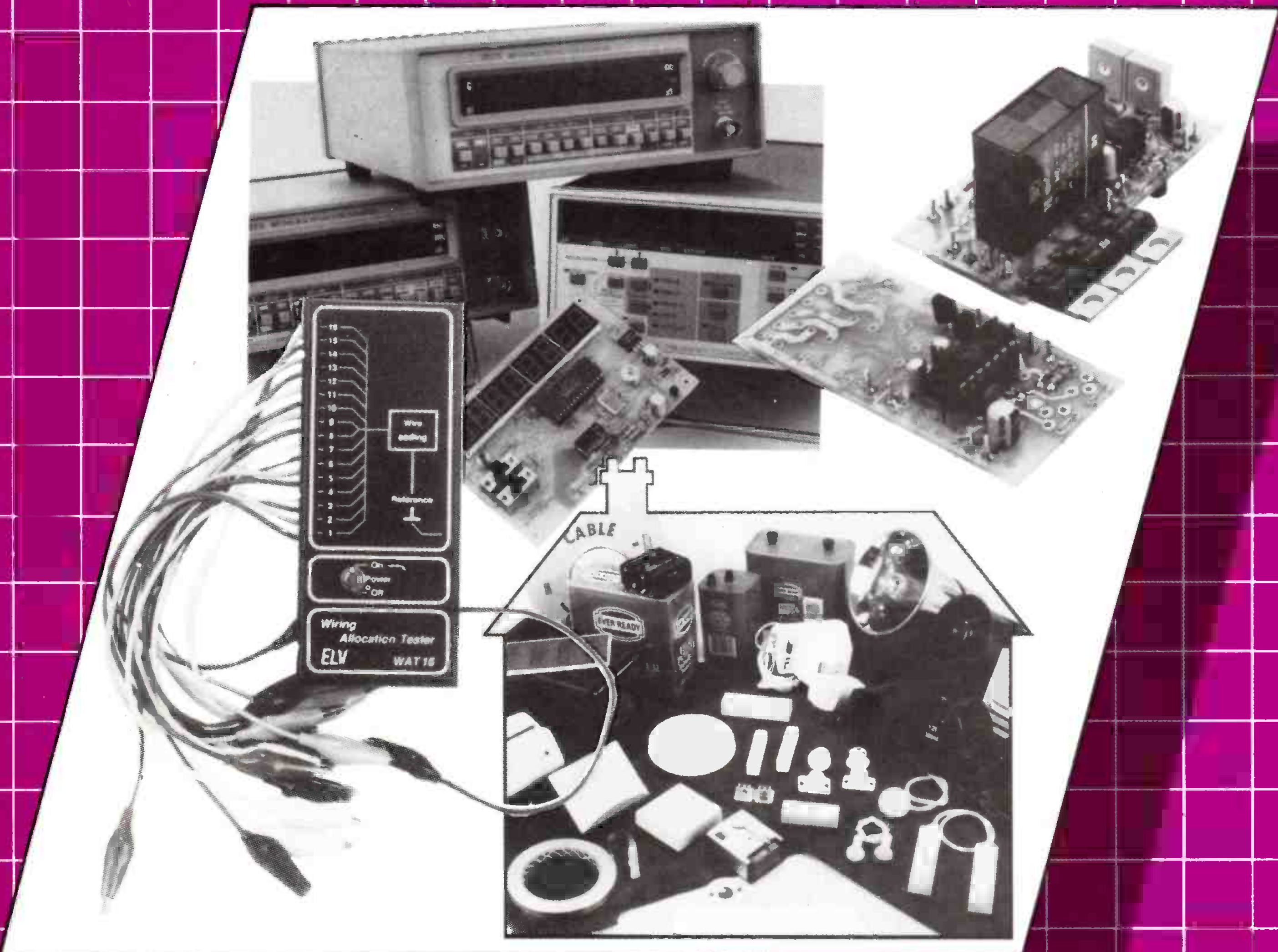
PROJECTS BOOK 45

Maplin Maplin Maplin



WIRING ALLOCATION TESTER
LOW-COST HOME ALARM
LOW-COST 10MHz COUNTER
PRECISION SERVO DRIVER

CONTENTS

MAPLIN PROJECTS BOOK FORTY FIVE

EDITORIAL

■ This Project Book replaces Issue 45 of *Electronics*, which is now out of print, and contains a compilation of projects from this magazine. Other issues of *Electronics* will also be replaced by Project Books once they are out of print. For current prices of kits please consult the latest Maplin Catalogue or the free price change leaflet, order as CA99H.

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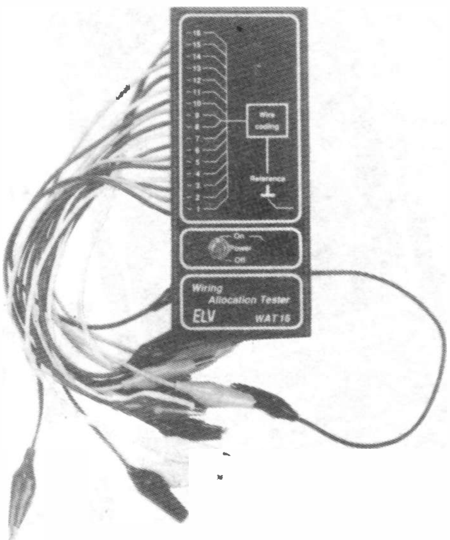
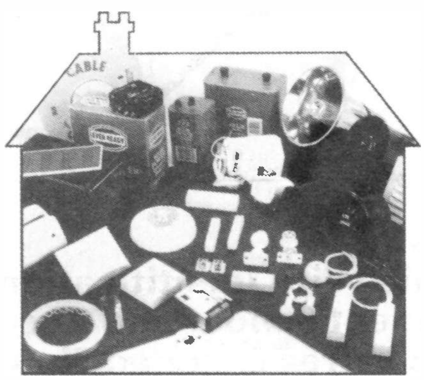
PROJECTS





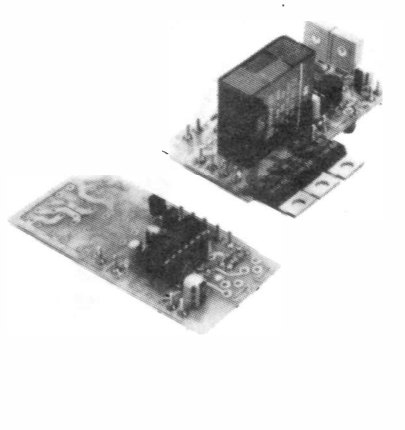


Photo 1. Transmitter with test leads.

Design by ELV
Text by
Alan Williamson

WIRING ALLOCATION TESTER

Features

- ★ Electronic Wire Identification
- ★ Independent Sender and Receiver
- ★ Up to 16 Wires Encoded Simultaneously
- ★ One Person Operation
- ★ Digital Readout of Wire Number
- ★ Crystal Controlled Accuracy

Introduction

This project is a handy test instrument which takes the hassle out of identifying and trouble-shooting multi-way cable installations.

Anyone who has ever installed a multi-way cable between two locations in the home or the office is probably familiar with the problem of wire identification. Often the connections must be made in awkward, difficult-to-reach corners, while communication with an assistant at the 'other end' may be difficult or impossible (or you may have no assistant). Such multi-way cables are commonly used in telephone, intercom and alarm systems.

Obviously a cable of only 2 conductors does not raise these sorts of problems, similarly if each conductor in a multi-way bundle has a unique colour. In many alarm systems, however, multi-way cables without colour coded conductors are in common use for security reasons. Also difficulties with wiring allocation may arise where a cable is extended by adding a length of multi-way cable that happens to be available, but is not identical.

In these instances it would be reassuring to be able to check and record the function or number of each conductor in the cable. The Wiring Allocation Tester provides this service in a fast and efficient manner that eliminates the risk of wrong connections. The system has two parts: at one end of the cable a code transmitter is used to send a unique signal on each conductor, while a special receiver at the other end checks whether each wire's code is coming through with the aid of a digital read-out. Both the transmitter and receiver are light-weight, battery-powered units in rugged ABS enclosures.

Principle of Operation

The transmitter can encode up to 16 different conductors at once by attaching small crocodile clips to the cable. If a cable has fewer than 16 conductors, the remaining transmitter connectors are simply not used. If there are more that 16 conductors in the cable, then these can be allocated in groups of 16 at a time. It is important however to make sure that the conductors to which the transmitter is connected have no voltages present or power applied, nor should they be shorted together or cross connected at any point.

At the transmitter end, each conductor must be labelled with numbers 1 to 16, corresponding to the numbers printed on the front panel of the transmitter. The single lead at the opposite side of the transmitter box is marked REFERENCE and must be connected, for any test, to the corresponding REFERENCE lead on the receiver. In many cases it is possible to make use of the cable screening braid if it has one, or a conductor in the bundle with some distinguishing feature that makes it identifiable from the others. If neither of these actions is possible then the REFERENCE leads on both the transmitter and the receiver may be clipped to a nearby earth connection such as a metal water supply pipe, or a central heating pipe.

The receiver has two leads, one for ground (REFERENCE) and one for testing any of the conductors previously allocated at the other end of the cable. Both receiver leads have crocodile clips as used on the transmitter. The signal input lead of the receiver is connected to the required conductor in the cable. The instrument indicates the number of the wire as defined at the transmitter side (1 to 16) on a liquid crystal display (LCD). Short-circuits to the REFERENCE potential are indicated by the display reading '36'.

Both the transmitter and the receiver are each powered by a 9V battery. The battery in the transmitter may be installed by unlocking the cross-head screw at the back of the instrument and removing the top half of the enclosure. The receiver has a separate battery compartment that may be opened without unlocking a screw.

The transmitter's battery will typically last for about 400 hours and the receiver's battery about 2,000 hours of operation assuming that a PP3 size Alkaline type is used (e.g. FK67X). The transmitter has a red flashing LED to indicate that the unit is switched on, which goes out if the battery voltage drops below about 6·5V, thus

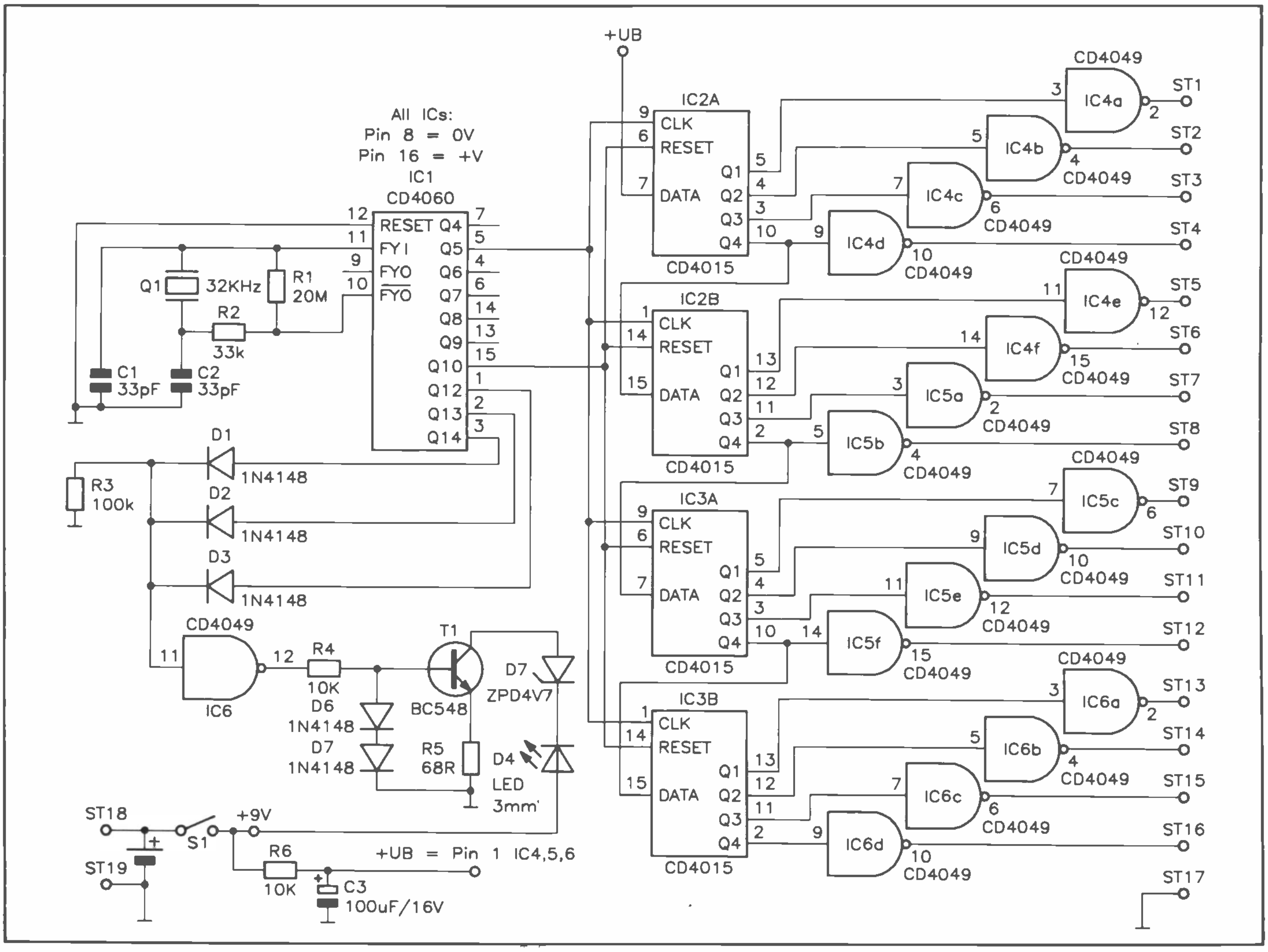


Figure 1. Circuit diagram of the transmitter unit.

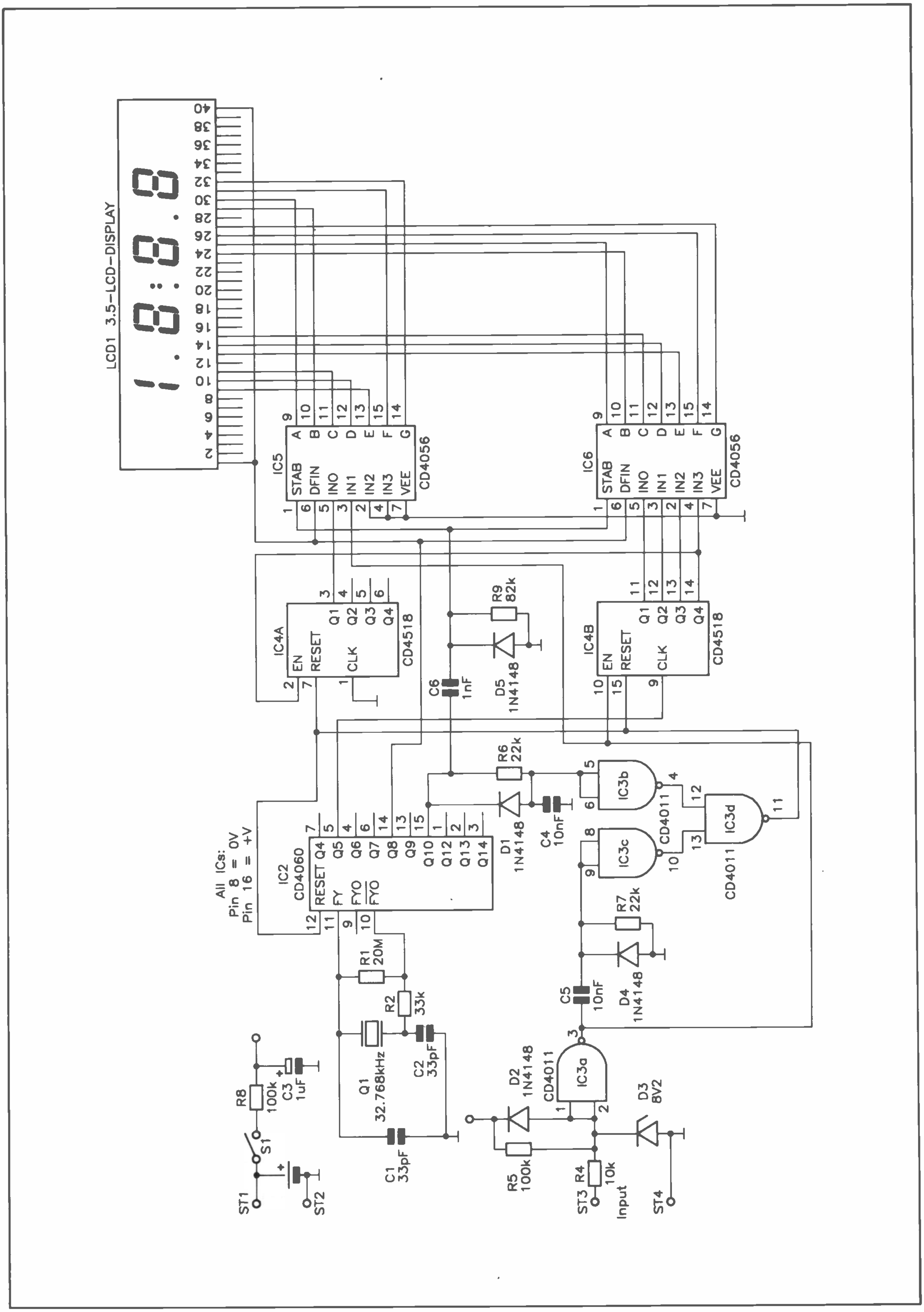


Figure 2. Circuit diagram of the receiver unit. The use of a battery is optional since the circuit may be powered by the transmitter.

indicating that a new one should be installed, but the instrument will continue to operate for a couple more hours.

The receiver's on/off slide switch is located on the left-hand side panel of the instrument. A conductor number is displayed when a valid code from the transmitter is received.

The Transmitter

The circuit diagram of the transmitter is given in Figure 1. The 9V supply voltage is applied to decoupling capacitor C3 via switch S1 and R6. The voltage across C3 is used to power all transmitter circuits with the exception of the LED. The actual circuit supply voltage is of relatively little importance and lies between 5V and 8V depending on the number of conductors connected since CMOS ICs, as used here, can usually operate from supplies between 3V and 15V

IC1 is a 14-stage, binary ripple up-counter containing an oscillator operating at 32·768kHz as determined by the quartz crystal Q1. Divider stages in IC1 provide a number of control signals for the other parts of the circuit. Output Q5 supplies a frequency of 1024Hz, used to clock all of the four 4-bit shift registers in IC2 and IC3 in parallel. The data input of IC2a is tied to the positive supply line, resulting in a logic one being transferred first to Q1 and then to all outputs of IC2a on each low to high transition of the clock pulse received from IC1.

As IC2a Q4 is the data source for the second shift register, IC2b, then Q1 of the second stage goes high on the fifth clock pulse applied to IC2a, and then outputs IC2b Q2, Q3 and Q4 go high on the sixth, seventh and eighth clock pulses respectively. This process continues through IC3a and b until the last output to go high is Q4 of IC3b. In other words all 16 outputs change state from low to high one after the other so that while the last, number 16, is high for just one clock cycle, the first is high for a full 16 clock cycles.

At the end of this Q10 of IC1 is used to clear or reset all shift registers to zero. The reset state is of the same duration as the period in which all 16 clock pulses are produced, so that when Q10 goes low again after 32 clock pulses, the shift registers are enabled again to accept the clock pulses supplied by Q5 of IC1. This sequence is repeated, starting with the low-to-high transition of Q1 of IC2a. The 'on' (logic high) time of any shift register output depends on its position in the chain, so that while IC2a Q1 has the maximum on-time of 16 clock periods, IC3b Q4 is high for only one period. It is by these time periods that the receiver recognises each of the 16 conductors. Hex inverters IC4 to IC6d buffer the 16 lines for output to the crocodile clips as active low.

