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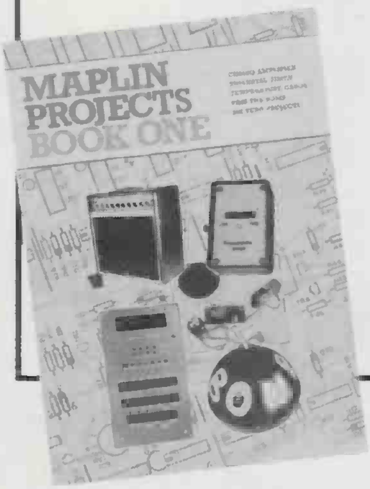

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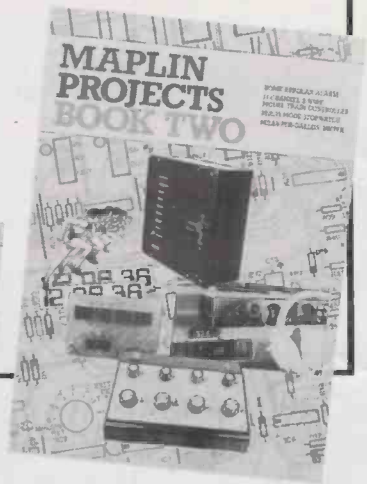

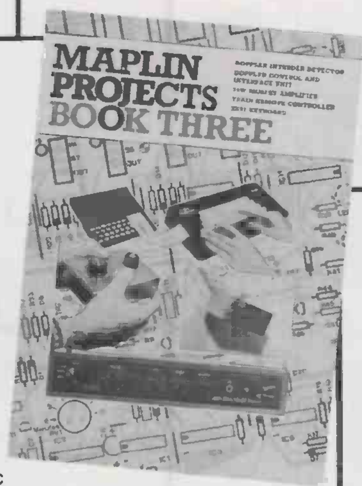

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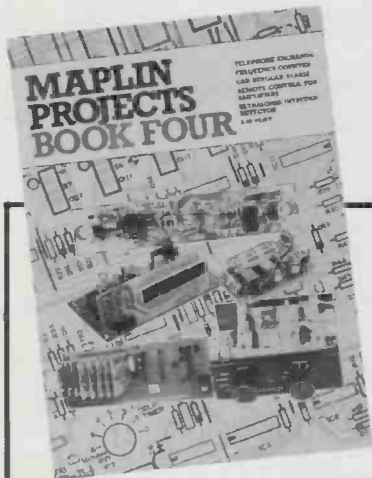

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September to November 1984
Volume 3 Number 12

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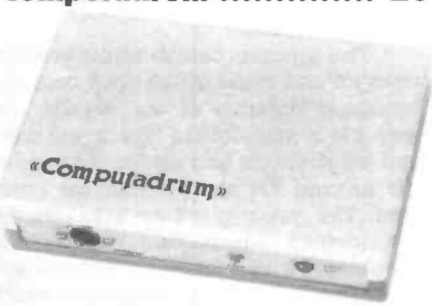
Electronics
THE MAPLIN MAGAZINE

PROJECTS

Easily as good as units selling for well over 4 or 5 times the price of this unit, the TU1000 features fixed or variable tone shifts, VCO controlled filters, receive and transmit capability and RS232 port for direct connection to your computer.



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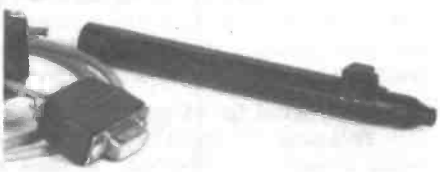

Draw pictures on your TV set or select menu options just by pointing, with our Light Pen all this is possible and much more. And its cheaper and better than most ready-built models as well!

A high performance model motor driver for 6V and 12V motors. The unit gives smooth control from off to full speed and is ideal for use in model boats and cars and in robotics.

Five fascinating circuits including a personal medium wave radio using a new IC, a telephone amplifier, an opto-coupled rpm meter, a tremolo unit and a model train chuffer controlled from the train speed controller on your layout.

FEATURES

A complete navigation system for your boat. The unit compares tides, wind speed and direction, and water speed and distance and can steer the boat for you. In a yacht the unit will tell you when to tack and the best course to sail allowing for the prevailing wind.

Another dip into the past to look at the late 19th century geniuses who were largely responsible for making the 20th century the electronics age.

More on the wide range of facilities offered by the 6522 and how to get the most out of this incredible chip.

Part seven looks at the CMOS digital integrated circuit family and features circuits for a timer and a piezo-electric timer.

The start of a brand new series that will prove invaluable to all home constructors. In part one we look at some of the most common problems encountered when building at home.

To complement our range of phone connectors featured in our last issue, this article describes how to use them and how your telephone works.

This month we look at the specialised test equipment available for use in fault-finding in digital circuits.

Shows how to measure dwell angle on your car using your multimeter. The method is far more accurate than using feeler gauges.

How to connect up the new range of space-saving and time-saving IDC connectors.

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The ZX81 and Your Boat

by D.I. Heaps   Part One

The ZX81 computer is robust, relatively powerful and has no moving parts. It is compact, uses 9 volts D.C. and is very cheap. A kit cost me £25. A boat is a joy to possess and sometimes a delight to sail. However there are two things which make sailing difficult – bad weather and having to navigate during bad weather. It is much easier in a rough sea to punch a few keys than to use a parallel rule and mental arithmetic. A computer can ask you all the right questions and unerringly give you the correct answers. It is not affected by sea sickness or exhaustion.

The following article describes how your ZX81 will aid your navigation and, in average seas, steer your boat. In bad weather, it at least removes the need for mental arithmetic. When sailing into the wind, it can calculate the best course and tell you when to tack. The program with this article contains five parts combined into a menu. It is written for use on a 16k extended ZX81 and is entered as one program. Each part can be used separately on a simple ZX81 with a little rewriting of the program.

The sections are:–

(1) Tides: Averages the tides.
(2) Navigation: Allows for tides and how close the boat will sail into the wind. It will tell you when to tack.
(3) Wind speed and direction: Uses an Input/Output port (I/O port) and simple hardware to tell the wind speed and direction.
(4) Water speed and distance: Uses an I/O port and a towed log to tell the speed of the boat and the distance travelled through the water.
(5) Steering: Uses an I/O port and purpose-built compass and servos to steer the boat.

By using the Navigation program several times it is possible to optimise your navigation. It removes the guesswork in choosing between a slower, shorter journey close hauled, or a faster but longer one off the wind. A further development would be to use the constantly available data from the wind speed and direction finder and that from the water log to enable the computer to adjust the course continually. This would ensure the most economical passage. As you can see there is scope for you to combine your computer and handyman skills to produce either an aid to navigating or a complete self-steering system which will compete with most on the market, but at a fraction of the price.

The Programs

These have been written as a menu of five parts entered as one program. All the parts display a brief description of their function and ask for input when needed. When the program has been entered (loading sign 'IN'), press RUN followed by NEWLINE and the television will display a menu with 5 options. Type in the number of the option required followed by NEWLINE and new information screens will be displayed. To return to the menu, press R.

Option 1. Tides.

This program calculates the average strength and angle of the tides over the estimated duration of the voyage. An estimate is made of the time it will take, and the strengths and angles of the tides are entered into the program for every hour. The output gives the averages for the journey which can be used in program 2. It also gives the Eastings and Northings of the accumulated tides which can be of great help if you decide to do some plotting.

Option 2. Navigation.

If motoring, this program calculates the course and distance through the water allowing for the tides. If sailing, it will also take into account the wind and properties of your boat. It will tell you if it will be necessary to tack, the courses to sail and distances through the water on each leg of the tack.

Option 3. Wind Speed and Direction.

This program displays on the TV the wind speed and direction. It uses a purpose-built anemometer and wind direction finder, and an I/O port. Wind speed is measured electronically by counting the rate that two small magnets pass a sensor. Wind direction is measured by four sets of Infra Red (IR) emitters and sensors. The signals are sent to the computer which decodes them and displays them on the TV screen.

Option 4. Water Speed and Distance.

This program displays the water speed and distance travelled through the water. It uses an I/O port and a trailed log. The rotation of the propeller on the log is measured by magnets and a small magnetic switch. The on/off signals are counted by two binary counters. A four-bit counter cycles from 0 to 15 and is sampled every cycle of the computer. It then calculates the speed of the boat and displays the result on the TV. An eight-bit counter continually counts the on/off

Figure 1. Block Schematic

signals and is sampled by the computer when required. The signals arriving at the counter are divided by 256 by two dividing circuits so that the equipment will record over about 30 miles. The displays can be zeroed by pressing the reset button on the computer interface.

Option 5. Steering.

This program steers the boat along a required course. It compares the data from a purpose-built compass with the course which has been entered into the computer. The computer sends instructions to the steering servo interface which instructs the servo to move the tiller. The servo interface knows where the tiller is due to an IR sensor on the tiller servo. The amount of movement of the tiller will be varied according to the amount the boat is off course. When the compass reading and the required course are displayed, the STEER CODE shown is the position code that the computer is sending to the servo interface.

Option 6. Optimiser?

This program is not included but is suggested as a further improvement. It could take the contents of the various program stores and issue amended instructions to the steering servo. It could react to changes in wind speed and direction and adjust the course in much the same way as would a skilled helmsman. It could measure the distance travelled along the first leg of a tack, and when at the tacking point, tack the boat. Of course, most boats would have to be specially fitted with a tacking jib to make this happen properly.

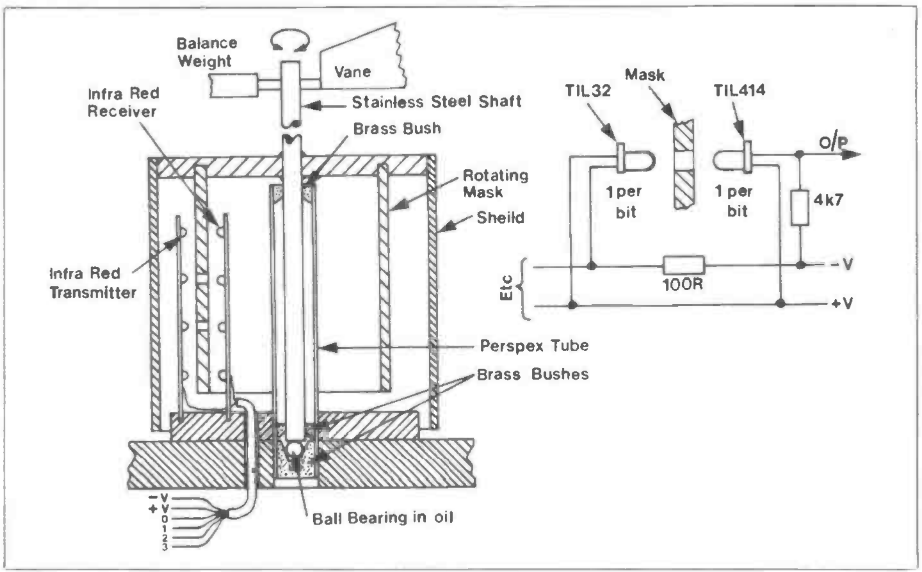


Figure 2. Wind Vane

Hardware

The Maplin I/O Port.

The first step is to get data into and out of the computer. The Maplin ZX81 I/O port has 3 ports which can be adjusted in many ways to read or change the environment for the computer. I have arranged for port A to be mainly dedicated to the 6 bit compass. It also sends instructions to change the data arriving at port B. Port B normally measures the distance travelled through the water. On instruction from port A the data arriving at it is changed to wind speed and direction. The higher part of port C is used to read water speed. The lower part issues the steering instructions to the servo interface.

Measuring Wind Speed and Direction.

This instrument is built from pieces of plastic piping, perspex and brass. Lengths of stainless steel are required for the axles and I used ball bearings for the pivots. Wind Direction is measured by a Wind Vane which is mounted on top of a circular four-bit encoder. Signals are sent to the computer which displays the direction on the TV. The signals are generated by four pairs of infra-red emitters and receivers placed on either side of a circular mask. The mask rotates with the wind vane. See Figure 2.

Two small magnets are mounted on the shaft of an anemometer to measure Wind Speed. As the anemometer rotates with the speed of the wind, the magnets pass close to a small electronic chip which is sensitive to changes in magnetic fields (Hall effect). The chip switches on at each passage of the magnets. These signals are counted by a four-bit counter which is sampled by the computer. Software is then used to calculate the speed of the wind and display the result. It may be a help to builders to know that I made the cups of the anemometer from the tops of roll-on deodorant containers. These have to be fixed to the ends of the rotating arms with Araldite. See Figure 3. The instrument can be calibrated by multiplying 'N' in line 3055 of the program by a suitable factor.

Water Speed and Distance Measurement.

The hardware for these measurements consists of a towed log and two small electronic circuits. The log is made from a rod of plastic about 100mm long and about 25mm in diameter. One end is shaped like a bullet. 25mm is cut off the

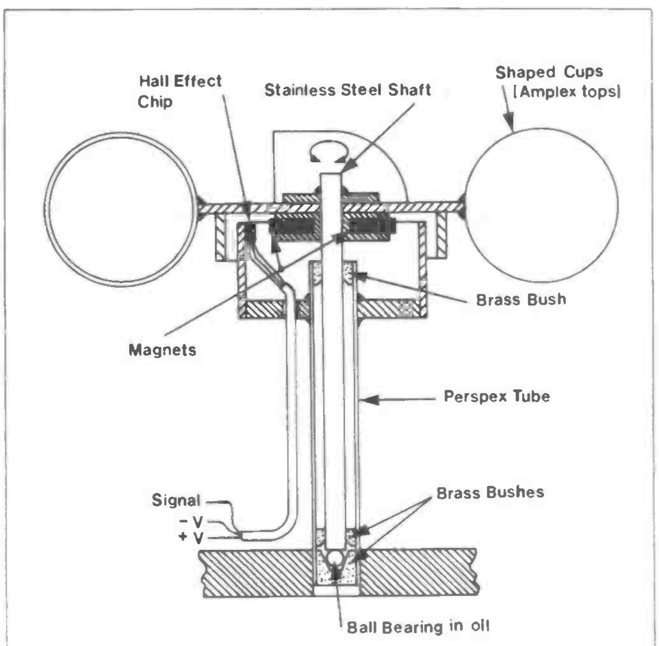


Figure 3. Anemometer

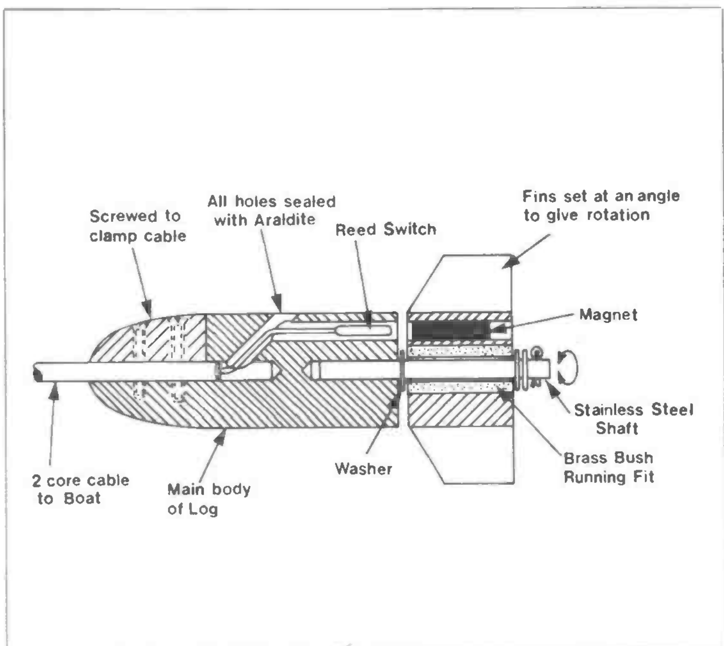


Figure 4. Log

other end to make the rotating part. The static bullet shaped part is drilled out to take the towing/signal wire and the shaft for the rotating part. A magnetic switch is located close to the flat end of the static part (Reed switch) and a magnet inserted in the rotating part. The Reed switch is wired through the body of the log to the towing wire. The bullet end of the log is split in two and then bolted around the towing wire to act as a clamp. All holes are then filled with Araldite. Two vanes are fitted to the rotating part and a small bush is pressed into its centre to aid free rotation. Care must be taken to see that the magnet passes close to the Reed switch when the spinner rotates. See Figure 4. The on/off signals from the log are counted by a four-bit counter as with the wind speed measurer. The computer samples the counter each cycle of the program and displays the speed through the water on the TV. Again the instrument can be calibrated by introducing a multiplyer into the software. The on/off signals from the log are also fed through a signal divider and then to an eight-bit counter. The eight-bit counter is then sampled on demand and the distance from the start of the journey displayed. The software can be used to calibrate the instrument.

Steering.

This part of the project compares the required course with that actually happening and adjusts the tiller accordingly. It requires a compass that the computer can read, a servo to move the tiller and a sensor to tell the computer where the tiller is. The required course can be calculated using program 2. Any allowance for lee-way should be made at this point.

The Compass is a purpose built compass which converts the direction being sailed into six-bit binary numbers. The computer then decodes these numbers, compares them with the required course and issues coded instructions to the steering servo. The construction of the coding part of the compass is similar to that of the wind direction finder. It consists of six pairs of infra red emitters and sensors separated by a mask. The mask is rotated by a compass magnet and has holes in it coded to give compass bearings. See Figure 5.

The tiller is moved by a servo made from a modified windscreen wiper motor. The one I used came from a D registered Mini and has served me well for three years so far. The motor drives a slider in a length of steel channel which in turn moves the tiller through a push rod. The motor moves the slider by a system of pulleys and ropes. See Figure 6. To make the motor rotate in either direction, it was necessary to modify it so that the field winding could be connected to the servo control box separately.

The Tiller Sensor consists of a four-bit infra red emitter and sensor which reads a coded mask to find out where the tiller is. The sensor is moved up and down the mask by the movements of the tiller slider. The mask is fixed so that it can be adjusted to allow for bias in the set of the sails or boat steering. The readings from the sensor are fed to a four-bit comparator chip which compares the position of the tiller with that instructed by the computer. If there is a difference between the two then the servo is made to move the tiller to the required position. The movement of the tiller will then change the heading of the boat, which will be noted by the compass and the computer. The computer will then give new instructions to the comparator chip which then goes through the process again. See Figure 7.

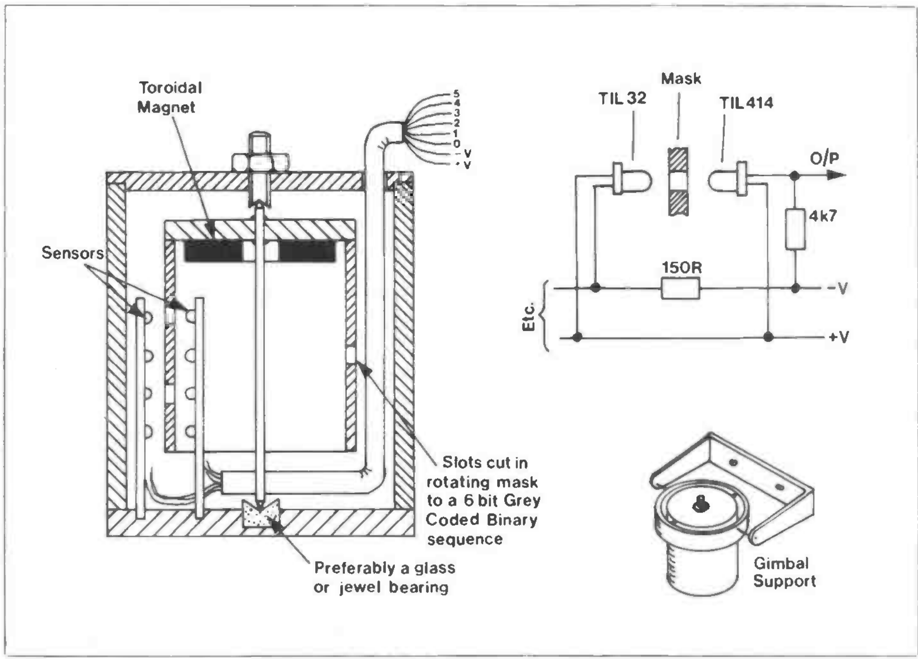


Figure 5. Compass

Installing the System

The ideal would be to have a television and a keyboard in the cockpit. However, as we are building an 'economy' system, we will have to put up with mounting our £50 black and white portable TV in the corner of the cabin. A good arrangement would be to build two

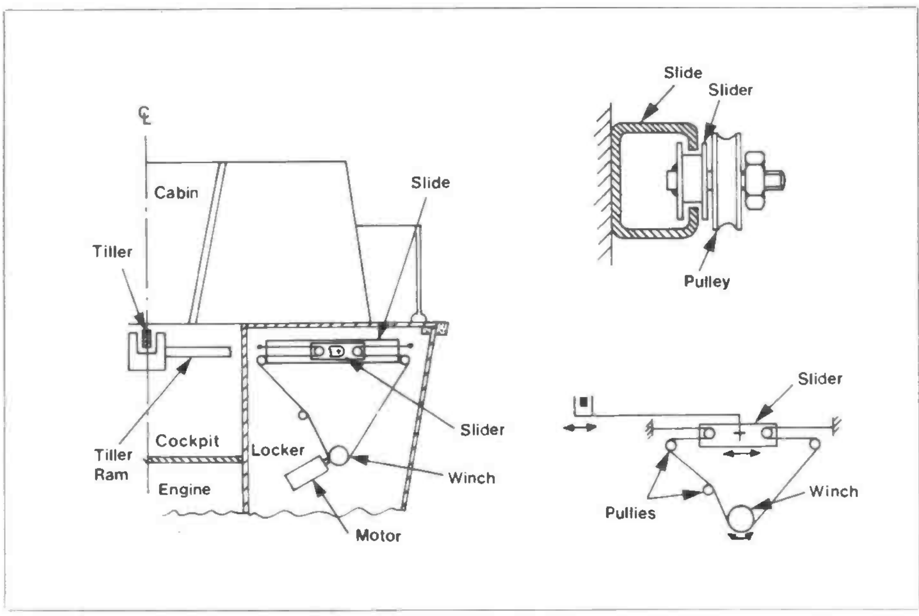


Figure 6. Tiller Servo

Continued on page 19.

The prototype RTTY unit

The Maplin TU1000 RTTY TERMINAL

Introduction

Home computers are mostly used for games and educational applications, but if you are looking for more than this, computer communications may be the answer. Many of you have probably heard of computers 'talking to each other', using a telephone modem. The major drawback to this system is the expense of running it. Telephone charges can run into pounds, for just a few minutes usage, though obviously this will depend on the distance and the time of the day. Transatlantic hook-ups are, therefore, prohibitively expensive and unless you are very wealthy, out of the question.

An alternative is not to use the telephone network, but use radio communications instead. The advantages are that there are no charges for hooking-up and no distance limitations. There is one slight problem: to use the system for sending data, you must have a licence to use a radio transmitter. However, no licence is required to *receive* data! This in itself is an interesting and absorbing pastime.

With a modest communications receiver it is possible to receive data transmitted by radio amateurs from all over the world. The short wave bands also abound with commercial stations sending news, weather reports and many other services, 24 hours a day. This system of typed data by radio, referred to as 'radio teletype' or abbreviated to RTTY, has been in use for many years.

by Chris Barlow

- ★ **RS232 Compatible**
- ★ **Fixed or Variable Tone Shifts**
- ★ **Receive and Transmit**
- ★ **Visual Tuning Aid**
- ★ **VCO Controlled Filters**

The system uses two audio tones which represent the two logic conditions, high or low, to control a mechanical teleprinter, or an ever increasing number of computer-based VDU systems.

The TU1000 has been developed for the purpose of demodulating the received audio tones into RS232 logic signals that a home computer, with the necessary software, can display. The TU1000 also offers audio output tones controlled by your computer for transmitting RTTY data.

The History of RTTY

As previously mentioned, RTTY dates back to the beginning of the 20th century and the code used goes back even further. In 1874 a Frenchman, Emile Baudot, formulated a five-unit code to control an electro-mechanical system. In 1903, Donald Murray modified Baudot's code to run his time division multiplex system which was used by the British Post Office. This code, although modified slightly over the years, is still referred to as the Baudot Code under the auspices of the International Telecommunication Union.

The earliest recorded use of radio teletype was in 1904 during the Russo-Japanese war, for military and civilian purposes. The first use of encrypted radio teletype signals was in the two world wars for communicating secret messages between military positions. Encryption, or 'scrambling' of the message, is still in use today for confidential and restricted information by various factions world-wide, although the majority of stations send messages in plain language.

The Baudot Code

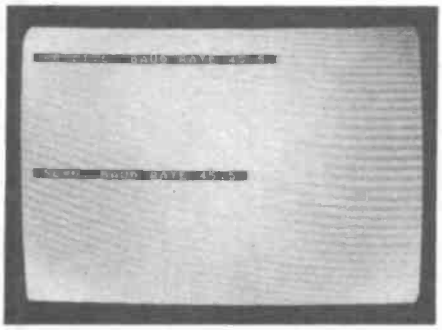
The code has five data bits, or elements, so there are only thirty-two possible characters to be interpreted. The alphabet takes twenty-six of the code values, which leaves six for control functions, null or no data, return, line-feed, space, letters and figures. The last two speak for themselves. 'Letters' puts the printer, or VDU into upper case A to Z and 'Figures' gives numbers 0 to 9, fifteen punctuation marks, and the 'bell' command.

If the 'bell' code were sent, on the receiving teleprinter a bell would sound to alert the operator to an incoming message. As you can see, the system does *not* support lower case as well as numbers and punctuation marks, unlike the majority of home computer displays.

A complete list of the Baudot Code, showing letters and figures, plus their decimal and hexadecimal values, is shown in Figure 1. Apart from the five data bits, the system uses 1 start bit and 1½ stop bits, although, in practice, you can set your RS232 port to 1 or 2 bits, if 1½ is not available.

The Two-Tone System

As stated in the introduction, RTTY uses two audio tones to represent the logic conditions high or low, commonly



referred to as mark and space tones. The mark produces the negative RS232 output and the standing tone when no data is being sent. The space tone gives the positive RS232 output and is generated when the RS232 input is taken positive.

The frequency difference of the tones can vary considerably but, in practice, three are used; 170Hz, 425Hz and 850Hz. The TU1000 has these three shifts, plus the ability to be tuned continuously up to a difference of 1000Hz between tones.

The space tone recognised by the TU1000 is 1275Hz. The mark is higher in frequency at 1445Hz for a 170Hz shift, 1700Hz for 425Hz, and 2125Hz for 850Hz shift.

The rate of change between the tones, or baud rate, has to be configured on your computer's RS232 port to resolve the incoming data correctly. Radio amateurs use baud rates of 45.45 or 50. Commercial stations tend to use 50, or 75 bauds, upwards.

LETTERS	FIGURES	DECIMAL	HEXA-DECIMAL
A	-	3	03
B	?	25	19
C	:	14	0E
D	$	9	09
E	3	1	01
F	! or %	13	0D
G	& or +	26	1A
H	£ or #	20	14
I	8	6	06
J	' or bell	11	0B
K	(	15	0F
L	)	18	12
M	.	28	1C
N	,	12	0C
O	9	24	18
P	0	22	16
Q	1	23	17
R	4	10	0A
S	bell or '	5	05
T	5	16	10
U	7	7	07
V	;	30	1E
W	2	19	13
X	/	29	1D
Y	6	21	15
Z	"	17	11
return	return	8	08
line feed	line feed	2	02
space	space	4	04
letters	letters	31	1F
figures	figures	27	1B
not used	not used	0	00

Figure 1. The Baudot Code

Circuit Description

The audio tones from the speaker or earphone socket are fed into the TU1000 via a two pin speaker DIN socket. The signal passes through choke CH1 and capacitor C1, to S1, the speaker on/off switch. The switch, when in the off position, connects the output of the receiver to an 8 ohm resistor to simulate a loudspeaker load. This facility is provided to mute the sound while maintaining the signal to the TU1000. When S1 is pressed in, the signal is fed, via CH2 and C2, to another two pin speaker DIN socket connecting your loudspeaker or earphone. The reason the incoming and outgoing signals go via the two chokes and capacitors, is to prevent any stray radio frequencies from entering the TU1000, if you use an amateur radio transmitter.

