for a down count; whilst pin 12 is high for a down count and low for an up count. Table 2 should explain this more clearly.

IC3	PIN 12	PIN 13	PIN 14	PIN 9
Switch on	1	1	1	1
Volume increase	0	1	1	‾|_|‾
Volume decrease	1	0	0	‾|_|‾

TABLE 2

IC6, a BCD up-down counter, generates a four bit binary output which is converted to an analogue voltage by R25 to 29, and fed via R30 to volume control input pin 12 of IC1. The stepped voltage ranges from 0v to +5.4v.

When a voltage step command is received IC3 pin 9 output pulses continuously at 15Hz, via IC4a, to IC5. The signal is then divided by four and steps IC6 through the up/down sequence. IC7, BCD to decimal decoder, examines all output codes from IC6, and gates IC4a output when one of two codes corresponding to either minimum or maximum volume are present. Otherwise, the volume sequence would keep running through max. to min. without control.

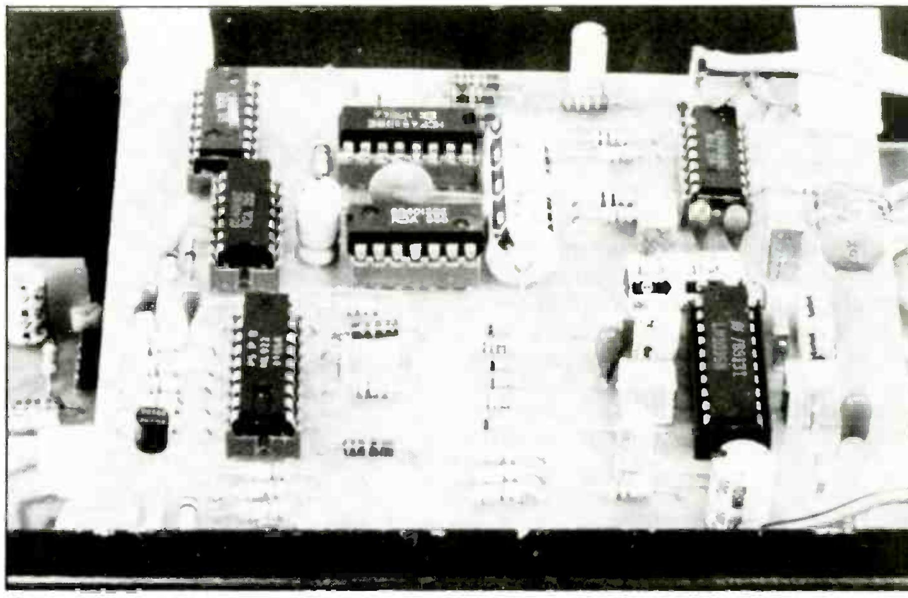
Figure 8 shows a BCD decoder to LED driver circuit, and has been included purely as an addition, not as part of the system. Connection can be made to pins 15-18 and +15v, 0v. Volume level settings are then displayed as numbers 0 to 9.

Finally, receipt of a 'flat' pulse code sets IC3 pins 2,16, and 18 to 2.7v internally. IC1 will interpret this as a flat response of bass and treble and even speaker balance.

Construction

Refer to parts list and figure 5.

Start by making and inserting all sixteen links, diodes D1 to 9 (noting that D1,4,6, and 8 are zeners), and resistors



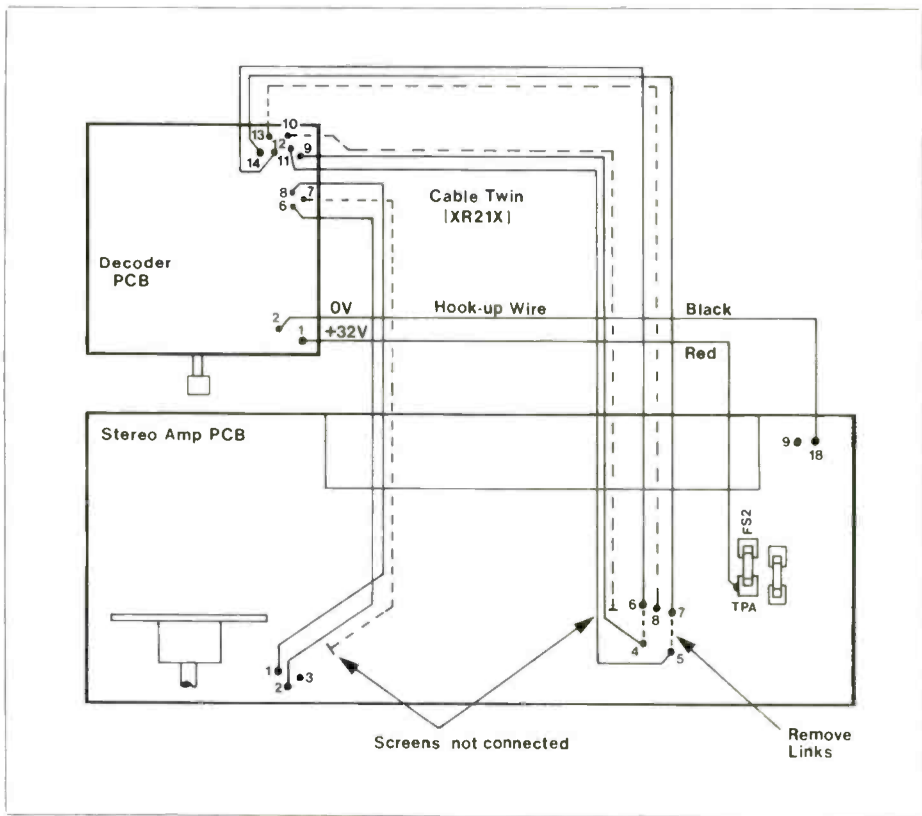


Figure 6. Connecting to 25W Mosfet Amplifier.

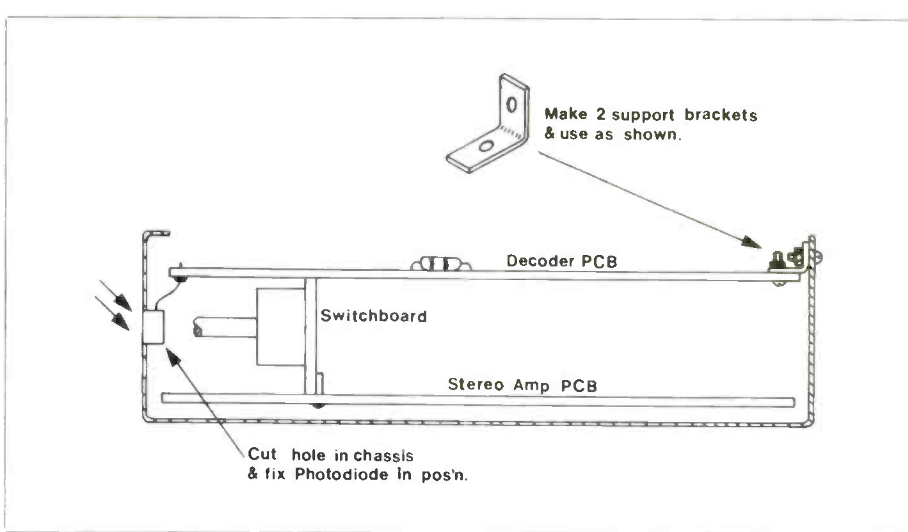


Figure 7. Mounting Decoder in 25W Mosfet Amplifier.

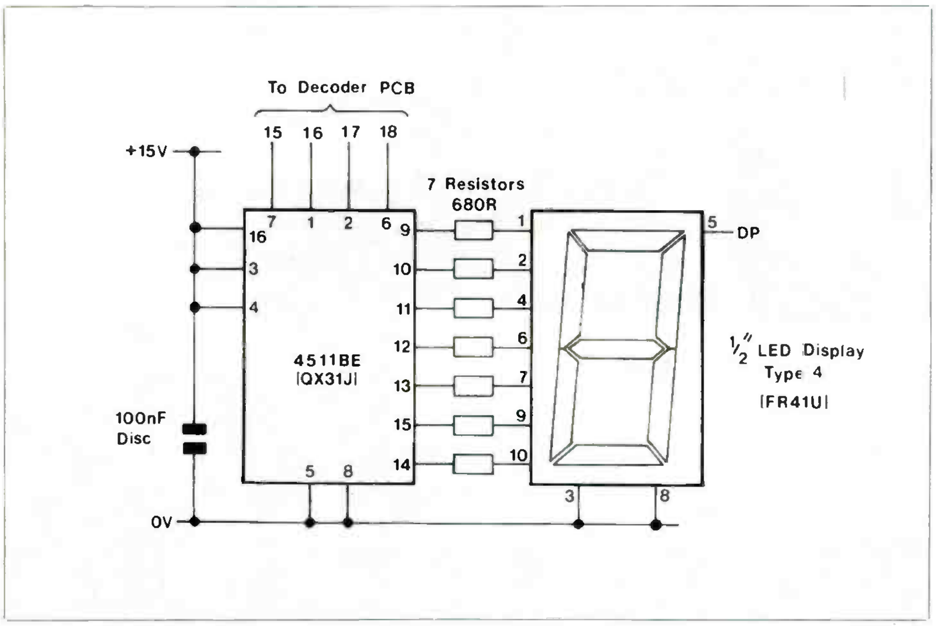


Figure 8. LED Volume Indicator.

R1 to 42. Some resistors are 1% tolerance, and should not be replaced by 5% min. types. R1 may get hot in use, and it would be advisable to mount this component a few mms above the PCB.

Axial, polycarbonate electrolytic, and tantalum capacitors can be fitted next. Note that these components are polarised, and that tantalums have a positive sign, whilst all others have a negative sign. Fit all remaining capacitors, taking care not to bend the polycarbonate leads, as they are easily broken. Insert remaining transistors and IC holders.

Solder all parts carefully, and clean track surface to remove flux and possible short circuits. Faults are easier to find this way. Insert Vero-pins, if used, and fit all integrated circuits. A final check over is always well-advised before applying power.

Assembly And Testing

Photodiode, D10, has one active and one insensitive side. Refer to the pin configuration drawing for correct use of this component, before fitting. On the prototype, D10 was fitted to the track side of the PCB, and inserted with the active area to the front.

When applying power, note that D1 and R1 are fitted for use with the +32v power supply from the MOSFET amp P.S.U. If available, a +15v power supply would be better for test purposes, and R1 will need to be bridged with a wire or clip, to avoide a large voltage drop across it.

Current consumption of the decoder should be approximately 55-60 mA, and a check with an ammeter in series with the positive supply will indicate this.

Use a voltmeter and check the following:

IC3	
pins 2,16,18	+2.7v
pins 8,9,12,13,14	+15v
pin 1	+7v
pin 7	0v
IC1	
pin 11	+14.3v
pin 7	+5.9v
TR2 collector	+15v
TR3 collector	+2.75v
TR4 collector	+1.5v

all with respect to 0v

These voltage readings may vary by up to 4%, depending on the +15v rail regulation, so allow accordingly.

Connect the voltmeter to IC3 pin 7 (R31 is the most convenient place to clip on to), and the infra-red transmitter can now be used. Hold the transmitter two to three feet in front of the photo-diode (no closer!), and press S2, volume increase. A reading of between three and five volts can be expected, varying with alterations in range. Transfer the voltmeter to the common junction of R25 and 30, above pin 19. Switch the decoder off, then on again to reset. Repeat the transmitter operation, and check the meter reading steps as follows:

0.5v, 1.2v, 1.8v, 2.5v, 3.1v, 3.7v, 4.3v, 4.7v, and 5.2v. Connect the meter to IC3 pin 8. A reading of 0v will be indicated. Press S10 on the transmitter, and +15v should appear. Press S1 or S2 and the reading will change to 0v.

Connect the meter to IC3 pin 2. Switch off the decoder and re-apply power to reset. The reading will be 2.7v. Press S4 and the reading should swing up to +5.4v. Press S3 and reading will swing down to 0v. Repeat on IC3 pin 16, using S5 and S6, and IC3 pin 18, using S7/S8 on the transmitter.

The decoder PCB is now ready for use. If using in conjunction with our 25w MOSFET Amp project, refer to figure 6 for wiring details. A connection is made to TPA (+32v) using hook-up wire, for the positive supply. Do not forget to remove the short across R1 before connecting to TPA, otherwise the ICs will incur damage. All audio connections are made using screened wire, and should be kept as short as possible. Figure 7 shows the decoder mounted into the amplifier chassis above the switchboard. Brackets or sticky pads can be used for securing in position, and D10 can be mounted on the front panel as shown. Obviously, you do not have to do this, and an external box, with PSU, could be used instead; connections being made with DIN or PHONO plug leads and sockets.

Alternatively, the decoder may be used with any other audio system that has access sockets, either for tape in/out or pre-amp to power amp in/out. In this case wire pin 8 to pin 9, and pin 6 to pin 11. Signal inputs will then be on pin 6/8, and outputs on pins 12/14.

Switching between remote control and local control can then be effected, although in some circumstances a 'pop' may be heard in the speakers whilst doing so. *continued on page 23*

STEREO AMP I/R CONTROLLER PARTS LIST

Resistors — all 0.4W 1% metal film unless specified.

R1	4k7	(M4K7)
R2	2k7	(M2K7)
R3	10k	(M10K)
R4	2k2	(M2K2)
RV1	47k hor-sub min preset	(WR60Q)

Capacitors

C1	470uF 10V axial electrolytic	(FB71N)
C2	10nF disc ceramic	(BX00A)
C3	220nF polycarbonate	(WW45Y)
C4	4u7F 16V tantalum	(WW64U)

Semiconductors

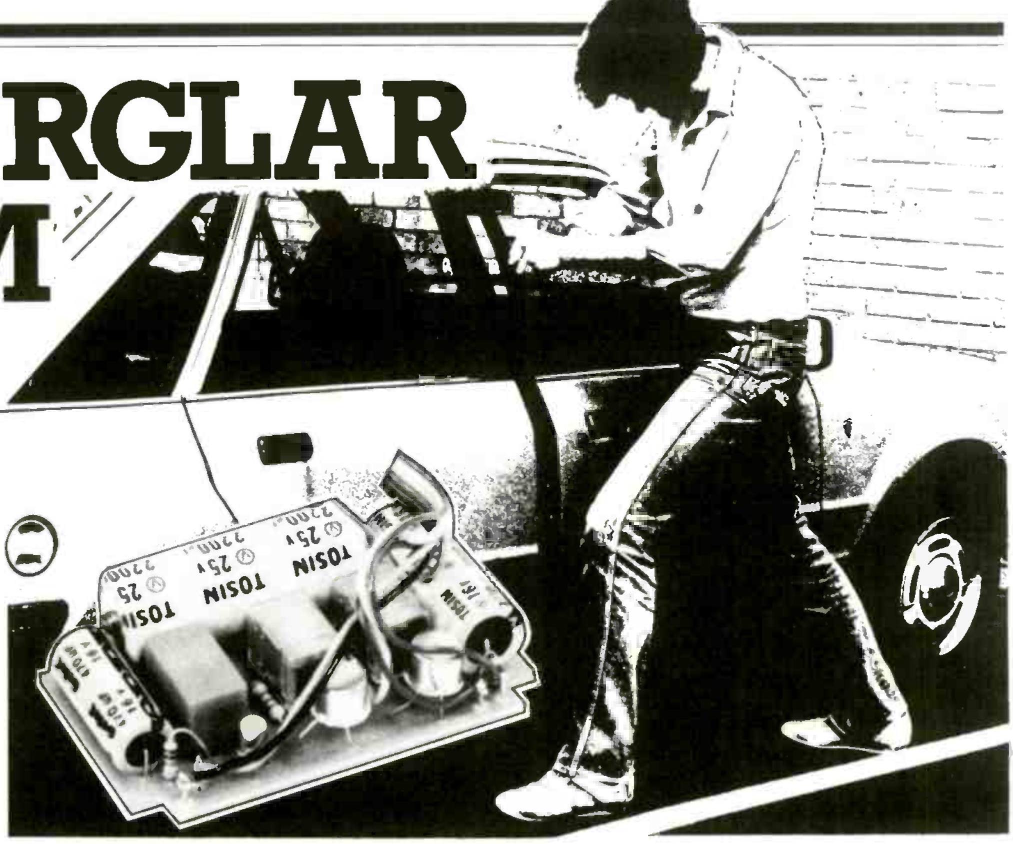
D1	1N4148		(QL80B)
D2,3,4	TIL 38	3 off	(YH70M)
TR1	VN10KM		(QQ27E)
TR2	BC179		(QB54J)
IC1	SL490		(YH66W)

Miscellaneous

S1-10inc.	Switch contacts (10 way)	(YR71N)
B1	NICAD PP3	(HW31J)
	Battery clip	(HF28F)
	Veropin 2141	(FL21X)
	Flip-top Box 601	(LQ03D)
	P.C.B.	(GA99H)
	Switch panel	(RK36P)

For kit details see Decoder Parts List

CAR BURGLAR ALARM



by Keith Baker

There are many car alarms available on the market, but none can offer complete protection against theft. Though no alarm will foil the professional thief, it will act as a deterrent to the small time thief or joyrider. This circuit, like most alarms, is triggered off by the door contacts for the courtesy light and will only work when fitted to a 12V negative earth car. The switch to the alarm is fitted on the inside of the car as opposed to the outside, thus ensuring that the switch is not tampered with.