The power on indicator D4 has its anode connected to the 9V supply voltage directly behind the contact of switch S1. The cathode is connected to the collector of T1 via 4·7V Zener diode D5, and these together with associated components D6, D7 and R5 form a 10mA current source. The LED will light at constant brightness

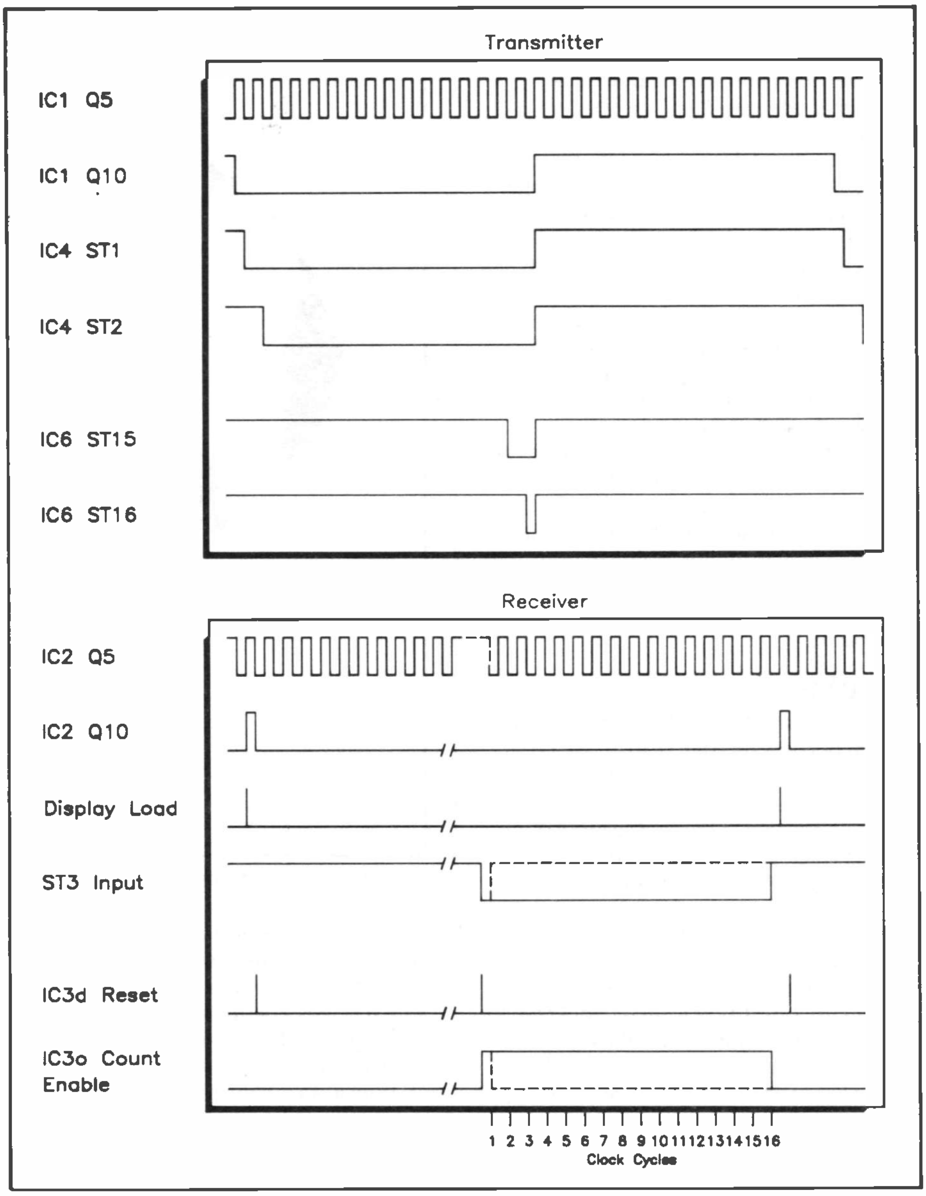


Figure 3. Timing diagrams to illustrate the operation of the code transmitter and receiver.

while the battery voltage exceeds about 6·7V. This value is obtained by subtracting the sum of the voltage drops across R5 (0·7V), D5 (4·7V), and D4 (1·3V) from the nominal battery voltage of 9V; there is negligible voltage drop across the collector-emitter junction of T1. If the battery voltage drops below 6·7V, the LED is rapidly reduced in brightness until it goes out at about 6·0V.

This current source is pulsed, thereby flashing the LED, to keep the overall current consumption as low as possible. IC1 outputs Q12 – 14 are combined with a wired OR function provided by D1 – 3 and R3 to produce an LED flash rate of about 2Hz. This arrangement results in a power saving of around 12·5%.

The Receiver

The circuit diagram of the receiver is given in Figure 2. Like the transmitter, the receiver is powered by a 9V battery via S1 and an RC network, R8 and C3. R8 has a relatively high value which ensures a circuit supply voltage of around 5V. Since the receiver circuit does not contain current-hungry components, the battery capacity will be sufficient for about 2,000 hours of operation.

Again a CD4060 oscillator/divider is used as the central clock source, IC2. The clock pulse frequency at output Q5 is also 1024Hz as derived from the quartz crystal, Q1, frequency of 32·768kHz. This signal is applied to the clock input of a first decade counter, IC4b at pin 9. The sampling period of the counter, during which a number of these clock pulses can be counted, is determined by the duration of a 'gating' or enable signal applied to pin 10. This period 'gate' control originates directly from the receiver's input.

The sequence of events can be followed commencing with the moment when output Q10 of IC2 supplies a reset pulse. This low-to-high transition is delayed by the integrator network R6 and C4 and inverted by IC3b which connects to IC3d. Because of the NAND logic function of IC3d, this now inverted low level input forces it to output a low-to-high transition which is used to reset the counters in both halves of IC4, as well as the oscillator/divider, IC2. Consequently output IC2 Q10 goes low again, terminating the reset pulse, and the circuit is then ready to begin a new count cycle.

If the receiver's input at ST3 is open circuit then the inputs of gate IC3a are pulled high by R5. As IC3a is wired as an inverter, its output is then at a constant logic low level that maintains the first stage counter IC4b in a disabled state by tying the enable pin low, even though this counter is receiving clock pulses. The display indicates '00' in this condition.

If however ST3 and ST4 are connected, then IC3a outputs a logic high that enables counter IC4b. Also on this transition a monostable made up from C5, D4, R7 and IC3c generates a very short, logic 0 pulse for the other input of IC3d, which again will reset the two counters in IC4, as well as the oscillator/divider, IC2. Since the pulse is very short, these circuits are re-enabled almost immediately afterwards, so that the clock pulses supplied by output Q5 of IC2 may again be counted by IC4b and IC4a from the beginning. It can be seen from this that, since the timebases of both the transmitter and receiver are identical, pulses from any of the transmitter's outputs when applied to ST3 will exactly synchronise both timebases.

Display

The four outputs of IC4b are in binary format but only register '0' to '9' (BCD). After '9' the counter rolls over to '0' again, but a carry is effected by Q4 going low while connected to the enable input of IC4a. With the 'CLK' input permanently grounded, 'EN' of IC4a becomes effectively a negative edge triggered clock input to register a count of 10.

Because it need only discriminate between 0 and 1 (higher values than 16 do not occur), only Q1 of IC4a is connected to the least-significant input of the associated BCD to 7-segment latch/decoder/LCD driver IC5. The next higher input of IC5,

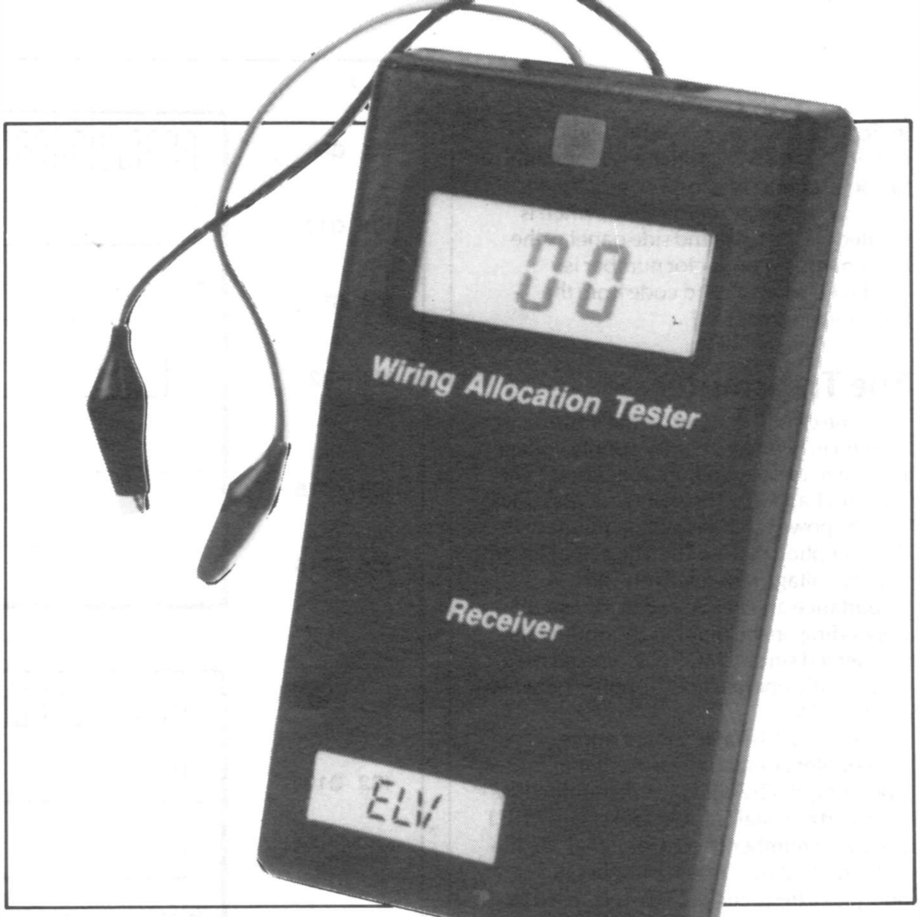


Photo 2. The finished receiver.

pin 3, is driven by IC3a, so that if a short-circuit exists between a conductor and the reference (ground) potential, this gate supplies a permanent logic high level causing the value received by IC5 to be increased by '2'. As a result, the count of '1' from IC4a is changed into '3', and this is why short-circuits in the cable are indicated by the unique value '36' on the display.

The low to high reset transition from IC2 Q10 is also communicated via a simple non-inverting monostable contrived from C6, D5 and R9 to the 'STRB' inputs of both IC5 and IC6, to latch the count into the drivers for display. This is why there is a need to delay the reset pulse with R6 and C4, so that the value can be retrieved before the counters are cleared by the same output, Q10. Since the previously established counter states are latched in IC5 and IC6, the display reading does not change. When the input terminals are disconnected, the display shows '00' after the next count cycle. Since the measurement rate is about 30 per second, the display changes for each wire connection test virtually immediately.

Since the LCD needs an AC backplane signal, the Q8 output of IC2 is utilised for this purpose, thus obviating the need for another special backplane generator chip. The frequency of the backplane signal is 128Hz.

Encoding the Cable

Figure 3 shows two timing diagrams for the transmitter and receiver. It can be seen that while the output of IC4 ST1 of the transmitter is low for all 16 clock cycles, each successive output goes low one cycle later, until IC6 ST16 is the last to go low for only one clock cycle. Hence each wire in a cable loom is identified by the duration of an active low pulse. Left to its own devices, i.e. with ST3 open circuit, the receiver idles at the same frequency but is not locked to the transmitter, and the counters are reset to zero by the reset pulse from IC2 Q10 after every 32 clock cycles. The display shows '00' (open circuit or

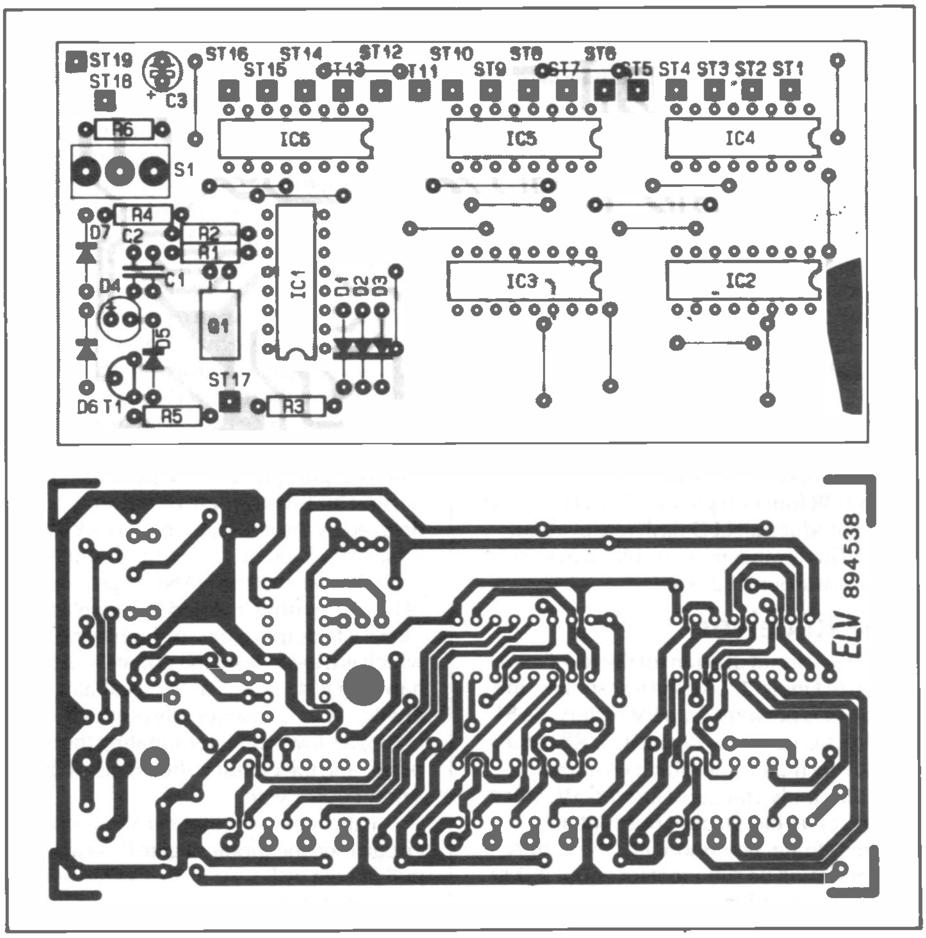
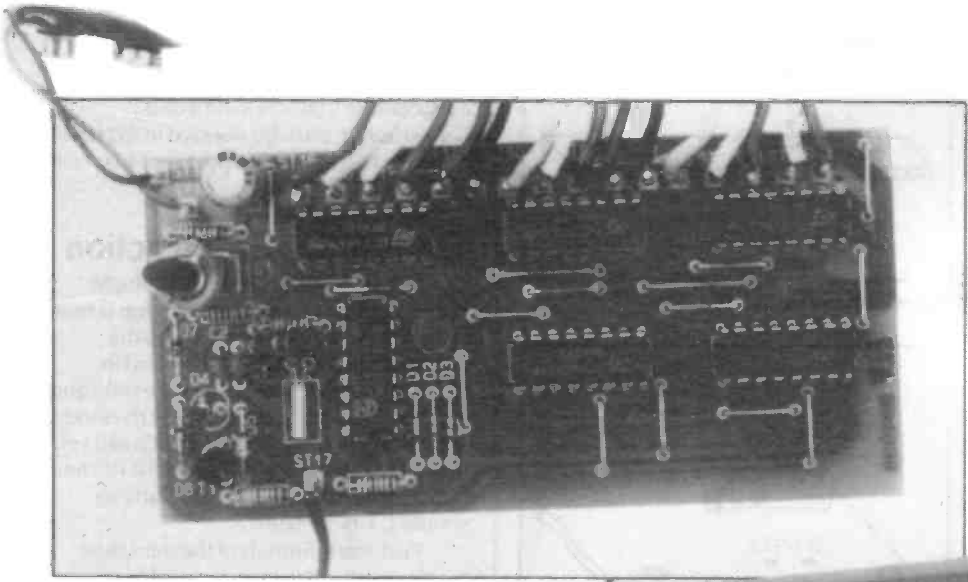


Figure 4. Printed circuit board for the transmitter.



'nothing') while IC3a output is low.

When the receiver is connected to one of the wires to test, the transmitted active low pulse, if present, first synchronises the receiver by the high to low leading edge resetting both its timebase and display counters via IC3d, before enabling the counters to count the timebase clock cycles with IC3a. The number of these depends on the length of the transmitted pulse and, because both the transmitter and receiver timebases are crystal controlled, the counts are very accurate. If the test pulse is the longest (16 clock cycles) then the receiver will be able to count a full sixteen of its own clock pulses before 'reset' transfers the result to the display. If however the test pulse is shorter, then the receiver is only allowed to count a correspondingly fewer number of cycles.

Note that ST1 – ST16 *do not* correspond to the front panel numbers on the transmitter, which are the reverse way round. Hence ST1 outputs the *longest* pulse allowing the maximum of 16 counts (for wire 16), while ST16 has the *shortest* allowing only one count made by the receiver (for wire 1). Hopefully this will avoid some confusion while testing the instrument.

The input of IC3d is protected by R4 in series with clamping diodes D2 and D3, the latter being a Zener type to limit positive going inputs, as D2 alone would not provide sufficient protection against

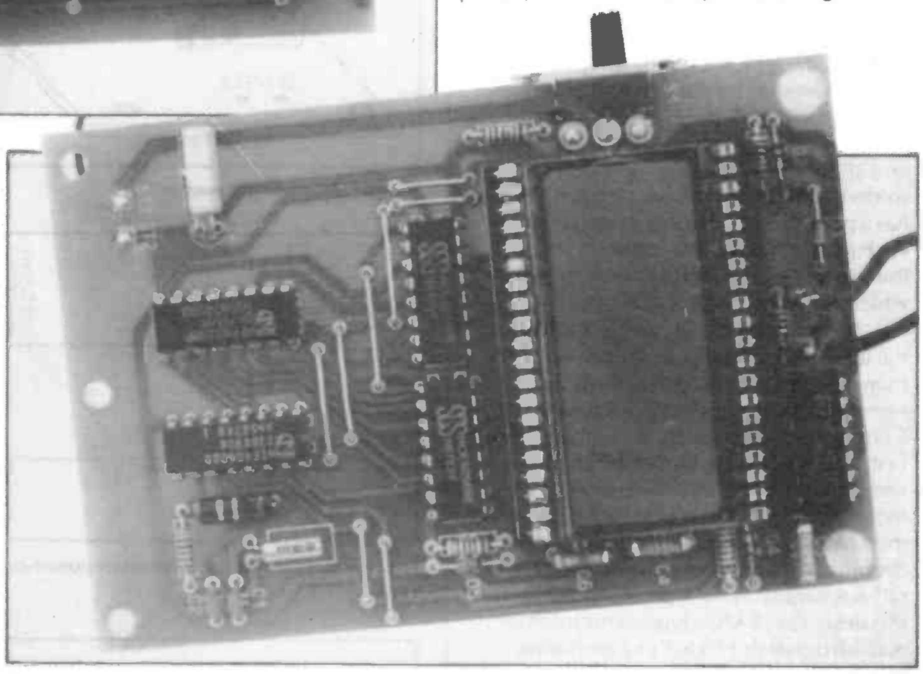


Photo 3. Transmitter and receiver assembled PCBs.

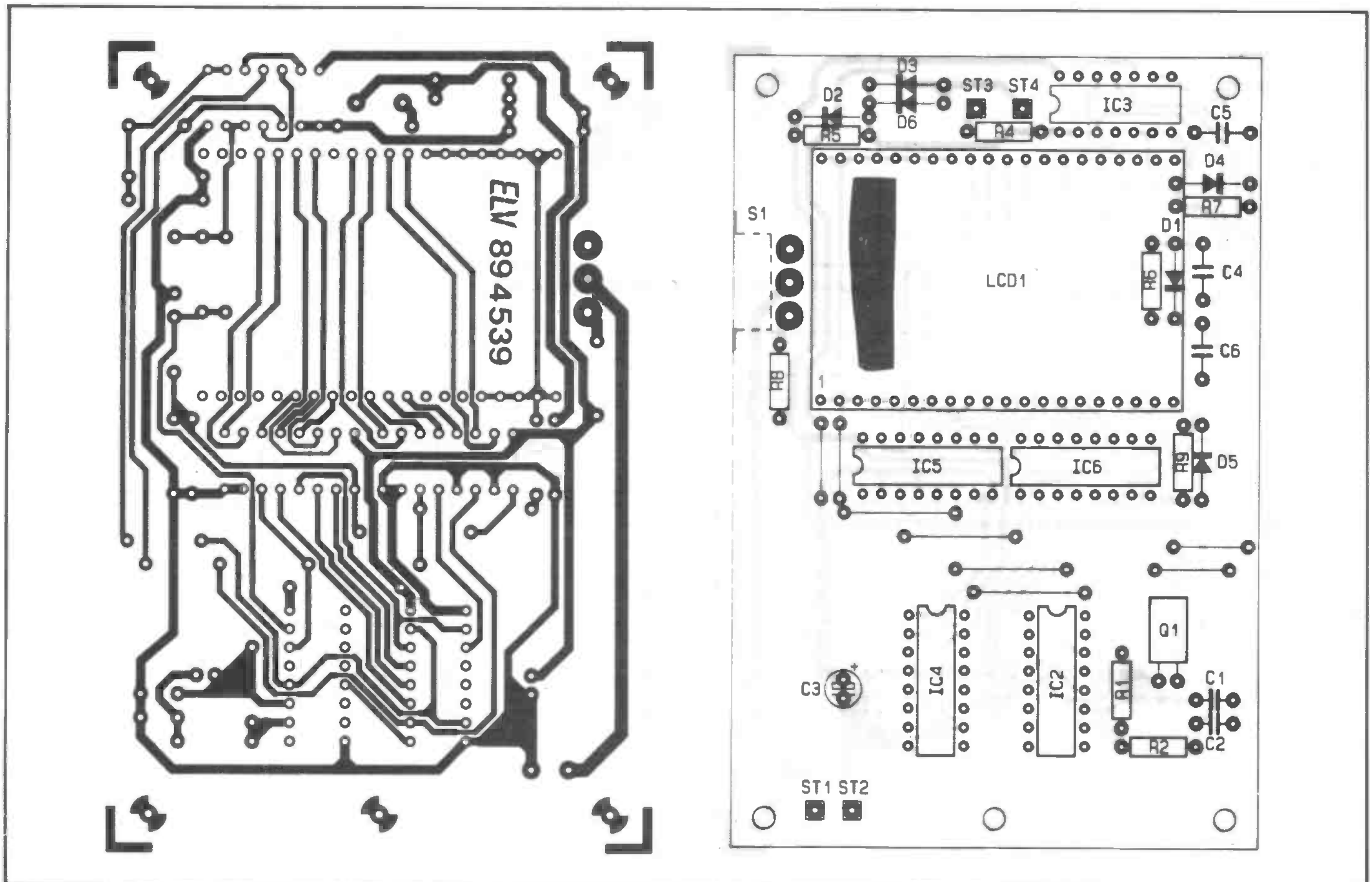


Figure 5. Printed circuit board for the receiver.

serious input overload conditions, although it serves to prevent the inputs of IC3a exceeding the chip's supply potential.