The audio signals passing through the system are tapped off S1 via the passive filter components R2, R3, C3 and C4 into IC1. IC1, with diodes D1 and D2, amplify the audio signal and limit the output to approximately 1 volt. This stage will provide limiting for an input as low as 10 millivolts. The limiting action is provided in order that the volume setting of the receiver and the fading radio signal are maintained to a constant level within the range of the circuit. At this stage, the frequencies are not separated for mark and space. The splitting of mark and space tones is achieved by feeding the output of the limiter to IC2 (MF10).

The MF10 is a dual switched capacitor filter. It offers two independent filter blocks controlled by a clock generator and, in the mode I have selected, the frequency passed by the filters is 100 times less than the clock frequency. That is, for a filter frequency of 1275Hz, the clock must run at 127.5kHz. The passband, or width of the filter, is very narrow because the difference between tones can be as little as 170Hz. There are two clock frequencies required to drive each filter. These clocks are generated by IC3 and IC4, which are voltage controlled oscillators. IC4's frequency is set by RV5, which is 127.5kHz. IC3 produces the clock frequencies for the mark filter, by switching in RV1 to RV4, setting the voltage controlled oscillator to 144.5kHz, 170kHz and 212.5kHz. These are the necessary shifts for 170Hz, 425Hz and 850Hz. RV1, 2 and 3 are preset potentiometers, while RV4 is a front panel potentiometer for the variable shift whose range is from almost 0 up to 1000Hz. IC's 3 and 4 also provide clock outputs which are required for generating the audio tones needed for transmitting data.

The mark and space tones leaving IC2, on pins 2 and 19, are buffered by IC5, a quad op-amp (3403). The remaining two stages of IC5 perform the task of driving the dual meter M1 that shows the mark and space tone levels. It is necessary to convert the mark and space tones to a DC voltage in order that the meters can display a *relative level*. This is achieved by D4 and D5 and the voltage produced here is fed to C13 and C14. The effect of

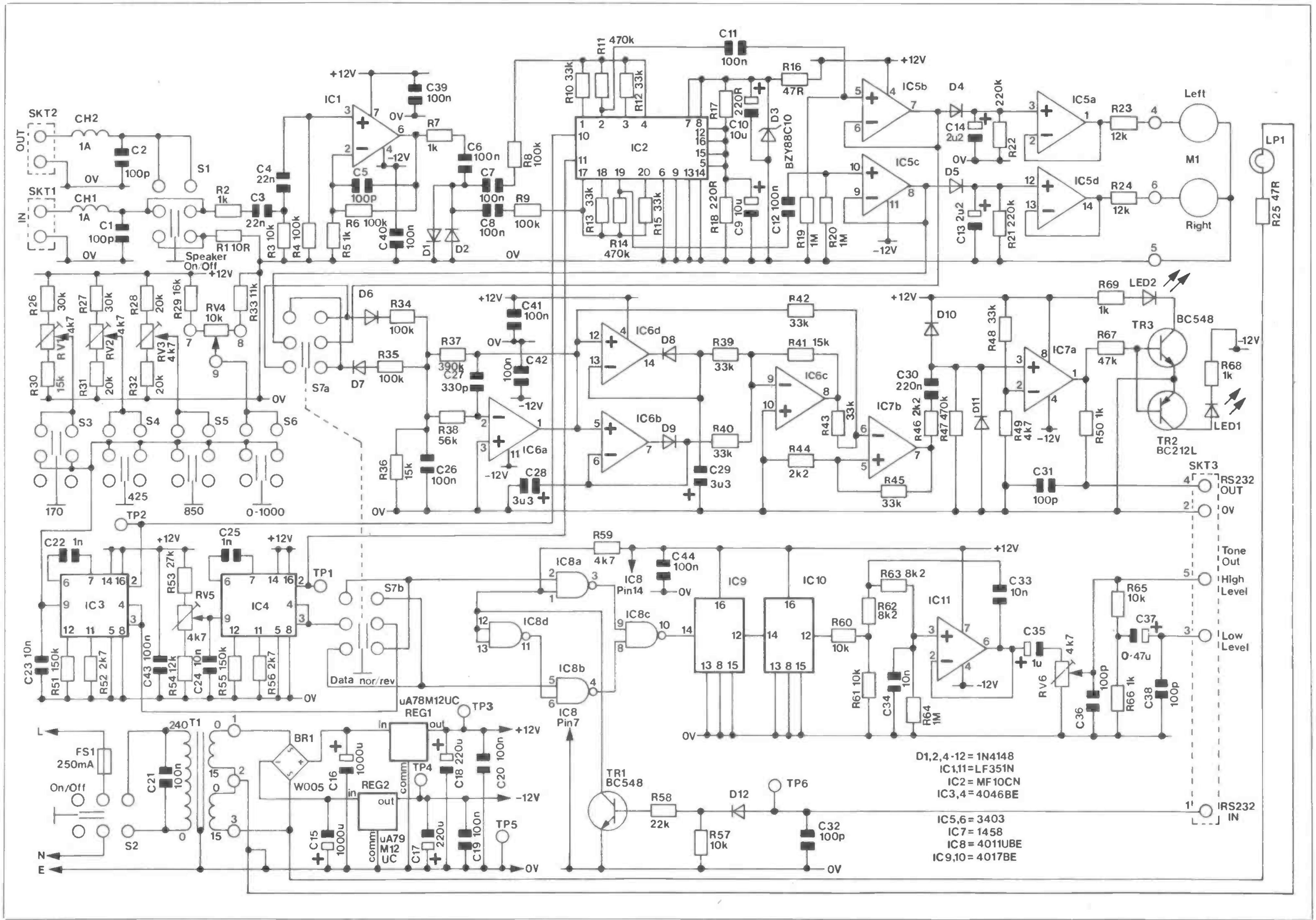
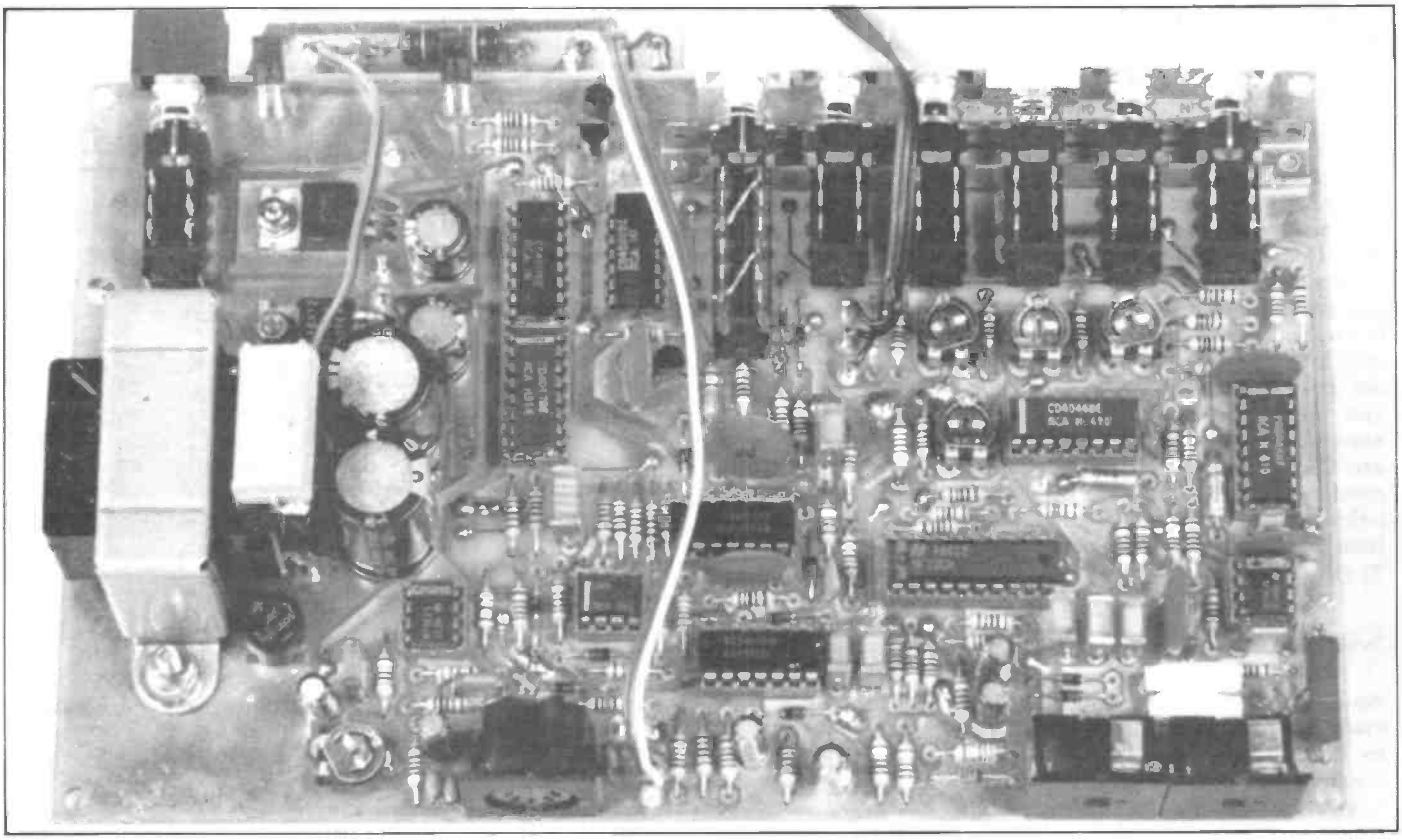


Figure 2. Circuit Diagram



this is to slow down the changes in level over a short period of time to maintain a more stable reading on the meters which are back-illuminated by LP1.

As previously mentioned, the mark and space tones are buffered by two sections of IC5, and are then fed, via S7 (section A), to the discriminator diodes D6 and D7. The function of S7 (A) is to accommodate normal or reversed tones. The discriminator circuit produces DC pulses, positive or negative, depending upon the dominant signal from either filter. The output from the discriminator is connected to IC6 (3403), which forms the active part of a low-pass filter. The signal is then fed to the remaining three sections of IC6, forming the signal balancing circuit. The output from this circuit provides a bias voltage which centres the output level of the low-pass filter to the input of the first part of IC7, a dual op-amp (1458). This section is referred to as the 'Slicer', the function of which is to allow only its output state to change when its input exceeds the pre-set threshold, set by the values of R44 and R45. This circuit prevents low level signals from producing spurious outputs.

The second half of IC7 forms the 'mark hold circuit' which returns the RS232's output negative if a space signal is longer than 150 milliseconds. Normally, this condition will not arise, because even at 45.45 bauds, the maximum space timing element is shorter in duration than 150 milliseconds, ensuring that if a prolonged tone is received, it will not hold the RS232 output high. The output from this stage is monitored by TR2 and TR3, which switch LED 1, or LED 2, on. These LED's indicate the logic state of the RS232 output. LED 1 indicates the mark, or negative output, while LED 2 indicates the space, or positive output. Before the RS232 output of IC7 is fed to pin 4 of the 5-pin DIN socket, it passes through R50 to limit the current should a short circuit accidentally appear on the RS232 line. Between pin 4 and ground, capacitor C31 has been placed to prevent any RF signals, that may be picked up on the leads connected to the 5-pin DIN socket, from entering the TU1000. This completes the description of the receiving part of the circuit and we now proceed to the audio tone generator used for transmitting.

If you recall, IC's 3 and 4 provide high frequency clock signal outputs which are now utilised in this part of the circuit to provide audio tones. S7, (section B), has the same function as section A, but allows normal or reversed tones to be transmitted. IC8 performs the function of selecting either the mark or the space high frequency clock when TR1 is turned on by the RS232 input on pin 1 of the 5-pin DIN socket. Normally, IC8 passes the mark clock frequency, however, when the RS232 input goes 'high', turning on TR1, IC8 gates the space clock frequency. The gated output of IC8 is fed to IC9 and IC10. These two IC's form a frequency 'divide by one hundred' stage which result in frequencies at the two audio tones required for transmitting. The audio tones will be directly related to the tones passed by IC2, the filter, because the same division ratio is used, which makes alignment of the transmit tones automatic, since they must be the same as the receive filter pass tones. In other words, once the receive tones are aligned, the transmit tones will *also* be aligned.

Before these tones can be fed to a transmitter, it is necessary to convert the square wave output of IC10 into a filtered signal, as a square wave is very rich in harmonics and can lead to a very wide transmitted signal. This is achieved by passing the square wave signal through a low pass filter, IC11. The cut-off frequency is set slightly higher than the maximum audio tone to be generated, and is set by the filter network, C33 and C34, R63 and R64. Although not a pure sine wave, the output is clean enough for transmitting

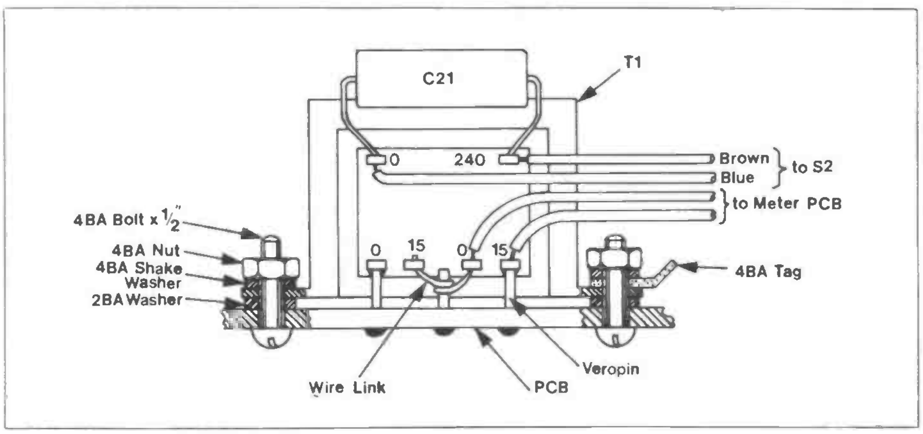


Figure 3. Transformer mounting

purposes. The level of signal is adjusted by RV6 from almost 0 to 2 volts peak to peak, available at pin 5 of the 5-pin DIN socket. A lower level signal is available at pin 3 which is again adjustable by RV6 from almost 0 to 200 millivolts peak to peak.

Finally, a brief description of the power supply. The transformer has a 15–0–15 volt AC secondary feeding BR1, a bridge rectifier which produces a DC positive and negative supply with respect to 0 volts. It is necessary to regulate *both* rails to + and −12 volts. This is carried out by regulators REG1 (μA78M12UC) and REG2 (μA79M12UC), and their associated decoupling capacitors C17 and C18. The only other power requirement in the circuit is for LP1, the lamp behind the meters. This supply is taken from one half of the 15 volt secondary of T1 (15 volts AC).

Construction

The components are mounted on a double-sided PCB and connections are made between the top and bottom tracks by through pins, the positions of which are indicated by the small circles on the board. You must insert the pins through the board, and solder them carefully on each side. It is important that these pins are installed *before* fitting any other components because some pins will be covered by certain IC sockets. The Veropins will be inserted next in the large circles marked on the board. These are pushed all the way into the board by applying the soldering iron to the head of the pin, and by pushing with a reasonable amount of pressure, the pin will go into the board. The IC sockets are fitted next, and care must be exercised in putting them in, matching the notch at the end of the socket with the printed mark on the legend. Starting with the 8-pin sockets at locations IC1, IC7, and IC11, then the three 14-pin sockets, followed by the four 16-pin sockets and finally the 20-pin socket. The IC's themselves are not inserted at this stage.

The 2-pin and 5-pin PCB mounted DIN sockets are installed next, making sure that the sockets are pushed tightly against the board. The next item to mount is the mains transformer. Take the solder tag included in the kit and fit the transformer using the 4BA hardware as shown in Figure 3. The secondary outputs from the transformer are then connected to the board in the following way: bend the two outer tags down carefully and solder them to the Veropins located beneath the tags. The two inner tags are connected to the remaining Veropin by using an off-cut from C21, the mains suppressor capaitor, as shown in the diagram. This capacitor is attached across the primary tags of the transformer. Finally, solder two insulated wires to the 0 and 15V tags using two wires from the 10-way ribbon cable.

The next components to be fitted are the voltage regulators, REG1 and REG2. These are installed using the 6BA nuts, bolts and shakeproof washers as per Figure 4. It is not necessary to use any silicone grease or mica washers for these devices.

The next item to be assembled is the 6-way switch-bank as shown in Figure 5. In the kit, you may receive a 6-way latchbracket and a 4-way latching bar. However, a 6-way latching bar may be supplied instead. If this is the case *carefully* cut off two tags to make a 4-way, and note that if the bar is bent in any way, it may cause the switch assembly to jam.

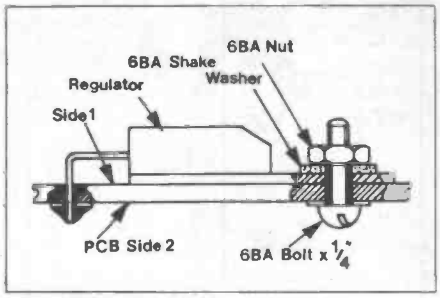


Figure 4. Fitting regulators

```
RECEIVED RTTY

YRYRYRYRYRYRYRYRYRYRYRYRYRYRYRYRYRYRYRYR DE

F6CDX F6CDX F6CDX

PR CN8EL CN8EL TKS DR OM FR CALL, MY

NAME NAME  JEAN PIERRE  JEAN PIERRE  JEAN PIERRE

QTH QTH  LA COQUILLE  LA COQUILLE  LA COQUILLE

(50KM SUD DE LIMOGES, IN SW FRANCE)

UR RST RST RST---599---599---599. FB REPORT. A VOUS CN8EL

DE F6CDX F6CDX F6CDX

FS KKKKKK
                             DE I8QFK I8QFK I8QFK
                            CQ CQ CQ DE I8QFK I8QFK I8QFK
                            CQ CQ CQ DE I8QFK I8QFK I8QFK
                            THIS IS I8QFK CALLING AND STANDING BY FOR ANY POSSIBLE CALL
                            PSE PSE K K K


                             CQ CQ CQ DE I2SFX I2SFX I2SFX (5)
                             CQ CQ CQ DE I2SFX I2SFX I2SFX (4)
                             CQ CQ CQ DE I2SFX I2SFX I2SFX (3)
                             CQ CQ CQVSIX I2SFX (2)
                             CQ CQ CQ DE I2SFX I2SFX J2SFX (1)
                             P S E ,K.K.K.K.K.K.............


  WPATHE BUREAU 73 73 73 GOOD DX GOOD LUCK
  TO YOU AND FAMILY AND I HOPE TO MEET YOU AGAIN IN THIS MODE OR OTHER
  MODE CIAO TON DE FRANCO IN COMO CITY BYE AND TKS FOR THIS NICE QSO
  CIAO PA0LUF PA0LUS PA0LUS DE I2KFW I2KFW J2KFW AR PSE SK SK SKFCQ CQ CQ CQ CQ CQ
   CQ CQ CQ DE


 FIRING PRACTICE SINCE16 UNTIL 21 OJULY FROM 0400Z TO 1600Z DVAILZ

 IN AREA BOUNDED BY :
 44 23 N  30 22 E          CQ CQ CQ CQ CQ CQ CQ CQ CQ CQ CQ CQ CQ CQ CQ CQ CQ CQ DE

 44 57 N  30 34            F6CDX F6CDX F6CDX

 45 44
   31 24 E
                           CQ CQ CQ CQ CQ CQ CQ CQ CQ CQ CQ CQ CQ CQ CQ CQ CQ CQ DE
 44 48 N  32 30 E
                           F6CDX F6CDX F6CDX
 43 58 N  31 28 E

 AREA TEMPORARILY DANGEROUS

 TO NAVIGATION AND AIRCRAFT    CQ CQ CQ CQ CQ CQ CQ CQ CQ CQ CQ CQ CQ CQ CQ CQ CQ CQ DE

 FLIGHTS UP TO 2500 METRES .   F6CDX F6CDX F6CDX


                           CQ CQ CQ CQ CQ CQ CQ CQ CQ CQ CQ CQ CQ CQ CQ CQ CQ CQ DE

                           F6CDX F6CDX F6CDX
```

Received RTTY messages

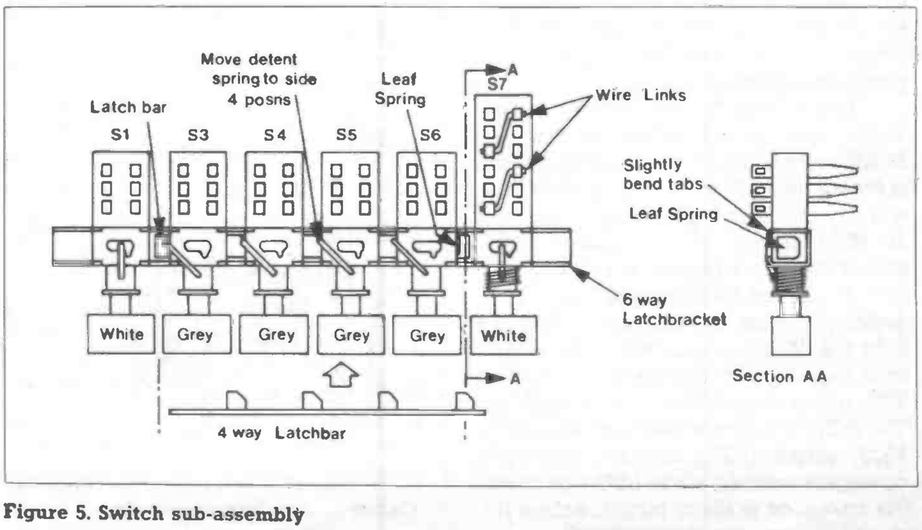


Figure 5. Switch sub-assembly

At switch position 6, install the leaf spring as shown in Figure 5. Using wire off-cuts from C21, solder two links onto S7. The switch assembly should not be mounted on the board at this stage.

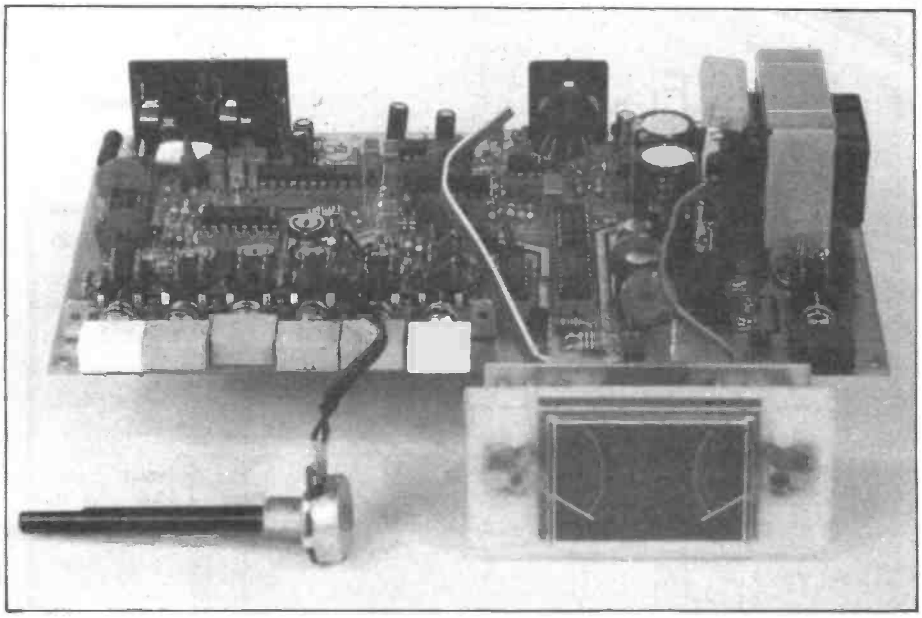
Install the Veropins on the meter PCB in the same manner as the main PCB. As you will see from Figure 6, the pins protrude through side one of the board. The lamp is mounted on side two. This board is now fitted to the back of the dual meter by carefully bending the lugs of the meter over the board and soldering in position on one side. The meter assembly is also fitted at a later stage.

Returning to the main PCB, fit the resistors in their respective positions according to the legend and remove any excess wire after they have been soldered into position. The five preset potentiometers are fitted next. They are all of the same value and should be set at the halfway point of travel. The tantalum and the electrolytic capacitors are installed next. Make sure that they are correctly positioned according to their polarity. The remaining capacitors can be installed either way round and are fitted next.

Fit D3, a 10V zener according to its polarity marking. The remaining diodes are all of the same type (1N4148), and are fitted with the same consideration to polarity. The three transistors can then be fitted by matching the flat on the transistor with the flat on the board and soldering in place. The two RF chokes are mounted immediately behind the two 2-pin DIN sockets. The two LED's have to be mounted so that they will fit neatly through the holes in the front panel, see Figure 7.

Fit the mains switch, S2, pushing the switch leads into the board as far as they will go. Fit the switch assembly, S1, S3 to S7 in the same manner. Check that each of these switches is operating smoothly. Using Figure 8 as a guide, wire RV4, the 10k linear pot, using three lengths of wire from the ribbon cable to the three Veropins immediately behind S6.

The dual meter assembly is also wired according to Figure 8, using wire from the ribbon cable. Three connections are made from the meter to the three Veropins close to the 5-pin DIN socket and the remaining two 15V wires from the mains transformer are connected to the meter board at the points shown in the diagram. This completes the construction of the main PCB, but note that the IC's are not to be inserted yet.