The idea is, that when leaving the car the alarm switch is turned to the on position and the 'arm' button is pressed. It is now safe to open the doors and get out of the car. After pressing the 'arm' button a timer circuit allows approximately 60 seconds to leave the car and shut the doors. After the 60 seconds, providing the doors are shut, the circuit will arm itself. If a door is then opened, the horn will sound after 15 seconds. This 15 second delay is sufficient time for the occupant to turn off the alarm, but not enough time for the thief to tamper with the switch. The horn will sound for a further 1½ minutes and the alarm will then arm itself again. If the door is left open the alarm will sound continuously.

The Circuit

Figure 1 shows the circuit diagram of the alarm and this is based on three timer circuits.

When the car door is opened the negative side of C2 is biased negative, C2 is charged and TR2 is biased hard on. TR2 now conducts down to -V and RLB changes over.

With RLB in its normal condition, it is keeping C3 fully charged and TR3 biased hard on. When RLB changes over, as described above, C3 starts discharging as R4 goes positive. In this state RLC is being shorted out, but as C3 discharges, the voltage drop across the collector and emitter of TR3 becomes larger until RLC 'pulls in' (approximately 15 seconds from RLB changeover). This causes +12V to be transmitted to the horn and allows C2 to start discharging.

When the base emitter voltage of TR2 starts to decrease, the voltage drop across RLB also decreases, until RLB 'drops out' cutting off the supply to RLC, which in turn cuts off the horn.

When leaving the car, to prevent the alarm circuit energising, C2 has to be kept discharged. This is done by making a break in the negative potential supplied by the door contacts for the courtesy light. By turning on the supply and pressing the push to make button S2, C1 charges up, TR1 turns hard on and RLA changes over, making a break between the door contacts and the negative side of C2.

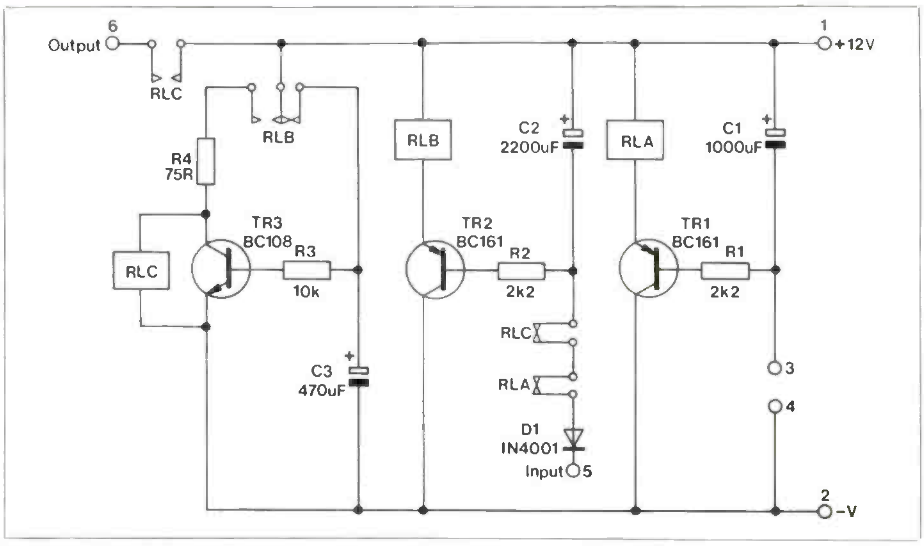


Figure 1. Circuit diagram.

R4 is in the circuit to provide a load when TR3 is biased hard on. D1 is in the circuit to prevent C2 from discharging. R1, R2 and R3 govern the discharge rate of capacitors C1, C2 and C3 respectively. These values can be varied to alter the time delays.

Construction

The complete circuit fits into a small plastic box 71.5mm x 49mm x 24.5mm and it is therefore suggested that a PCB is used. The track side and component side of this can be seen in Figure 2. Fit and solder into position the resistors and the diode, then mount RLA, B & C, TR1, 2 & 3 and solder in position. Lastly, fit C1, 2 & 3 taking note of capacitor polarity.

On the completion of the circuit board, a small hole can be drilled in the box, as an exit for the wires and a piece of plastic foam at the top and bottom of the completed PCB will protect it when installed. The supply switch is inserted in the circuit between supply and +12V.

For cheapness, a concealed switch can be used, e.g. fitted under the dashboard or in the glove compartment etc. A key switch proves quite effective and is relatively easy to install. The most novel idea is a combination lock, a simple version of which is shown in Figure 3.

The switch arrangement is achieved by using three 1 pole 12 way rotary switches. By connecting all of the terminals of the switch together except one, there is only one position where the switch will not conduct from the outside terminals to the inside pole. By connecting the three switches as shown, there is only one combination that will cut off the supply. In the example it is 6, 3, 6. These three switches connected in this way allow a possible 1728 different combinations.

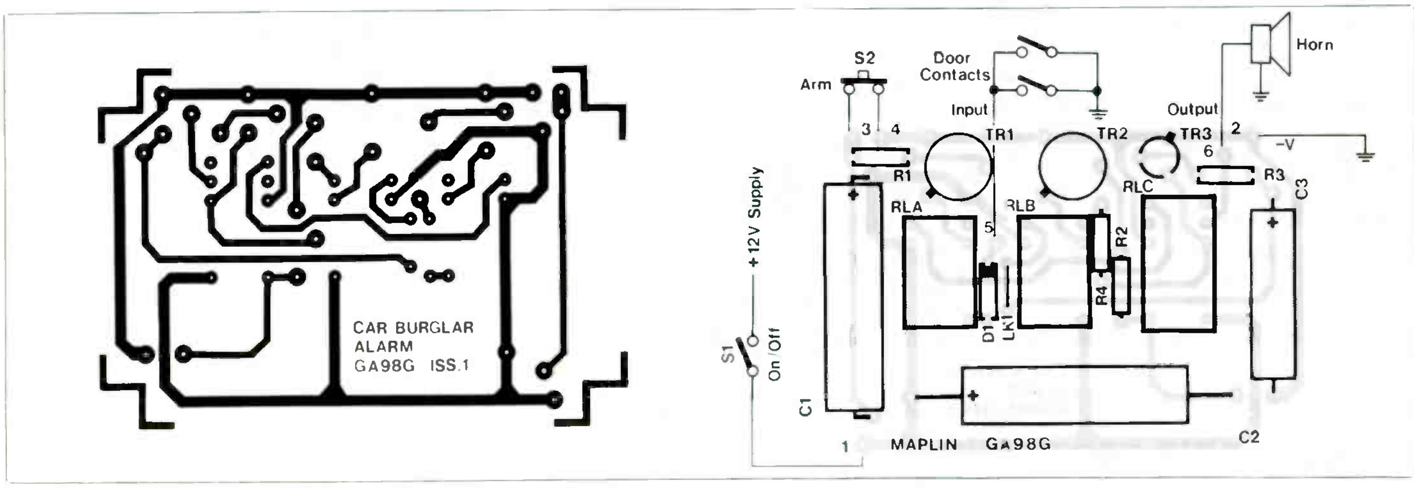


Figure 2. Track layout and component diagram.

Installation

With reference to Figure 2 proceed as follows:

1. Find a convenient positive supply source and fit one of the switches as described in the previous paragraph, between the supply and the +12V of the circuit (pin 1).
2. Take a single wire from the negative of the circuit (pin 2) and connect it to a metal part of the car body.
3. Take a single wire from the negative side of the courtesy light and connect to INPUT (pin 5).
4. Take a single wire from the positive horn contact and connect it to OUTPUT (pin 6).
5. Fix the 'arm' button to a convenient position on the dashboard and connect to the PCB at pins marked 3 & 4.

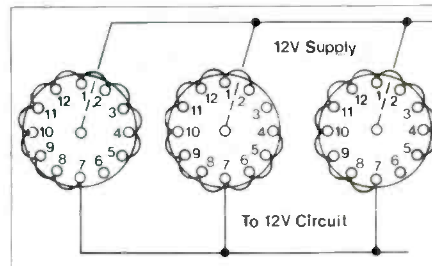


Figure 3. Combination lock.

CAR BURGLAR ALARM PARTS LIST

			Maplin Code
Resistors — all 0.4W metal film unless specified.			
R1,2	2k2	2 off	(M2K2)
R3	10k		(M10K)
R4	75R (½W)		(S75R)
Capacitors			
C1	1000uF 16V axial electrolytic		(FB82D)
C2	2200uF 25V axial electrolytic		(FB90X)
C3	470uF 16V axial electrolytic		(FB72P)
Semiconductors			
TR1,2	BC161	2 off	(QB49D)
TR3	BC108		(QB32K)
D1	1N4001		(QL73Q)
Miscellaneous			
RLA,B	Ultra-min relay SPDT	2 off	(YX94C)
RLC	Ultra-min relay DPDT		(YX95D)
S1	See text		—
S2	Push switch		(FH59P)
	Verobox 301		(LL12N)
	Veropin 2145	6 off	(FL24B)
	PCB		(GA98G)
	Wire		As required

A complete kit of parts is available for this project.
Order As LW78K (Car Burglar Alarm Kit).

IR REMOTE CONTROLLER

continued from page 21

Maximum range is quite good, and may be improved by careful adjustment of RV1 on the transmitter PCB. Most average sized rooms should be adequately covered, but close range use (i.e. three feet or less) may not work reliably, and local control is preferable here. When first switching everything on, the decoder will be in local control mode; remote control is effected by pressing the volume buttons. Set bass, treble, and balance to suit, or press LOC/REM button for return to local control. When changing control from local to remote all other settings switch 'flat' and will need re-adjustment as necessary with the appropriate button.

PARTS LIST — STEREO AMP I/R DECODER

Resistors — all 0.4W metal film unless specified.			
R1	270R (3W) wirewound		(W270R)
R2,3,31,33,40	4k7	5 off	(M4K7)
R4,5,37,41	1M0	4 off	(M1M)
R6-11	3k9	6 off	(M3K9)
R12,14-18inc.,22	56k	7 off	(M56K)
R13	16k (½W 1%)		(T16K)
R19	51k (½W 1%)		(T51K)
R20,24,39	100k	3 off	(M100K)
R21	68k		(M68K)
R23,32,36	10k	3 off	(M10K)
R25	130k (½W 1%)		(T130K)
R26	62k (½W 1%)		(T62K)
R27	30k (½W 1%)		(T30K)
R28	16k (½W 1%)		(T16K)
R29	13k (½W 1%)		(T13K)
R30,34,35	220k	3 off	(M220K)
R38	82k		(M82K)
R42	2M2 (10%)		(B2M2)
Capacitors			
C1	100uF 25V P.C. electrolytic		(FF11M)
C2	470uF 16V axial electrolytic		(FB72P)
C3,4	470nF polycarbonate	2 off	(WW49D)
C5,6	2u2F 35V tantalum	2 off	(WW62S)
C7,21,22	100nF disc ceramic	3 off	(BX03D)
C8,9	10nF polycarbonate	2 off	(WW29G)
C10	47uF 25V axial electrolytic		(FB39N)
C11,12	390nF polycarbonate	2 off	(WW48C)
C13	10uF 35V P.C. electrolytic		(FF04E)
C14	10uF 25V axial electrolytic		(FB22Y)
C15,17	3u3F 35V tantalum	2 off	(WW63T)
C16,19,20,26	1uF 35V tantalum	4 off	(WW60Q)
C18	33nF polycarbonate		(WW35Q)
C23	4u7F 63V P.C. electrolytic		(FF03D)
C24	1uF 100V P.C. electrolytic		(FF01B)
C25	470nF 100V P.C. electrolytic		(FF00A)
C27	2n2F ceramic		(WX72P)
C28	1nF ceramic		(WX68Y)
C29	47nF polycarbonate		(WW37S)
Semiconductors			
D1	BZX61C15V		(QF57M)
D2,3,5,7,9	1N4148	5 off	(QL80B)
D4,6,8	BZY88C5V6	3 off	(QH08J)
D10	TIL 100		(YH71N)
TR1	BC548		(QB73Q)
TR2,4	BC179	2 off	(QB54J)
TR3	BC109C		(QB33L)
IC1	LM1035		(QY19V)
IC2	4066 BE		(QX23A)
IC3	ML922		(YH67X)
IC4	4011 BE		(QX05F)
IC5	4013 BE		(QX07H)
IC6	4510 BE		(QW83E)
IC7	4028 BE		(QX17T)
Miscellaneous			
	Veropin 2141	19 off	(FL21X)
	P.C.B.		(GA97F)

A complete kit of all the parts needed to build the Encoder and Decoder are available.
Order As LW77J (Amp Remote Control Kit).

THE ULTRASONIC INTRUDER DETECTOR

by Dave Goodman

★ **Range up to 20 feet (400 sq. ft. area)**
★ **Adjustable sensitivity**
★ **Direct connection to the Maplin Home Security System via our ultrasonic interface plug-in module**
★ **Single PCB construction with no setting up required**
★ **Up to three may be used on any Maplin Home Security System**

The new ultrasonic intruder detector is a worthwhile addition to your Maplin Home Security System. It will function over a much wider area than conventional switch contacts, it is highly portable, can be used almost anywhere, and can offer total security of a fairly large room.