General PCB Assembly

For those readers with little experience in project building, a 'Constructors' Guide' (stock code XH79L) is available to help with component identification. This helpful booklet also contains hints and tips on soldering and constructional techniques. Please note that, unlike most other Maplin kits, this guide is *not* included in this kit.

If errors are made during assembly of the PCB, the removal of a misplaced component may be difficult without causing too much damage, so *please* double-check each component type, value and its polarity where appropriate, before soldering! Each printed circuit board (PCB) has a printed legend to assist in positioning each item correctly, see Figures 4 and 5 for the transmitter and receiver respectively, which also show the track layouts.

In each case install, solder and trim the leads from all the components ensuring than no wires stand proud of the board by more than two or three millimetres. Commence with resistors and capacitors first, and diodes last. Only after all other components have been fitted would you then carefully insert the relevant ICs into their places, making sure to correctly align the pin number 1 marker at one end of each DIL package with the legend. All the ICs in this design are CMOS types which can be at risk from static electric charge during handling, so do not remove them from their protective packaging until they are needed, and handle them carefully when you do so. All ICs have to be soldered in position, which should be done carefully with pauses of several seconds between soldering each pin. To ensure that the package lies flat on the PCB, solder two diagonally opposite pins at two corners first while pressing the device to the PCB.

Make sure that electrolytic capacitors are fitted the correct way round. The negative lead, indicated by a dark stripe and minus (−) sign on the body of the capacitor (or light stripe on a dark background), must be inserted in the hole opposite that marked as positive (+) on the PCB legend.

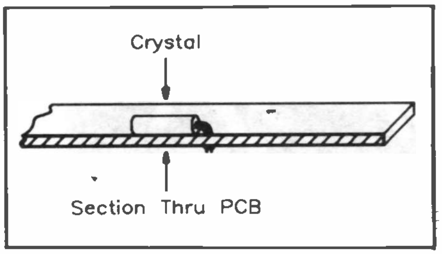


Figure 6. Mounting the crystal Q1.

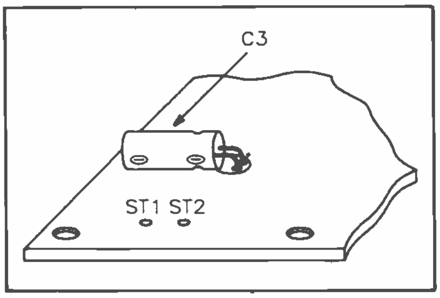


Figure 7. Mounting capacitor C3.

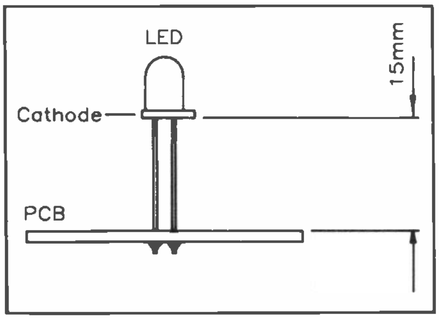


Figure 8. Positioning the transmitter power-on LED.

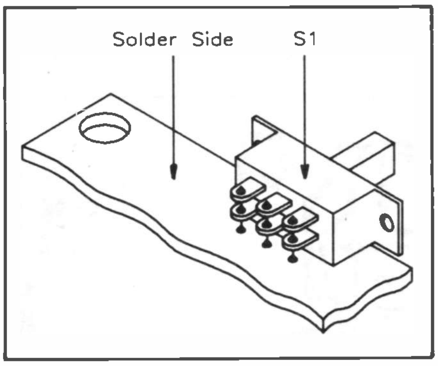


Figure 9. Mounting the receiver's on/off switch.

Transmitter Construction

The transmitter is built on a single printed-circuit board. Construction is quite straightforward with reference to the transmitter parts list and the legend in Figure 4. Begin by fitting the wire links and resistors, then the capacitors. Fit the diodes and transistor next, *but not the ICs just yet*. Crystal Q1 should be mounted flat on the PCB as shown in Figure 6, similarly so should C3 as in Figure 7.

Push the terminals of the miniature toggle switch, S1, as far as possible into its allocated holes, then solder them at the track side. Fit the LED D4 so that the lower side of its plastic body is about 15mm above the board surface, as shown in Figure 8. It may help to cut a 15mm wide strip of card for insertion between the pins to accurately position this item.

Connect the battery clip wires to solder points ST18 (+, red wire) and ST19 (−, black wire). ICs 1 to 6 can then be installed with regard to the precautions mentioned earlier.

Seventeen crocodile clips and flexible leads are provided with the kit for the transmitter. The leads should be arranged into a regular colour distribution, with either black or white for the individual 'REFERENCE' connection. Insert the free end of each lead into its respective hole in the side of the top half of the transmitter case. Make a knot in each lead on the inside to provide a strain-relief and a free length of about 10mm. Connect all 16 signal input leads, and the single reference lead, to their respective points on the PCB, bearing in mind that, as mentioned earlier, wires numbered 1, 2 and so on go to ST16, 15 etc., up to wire 16 at ST1, in 'reverse order'. Otherwise the PCB will be connected to the case top half back to front! Finally attach the chosen 'REFERENCE' wire to ST17.

Carefully fit the completed PCB into the lower half of the enclosure, and install

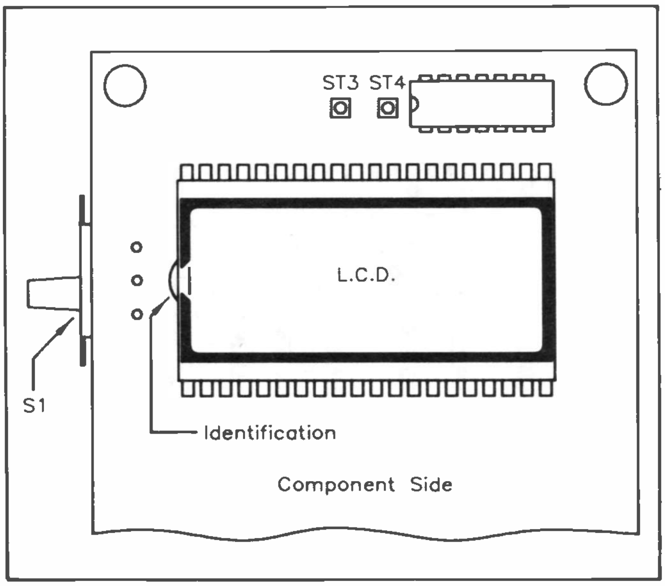


Figure 10. Orientation of the LCD.

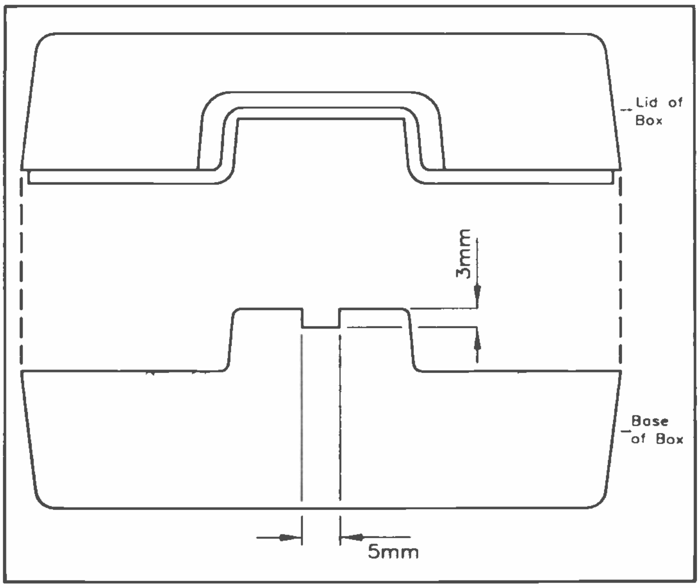


Figure 11. Receiver box cut-out details.

and connect the battery. Remove the nuts from the switch's threaded boss and place the top half of the enclosure onto the lower half, while carefully drawing out all 17 leads up to their strain-relief knots. Also make sure that the top of the LED is about level with the front panel surface. Then the top and the bottom halves of the case can be secured with the self-tapping screw provided.

Receiver Construction

The construction of the receiver is also straightforward but a few special points should be noted.

The LC display is not soldered directly onto the board but instead plugs into the pair of 20-way contact strips, which are soldered in place first. These contact strips raise the LC display a little so that its face is at the correct height for the front panel of the enclosure, but especially to prevent heating of its pins by a soldering iron splitting the glass! Do not insert the display at this stage yet.

As with the transmitter, fit the wire links and resistors followed by the capacitors and diodes. Again fit capacitor C3 and the crystal Q1 flat on the board. To fit S1, cut off three 10mm long pieces of the wire supplied in the kit and solder these at one end into the three holes for the slide switch S1. Make sure they remain vertical. Next, slide the solder terminals of S1 over the wires until S1 is flush on the board, and solder in position, but without also melting and moving the PCB solder joints on the PCB! See Figure 9 for an illustration.

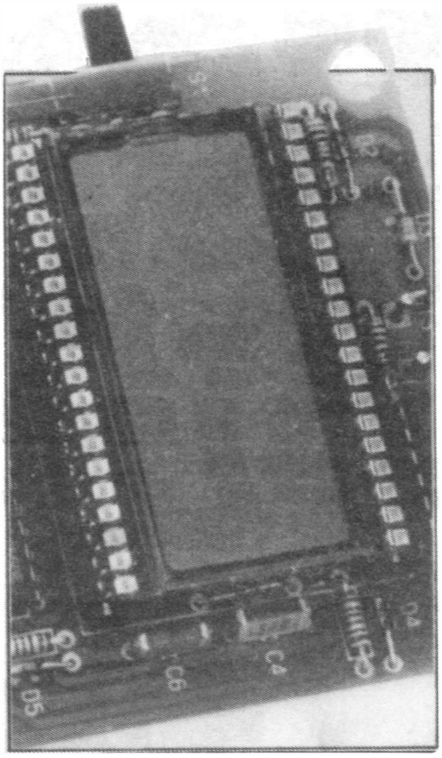


Photo 4. How the contact strips are used for the LCD.

Lastly install ICs 2 to 6 (there does not seem to be an IC1 for some reason) with the same care as for the transmitter. *Carefully* insert LCD1 into its two rows of pin connectors making sure it is the right way round according to the alignment identification illustrated in Figure 10. The result should be as shown in Photo 4. With this the PCB is practically complete. The receiver's pair of input leads are threaded through their holes and tied with a strain relief knot in the same manner as those of the transmitter. The red wire goes to ST3, the black (or white) to ST4. The battery clip red wire goes to ST1 (+), and the black wire to ST2 (−).

Turn the receiver's case front or top half front-side down, and install the PCB in it with the LC display facing down behind the window aperture. Push the PCB down until the surface of the LCD is about level with the inner front panel surface. Don't forget that these LCDs often have a thin, protective plastic film on the front glass surface which should be peeled off. The PCB is secured with two self-tapping screws at the side of the battery compartment. Apply glue beside the input terminals to secure the PCB in this area.

Remove the battery cover and assemble the two halves of the case. At the same time, as with the transmitter, draw out the two input wires and guide the battery clip wires to the battery compartment, through the slot provided. If necessary adjust the position of the battery clip in the compartment.

Join the two case halves with the screws provided, and install the battery. The wiring allocation tester is now ready for use. No alignment is required, but proper operation can be verified by directly examining each of the transmitter's outputs in turn with the receiver.

RECEIVER PARTS LIST

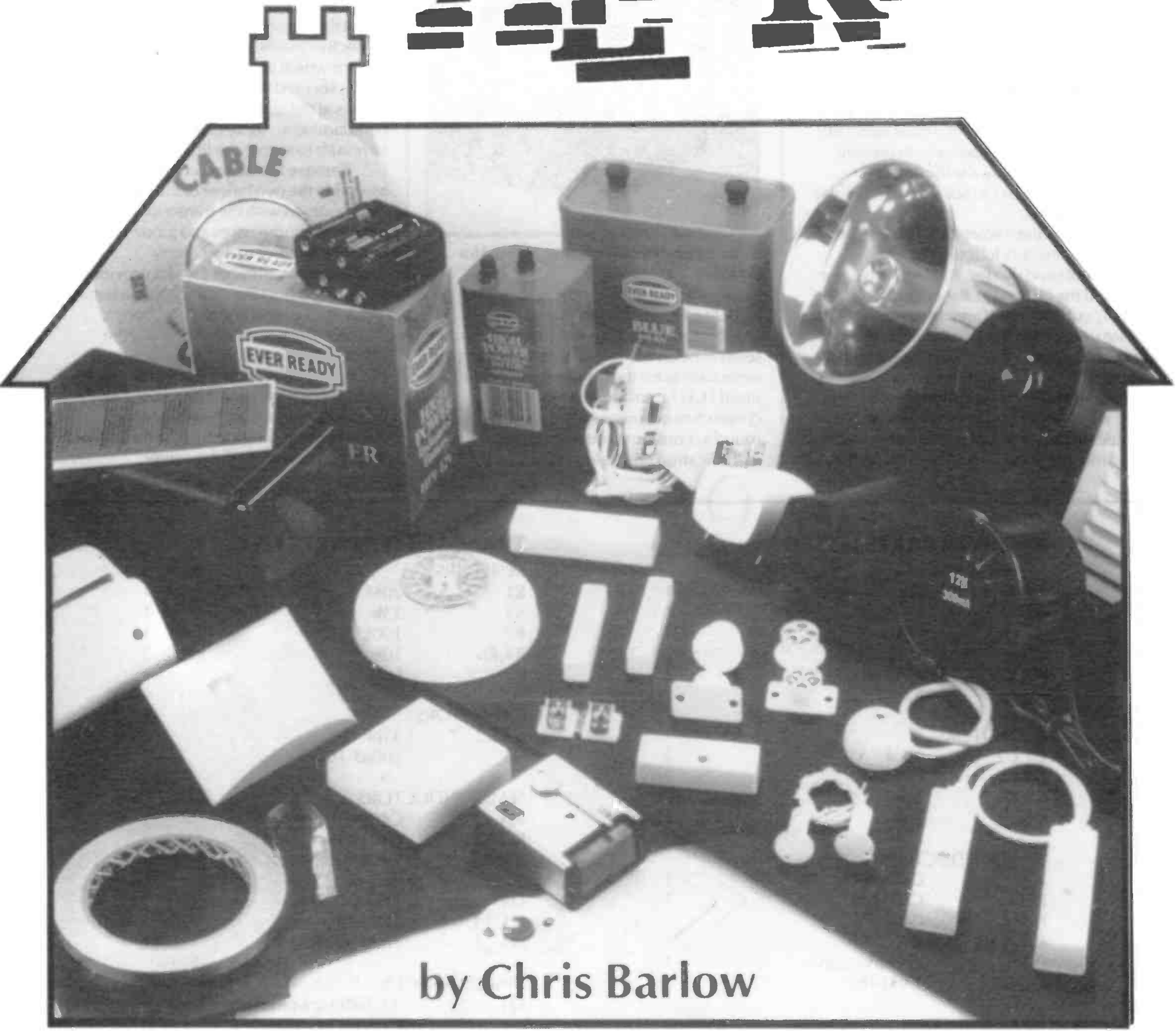
RESISTORS		
R1	20M	1
R2	33k	1
R4	10k	1
R5,R8	100k	2
R6,R7	22k	2
R9	82k	1
CAPACITORS		
C1,C2	33pF	2
C3	1µF 16V	1
C4,C5	10nF	2
C6	1nF	1
SEMICONDUCTORS		
IC2	C4060BE	1
IC3	C4011BE	1
IC4	C4518BE	1
IC5,IC6	C4056BE	1
D3	ZPD 8V2 Zener	1
D1-D5	1N4148	5
MISCELLANEOUS		
Q1	32·758kHz Miniature Quartz Crystal	1
LCD1	3½ Digit Display	1
S1	SPDT Slide Switch	1
	PP3 Battery Clip	1
	40-Way IC Contacts	1 Stp
	Test Lead with Crocodile Clip	2
	Silvered Wire	39cm

TRANSMITTER PARTS LIST

RESISTORS:		
R1	20M	1
R2	33k	1
R3	100k	1
R4,R6	10k	2
R5	68Ω	1
CAPACITORS		
C1,C2	33pF	2
C3	100µF 16V	1
SEMICONDUCTORS		
IC1	C4060BE	1
IC2,IC3	C4015BE	2
IC4-6	C4049UBE	3
T1	BC548	1
D5	ZPD 4V7 Zener	1
D1-3,D6,D7	1N4148	5
D4	3mm LED Red	1
MISCELLANEOUS		
Q1	32·768kHz Miniature Quartz Crystal	1
S1	SPDT Min Toggle	1
	PP3 Battery Clip	1
	Test Lead with Crocodile Clip	17
	Silvered Wire	39cm
	Instruction leaflet	1

The above items are available as a kit only:
Order As LP61R (Wire Alloc Tester Kit).

LOW COST HOME ALARM



by Chris Barlow

FEATURES

- ★ Low Cost
- ★ Normally Open and Closed Security Loops
- ★ Arm Key Switch
- ★ Adjustable Exit/Entry Delay
- ★ Tamper and Panic Button Loops
- ★ Audio/Visual Status Indicators
- ★ Extremely Low Standby Current

Specifications of Prototype

Power supply input voltage:	6V to 12VDC
Current at 12V:	Standby = 1·3μA
	Active = 3mA
	Intruder= 7·5mA
	Help = 4·5mA
Siren Switching Current:	1A Maximum
Exit/Entry Delay Time:	1 to 60 seconds
Security Loops:	Normally Open and Normally Closed
Tamper Loop:	Normally Closed
Panic Button Loop:	Normally Open

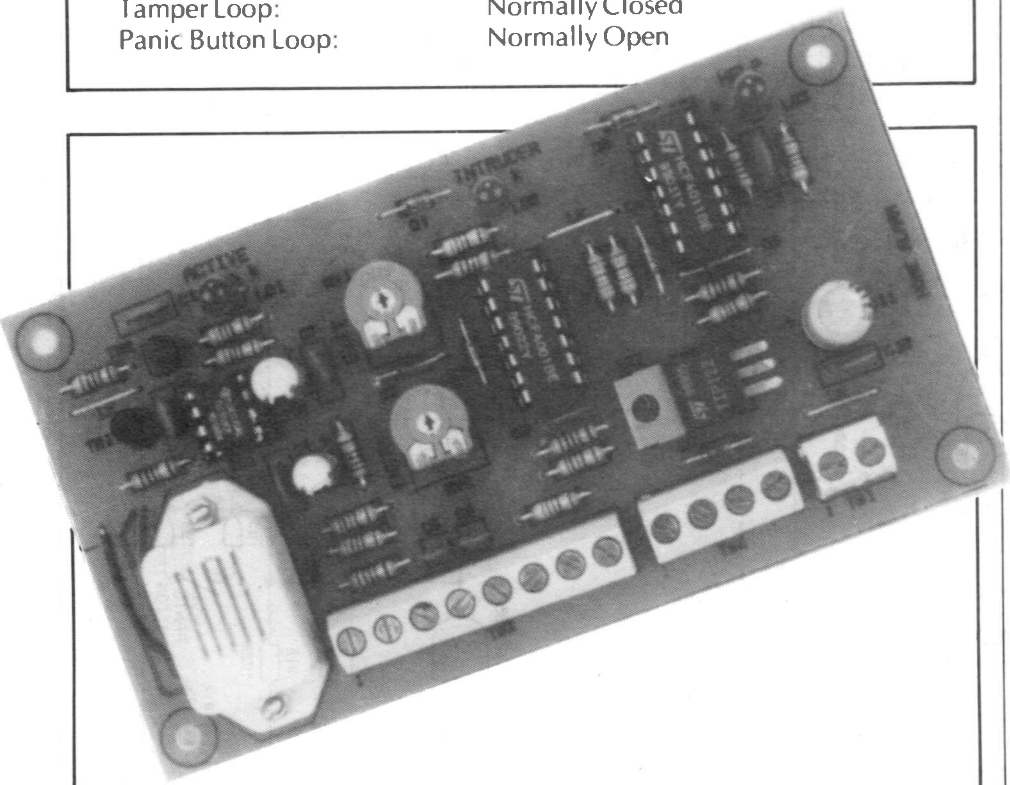


Photo 1. Completed PCB.