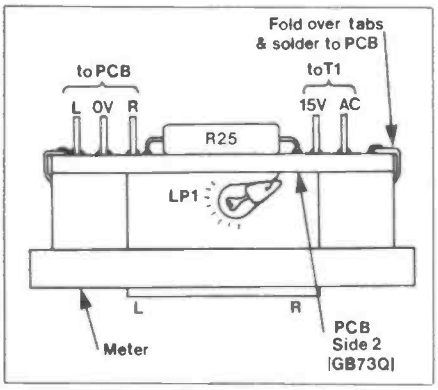


Figure 6. Meter illumination

Initial Tests

Visually check the circuit board for the correct installation of the components, unsoldered joints, solder bridges, dry joints, capacitor and diode polarisation, and transistor orientation. Place the PCB on a clean non-conductive surface, with the meter assembly and RV4 clear of the board. Temporarily solder the mains

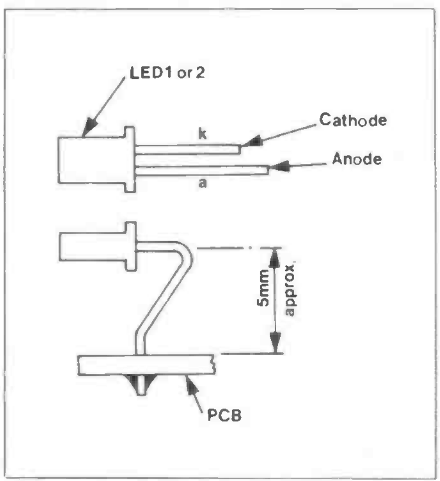


Figure 7. Fitting the LED's

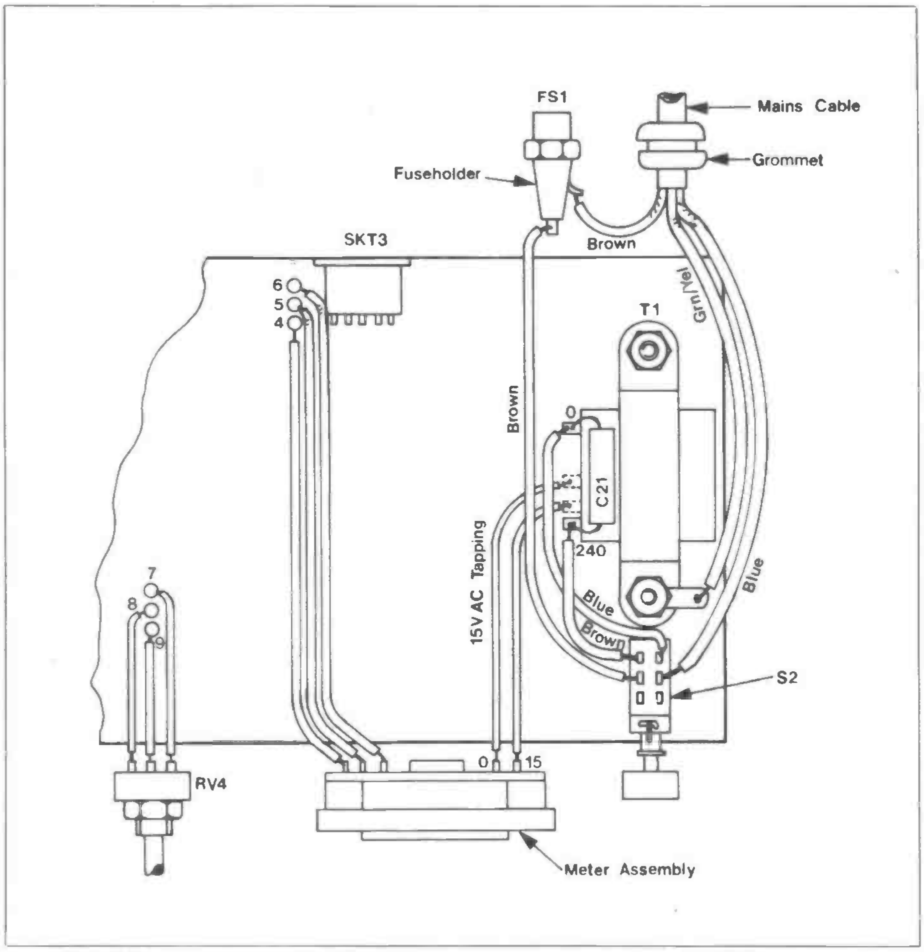


Figure 8. Wiring

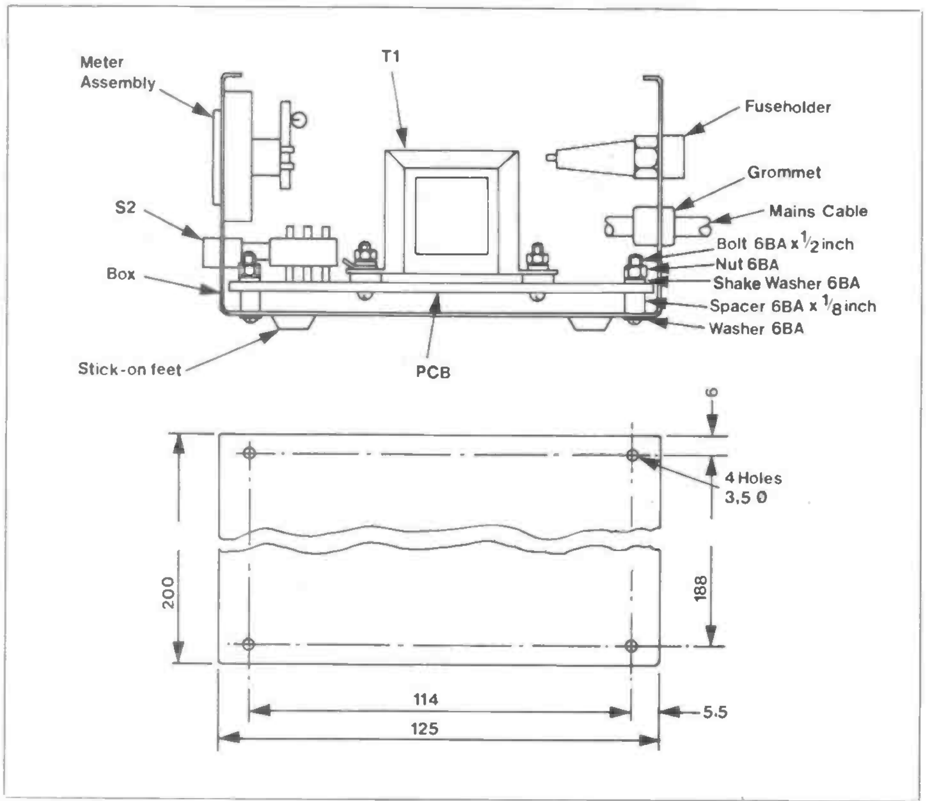


Figure 9. Case layout

cable to the transformer 0 and 240V tags and the mains earth lead to the solder tag installed on the transformer fixings. Insert a 3A fuse into a mains plug. WARNING!! *There will be live mains on the transformer, so please use extreme care.*

A voltmeter will be required in the following stages to check the power supplies to the various parts of the circuit. Plug the unit into the mains. At this stage LED1 and 2 will not light, but the meter bulb should. Set the voltmeter to cover a range suitable for 12V DC, connect the −V lead to Test Point 5 and the +V lead of the meter to Test Point 3, when a reading of between 11.5V and 12.5V should be seen. Reconnect the +V lead to Test Point 5 and the −V lead to Test Point 4, when a similar reading should be seen. Connect the −V lead to Test Point 5 and the +V lead to the cathode or banded end of D3. An approximate reading of 10V should be seen. If the readings you have obtained are within this range, the initial voltage tests are complete.

Disconnect the mains supply from the unit and insert all the IC's. You must be careful to insert these devices according to the notches on the IC and with the markings on the PCB. Check that all the pins are fitted into their respective holes, because they are easily bent under the IC. Reconnect the mains supply and LED1 should light, but not LED2. Repeat the voltage tests from the initial checks once more when you should obtain the same readings for each test as before.

These voltage tests allow us to proceed to the function tests. Set the following controls: S1 on (in), S3 on (in), RV4 set half way, and S7 off (out). Connect a piece of insulated wire between pin 5 of the 5-pin DIN socket and the round pin marked S on SKT1, one of the 2-pin DIN sockets. The left-hand meter should indicate a full scale deflection and LED1 should remain on. Connect another piece of wire between Test Point 6 and Test Point 3. LED1 and 2 should momentarily change state and the left-hand meter should go from full scale deflection to low, and the right-hand meter should go to full scale. If S7 is switched on (in), the meter conditions will be reversed. Repeat this test for S4, S5 and S6. Remove the wire from Test Points 3 and 6. This completes all the function tests. Disconnect the unit from the mains supply, desolder and remove the mains connections from the transformer and earth tag.

Final Assembly

Referring to Figure 9, drill the holes for the PCB mounting pillars, drill the front and rear holes and cut the window for the meter using the decorative front and rear labels as templates. Thoroughly clean any swarf from the holes, clean the case with detergent and warm water and give all surfaces a thorough going over with methylated spirit. Remove the backing from the decorative front and rear labels and carefully stick them in position.

Stick the rubber feet supplied with the case in place on the base of the case. Carefully scrape away the paint from around the holes in the bottom inside surface of the case. This will provide an earth connection between the PCB and the case via the pillars. The PCB is mounted as shown in Figure 9, using the 6BA hardware from the kit. Strip approximately 5 inches of the outer sleeving from the mains cable provided, and cut off a 3 inch length from the brown wire and discard it. Strip a ¼ inch length from all of the wires and twist and tin the ends with solder. Pass the prepared lead through the mains inlet hole and fit the strain relief grommet. Solder the green/yellow earth lead to the solder tag on the transformer, and the blue 'neutral' wire to S2 (Figure 8). Fit the fuseholder, and solder the brown 'live' wire to the terminal as shown in Figure 8. Locate the 6 inch length of blue and brown mains wire from the kit and complete the wiring according to the diagram. Because all of these connections are directly associated with mains voltages check all of them very carefully before connecting the unit to the mains. Bolt RV4 into position and cut the plastic shaft to fit the knob. Carefully put a coat of impact adhesive to the recessed portion of the meter (M1) and also a suitable area around the inside of the cut-out in the case, following the adhesive maker's instructions. If not already fitted, put the control buttons onto the switches. With the completion of this stage, we can now proceed to the alignment of the unit.

Alignment

There are two basic methods of alignment: with test gear, or tuning around on a radio and adjusting the presets until you can resolve the incoming data. Tuning around is the least accurate method of the two, but you can, in time, obtain quite good results.

Using test gear is much more accurate, and this method is to be preferred if the unit is to be used for transmitting. The only test gear required is a digital frequency counter, the resolution of which must be capable of reading down to at least 100Hz. Because the frequencies involved are below 1MHz, even a modest counter is more than adequate.

Connect the test lead of the counter to Test Point 5, ground. The signal input lead of the counter should be connected to Test Point 1 and RV5 adjusted to give a reading of 127.5kHz. This sets the frequency of the space filter and the space tone output for transmit. Now connect the test lead to Test Point 2 and push in S3, adjusting RV1 to produce a reading of 144.5kHz. Leaving the leads in this position, press S4 and adjust RV2 for a reading of 170.0kHz. The last preset shift is set by RV3 and with S5 pushed in, adjust this preset to give a reading of 212.5kHz. This completes the fixed shifts and if S6 is pressed, the front panel control, RV4, will produce a reading of about 127.5kHz in the fully anti-clockwise position and about 227.5kHz in the fully clockwise position. The alignment of the TU1000 is now complete and you may connect it up to a computer and a suitable receiver.

RTTY Software

The software necessary to receive and transmit RTTY data can be as complex as you care to write. Not many RTTY or communication programs have been published in the computer magazines, but the program included in this article is for use with an Atari home computer and the Atari 850 RS232 interface. Due to the large number of

```
100 CLR :REM R.T.T.Y BY Chris Barlow.
200 REM 850 INTERFACE MODULE RS-232 PORT 1.
300 TRAP 10900:CLOSE #2:OPEN #2,4,0,"K:"
400 GRAPHICS 0:POKE 710,180:POKE 709,0:POKE 712,180:POKE 559,0
500 SOUND 0,80,10,5
600 REM **** BAUDOT TO ATASCII SET-UP ****
700 DIM BA$(7):DIM ATASCII(64):DIM BAUDOT(128):DIM RT$(1000):
DIM RP$(5000)
800 LET RT$="":LET PO=0:LET KEY=49:LET RP=1
900 LET SX2=1:LET SY2=1:POKE 82,1
1000 FOR I=1 TO 64:READ DAT:LET ATASCII(I)=DAT:NEXT I
1100 REM **** ATASCII TO BAUDOT SET-UP ****
1200 FOR I=1 TO 128:READ DAT:LET BAUDOT(I)=DAT:NEXT I
1300 FOR I=0 TO 33:READ D:POKE 1556+I,D:NEXT I
1400 LOW=PEEK(106)-8:LOWZ=LOW+4
1500 HIGH=PEEK(106)-4:HIGHZ=HIGH+4
1600 POKE 1556+4,LOW:POKE 1556+19,HIGH
1700 POKE 88,0:POKE 89,HIGH:POKE 106,HIGHZ:PRINT CHR$(125)
1800 POKE 89,LOW:POKE 106,LOWZ:PRINT CHR$(125)
1900 POKE 560,20:POKE 561,6
2010 FOR LOOP=0 TO 17:READ D:POKE 1536+LOOP,D:NEXT LOOP
2020 MAC=USR(1536):POKE 559,34:POKE 712,0
2090 GOSUB 9300
2100 REM *** RECEIVE ***
2200 LET SHIFT=0
2300 LET SX1=1:LET SY1=3
2400 REM KEY TEST
2500 IF PEEK(53279)=5 THEN GOSUB 4000
2600 IF PEEK(53279)=3 THEN GOSUB 8900
2700 IF PEEK(764)<255 THEN GOSUB 11200
2710 STATUS #1,A
2800 IF PEEK(747)=0 THEN 2400
2900 GET #1,RECEIVE:GOSUB 3100
3000 GOTO 2400
3100 LET RECEIVE=ATASCII(RECEIVE-224+SHIFT+1)
3200 IF RECEIVE<0 THEN RETURN
3300 IF RECEIVE=0 THEN SHIFT=0:RETURN
3400 IF RECEIVE=1 THEN SHIFT=32:RETURN
3500 POSITION SX1,SY1:PRINT CHR$(RECEIVE);
3600 LET SX1=PEEK(85):LET SY1=PEEK(84)
3700 IF SX1>38 THEN PRINT CHR$(155);:LET SX1=1:
LET SY1=SY1+1
3800 IF SY1>10 THEN POKE 752,1:POSITION 1,1:PRINT CHR$(156):
LET SY1=10:POKE 752,0:POSITION SX1,SY1-1:PRINT
3810 LET RP$(RP)=CHR$(RECEIVE):LET RP=RP+1:IF RP>4999
THEN RP=4999
3900 RETURN
4000 REM **** SEND BUFFER ****
4100 CLOSE #1:OPEN #1,8,0,"R1:":LET AL=1
4200 IF LEN(RT$)<1 THEN 6300
4300 POKE 89,HIGH:POKE 106,HIGHZ:POKE 752,1:POKE 712,21
4310 POSITION 1,1:PRINT " "  <-You must enter 38 spaces between these quote marks.
4400 POSITION 1,1:PRINT " SEND BUFFER. BAUD RATE ";BA$
4500 FOR Q=1 TO LEN(RT$)
4600 IF PEEK(53279)=6 THEN 8500:REM START KEY TO RETURN TO
RECEIVE.
4700 KEY=ASC(RT$(Q)):LET OUT=KEY
4800 IF OUT>127 THEN LET OUT=OUT-128
4900 LET OUT=BAUDOT(OUT+1)
5000 IF OUT=0 THEN 4600
5100 IF AL=1 THEN 5500
5200 IF OUT<0 THEN 5700
5300 LET AL=1:PUT #1,31
5400 GOTO 5700
5500 IF OUT>0 THEN 5700
5600 LET AL=0:PUT #1,27
5700 PUT #1,ABS(OUT)
5800 IF OUT<>8 THEN 6100
5900 PUT #1,2:PUT #1,31
6000 LET AL=1
6100 NEXT Q:XIO 32,#1,0,0,"R1:"
6200 PRINT CHR$(125):PRINT " BUFFER SENT. KEYBOARD ON
LINE.":POKE 752,0:PRINT :LET SX2=1:LET SY2=3:GOTO 6420
6300 POKE 89,HIGH:POKE 106,HIGHZ:PRINT CHR$(125):LET SX2=1:
LET SY2=3
6400 POKE 752,1:PRINT " SEND. BAUD RATE ";BA$:POKE 752,0
6420 POKE 712,21
6500 IF PEEK(53279)=6 THEN 8500:REM START KEY TO RETURN TO
RECEIVE.
6600 IF PEEK(764)=255 THEN 6500
6700 GET #2,KEY:LET OUT=KEY
6800 IF OUT>127 THEN LET OUT=OUT-128
6900 LET OUT=BAUDOT(OUT+1)
7000 IF OUT=0 THEN 6500
7100 POSITION SX2,SY2:PRINT CHR$(KEY);
7200 LET SX2=PEEK(85):LET SY2=PEEK(84)
7300 IF SX2>38 THEN PRINT CHR$(155);:LET SX2=1:LET SY2=SY2+1
7400 IF SY2>10 THEN POKE 752,1:POSITION 1,1:PRINT CHR$(156):
LET SY2=10:POKE 752,0:POSITION SX2,SY2-1:PRINT
7500 IF AL=1 THEN 7900
7600 IF OUT<0 THEN 8100
7700 LET AL=1:PUT #1,31
7800 GOTO 8100
7900 IF OUT>0 THEN 8100
8000 LET AL=0:PUT #1,27
8100 PUT #1,ABS(OUT)
8200 IF OUT<>8 THEN 6500
8300 PUT #1,2:PUT #1,31
8400 XIO 32,#1,0,0,"R1:":LET AL=1:GOTO 6500
8500 CLOSE #1:OPEN #1,5,0,"R1:":XIO 40,#1,0,0,"R1:"
8600 PRINT CHR$(125)
8700 POKE 89,LOW:POKE 106,LOWZ:PRINT CHR$(125):LET SX1=1:
LET SY1=3:LET SX2=1:LET SY2=1:POKE 712,0
8800 PRINT " RECEIVE. BAUD RATE ";BA$:PRINT :LET PO=0:
LET RT$="":RETURN
8900 REM ..... BAUD RATE 45.5 TO 300...
9000 PRINT CHR$(125):POKE 752,1:PRINT " BAUD RATE 45.5 TO 300
- INPUT 1 TO 8 "
9010 PRINT :PRINT " PRESS P FOR PRINT-OUT "
9100 GET #2,KEY:IF KEY>127 THEN KEY=KEY-128
9105 CLOSE #1
9110 IF KEY=80 THEN LPRINT :LPRINT "RECEIVED RTTY":LPRINT :
LPRINT RP$:LET RP=1:LET RP$=""
9200 IF KEY<49 OR KEY>56 THEN 10200
9300 IF KEY=49 THEN BA$="45.5 "
9400 IF KEY=50 THEN BA$="50.0 "
9500 IF KEY=51 THEN BA$="56.875 "
9600 IF KEY=52 THEN BA$="75.0 "
9700 IF KEY=53 THEN BA$="110.0 "
9800 IF KEY=54 THEN BA$="134.4 "
9900 IF KEY=55 THEN BA$="150.0 "
10000 IF KEY=56 THEN BA$="300.0 "
10100 RATE=KEY-48
10200 BAUD=48+RATE
10300 OPEN #1,5,0,"R1:":REM PORT 1 INPUT ONLY (CONCURRENT
MODE)
10400 XIO 36,#1,BAUD,0,"R1:"
10500 XIO 40,#1,0,0,"R1:":REM PORT 1 CONCURRENT MODE SET
10600 XIO 38,#1,32,0,"R1:":REM NO TRANSLATION
10700 LET SX1=1:LET SY1=3
10800 PRINT CHR$(125):PRINT " RECEIVE. BAUD RATE ";BA$:
POKE 752,0:PRINT :RETURN
10900 SOUND 0,25,10,10
11000 POKE 752,1:PRINT :PRINT "< SYSTEM ERROR > ";
11100 LET E=PEEK(195):PRINT E:FOR I=0 TO 300:NEXT I:GOTO 100
11200 PO=PO+1:IF PO>1000 THEN PO=1000
11300 GET #2,KEY:LET RT$(PO)=CHR$(KEY)
11400 POKE 89,HIGH:POKE 106,HIGHZ
11500 POSITION SX2,SY2:PRINT RT$(PO);
11600 LET SX2=PEEK(85):LET SY2=PEEK(84)
11700 IF SX2>38 THEN PRINT CHR$(155);:LET SX2=1:LET SY2=SY2+1
11800 IF SY2>10 THEN POKE 752,1:POSITION 1,1:PRINT CHR$(156):
LET SY2=10:POKE 752,0:POSITION SX2,SY2-1:PRINT
11900 POKE 89,LOW:POKE 106,LOWZ:RETURN
12000 REM BAUDOT TO ATASCII DATA.
12100 DATA -1,69,-1,65,32,83,73,85,155,68,82,74,78,70,67,75,84,90,76,
87,72,89,80,81,79,66,71,1,77,88,86,0
12200 DATA -1,51,-1,45,32,39,56,55,155,36,52,39,44,33,58,40,53,34,41,
50,35,54,48,49,57,63,43,1,46,47,59,0
12300 REM ATASCII TO BAUDOT DATA.
12400 DATA 0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,8,0,0,0,0
12500 DATA 4,-45,-17,-20,-9,0,-26,-11,-15,-18,0,-26,-12,-3,
-28,-29,-22,-23,-19,-1,-10,-16,-21,-7
12600 DATA -6,-24,-14,-30,0,0,0,-25,0,3,25,14,9,1,45,26,20,6,11,15,
18,28,12,24,22,23,10,5,16,7,30,19
12700 DATA 29,21,17,0,0,5,0,0,0,3,25,14,9,1,45,26,20,6,11,15,18,28,12,24
12800 DATA 22,23,10,5,16,7,30,19,29,21,17,0,0,5,0,0
12900 DATA 112,112,66,0,20,2,2,2
13000 DATA 2,2,2,2,2,2,2,2
13100 DATA 48,66,0,0,2,2,2,2
13200 DATA 2,2,2,2,2,2,65,20,6
13300 DATA 104,169,6,162,6,160,11,32,92
13400 DATA 228,96,169,0,133,77,76,95,228
```

RTTY Program for Atari

microcomputers used in the home, it is not possible, at the moment, to produce a program listing which will run satisfactorily on all machines. This is due to the various BASIC dialects and differing internal structures, such as port addressing and PEEK's and POKE's. It is hoped that sufficient interest will be generated in this article so that more computer systems might run RTTY software. If there is any feedback from this article, programs for other processors may be published in future editions of 'Electronics'. But note that Scarab Systems, 39 Stafford Street, Gillingham, Kent produce a range of suitable software for most of the popular home computers.

In order to help you write your own programs, here are a few guidelines. The program, if intended to be used for transmitting as well as receiving data, must have the ability to select either mode. If you intend to receive only, virtually half of the program may be discarded. As you can see from Figure 1. the decimal value allocated to each character is not the same as the ASCII value. For this reason, the value of one must be translated to the other for received codes as well as transmitted codes. A simple method for achieving this is to set up an array of sixty-four ASCII values, their positions in the array relating to the decimal value of the incoming or outgoing data. For example if the third value in the array was 65, this would represent the letter 'A'. When the 'figures shift' code is received, an additional offset must be added to select the correct position in the array to return the ASCII character codes for numbers and punctuation marks. If the program is written to support transmit facilities, an additional array of 128 values must be set up to convert ASCII values to the correct decimal value representing the outgoing data. The reason for the size of the ASCII array is due to the large number of possible values returned by a typical computer keyboard. Any non-valid key should be converted by the array, to a value of 0. This will inhibit values outside the range of the five-bit code.

This would be the minimal requirement for an RTTY program, but should really be used as the basis for additional refinements. Such refinements could be a split-screen to enable one, if transmitting, to compose your reply while the incoming message is being displayed on the other half of the screen, or it may be useful, if a printer is available, to add a hard copy option to the program. If you do not possess a printer, another manner of storage is to create a file on cassette, or preferably disc. Another very useful option is to be able to select the baud rate, if your system allows software control of the RS232 parameters. Prerecorded messages and tests (RYR) could be retrieved from cassette or disc – another useful feature if you are transmitting. It is also possible that you may require other features to be built into your program. The possibilities are quite large and limited only by one's imagination.

The TU1000 In Use

A receiver that is capable of resolving RTTY signals must have a BFO (beat frequency oscillator), although most communications receivers have a built-in CW or SSB position, and of course an antenna to pick up the signals. The frequencies covered by a modern receiver are typically between 1 and 30MHz. It is within this range of frequencies that there are literally thousands of RTTY signals. Probably the best antenna to use for simple monitoring is a long wire, as long as possible and as high as possible. If you can orientate it South-West – North-East, so much the better. It is advisable to tune the receiver against a good external ground system, such as a buried bare copper wire, or a ground rod.

The connection to the TU1000 is made through the headphone or loudspeaker socket. Provision has been made on the TU1000 for muting the sound output by pressing S1. This switches off the loudspeaker and introduces a 10Ω resistor which acts as a dummy load for the receiver audio circuit. The initial tuning is done by identifying the characteristic sound produced by RTTY transmissions and once this is done the data will be presented on the VDU avoiding the need to sit for hours listening to the tones.

I would recommend that initially you tune into one of the amateur RTTY portions of the band. A good start would be to set the receiver to 14.090MHz. It is around this frequency that RTTY signals will be found 24 hours a day, except in the winter when they will tend to disappear around sunset or shortly after. RTTY is easy to identify from the other signals most likely to be found in this portion of the band, namely morse code. RTTY signals have a pronounced warble as one tone is transmitted and then the next. Amateur RTTY transmissions are set at 170Hz shift between mark and space tones. Using the main tuning control of the receiver, tune across the RTTY transmission and you will notice that the sound of the pitch of the signal will change, the S-meter on the receiver will peak and the twin meters on the TU1000 should also peak together, usually at full scale. At the same time the LED's on the front panel should flash.

RECEIVED RTTY

E 9
PRAVDA ON INDIAN WHITE BOOK
M O S C O W , JULY 15 ADN - AN IMPORTANT DOCUMENT - THIS IS HOW THE
LEADING SOVIET PAPER PRAVDA ON SUNDAY CALLS THE WHITE BOOK PUBLISHED
BY THE INDIAN GOVERNMENT ON THE EVENTS IN THE COUNTRY IN THE PAST
THREE YEARS. THE CORRESPONDENT'S REPORT SAYS THE DOCUMENT POINTS TO
A GRAVE DANGER WHICH HAS ARISEN FOR INDIA FROM CONSPIRACIES OF
RELIGIOUS FANATICS AND OTHER DIVISIONIST FORCES RECEIVING SUPPORT
FROM ABROAD.

E 10
TUNISIAN PRESIDENT RECEIVES SPANISH PREMIER
T U N I S , JULY 15 ADN - PRESIDENT HABIB BOURGUIBA OF TUNISIA
RECEIVED THE SPANISH PRIME MINISTER, FELIPE GONZALES, ON SATURDAY.
THEY CONFERRED ON BILATERAL RELATIONS, THE SITUATION IN THE MIDDLE
EAST AND ON QUESTIONS OF MUTUAL INTEREST.
THE PREMIER IS ON A PRIVATE VISIT IN TUNISIA.

E 11
FOUR TONS OF FALSE MONEY SEIZED
P A R J S , JULY 15 ADN - FRENCH CUSTOMS OFFICERS HAVE SEIZED A
LORRY AND TRAILER WITH 500,000 (500,000) FALSE TEN-FRANC COINS,
WEIGHING FOUR TONS, ON THE ITALIAN BORDER.

E 12
CHILEAN POLICE DENY ENTRY TO DAUGHTER OF LUIS CORVALAN
B U E N O S A I R E S , JULY 15 ADN - THE CHILEAN POLICE HAS
REFUSED MARIA VICTORIA CORVALAN ENTRY INTO HER HOME COUNTRY, PRENSA
LATINA REPORTS.
THE DAUGHTER OF THE GENERAL SECRETARY OF THE COMMUNIST PARTY OF
CHILE WAS PREVENTED FROM ENTERING THE COUNTRY AT SANTIAGO DE CHILE'S
INTERNATIONAL PUDAHUEL AIRPORT AND PUT BY POLICE ON A PLANE TO
ARGENTINA ALTHOUGH SHE HELD A VALID PASSPORT. MARIA VICTORIA
CORVALAN WANTED TO VISIT FAMILY MEMBERS IN CHILE.

E 16
TALKS BETWEEN CUBA AND UNITED STATES JN NEW YORK
H A V A N A , JULY 15 ADN - CUBAN AND UNITED STATES GOVERNMENT
OFFICIALS HELD TALKS IN NEW YORK ON JULY 12 AND 13, ACCORDING TO A
STATEMENT RELEASED BY THE CUBAN FOREIGN MINISTRY AT THE WEEKEND.
ACCORDING TO PRENSA LATINA, THE TALKS CENTRED ON ENTRY REGULATIONS
BETWEEN THE TWO COUNTRIES AND ON WAYS OF CUBANS WHO HAD COMMITTED
CRIMES RETURNING FROM THE U.S. TO CUBA. PREPAREDNESS FOR NEGOTIATING
THESE QUESTIONS WAS STATED BY FIDEL CASTRO DURING HIS MEETING WITH
U.S. PRESIDENTIAL CONTENDER JESSE JACKSON WHEN THE LATTER VISITED
CUBA AT THE END OF JUNE.
THE CUBAN DELEGATION WAS LED BY DEPUTY FOREIGN MINISTER RICARDO
ALARCON.