The ultrasonic detector works on the Doppler Effect Principle (see issue 3, page 7), which in this case means transmission of a 40kHz carrier signal, and reception of the fundamental carrier along with additional frequency shifted signals. These extra signals can vary in frequency by up to 200Hz either side of the fundamental, and are quite small in amplitude. Several stages of

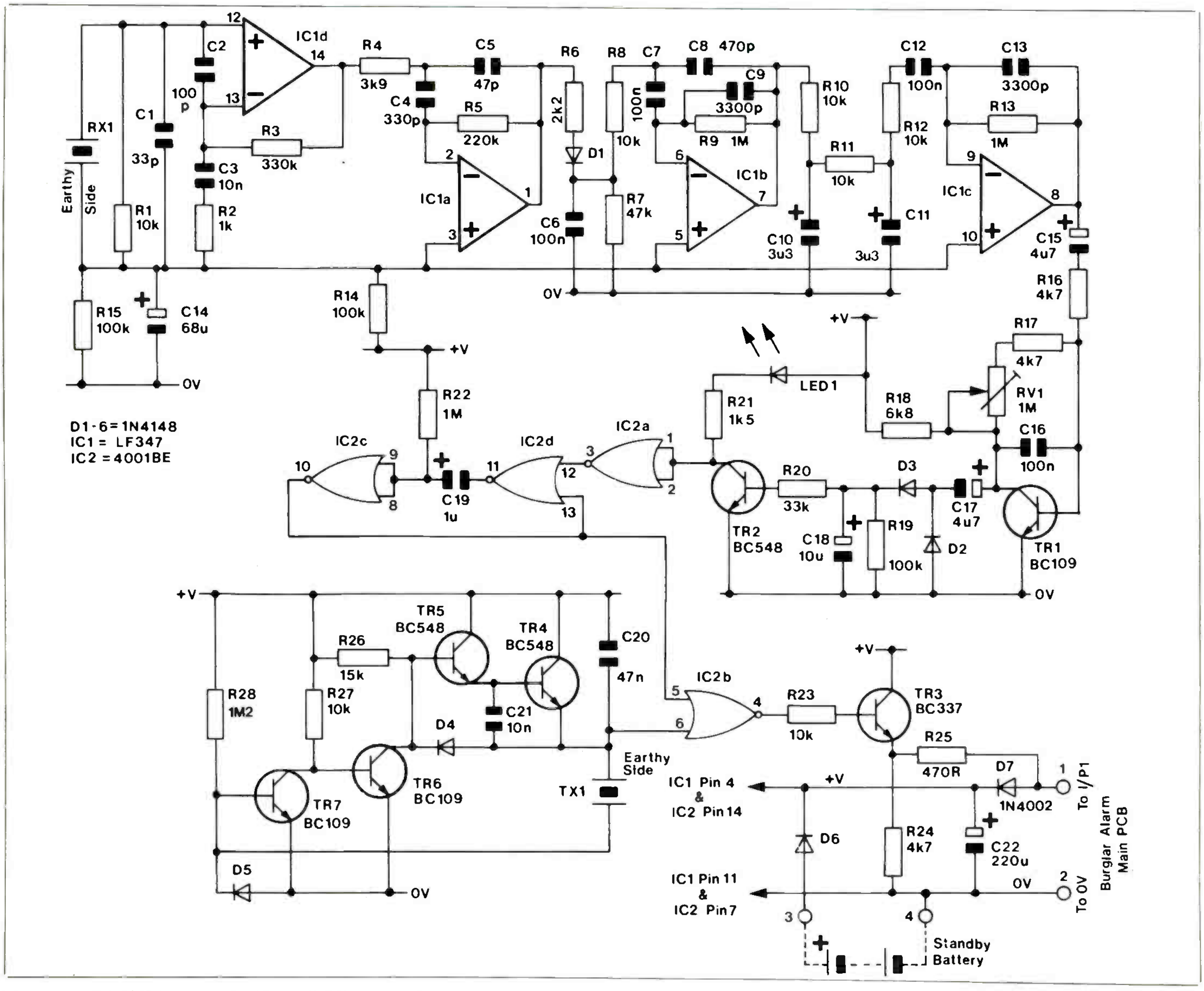


Figure 1. Circuit diagram of the Ultrasonic Transceiver.

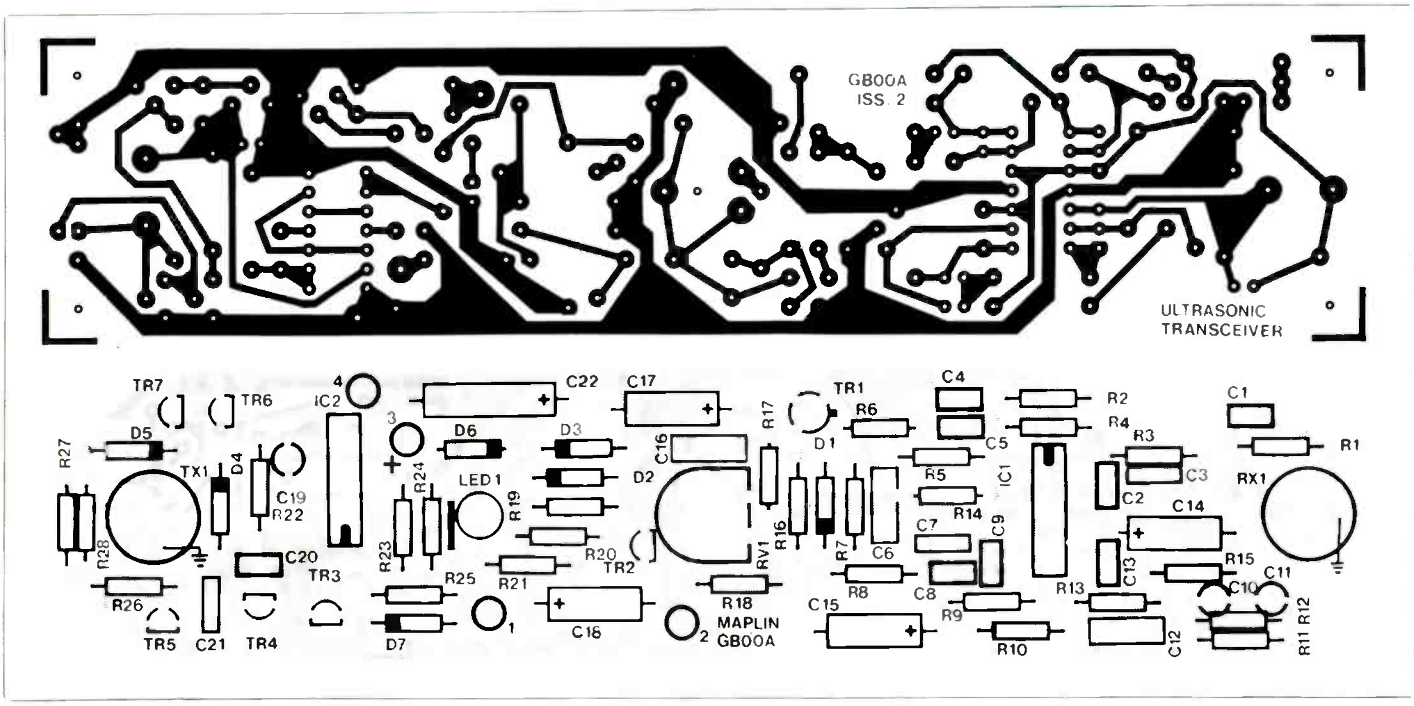
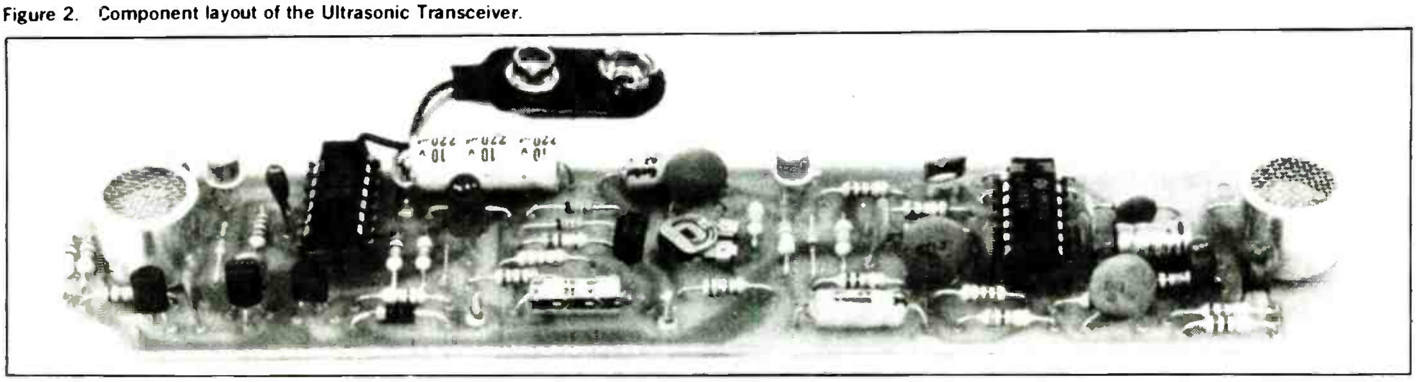


Figure 2. Component layout of the Ultrasonic Transceiver.



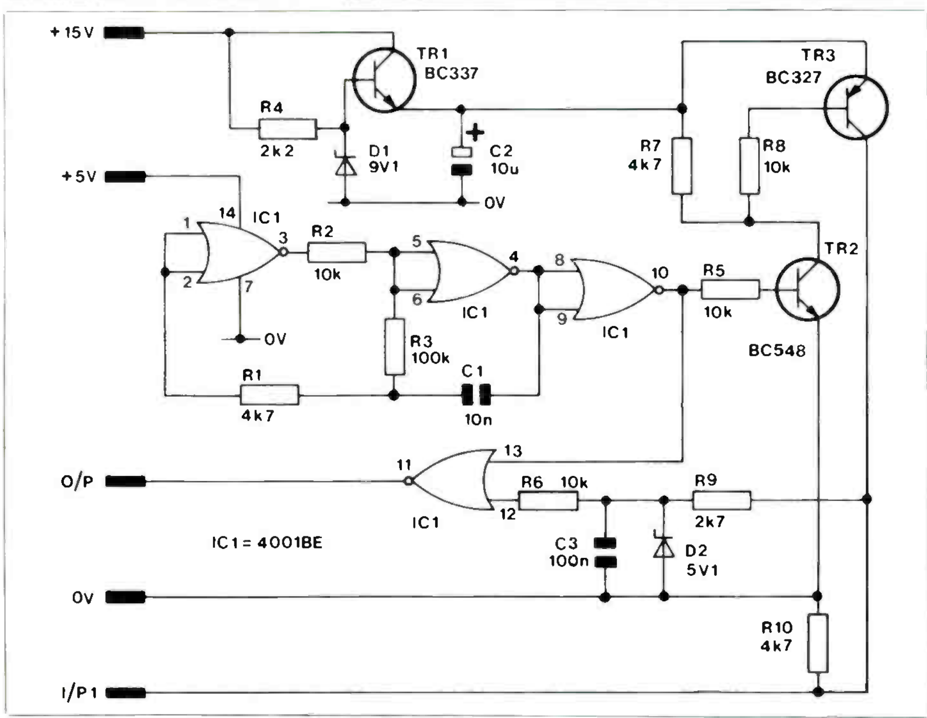


Figure 3. Circuit diagram of the Ultrasonic Interface.

filtering are required to remove the carrier, spurious r.f., and mains interference. The remaining signals are amplified, and, if they are sufficiently large, the alarm will be triggered. The level of triggering is dependent on the sensitivity setting. In this design the transmitter and receiver are both mounted on the same PCB, along with their associated circuitry, and signals are 'bounced' around the room.

The Transmitter

As an improvement over conventional systems, in which the oscillator may require many tedious hours of alignment, we have designed a system in which the transducer determines the oscillator frequency, i.e. the circuit needs NO setting up at all.

The circuit TR4,5,6 and 7, allows the transducer to oscillate at its self-resonating point. C20 at switch-on discharges through the transducer, causing it to resonate. The produced signal is amplified by TR6 and 7, and a constant current circuit comprising TR4, 5 and D4, allows the necessary feedback for sustained oscillation. From this it can be seen that the normal operating frequency becomes dependent on the transducer.

The Receiver

Ultrasonic signals transmitted in an enclosed area will reflect and bounce off hard surfaces, and be absorbed by soft surfaces. A percentage of these signals (called nodes and anti-nodes) are reflected back at the receiver transducer. The transmitter and receiver being matched pairs means that the receiver has a greater affinity for signals transmitted by its partner than for those produced by anything else. Because we are dealing with audio signals, it is possible for low frequency signals of sufficient amplitude (e.g. the rumble of a lorry going past) to trigger the intruder system, so filtering is required. Tests have shown that beat frequencies of between 5Hz and 100Hz can be produced by objects moving through the ultrasonic field. C1 and C2 remove unwanted r.f. signals present at the input of IC1d. This stage has a gain of 300, and high rejection of signals above the ultrasonic band. IC1a amplifies the received ultrasonic signals only, and has a first order response. D1 allows only the positive portion of the signal through, and the carrier part of the signal is removed by C6/R7, leaving only the lower frequency content of the signal. IC1b amplifies all low frequency (l.f.) signals, also filtering any possible remaining high frequency (h.f.) content. R10/11/12 and C10/11 form a low pass filter, which only allows signals below 50Hz to pass through to the final amplifying stage of IC1c. We should now be looking (on pin 8) at what is a stable threshold voltage of about +3v, modulated by l.f. signals of 5-50 Hz, and up to 5v in amplitude.

The stage comprising TR1, RV1, and R16/17 determines the overall sensitivity of the receiver, with a range from unity to x100. Amplified signal peaks are coupled to the diode pump D2/3, C18, R19, so that when the voltage across C18 develops more than 0.7v, sufficient current is produced to bias TR2 into conduction. LED1 illuminates. This has been included to give the user a means of visibly testing the circuit range and coverage (see setting-up procedure).

IC2a inverts and buffers the output from TR2. IC2c and IC2d form a monostable triggered by IC2a. IC2b is a control gate switching the 40kHz carrier from the transmitter oscillator to TR3.

With the working system in a stable condition the 40kHz carrier is coupled via R25 to the incoming supply rail. If the system is triggered the carrier is removed. Note that the supply rails connect to the burglar alarm via a plug-in module (the u/s interface PCB, GB01B).

A standby battery (PP3-9V) is shown connected, positive terminal to pin 3, and negative terminal to pin 4. Charging or 'topping up' facilities have not been added to this part of the circuit, so periodical checks on battery conditions are advisable. Note that the battery will not be required when using the transceiver in conjunction with a u/s interface PCB and our Home Security System, although it will be necessary to increase the NiCad battery pack from 7.8v to 9v. This can be accomplished with a total of eight NiCads (1.2v nominal) and two 6v battery holders (HF29G).

Ultrasonic Interface PCB

This simple circuit identifies the carrier signals transmitted by the ultrasonics module. These signals appear between each 2ms current pulse (used for powering the transceiver), and allows monitoring of the two wire supply connection.

IC1a and b form a 500Hz CMOS oscillator, and switch the buffer transistor TR2 at this rate. The regulator D1, TR1, applies 8.6V d.c. to TR3, which is pulsed on and off by TR2, producing an 8.6V, 500Hz signal across R10. This signal is rectified by D7 and C22 (figure 1) in the transceiver, producing 8.2V on the positive rail.