Introduction

The need for an inexpensive but effective home alarm is becoming of greater importance as time passes. This simple unit has several features which are normally found on more expensive alarms now available.

No alarm can offer complete protection against the determined professional burglar, but it will act as a strong deterrent to the small-time thief. This alarm can be triggered from a wide range of security sensors, such as a reed switch, pressure mat, window foil, etc. It can be expanded further to include heat, vibration and infra-red detectors. This system flexibility ensures that the potential thief never knows just what to expect from house to house.

The operating principle is that when the arm key is turned on, you then have up to 60 seconds to secure the building; during this exit time a buzzer will be sounding. After this delay the alarm is active and ready to be triggered by any of the sensors in the security loops. If you are still inside the building a red indicator acts as a reminder that the system is active. When one or more of the sensors is disturbed the alarm is triggered, lighting the intruder indicator and sounding the buzzer. You now have up to 60 seconds of entry delay to deactivate the alarm before the main siren goes off.

The alarm is equipped with two additional security loops which are permanently active and immediately trigger the main siren when disturbed. The first of these is a 'tamper-proof' loop which when broken sounds the siren until it is re-connected. The second loop is used for manually operated panic buttons, and if either loop is triggered, the help indicator will light up until the alarm is reset by the key switch being turned from the standby to the armed condition.

Circuit Description

A circuit diagram detailing the complete unit is shown in Figure 1. The timing and control of the sequence of events is governed by the logical function of the following Integrated Circuits (IC) and Transistors (TR):

IC1 TLC555 timer, 1 to 60 seconds exit/entry delay.

IC2a,b 4001BE latch, alarm active and exit/entry delay select.

IC2c,d 4001BE latch, security loop trigger.

IC3a,b 4011BE gate, siren entry delay.

IC3c,d 4011BE latch, tamper and panic loop trigger.

TR1 BC548 timer entry re-trigger.

TR2 BC548 exit/entry buzzer switch.

TR3 TIP122 siren switch.

PCB Construction

All information required about soldering and assembly techniques can be found in the 'constructors guide' included in the kit (stock code XH79L). Removal of a misplaced component will be fairly difficult so please double-check each component type, value, and its polarity where appropriate, before soldering! The Printed Circuit Board (PCB) has a legend to help you correctly position each item, see Figure 2. Install all the components including the buzzer which is secured to the board using the 8BA screws and nuts. When mounting the red Light Emitting Diodes (LEDs) you must ensure that their polarity and positioning is correct. The cathode (K) is denoted by the shorter of the two leads and by a flat on the bottom edge of the package as shown in Figure 3.

When the assembly of the circuit board is complete you should check your work very carefully, making sure that all solder joints are sound. It is also very important that the solder (track) side of the PCB does not have any trimmed component leads standing proud by more than 2mm, as they may cause short circuits. The completed PCB assembly is shown in Photo 1.

Testing

All the tests can be made with the minimum of equipment. You will need a regulated 12V DC power supply, or 12V battery, capable of providing the current required by the siren you have chosen to use, but which must not draw more than 1A, and some hook-up wire. The following quoted meter readings were taken from the prototype using a digital multimeter; some of the readings you obtain may vary slightly depending upon the type of meter you use.

Before you commence testing the unit, set the two presets, RV1 and RV2, fully counter-clockwise (CCW). Next, fit two wire links to Terminal Block 3 (TB3) as follows:

Terminal 3 to 4 (normally closed security loop), see Figure 4.

Terminal 7 to 8 (normally closed tamper loop).

Prepare the key switch S1 and siren SR1, then connect them to TB2 as follows:

S1 to terminals 1 and 2 (set key switch to its clockwise ON position).

SR1 red lead (+V) to terminal 3 and black (−V) to 4.

Do not connect any power to TB1 until it is called for during the testing procedure!

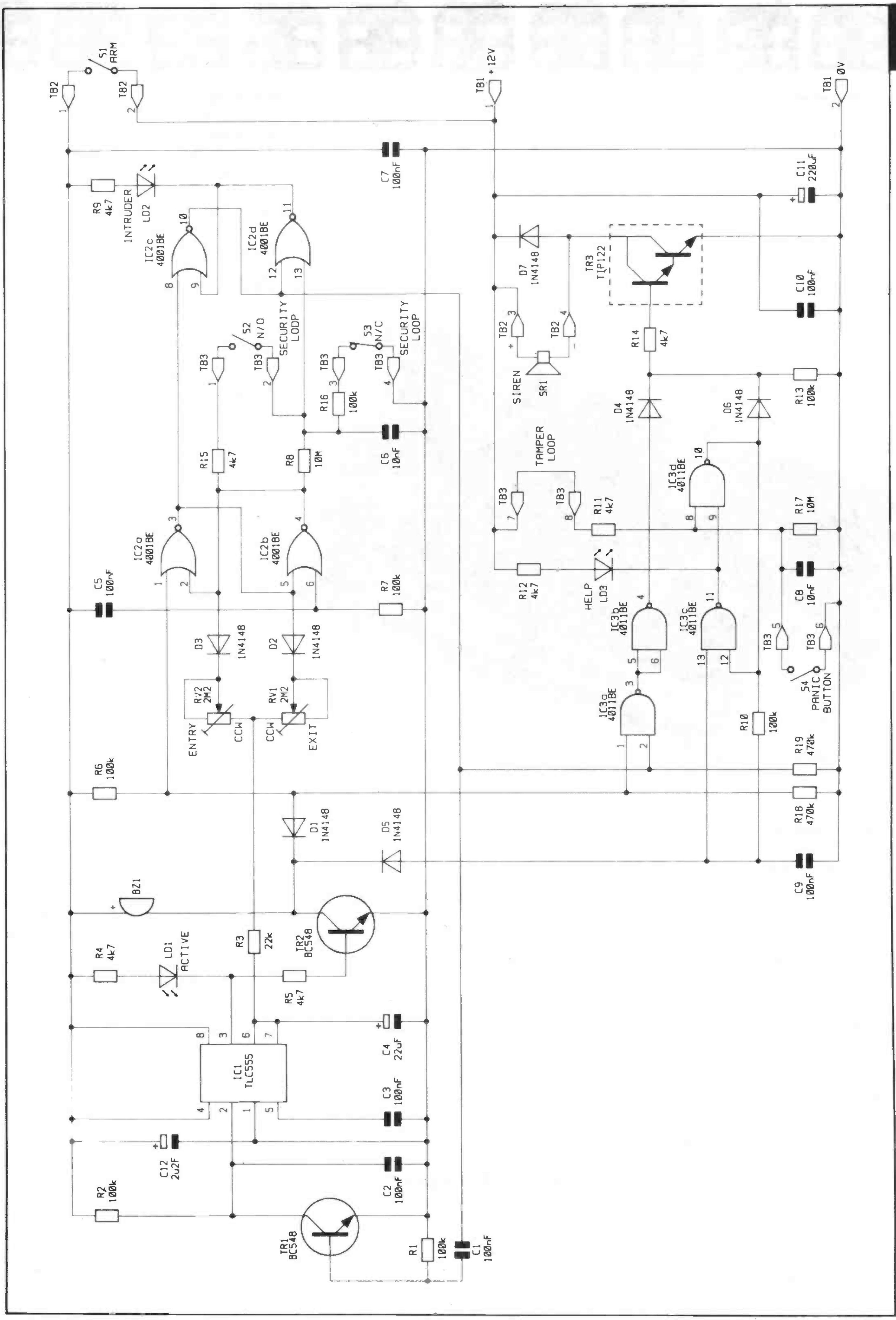


Figure 1. Circuit diagram.

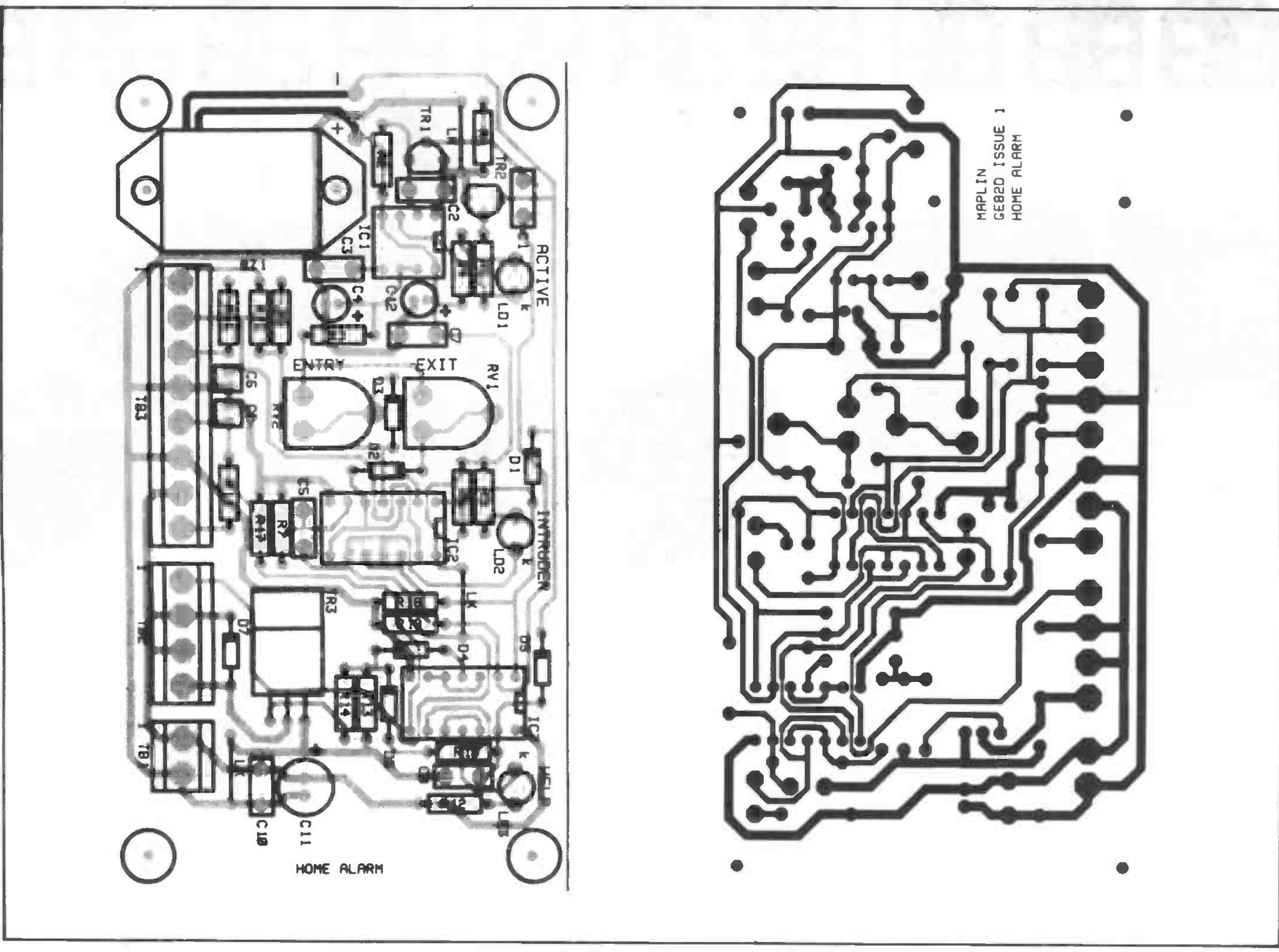


Figure 2. PCB legend.

The first test is to ensure that there are no short circuits before you connect the power supply. Set your multimeter to read OHMS (Ω) on its 20kΩ or equivalent resistance range, and connect the test probes to terminals 1 and 2 of TB1. With the probes either way round a reading greater than 1kΩ should be obtained.

Before testing the current consumption of the unit, set S1 to its counter-clockwise OFF position. It is also recommended that the output of the siren is muffled to reduce its sound intensity! Now set your meter to read DC mA and place it in series with the positive line of the power supply to TB1 terminal 1. When the negative power line is connected to TB1 terminal 2 the following should be observed:

1. None of the LED's should light.
2. Buzzer should not sound.
3. Siren should not sound.
4. A current reading of approximately 1·3μA should be obtained.

Next, turn the key switch clockwise to its ON position, which should arm the alarm system. At the same time the buzzer should sound for approximately one second, and at the end of this time the active indicator, LD1, should light. Repeat this procedure whilst advancing the position of RV1 in small steps. Each time the setting is increased, the exit delay should also increase until, when RV1 is fully clockwise, a maximum delay of approximately 60 seconds is reached. During the exit delay a current reading of approximately 35mA should be observed, dropping down to 3mA when the system is active.

To test the alarm trigger function, each security loop on TB3 must be individually opened or closed. Set RV1 and RV2 fully counter-clockwise. Then turn the key switch S1 to its ON position (system armed) and perform the following tests:

1a. Link terminals 1 and 2 (normally open security loop).

Result: Active indicator LD1 goes out. Intruder indicator LD2 lights up. Buzzer sounds for a one second entry delay.

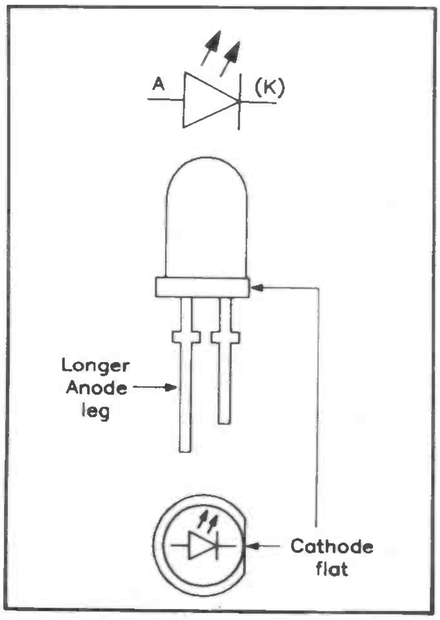


Figure 3. LED information.

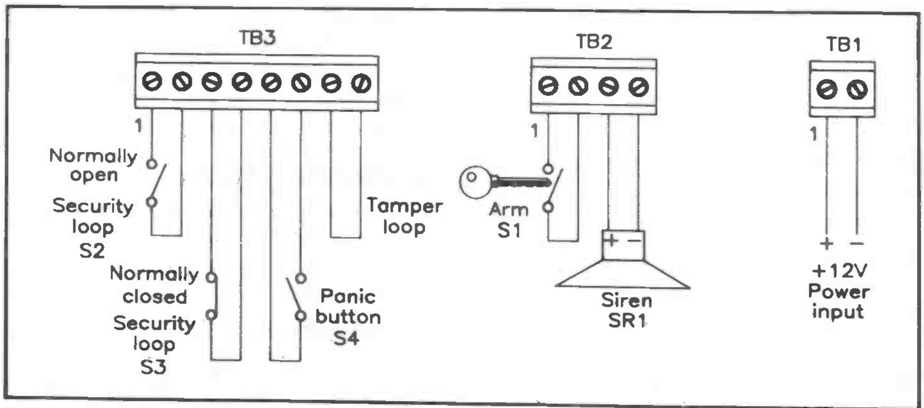


Figure 4. Wiring diagram.

Photo 2. Batteries and AC adaptor (FK64U, RK44X, YJ19V, YJ22Y, YB23A).

Photo 3. Sirens (JK42V, JK43W, YK60Q, YP11M, XG14Q, YN59P, YZ03D).

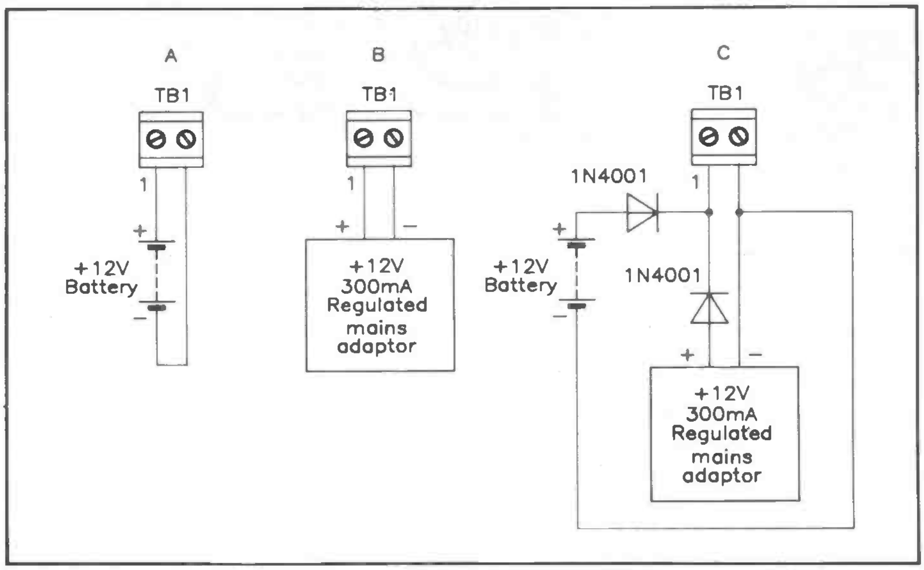


Figure 5. Power supplies.

Active indicator LD1 lights up.
Siren SR1 sounds.
Supply current reading increases by that demanded by your siren.

1b. Reset the alarm by turning the key switch off (system standby).

Result: All indicators go out.
Siren stops sounding.
Current reading drops back to 1·3μA.
Remove the link from terminals 1 and 2.

2a. Re-arm the system.
Remove the link from terminals 3 and 4 (normally closed security loop).

Result: Same as test 1a.

2b. Reset the alarm (system standby).

Result: Same as test 1b.
Refit the link at terminals 3 and 4.

3a. Link terminals 5 and 6 (normally open panic loop).

Result: Help/tamper indicator LD3 lights up.
Siren sounds immediately.

3b. Remove the link from terminals 5 and 6.
Arm the system.

Result: Help/tamper indicator LD3 goes out.
Siren stops sounding.
Reset the alarm (system standby).

4a. Remove the link from terminals 7 and 8 (normally closed tamper loop).

Result: Same as test 3a.

4b. Refit the link at terminals 7 and 8.
Arm the system.

Result: Same as test 3b.
Reset the alarm (system standby).

This completes the testing of the alarm. Now disconnect the power, test links and your multimeter from the unit.

Using the Alarm

Before the completed module can be used in a practical working environment the following operating conditions should be considered.

Power Supply: as can be seen from Figure 5, there are three basic power supply options. The simplest is shown in 'A' where a 12V battery supplies all the power to the alarm system. It must be remembered that the capacity of the battery will determine the effective operational life of the unit, which is in turn governed by the sequence of events. In its standby condition the alarm draws very little current (1·3μA), so even small capacity batteries will last for a relatively long period. However, when armed the supply current increases to 3mA and once triggered the current drawn by the siren can go up to 1A depending upon the type you have selected. For this reason it is advantageous to use a battery with a high capacity to ensure good long term operation, as illustrated in Photo 2.