E 17
SOLIDARITY WEEK JN PUERTO RICO
S A N J U A N , JULY 15 ADN - A WEEK OF PEACE AND SOVEREIGNTY
BEGAN IN THE PUERTO RICAN CAPITAL SAN JUAN ON SUNDAY. JT HAS BEEN
SPONSORED BY THE PUERTO RICAN CENTRE FOR COORDINATING SOLIDARITY
WITH CENTRAL AMERICA AND THE CARIBBEAN AND BY THE NATIONAL
COMMMITTEE FOR SOLIDARITY WITH CENTRAL AMERICA. THE EVENTS ARE BEING
MARKED BY SOLIDARITY WITH THE PEOPLES OF NICARAGUA AND CUBA.

E 18
OPERATIONS OF SALVADOREAN LIBERATION FIGHTERS
S A N S A L V A D O R JULY 15 ADN - MEMBERS OF EL SALVADOR'S
NATIONAL LIBERATION FRONT FARABUNDO MARTI HAVE LAUNCHED FRESH
ACTIONS AGAINST LINES OF SUPPLY OF THE TROOPS OF THE DUARTE REGIME.
FORTY KILOMETRES NORTH OF HERE THEY STOPPED A TRAIN DURING WHICH
THEY PUT FORTY SOLDIERS OUT OF ACTION IN A SEVERAL-HOUR
BATTLE.

News from every corner of the world

Connect the TU1000's RS232 I/O port to your computer system. The normal rate of an amateur RTTY transmission is either 45.45 or 50 bauds. The majority of them are at 45.45 bauds. With this rate set by your system and the software set to receive, the data should now be displayed on the screen. S7 will have to be pressed if the signal is garbled, because the tones may be reversed. If the transmission is idling, the mark tone will cause the meter to peak. Therefore if the right-hand meter is peaked, then the reverse tones are being transmitted and if it is the left-hand needle that is peaked

then the tones are being transmitted in the normal manner. If, after trying these settings, the data is not being resolved, it is likely that the transmission is at 50 baud and again could be normal or reversed. When it is not possible to peak both meters, it is likely that a shift other than 170Hz is being used, so try pressing the other fixed tone shift switches, or the variable control RV4.

If you would like to learn more about the subject, I would recommend contacting John Perkins, The British Amateur Radio Teleprinter Group, 5 Ash Keys, Southgate, Crawley, W. Sussex, who would be best able to assist. There are numerous books on the subject and again the secretary of BARTG can supply a list. I can personally recommend 'Guide to RTTY Frequencies' by Oliver P. Ferrell and published by Gilfer Associates Inc.

RTTY UNIT TU1000 PARTS LIST

RESISTORS: All 0.4W 1% Metal Film unless specified			
R1	10Ω 3W Wirewound	1	(W10R)
R2,5,7,50,66,68,69	1k	7	(M1K)
R3,57,60,61,65	10k	5	(M10K)
R4,6,8,9,34,35	100k	6	(M100K)
R10,12,13,15,39, 40,42,43,45,48	33k	10	(M33K)
R11,14,47	470k	3	(M470K)
R16	47Ω	1	(M47R)
R17,18	220Ω	2	(M220R)
R19,20,64	1M	3	(M1M)
R21,22	220k	2	(M220K)
R23,24,54	12k	3	(M12K)
R25	47Ω 1W Carbon Film	1	(C47R)
R26,27	30k	2	(M30K)
R28,31,32	20k	3	(M20K)
R29	16k	1	(M16K)
R30,36,41	15k	3	(M15K)
R33	11k	1	(M11K)
R37	390k	1	(M390K)
R38	56k	1	(M56K)
R44,46	2k2	2	(M2K2)
R49,59	4k7	2	(M4K7)
R51,55	150k	2	(M150K)
R52,56	2k7	2	(M2K7)
R53	27k	1	(M27K)
R58	22k	1	(M22K)
R62,63	8k2	2	(M8K2)
R67	47k	1	(M47K)
RV1,2,3,5,6	4k7 Hor S-Min Preset	5	(WR57M)
RV4	10k Pot Lin	1	(FW02C)
CAPACITORS			
C1,2,5,31,32,36, 38	100pF Ceramic	7	(WX56L)
C3,4	22nF Polycarbonate	2	(WW33L)
C6,7,8,11,12,26	100nF Polycarbonate	6	(WW41U)
C9,10	10μF 35V PC Electrolytic	2	(FF04E)
C13,14	2μ2F 63V PC Electrolytic	2	(FF02C)
C15,16	1000μF 25V PC Electrolytic	2	(FF18U)
C17,18	220μF 16V PC Electrolytic	2	(FF13P)
C19,20,39-44	100nF Disc Ceramic	8	(BX03D)
C21	100nF IS Cap	1	(FF56L)
C22,25	1nF Polystyrene 1%	2	(BX56L)
C23,24	10nF Ceramic	2	(WX77J)
C27	330pF Ceramic	1	(WX62X)
C28,29	3μ3F 35V Tantalum	2	(WW63T)
C30	220nF Polycarbonate	1	(WW45Y)
C33,34	10nF Polycarbonate	2	(WW29G)
C35	1μF 100V PC Electrolytic	1	(FF01B)
C37	0.47μF 100V PC Electrolytic	1	(FF00A)
SEMICONDUCTORS			
D1,2,4-12	1N4148	11	(QL80B)
D3	BZY88C10	1	(QH14Q)
LED1,2	Red LED Shape R1	2	(YY45Y)
TR1,3	BC548	2	(QB73Q)
TR2	BC212L	1	(QB60Q)
BR1	W005	1	(QL37S)
REG1	μA78M12UC	1	(QL29G)
REG2	μA79M12UC	1	(WQ89W)
CH1,2	RF Supp Choke 1A	2	(HW04E)
IC1,11	LF351	2	(WQ30H)

IC2	MF10C	1	(QY35Q)
IC3,4	4046BE	2	(QW32K)
IC5,6	3403	2	(QH51F)
IC7	1458C	1	(QH46A)
IC8	4011UBE	1	(QL04E)
IC9,10	4017BE	2	(QX09K)
MISCELLANEOUS			
T1	Min Tr 15V	1	(WB15R)
M1	Dual VU Meter	1	(YQ47B)
LP1	Wire Bulb 12V	1	(WQ13P)
S1-6	Latchswitch 2-pole	6	(FH67X)
S7	Latchswitch 4-pole	1	(FH68Y)
FS1	250mA Fuse 20mm	1	(WR01B)
SKT1,2	2-pin DIN Skt	2	(YX90X)
SKT3	5-pin DIN Skt	1	(YX91Y)
	Latchbracket 6-way	1	(FH80B)
	Rct Latchbutton Grey	4	(FH62S)
	Rct Latchbutton Red	1	(FH63T)
	Rct Latchbutton White	2	(FH64U)
	Safuseholder 20mm	1	(RX96E)
	DIL Skt 8-pin	3	(BL17T)
	DIL Skt 14-pin	3	(BL18U)
	DIL Skt 16-pin	4	(BL19V)
	DIL Skt 20-pin	1	(HQ77J)
	SR Grommet 6W-1	1	(LR49D)
	Knob K7B	1	(YX02C)
	Veropin 2141	1 pkt	(FL21X)
	Track Pin	1 pkt	(FL82D)
	C6A Mains Cable Black	2m	(XR03D)
	10-way Ribbon Cable	1m	(XR06G)
	Wire 3202 Blue	1m	(XR33L)
	Wire 3202 Brown	1m	(XR34M)
	6BA Bolt ¼"	1 pkt	(BF05F)
	6BA Nut	1 pkt	(BF18U)
	6BA Shakeproof Washer	1 pkt	(BF26D)
	4BA Bolt ½"	1 pkt	(BF03D)
	4BA Nut	1 pkt	(BF17T)
	4BA Shakeproof Washer	1 pkt	(BF25C)
	2BA Washer	1 pkt	(BF20W)
	4BA Tag	1 pkt	(BF28F)
	4BA Spacer ⅛"	1 pkt	(FW30H)
	TU1000 PCB	1	(GB67X)
	Meter PCB	1	(GB73Q)
	Front Panel	1	(FJ53H)
	Rear Panel	1	(FJ54J)
OPTIONAL			
	Blue Case 222	1	(XY45Y)
	DIN Plug L/S	2	(HH24B)
	DIN Plug 5-pin	1	(HH27E)
	13 Amp Plug	1	(RW67X)
	3 Amp Fuse	1	(HQ32K)

A complete kit of parts (excluding Optional items) is available.
Order As LK53H (TU1000 RTTY Kit) Price £49.95

The following parts used in this project are also available separately, but are not included in our current catalogue.

FJ53H	Front Panel	Price £1.65
FJ54J	Rear Panel	Price £1.45
GB67X	Main PCB	Price £7.50
GB73Q	Meter PCB	Price £1.75

ELECTRONIC CHRONICLES

A Brief History of Electronics

by Mike Wharton Part 3

In this issue we shall continue following the infant subject of electronics as it developed during the last half of the 19th century. The foundations had been laid down by the earlier pioneers, but from this point the rate of development was to increase dramatically as the general tide of scientific advancement pushed forward. During the previous centuries the work had been carried out by a few individuals who had contributed single, but vital, pieces to the emerging 'jig-saw' puzzle of electricity. From now on the modern subject of electronics can be seen to take shape, supported by the many discoveries in the connected areas of physics and chemistry. It was during this period that some of the land-marks were pointed out by the leaders in their field, although it was not until 1897 that J. J. Thomson was able to prove the existence of the electron.

In 1868 Georges Leclanché invented a cell which bears his name, and which was the fore-runner of the modern dry battery. The availability of such a convenient current source made it possible to investigate the effect of passing an electric current through almost anything the scientists could lay their hands on. Passing a current along a wire gives rise to the heating and magnetic effects; passing a current through a solution produces effects which have led to the whole subject of electro-chemistry; and passing a current through a gas at low pressure eventually led to the production of the modern cathode ray tube, or CRT, something which we all look at every day!

HENRY

Up until this time, nearly all the work had been done by people living in Europe; the only notable exception being the American Benjamin Franklin. However, the name of another American, Joseph Henry, cannot go unmentioned here, since if history had been played a little differently it might have been his name we remember rather than Michael Faraday's.

Joseph Henry 1797-1878

Henry was born in Albany, the state capital of New York in 1797. He had only the barest of educations, but he was an avid reader. Like his contemporary, Faraday, a chance encounter with a book on science led to him studying seriously for entry to the Albany Academy, where he studied chemistry, anatomy and physiology with the intention of becoming a doctor of medicine. However, in 1825 he gave up the idea of becoming a doctor in favour of a career in engineering. After qualifying, he worked at the Academy for some years as a teacher and was appointed Professor of Mathematics. Six years after this he was made Professor of Natural Philosophy at the University of Princeton, where he taught a range of subjects, from mathematics and physics to astronomy and architecture.

From 1846, and for the remainder of his long life, Henry was the first director of the Smithsonian Institute in Washington. This well-known organisation was founded by James Smithson, the wealthy son of the Duke of Northumberland. From the Smithsonian many other scientific bodies were to emerge, such as the Meteorological Bureau and the National Museum. Henry was also a founder member of the National Academy of Science and, during the American Civil War, was a technical adviser to Abraham Lincoln.

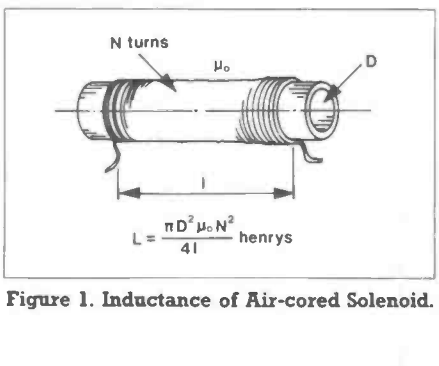


Figure 1. Inductance of Air-cored Solenoid.

From his early days Henry was interested in electro-magnetism, and he greatly improved the power of his electro-magnets by using insulated wire, rather than just insulating the core. By this means he was able to use many layers of overlapping turns. He made a large electro-magnet for Yale College which was able to raise a load of one ton, a record at that time.

One of his major contributions to the subject of electronics was the discovery of self-inductance. He showed that when a current in a coil of wire changes in strength with time, a weaker current flowing in the opposite direction is produced, which retards the change in the original current. Another important discovery was that a varying current flowing in a coil produced a current in an adjacent coil, which is the basis of the transformer.

The American inventor was mortified when Faraday, who published his work on similar lines in 1831, received all the credit. Henry's other duties of teaching, together with his involvement on numerous committees, had delayed the publication of his own work. He was later given some recognition, and of course his name is remembered in the SI unit of inductance, an honour which was bestowed in 1893, after his death.

Henry also parallelled Faraday by constructing one of the first electric motors, which he regarded simply as a toy! He also designed and operated the first electric telegraph over a distance of a mile, and later used it to collect data for weather forecasts from a number of volunteers scattered around the country. With the help of his brother-in-law he carried out investigations into sunspots and solar radiation. By using a sensitive thermo-galvanometer he was able to show that sunspots are cooler than the normal surface of the sun. A potentially more significant discovery to the study of electronics was that the discharge from a Leyden jar, which was a primitive form of capacitor, was of an oscillatory nature. Moreover, the oscillations were of a very high frequency, and this was to be of great value to Hertz in his later work on electro-magnetic radiation.

Joseph Henry died in 1878 in Washington DC, and is considered by Americans to be one of their greatest scientists. Many claim that he actually beat Faraday by at least one year in discovering electro-magnetic induction, but that his other work delayed publication of the results. It is quite possible that had he devoted more time to his scientific pursuits and less to committee work he would have been of greater service to American science.

Ernst Werner Von Siemens 1816-1892

SIEMENS

Ernst Werner von Siemens was the eldest of four gifted brothers who were all engineers and inventors. Werner was born in 1816 at Lenthe in Hanover, Germany. His father was a patriot who believed in the unification of Germany, and so the family moved from the 'Royal British' province of Hanover to Meuzendorf in Mecklenburg-Strelitz. The young Siemens went to school in Lubeck and then decided to study engineering. His father thought that the Berlin Academy would be too expensive and decided that the Army could provide just as good an education for free! After some difficulty he managed to gain entry to the Prussian Army Engineer Corps, for special permission was needed from the King of Prussia for a 'foreigner' to join the army. He enjoyed the strict discipline of the army, and studied maths, physics and chemistry with great enthusiasm. However, he still managed to get involved in a duel, for which he served a short term in prison.

After a period spent at the Engineers and Artillery School in Berlin he moved to Wittenburg, where he produced his first invention. This was the plating of metal articles with gold and silver. He sold the rights to the process, and then used the money to finance further projects. As he began to make money from his inventions

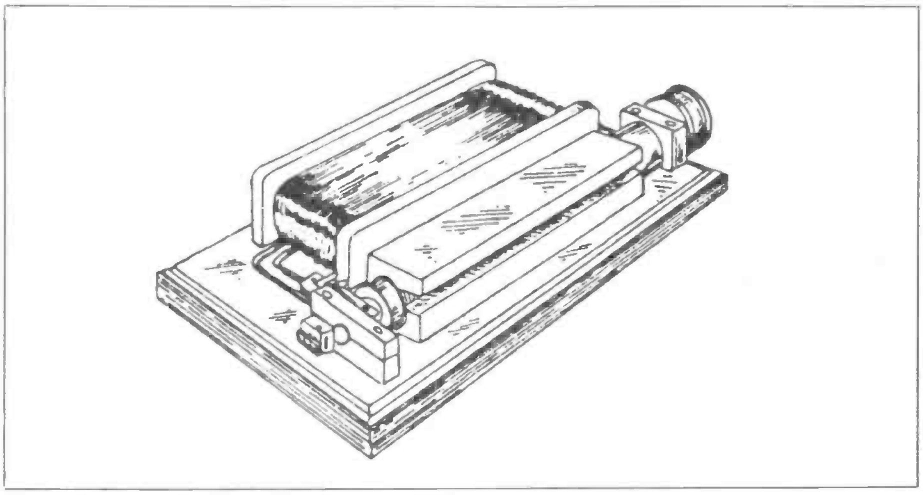


Figure 2. Siemens' self-exciting Dynamo, 1867.

he paid for one of his brothers, Karl Wilhelm, to travel to England to develop the market for his electro-plating and other inventions related to electricity. His brother eventually returned to Germany, but soon made his way back to England, which became his second home. Here he became involved with the manufacturers of iron and steel, and invented the Siemens Open Hearth Furnace. Meanwhile, back in Germany, Werner was busy developing other electrical inventions, such as the Wheatstone dial telegraph in which he introduced automatic make and break circuits, and which was adopted by the German and Russian railways in 1846. In 1847 the world famous firm of Siemens and Halske was founded in Berlin; J.G. Halske was Werner's brilliant mechanic. The factory made needle telegraphs, sounders for railways and insulated wire. Siemens also turned his attention to the generation of electric power. He developed a generator in which the usual permanent field magnets were replaced by electro-magnets, and invented the 'H' armature. He and his brothers were responsible for a great many inventions. Between them they were involved in the design of the trans-Atlantic cable laying ship 'Faraday', building an electric railway at Portrush in Ireland and the introduction of a telegraphy system throughout Russia; the news from the Crimean War reached St. Petersburg on the longest land-line of the day.

Ernst Werner von Siemens died in 1892 at the age of 76 at Charlottenburg in Germany. He had experienced the satisfaction of seeing his inventions come to fruition and attaining public acclaim worthy of his great creativeness. Besides other honours bestowed on him and his brothers, Werner also has the honour to have an SI unit named after him. The 'siemen' (S) is the unit of conductance, the inverse of the ohm.

KIRCHHOFF

Gustav Robert Kirchhoff was born at Königsburg, Prussia, now part of the Soviet Union, in 1824. On leaving school he entered Königsburg University where he studied theoretical physics. After getting his doctorate in 1848, he moved to a teaching post at Berlin University, where he met the famous Bunsen. Both men then moved to Heidelberg, where they teamed up with Helmholtz. They were so successful that students flocked from all over Germany and abroad to hear their lectures and attend the laboratories. Kirchhoff was particularly interested in the field of spectrum analysis, and with Bunsen, discovered the metals Caesium and Rubidium. It was the almost non-luminous flame of Bunsen's famous burner that made such work possible, and it was originally designed for this purpose rather than the one it is usually put to these days in school laboratories.

Gustav Robert Kirchhoff 1824-1887

It is Kirchhoff's early work on electricity for which he is remembered in the form of 'Kirchhoff's Laws'. These describe in a formal manner the fact that the sum of any currents flowing into a junction is zero, and that in a closed circuit the e.m.f. applied is equal to the sum of the products of current and resistance.

An interesting story concerns Kirchhoff's bank manager who, when told by Kirchhoff of the discovery of terrestial metals on the sun remarked "what use is gold on the sun if I can't get it down to earth?". Later, after Queen Victoria had presented him with a medal and a prize in gold sovereigns for his work on the sun's spectrum, he took it to the bank manager and said, "Look, gold from the sun!"

In 1868 he seriously injured his leg and this affected his general health. He returned to Berlin to the Chair of Physics, which was a less arduous job. His health continued to deteriorate and he was forced to retire in 1884. He died in Berlin in 1887 at the age of 63.

William Thomson, Lord Kelvin 1824-1907

LORD KELVIN

Lord Kelvin was born William Thomson in Belfast in 1824. His father was Professor of Mathematics, first at Belfast and then at Glasgow University when the family moved to Scotland. His mother died when he was only six, and his father took on the job of educating both him and his brother, James. He must have made a good job of it judging by the results, for William managed to pass the entrance exam to Glasgow University at the incredibly early age of ten. He was a very gifted student, and had produced no less than twelve research papers before he had even graduated. At the age of twenty-two he became Professor of Natural Philosophy at Glasgow and his work was soon known throughout Europe. He produced a flood of research works and, unlike many other scientists, kept his finances in strict order. During his life-time he amassed the sum of £160,000, a fortune in those days. The success of the Atlantic Telegraph Cable was due largely to his engineering genius. He determined the most suitable method for transmitting the signals, and invented instruments of the highest standard for sending and receiving them. For example he was responsible for the Kelvin bridge, which was used for measuring very low resistance, the Kelvin sounder and the Kelvin compass. He also discovered the 'Kelvin effect', also called the skin effect, where high frequency currents tend to concentrate at the surface of a conductor, a phenomenon which has been of great importance in radio and high frequency heating. He also devised Kelvin's Law, which determines the most economical size of conductor for carrying electrical power, taking into account the cost of the cable used and the resistive losses incurred.

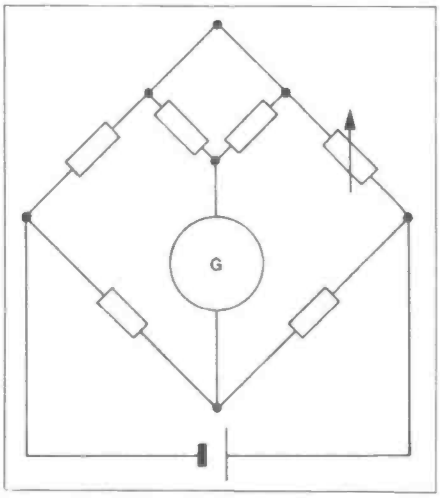


Figure 3. Kelvin Bridge (Thomson Double Bridge).

Kelvin was also greatly interested in the theory of conservation of energy, and developed the idea of an absolute scale of temperature. Thus he is remembered for the work which he did in this area, rather than that of electricity, and thermodynamic temperature is now expressed in the SI unit of kelvins, (K).

Thomson was knighted in 1866 for his many contributions to science and engineering, and took the title Lord Kelvin of Largs. He died at Netherhall, near Largs in Ayrshire in 1907 at the ripe old age of 83. During his life he had produced 600 scientific papers, taken out 70 patents, received honours from 250 academies and societies around the world, and made a considerable fortune.

James Clerk Maxwell 1831-1879

MAXWELL

James Clerk Maxwell is universally accepted as the greatest theoretical physicist of the nineteenth century. He possessed a wondeful mathematical ability and a complete grasp of physical reality together with a brilliant imagination. Thus he was able to make great advances in science without recourse to any preconceived ideas about the working of nature. Maxwell is mainly remembered in the study of electricity for his mathematical interpretation of Faraday's concept of the electro-magnetic field which had been deduced by his laboratory experiments. In carrying out this task he gave the world the electro-magnetic theory of light which paved the way for the discoveries of Rudolf Hertz 23 years later.

Maxwell was born in Edinburgh in 1831, but spent most of his early life on his parents estate at Middlebie. His mother died when he was eight years old and, like Kelvin, he was brought up by his father. At the age of ten he was sent to Edinburgh Academy where his broad Galloway accent and rather fancy clothes, in which his father had unfortunately dressed him, earned him the nick-name 'Dafty'. The other boys bullied him and he arrived home at the end of his first day bleeding and his clothes in tatters.

He showed no particular ability until he was put onto a course in maths at the age of thirteen. He then made such swift progress that by the age of fourteen he had won a gold medal in the subject. At sixteen he entered Edinburgh University, where he made such an impression that he was allowed the run of the physics and chemistry labs, and was able to carry out any research in which he was interested. He then entered Trinity College, Cambridge in 1850 and was appointed Professor of Natural Philosophy at Aberdeen in 1856. In 1860 he was appointed Professor of Natural History at King's College, London.

During his time at King's College he carried out a great deal of research work on a variety of subjects, including the kinetic theory of gases and statistical mechanics. His work on electricity yielded the Maxwell bridge for measuring capacitance and inductance and his famous field equations. These formalized the ideas of Gauss, Faraday and Ampère and may be used to derive the theory of electro-magnetic radiation. He was able to predict the possibility of radio waves many years before their existence was shown by Hertz, and thus led the way to all the inventions which were to come in the field of electro-magnetic radiation.

On the death of his father in 1865 he retired from academic life and returned to the family estate in Scotland, where he devoted himself to research and writing his great treatise on electro-magnetism. In 1871 he was persuaded to accept the Cavendish Professorship at Cambridge, where he designed the new Cavendish Laboratories. He continued to work with unabated enthusiasm until the time of his death, which occured after some stomach trouble, ignored because of the pressure of work. He suddenly became seriously ill and died on November 5th 1879 at the age of 48.

Heinrich Rudolf Hertz 1857-1894

HERTZ

Heinrich Rudolf Hertz was the son of a successful lawyer, born in the city of Hamburg in Germany in 1857. At school he was particularly fascinated by experiments in optics and mechanics, and attended additional evening classes on engineering and the use of measuring instruments. On leaving school young Rudolf decided to become an engineer and attended the Polytechnic Institute at Munich. After one year, though, he realized that his interest lay in the field of pure science and so moved to Berlin

University to study under the famous trio, Kirchhoff, Bunsen and Helmholtz. Later on he went to Kiel for further study and was then appointed Professor of Physics at Karlsruhe, where he carried out his famous experiments on radio waves. It had been some years previously that Maxwell had put forward his theory that electrical oscillations could produce electro-magnetic waves, and that they would travel at the speed of light. Hertz used a spark coil to generate the electro-magnetic radiation, with large plates attached to each side of the spark gap. When the receiver was positioned close to this 'transmitter' a feeble spark could be observed in the receiver gap. Hertz then went on to show that the radiation had a wavelength of only 24cm, the same frequency used nowadays for microwave communication and radar. Moreover, he showed that the radiation behaved in the same manner as light, and could be reflected, refracted and polarised, and that its velocity was the same as that of light, 30,000,000 metres per second.

The name of Rudolf Hertz has become more prominent since the introduction of the Système International d'Unites (SI). Previously the term for the frequency of a periodic vibration was not connected with anyone's name, simply being described as 'cycles per second' or possibly 'vibrations per minute'. However, it is now named in honour of the German physicist who first demonstrated the transmission of radio waves and thus paved the way for the invention of wireless telegraphy.

In 1889 Hertz succeeded Clausius (of thermodynamics fame) as Professor at Bonn, but his career here was short-lived. Five years later, at the age of only 37, he died as a result of blood-poisoning on New Years Day, 1894. Seven years later the Italian engineer Gugleilmo Marconi was successfully to transmit a wireless signal across the Atlantic.

This latter event heralded the enormous advances which were to be made in the 20th century, and next time we shall have a look at those famous names involved during this period.

$$\text{curl}\, H = \partial D/\partial t + j$$
$$\text{div}\, B = 0$$
$$\text{curl}\, E = -\partial B/\partial t$$
$$\text{div}\, D = \rho$$

Where:
H is the magnetic field strength
D is the electric displacement
t is time
j is the current density
B is the magnetic flux density
E is the electric field strength
ρ is the volume charge density

Figure 4. Maxwell's Field Equations.

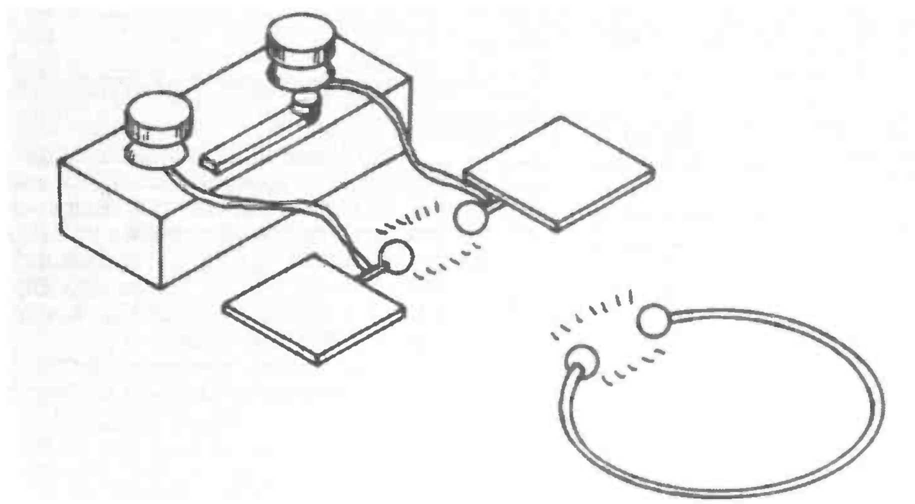


Figure 5. Hertz' Experiment.