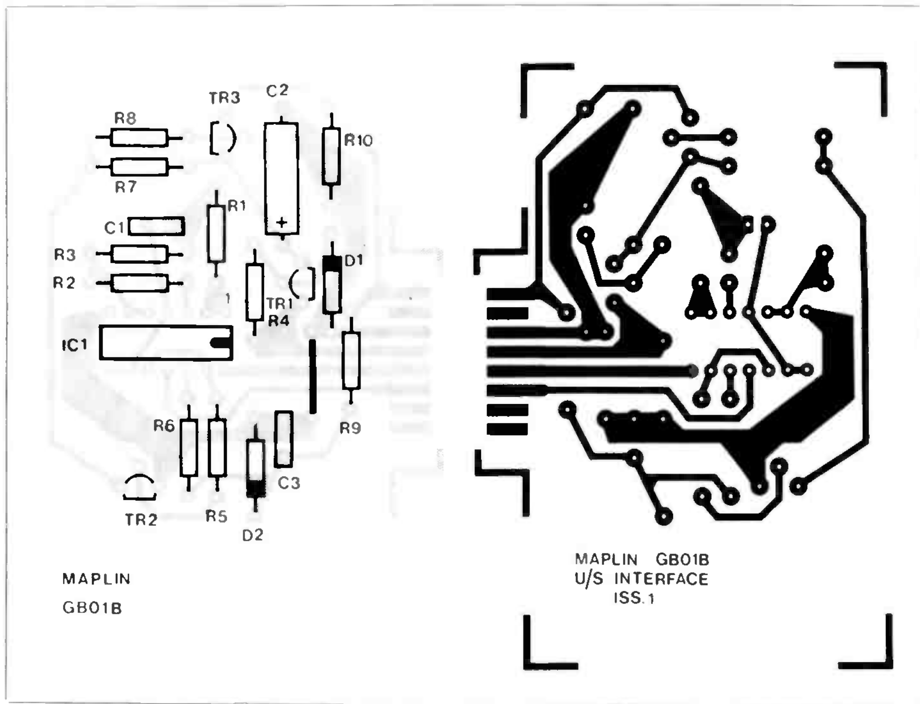
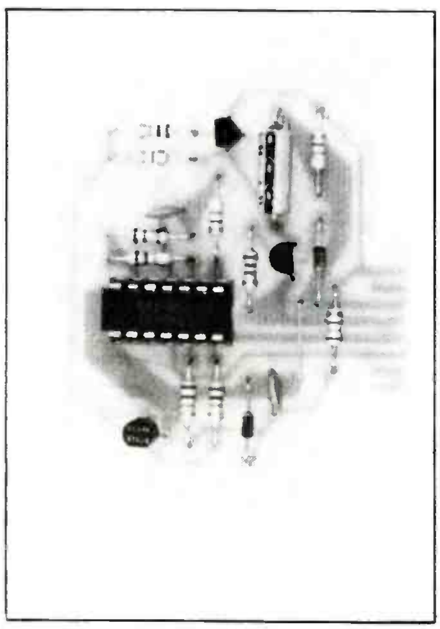


Figure 4. Component layout of the Ultrasonic Interface.



IC1d has a 500Hz clock pulse on pin 13, and an in-phase signal of 500Hz on pin 12. The two signals cancel at the output, pin 11, producing an inverted trigger signal, which fires the burglar alarm. However, under normal conditions a carrier signal will be present across R10, appearing between each 2ms pulse. R6, R9, D2, and C3 filter and limit this composite signal, and IC1d output remains low. Either disconnection of the supply, or triggering the transceiver will remove the 2ms 'carrier' from across R10, sending IC1d output high (+5V), and setting off the alarm.

Constructional Details for Ultrasonic Intruder Detector

Refer to the parts list and figure (2). Mount D1 to D7 ensuring correct orientation. Mount resistors R1 to R28, and capacitors C1 to C22. Check that the electrolytics C14, C15, C17, C18 and C22, also tantalums C10, C11 and C19 are mounted with correct polarisation. Electrolytics are marked at the negative end but tantalums at the positive. Fit the I.C. sockets, and all transistors. TR1, TR6, and TR7 have their emitters marked with a pip on the case, and should line up with the legend marked on the PCB. If a metal case is used, it is important that the transducers do not touch the chassis. The transducers each have one pin connected directly to their case, and this pin should be connected to the hole marked ⏚ (figure 2).

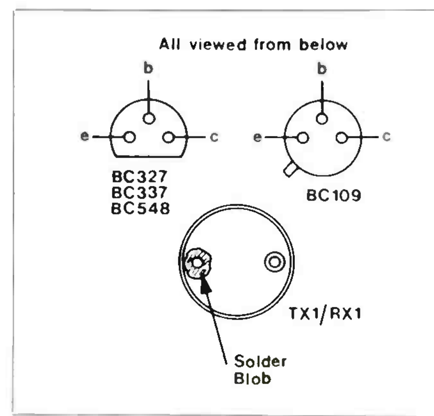


Figure 5. Pin Designations.

Assembly of Ultrasonic Trigger

Observe the usual precautions when mounting components. Use an I.C. holder, for IC1, and double-check all solder joints. Plug the module into any channel on the main PCB of the Home Security System (issue 2, figure 5), and apply power. If you have a voltmeter, check across pins 0V and I/P 1 on the main PCB. This should read approx. 5.0V dc. Also the selected channel should trigger, and the monitoring LED will light.

Setting Up

Set RV1 anti-clockwise. Connect a 9V battery across pin 3 (positive) and pin 4 (negative). LED 1 should come on for a few seconds and then extinguish. Allow 30 seconds settling time, and then wave your hand about six inches away from the transducers. Response to movement should be indicated by LED 1 illuminating, and it should remain so for a few seconds. If there is no response, turn RV1 to approximately ¼ travel to increase sensitivity, and repeat check. If the LED now stays on, move away to a point where the LED is still visible, and keep completely still. After a few seconds the LED should go out. If the circuit still does not work, try disconnecting the battery, and repeating the above checks. If all is satisfactory remove the battery and connect the transceiver to the Maplin Home Security System main PCB.

Use either bell wire, or our 4-wire phone cable (XR66W) to connect the transceiver to the main PCB (burglar alarm). Pin 2 will connect to 0V and Pin 1 will connect to I/P 1.

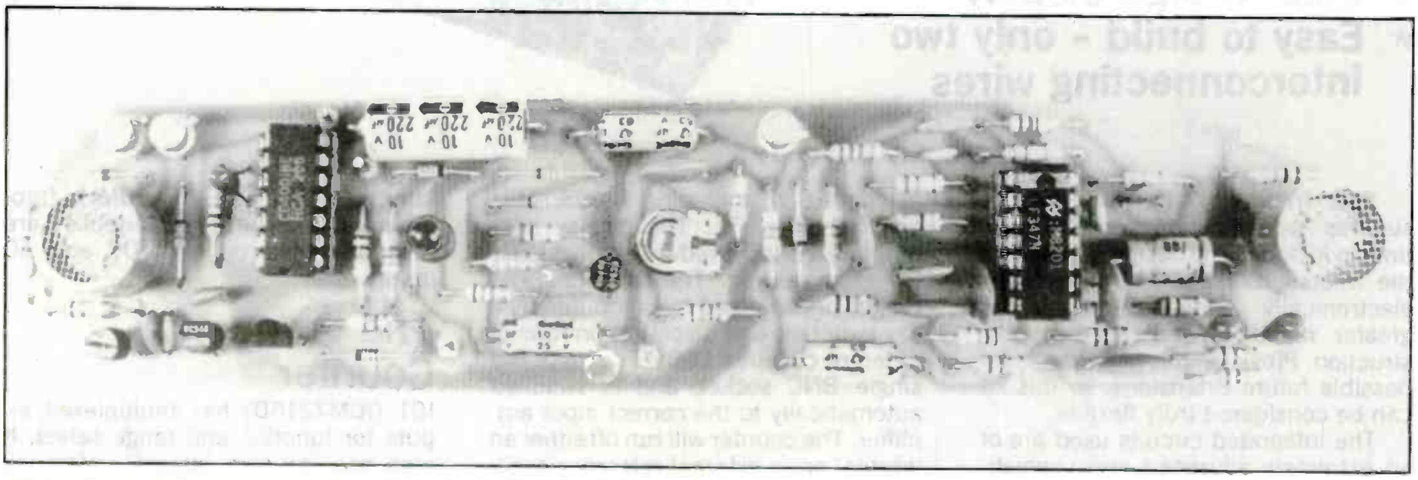
Whatever channel is used for this project, ensure that a u/s interface module is plugged in to this position only.

At switch-on the burglar alarm channel LED will flash. Allow about a minute for the transceiver to stabilise. Turn the sensitivity control RV1 clockwise, to suit conditions, and set the key switch for 'ARM'. Don't forget to switch in the selected channel (switches 3 to 8).

If stand-by batteries are to be used, remove the mains supply, then reconnect. Check that the system does not trigger. If all is well, experiment with RV1 settings for optimum results before putting into service.

Using Ultrasonics

The module is best placed in a corner of the room to be protected, preferably just below ceiling level, and inclined at an angle of 30 to 45 degrees downwards. Keep as far away as possible from windows, radiators, central heating thermostats, and telephones and bells. Remember that anything that moves (e.g. curtains, telephone bells) can set off the alarm, dependent on sensitivity. RV1 must now be adjusted for required sensitivity. Obviously, the more sensitive the system, the greater the possibility of false triggerings occurring. If areas greater than 400 square feet need covering, then two or more devices may be used. Note that each transceiver will draw 24mA, and up to three may be used on one system, dependent on what else is connected to the system.



ULTRASONIC TRANSCEIVER PARTS LIST

Resistors: All 0.4W metal film unless specified.

R1,8,10-12 inc,23,27	10k	(7 off)	(M10K)
R2	1k		(M1K)
R3	330K		(M330K)
R4	3k9		(M3K9)
R5	220k		(M220K)
R6	2k2		(M2K2)
R7	47k		(M47K)
R9,13,22	1M	(3 off)	(M1M)
R14,15,19	100k	(3 off)	(M100K)
R16,17,24	4k7	(3 off)	(M4K7)
R18	6k8		(M6K8)
R20	33k		(M33K)
R21	1k5		(M1K5)
R25	470R		(M470R)
R26	15k		(M15K)
R28	1M2		(B1M2)
RV1	1M hor sub-min preset		(WR64U)
Capacitors			
C1	33pF ceramic		(WX50E)
C2	100pF ceramic		(WX56L)
C3,21	10nF disc ceramic	(2 off)	(BX00A)
C4	330pF ceramic		(WX62S)
C5	47pF ceramic		(WX52G)
C6,7,12,16	100nf disc ceramic	(4 off)	(BX03D)
C8	470pF ceramic		(WX64U)
C9,13	3300pF ceramic	(2 off)	(WX74R)
C10,11	3u3F 35V tantalum	(2 off)	(WW63T)
C14	68uF 6V3 axial electrolytic		(FB44X)
C15,17	4u7F 63V axial electrolytic	(2 off)	(FB18U)
C18	10uF 25V axial electrolytic		(FB22Y)
C19	1uF 35V tantalum		(WW60Q)
C20	47nf minidisc		(YR74R)
C22	220uF 10V axial electrolytic		(FB60Q)
Semiconductors			
D1-6 inc.	1N4148	(6 off)	(QL80B)
D7	1N4002		(QL74R)
LED 1	LED RED		(WL27E)
TR1,6,7	BC109c	(3 off)	(QB33L)
TR2,4,5	BC548	(3 off)	(QB73Q)
TR3	BC337		(QB68Y)
IC1	LF347		(WQ29G)
IC2	4001BE		(QX01B)
Miscellaneous			
TX1/RX1	Ultrasonic transducers (pair)		(HY12N)
	Veropin 2141		(FL21X)
	14 pin DIL Skt	(2 off)	(BL18U)
	Ultrasonic Transceiver PCB		(GB00A)

A complete kit of all the above parts is available. Order As LW83E (Ultrasonic Xceiver Kit)

U/SONIC INTERFACE PARTS LIST

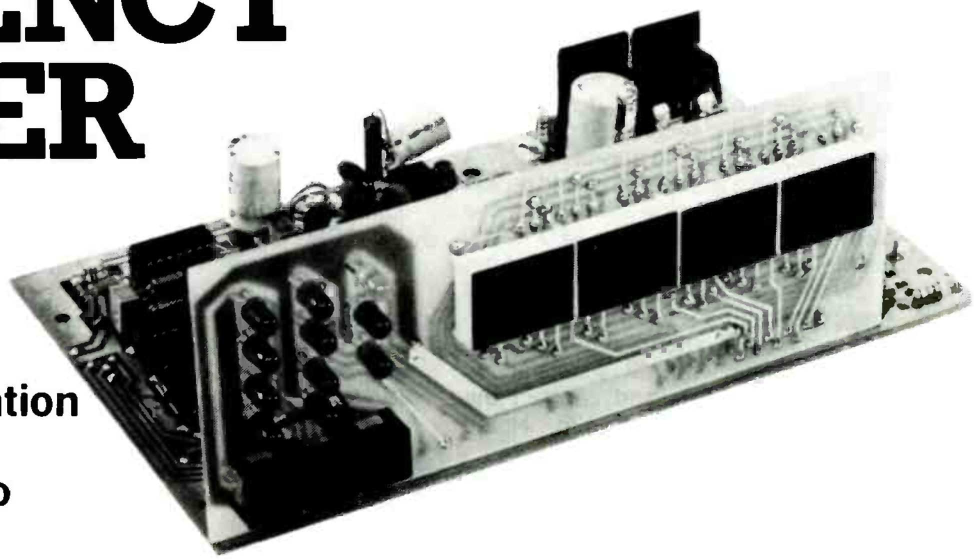
Resistors: All 0.4W metal film.

R1,7,10	4k7	(3 off)	(M4K7)
R2,5,6,8	10k	(4 off)	(M10K)
R3	100k		(M100K)
R4	2k2		(M2K2)
R9	2k7		(M2K7)
Capacitors			
C1	10nF mini disc		(YR73Q)
C2	10uF 25V axial electrolytic		(FB22Y)
C3	100nF mini disc		(YR75S)
Semiconductors			
D1	BZY88 C9V1		(QH13P)
D2	BZY88 C5V1		(QH07H)
TR1	BC337		(QB68Y)
TR2	BC548		(QB73Q)
TR3	BC327		(QB66W)
IC1	4001BE		(QX01B)
Miscellaneous			
	14 pin DIL Skt		(BL18U)
	U/S Interface PCB		(GB01B)

A complete kit of all the above parts is available. Order As LW84F (Ultrasonic Interface Kit)

THE 8-DIGIT FREQUENCY COUNTER

by Chris Barlow



- ★ **Ranges from 100Hz to 500MHz**
- ★ **Mains or 12V DC operation**
- ★ **Clear 8-digit display**
- ★ **Easy to build - only two interconnecting wires**

This frequency counter offers a superior specification for the first time in kit form. The design is based on the Intersil ICM7216D, and includes electronically switched ranges for greater reliability and ease of construction. Provision has been made for possible future extensions, so this kit can be considered truly flexible.

The integrated circuits used are of an extremely advanced and sophisticated design, including CMOS, ECL, and Schottky TTL. The display uses multiplexed large red 7-segment LEDs for easy viewing. The functions and ranges are selected by computer-style key switches, and displayed on rows of different coloured LEDs. The input is a single BNC socket, and is switched automatically to the correct input amplifier. The counter will run off either an internal or an external reference oscillator, of either 1MHz or 10MHz (programmable). The power supplies are fuse protected on both DC and AC inputs.