The second option, 'B', uses a 12V regulated mains adaptor which must have sufficient current capacity to drive the siren. The prototype used a siren which drew less than 300mA, so only a small mains adaptor (YB23A) was necessary. Although this option gives a virtually un-interrupted supply you must take into account the fact that should the 240V AC mains fail, then the alarm system is left inoperable. For this reason a secondary battery back-up supply is advantageous, as indicated in option 'C' of Figure 5. Combining both supplies requires two 1N4001 1A rectifier diodes (QL73Q) connected as shown which effectively isolate the supplies from each other.

Siren: as can be seen from Photo 3 there is a wide range of sirens available from Maplin, and their current consumption starts as low as 30mA (YP11M), extending up to 600mA (YN59P). Since the alarm has a switching capacity of 1A it is permissible to use more than one siren as long as the total current demand is less than 1A and within the capacity of the power supply, in other words the following combinations are possible:

Where all sirens are wired in parallel:
Up to 33 30mA piezo electronic sirens (YP11M), total current 990mA.
Up to 6 150mA micro sirens (JK42V), total current 900mA.

Up to 3 300mA miniature piezo sirens (JK43W), total current 900mA.
Up to 3 300mA low cost electronic sirens (YK60Q), total current 900mA.
Up to 3 300mA staccato electronic sounders (YZ03D), total current 900mA.
Up to 2 500mA electronic sirens (XG14Q), total current 1A.
1 600mA metal horn siren (YN59P).
Or any combination of these totalling 1A.

The siren chosen for testing the prototype was the micro siren (JK42V) drawing only 150mA but producing a very loud output. All the sirens are loud and there must be careful consideration when choosing where to install them as you could very easily upset the neighbours!

Box: it's good practice to build as much as possible into the box, because the more wiring there is outside the easier it is to tamper with. The choice of box will depend upon the following design criteria:

1. Size of assembled alarm PCB.
2. Size of batteries.
3. Size of mains power supply. Can be external if battery back-up fitted.
4. Size of siren. Additional sirens can be outside the box.
5. Box material plastic or metal.
6. Free-standing or wall mounted.
7. Front panel layout and markings.

A comprehensive range of boxes is available from Maplin which can be found in the current catalogue.

Security Sensors: as can be seen from

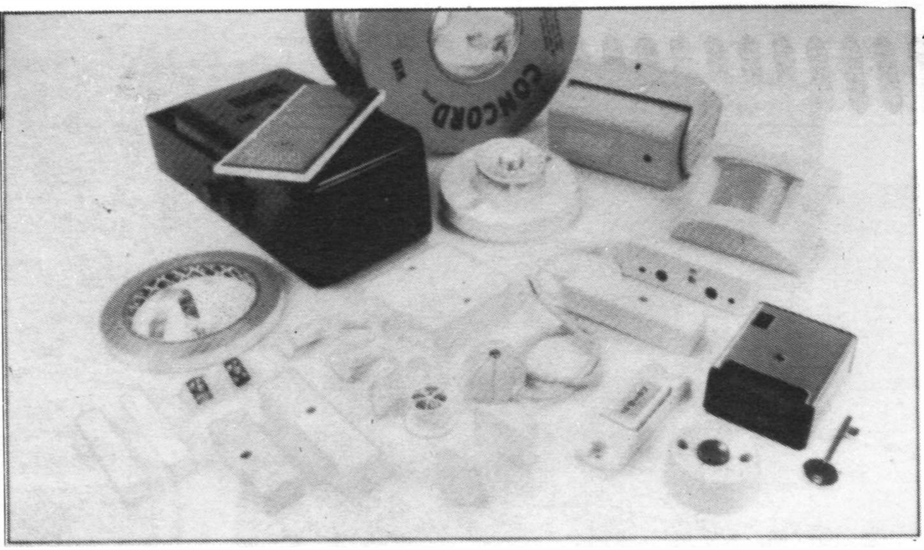


Photo 4. Security loop sensors (YW46A, FK77J, JU65V, YW47B, FK46A, FP12N, YZ67X, YB91Y, FK79L, YW50E, YW51F, FP11M, YU81C, JG24B, YM87U, FK47B, FK78K, YW48C, YW49D, FK76H, PA77J).

Photo 4 shows a wide range of sensors and your selection will depend on your requirements. Here is a list to help you select those most suitable for your needs.

Reed switches

Recessed door or window	YW46A
Recessed five terminal door or window	FK77J
Recessed panel pin fixing, five terminal door or window	JU65V
Surface mounting, door or window	YW47B

Panic buttons

Round panic button	FK46A
Help button	FP12N
Metal panic button	YZ67X

Pressure mats

Standard carpet	YB91Y
Stair carpet	FK79L

Window protection

Window foil	YW50E
Foil terminals	YW51F
Glass break detector	FP11M

Infra-red

Photo relay system	YU81C
Indoor pulsed infra-red movement detector	JG24B
Indoor passive infra-red movement detector	YM87U

Miscellaneous

Heat detector	FK47B
Vibration detector	FK78K
Door junction box	YW48C
5-Way junction box	YW49D
8-Way junction box	FK76H
4-Core burglar alarm cable (1 metre)	XR89W
(100 metres)	PA77J

LOW COST HOME ALARM PARTS LIST

RESISTORS: All 0.6W 1% Metal Film

R1,2,6,7,10,13,16	100k	7	(M100K)
R3	22k	1	(M22K)
R4,5,9,11,12,14,15	4k7	7	(M4K7)
R8,17	10M	2	(M10M)
R18,19	470k	2	(M470K)
RV1,2	Hor Encl Preset 2M2	2	(UH10L)

CAPACITORS

C1,2,3,5,7,9,10	Disc Ceramic 100nF	7	(YR75S)
C4	PC Electrolytic 22μF 25V	1	(FF06G)
C6,8	Disc Ceramic 10nF	2	(BX00A)
C11	PC Electrolytic 220μF 16V	1	(FF13P)
C12	PC Electrolytic 2μ2F 100V	1	(FF02C)

SEMICONDUCTORS

D1,2,3,4,5,6,7	1N4148	7	(QL80B)
LD1,2,3	LED Red 5mm 2mA	3	(UK48C)
TR1,2	BC548	2	(QB73Q)
TR3	TIP122	1	(WQ73Q)
IC1	TLC555CP	1	(RA76H)
IC2	4001BE	1	(QX01B)
IC3	4011BE	1	(QX05F)

MISCELLANEOUS

	DIL Socket 8-Pin	1	(BL17T)
	DIL Socket 14-Pin	2	(BL18U)
	Low Cost Alarm PCB	1	(GE82D)
TB1	2-Way PC Terminal	1	(FT38R)
TB2	4-Way PC Terminal	1	(RK73Q)
TB3	8-Way PC Terminal	1	(RK38R)
S1	Plas Key Switch	1	(FV42V)
BZ1	Buzzer 12V	1	(FL40T)
	Bolt 8BA ½in.	2 Bolts	(BF09K)
	Nut 8BA	2 Nuts	(BF19V)
	Constructors' Guide	1	(XH79L)
	Home Alarm Leaflet	1	(XT03D)

OPTIONAL

SR1	Micro Piezo Siren	1	(JK42V)
S4	Help Button	As Reqd	(FP12N)

Security Loop Switches:

S2	Std Pressure Mat	As Reqd	(YB91Y)
S3	Surface BA Reed	As Reqd	(YW47B)
	Window Foil	As Reqd	(YW50E)
	Foil Terms	As Reqd	(YW51F)
	4-Wire Burglar Cable	As Reqd	(XR89W)

Batteries:

	Alkaline KAA	8	(FK64U)
	12V Battery Box	1	(RK44K)
	PP3 Clip	1	(HF28F)
	Gen Purpose 991	2	(YJ19V)
	Gen Purpose HP992	2	(YJ23A)
	Gen Purpose HP1	1	(YJ22Y)
	AC Adaptor Regulated	1	(YB23A)
	Rectifier Diode 1N4001	2	(QL73Q)

The above parts, not including Optional items, are available as a kit:
Order As LP72P (Low Cost Home Alarm Kit)
The following item is also available separately although not shown in the 1991 Maplin catalogue:
Low Cost Alarm PCB **Order As GE82D**

by Tony Bricknell

LOW COST 10MHz COUNTER

F E A T U R E S

★ *Functions as a frequency counter/period counter/unit counter*
★ *Three internal gate times in frequency counter mode*
★ *10 cycle, 100 cycle and 1000 cycle gate times in period mode*
★ *Leading zero blanking and automatic decimal point shifting*
★ *Reverse polarity protection* ★ *Reset switch for added flexibility*
★ *8 Segment multiplexed LED display* ★ *Low cost design*
★ *Minimal wiring required*

This project is the first in a suite of low cost test equipment for the hobbyist. During this series the construction of several useful items of test equipment will be covered.

1.2.3.4.5.

There are many multifunction counters available but, unfortunately, most are priced way out of the range of the home hobbyist. This project aims to fill the gap in the lower end of the market by offering a counter, packed with features normally found on its more expensive counterparts (no pun intended).

The design is based on the Intersil ICM7216A, giving measurements of frequency, periodic time or totalising counter (event counter). The counter input has a maximum frequency of 10MHz in frequency and unit counter modes, and 2MHz in periodic time mode. For period measurement the unit gives a 0·1μs resolution. In the frequency mode, the user can select input gating periods of 0·1, 1 or 10 seconds. With a 10 second gate time, the frequency can be displayed to an accuracy of 0·1Hz in the least significant digit. There is a delay of 0·2 seconds between each measurement for all ranges, and the ICM7216A allows leading zero blanking and automatic decimal point positioning, according to range to be incorporated. The reading is displayed in kilohertz in the frequency mode, and in micro-seconds for the time measurement mode. Four 0·56in. high contrast, double digit displays are used, which are multiplexed at 500Hz with a 12·5% duty cycle for each digit. A full specification of the prototype can be found in Table 1.

Input Amplifier

With reference to Figure 1, it can be seen that the signal input on P1 (signal) and P2 (ground) is immediately capacitively coupled to remove any DC bias. The signal, clamped by D1 and D2, enters a wide band discrete amplifier. To achieve a high input impedance an FET is used for TR1. The output signal from the drain of TR1 is fed into TR2, to provide a clean switching waveform to drive the A input of IC1.

Logic and Display

IC1 handles the range and function switching, display buffering and multiplexing, and the internal and external oscillators. Its block diagram can be found in Figure 2. The output from the collector of TR2 enters IC1 on pin 28. The internal crystal frequency is determined by the setting of VC1. IC1 provides the digit and segment drive for the 8-digit, 7-segment display. The function and range inputs are time multiplexed to select the input function desired. This is achieved by connecting the appropriate digit driver output to the inputs. Noise on the multiplex inputs can cause improper operation, which is particularly

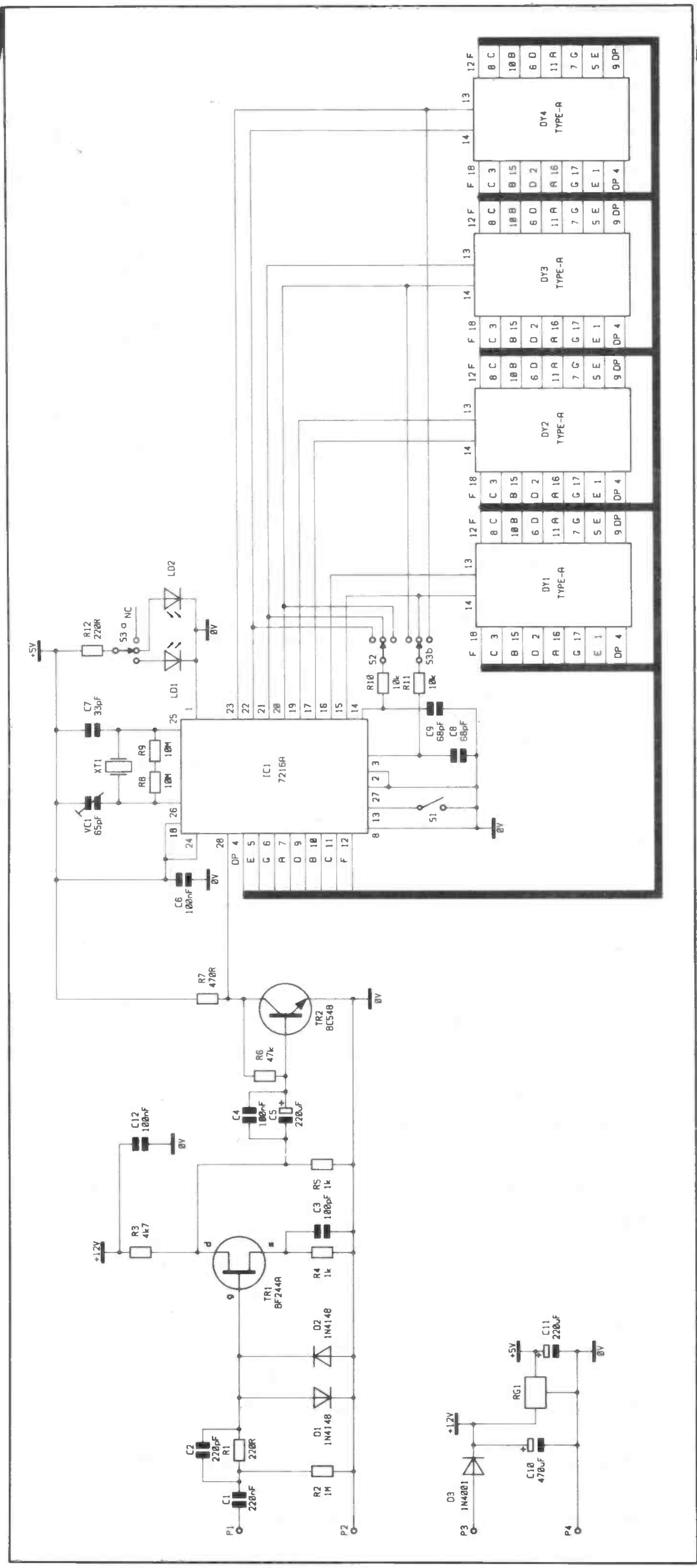


Figure 1. Circuit diagram.

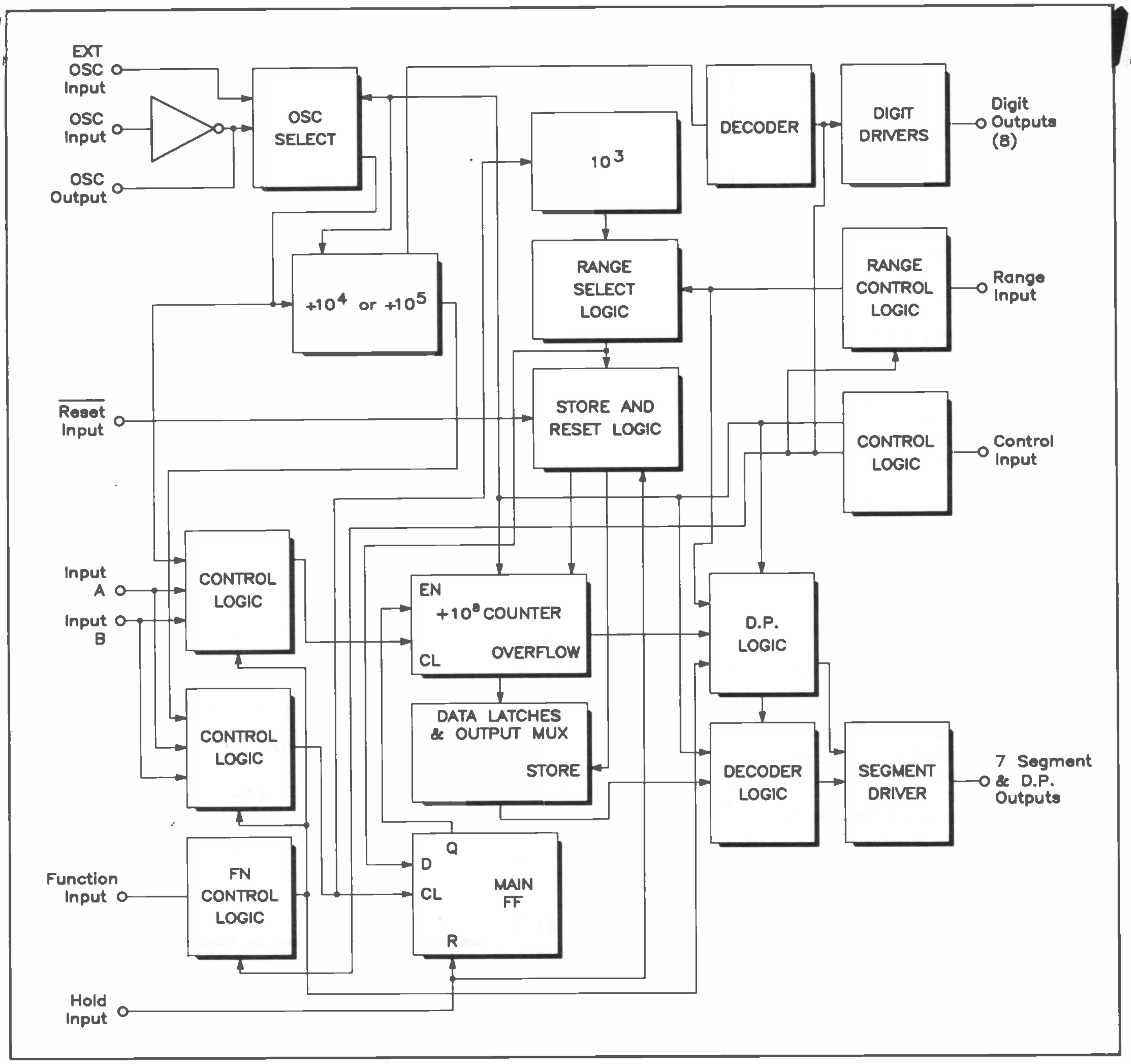


Figure 2. Block diagram of the ICM7216A.

Supply voltage	10V–15V
Average supply current @ 12V	110mA
Nominal input impedance	1MΩ
Input signal frequency range	10Hz–10MHz
Input signal amplitude (p.d.) 10kHz – 1MHz input frequency, 1MHz – 5MHz input frequency, 5MHz – 10MHz input frequency,	 30mV 45mV 90mV
Functions	Frequency, Periodic time, Unit counter
Gate times	0.1, 1, 10 seconds (Frequency mode) 10, 100, 1000 cycles (Period mode)
Best resolution	0.1Hz (Frequency mode) 0.1μs (Period mode)
Indicators	8 seven–segment displays, 2 range LED's, Over–range
Timebase	10MHz high–stability crystal

Table 1. Specification of prototype.

true when the unit counter mode is selected, since voltage changes on the digit drivers can be capacitively coupled through the LEDs to the multiplex inputs. For maximum noise immunity, a low pass filter consisting of a 10kΩ resistor and 68pF capacitor is placed in series with the multiplexed inputs.

Power Supply

A 12V regulated input is required which can be supplied from an AC adapter. D3 ensures that no damage will be done to the circuit if the power supply is connected with incorrect polarity. This 12V line powers the front-end amplifier directly, while a regulated 5V line is taken from this supply to drive all the additional circuitry including the LED display.

Construction

The Low-Cost Counter is constructed on a single-sided glass fibre PCB, chosen for maximum reliability and stability.

Figure 3 shows the PCB, with printed legend, to help you correctly locate each item. The order in which the components are fitted is not critical, however the following instructions will make the assembly task as straightforward as possible. For general information on soldering and assembly techniques, refer to the Constructors' Guide in the kit.

From the short length of 22 s.w.g. TC wire included in the kit, cut and fit the 39 links. Next, fit the four PCB pins. After insertion, use a hot soldering iron to press the pins into position. If sufficient heat is used, it should not be necessary to use a great amount of force. Once in place, the pins may be soldered.

Now fit the remaining components, starting with the small resistors and diodes, working upwards in size until the switches are fitted last. The IC socket should be fitted before any other high profile components, as it must be kept flush with the PCB. Ensure that the notch at the end of the socket aligns with the white block on the legend. *Do not* insert the IC until it is called for during the test procedure!

Special precautions are needed when fitting the semiconductors (diodes and transistors). In particular, take care not to overheat them during soldering. All the silicon diodes have a band identifying one end, be sure to position these adjacent to the white blocks marked on the legend.

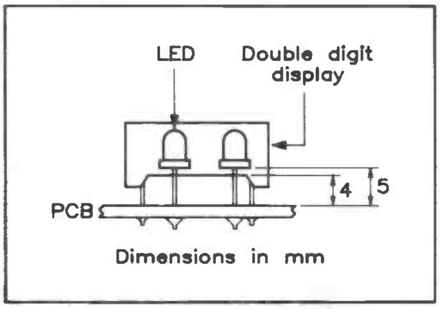


Figure 4. Inserting LD1, LD2 and DY1-4.