ZX81 & YOUR BOAT *Continued from page 5.*

shelves in the corner, one above the other. The top one would carry the TV whilst the lower one would carry the ZX81 and the interface box. If the shelves were mounted over the chart table, so much the better. Of course, the shelves will have to be strong enough to hold the instruments in a rough sea. The best place for the wind instrument is on top of the mast. However, this will need long leads and make any maintenance very difficult. A 3 metre long pole fixed to the push pit would make life much easier. The instrument could be fixed to the top of this and the leads would be short and access would be easier. The trailer log can be fixed to the push pit by a length of rope in much the normal way. You may need to use a length of shielded wire through the cockpit or past any engine. On a previous model of the log, I found that I was counting the revs. of the engine as well! The positioning and securing of the compass should be considered very carefully. The device does not have a very high resolution but you do want it to give you the best service it can. It must be able to swing freely on its gimbles in all directions. It must not be close to any engines, metal or electronics. This compass doesn't have to be 'read' so it can be mounted safely in a locker out of sight and out of harms way. The tiller servo and follower can be mounted in a cockpit locker. The moving parts must be clear of obstructions. It would be useful if the tiller follower mask was accessable so that it can be adjusted easily.

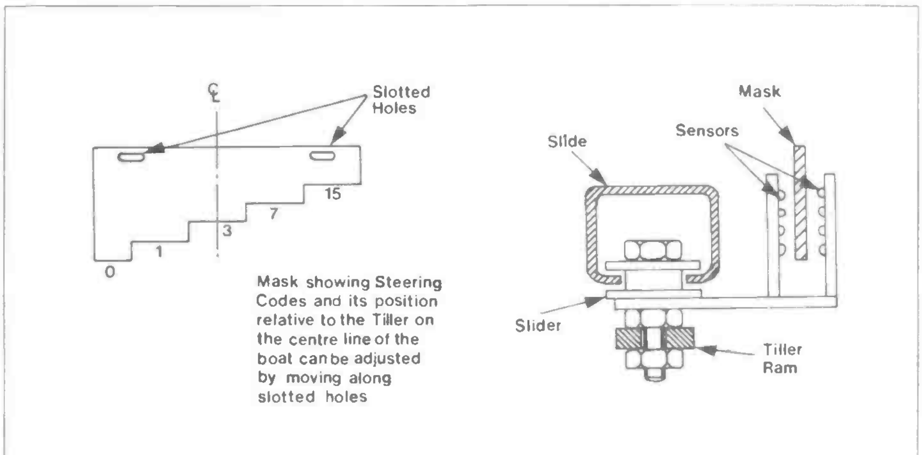
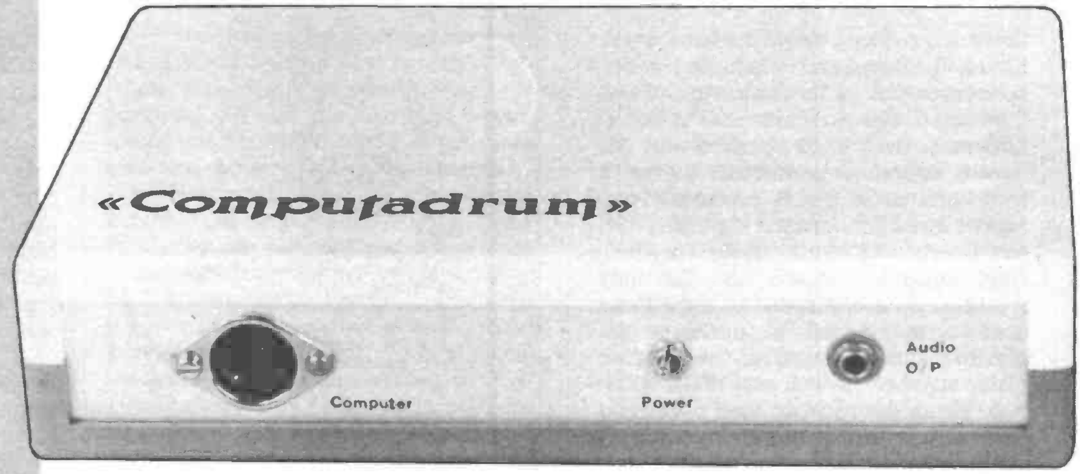


Figure 7. Tiller Follower

Power for the servo and the TV can be taken straight from the boats 12 volt DC supply. (Of course, the TV can be switched off if a display is not required, say during automatic steering.) It is necessary to use a separate power supply for the electronics. The ZX81 and the other circuits can be affected by the 'spikes' in voltage caused by the switching of the relays and the servo motor. The power needed is quite small and an old, but not dead, car battery will give many months of power. In part 2 of this article, I will give the circuitry and the program listing plus some hints on navigation.

COMPUTADRUM



by Robert Penfold

This is a six channel drum synthesiser which is designed specifically for use with a home computer. The computer acts as a sophisticated sequencer, and the unit can be directly driven from the BBC model B, VIC-20, Commodore 64, Atari 400/600XL/800/800XL, and Memo tech MTX500/512 machines.

It can also be used with machines such as the ZX81 and ZX Spectrum if they are fitted with an external input/output port that provides at least six digital outputs. For example, a ZX81 plus the Maplin ZX81 I/O Port would be perfectly suitable. The Computadrum only requires brief trigger pulses from the controller, and it could even be used with a non-computer based control circuit.

The sound generated by the unit is a simple fixed pitch drum sound rather than a falling pitch disco drum sound, but the pitch of each channel is tunable over a reasonably wide range using a preset control. Also, each channel has a resonance control which enables the output sound to be varied from a dull, short duration signal to a rich and resonant sound lasting a few seconds. Each drum has a different central pitch, and together they provide a very wide pitch range. The unit is battery powered and has an output for use with an external amplifier and loudspeaker.

Filters

Figure 1 shows the unit in block diagram form, and the circuit consists basically of six filters with their outputs combined by an active mixer stage. The output signal from the computer is a short pulse which gives a 'click' sound, and each filter is fed from a digital output of the computer. A lowpass filter is used to remove most of the high frequency content on each input pulse to give a lower pitched 'thud' sound, like the initial sound when a drum is struck. A bandpass filter close to oscillation is fed with this signal, which excites the filter giving a short burst of sinewave signal at the output. The signal has a fast attack and slower decay, with the latter being controlled by means of the resonance control.

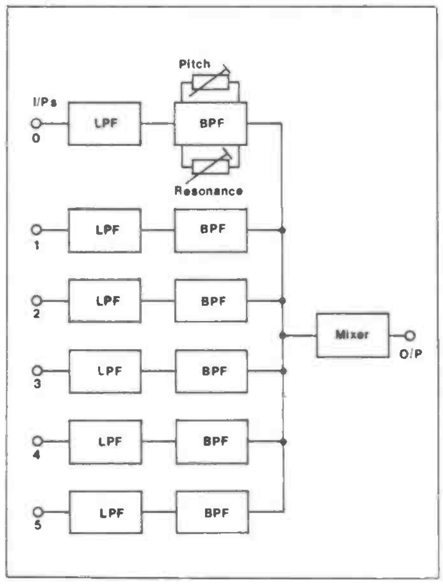


Figure 1. Block diagram

This gives a straightforward but quite realistic drum sound. The pitch and decay times can be controlled using the preset pitch and resonance controls, and the attack time is controlled by the cut-off

★ **Complete Electronic Drum Kit for Your Home Computer**
★ **Six Variable Pitch Drums**
★ **Resonance Control Varies Drum Timbre**
★ **Works With Many Makes of Home Computer**

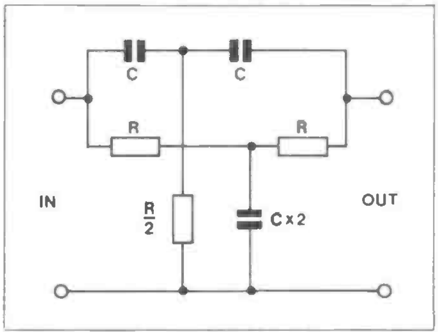


Figure 2. Twin T Filter

frequency of the lowpass filter. The operating frequency of each lowpass filter is not adjustable, but if desired the attack times can be altered by changing the value of the filter capacitor used in each lowpass filter. Thus, although this is an extremely simple way of generating a drum sound, it does give good control over the sound produced.

The bandpass filters are all based on the twin T arrangement shown in Figure 2, and the way in which this filter configuration obtained its name will probably be obvious. This passive filter circuit gives a notch of (theoretically) infinite attenuation at a certain frequency (the frequency at which the impedance of C is equal to that of R). This type of filter provides quite a narrow notch of attentuation, with losses of only a few dB being produced slightly 'off-tune'.

Of course, what we require in this application is a sharp bandpass response, which is the exact opposite of what the twin T configuration provides. However, by using a twin T filter in the negative feedback circuit of a reasonably high gain amplifier the required high Q bandpass response is obtained. All that happens here is that the twin T filter provides a low impedance path at frequencies outside the notch, giving a large amount of negative feedback and little voltage gain. At the notch frequency (and very close to it) the impedance through the twin T network is so high that there is no significant negative feedback, and the amplifier has its open loop voltage gain.

The Circuit

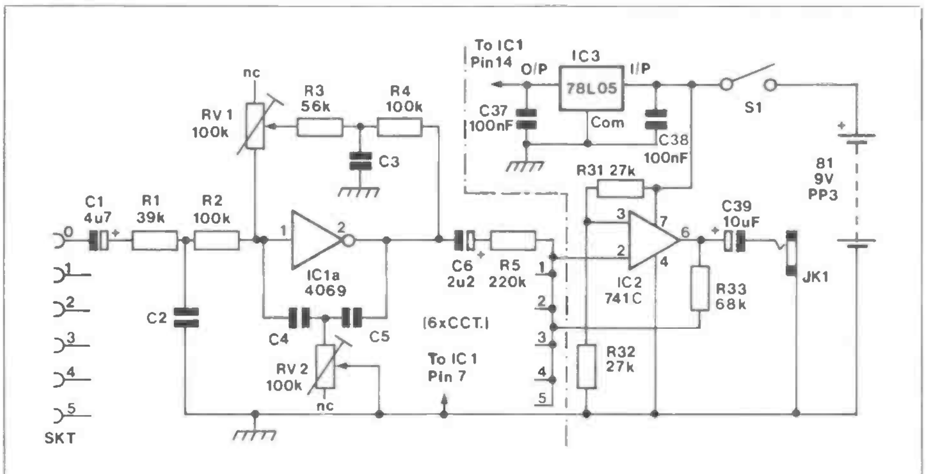
Figure 3 shows the circuit diagram of the Computadrum. The filters are each built around one section of a CMOS 4069BE hex inverter. Although not really intended for use in linear applications, a CMOS inverter will operate as a linear amplifier having a voltage gain of about 34dB (50 times) if a bias resistor is connected between its input and output terminals. In this case the bias resistance is provided by two resistors in the twin T circuit. The six filters are essentially the same, the only difference being the use of different values in each one so that a different pitch range is covered.

If we consider the filter based on IC1a, C1 provides DC blocking at the input while R1 and C2 form the lowpass filter circuit. C4, C5 and RV2 are one of the T networks, and RV2 acts as the resonance control. Using the theoretically correct value in the RV2 position the circuit oscillates at its resonant frequency. This is due to the phase changes that occur through the twin T circuit, giving positive rather than negative feedback at the resonant frequency. RV2 is therefore used to give a somewhat higher resistance which prevents continuous oscillation from being produced. If RV2 is set just below the threshold of oscillation the input pulse will still produce strong oscillations that take several seconds to decay, giving a very resonant drum sound. If, on the other hand, RV2 is well backed off from this point, the filter will have a low Q and the oscillations will rapidly die away, giving a short, well damped drum sound.

The other T network is formed by RV1, R3, R4 and C3. RV1 enables the resonant frequency of the filter to be adjusted, but as only one resistive element of the T network is being varied this inevitably means that adjustment of RV1 has some effect on the resonance setting of the filter. Similarly, adjustment of RV2 has a small effect on the operating frequency of the filter. In practice this interaction is too slight to be a major drawback, and it does not result in the unit being difficult to set up ready for use.

IC2 is used in the mixer circuit which is a standard operational amplifier summing mode type. The output from each filter circuit is quite high at a few volts peak to peak, and the mixer circuit has therefore been given less than unity voltage gain to prevent overloading if more than one drum is activated at any one time. The input resistors of the mixer have been given high values so that a high input impedance (about 220k) is provided at each input. This is essential as an input impedance of several kilohms or less is sufficient to damp the filters to the point where a resonant drum sound cannot be achieved.

Power for the circuit is provided by a 9 volt battery, and the current consumption of the circuit is only about 7 milliamps. IC3 is used to provide a well stabilised supply to the filter circuits, and this is necessary because changes in supply voltage affect the gain of the amplifiers, and therefore the resonance setting. The use of a stabilised supply for the filters ensures that consistent results are obtained, as the battery voltage drops due to ageing.



SKT1	Values as circuit (or) as shown below (filter ccts. only)												IC1
0	R1	R2	R3	R4	R5	RV1	RV2	C1	C2 68nF	C3 15nF	C4 6n8	C5 6n8	C6	(a) 1 - 2
1	R6	R7	R8	R9	R10	RV3	RV4	C7	C8 100nF	C9 22nF	C10 10nF	C11 10nF	C12	(b) 3 - 4
2	R11	R12	R13	R14	R15	RV5	RV6	C13	C14 150nF	C15 33nF	C16 15nF	C17 15nF	C18	(c) 5 - 6
3	R16	R17	R18	R19	R20	RV7	RV8	C19	C20 220nF	C21 47nF	C22 22nF	C23 22nF	C24	(d) 9 - 8
4	R21	R22	R23	R24	R25	RV9	RV10	C25	C26 220nF	C27 68nF	C28 33nF	C29 33nF	C30	(e) 11 - 10
5	R26	R27	R28	R29	R30	RV11	RV12	C31	C32 330nF	C33 100nF	C34 47nF	C35 47nF	C36	(f) 13-12

Figure 3. Circuit Diagram

Construction

Details of the printed circuit board are provided in Figure 4. IC1 is a CMOS device, and it should be fitted in a 14 pin DIL IC socket. Leave it in the antistatic packaging and do not fit it into the socket until the board is in other respects finished. Handle the device as little as possible. The only other point to watch when building the board is to make sure that components are inserted in the right positions in the board. There are numerous resistors and physically similar capacitors, which makes it all to easy to produce mistakes. It is advisable to work through the components methodically and carefully, rather than just taking them at random and fitting them onto the board. Use Veropins at points on the board where connections to SK1, JK1, and S1 will eventually be made.

A Verocase measuring about 180 by 120 by 40 millimetres will comfortably accomodate all the components. SK1, JK1, and S1 are mounted on the front panel, as can be seen be refering to the photographs of the prototype. A 7 way DIN

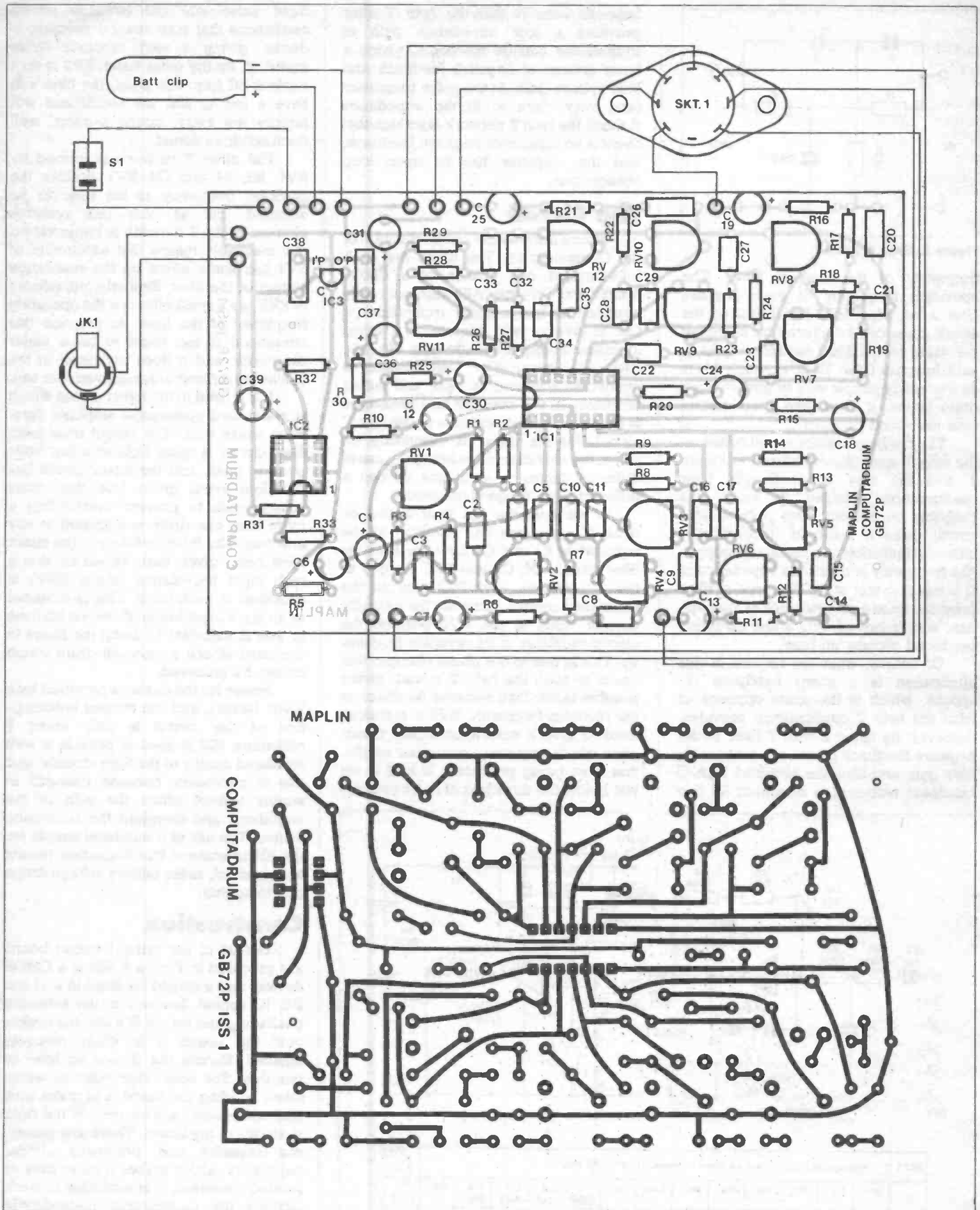


Figure 4. Artwork and wiring

socket is specified for SK1, and this is likely to be the most convenient type to use in practice, but obviously any socket having 7 or more ways will do. Assuming a DIN connector is used, two 6BA 1/4 inch mounting screws plus nuts are required.

Mount the completed printed circuit board on the base panel of the case using 6BA or M3 mounting bolts about 12 millimetres long. There are four mounting pillars moulded into the lower section of the case, but these serve no useful purpose in this case, and may in fact get in the way. They can easily be drilled out using a bit of about 8 to 10 millimetres in diameter. Finally, the hard wiring is added using ordinary multistrand insulated hook-up wire.

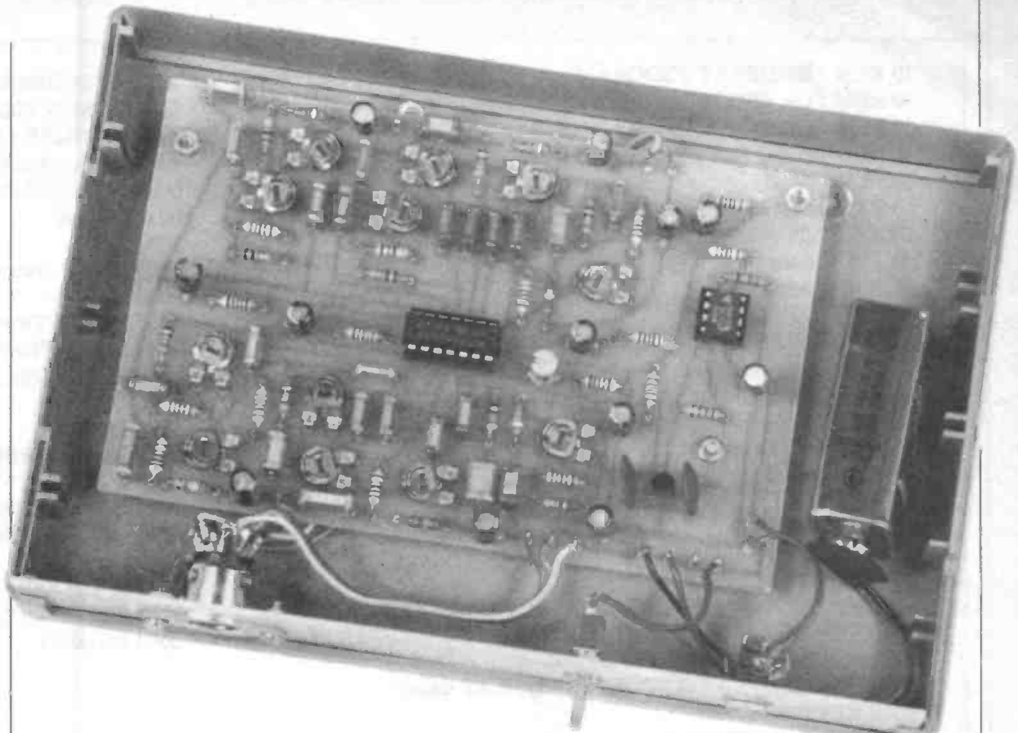
Connection

The audio output of the unit is coupled to the amplifier (or whatever) using an ordinary screened audio cable fitted with a 3.5mm jack plug which connects to JK1. Connection to the computer is via a piece of 7 way ribbon cable about 1 metre long, and fitted with a 7 way DIN plug at the end, which connects to SK1. The connector used at the other end of the lead must obviously be varied to suit the computer used as the sequencer. For a VIC–20 or Commodore 64, a 2 by 12 way 0.156 inch edge connector is required; a 20 way IDC header socket is required for the BBC model B; the Atari machines need two 9 way D sockets; and for the Memotech machines a 14 pin DIL header plug is needed. Figure 5 gives connection details for all these computers. Note that the Memotech computers require a shorting lead from the output strobe terminal (pin 5) to ground (pin 16), to enable the outputs.

With any of the computers, an output pulse to trigger the unit is generated by setting an output line high and then immediately setting it low again. The speed of BASIC is such that a pulse of a few milliseconds in duration will be generated, and this is ideal. With machine code programs the output pulse generated will be too short unless a delay loop is used to suitably extend the pulse.

With the Memotech machine there is no setting up procedure required, and the Computadrum is controlled by writing data to the user port using the OUT 7,X instruction, where X is the value written to the port (e.g. OUT 7,2: OUT 7,0 would trigger channel 1).

With the VIC20, Commodore 64, and BBC model B computers the six lines of the user port that are used to control the unit must be set up as outputs. This is done by writing 63 to the data direction register which is at 37138, 56579, and &FE62 for the VIC20, Commodore 64, and BBC model B respectively. The Computadrum is then controlled by writing data to the user port which is at 37136, 56577, and &FE60 respectively. Joystick ports 1 and 2 of the Atari machines are set



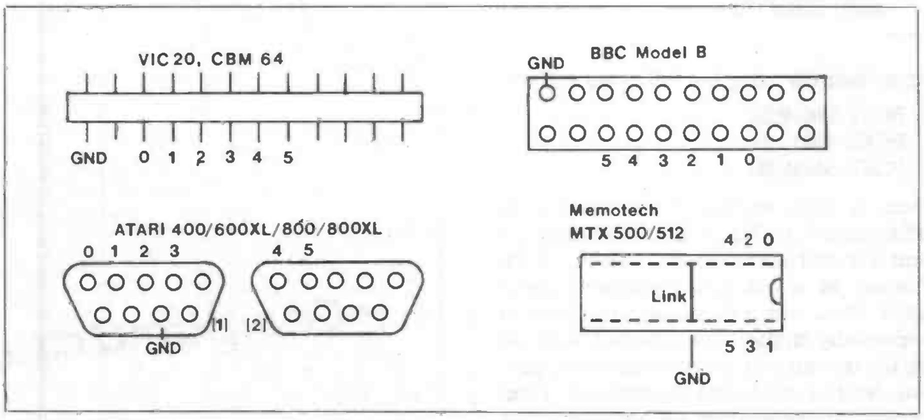


Figure 5. Connections to various computers

```
10 REM DRUMBEAT PROGRAM
20 REM FOR VIC20
30 REM SETUP
40 DIM ST(20)
50 POKE 37138,63
60 REM MAIN PROGRAM
70 GOSUB 1000:REM INPUT
80 GOSUB 2000:REM PLAYLOOP
90 GOTO 70
1000 PRINT "":REM CLEAR SCREEN
1010 INPUT "NUMBER OF DRUMBEATS";N
1020 FOR P=1 TO N★2 STEP 2
1030 INPUT "DRUM NO.";ST(P)
1040 INPUT "TIME INTERVAL";D
1050 ST(P+1)=D★50
1060 NEXT P
1070 RETURN
2000 PRINT:PRINT"PRESS ANY KEY TO STOP"
2010 FOR P=1 TO N★2 STEP 2
2020 POKE 37136,ST(P):POKE 37136,0
2030 FOR DE=0 TO ST(P+1):NEXT DE
2040 NEXT P
2050 GET A$:IF A$="" THEN 2010
2060 RETURN
```

For Commodore 64, change to:–

```
50 POKE 56579,63
2020 POKE 56577,ST(P):POKE 56577,0
```

```
10 REM DRUM CONTROLLER PROGRAM
20 REM FOR ATARI COMPUTERS
30 REM SETUP
40 DIM STORE(20)
50 POKE 54018,56
60 POKE 54016,63
70 GOSUB 1000:REM INPUT ROUTINE
80 GOSUB 2000:REM PLAY ROUTINE
90 GOTO 70
1000 ?CHR$(125):REM CLEAR SCREEN
1010 PRINT "NUMBER OF DRUMBEATS IN LOOP"
1020 INPUT N
1030 FOR P=1 TO N★2 STEP 2
1040 PRINT "DRUM ";
1050 INPUT DRUM:STORE(P)=DRUM
1060 PRINT "TIME INTERVAL ";
1070 INPUT DELAY:STORE (P+1)=DELAY★50
1080 NEXT P
1090 RETURN
2000 PRINT: PRINT "PRESS SELECT TO STOP"
2010 FOR P=1 TO N★2 STEP 2
2020 POKE 54016, STORE (P):POKE 54016,0
2030 FOR D=0 TO STORE (P+1):NEXT D
2040 NEXT P
2050 POKE 53279,8:IF PEEK (53279)<>5 THEN GOTO 2010
2060 RETURN
```

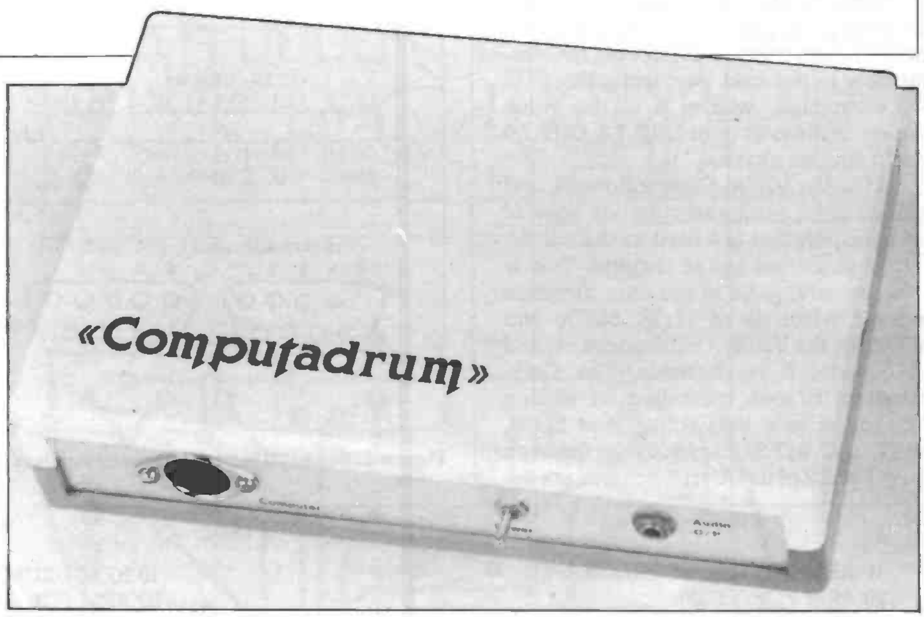
```
10 REM DRUMBEAT PROGRAM
20 REM FOR BBC MODEL B.
30 REM SETUP
40 DIM STORE (20)
50 ?&FE62=63
60 REM MAIN PROGRAM
70 REPEAT
80 PROCinput
90 PROCloop
100 UNTIL FALSE
1000 DEF PROCinput
1010 CLS
1020 INPUT "Number of drumbeats", N%
1030 FOR P=1 TO N%★2 STEP 2
1040 INPUT "Drum No.",STORE (P)
1050 INPUT "Time interval", D
1060 STORE (P+1)=D★100
1070 NEXT P
1080 ENDPROC
2000 DEF PROCloop
2005 PRINT"PRESS ANY KEY TO STOP":REPEAT
2010 FOR P=1 TO N%★2 STEP 2
2020 ?&FE60=STORE(P):?&FE60=0
2030 FOR delay=0 TO STORE (P+1):NEXT delay
2040 NEXT P
2045 UNTIL INKEY$(1)<>""
2050 ENDPROC
```

```
10 REM DRUMBEAT PROGRAM
20 REM MTX 500/512 VERSION
30 DIM STORE (20)
40 GOSUB 1000:REM INPUT
50 GOSUB 2000:REM PLAY LOOP
60 GOTO 40
1000 CLS
1010 INPUT "Number of drumbeats?";N
1020 FOR P=1 TO N★2 STEP 2
1030 INPUT "Drum No.?";STORE (P)
1040 INPUT "Time interval?";DELAY
1050 LET STORE (P+1)=DELAY★50
1060 NEXT P
1070 RETURN
2000 PRINT: PRINT "PRESS ANY KEY TO STOP"
2010 FOR P=1 TO N★2
2020 OUT 7,STORE(P): OUT 7,0
2030 FOR D=0 TO STORE (P+1): NEXT D
2040 NEXT P
2050 IF INKEY$="" THEN GOTO 2010
2055 PRINT "OUT OF LOOP"
2060 RETURN
```

up as outputs using the following routine:

```
POKE 54018,56
POKE 54016,63
POKE 54018,60
```

Data is then written to the outputs at address 54016. When initially testing the unit it is probably best to start with all the presets at about half maximum resistance. Then use a short loop program to repeatedly trigger one channel, and set up the two presets for that channel to give the desired pitch and reasonance. Then repeat this procedure for the other five channels. For those who do not wish to devise their own software the accompanying listings give suggested software for each of the machines mentioned here, and these programs are self explanatory in use.