The Frequency Counter

IC1 (ICM7216D) has multiplexed inputs for function and range select. It also has its own internal reference

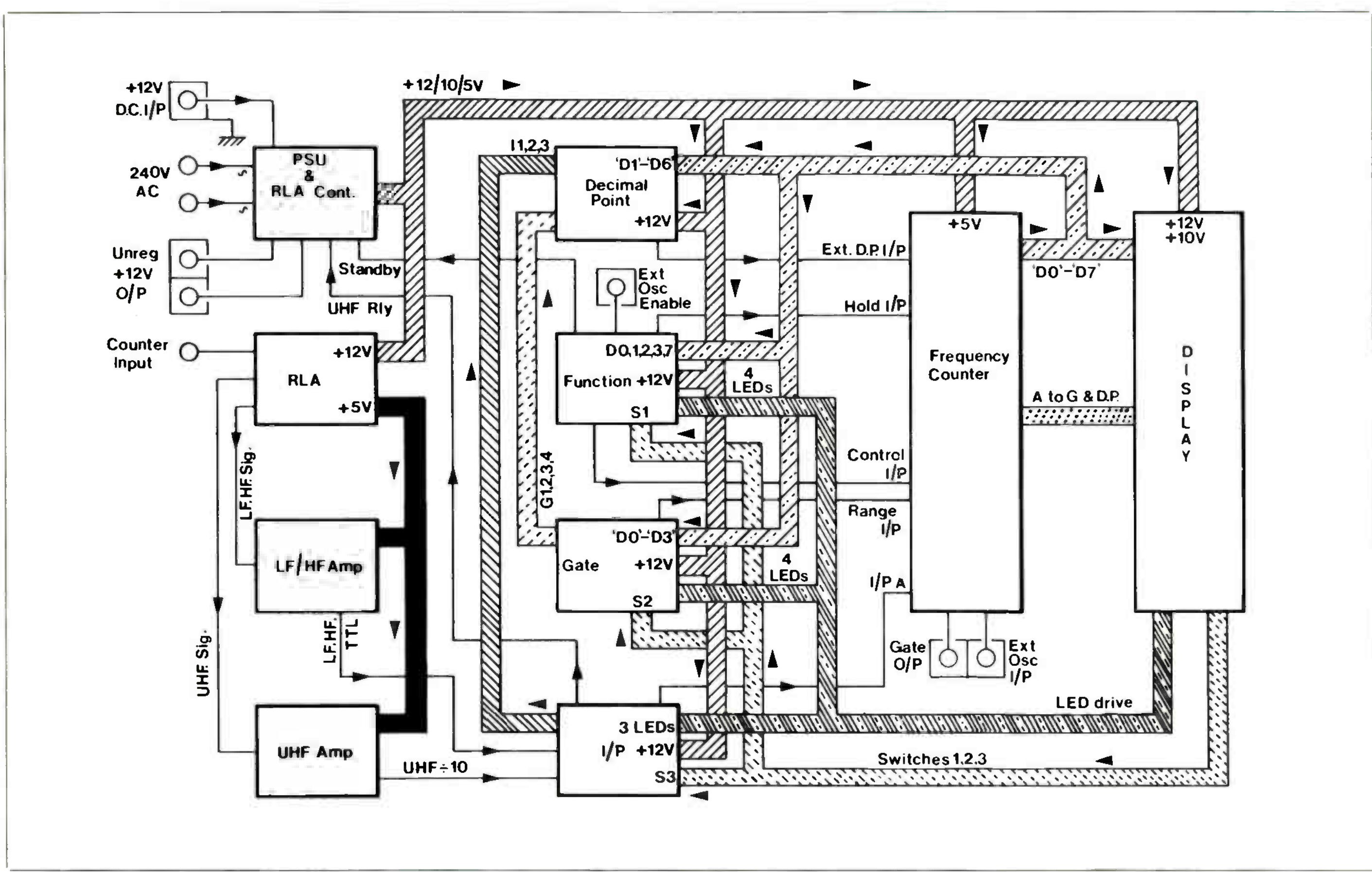


Figure 1. Block schematic of counter.

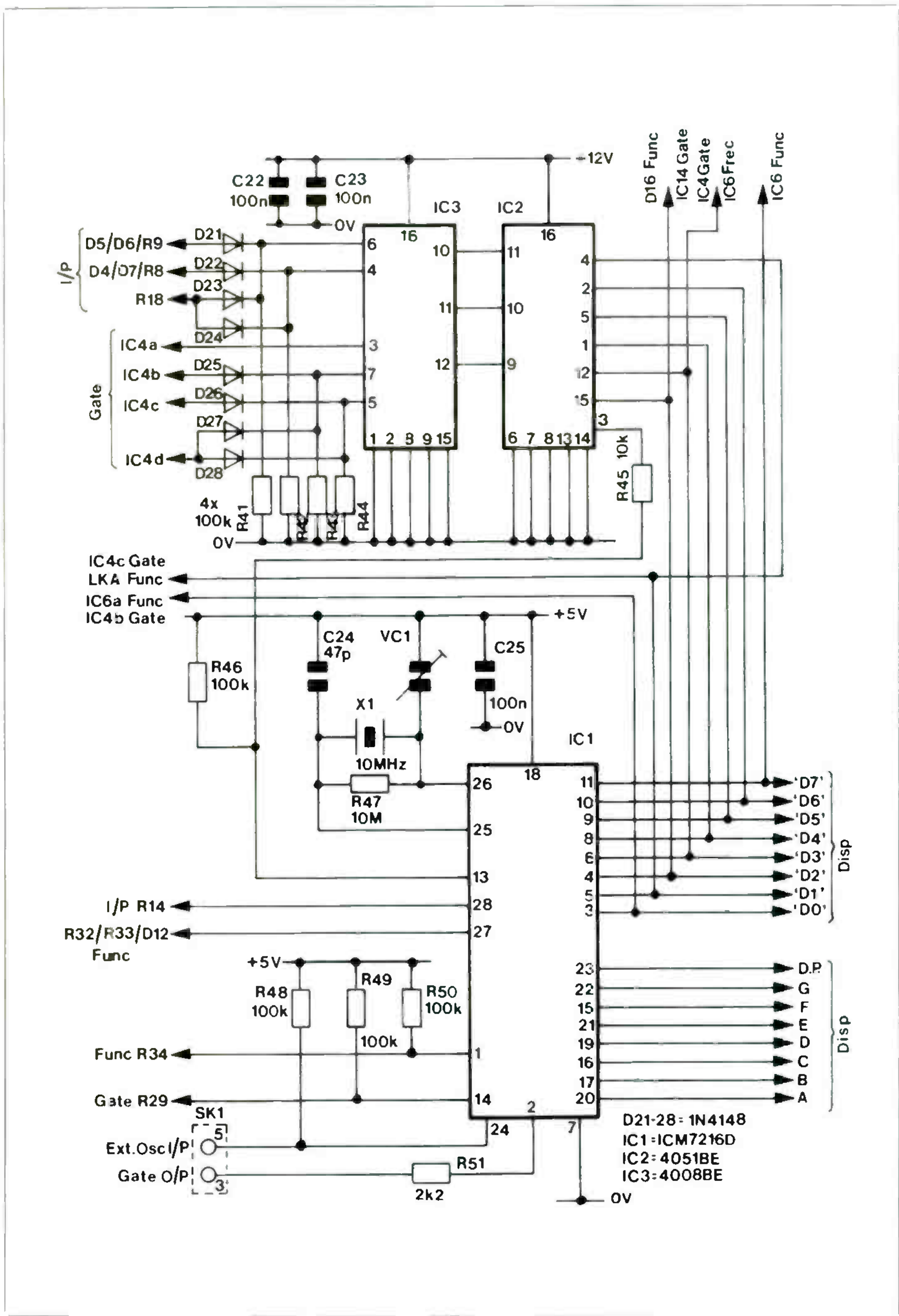
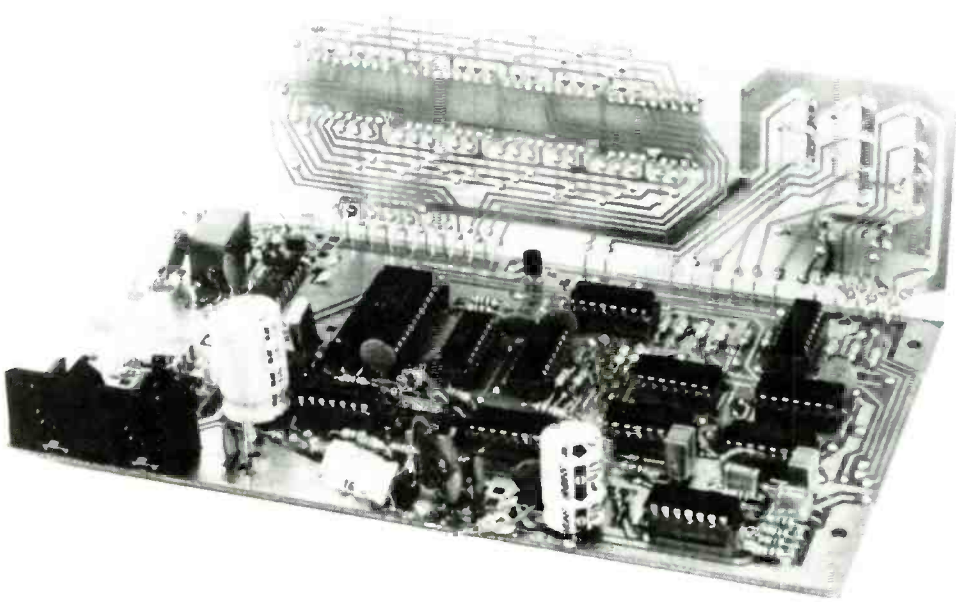


Figure 2. Frequency counter and decimal point logic counter.



oscillator, as well as provision for an external oscillator input (pin 24). Its internal oscillator is controlled by either a 10 MHz or a 1 MHz crystal. A 10 MHz crystal is supplied with the kit. Please note that if you wish to use the 1 MHz option, LKA on the PCB must be fitted. The crystal frequency is set by VC1. The setting of VC1 will determine the accuracy of the displayed frequency, and care should be taken in making this adjustment. IC1 provides the digit and segment drive for the 8-digit 7-segment displays. The digit drive multiplex signal is also used in the function and gate time selects circuits, to control the function and range inputs of IC1. Pin 2 of IC1 provides a gated signal output, which is fed to pin 3 of SK1, for possible future expansion to the system.

The Decimal Point

ICs 2 and 3 (CMOS 4051 and 4008) control the position of the decimal point. This is calculated by looking at the input range and gate time settings. The decimal point occurs at the transitional point between MHz and 100s kHz, except for the 10s gate time on L.F. range, where the decimal point occurs between Hz and tenths of Hz.

The Gate Time Function

This uses the CMOS 4093 (IC11) and 4017 (IC5) to select the gate times. The 4017 controls the CMOS bilateral switch CMOS 4016 (IC4). This selects the appropriate multiplex data line, which controls the range input (pin 14 of IC1). ICs 9 and 10 are the LED drivers for the four LEDs used in the display.

The Function Circuit

This is almost identical in operation to the Gate Time Circuit, but the multiplex data selected is fed to the control pin of IC1 (pin 1). In addition, the function circuit feeds signals to the input select, gate time select, and +10V control circuits. This disables the input select and gate time select in every mode except COUNT, also the +10V control is shut down in the DISPLAY OFF mode. A hold signal is generated in the function circuit which is fed to pin 27 of IC1, so that the frequency displayed can be stored for as long as is required. The display LEDs are driven by IC10 (CMOS 4049).

The Input Range Select Circuit

This functions similarly to the previous two, but features the control of Schottky TTL gates, which select either direct frequency, divide by ten, or divide by a hundred ranges. This is necessary because the maximum frequency that IC1 can handle is 10 MHz, therefore, for HF and UHF, division of the input signal is necessary. IC13 is the divide by ten chip used for HF and UHF ranges. In the UHF mode the prescaler IC14 divides by ten, which is then fed into IC13, making a total division of one hundred. IC9 drives the display LEDs.

The UHF Input Amplifier/Prescaler

The UHF input stage uses a ZTX326 (TR3) broad band, high frequency amplifier in the common base mode. The UHF signal is fed to TR3 via the input relay circuit. It is then fed to the input pins (15 and 16) of IC14. The IC divides the signal by a factor of ten, and the signal is then fed to the input select circuit.

The LF/HF Amplifier

The input to the amplifier is a FET source follower, TR5, to provide a high input impedance. This feeds the signal into pin 5 of IC16, a three stage broadband amplifier. The output on pin 15 is a 1V peak-to-peak signal, which is fed to the base of TR4. This then converts the signal into a TTL switching level, which is fed to pin 1 of IC15. This provides a clean switching waveform to drive the input select circuit. The output is on pin 8.

Power Supply and Relay Control

This consists of a standard transformer/bridge rectifier network, which provides an unregulated 12V supply for the CMOS circuits. REG 1 is a +5V, ½A regulator, and has a 1N4148 diode in its common return to increase the output voltage to +5.6V. This gives a brighter display and more reliable TTL switching. The 10V controlled output feeds the display LEDs on GATE TIME and INPUT ranges. The 10V is shut down in the DISPLAY BLANK mode, by IC11 controlling TR1. The relay RLA is controlled by TR2/IC9, and is active when UHF is selected. The relay controls the voltage and signal feed to either the LF/HF amplifier, or the UHF input amplifier/prescaler.

The Input Protection Circuit

This provides DC isolation to 500V, and AC protection up to a 5V peak-to-peak signal. This is achieved with limiting diodes and DC isolation capacitors on the input.

Construction

This project has been designed to fit into the aluminium instrument case XY45Y. Holes have to be drilled for the transformer, regulator, mains input socket, and fuse, as they are all mounted on the back of the box. Holes also have to be drilled to allow access to the PCB mounted power connector and auxiliary socket. The front of the case requires holes drilling for the BNC input socket, the three key switches, the

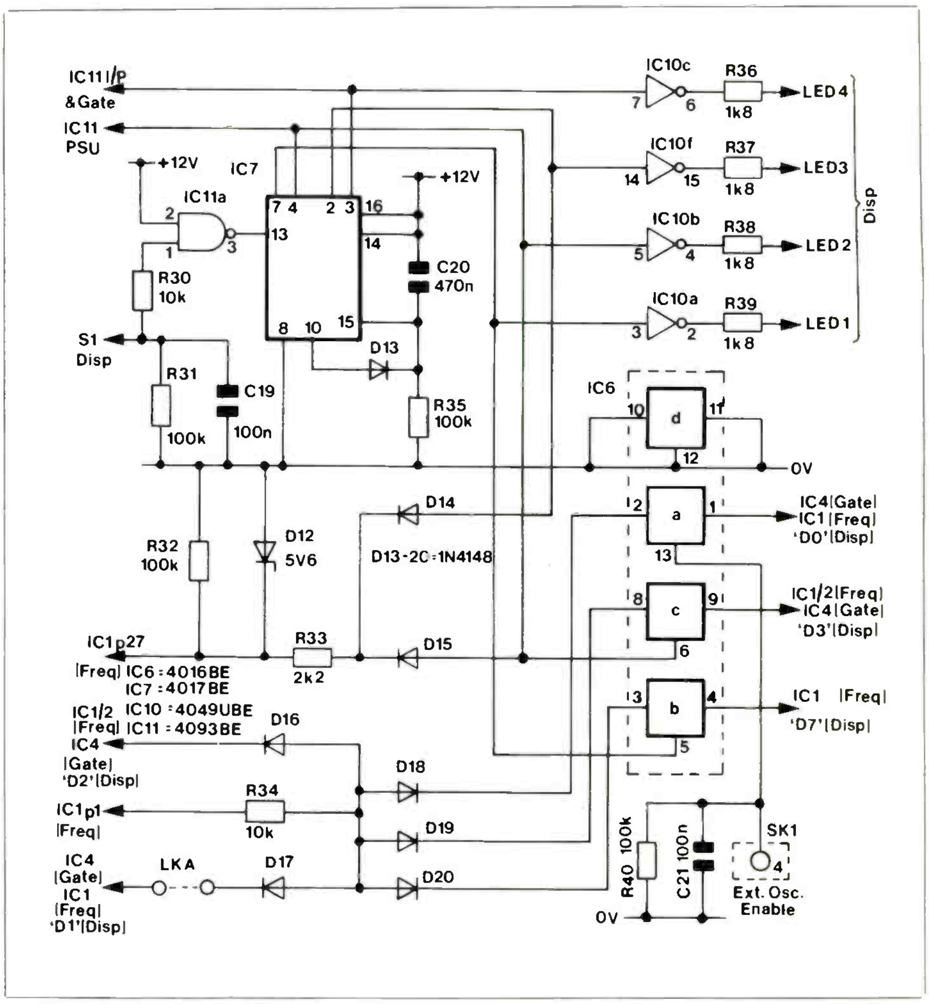


Figure 3. Function select circuit.