When installing the transistors, match the shape of each case to its outline on the legend. Take care with the polarity of the electrolytic capacitors, which is indicated by a full-length negative (−) stripe, the lead *nearest* this symbol goes into the hole *opposite* to that marked with a positive (+) symbol on the legend.

Install LD1 and LD2 at a height of 5mm above the PCB, matching the flat side of the package with that shown on the legend. The double-digit displays DY1 – 4 are installed next, and must be raised off the PCB to a height of 4mm, as shown in Figure 4.

Before continuing further it is recommended that you take several minutes to double-check your work to make sure that there are no dry joints, or stray strands of solder that could cause a short circuit. It is also very important that the solder side of the circuit board does not have any trimmed component leads standing proud by more than 3mm, as this may cause a short circuit.

No specific box has been designated for the project, however, the single board prototype fitted nicely into an ABS box with

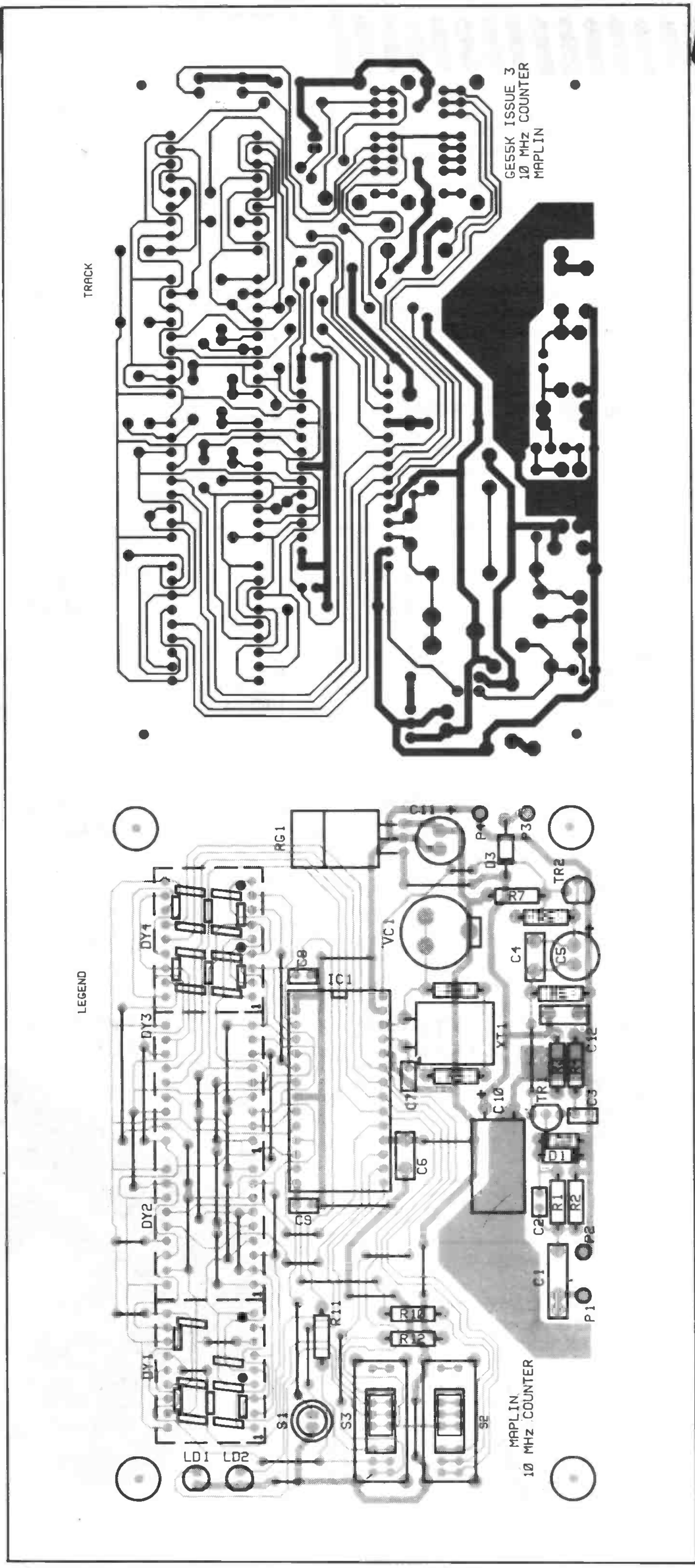


Figure 3. PCB with legend.

metal front panel type M4005 (stock code WY02C), see Figure 5 for box drilling details.

The choice of connectors for the power and input leads is entirely up to you. However, it is good practice not to use the same type of connector for different functions.

When installing the complete PCB assembly remember to use some form of spacer between its solder side and the inside surface of the case, particularly vital if you are using a metal case or chassis.

Setting Up and Testing

Apply power to the PCB (+12V to P3, 0V to P4) and check the voltage present across pin 18 (+V) and pin 8 (0V) of the socket for IC1 using a multimeter. A

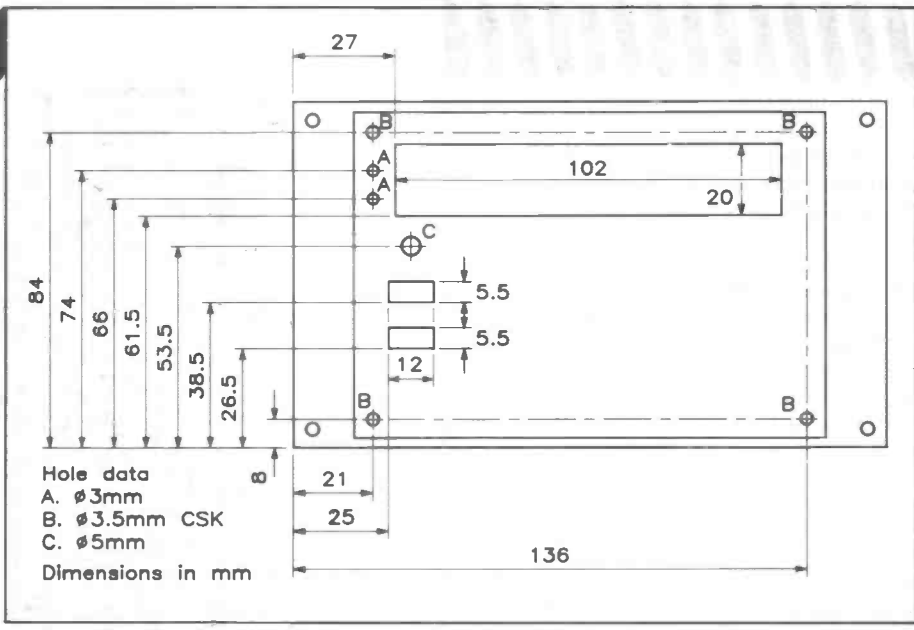


Figure 5. Box drilling details.

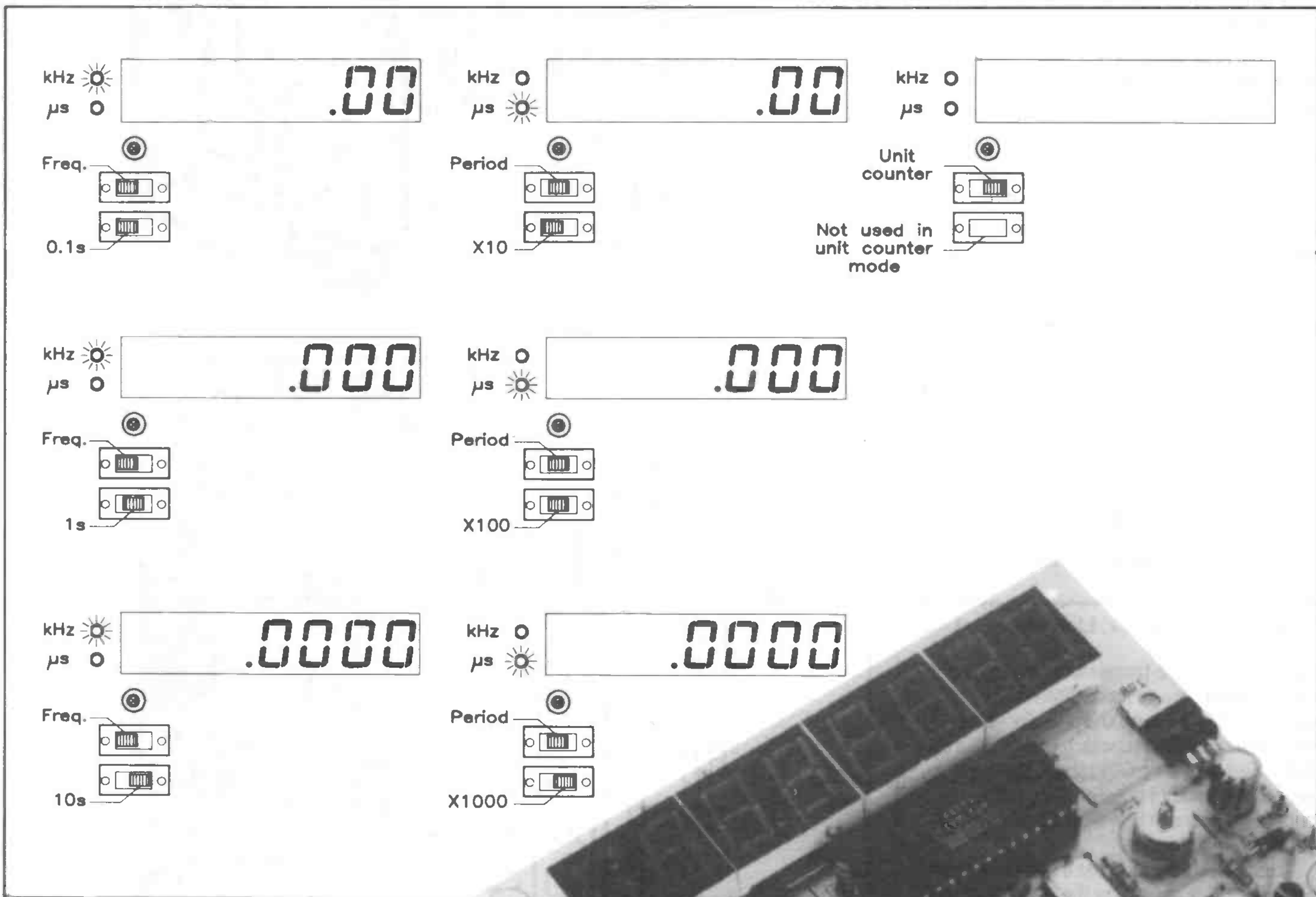
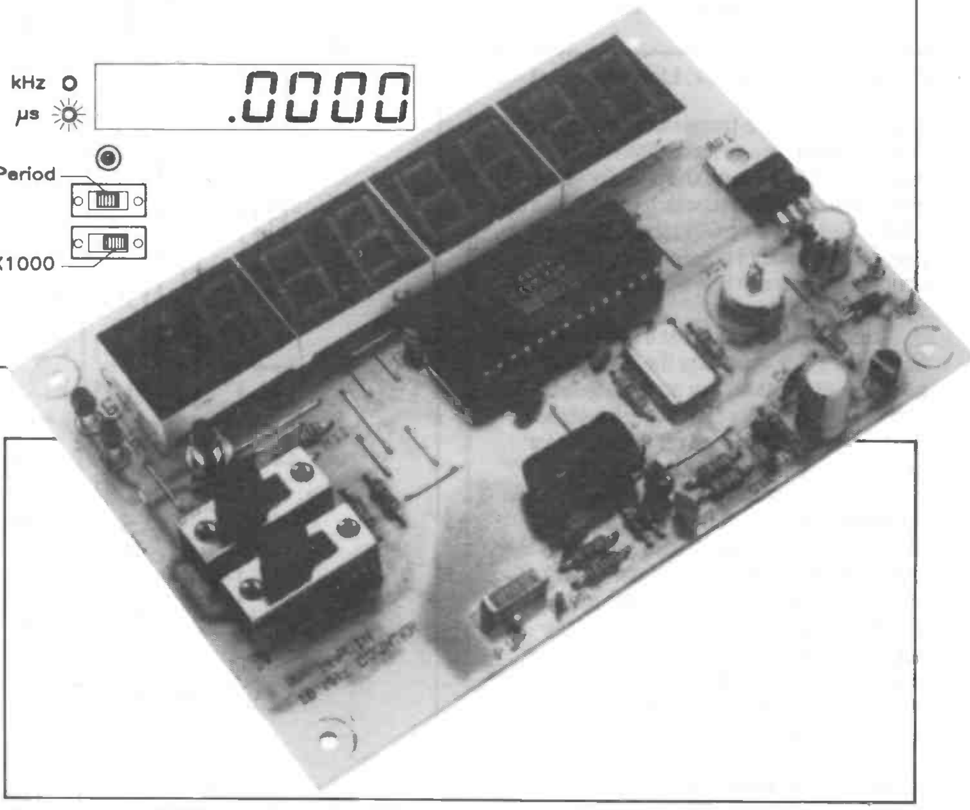


Figure 6. Display conditions.

reading no greater than 5·5V and no less than 4·5V should be present. If there is zero volts present then you may have the power supply polarity incorrectly connected. By moving S2, LD1 and LD2 may be made to illuminate. If everything is satisfactory, remove the power supply and insert IC2. Be careful not to bend the pins which are easily damaged. Temporarily short together P1 and P2, and re-connect power. The format of the display will differ depending which mode you are in. Switch through the ranges with S2 and check that the display varies as shown in Figure 6. The multifunction counter is now fully working.



The completed PCB. A project you can count on!

Mode	Main Counter	Reference Counter
Frequency	Input A	100Hz (Oscillator – 10^5)
Period	Oscillator	Input A
Unit counter	Input A	Not Applicable

Table 2. Internal counters.

Calibration and Accuracy

The unit is calibrated by applying a signal of known frequency and accuracy to the input, and then adjusting VC1 until the correct frequency is displayed. The setting of VC1 will determine the accuracy of the unit, and care should be taken in making this adjustment. However, if a reference signal is not available, set VC1 to its mid-point. It was found that, on the prototype, this procedure produced a small, but acceptable error equating to 0·002%, with an input frequency of 10MHz.

In a universal counter such as this, it must be realised that there can be crystal drift and quantisation errors. In frequency and period modes, a signal derived from the oscillator is used by either the reference counter or the main counter. Therefore, in these modes an error in the oscillator frequency will cause an identical error in the measurement. For instance, an oscillator temperature coefficient of 20ppm/°C will cause a measurement error of 20ppm/°C.

In addition, there is a quantisation error inherent in any digital measurement of ±1 count. Clearly this error is reduced by displaying more digits. In the frequency mode the maximum accuracy is obtained with high frequency inputs, and in period mode maximum accuracy is obtained with low frequency inputs.

In Use

The selected mode of operation decides which signal is counted into the main counter, and which signal is counted by the reference counter, as shown in Table 2.

Reset switch S1 — When the reset switch is depressed, any measurement in progress is stopped, the main counter is reset, and the chip is held ready to initiate a new measurement. The latches which hold the main counter data remain enabled, resulting in an output of all zeros. When the Reset switch is released, a new measurement is initiated.

Function switch S2 — Changing the function with S2 will stop the measurement in progress without updating the display, and then initiate a new measurement. This prevents an erroneous first reading after the function switch is moved.

Gate switch S3 — In frequency counter mode this switch selects a 0·1s, 1s or 10s gate time. In period mode the switch selects 10 cycle, 100 cycle or 1000 cycle gate times.

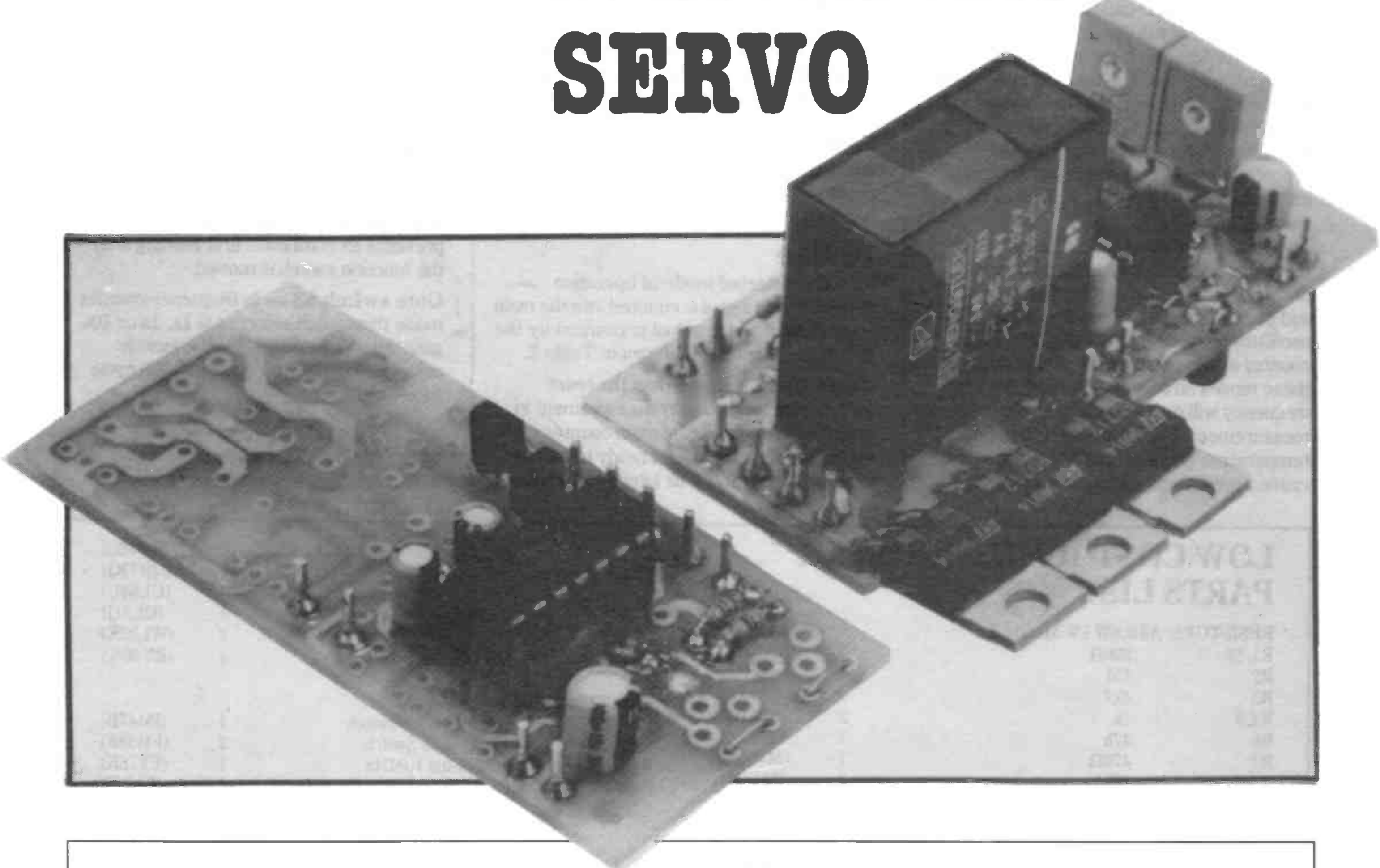
In every range, any overflow is shown by the decimal point in the most significant (left-hand) digit being illuminated.