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R1,6,11,16,21,26	39k	6	(M39K)
R2,4,7,9,12,14,17, 19,22,24,27,29	100k	12	(M100K)
R3,8,13,18,23,28	56k	6	(M56K)
R5,10,15,20,25,30	220k	6	(M220K)
R31,32	27k	2	(M27K)
R33	68k	1	(M68K)
RV1-12	100k Hor Sub-Min Preset	12	(WR61R)

CAPACITORS

C1,7,13,19,25,31	4µ7 63V PC Electrolytic	6	(FF03D)
C2,27	68nF Polycarbonate	2	(WW39N)
C3,16,17	15nF Polycarbonate	3	(WW31J)
C4,5	6n8 Polycarbonate	2	(WW27E)
C6,12,18,24,30,36	2µ2 63V PC Electrolytic	6	(FF02C)
C8,33	100nF Polycarbonate	2	(WW41U)
C9,22,23	22nF Polycarbonate	3	(WW33L)
C10,11	10nF Polycarbonate	2	(WW29G)
C14	150nF Polycarbonate	1	(WW43W)
C15,28,29	33nF Polycarbonate	3	(WW35Q)
C20,26	220nF Polycarbonate	2	(WW45Y)
C21,34,35	47nF Polycarbonate	3	(WW37S)
C37,38	100nF Minidisc	2	(YR75S)
C39	10µF 35V PC Electrolytic	1	(FF04E)
C32	330nF Polycarbonate	1	(WW47B)

SEMICONDUCTORS

IC1	4069BE	1	(QX25C)
IC2	µA741C (8 pin)	1	(QL22Y)
IC3	µA78L05AWC	1	(QL26D)

MISCELLANEOUS

SKT1	DIN Socket 7 Pin	1	(HH37S)
JK1	Jack Socket 3.5mm	1	(HF82D)
S1	SPST Ultra-Min Toggle	1	(FH97F)
	Printed Circuit Board	1	(GB72P)
	Veropin 2145	1 pkt	(FL24B)
	PP3 Clip	1	(HF28F)
	DIL Socket 14-pin	1	(BL18U)
	DIL Socket 8-pin	1	(BL17T)
	Hook-up Wire	2m	(BL00A)

OPTIONAL

	Case Verobox 214	1	(LQ07H)
	Bolt 6BA ½inch	1 pkt	(BF06G)
	Nut 6BA	1 pkt	(BF18U)
	Spacer 6BA ⅛inch	1 pkt	(FW33L)
	Plug Scr. 3.5mm	1	(HF81C)
	DIN Plug 7-pin	1	(HH30H)

A complete kit of parts (excluding Optional items) is available.
Order As LK52G (Computadrum Kit) Price £9.95

The Printed Circuit Board used in this project is available separately.
Order As GB72P Computadrum PCB Price £2.95

MACHINE CODE PROGRAMMING WITH THE 6502

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

Introduction

The 6522 VIA, which is often associated with the 6502, offers 16 parallel input/output lines plus several control lines which can oversee the transfer of data between the micro and certain peripherals. A basic discussion of this was undertaken in the last article and it is now time to look at further facilities offered by this extremely versatile support chip. We shall start with the 6522's timer facilities.

The 6522 Timers

The 6522 has two timers, designated logically as Timer 1 and Timer 2. They are able to perform either input or output functions. When used on output, a timer will generate a specified single pulse or train of pulses. The duration of the pulse or the number of pulses will be specified by the contents of the timer register. When used on input, a timer will either measure the length of a pulse or count the number of input pulses. The register mentioned above is first cleared in this mode. Whether used as input or output, when dealing with single pulses the timer is said to be in the 'one-shot' mode. However, when handling trains of pulses, the timer is in the 'free-running' mode.

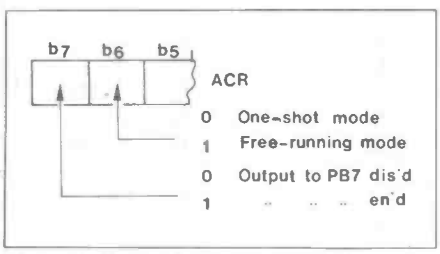


Figure 1. Use of the ACR to control Timer 1 modes.

Timer 1 has four operating modes which are determined by bits 6 and 7 of the Auxiliary Control Register (ACR). This is shown in Figure 1. Bit 6 determines whether the timer is in single-shot or free-running mode, while bit 7 enables or disables an output on PB7 of Port B. This latter can be used to signal the end of a timed period when timing out for example. The easiest way to assimilate this is by an application example, which will now be described.

Performing Two Simultaneous Tasks

This is an apt heading in more senses than one since, not only can one show how to make the micro perform two (or more) unrelated tasks but, at the same time, the use of the timer facility can be demonstrated. Let us start by specifying the two tasks:

(i) the micro will generate a square-wave of a specified frequency and mark/space ratio, for outputting to some external device.

(ii) the micro will also continuously monitor data input at a port and process this data.

Taking item (i) first, it was shown in Part Four of this series that square-waves could be generated by successively taking an output line to logical 1, logical 0, logical 1, etc. while interposing a delay loop between these transitions in order to specify the frequency and mark/space ratio. This method does work but has the disadvantage that the micro is 'twiddling its thumbs', so to speak, between said transitions. Why not make it fill in the time with some useful employment? This is exactly what will be done by passing the responsibility for generating the time intervals over to one of the 6522 timers, say Timer 1. This allows the micro to get

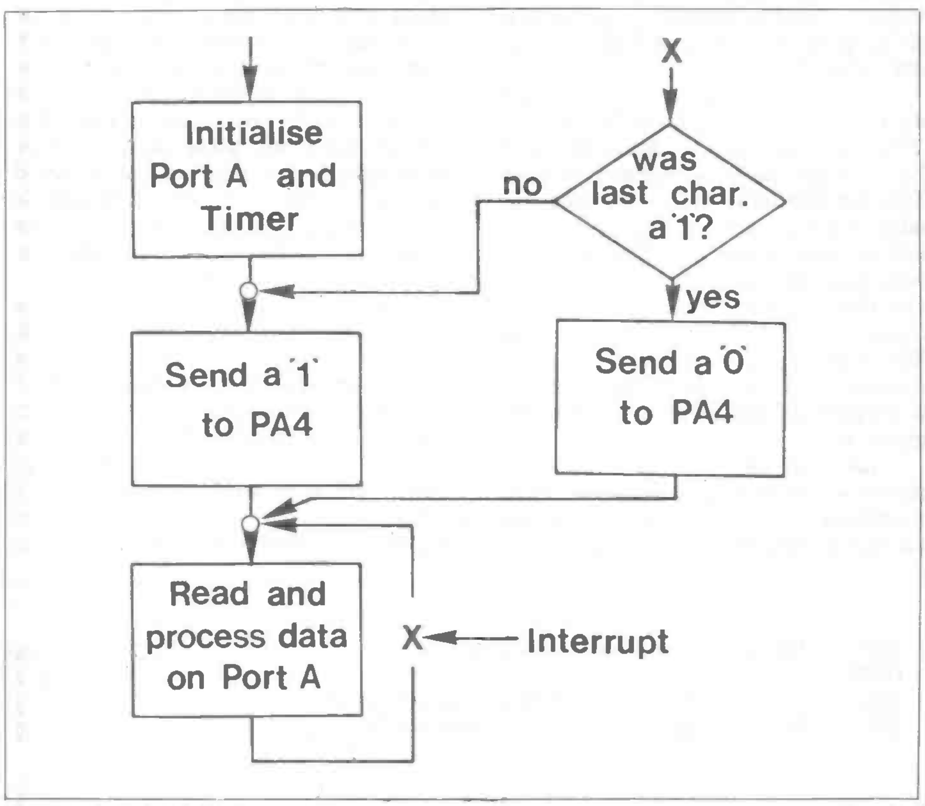


Figure 2. Flow-chart for timer application example.

LDA	#F0	Initialise Port A: PA0 - 3 as inputs;
STA	DDRA	PA4 - 7 as outputs (square-wave on PA4).
SEI		Disables $\overline{IRQ}$.
LDA	#C0	Initialise timer: output to PB7 enabled;
STA	ACR	free-running mode selected.
LDA	#00	Set timer count i.e. establish frequency
STA	T1L	of square-wave (mark/space ratio is 1:1).
LDA	#02	
STA	T1H	

Table A.

SEND1	LDA	#10	Send '1' to PA4.
	STA	DRA	
	STA	MEM0	Notes that PA4 is at logic 1.

Table B.

INDATA	LDA	DRA	Get four lowest bits only (PA0 - 3)
	AND	#0F	of Port A.
	JMP	SUB1	Jumps to data handling routine (actual routine not specified); returns to INDATA, forming a continuous loop.

Table C.

on with some other job while the timer ticks happily away. This 'other job' is, of course, the task specified in (ii) above i.e. data handling at Port A. When the timer 'times out' we just 'interrupt' the data handling program momentarily while the next transition of the square-wave is generated and then return, hardly knowing that we have been away. If the timer has been put into the free-running mode it will go straight into another timing sequence exactly as before. The result will be a continuous square-wave output and a data-handling program that appears continuous so short are the breaks in it. Bearing all the foregoing in mind, the problem should be formally stated now, in the form of a flow-chart (Figure 2).

The Flow Chart

A flow-chart is not just a pretty picture. It really does help to clarify one's thought processes, get the procedure sorted out, break the program down into separate blocks and, finally, test the likelyhood of the program's success by means of a dry run. In this case, there are five blocks, the first of which is concerned with initialising the ports and timers i.e. establishing their exact roles in the program. In Assembly Code it looks like Table A.

The Timer 1 register is sixteen bits wide, each byte being loaded separately (T1L = low byte; T1H = high byte). So in this example the initial register value is 0200 and the timer will decrement this value down to zero, at which point it is said to have 'timed out'. Obviously any value from 0000 to FFFF could be loaded into this register, giving a range, in decimal, from 0 to 65535. The value of 0200 in decimal is 512 and is an arbitrary choice in this case; it gives a square-wave of frequency 500Hz with a unity mark/space ratio.

The next block on the flow-chart generates the leading (positive) edge of the square-wave. This it does by loading the Port A Data Register (DRA) with the HEX value 10. Write out this number in binary (00010000) to see that it puts a '1' into the fifth bit position from the right which corresponds to PA4. This is a very short program segment which, in Assembly Code is shown in Table B.

One little trick in the program is to generate the alternate positive and negative edges of the square-wave. This means taking PA4 alternately to the logic 1 and logic 0 levels. It is necessary to note the direction of the last transition in order to know which way it has to go next time. To this end, MEM0 is a memory location that holds a '1' or a '0' according to the direction of the last transition. This is then consulted before each new transition and updated after it.

At this point, on the first pass through the program, the leading edge of the square-wave would have been generated and the timer would be counting down. It is possible to put the 6502 to work on the main program of data handling while leaving the 6522 to look after the first half-cycle of the square-wave.

Table C shows a program segment using a 'masking' operation (AND#0F) to get the data input on lines PA0 - 3. This is then handled by a sub-routine which keeps returning for more data. This it does until 'interrupted'. And that is the important point. It should be appreciated that it doesn't really matter what task the main program is performing. What is being demonstrated is that the micro can occupy itself with some job but can be diverted, momentarily, at the required instant in order to do something else. In this example it is the cessation of the timing period that initiates the interrupt procedure.

Assuming that an interrupt occurs during the main program then this will bring us to the decision diamond on the flow-chart. Was the last character a 1? This question is answered in the program segment that follows, (Table D), by the CMP#01 instruction and the two branches BEQ and BMI. It will be remembered that the CMP#01 instruction subtracts 01 from the Accumulator contents (without actually affecting these contents) and conditions flags in the Processor Status Register according to the result. If the Accumulator is first loaded with the contents of MEM0 then, if MEM0 holds a '1', the result is zero (BEQ branch taken to SEND0), since last transition was positive, this one must be negative. But, if MEM0 holds a '0', this will give a negative result and the BMI branch to SEND1 will be taken. Thus MEM0 is consulted, as stated previously, in order to determine the sign of the last transition. See Table D.

We come now to the final program in which PA4 is taken to logic 0 when required and MEM0 is updated to record this fact. This loops back to the main program to continue handling data input as before. See Table E.

Now count the number of lines in the

PC	OPCODE	BYTE 2	BYTE 3
0020	A9	F0	
0022	8D	03	09
0025	78		
0026	A9	C0	
0028	8D	0B	09
002B	A9	00	
002D	8D	04	09
0030	A9	02	
0032	8D	05	09
0035	A9	10	
0037	8D	01	09
003A	85	60	
003C	AD	01	09
003F	29	0F	
0041	4C	00	03
0044	A5	60	
0046	C9	01	
0048	F0	02	
004A	30	E9	
004C	A9	00	
004E	8D	01	09
0051	85	60	
0053	4C	3C	00

Table F.

LDA	MEM0	Tests last transition at PA4.
CMP	#01	
BEQ	SEND0	Branches to SEND0; makes PA4 logic 0.
BMI	SEND1	Branches to SEND1; makes PA4 logic 1.

Table D.

SEND0	LDA	#00	Send a '0' to PA4.
	STA	DRA	
	STA	MEM0	Notes that PA4 is at logic 0.
	JMP	INDATA	Returns to main program.

Table E.

complete Assembly Code program i.e. Tables A to E inclusive: there are 23 all told. Thus, there will be the same number of lines in the Machine Code program. A line by line comparison should present no problems and there are no tricks in encoding into machine code. Only four addressing modes are used (all non-indexed): Implied (Inherent); Zero-page; Absolute and Relative. Assigning addresses is a matter for the programmer according to the specific machine in use. Those given in Table F are mainly on zero page, the exceptions being the 6522, which is on page 9 as previously agreed, and the sub-routine for the data handling, which has been located on page 3. The complete machine-code program is shown in Table F.

The data for the branches is computed in the usual way. Just as a reminder, the branch length is always taken from the address 'immediately after' the program line for the branch. Thus for the BEQ instruction, the branch starts at 004A and ends at 004C (2 steps FORWARD), while for the BMI instruction, the branch starts at 004C and ends at 0035 (23 steps BACKWARDS). Converting these two distances to signed HEX gives: +2 = 02 and −23 = E9.

Interrupts $\overline{\text{NMI}}$ and $\overline{\text{IRQ}}$

It will be remembered that programming bit 7 of the ACR enabled or disabled an output on PB7 (bit 7 on Port B) and, since this occurs at the end of the timer period, it effectively signals its conclusion. The question is – how can we make use of this facility?

What we want to do is to interrupt the 6502 processor at the end of each timed period in order to generate either the leading or the trailing edge of the square-wave. The 6502 has two interrupt lines, one of which has a lower priority than the other.

The lower priority line is $\overline{\text{IRQ}}$ – INTERRUPT REQUEST in full. This line, when taken low, will stop the execution of the program, allowing the processor to complete its current instruction only before initiating an interrupt sequence which diverts it from the main program to do something else; that 'something else' is called INTERRUPT SERVICE ROUTINE (ISR). In the example that we are dealing with the ISR is merely a short piece of program that produces the square-wave transitions at PA4. However, the 6502 will

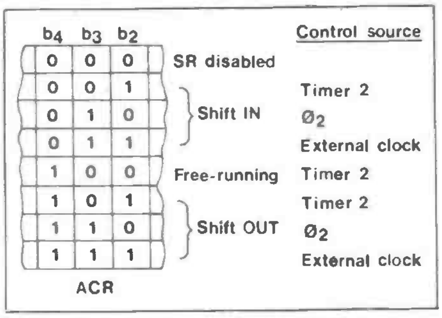


Figure 3. Role of the ACR in shift register control.

only respond to $\overline{\text{IRQ}}$ going low if the 'interrupt flag' in the Processor Status Register is 'clear'. This is achieved with a CLI (Clear Interrupt Mask) instruction. If, however, the SEI (Set Interrupt Mask) instruction has been used then the interrupt flag will be 'set' and the $\overline{\text{IRQ}}$ going low will be ignored. It has been 'masked out', giving priority to calls on the other interrupt line $\overline{\text{NMI}}$ (Non-Maskable Interrupt). It is this procedure that assigns the priority in a case where both interrupt lines are in use. In the specific program that we are dealing with we could equally well have used $\overline{\text{IRQ}}$. However, $\overline{\text{NMI}}$ was chosen in order to introduce the SEI instruction just as if there were another device connected to $\overline{\text{IRQ}}$.

Now to return to the 'end of timing' signal on PB7. To make use of this we must do two things:

(i) Make an electrical connection from PB7 on Port B of the 6522 to the $\overline{\text{NMI}}$ pin of the 6502

(ii) Tell the 6502 where to find the start address of the Interrupt Service Routine. This is known as the 'interrupt vector'. This interrupt vector is contained in two specific, consecutive memory locations (which are machine dependent – see user manual). The programmer must remember to load this vector into these two locations at the time that he enters the rest of the program into RAM. For this particular program the ISR starts at location 0044; this is therefore the interrupt vector for this program.

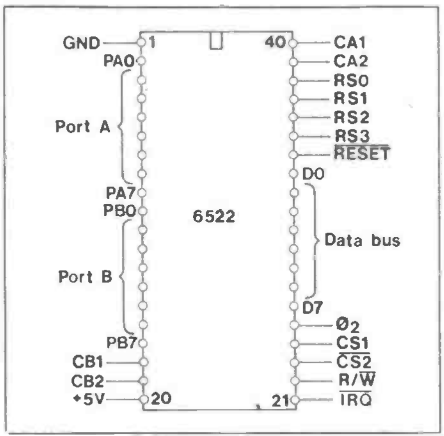


Figure 4. 6522 VIA pin-out diagram.

The subject of interrupts will be dealt with in detail in the next article together with the topic of 'stack' operations.

The Shift Register (SR)

This section of the 6522 chip operates as either a parallel - serial (output) or serial - parallel (input) converter. It can be programmed to shift data at a rate determined by one of a number of sources e.g. Timer 2, 02 of the system clock, or an external clock. It is also able to output data continuously (free-running mode) under the control of Timer 2. These modes are selected by programming the appropriate pattern of bits into bit positions 2, 3 and 4 of the ACR, as shown in Figure 3. The Shift Register is actually connected to pin CB2 of the 6522.

To use this register on output the user first loads it with data, which operation initiates the shifting process. At the end of an 8-bit shift, bit 2 of the Interrupt Flag Register is set, a fact which can be tested by the program. An example of a parallel - serial 'shift out' is given in the Assembly Code segment - shown in Table G.

To shift data in serially and then fetch it as an 8-bit word (parallel input) is similar. The ACR is cleared and initialised to select the mode, which also starts the shifting. A loop is set up to keep testing bit 2 of the IFR to establish when the whole 8-bit word is in. When bit 2 is set the data word can be stored in memory via the accumulator.

In Assembly Code, a typical serial - parallel 'shift-in' program is shown in Table H.

This completes what is, necessarily, a fairly brief survey of the facilities of the 6522. It is evident that it offers a lot of potential in the handling of input and output data, whether in parallel or serial form. Further, the timers allow functions to be performed while the processor is otherwise occupied. Interrupts allow this task to be suspended momentarily. The pin–out for the 6522 is shown in Figure 4.

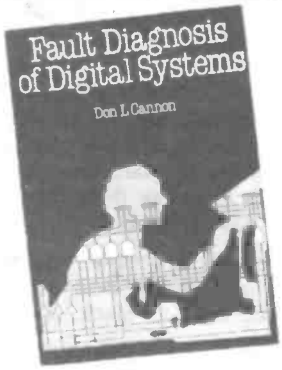
```
LDA   #00    Clear ACR.
STA   ACR
LDA   #18    Program bits 3 and 4 of the ACR to
STA   ACR    be '1's, — shift out under 02 control.
LDA   MEM1   Fetch data from a memory location.
STA   SR     Send data to shift register.
```

Table G.

```
       LDA   #00     Clear ACR.
       STA   ACR
       LDA   #08     Program bit 3 of the ACR to be 1,
       STA   ACR      shift in under 02 control.
AGAIN  LDA   IFR     Done for 8 bits? [Tests bit 2 of
       AND   #04     IFR (SR interrupt flag)].
       BEQ   AGAIN   Keep testing.
       LDA   SR      Get data from shift register.
       STA   MEM2    Store data in memory.
```

Table H.

New Books



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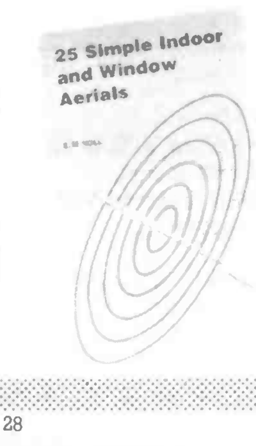

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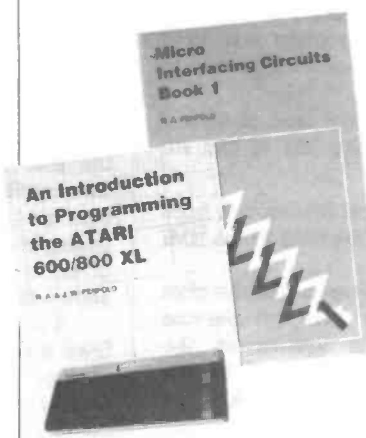

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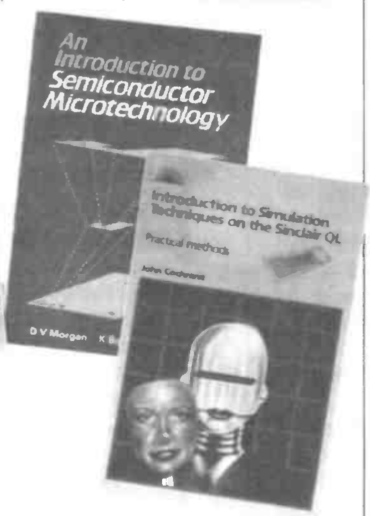

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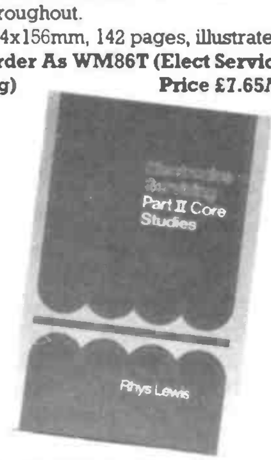

Continued on page 36.