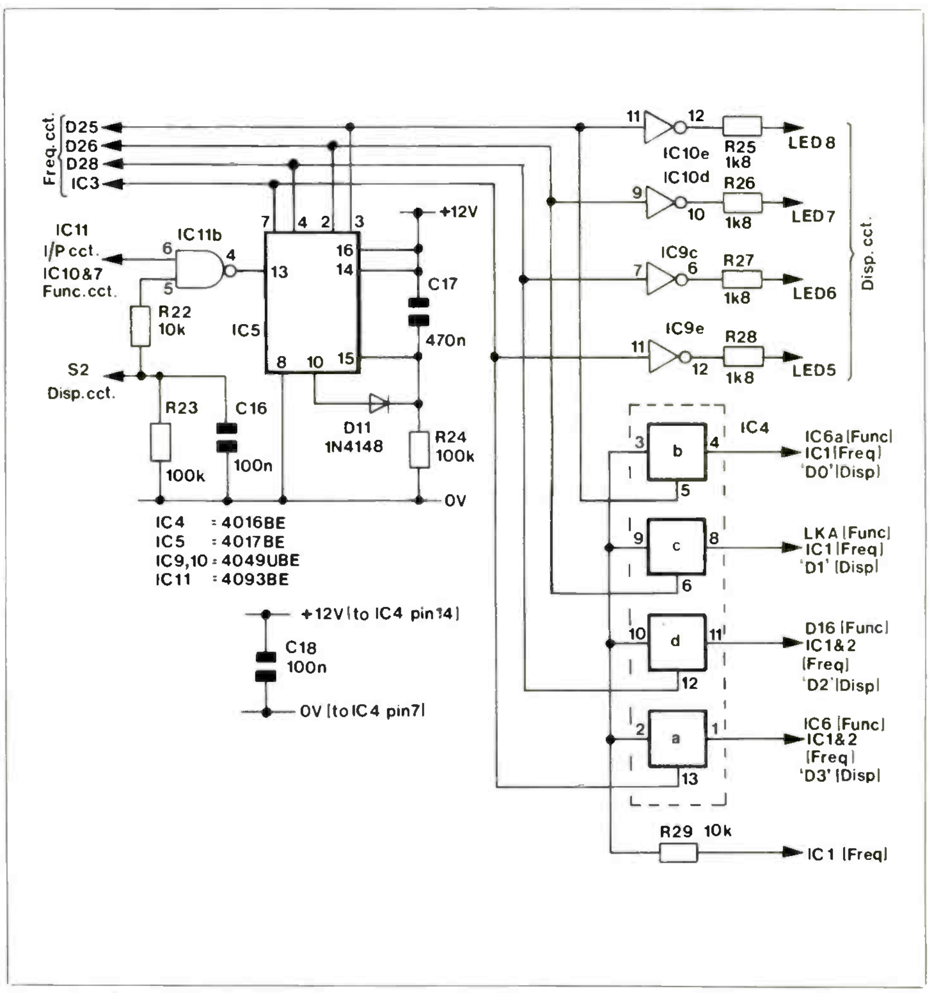


Figure 4. Gate time circuit.

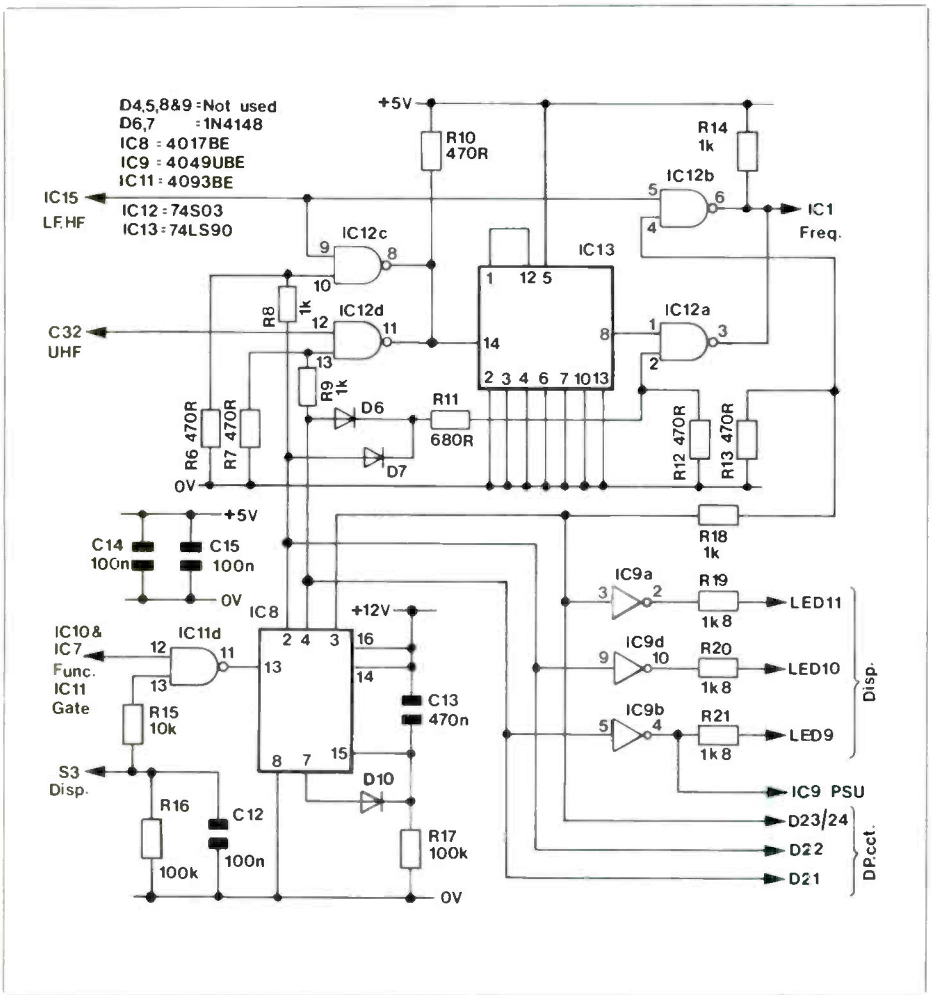


Figure 5. Input select circuit.

three rows of LEDs, and a rectangular window needs cutting for the display. The holes are already provided on the bottom of the box to fit the main PCB on ⅛" 6BA spacers. The CMOS ICs are all provided with sockets, and care should be taken when handling these devices.

The Main PCB

First, fit all track pins, making sure that they are all soldered on both sides. Then insert and solder the Vero pins into their correct positions, and fit all resistors and diodes, including BR1, checking for correct polarity on all the diodes.

Fit the two PCB mounting connectors and the fuse clips. Fit all capacitors, including VC1. Make sure that all the electrolytics and tantalums are correctly polarised. Fit the relay RLA and all IC sockets. These are *only* provided for CMOS ICs. Sockets should *not* be fitted to the ECL and TTL devices, as these can operate at frequencies that make the use of sockets undesirable. Fit the transistors, including the input FET, and solder the regulator into a position enabling it to be bolted to the back panel when the PCB is fitted into the case. Fit the crystal, taking care not to overheat this component. Clean the underside of the PCB, and check soldering for possible dry joints etc.

The Display PCB

Fit all track pins. Fit all 7-segment displays, ensuring correct orientation with markings towards the bottom of the board. Fit all display LEDs, and then the three push switches as shown in Figure 10. Check your soldering!

Fitting the Display PCB to the Main Board

The display PCB must be mounted at an angle of 90 degrees to the main board, and the bottom edge must run parallel to the front edge of the main PCB. Solder the inter-PCB connecting links to the main board.

All CMOS chips with the exception of IC1 should now be fitted. Normal CMOS precautions should be observed. Fit the BNC socket and glue the red filter to the front panel (as shown in Figure 11). The main PCB should now be tested (see the setting up procedure). After testing, mount the PCB with spacers (Figure 11), and bolt the regulator (using the mica washer), the mains transformer, the fuseholder, and the mains input socket to the back panel (Figure 12), and wire up as shown. Fit the capacitors to the back of the BNC socket as shown in Figure 11.

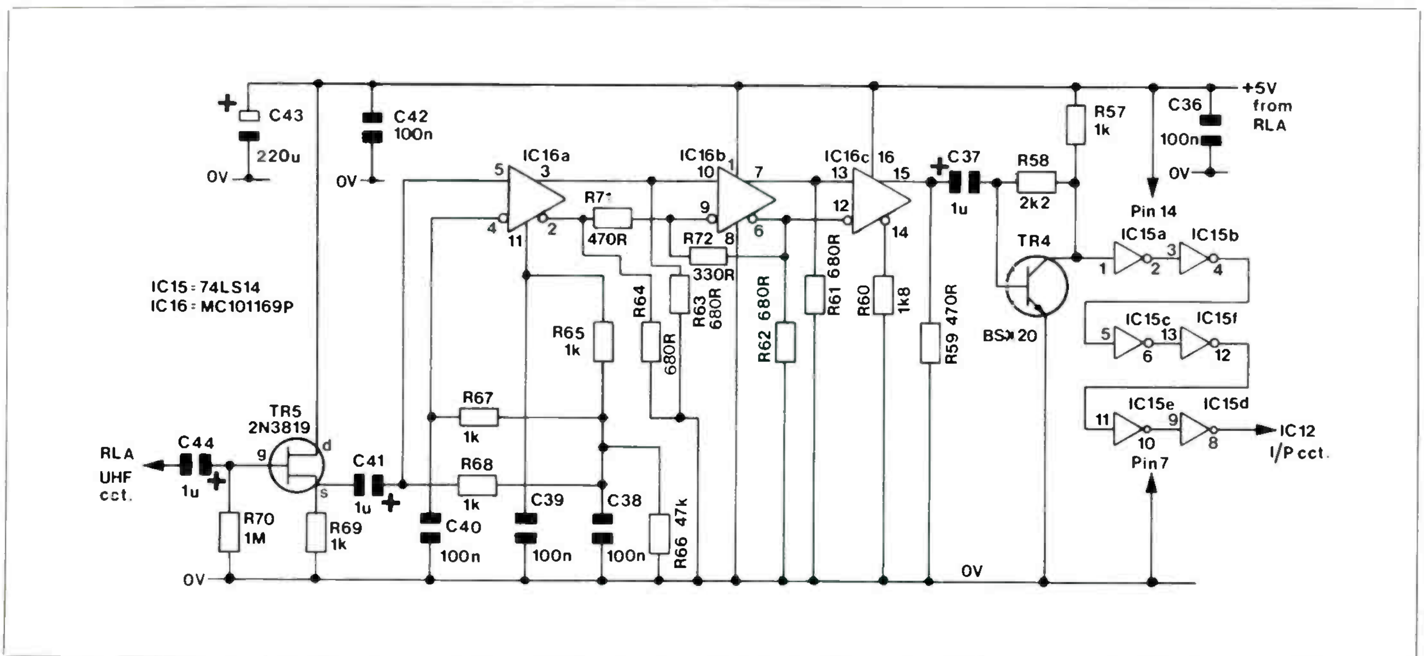


Figure 6. LF/HF input circuit.

Setting Up

Before fitting into the case, the voltage regulator and CMOS control logic can be tested. A 12V DC supply is needed. This can be a battery, C.B. power supply, or similar. Fit a meter capable of reading 1A fsd across the PCB fuseclips, with the negative lead on the side of the fuseclip which connects to the anode of D3. Fit a temporary heatsink (e.g. a croc clip) to the metal tab of the regulator. Connect the 12V supply via the PCB mounted power input socket. A current of no more than 200mA should be observed. If there is more than 200ma, disconnect immediately and check the construction. If there is zero current, you may have incorrect polarity on the power supply. If all is correct the bottom LED in each row should be lit, but none of the 7-segment displays. Press each switch in turn, and check that the LEDs illuminate in sequence. The function should be kept in COUNT mode whilst checking the ranges. When the function is in any mode other than COUNT, the other two switches should have no effect. In 'DISPLAY OFF' mode, the range LEDs will extinguish. Remove the meter and replace the fuse FS2. The regulator output should now be measured, using a voltmeter connected with the negative lead to 0V, and the positive lead to test point 1. A reading of approximately 5.5V should be obtained. Ensure there is no more than +5V DC present on pins 1, 13 and 14 of IC1 holder, and when the function is on HOLD there should not be more than 6V on pin 27. Remove the power and carefully insert IC1. Re-apply the power and a display should be visible, as

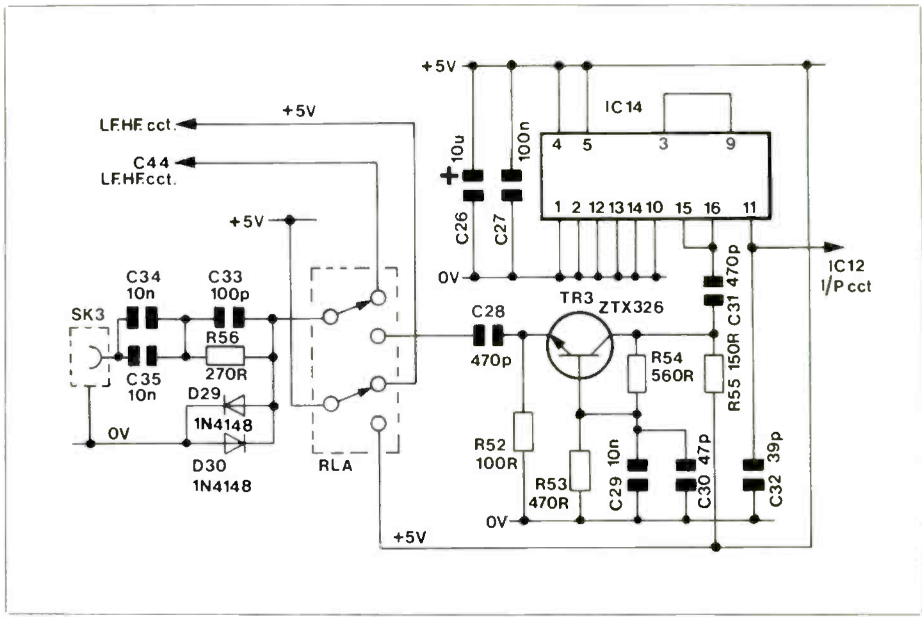
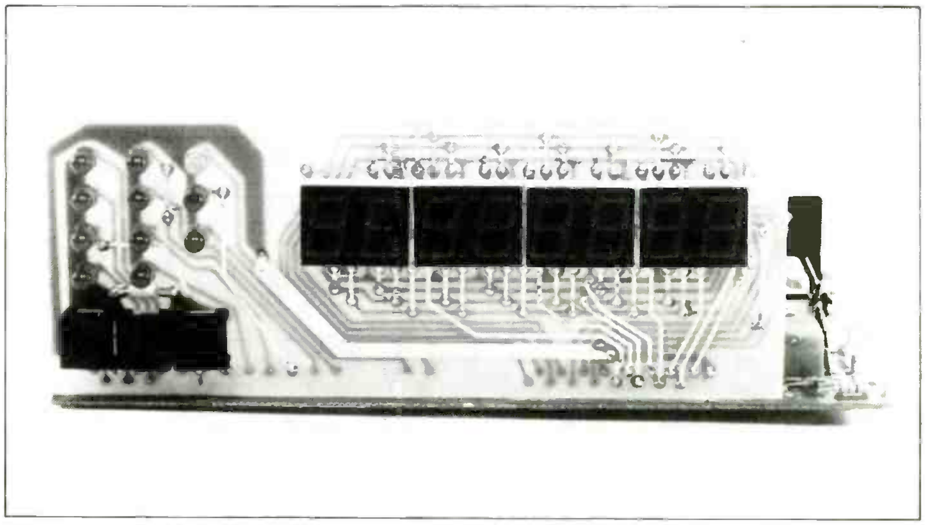


Figure 7. UHF input and relay circuit.