LOW COST 10MHz COUNTER PARTS LIST

RESISTORS: All 0.6W 1% Metal Film			
R1,12	220Ω	2	(M220R)
R2	1M	1	(M1M)
R3	4k7	1	(M4K7)
R4,5	1k	2	(M1K)
R6	47k	1	(M47K)
R7	470Ω	1	(M470R)
R8,9	10M	2	(M10M)
R10,11	10k	2	(M10K)
CAPACITORS			
C1	220nF Poly Layer	1	(WW45Y)
C2	220pF Ceramic	1	(WX60Q)
C3	100pF Ceramic	1	(WX56L)
C4,6,12	100nF 16V Minidisc Ceramic	3	(YR75S)
C5	220μF 16V PC Electrolytic	1	(FF13P)
C7	33pF Ceramic	1	(WX50E)
C8,9	68pF Ceramic	2	(WX54J)
C10	470μF 16V PC Electrolytic	1	(FF15R)
C11	220μF 10V Minelectrolytic	1	(JL06G)
VC1	65pF Trimmer	1	(WL72P)
SEMICONDUCTORS			
D1,2	1N4148	2	(QL80B)
D3	1N4001	1	(QL73Q)
TR1	BF244A	1	(QF16S)
TR2	BC548	1	(QB73Q)
IC1	7216A	1	(UL64U)
RG1	μA7805UC	1	(QL31J)
LD1,2	Mini LED Red	2	(WL32K)
DY1,2,3,4	DD Display Type A	4	(BY66W)
MISCELLANEOUS			
S1	Sub Min Push Switch	1	(JM47B)
S2,3	4 Pole Slide Switch	2	(FH38R)
XT1	FS Crystal 10MHz	1	(FY78K)
P1-4	Pin 2145	4 Pins	(FL24B)
	DIL Socket 28-Pin	1	(BL21X)
	LC 10MHz Counter PCB	1	(GE55K)
	Constructors' Guide	1	(XH79L)
	LC 10MHz Counter Leaflet	1	(XK31J)
OPTIONAL			
	Box M4005	1	(WY02C)
	Red Display Filter	1	(FR34M)
	Regulated Adaptor	1	(YB23A)

The above parts, excluding Optional items, are available as a kit:
Order As LP37S (LC 10MHz Counter Kit)
The following is also available separately although not shown in our 1991 catalogue:
LC 10MHz Counter PCB **Order As GE55K**

ZN419/409 PRECISION SERVO



FEATURES

★ HIGH OUTPUT DRIVE CAPABILITY ★
★ LOW COMPONENT COUNT ★

APPLICATIONS ★ Motor Speed Control ★ Servo Control ★

Introduction

The ZN419 precision servo IC (also supplied as the ZN409) is specifically designed for use with pulse width operated servo mechanisms, used in a variety of control applications. A low external component count and relatively low power consumption make the device ideal for use in model boats, aircraft and cars where battery life, space and weight are of prime consideration.

In addition to the role of a servo driver, it is also possible to use the IC in motor speed control applications. The device is supplied in a 14 pin DIL package. Figure 1 shows the IC pinout and Table 1 shows some typical electrical characteristics for the device.

General Description

A typical control system is that based on the operation of a joy-stick to vary the pulse width of a timing circuit. Large numbers of pulses are multiplexed by time division and are used to modulate a radio control transmitter. At the receiver, the received signal is demodulated and a train of pulses is produced to control a servo. The servo consists of a motor driven reduction gearbox which has a potentiometer coupled to the output shaft. The servo potentiometer produces an output which corresponds to the position of the output shaft. The output from the potentiometer is used to control the pulse width of a timing

Parameter	Conditions	Min	Typ	Max
Supply voltage		3·5V	5V	6·5V
Supply current	Quiescent	4·6mA	6·7mA	10mA
Input resistance		20k	27k	35k
Input current		350μA	500μA	650μA
Lower input threshold	(Pin 14)	1·15V	1·25V	1·35V
Upper input threshold	(Pin 14)	1·4V	1·5V	1·6V
Minimum output pulse		2·5ms	3·5ms	4·5ms
Output saturation voltage	Load current = 400mA		300mV	400mV

Table 1. ZN419 typical electrical characteristics.

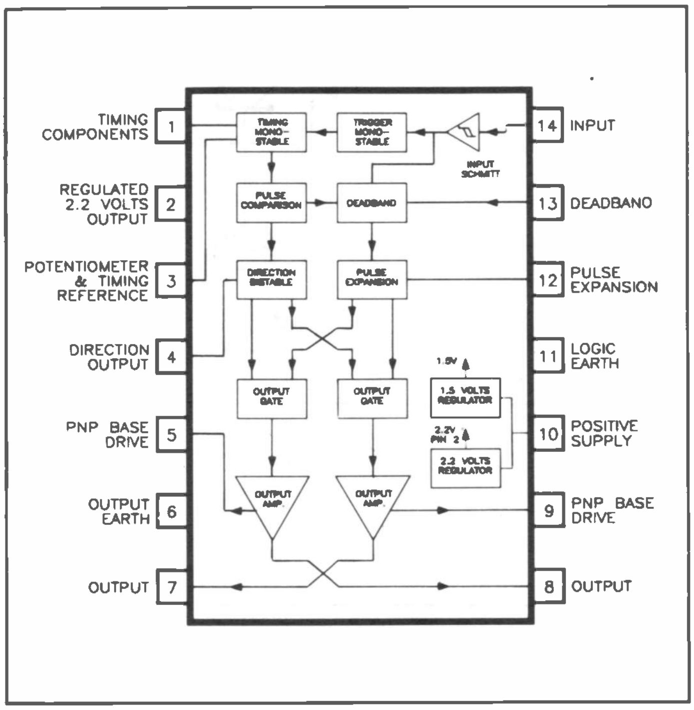


Figure 1. IC pinout.

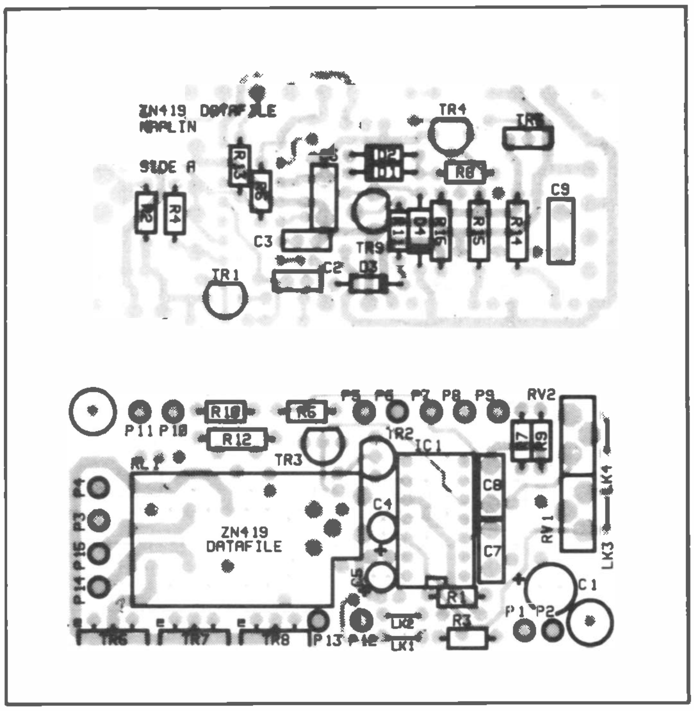


Figure 3. Legend on both sides of PCB.

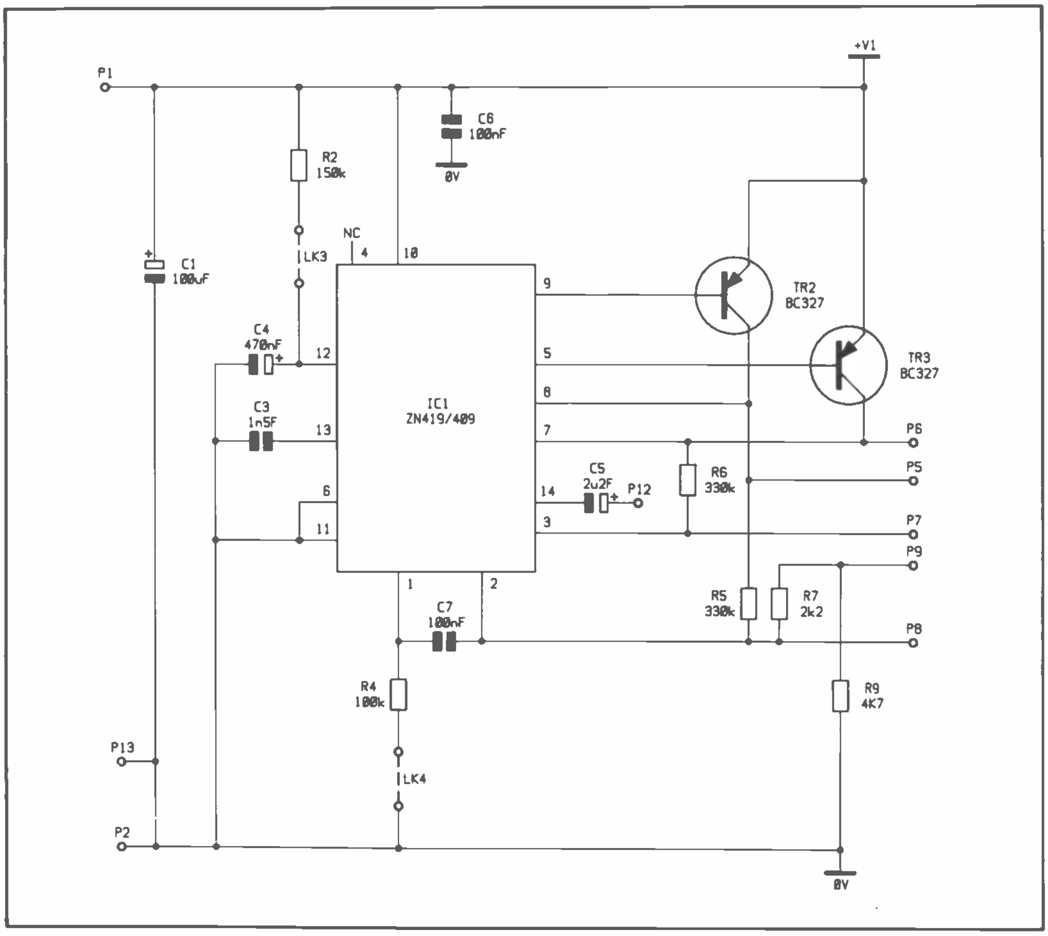


Figure 4. Circuit diagram of servo application.

monostable which forms part of the ZN419 IC. An internal pulse comparison stage compares the input pulse width with that of the monostable pulse and produces an output which determines the correct phase of the on-chip power amplifier. Another output from the pulse comparison circuit drives a pulse expansion circuit which expands the difference between the input and monostable pulses. The difference pulse is used to drive the motor in such a direction as to reduce the difference so that the servo takes up a position which corresponds to that of the controller joy-stick.

In addition to driving servo motors, the ZN419 can also be used for motor speed control. In this application the IC acts as a linear pulse width amplifier. The motor is driven with a train of pulses which have a variable pulse width such that the speed of the motor can be controlled between zero and maximum. The ZN419 uses fixed timing components and a fixed resistor is used in place of the servo potentiometer. The centre of the range monostable period represents zero motor speed, and pulses less than or greater than this drive the motor in the forward or reverse direction respectively. A direction output is produced on pin 4 of the IC and this may be used to control a relay to determine the motor direction. The pulse expansion components should be chosen to provide a suitable relation between the controller joy-stick position and the speed of the motor.

A 'deadband' is required around the centre of this range, between the minimum forward and reverse positions, where no power is applied to the motor. The IC contains an internal deadband control circuit and the size of the deadband is adjustable to suit different requirements.

Because of the high current consumption of many motors, using the device in motor speed control applications usually requires a separate high current power supply to increase the operating time between recharging the batteries.

IC Power Supply

The IC requires a 4V to 6·5V (absolute maximum) single rail power supply which is capable of supplying a current of up to 10mA. As the device is primarily

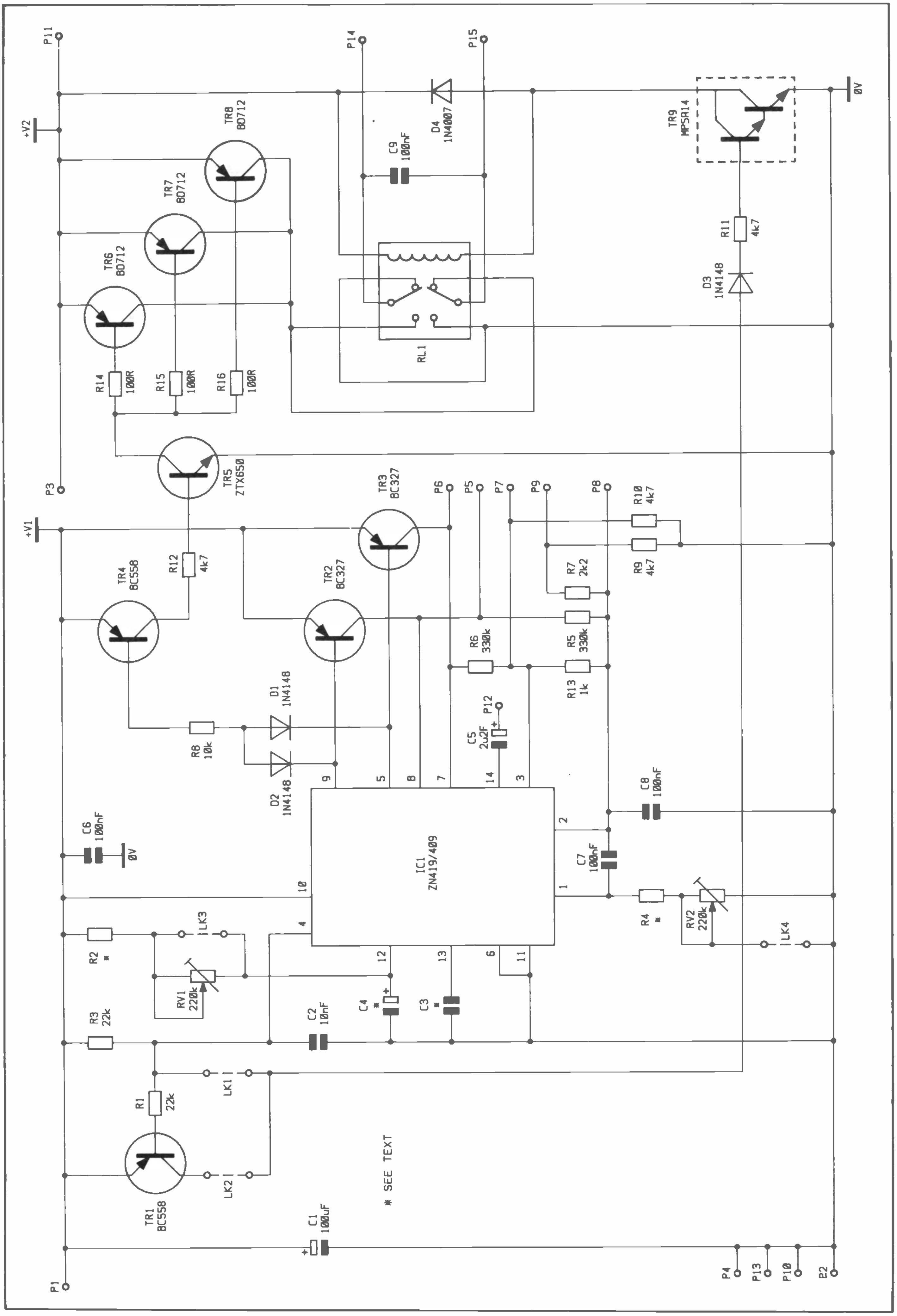


Figure 2. Combined circuit diagram of module.

designed for use in radio controlled models the supply is usually derived from a battery. For reliable operation it is recommended that high frequency supply decoupling is used close to the IC to prevent high frequency voltage spikes on the supply rail.

PCB Available

A high quality, double sided, fibreglass PCB with screen printed legend is available as an aid to constructors wishing to use the ZN419 IC. The PCB may be utilised in the construction of either a servo driver or a motor speed control circuit. Figure 2 shows the combined circuit diagrams for both the speed controller and servo driver options. The PCB legend is shown in Figure 3.

In order to make the PCB as small as possible, components are mounted on both sides of the board. The PCB is marked "side A" and "side B" for ease of identification. When constructing either circuit, the components mounted on side A should be fitted first, followed by the components on side B. It is necessary to solder some components on the same side of the PCB as they are mounted, instead of the normal 'other side'. This is particularly the case with R5, R8, R11, R13, R14, R15, R16 and D4. Protruding component leads should be cut as close to the PCB as possible so that they do not obstruct components on the other side of the board.

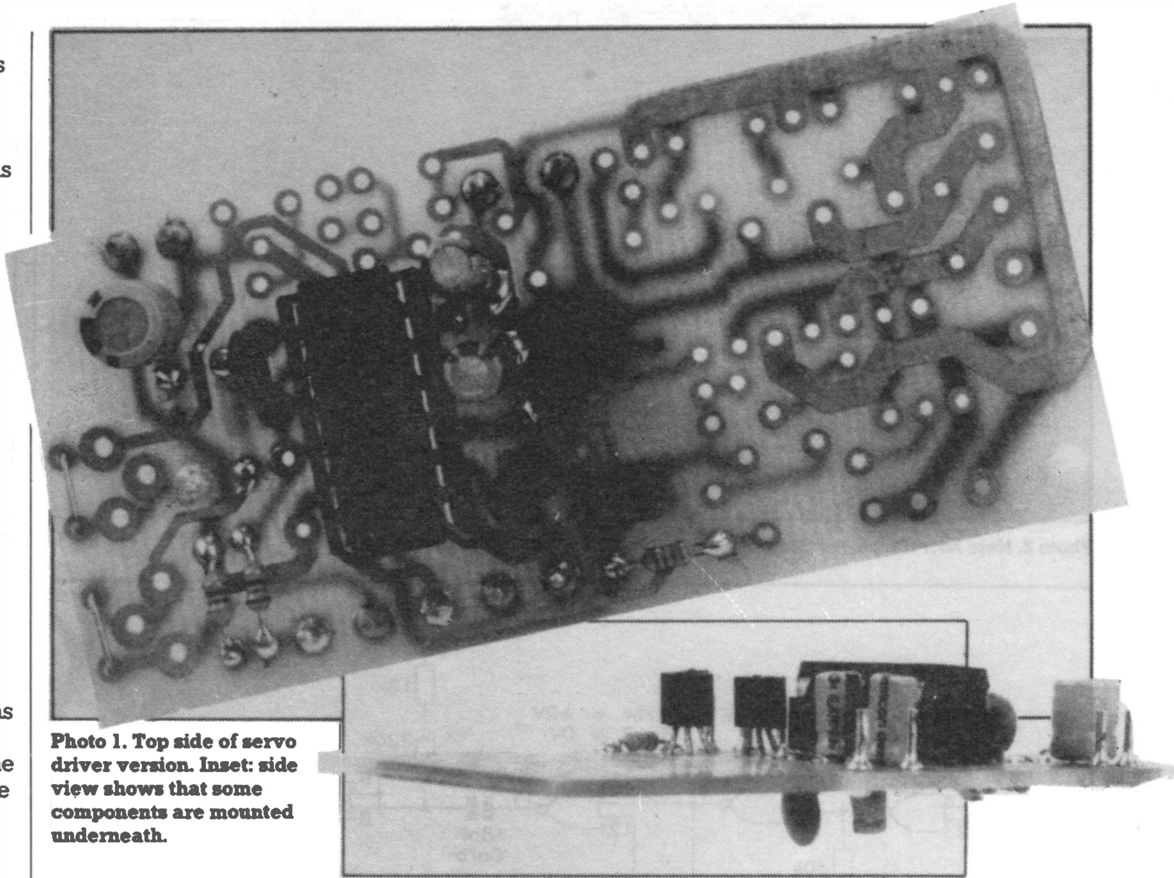


Photo 1. Top side of servo driver version. Inset: side view shows that some components are mounted underneath.

Servo Driver Option

Figure 4 shows the circuit diagram of the servo driver application. If building this circuit, reference should be made to the servo driver parts list only and *not* to the motor speed controller parts list which shows a different set of component values. Figure 5 shows the wiring diagram for the module when used as a servo driver.

The circuit is primarily designed to operate from a 6V battery but may be powered from any supply voltage between 4V and 6V. Power supply connections are made to P1(+V) and P2(0V). A pulse width modulated input is required to drive the module, with a variable pulse width between 0·2ms and 2·5ms as illustrated in Figure 6 and Figure 7. A typical test circuit is shown

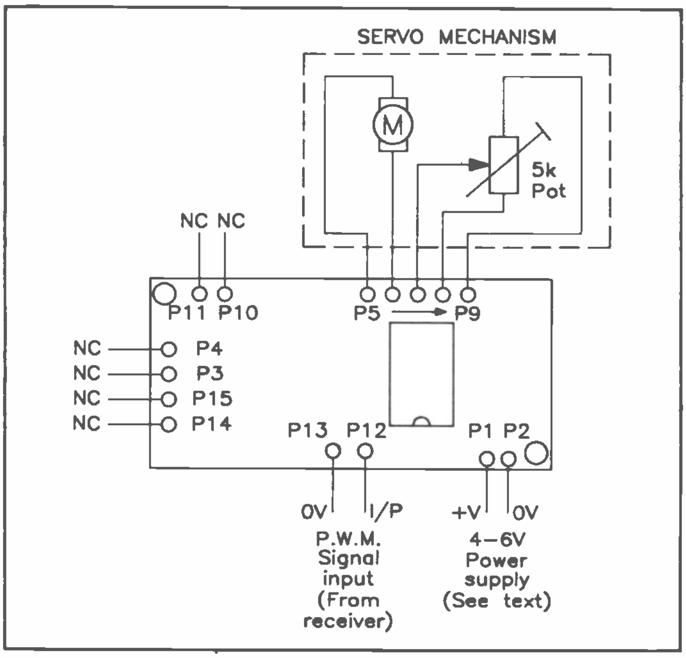


Figure 5. Servo driver wiring diagram.