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KH21X Telengard Cass DIS

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KH07H Curse Crwly Mnr Cass DIS
KB31J Zork III Disk DIS

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KB74R Baja Buggies Cass DIS
BG44X Canyon Climber Cass DIS●

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KH16S Controller Cass DIS
KF10L Defender Cart DIS
KF17T Dig Dug Cart DIS●
KT22Y Donkey Kong Atari DIS

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KT33L Donkey Kong Jr DIS
KH13P Elmntr (Fire Fx) Cas DIS●
BQ62S Galactic Chase Cass DIS
KH29G Gridrunner Cass Atar DIS
KB44X Gorf Cart DIS●

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KT43W Joust Atari DIS
KF68Y Jump Man Disk £27.45
BQ16S Lunar Lander Cass DIS

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KT28F Ms. Pac-Man DIS
KF93B Number Stumper Cass DIS
KF94C Number Stumper Disk DIS
KT34M Pengo Atari DIS

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KT35Q Pole Position DIS
KF16S Qix Cart DIS
BG99H Roadracer Cassette DIS

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BG19V Shoot Gallery Disk DIS
KT47B Soccer Atari DIS
BG42V Space Chase Cassette DIS

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KB94C Wizard Of Wor Cart DIS
KH18U Tank Arcade Cass DIS
KT29G Tennis DIS
KB63T Tutti Frutti Cass DIS
KH36P Up Up & Away Cass AT DIS

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KF20W Zaxxon Cass DIS
KB38R Battle Normandy Cass DIS
BG71N Dnieper Line Cass DIS●
KT25C Eastern Front - 1941 DIS

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KB00A Legionnaire Cassette DIS
BG83E NA Convoy Raider Css DIS
KB01B Tigers in Snow Cass DIS

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BG67X Acquire Disk DIS
KT23A Biorhythm Atari DIS
KT31J Family Finances Atri DIS

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KF52G Home Filng Mngr Disk DIS
BQ38R Humpty Dumpty DIS●
BQ39N Hickory Dickory Dock DIS
KH42V Mailing List Cass/At DIS
YG48C Music Composer DIS

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BG92A Stocks and Bonds Dsk DIS
BQ13P Sunday Golf DIS
KT24B Timewise Atari DIS
BQ45Y Pool DIS

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KF18U Atariwriter Cart DIS●
BQ65V Financial Manager DIS

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KH47B Book Keeper Disk /At DIS
YL39N Visicalc DIS
KT39N Atari Music I Cass DIS
KT40T Atari Music I Disk DIS
KT41U Atari Music II Cass DIS
KT42V Atari Music II Disk DIS
YG57M Euro Country & Caps DIS
KF47B Juggles Rainbow Cass DIS
KF48C Juggles Rainbow Disk DIS
KF49D Juggles House Cass DIS
KF50E Juggles House Disk DIS
BG00A Kids 1 Cassette DIS

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BG02C Kids 2 Cassette DIS
KT26D Mickey Outdoors Cass DIS
KT27E Mickey Outdoors Disk DIS
KF51F Speed Reading Cass DIS
KH67X Action Cart Atari DIS
YG68Y Assembler Editor DIS●
BQ27E Atari World DIS
YL32K Assembler DIS

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KB86T Diskey Disk DIS●

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KT30H Logo Atari DIS
KT32K Microsoft BASIC II DIS
BQ75S Pilot Educator DIS

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KB15R SAM Disk DIS●
KB83E Syn Assembler Disk DIS●
YG59P Telelink DIS
YL30H Disassembler Cass DIS
KH57M Coco Cass+Disk/Atari DIS
KH58N Coco2 Cas+Disk/Atari DIS
BQ67X Inv To Prog 2 DIS●
BQ68Y Inv To Prog 3 DIS●

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BG06G Tricky Tutorial Cass DIS
KF69A Disk Utilities Disk DIS●

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KH60Q Advance Anim Disk/At DIS
GG24B Analog Subscription £18.00 NV
UG03D Atari User Grp Mag 3 DIS

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KH75S BBC Conflict Cass DIS
KH80B BBC Galaxy Conf. Cas DIS
KH87U BBC Space Invadr Cas DIS
KH89W BBC Music Proces Cas DIS

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AF57M Dragon 32 Computer DIS●
†BC30H Dragon Joysticks £14.95●

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KL13P Doodlebug Cart (32) DIS
KL16S Countdown Cass (32) £6.36

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KL32K Android Attk Cas(32) DIS
KL33L King Cass (32) DIS
KL39N Eng/Stalag Cass (32) DIS

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KL42V Shark Treas Cas (32) DIS
BC76H Chess Cart DIS

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KL49D Selection 4 Cas (32) DIS
KL50E Ent Dragn Cas A (32) DIS
KL51F Ent Dragn Cas B (32) DIS

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KL72P Alld Ed/Assem cas 32 DIS
KL73Q Dream Ed/Ass Cas(32) DIS
BC44X Computavoice DIS

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AF51F VIC 3K RAM DIS●
AF52G VIC 8K RAM DIS●
KH94C Annihilator Cas (64) DIS
KH95D Camel Attck Cas (64) DIS
KH96E Centropods Cass (64) DIS
KH98G Super Cassett B (64) DIS
KH99H Cyclons 64 Cass (64) DIS
KK62S Escape MCP Cass (64) DIS
KK63T Galaxy Conf Cas (64) DIS

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KK65V Gridrunner Cass (64) DIS
KK67X Pakacuda Cass (64) DIS
KK68Y Rox 64 Cass (64) DIS
KK51F Benji's Space Rescue DIS●
KK70M Easy Script dsk (64) DIS
KK52G Omnicalc (64) DIS

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KK75S Basic Intr Cas1 (64) DIS
KK55K Coco 2 Cart (64) DIS
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KK81C Sprite Edit Cas (64) DIS
KK47B Turtle Graphics (64) DIS
KK44X 6510 Assembler (64) DIS
KK86T Chemistry Cass (64) DIS
KK87U Depth Charg Cas (64) DIS
KK88V Easyspell Disk (64) DIS●
KK89W English Cass (64) DIS

KK90X Geography Cass (64) DIS
KK91Y History Cass (64) DIS
KK92A Home Man Cas+Dsk(64) DIS
KK93B Labyrinth Cass (64) DIS
KK95D Maths 1 Cass (64) DIS
KK96E Maths 2 Cass (64) DIS
KK97F Maze Mast Cart (64) DIS
KK98G Paint Brush Cart(64) DIS
KK99H Physics Cass (64) DIS
KL00A Rat Race Cass (64) DIS
KL01B Sea Wolf Cass (64) DIS
KL02C Simons Bas Cart (64) DIS
KL03D Snowman Cass (64) DIS
KL04E Stellar Wars Cas(64) DIS
KL05F Superblitz Cass (64) DIS
KL06G Super Fruit Cass DIS
KL07H Swordpoint Disk (64) DIS
KL08J Sythesound Cart (64) DIS
KL09K Turtle Train Cart 64 DIS
KL10L Turtle Tutor Cart 64 DIS

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KS17T Cowboy/Barricade DIS
KS18U Guttang Guttong Cart DIS
KS07H M5 Boxing DIS
KS09K M5 Tennis DIS
KS02C M5 BASIC F DIS
KS00A M5 FALC DIS
KS20W M5 Graphic Design DIS
KS08J M5 Skiing DIS
KS05F M5 Word Maze DIS
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KL76H Arcadia Cass (SP) DIS
KL78K Astroblastr Cas (SP) DIS
KL80B Centi/Paint Cas (SP) DIS
KL82D Frenzy Cass (SP) DIS
KL85G Halls Things Cas(SP) DIS
KL86T Headbangers Cas (SP) DIS
KL87U Air Traffic Cas (SP) DIS
KL89W Maze Chase Cass (SP) DIS

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KL90X Mined Out Cass (SP) DIS
KL91Y Nightflite Cass (SP) DIS
KL92A Penetrator Cass (SP) DIS
KL94C Schizoids Cass (SP) DIS
BC90X Space Intruders Cass £3.96
KL99H Terrordacktil Cas SP DIS

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KH30H Dungeon Master Cass DIS
BC88V The Hobbit (48K) Cas DIS
KH31J Trader Tril Cas (SP) DIS
KH32K Quest Adv Cass (SP) DIS
KH41U Countries World Cass DIS

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KH45Y Word Proc Cass (SP) DIS
KH48C Edit/Assem Cass (SP) DIS
KH50E Spec Mach Lan Cas SP DIS
KH51F Spect Mon Cass (SP) DIS
KH55K Manic Miner Cas (SP) DIS
KM00A Vic Abductor Cass DIS
KM01B Vic Andes Attck(+8k) DIS
KK17T Ant Eater Cart DIS

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KM03D Vic Arcadia Cass DIS
KM05F Vic Catch Snatch Cas DIS
AC82S VIC Cosmic Crunchers DIS●
KM08J Vic Escape MCP Cass DIS●

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KM10L Vic Games Pack Cass DIS
KK34M VIC Games Pack 1 DIS
KK35Q VIC Games Pack 2 DIS
AC90X Gorf Cartridge DIS
BC47B VIC Hoppit DIS
KM13P Vic Inovative Cas. 2 DIS
KM14Q Vic Inovative Cas. 3 DIS

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KM16S Vic Matrix Cass DIS
KK04E Night Crawler Cass DIS
AC91Y Omega Race Cartridge DIS
KK16S Princess & Frog Cart DIS

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KK59P VIC Sub Commander DIS
KK01B Skramble Cass DIS
KM22Y Vic Sky Hawk Cass DIS
KK06G Space Phreeks Cass DIS

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AC60Q VIC Star Battle DIS
KM53H VIC Tank Arcade Cass DIS
KM09K Vic Skramble Cass DIS
KM26D Vic Wacky Waits Cass DIS
AC79L VIC Panic DIS
KK61R VIC War Games DIS
AC86T VIC Adventureland £9.99

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AC87U VIC Mission Impossbl DIS
AC84F VIC Pirate Cove DIS
AC89W VIC The Count DIS
KM27E Vic Wiz & Princs Cas DIS

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AC88V VIC Voodoo Castle DIS
KM29G Vic Camels Cart DIS
BC52G VIC Cosmic Jailbreak DIS
KM31J Vic Kindercomp Cart DIS
KM35Q Vic Necromancer Cart DIS
KM36P Vic Pharoah Cart DIS
KM37S Vic Slime Cart DIS
KM38R Vic Story Machine DIS
BC18U Garden Planner DIS
BC19V Interior Designer DIS
KK18U Typo Cart DIS
BC51F VIC Pinball DIS
BC97F Multisound Synth Cas DIS
AC77J VIC Sargon II Chess DIS

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KK07H Chess (+16K) Cass DIS
BC16S VIC Money Manager DIS

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AC97F VIC Writer Cassette DIS
KK26D VIC Word Processor £27.50
BC98G Jnr Maths: Birds Cas DIS

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BC99H Jnr Maths:Engine Cas DIS
KK00A Jnr Maths:Lghtho Cas DIS
KM51F Words Words Cass DIS

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†AC57M Intro To Basic Part1 £11.96●
AC58N Intro To Basic Part2 DIS
KK28F VIC Machine Code Mon DIS
AC56L Machine Code Mon DIS

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BK95D Date Cassette £1.95
AF38R Epson RX80 DIS●

CONNECTORS

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HF23A Alligator Clip Black 19p (G)
HF26D Charger Clip 28p (F)
YX47B Comcon Block 5-way 48p (F)
YX48C Comcon Terminal 7p (H)
HF02C Terminal Post Black 45p (F)
HF03D Terminal Post Blue 45p (F)
HF04E Terminal Post Brown 45p (F)
HF05F Terminal Post Green 45p (F)
HF07H Terminal Post Red 45p (F)
HF09K Terminal Post Yellow 45p (F)
HF13P Press Terminal Black 34p (F)
HF15R Press Terminal Green 34p (F)
HF16S Press Terminal Red 34p (F)
HF17T Press Terminal White DIS (F)
HF18U Press Terminal Yellw 39p (F)

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WL57M 1mm Plug Black 24p (G)
WL58N 1mm Plug Red 24p (G)
HF46A 2mm Socket Green DIS (G)
HF49D 2mm Socket Yellow 18p (G)
HF55K Wander Plug Yellow DIS (G)
HF56L Wander Socket Black 16p (G)
†HF57M Wander Socket Blue 16p (G)
HF58N Wander Socket Green 16p (G)
HF59P Wander Socket Red 16p (G)
HF61R Wander Socket Yellow DIS (G)
HF62S 4mm Plug Black 18p (G)
HF63T 4mm Plug Blue 18p (G)
†HF64U 4mm Plug Brown 18p (G)●
HF65V 4mm Plug Green 18p (G)
HF66W 4mm Plug Red 18p (G)
HF67X 4mm Plug White 18p (G)
HF68Y 4mm Plug Yellow 18p (G)
HF70M 4mm Socket Blue 18p (G)
†HF71N 4mm Socket Brown 18p (G)●
HF72P 4mm Socket Green 18p (G)
HF73Q 4mm Socket Red 18p (G)
HF74R 4mm Socket White 18p (G)
HF75S 4mm Socket Yellow 18p (G)
HH01B Scr Phono 19p (G)
YW06G Threaded Phono Skt 18p (G)

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BW74R Phono Socket Quad 42p (F)
BW76H Phono Socket 6-way 58p (E)
HH05F Phono Conn 24p (G)
HF77J 2.5 Plug Scr 29p (F)
HF78K 2.5 Jack Socket 18p (G)
HF80B Plug Plas 3.5 19p (G)
HF81C Plug Scr 3.5 28p (F)
HF82D Jack Socket 3.5 16p (G)
HF83E Line Socket Plas 3.5 16p (G)
RK51F Stereo Plas 3.5 Skt 38p (F)
HF85G Jack Plug Plas 24p (G)
HF87U Jack Plug Scr 45p (F)

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HF88V Jack Pl Sto Plas 36p (F)
HF89W Jack Pl Sto Scr 62p (E)
HF90X Jack Skt Brk 24p (G)
HF91Y Jack Skt Open 22p (G)
HF92A Jack Skt Sto 28p (F)
HF93B Stereo Open Skt 39p (F)
BW80B DPDT Jack Socket 60p (E)

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YW08J Co-ax Plug Imp 16p (G)
HH17T BNC Plug 95p (E)
HH18U BNC Socket 95p (E)
YW03D BNC T Adaptor £2.45 (C)
BW81C Plug PL259 65p (E)

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BW84F UHF Socket Round 53p (F)
BW85G Socket SO239 58p (E)
YW04E Adaptor 239 £1.45 (D)
YW05F Adaptor 259 £1.48 (D)
YX53H Audio Conn 4-way £1.55 (D)
YX54J Audio Conn 5-way £1.95 (D)

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RK52G 10 Way Line Skt £2.98 (C)
RK53H 10 Way Line Plug £3.95 (C)
★RK54J 10 Way Chassis Skt £1.95 (D)
BW90X XLR Chassis Socket £2.95 (C)
HH26D DIN Plug 4-pin 22p (F)
HH27E DIN Plug 5-pin A 18p (G)
HH29G DIN Plug 6-pin 22p (F)
HH32K DIN Socket 3-pin 14p (G)
HH37S DIN Socket 7-pin 37p (G)

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HH40T DIN Line Skt 2-pin 12p (G)
YX90X PC DIN Skt 2-pin 26p (F)
YX91Y PC DIN Skt 5-pin A 22p (F)
RK60Q D-Range 9 Way Plug 68p (E)●
BK58N D-Range 15-Way Plug 95p (D)●
YQ48C D-Range 25-Way Plug £1.39 (D)●
RK61R D-Range 9 Way Skt 95p (D)
BK59P D-Range 15-Way Skt £1.43 (D)
YQ49D D-Range 25W Socket £2.19 (C)●
FG25C RA D-Range 9-Way Skt £1.79 (D)●
FG26D RA D-Rnge 15-Way Skt £2.62 (D)
FG27E RA D-Rnge 25-Way Skt £3.95 (D)
FG67X RA D Range 15 Wy Plg £1.95 (D)
FG68Y RA D Range 25 Wy Plg £2.95 (C)
RK62S D-Range 9 Way cover £1.14 (D)●
BK60Q D-Range 15 Way cover 99p (D)●
YQ50E D-Range 25-Way Cover £1.14 (D)●
RK63T D Range 9 Way Latch 48p (F)●
YQ51F D-Range 25-Way Latch 54p (F)

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WQ14Q PCB Conns 45 9p (H)
RK35Q PC Edgeconn 2x23-way £2.20 (C)
FG23A 0.1in 2x28 PC Edgcon £1.95 (C)
BK74R 2x12 Way PC Edgecon £2.20 (C)
FL83E Edge Conn 108 88p (E)●
FL84F Edge Conn 118 £1.29 (D)●
FL85G Edge Conn 124 £1.62 (D)
FL91Y Edge Conn Feet G 22p (G)
FL92A Edge Conn Feet H 22p (G)
YR58N Edge Conn End Bkt 33p (F)

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YX34M Multicon Plug 4-way 29p (G)●
YX36P Multicon Plug 15-way 58p (F)
YX37S Multicon Plug 24-way 89p (E)
YX38R Multicon Plug 36-way £1.20 (E)
YX39N Multicon Skt 2-way 23p (G)
YX40T Multicon Skt 4-way 27p (G)
HL01B Octal Ch Plug 96p (E)
RK65V Minicon Latch Pl 2w 17p (G)
YW11M Minicon Latch Pl 4w 29p (G)
FY93B Minicon Latch Pl 5w 33p (F)
YW12N Minicon Latch Pl 6w 39p (F)
YW13P Minicon Latch Pl 8w 39p (F)
RK66W Minicon Latch Pl 10w 52p (F)
BH61R Minicon Latch Pl 17w 95p (E)

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YW15R RA Lch Minicn Pl 3w 38p (F)
FY91Y RA Lch Minicn Pl 4w 42p (F)
RK67X RA Lch Minicn Pl 5w 45p (F)
FB99H RA Lch Minicn Pl 6w 58p (F)
YW18U RA Lch Minicn Pl 8w 65p (E)
RK68Y RA Lch Minicn Pl 10w 69p (F)
YW24B Mncn Ltch Hsng 12way 21p (G)

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- RK69A Mncn Ltch Hsng 17way 29p (F)
- YW28F Minicon Skt 6-way 39p (F)
- YW30H Minicon Skt 12-way 69p (E)
- YW96E IDC Con 4-way 35p (F)•
- YW98G IDC Con 8-way 79p (E)
- YW99H IDC Con 12-way £1.20 (E)
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- FG85G 2x13 dil IDC Socket £1.62 (C)
- FG86T 2x17 dil IDC Socket £2.98 (C)•
- FG87U 2x20 dil IDC Socket £3.45 (C)•

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- HL06G Wafercon Plug 6-pin 22p (G)
- HL07H Wafercon Plug 8-pin 22p (G)
- HL08J Wafercon Plug 12-pin 34p (F)
- HL13P Wafercon Skt 12-way 32p (F)
- RK38R 8-Way PC Terminal 65p (E)
- YY22Y CB Pin Blue 44p (F)
- YY26D CT Pin White £1.62 (D)
- YB08J Large Patchboard £174.95 (A)•
- WQ10L Large Patch Plug 38p (F)

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- HH38R Universal Plug 95p (E)
- HH60Q Std Power Plug 2.1 16p (G)
- HH63T Long Pwr Plug 2.5 18p (G)

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- RW64U Cas Lead Sharp DIS (E)
- RW65V Cas Lead Sony DIS (E)
- HL43W Euro Facility Plug £1.15 (E)•
- ★WY16S Euroboard 4-way £9.89 (B)
- WY17T Euroboard 6-way £5.95 (B)
- HL23A Mains Socket P430SE £1.52 (D)

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- HL27E Mains Plug SA2190 £1.15 (F)•
- HL30H Mains Plug SA2019A £1.64 (D)
- HL34M Mains Socket SA2368 98p (E)
- HL36P Mains Plug P635 £1.36 (D)

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- HL39N Mains Plug P551 £3.40 (C)
- HL40T Mains Socket P552 £1.20 (E)
- HL50E Sleeve 8037 14p (G)
- FG28F Line Jack Unit £2.95 (C)
- FG29G PTC Line Cord £1.95 (B)
- RK71N Video Kopy Kit £9.95 (A)•
- RK84F Video Lead 1 £2.65 (C)

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- FG18U Computer Lead 1 £2.22 (D)
- FG30H Printer Cable 1 £8.45 (D)•
- RK87U Video Lead 5 £2.32 (C)
- FG31J Printer Cable 2 £8.45 (D)•

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- RW01B Adaptor B 45p (F)
- YW38R Adaptor W DIS (E)
- RW07H Adaptor H DIS (F)
- RW03D Adaptor D DIS (F)
- RW08J Adaptor J 39p (F)
- YW35Q Adaptor T 95p (D)
- RW05F Adaptor F 45p (F)
- RW09K Adaptor K DIS (F)
- RK55K Adaptor Y 45p (F)
- RW26D Dinpak N DIS (D)
- RW15R Dinpak B DIS (D)

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- RW22Y Dinpak J 95p (E)
- RW23A Dinpak K 95p (E)
- RW18U Dinpak E 86p (E)
- RW17T Dinpak D £1.68 (D)
- RW20W Dinpak G £1.68 (D)
- RW49D Dinpak 280 DIS (D)
- RK58N Plugpak Y £1.84 (D)

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- RW67X 13 Amp Plug Nylon 69p (E)
- HL61R Flex Connector £1.72 (D)

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- HL82S Mains Adaptor 2-way £1.62 (C)
- HL83T Mains Adaptor 3-way £2.98 (C)
- HL84U Shaver Adaptor £1.46 (D)
- HL67X Junction Box RM £1.24 (D)
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- HL73Q Trailing Skt Single £1.86 (D)
- HL74R Trailing Dble Skt £3.96 (C)
- HL78K Shaver Skt Isolated £22.64 (A)

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- HL83E Switched Flex Outlet £4.75 (C)
- HL86T Blanking Plate 92p (E)
- HL87U 20A Plateswitch £3.82 (C)
- HL88V 20A Water Htr Switch £5.26 (C)
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- FQ16S Auto Security Switch £17.98 (A)
- YB09K Fl Pattress 16mm Sgl 98p (E)
- YB10L Fl Pattress 25mm Sgl 79p (E)

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- YB14Q Sur Patt 20mm Sngl 84p (E)
- YB16S Sur Patt 29mm Dble £1.84 (D)
- YB17T Sur Patt 47mm Dble £2.98 (C)
- YB18U Conversion Pattress £2.82 (C)
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- FQ02C Lampholder 702 92p (E)
- FQ05F Ceiling Rose £1.39 (D)•
- ★YB19V Time Switch £18.95 (A)

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- WY23A Timetouch £34.95 (A)
- YB20W Room Thermostat £12.15 (B)•
- XY08J Extn Lead 5A £15.25 (A)•

HARDWARE

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- BF00A Bolt 2BA 1/2in 62p (F)
- BF05F Bolt 6BA 1/4in 18p (G)
- BF06G Bolt 6BA 1/2in 21p (G)•
- BF08J Bolt 8BA 1/4in 55p (F)
- BF09K Bolt 8BA 1/2in 59p (F)
- LR56L C/S Screw 6BA 1/4in 18p (H)•
- LR00A C/S Screw 8BA 1/2in 39p (F)
- BF14Q Panel Screw 5p (H)
- LR75S C/S Panel Screw 8p (H)
- BF16S Nut 2BA 22p (G)•
- BF31J Pozi Screw M5 12mm 29p (F)
- LR58N Pozi Screw M3 40mm 65p (F)
- BF39N Pozi Screw M2.5 6mm 26p (G)
- BF40T Pozi Screw M2.5 12mm 21p (G)

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- BF46A Isobolt M5 12mm 72p (E)•
- BF48C Isobolt M4 6mm 38p (F)
- BF49D Isobolt M4 12mm 38p (F)
- BF53H Isobolt M3 25mm 42p (F)
- BF55K Isobolt M2.5 12mm 28p (F)
- BF61R Isowasher M4 12p (H)
- LR63T Isotag M4 33p (G)•
- LR64U Isotag M3 17p (G)•
- LR65V Isotag M2.5 17p (G)•
- BF72P Nyl 4BA 1/2in 57p (F)•
- BF74R Nyl 4BA 1.1/2in DIS (D)•
- BF77J Nyl 8BA 1/2in £1.59 (E)•
- BF81C Nyl Nut 8BA 65p (E)
- WH19V Nylon Nut M3 33p (H)•

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- FW13P Studding 2BA 36p (F)
- FW30H 4BA Spacer 1/8in 68p (F)
- FW31J 4BA Spacer 1/4in 68p (F)
- FW32K 4BA Spacer 1/2in 68p (E)
- FW33L 6BA Spacer 1/8in 42p (F)
- FW34M 6BA Spacer 1/4in 45p (F)
- LR70M 8BA Spacer 1/4in 42p (F)
- FG37S M4 Spacer 1/2 86p (E)
- LR72P Thrded Spcr 6BA 68p (E)
- FW18U Standoff Long 9p (H)

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- LQ12N Sealing Strip 84p (E)
- LH13P Aly Sheet 16 swg £4.42 (C)
- XX31J PCB Guides 29p (F)

HEATHKIT

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- HK61R HW-5400 Syn HF Xcvr £549.95•
- HK62S HWA-5400-1 PSU/Clk £229.95•
- HK63T HWA-5400-3 Keypad £69.95•
- HK66W HWA-5400-2 Filter £69.95•
- HK73Q HD-1418 Active Filtr £149.95•

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- HK43W HW-8 QRP Xcvr DIS
- †HK44X HWA-7-1 Power Supply £39.95
- HK24B HN-31A Cantenna Load £34.95
- HK25C HD-1234 Antenna Sw £25.95•
- HK74R HM-9 HF/VHF Wattmete £59.95•
- HK75S HFT-9 50W Tuner £64.95•

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- HK22Y HD-1416 Morse Cd Osc £34.95
- HK76H HM-2140A Dual Wattmt £109.95•
- HK27J PS-2450 Power Unit £22.95
- HK23A HD-1250 Dip Meter £94.95•

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- HK78K HD-8999 Pro CW Keybd £229.95•
- HK41U SA-5010 uMatic Keyer £109.95•
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- HK31J CI-1080 Exhst Anlysr £139.95•
- HK29G CI-2065 Chargng Tstr £29.95
- HK01B GC-1107 Dig Alarm Cl £39.95
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- HK39N GD-1246AE Flrsct Lmp DIS•
- HK80B NE-2112 Heat Sniffer £34.95
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- HK33L EI-3133 Solderng Crs £25.95•
- HK45Y EB-1010 Elect Dctnry £18.95 NV
- HK04E EE-3140 Hobby Elect £79.95
- HK32K EE-3100 Basic Eltrty £34.95 NV
- HK05F EE-3101A DC Elct Crs £64.95•

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- HK06G EE-3102A AC Elct Crs £69.95•
- HK07H EE-3103A Semi Dv Crs £69.95•
- HK08J EE-3104A Elect Crs £79.95

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- HK09K EE-3105A Tst Eqp Crs £79.95
- HK42V EE-3106 Elct Com Crs £74.95•
- HK10L ET-3100B Exp Trainer £109.95•
- ★HK11M ETW-3100B Assembled £189.95•

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- HK81C EE-1001 Passive Crs £64.95•
- HK82D EE-1002 Transtr Crs £74.95•
- HK83E ET-1000 Eng Trainer £229.95•
- ★HK84F ETW-1000 Assembled £429.95•

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- HK48C EH-701 Linear Course £59.95
- HK49D EH-702 TTL/CMOS Crs £74.95•
- HK92A EE-4201 Fibre Op Crs £109.95
- HK12N EE-3201 Dig Tech Crs £109.95•
- HK64U EE-3202 CMOS Tch Crs £99.95

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- HK13P ET-3200B Dig Trainer £109.95•
- ★HK14Q ETW-3200B Assembled £219.95•
- HK15R EE-3401 Micro Course £119.95•

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- HK16S EE-3402 Intrfcng Crs £119.95•
- HK17T EE-3404 Adv Mic Crs £119.95•
- HK65V EE-3403 Synth Course £119.95•
- HK18U ET-3400AE Micro Trnr £269.95 (A)•
- ★HK19V ETW-3400A Assembled £419.95•

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- ★HK46A ETA-3400 Accessory £199.95
- ★HK91Y EWA-3400 Assembled £309.95•
- HK47B ETA-3400-1 Chip Set £64.95
- HK85G EE-8088 16-Bit Cours £98.95 NV

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- HK86T ET-100E 16-Bit Trnr £899.95•
- HK87U ETA-100A 16-Bit Accy £1499.95•
- ★HK88V EWA-100A Assembled £1849.95•
- HK97F Z-205-1 64K RAM Kit DIS
- HK20W ETS-18 Hero 1 Robot £1349.95

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- HK89W ET-18-4 Hero Dem ROM £59.95•
- HK90X ET-18-5 Mon ROM List £39.95 NV
- HM10L EB-1020 Computr Dict DIS•

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- HM08J EC-1100 Learn BASIC £49.95 NV
- HM09K EC-1110 M-soft BASIC £84.95 NV•
- HM07H EC-1120 CP/M 80 Crs £99.95 NV
- HM06G EC-1108 Ass Lng Crs £64.95 NV

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- HM11M EB-6140-C of E Text £24.95 NV
- HM12N EB-6140-40 C E Wkbk £11.95 NV
- HM13P EB6140-50 C E Instr £10.75 NV
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- HM24B EB6102-50 AC Instr £10.75 NV
- HM25C EB-6102-30 AC Parts £17.95 NV
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- HM29G EB-6103-40 Semi Wkbk £12.95 NV
- HM30H EB6103-50 Semi Instr £10.75 NV
- HM31J EB-6103-30 Semi Part £20.95
- HM34M EB-6104 Elc Clr Text £20.95 NV
- HM35Q EB-6104-40 Elec Wkbk £12.95 NV
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- HM42V EB6105-50 Test Instr £10.75 NV
- HM43W EB-6105-30 Test Part £29.95
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- HM62S EB-6402-40 Intf Wkbk £11.95 NV
- HM63T EB6402-50 Intf Instr £10.75 NV
- HM64U EB-6402-30 Intf Part £69.95
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- HM84F EB-1801-30 Robot Prt £59.95•
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- HM72P EB6100-40 BASIC Wkbk £12.95 NV
- HM73Q EB6100-50 BASIC Inst £10.75 NV
- HM74R EB-6108 Ass Lan Text DIS
- HM75S EB6108-40 Lnguge Wbk DIS
- HM76H EB6108-50 Ass Instr DIS

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- HK96E Z-207-3 Disk Drive £459.95
- HK98G Z-219-1 Colour RAM £159.95•
- HM00A Z-205 256K RAM £899.95•