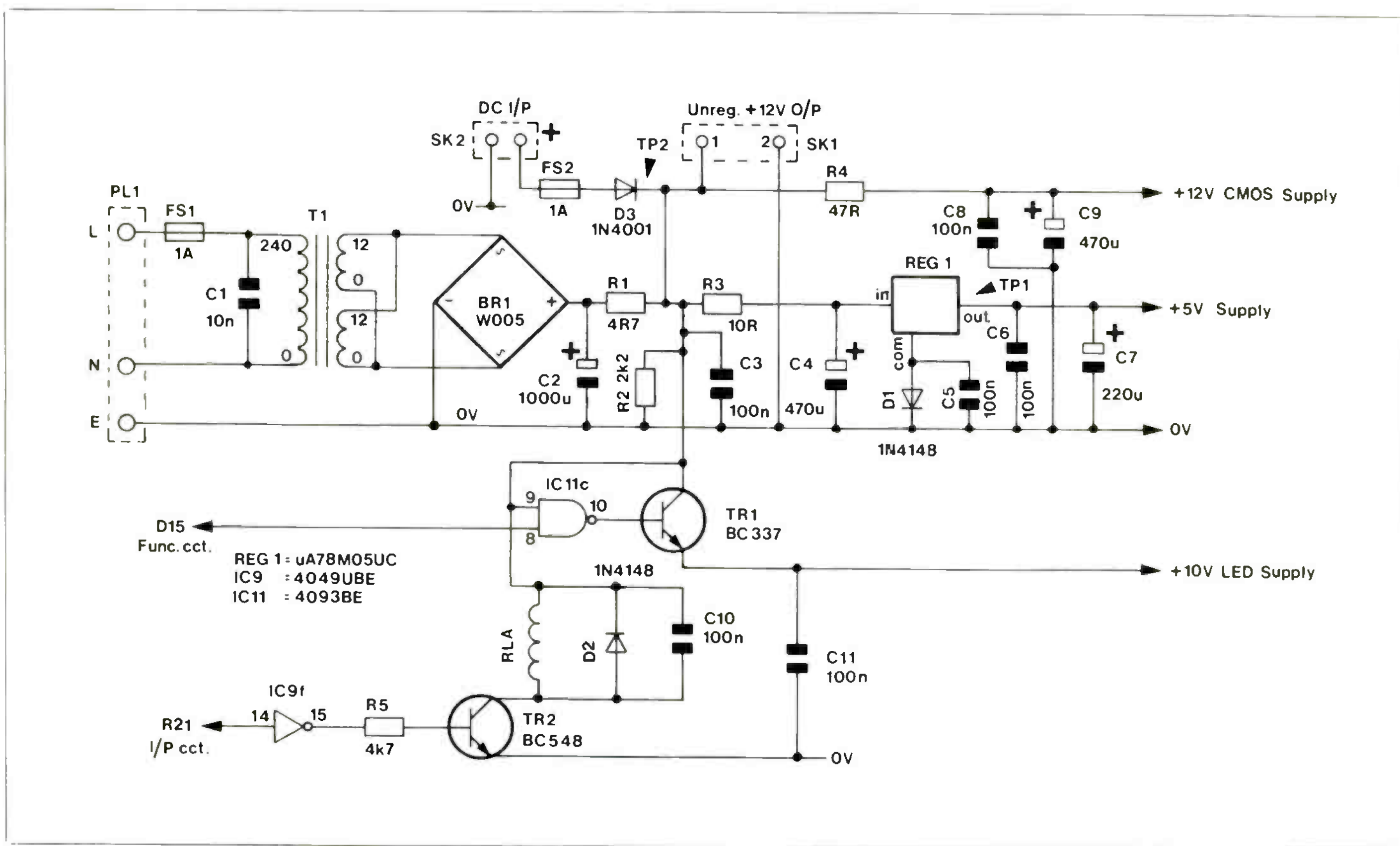


Figure 8. Power supply circuit.

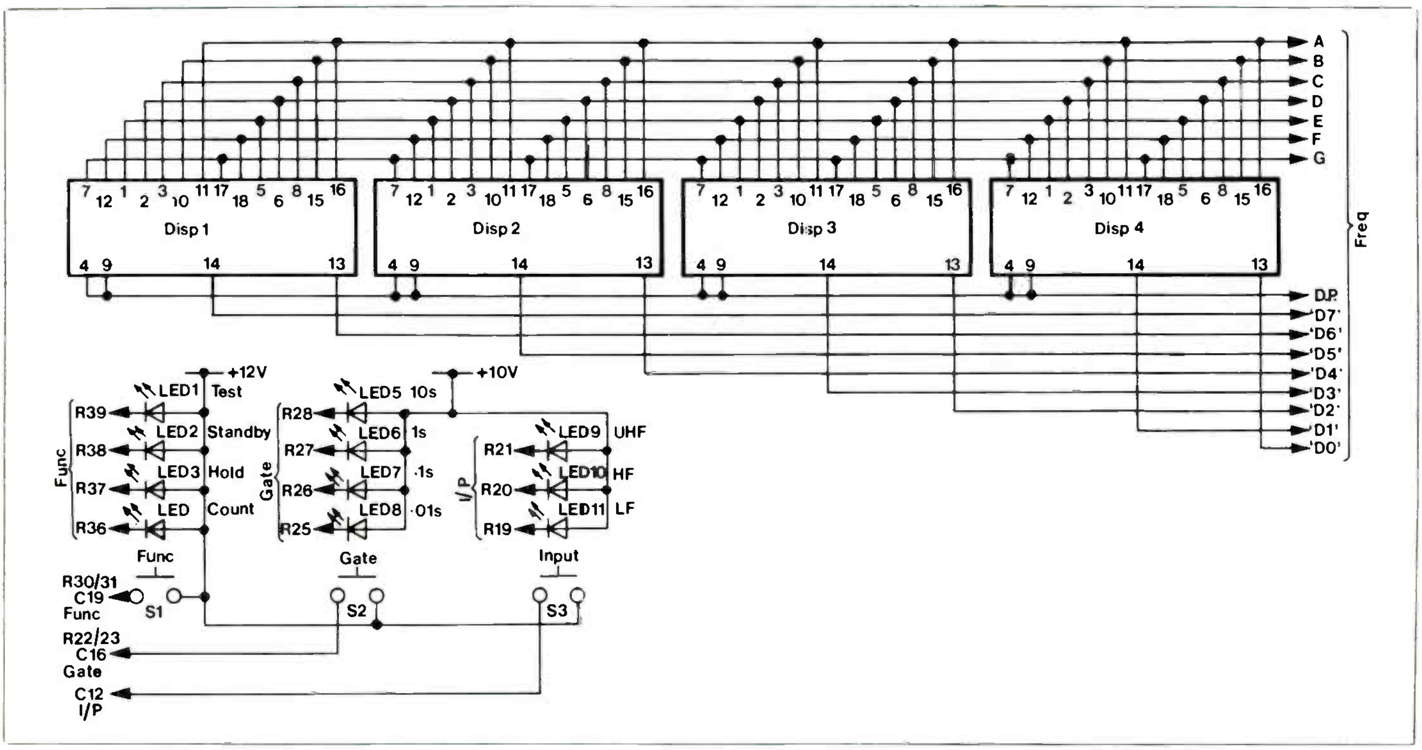


Figure 9. Display circuit.

MAIN PARTS LIST

Resistors: All 1% 0.4W metal film unless specified.

R1	4R7(½W)		(S4R7)
R2,33,51,58	2k2	(4 off)	(M2K2)
R3	10R (3W wirewound)		(W10R)
R4	47R(½W)		(S47R)
R5	4k7		(M4K7)
R6,7,10,12,13, 53,59,71	470R	(8 off)	(M470R)
R15,22,29,30, 34,45	10k	(7 off)	(M10K)
R8,9,14,18,57,65, 67,68,69	1k	(9 off)	(M1K)
R16,17,23,24,31, 32,35,40-44,46, 48-50	100k	(16 off)	(M100K)
R19-21,25-28, 36-39,60	1k8	(12 off)	(M1K8)
R70	1M		(M1M)
R52	100R		(M100R)
R54	560R		(M560R)
R55	150R		(M150R)
R56	270R(½W)		(S270R)
R11,61-64	680R	(5 off)	(M680R)
R66	47k		(M47K)
R47	10M		(B10M)
R72	330R		(M330R)
Capacitors			
C1	10nF suppression Cap.		(FF53H)
C2	1000uF 25V P.C. Electrolytic		(FF18U)
C3,5,6,8,10,11, 14,15,18,21-23, 25,27,36,38-40, 42,12,16,19	100nF disc ceramic	(22 off)	(BX03D)
C4,9	470uF 25V P.C. Electrolytic	(2 off)	(FF16S)
C7,43	220uF 16V P.C. Electrolytic	(2 off)	(FF13P)
C13,17,20	470nF Polycarbonate	(3 off)	(WW49D)
C24	47pF Silver Mica		(WX09K)
C26	10uF 16V Tantalum		(WW68Y)
C28,31	470pF Ceramic	(2 off)	(WX64U)
C29	10nF Disc Ceramic		(BX00A)
C30	47pF Ceramic		(WX52G)
C32	39pF Ceramic		(WX51F)
C33	100pF Ceramic		(WX56L)
C34,35	10nF 500V H.V. disc	(2 off)	(BX15R)
C37,41,44	1uF 35V Tantalum	(3 off)	(WW60Q)
VC1	Trimmer 65pF		(WL72P)
Semiconductors			
D1,2,6,7,10,11, 13-30 inc.	1N4148	(24 off)	(QL80B)
D3	1N4001		(QL73Q)
D12	BZY88C5V6		(QH08J)
TR1	BC337		(QB68Y)
TR2	BC548		(QB73Q)
TR3	ZTX326		(QL54J)
TR4	BSX20		(QF32K)
TR5	2N3819		(QR36P)
REG.1.	uA78M05 JC		(QL28F)
IC1	ICM7216D		(YY94C)
IC2	4051BE		(QW34M)
IC3	4008BE		(QW14Q)
IC4,6	4016BE	(2 off)	(QX08J)
IC5,7,8	4017BE	(3 off)	(QX09K)
IC9,10	4049UBE	(2 off)	(QX21X)
IC11	4093BE		(QW53H)
IC12	74S03		(QY24B)
IC13	74LS90		(YF38R)
IC14	SP8680		(QY18U)
IC15	74LS14		(YF12N)
IC16	MC10116P		(QY23A)
BR1	W005		(QL37S)
Miscellaneous			
X1	10MHz crystal		(FY78K)
RLA	Ultra-min Relay DPDT		(YX95D)
SK1	P.C. Mtg. Power Skt.		(RK37S)
SK2	P.C. Din SKT 5-Pin 'A'		(YX91Y)
FS2	20mm Fuse 1A		(WR03D)
	Fuse clip	(2 off)	(WH49D)
	28 Pin DIL Skt		(BL21X)
	14 Pin DIL Skt	(3 off)	(BL18U)
	16 Pin DIL Skt	(7 off)	(BL19V)
	Veropin 2141	(1 Pkt)	(FL21X)
	Track Pin	(2 Pkt)	(FL82D)
	P.C.B.		(GB02C)
	Screw 6BAx½"	(1 Pkt)	(BF06G)
	6BA Nut	(1 Pkt)	(BF18U)
	6BA Washer	(1 Pkt)	(BF22Y)
	6BA Spacer x ⅛"	(1 Pkt)	(FW33L)
	Kit (P) Plas		(WR23A)

DISPLAY PARTS LIST

Disp 1-4	'DD' Display Type C	(4 off)	(BY68Y)
S1,2,3	Click Key Black	(3 off)	(HY34M)
LED 1-4, 10	Red LED	(5 off)	(WL27E)
LED 5-8, 11	Green LED	(5 off)	(WL28F)
LED 9	Yellow LED		(WL30 H)
	Track Pin	(2 Pkt)	(FL82D)
	P.C.B.		(GB03D)

ADDITIONAL ITEMS LIST

T1	Transformer 12V 500mA	(YK28F)
FS1	20mm Fuse 1A	(WR03D)
	Chassis Fuseholder	(RX96E)
PL1	Euro Conn. Lead set	(BW99H)
SK3	BNC Skt	(HH18U)
	Case	(XY45Y)
	Filter Red	(FR34M)
	BNC Earth Tag	(QY22Y)
	Freq. C. Front Panel	(RK39N)
	Long Power Plug	(HH61R)
	13A Mains Plug	(RW67X)
	Mains Fuse 3A	(HQ32K)

A complete kit of parts is available for this project including an attractive printed and punched adhesive aluminium front panel.
Order As LW79L (Frequency Counter Kit)

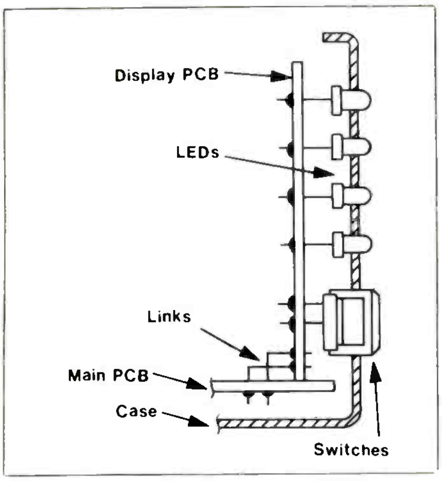


Figure 10. Mounting of switches and LEDs.

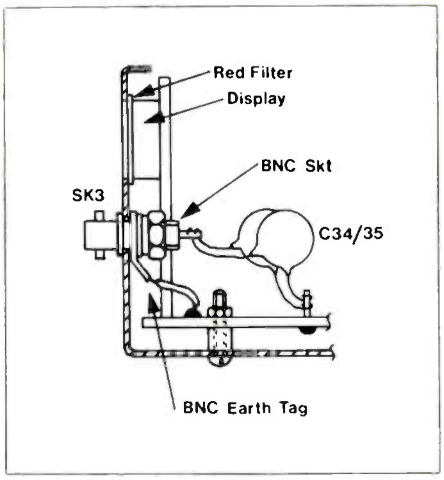


Figure 11. Suggested assembly.

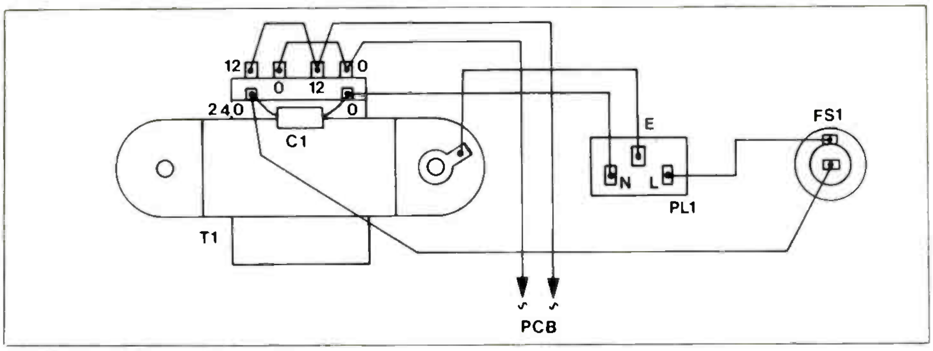


Figure 12. Back panel assembly.

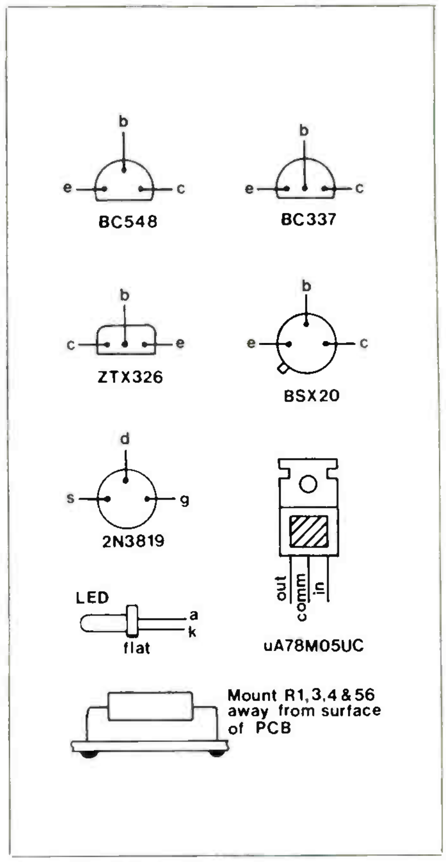


Figure 14. Pin designations.