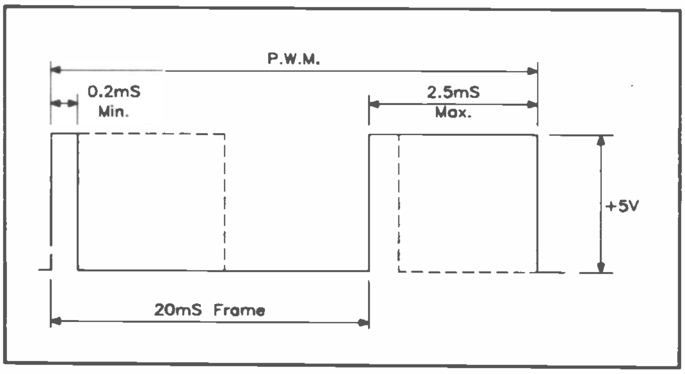


Figure 6. Control signal.

in Figure 8. Please note: LK1 and LK2 are *not* fitted for the servo driver application, but *both* LK3 and LK4 should be fitted.

Motor Speed Control Option

Figure 9 shows the diagram of the motor speed control circuit. When building this circuit reference should be made to the motor speed control parts list only and *not* to the servo driver parts list which shows a different set of component values. Figure 10 shows the wiring diagram for the module when used as a motor speed control circuit.

The circuit has two separate power supply rails. A 4 to 6V power supply is used for IC1 and associated components, and the connections from this supply are made to P1(+V) and P2(0V). An additional supply (usually provided by a rechargeable Ni-Cd pack) is required for the motor drive circuitry and connections from this supply are made to P3(+V) and P4(0V). The supply voltage for the motor may be between approximately 6V and 8V at continuous currents up to 5A using the components specified; however, higher voltages and currents can be accommodated using different component values. In particular, the power handling capability of relay RL1 and resistors R14–R16

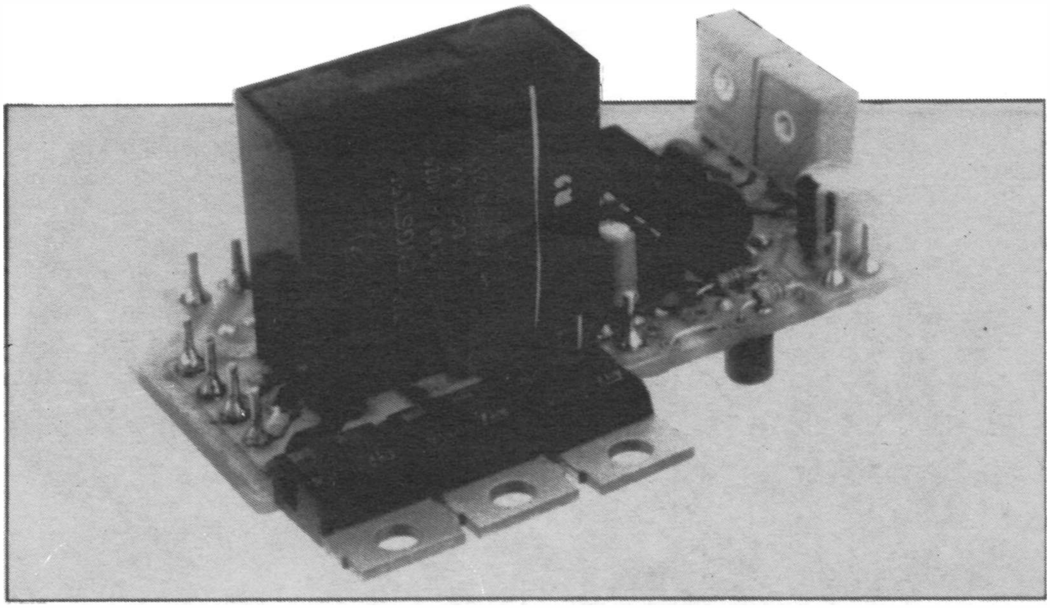


Photo 2. Note how the power transistors are mounted on the motor driver option.

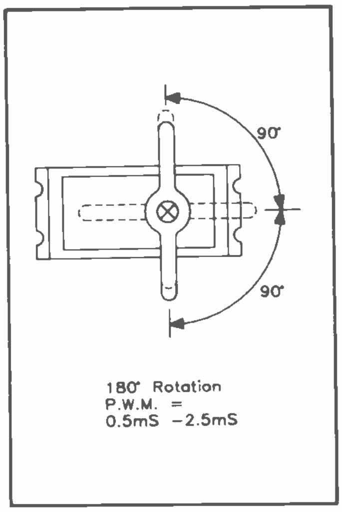


Figure 7. Servo operation.

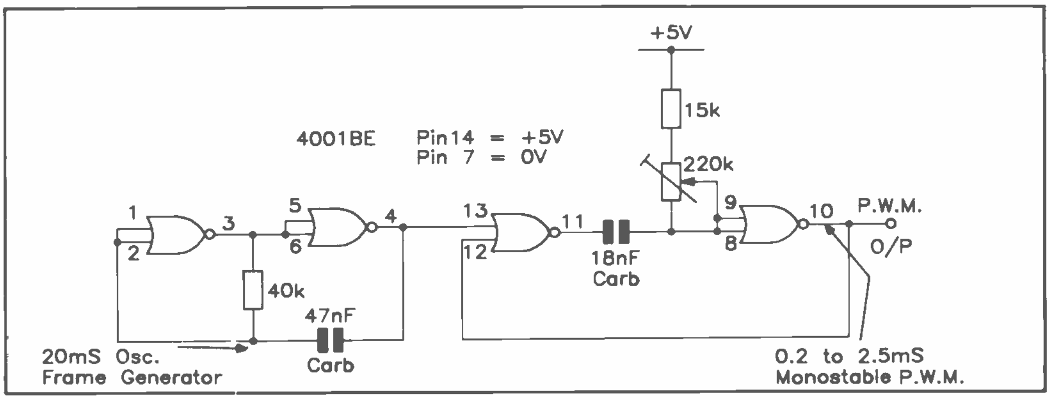


Figure 8. Typical test circuit.

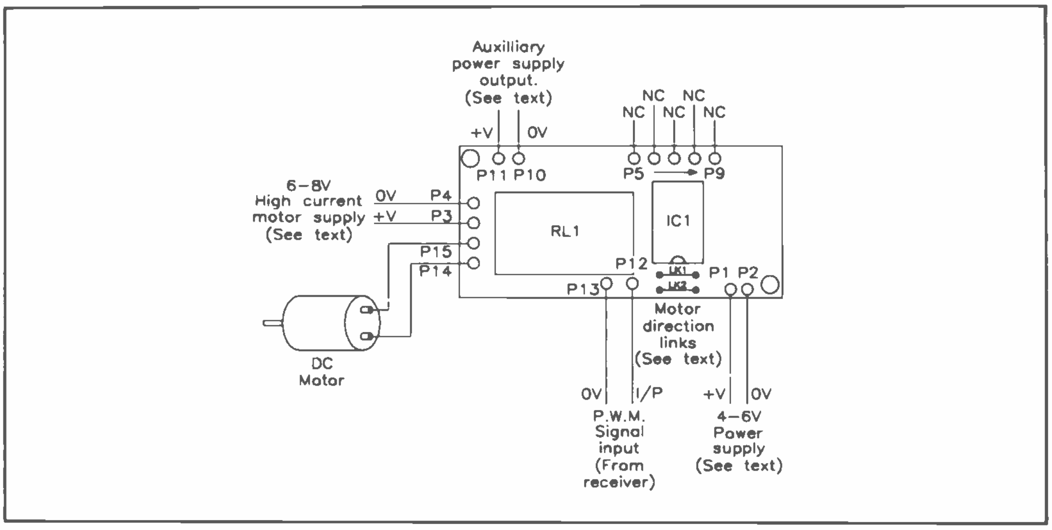


Figure 10. Motor speed control wiring diagram.

Servo Driver Application		
Power Supply Voltage		4V – 6V
Power Supply Current (quiescent)		8mA at 6V
Input Pulse Width		0·2ms – 2·5ms
Motor Speed Control Application		
Power Supply Voltage	Low current supply (P1 & P2)	4 – 6V
	High current supply (P3 & P4)	6 – 8V
Power Supply Current	P1 & P2 (quiescent)	8mA at 6V
	P3 & P4	See text
Input Pulse Width		0·2ms – 2·5ms

Table 2. Specification of prototype.

should be taken into consideration as well as the power dissipation of transistors TR5 – TR8. A suitable 12V relay to use in place of RL1 is FJ43W.

Power transistors TR6 – TR8 are positioned close to the edge of the PCB (see photo 2), to allow the installation of heatsinks as required. There is a small 'e' on the legend denoting the emitter of the transistor for reference purposes. If and to what extent a heatsink is required is really determined by the power consumption of the motor being driven; higher power motors will obviously require additional heatsinking. If the model has a metal chassis, it is often possible to use this as a heatsink for the motor drive transistors. It should be remembered though that the transistor heatsink tags are at collector potential and if necessary should be insulated from the heatsink using a suitable bush and insulating washer such as stock code WR23A.

The direction of rotation of the motor is set by fitting either wire link LK1 or LK2. Please note LK1 and LK2 *should never be used together at the same time!* LK3 and LK4 are not used in the motor speed control application.

Two preset resistors are used to align the module. The relationship between the control stick and the speed of the motor is set using RV1. Because both forward and reverse motor drive are required, a "no drive" or zero position is needed; this is determined by adjusting RV2. Some experimentation is necessary to optimise the parameters of the module for individual applications.

Finally, Table 2 shows the specifications for both the servo driver and speed control options from the prototype module.

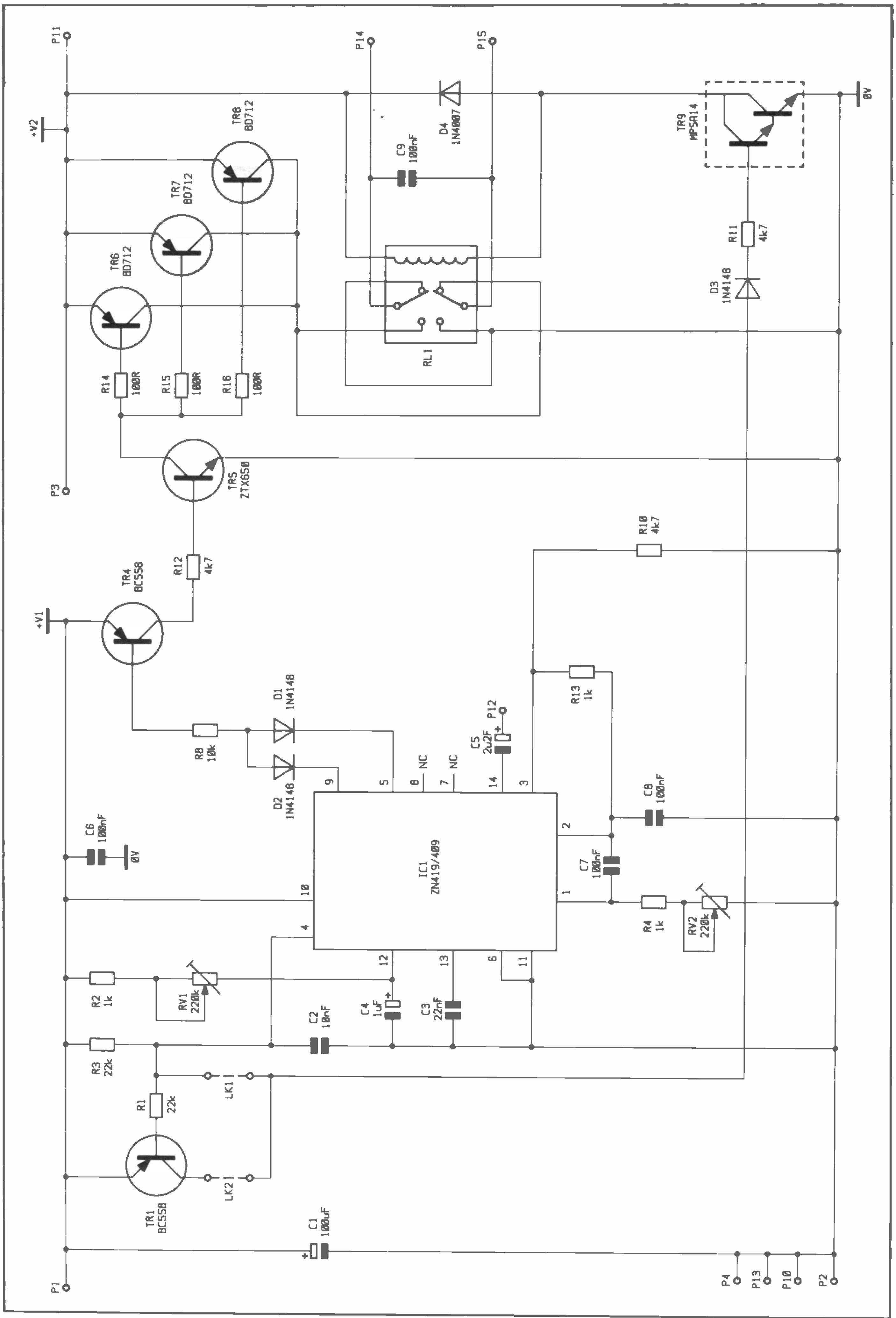


Figure 9. Circuit diagram of motor speed control application.

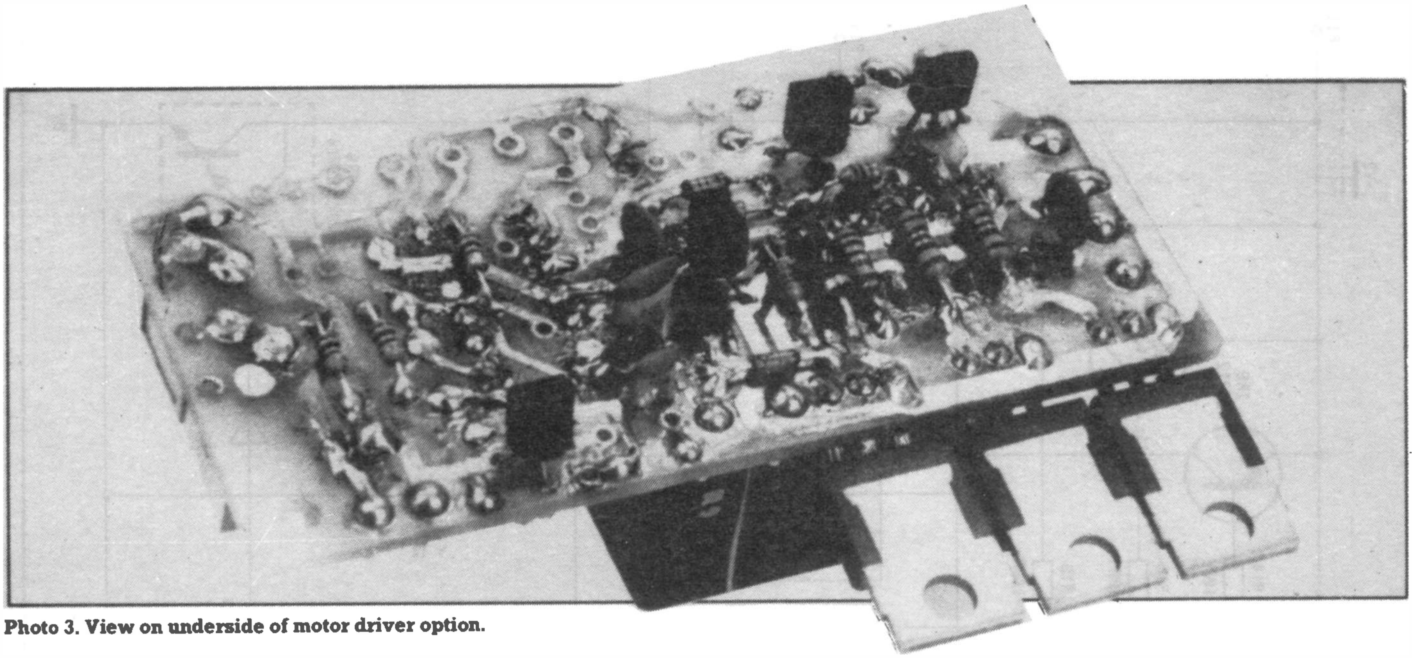


Photo 3. View on underside of motor driver option.

SERVO DRIVER PARTS LIST

RESISTORS: All 1/8W 5% Carbon Film			
R1,3	Not Fitted	–	
R2	Micro Res 150k	1	(U150K)
R4	Micro Res 100k	1	(U100K)
R5,6	Micro Res 330k	2	(U330K)
R7	Micro Res 2k2	1	(U2K2)
R8	Not Fitted	–	
R9	Micro Res 4k7	1	(U4K7)
R10,11	Not Fitted	–	
R12	Not Fitted	–	
R13	Not Fitted	–	
R14,15,16	Not Fitted	–	
RV1,2	Not Fitted	–	
CAPACITORS			
C1	Minelect 100μF 10V	1	(RK50E)
C2	Not Fitted	–	
C3	Ceramic 1500pF	1	(WX70M)
C4	Minelect 470nF 63V	1	(YY30H)
C5	Minelect 2200nF 63V	1	(YY32K)
C6,7	Minidisc 100nF 16V	2	(YR75S)
C8,9	Not Fitted	–	
SEMICONDUCTORS			
IC1	ZN419/409CE	1	(YH92A)
TR1,4	Not Fitted	–	
TR2,3	BC327	2	(QB66W)
TR5	Not Fitted	–	
TR6,7,8	Not Fitted	–	
TR9	Not Fitted	–	
D1,2,3	Not Fitted	–	
D4	Not Fitted	–	
MISCELLANEOUS			
RL1	Not Fitted	–	
	DIL Socket 14 Pin	1	(BL18U)
P1,2,5,6,7,8, 9,12,13	Pin 2145	1 Pkt	(FL24B)
LK1	Not Fitted	–	
LK2	Not Fitted	–	
LK3	Wire Link	Fit Wire Link	
LK4	Wire Link	Fit Wire Link	
	PC Board	1	(GE83E)
	Leaflet	1	(XK49D)
	Constructors' Guide	1	(XH79L)

MOTOR DRIVER PARTS LIST

RESISTORS: All 1/8W 5% Carbon Film (unless specified)			
R1,3	Micro Res 22k	2	(U22K)
R2,4,13	Micro Res 1k	3	(U1K)
R5,6	Not Fitted	–	
R7	Not Fitted	–	
R8	Micro Res 10k	1	(U10K)
R9	Not Fitted	–	
R10,11	Micro Res 4k7	2	(U4K7)
R12	4k7 (0·6W 1% Metal Film)	1	(M4K7)
R14,15,16	100Ω (0·6W 1% Metal Film)	3	(M100R)
RV1,2	Vert Encl Preset 220k	2	(UH20W)
CAPACITORS			
C1	Minelect 100μF 10V	1	(RK50E)
C2	Ceramic 10,000pF	1	(WX77J)
C3	Ceramic 22,000pF	1	(WX78K)
C4	Minelect 1μF 63V	1	(YY31J)
C5	Minelect 2200nF 63V	1	(YY32K)
C6,7,8,9	Minidisc 100nF 16V	4	(YR75S)
SEMICONDUCTORS			
IC1	ZN419/409CE	1	(YH92A)
TR1,4	BC558	2	(QQ17T)
TR2,3	Not Fitted	–	
TR5	ZTX650	1	(UH46A)
TR6,7,8	BD712	3	(WH16S)
TR9	MPSA14	1	(QH60Q)
D1,2,3	1N4148	3	(QL80B)
D4	1N4007	1	(QL79L)
MISCELLANEOUS			
RL1	Min 6V 6A Relay	1	(FJ42V)
	DIL Socket 14 Pin	1	(BL18U)
P1,2,3,4,10,11, 12,13,14,15	Pin 2145	1 Pkt	(FL24B)
LK1	Wire Link	See Text	
LK2	Wire Link	See Text	
LK3	Not Fitted	–	
LK4	Not Fitted	–	
	PC Board	1	(GE83E)
	Leaflet	1	(XK49D)
	Constructors' Guide	1	(XH79L)

The following item is not shown in our 1991 catalogue:
ZN419 PWM PCB **Order As GE83E**

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