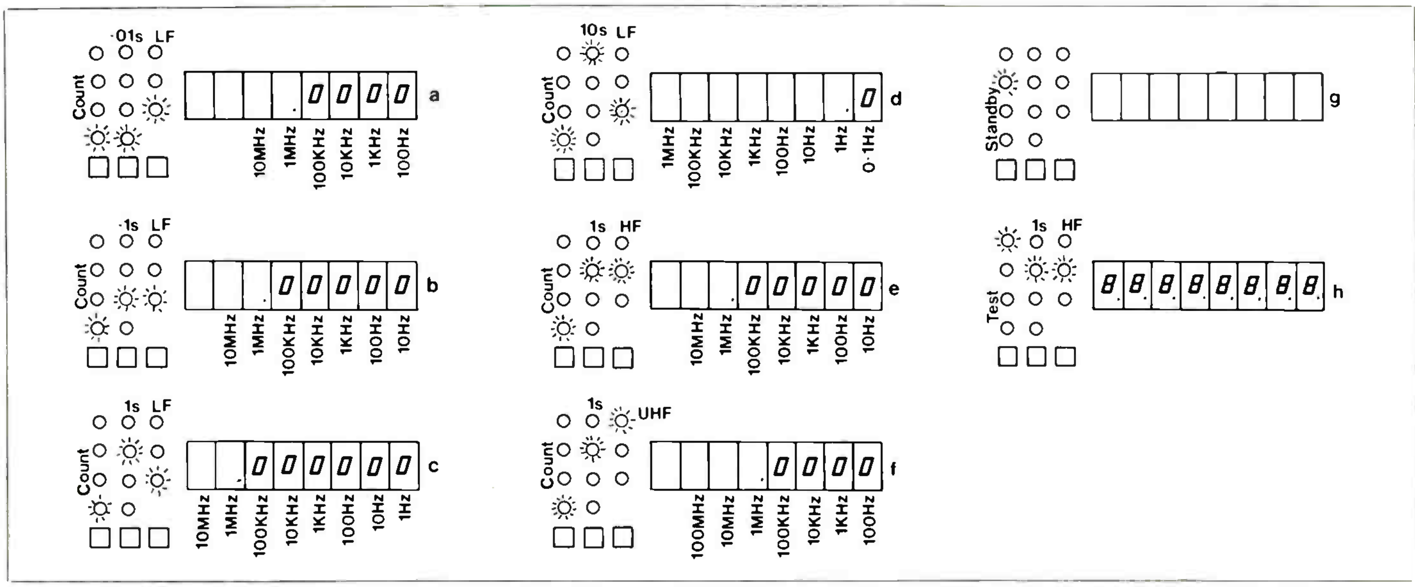


Figure 13. Display conditions.

shown in Figure 13a. Switch through the ranges, and check that the display varies as in Figures 13b to 13h. At this stage the counter is fully working, and frequency measurement is possible.

When the function is in the TEST position, no more than 320mA should be drawn from the DC supply. The counter should now be assembled as described in Construction Details, and the AC feed wires should be connected to the PCB.

Plug in the mains, and check that all functions are correct as before. A DC voltage measurement should be taken between 0V and TP2. Not more than +15V, and not less than +11V should be present. The trimming capacitor VC1 should be adjusted for correct reading using an input of known frequency.■

Note: On the frequency counter PCB legend, two circles designating through pins have been omitted. One is situated just above R6, and the other is just below R6.

IC14 is now supplied as an SP8680, although this was originally an 11C90. The reason for this change was the improved frequency response that this gives.

Because of the style of construction of the polycarbonate capacitors C13, 17 and 20 (WW49D), there is a possibility that these capacitors may short out to the PCB or to each other. We therefore recommend that either steps are taken to ensure that this does not happen, or that encapsulated polycarbonate capacitors are used. Other types of capacitor will not work in these applications.

continued from page 5

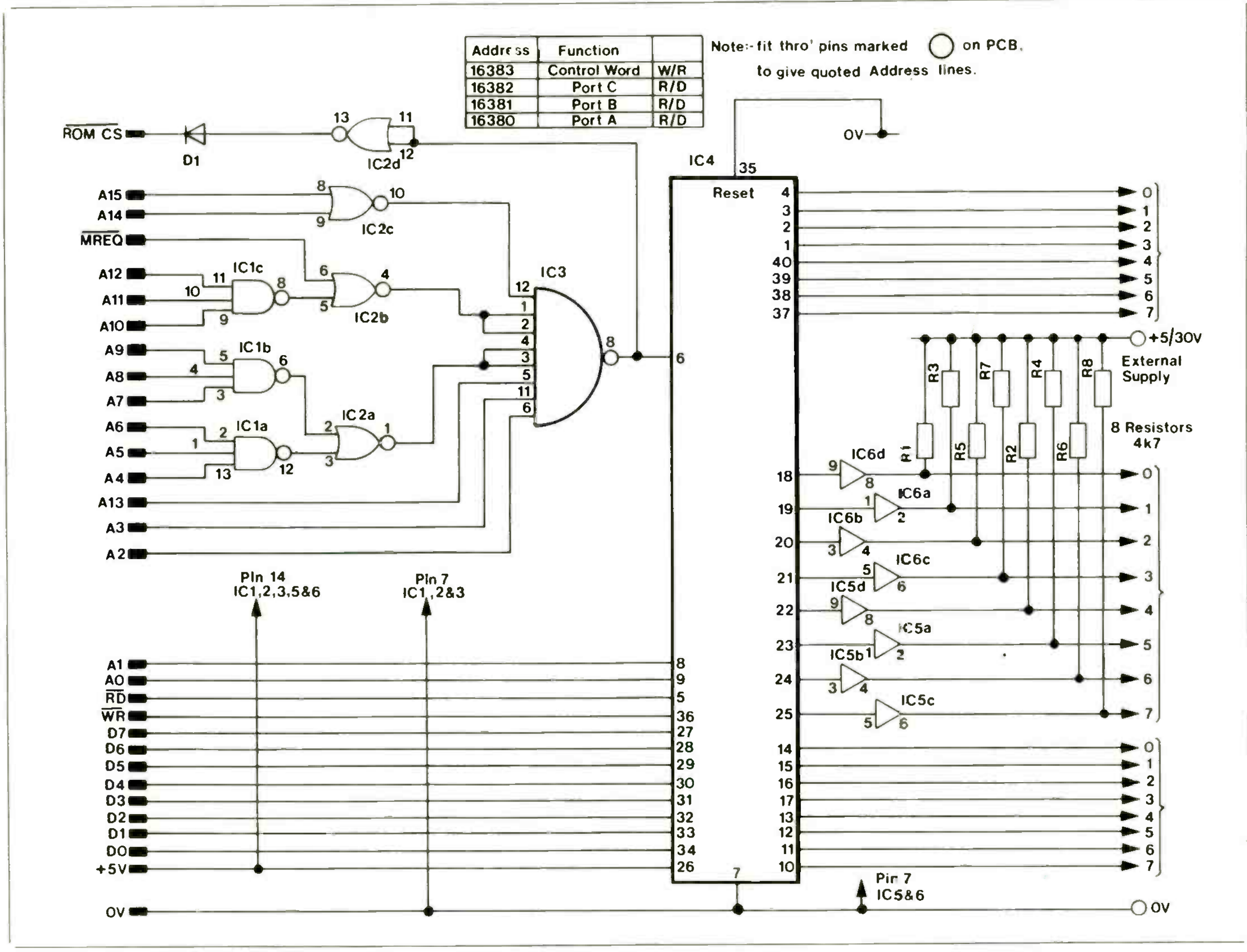


Figure 5. Circuit diagram of I/O Port with alternative address decoding.

MAPLIN TRAIN CONTROLLER PROGRAM FOR ZX81

by Dave Goodman

This program has been designed for use with the ZX81 1k or 16k RAM and our I/O port interface PCB.

Port address used is "16361", and the POKE command in line 3 simulates a track supply fail, bringing on the LED and stopping all trains.

Table 1 shows the decimal value (which, of course, appears as a binary number between 0 and 255) on the data lines.

	A	B	C	D
F	0-9	32-41	64-71	96-105
R	16-25	48-57	80-89	112-121

Table 1. Direction and speed.

So, if controller "A" is required to move a train in a forward direction at a 'snails pace' speed of 1, then the decimal code set up will be 1.

Similarly, to select controller "D" with reverse direction and speed at maximum (9), the required decimal code will be 121.

Type in the program, followed by RUN and NEW LINE. Two statements are printed. The first, EMERGENCY STOP E, allows key E, when pressed, to stop all trains running at any time, and the second, CONTROLLER A-D?, X TO CHANGE, allows you to select the required train control unit A, B, C, or D. Pressing key X allows you to re-select a control unit.

Select a control unit (A-D) and note that a third statement is added, DIRECTION F/R?.

```
1 POKE 16363,128
2 LET E "16361"
3 POKE E, 128
4 CLS
5 PRINT "Emergency STOP E"
6 PRINT "Controller A-D?, X To change"
7 GOSUB 100
8 IF C$<"A" OR C$>"D" THEN GOTO 7
9 LET D$=C$
10 PRINT "Direction F/R?"
11 GOSUB 100
12 IF C$="F" OR C$="R" THEN GOTO 14
13 GOTO 11
14 LET E$=C$
15 IF E$="F" THEN LET H=0
16 IF E$="R" THEN LET H=16
17 PRINT "Speed 0-9?"
18 GOSUB 100
19 IF C$<"0" OR C$>"9" THEN GOTO 18
20 IF D$="A" THEN POKE E, VAL C$+H
21 IF D$="B" THEN POKE E, VAL C$+H+32
22 IF D$="C" THEN POKE E, VAL C$+H+64
23 IF D$="D" THEN POKE E, VAL C$+H+96
24 GOTO 4
100 IF INKEY$<>"" THEN GOTO 100
101 IF INKEY$ ="" THEN GOTO 101
102 LET C$= INKEYS
103 IF C$="E" THEN GOTO 3
104 IF C$="X" THEN GOTO 4
105 RETURN
```

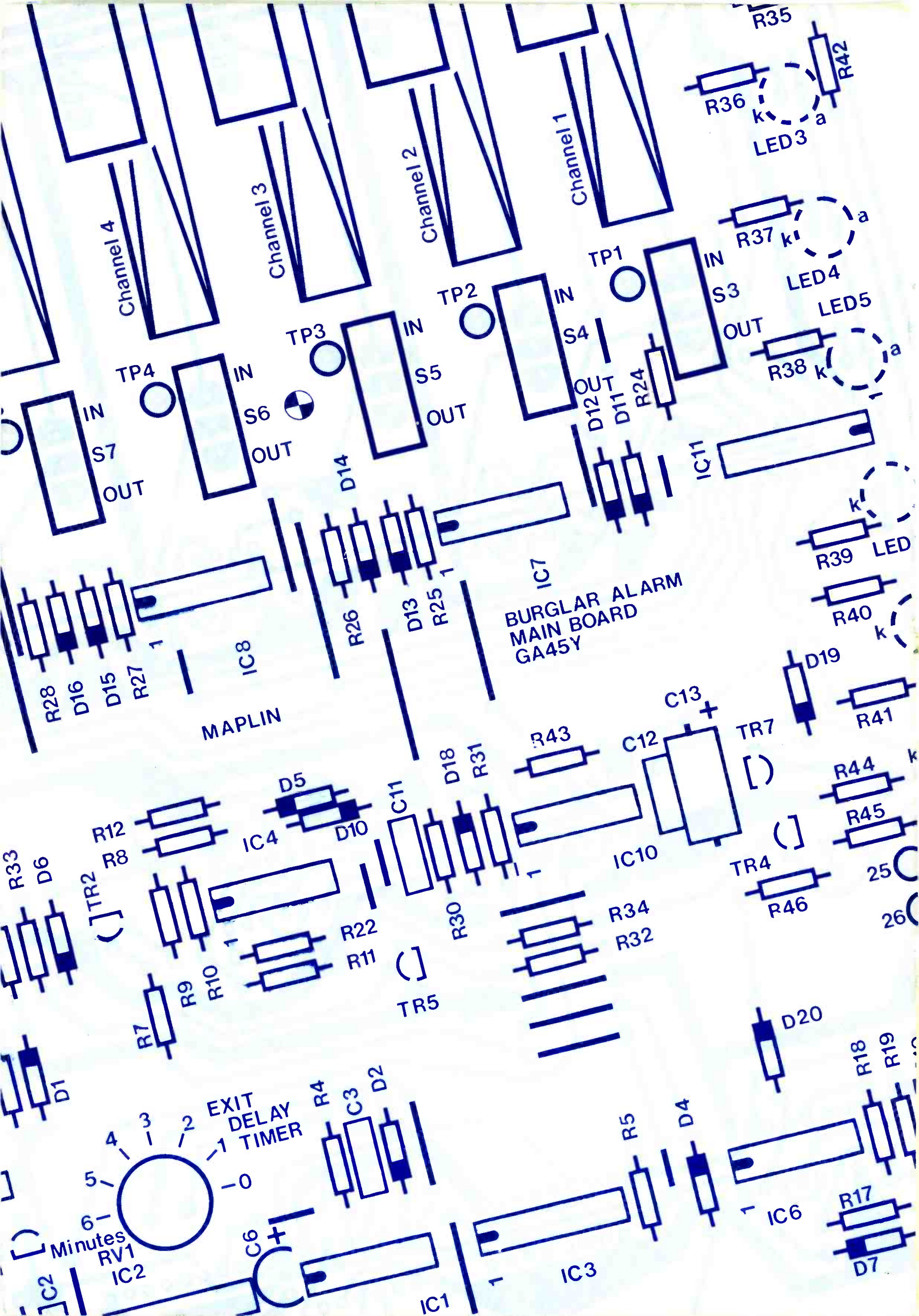
Now that you have selected a controller the direction of travel is needed. Press key F for forward, key R for reverse.

Finally a fourth statement is added, SPEED 0-9?. Now that control and direction are set, train speed must be chosen. Note that speeds minimum (0, stopped) to maximum (9) are set by keys 0 to 9 in either forward or reverse. Press a number, and the code corresponding to all variables will set the train running. The screen will then return to the first two statements, waiting for A-D, F-R, and 0-9 to be input again. Remember that E (panic), and X (train controller) can be pressed at any stage, and that NEWLINE is not required during the program. Under normal conditions the program should be found to be crashproof, and entry to the program is made by pressing the BREAK key (D/101) and NEWLINE.

Connections from the I/O port PCB to the train control remote latchboard are as follows:—

I/O port B pins	Remote data latch PCB pins
0	28 - B5
1	27 - B6
2	30 - B4
3	31 - B0
4	32 - B1
5	33 - B2
6	34 - B3
7	26 - B7
OV	28 - B5

The +5V supply for the I/O port buffers IC5 and 6 can be taken from the ZX81 +5V supply.


BURGLAR ALARM
MAIN BOARD
GA45Y
MAPLIN
Channel 1
Channel 2
Channel 3
Channel 4
TP1
TP2
TP3
TP4
S3
S4
S5
S6
S7
IN
OUT
LED3
LED4
LED5
LED
R35
R36
R37
R38
R39
R40
R41
R42
R43
R44
R45
R46
IC1
IC2
IC3
IC4
IC6
IC7
IC8
IC10
IC11
D1
D2
D4
D5
D6
D7
D10
D11
D12
D13
D14
D15
D16
D18
D19
D20
R4
R5
R7
R8
R9
R10
R11
R12
R17
R18
R19
R22
R24
R25
R26
R27
R28
R30
R31
R32
R33
R34
C2
C3
C6
C11
C12
C13
TR2
TR4
TR5
TR7
25
26
EXIT
DELAY
TIMER
Minutes
RV1
0
1
2
3
4
5
6