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- HM01B HS-207-41 One Drive £1249.95
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- HM03D Z-207-6 Add-On Disk £799.95
- HM04E HS-217 Winchester Dr £2199.95
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- HK27E IG-5218 Audio Genrtr £159.95•
- HK52G IN-3117 Resistnc Box £69.95•
- HK50E IM-5258 Distrtn Anly £299.95
- HK26D IG-5280 RF Oscilltr £59.95•

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- HK34M IB-5281 RCL Bridge £59.95•
- HK28F IT-2250 Capactnc Mtr £179.95•
- HK93B IMA-100-10 DC Probe £19.95•
- HK54J IM-2410 Freq Counter £149.95•

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- HK55K IM-2400 Hand-Freq Ct £159.95•
- HK67X PS2405 Hand-Freq PSU £17.95•
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- HK53H IP-2718 Tri-Otpt PSU £129.95•

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- HK95D IG-4244 Osc Calibrtr £169.95•
- HK35Q IP-2728 Low-Volt PSU £54.95•

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- HK56L ID-4001 Weather Cmpr £449.95 (A)•
- HK57M ID-1590E Wnd Spd Ind DIS•
- HK72P ID-1990 Digi Baromtr £129.95
- †HK59P ID-2090E Digi-Baromt £159.95

KNOBS

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- RW75S Knob BK12 22p (G)
- RX99H Knob RN92 38p (F)
- HB24B Knob K2 45p (F)
- RW88V Knob M1 35p (F)•
- RW89W Knob M2 32p (F)
- RW90X Knob M3 28p (F)
- RX00A Knob M4 49p (F)

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- HB29G Knob R52 78p (E)•
- RX07H Knob R76 82p (E)•
- YR64U Knob K8A 65p (F)
- YR66W Knob K8C 95p (E)
- RK90X Knob K10B 75p (E)
- HB38R Knob K30 DIS (E)
- HB41U Knob K46 DIS (D)

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- WL52G 15mm Collet Pntr Blu DIS (H)
- WL53H 15mm Collet Pntr Grn DIS (H)
- YG40T Low-Cost Collet Knob 33p (F)
- QY00A LC Cap Black 8p (H)
- QY01B LC Cap Blue 8p (H)
- QY02C LC Cap Green 8p (H)
- QY03D LC Cap Grey 8p (H)
- QY04E LC Cap Red 8p (H)
- QY05F LC Cap White 8p (H)
- QY06G LC Cap Yellow 8p (H)
- YG09K Slide Knob B 21p (G)
- YG10L Slide Knob C Black DIS (G)
- RX29G Spindle Coupler 95p (E)

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- RX38R Nylon Rod 32p (G)
- RX43W Cord Drum Small 98p (E)
- RX39N Vernier Dial Small £2.95 (C)
- RX41U Vernier Dial Large £4.98 (C)•
- HB46A White Pointer 44p (F)
- HB47B Ball Drive Pointer 68p (E)

MICROPHONES

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- YB33L Electret Casette Mic £2.62 (C)

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- LB69A Tie-Clip Mic £7.24 (B)
- YK63T Electret Mic ECM1066 £10.45 (B)

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- YK64U Electret Mic ECM1067 £12.95 (A)
- YK65V Professional Mic 1 £19.95 (A)
- YK66W Professional Mic 2 £25.95 (A)
- YK68Y Stereo Electret Mic £21.85 (A)
- YK69A Professional Mic 4 £35.95 (A)

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- LB94C Screen S15 £8.95 (B)
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- BK01B FM Mic £27.95 (A)
- BK02C FM Mic Adaptor £24.45 (A)
- LB35Q Mic Windshield 65p (F)
- YW76H Extra Hgt Mic Stand £7.95 (B)

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- ★YB39N Pre-Amp CS5 £8.43 (B)
- †XB30H Mono Mic Mixer £9.86 (B)•
- YK55K Stereo Mixer MM2 £12.95 (A)
- XB29G Stereo Mixer DIS (A)

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- AF60Q Graphic Eqlizr GE206 DIS (A)•
- AF27E GE1305 Equaliser DIS (A)
- AF59P Graphic Eq. GE909 DIS (A)
- LB66W Mini-Phaser £26.95 (A)
- XB41U Fuzz-Wah Pedal DIS (A)

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- XB34M Vibra Chorus DIS (A)•
- XG30H BBD Echo EM-006 £78.00 (A)
- XY80B BBD Echo Machine DIS (A)

OPTO-ELECTRICAL

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- YB42V Steel Mag Pick-up £10.95 (B)
- YL07H Pickup Switch £3.62 (C)
- LB60Q Guitar Strings Steel £2.15 (D)

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- RX86T MES Batten Hldr 23p (G)
- RX67X Flt-Tp LES Lhldr Blu 45p (F)
- RX68Y Flt-Tp LES Lhldr Grn 45p (F)
- RX69A Flt-Tp LES Lhldr Red 45p (F)
- FF66W Fluted Lhldr Amber 34p (F)
- FF69A Fluted Lhldr Red 34p (F)
- YY00A LES Cover Amber 9p (H)•
- YY04E LES Cover Red 9p (H)•
- BK52G Min Neon Red 45p (F)
- BK53H Min Neon Green 45p (F)
- BK54J Min Neon Amber 45p (F)
- RX82D Pan Neon Amber 36p (F)
- RX83E Pan Neon Red 36p (F)
- BK51F Pan Neon Green 44p (F)

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- WL78K Bulb MES 6V 0.6W 35p (F)
- LQ11M 12V Tube £2.48 (D)•
- †LL15R 240V Inspection Lamp £5.60 (B)•
- YB29G Spot Holder £5.45 (C)

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- YY40T LED Clip 4p (H)
- QW96E Square LED Red 41p (F)
- YH60Q Square LED Green 39p (F)
- YY47B Shape LED R1 Orange 35p (F)•
- YY48C Shape LED R1 Yellow 22p (F)
- YY52G Shape LED S3 Green 27p (F)•
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- YY59P Chrome LED Small 59p (F)
- QY46A Chrome LED Small Gn 58p (E)
- QY47B Chrome LED Large Gn 65p (E)
- QY48C Black Bezel LED Red 48p (F)•
- YH77J Dual LED Array Red 48p (F)•
- †BK03D Vertisocket Type 1 £1.26 (D)
- BK04E Vertisocket Type 2 £3.45 (C)•

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- FR41U 1/2" Display Type 4 £1.38 (D)•

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- FY89W Lqd Crystal Display £4.95 (C)•
- YY63T Quad Opto-Isolator £3.62 (C)

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- YY66W Infra-Red Sensor 92p (F)
- YH71N Photodiode TIL100 £1.95 (D)
- YH70M IR Emitter TIL38 68p (F)•

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- QF30H BPX25 £4.45 (C)
- HQ61R MEL 12 98p (F)
- RK22Y Solar Panel 6V DIS (B)•
- HQ63T Lens £2.98 (C)
- HQ64U Lensholder £1.98 (D)

ORGAN COMPONENTS

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- XB84F Long Spring Line £11.95 (A)
- XB17T Mid Kbd 49-Note C-C £19.95 (A)
- XB13P KB Mounting Strip 54p (F)

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- XB14Q Keyboard 48-Note £28.95 (A)
- BH62S Spacer Block 6p (H)•
- XB94C Contact Block 1WG 32p (F)
- QY07H Contact Springs 9p (H)
- XB00A Gold Wire £1.95 (D)

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- †BH49D Tablet Rocker Gray 96p (E)•
- †BH50E Tablet Rocker Orange 96p (E)•
- †BH51F Tablet Rocker Red 96p (E)•
- BY21X Mar Ky Tb D/B to Rtr DIS•

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- XB21X Piano Pedal £12.45 (A)
- XY89W Switched Swell Pedal £15.48 (A)•

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- XY28F Remote Foot Control £13.95 (A)
- $XY99H Roll Top £22.95 (A)•
- XB95D Organ Stool £32.45 (A)•

PANEL METERS

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- YQ47B Dual VU Meter £3.75 (C)
- RK10L Quick-Fit Meter 5mA TEMP (C)
- RK12N Quick-Fit Meter 50mA DIS (C)
- RK20W Punch 27.5mm £7.95 (B)•

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- RW94C 2in. Pan Meter 1mA £6.98 (B)
- RW95D 2in. Pan Meter 5mA £6.98 (B)
- RW96E 2in. Pan Meter 10mA £6.98 (B)
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- RX36P 2in. Pan Meter 50V DIS (B)
- RX52G 2in. Pan Meter 'S' DIS (B)
- RX53H 2in. Pan Meter 'VU' £7.95 (B)
- RX54J Large Panel Meter £8.95 (B)

PCB EQUIPMENT

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- FL02C SRBP 0.1in Type 3 £1.29 (D)
- FL06G Vero 14354 32p (F)
- FL07H Vero 10345 £1.32 (D)
- FL08J Vero 10346 £1.05 (E)
- FL09K Vero 10347 £1.62 (D)
- FL10L Vero 10348 £1.32 (D)
- HQ48C Vero V-Q Board £2.45 (C)
- FL25C Tool 2022 £1.95 (D)
- FL26D Tool 2150 £2.72 (C)
- FL27E Tool 2151 £2.72 (C)
- FL20W Pin 2140 72p (E)
- FL21X Pin 2141 72p (E)
- FL23A Pin 2144 68p (E)

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- FL80B Pin 0266 Pk of 100 £2.95 (C)
- FL81C Pin 1657 Pk of 10 39p (F)
- RK94C Verowire Kit £6.95 (B)
- HY16S Verowire Pen £4.68 (B)
- HY17T Verowire Spool £1.05 (E)
- FY33L Verowire Comb 10p (H)
- YL11M Vero Plugblock £5.45 (C)
- HQ84F Verobloc Bracket 79p (E)
- BK62S Engineer Design Sht 75p (E)

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- XB43W Seno Etch System £8.60 (B)

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- XX12N Etch Crystals £1.95 (D)
- HX02C PCB Pen £1.65 (D)
- HX00A PCB SRBP Smll Single 65p (F)
- WF39N PCB SRBP Lrg Single £1.62 (D)
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- WF40T PCB F.Glass Med Sngl £1.95 (D)
- WF41U PCB F.Glass Lrg Sngl £2.95 (C)
- WF42V PCB F.Glass Med Dble £1.95 (D)

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- HX04E Polish Block £1.60 (D)
- XB90X Fixircuit £9.80 (B)
- BW24B Track Tape 62 £1.82 (D)
- BW26D Track Tape 100 £1.82 (D)
- BW30H Pad 075 £1.95 (D)
- BW33L Pad 150 £1.95 (D)
- ★BW40T IC Pads 200 £6.45 (B)

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- BW41U Drafting Template £1.30 (E)

PROJECTS

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- BH64U Minicon Pl 17way 73p (F)
- †BX98G Jumper Cable 17-way £3.65 (C)•
- XY88V Matinee Contact PCB £8.95 (B)•
- XH55K Matinee Book £3.45 NV (C)•

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- BY87U Synth Preset Mtg Bd 79p (E)

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- BB43W Synth Trns Gen 1 PCB £3.46 (C)
- BY81C Synth Trns Rept PCB £1.52 (D)
- BB38R Synth Oscillator PCB £5.20 (C)
- BB48C Synth Ext I/P's PCB £1.64 (D)
- BB65V 3600 VCF PCB £2.95 (C)
- BF95D Joylever PCB £1.10 (E)
- LW53H 5600S Synth Kit £699.95 (A)

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- BY86T 3800 Interface PCB £3.15 (C)•
- BB47B Synth Otpt Stge PCB £6.86 (B)

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- LW66W Sequencer Kit £99.95 (A)

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- GA36P Spectrum VCO PCB £7.32 (C)
- GA57M Spectrum VCF PCB £4.62 (C)

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- BY78K Piano PSU/Voice PCB £4.95 (C)
- BY80B Piano Two-Oct PCB £7.20 (B)
- GA32K Hexadrum PCB £2.72 (C)
- LW85G Hexadrum Kit £19.95 (A)
- LW86T Syntom Kit £12.95 (A)

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- LW87U Synwave Kit £11.95 (A)
- LK15R Synchime Kit £11.95 (A)

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- LW88V Volume Pedal Kit £27.95 (A)
- LW89W Auto Swell Kit £11.95 (A)•
- GA24B Guitar Tuner PCB £1.75 (D)•
- LW90X Guitar Tuner Kit £12.95 (A)

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- LW91Y Harmony Gen Kit £17.95 (A)
- LW92A Combo-Amp Kit £99.95 (A)

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- GA71N Stereo Amp PCB £5.75 (C)•
- GA78K Stereo Amp Sw PCB 48p (F)
- LW71N 25W Stereo Amp Kit £69.95 (A)•

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- RK36P Switch Panel £1.65 (D)
- LW77J Amp Remote Cntrl Kit £29.95 (A)

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- †XH48C MES33 40p NV
- LR13P HQ Mixer PCB No.2 £1.98 (D)

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- LR34M HQ Mixer PCB No.24 £2.45 (C)
- LR16S HQ Mixer PCB No.5 £1.38 (D)
- LR35Q HQ Mixer PCB No.25 £1.98 (D)
- LR21X HQ Mixer PCB No.6 £1.24 (D)
- LR22Y HQ Mixer PCB No.7 £1.98 (D)

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- LR23A HQ Mixer PCB No.8 £1.72 (D)
- LR24B HQ Mixer PCB No.9 £1.98 (D)
- LR42V HQ Mixer PCB No. 29 £3.95 (C)
- LR25C HQ Mixer PCB No.10 £2.26 (C)
- LR26D HQ Mixer PCB No.14 £2.20 (D)

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- YQ19V LM380 Amp PCB £2.49 (C)
- BY73Q 8W Amp PCB 72p (E)

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- YQ43W 15W Amp Kit £5.75 (B)
- YQ20W 20W Amp PCB £2.20 (D)

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- HQ68Y 50W Hi-Fi PCB £3.95 (C)
- LW35Q 50W Amp Kit £15.95 (A)
- GA28F 75W MOSFET Amp PCB £1.99 (D)
- LW51F 75W MOSFET Amp Kit £15.95 (A)•

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- LW32K 150W Power Amp Kit £21.95 (A)

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- †LW41U Tuner PSU Module £24.96 (A)•
- †LW42V Tuner Switching Mod £16.20 (A)•
- †LW40T Tuner Metalwork Kit £43.90 (A)•

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- †LW43W Tuner IF Module £18.98 (A)•

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- XB75S 10-Chl Eqlsr Wwrk £9.98 (B)

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GA30H	Compander PCB	£3.36 (C)
GA43W	Noise Gate PCB	£1.42 (D)
GB13P	Tnbl Scrtch Fltr PCB	£2.32 (C)
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XY26D	Heatsink Mtg Plate	£4.20 (C)
XB77J	Disco Cabinet	£55.45 (A)●
BB81C	Disco Pre-Amp Tn PCB	£5.26 (C)
BB19V	Disco PSU PCB	£2.10 (D)
BB20W	150W Amp Board	£2.42 (C)
BB26D	Motor Switch PCB	£1.26 (D)
BB27E	Light Mod Bd	£5.98 (B)
BB24B	Disco Fader Bd	£2.32 (C)
XB37S	Sound To Light Case	£14.20 (A)
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LW93B	Partylite Kit	£9.95 (B)
LW65V	Stopwatch Kit	£39.95 (A)●
YQ21X	Snd/Light Conv PCB	£2.98 (C)
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GA62S	Timer Switch Board	£3.95 (C)
LW94C	Universal Timer Kit	£47.95 (A)
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GB04E	E.L.C Board	£6.45 (C)
GB07H	T/E PSU PCB	£5.98 (C)●
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LW73Q	RTX3 Doppler Kit	£48.95 (A)●
LW74R	Radar Ch/PSU Module	£15.95 (A)●
LW83E	Usonic Xceiver Kit	£10.95 (A)
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YQ45Y	Magnum 2 PCB	£3.32 (C)
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LW62S	Train Control Kit	£7.50 (B)
LW99H	Modem Kit	£44.95 (A)
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LK12N	Drgn/RS232 Intfc Kit	£18.95 (A)●
LK18U	Dragon I/O Port	£14.95 (A)
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LK00A	VIC 20 Talkback Kit	£22.95 (A)
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LW72P	ZX81 Keyboard Kit	£23.95 (A)
XG22Y	ZX81 Keyboard	£32.50 (A)
GA90X	I/O Port PCB	£2.26 (D)
LW76H	ZX81 I/O Port Kit	£10.49 (B)
GB08J	ZX81 Extendiboard	£2.40 (C)
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LW96E	Sound Generator Kit	£13.49 (A)
GB18U	ZX81 Talkback PCB	£3.20 (C)
LK01B	ZX81 Talkback Kit	£19.95 (A)
Page 305		
LK08J	ZX81 Modem Intfce Kt	£29.95 (A)
LK21X	Spctrm/RS232 Intf kt	£19.95 (A)
†XF03O	MES26	£1.28 NV●
†BB28F	RC Coder PCB	£2.32 (D)●
†BB29G	RC Xmitter PCB	£2.35 (C)●
†BB30H	RC Receiver PCB	£1.96 (D)●
†BB31J	RC Interface PCB	£1.69 (D)●
†BB32K	RC Decoder PCB	£1.95 (D)●
†BB33L	RC Relay Drive PCB	£1.30 (E)●
†BB34M	RC Servo Drive PCB	£1.32 (D)●
†BB35Q	RC Servo Amp PCB	£1.08 (E)●
†BB36P	RC Tone Gen PCB	98p (E)●
†BB37S	RC Tone Decoder PCB	£1.10 (E)●
YQ03D	McM Encoder PCB	£2.95 (D)●
YQ05F	McM Rcvr Dcdr PCB	£2.20 (D)
YQ07H	McM Transmitter PCB	£3.22 (C)
Page 306		
LK05F	D'Xers Processor Kit	£9.85 (A)
LW95D	Inverter Kit	£55.95 (A)●
LK07H	Enlarger Timer Kit	£37.95 (A)●
Page 308		
LW78K	Car Burglr Alarm Kit	£7.49 (B)
LW67X	MPG Meter Kit	£54.95 (A)
Page 309		
GB02C	Freqency Counter PCB	£5.95 (C)●
GB03D	Freq Ctr Display PCB	£2.20 (D)
BB72P	Sine/Square Gen PCB	£3.62 (C)
Page 310		
LK10L	CMOS Xtal Clbrtr Kit	£19.95 (A)
LK06G	Sweep Osc Kit	£21.95 (A)
GB31J	Probe Lower PCB	£2.15 (E)
QY54J	Low Current Disp	£3.45 (C)
LK13P	Logic Probe Kit	£10.95 (B)
Page 311		
LK09K	Minilab Kit	£35.95 (A)
Page 312		
XF56L	E&MM February 1982	DIS●
XF58N	E&MM April 1982	DIS
XF59P	E&MM May 1982	DIS●
†XF60Q	E&MM June '82	£1.10 NV
XF61R	E&MM July 1982	DIS●
XF62S	E&MM August 1982	DIS●
XF63T	E&MM September 1982	DIS●
†XF65V	E&MM November 1982	£1.10 NV
†XF66W	E&MM December 1982	£1.10 NV
XF67X	E&MM January 1983	£1.10 NV

PROTECTION

Page 314		
RX97F	Safuseholder 1.1/4in	£1.98 (D)
RX49D	Chassis F/H 20mm	14p (G)
RX50E	Chassis F/H 1.1/4 in	25p (G)●
RX51F	F/H Car	11p (G)
WR19V	Fuse A/S 1A	13p (G)
WR20W	Fuse A/S 2A	13p (G)
HQ33L	Plug Fuse 5A	13p (G)
Page 315		
BK22Y	Thermal Breaker 3A	£2.25 (D)
BK23A	Thermal Breaker 5A	£2.10 (D)
BK20W	Thermal Breaker 15A	£1.95 (D)
HB51F	Fuse Wire	33p (F)
HW06G	RF Supp Choke 3A	44p (F)
HW07H	Delta Cap	£1.20 (E)
★YW47B	Surface BA Reed	£1.95 (D)
Page 316		
XY33L	Smoke Detectr Type 1	DIS (A)

RECORD & TAPE

1984 Catalogue Page No.		VAT Inclusive Price
Page 317		
XQ00A	Autochanger	DIS (A)●
XB25C	Belt Drive Turntable	£42.95 (A)
LB75S	Drive Wheel BSR	£2.20 (D)
Page 318		
FQ36P	Garrard Drive Belt	£3.48 (C)●
HR09K	Ctrdg BSR SC12M	£4.95 (C)
HR17T	Ctrdg Sono V100	£7.95 (B)
Page 319		
HR16S	Ctrdg Goldring G800	£9.95 (B)
FQ38R	Ctrdg Goldring G800H	£9.95 (B)●
FQ41U	Cdg Tenorel T2001ED	£9.62 (A)
Page 322		
BK07H	Stylus ATN3400	£7.45 (C)
HR66W	Stylus Acos SM6	£5.95 (C)
BK09K	Re-enter As FG88U	£6.30 (C)
HR39N	Stylus BSR TC8 D	DIS (D)
HR74R	Stylus BSR ST21	95p (D)
HR76H	Stylus D110E	£5.95 (B)
YX20W	Styl Phlps GP401Mk2	£5.95 (B)
HR95D	Stylus Sansui SN28	£5.95 (C)
FG98G	Sanyo ST26 Stylus	DIS
FG94C	Sharp ST7123 Stylus	£7.32
YX26D	Stylus Sonotone V101	£5.95 (B)
HR53H	Stylus KS40A DD	£1.45 (D)
FG96E	Sony ND250 Stylus	DIS
†BK18U	Stylus ND200	£7.25 (B)●
YX27E	Stylus Sony XL15	£4.95 (C)
YX28F	Stylus Sony ND126	DIS (C)
YB47B	Hi-Fi Care Kit C72	£7.95 (C)
LX06G	Cleaning Arm C100	£3.45 (C)
FR46A	Stylus Cleaner C50	DIS (E)
Page 323		
FG71N	Rollacleana	£5.42
LX10L	Anti-Stat Mat C119	£2.95 (C)
Page 324		
FG74R	Head + Capstan Kit	£1.64
FR62S	Straight Demagnetizer	DIS (C)●
LX17T	Splicing Tape	78p (E)●
RB01B	Cassette Fast Winder	£3.45 (C)●
YG25C	Cassette Tape C60	65p (E)
Page 325		
FQ83T	GF Cassette Head	£9.62 (A)
FQ66W	Cassette Erase Head	£1.96 (C)
FQ65V	Stereo Cassette Head	£3.95 (C)

RESISTORS

Page 327		
W	W/W Min 0.22R to 1R	37p (F)
W	W/W Min 2R2 to 22K	22p (G)
Page 328		
L	7W W/W	33p (F)
H	10W W/W	42p (F)
V	HV Res 1M-33M	15p (G)
V	HV Res 47M	29p (F)
YY12N	Resnet 100R	89p (E)
YY15R	Resnet 1k	89p (E)
YY20W	Resnet 47k	79p (E)
Page 329		
WR81C	Hor Skeleton 1k	28p (F)
WR82D	Hor Skeleton 2k2	33p (F)
WR83E	Hor Skeleton 4k7	28p (F)
WR84F	Hor Skelton 10k	28p (F)
WR85G	Hor Skeleton 22k	28p (F)
WR86T	Hor Skeleton 47k	28p (F)
WR87U	Hor Skeleton 100k	32p (F)
WR88V	Hor Skeleton 220k	32p (F)●
WR89W	Hor Skeleton 470k	31p (F)
WR90X	Hor Skeleton 1M	31p (F)
WR91Y	Hor Skeleton 2M2	28p (F)
WR92A	Hor Skeleton 4M7	28p (F)
WW00A	Vrt Skeleton 100R	31p (F)
WW01B	Vrt Skeleton 220R	33p (F)
WW02C	Vert Skeleton 470R	33p (F)
WW03D	Vrt Skeleton 1k	31p (F)
WW04E	Vrt Skeleton 2k2	31p (F)
WW05F	Vrt Skeleton 4k7	31p (F)
WW06G	Vrt Skeleton 10k	31p (F)
WW07H	Vrt Skeleton 22k	33p (F)
WW08J	Vrt Skeleton 47k	31p (F)
WW09K	Vrt Skeleton 100k	31p (F)
WW10L	Vrt Skeleton 220k	31p (F)
WW11M	Vrt Skeleton 470k	31p (F)
WW12N	Vrt Skeleton 1M	31p (F)
WW13P	Vrt Skeleton 2M2	31p (F)
WW14Q	Vrt Skeleton 4M7	31p (F)
WR49D	15-Turn Cermet 10k	£1.20 (E)
WR50E	15-Turn Cermet 50k	£1.20 (E)
WR51F	15-Turn Cermet 100k	£1.20 (E)
BW06G	Edge Control Pot	DIS (E)
BW07H	Edge Knob Small Blk	DIS (H)●
BW09K	Edge Knob Large Blk	DIS (H)
BW10L	Edge Knob Large Grey	DIS (H)
Page 330		
FW84F	Dual Pot Lin 4k7	£1.42 (D)
FW85G	Dual Pot Lin 10k	£1.42 (D)
FW86T	Dual Pot Lin 22k	£1.42 (D)
FW87U	Dual Pot Lin 47k	£1.42 (D)
FW88V	Dual Pot Lin 100k	£1.42 (D)
FW89W	Dual Pot Lin 220k	£1.42 (D)
FW90X	Dual Pot Lin 470k	£1.42 (D)
FW91Y	Dual Pot Lin 1M	£1.42 (D)
FW92A	Dual Pot Lin 2M2	£1.42 (D)
FX08J	Dual Pot Log 4k7	£1.42 (D)
FX09K	Dual Pot Log 10k	£1.42 (D)
FX10L	Dual Pot Log 22k	£1.42 (D)
FX11M	Dual Pot Log 47k	£1.42 (D)
FX12N	Dual Pot Log 100k	£1.42 (D)
FX13P	Dual Pot Log 220k	£1.42 (D)
FX14Q	Dual Pot Log 470k	£1.42 (D)
FX15R	Dual Pot Log 1M	£1.42 (D)
FX16S	Dual Pot Log 2M2	£1.42 (D)
Page 331		
FW50E	W/W Pot 10R	DIS (C)
FW51F	W/W Pot 25R	DIS (C)
FW73Q	W/W Pot 500R	£2.49 (C)
FX32K	Slide Pot Lin 5k	82p (E)
FX33L	Slide Pot Lin 10k	82p (E)
FX34M	Slide Pot Lin 25k	82p (E)
FX35Q	Slide Pot Lin 50k	82p (E)
FX36P	Slide Pot Lin 100k	82p (E)
FX37S	Slide Pot Lin 250k	82p (E)
FX38R	Slide Pot Lin 500k	82p (E)
FX53H	Slide Pot Log 5k	82p (E)
FX54J	Slide Pot Log 10k	82p (E)
FX55K	Slide Pot Log 25k	82p (E)
FX56L	Slide Pot Log 50k	82p (E)
FX57M	Slide Pot Log 100k	82p (E)
FX58N	Slide Pot Log 250k	82p (E)
FX59P	Slide Pot Log 500k	82p (E)
FX76H	Dual Slide Lin 5k	£1.48 (D)
FX77J	Dual Slide Lin 10k	£1.48 (D)
FX80B	Dual Slide Lin 100k	£1.48 (D)
HB02C	Dual Slide Log 10k	£1.48 (D)
HB04E	Dual Slide Log 50k	£1.48 (D)
HB05F	Dual Slide Log 100k	£1.48 (D)
HB07H	Dual Slide Log 500k	£1.48 (D)

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Page 332		
FX21X	Thermistor VA1055S	68p (E)
FX42V	Thermistor VA1066S	68p (F)
FX43W	Thermistor VA1067S	78p (F)●
FX62S	Thermistor R53	£6.95 (B)

SEMICONDUCTORS

Page 334		
QB01B	AC126	58p (F)●
QB05F	AC142	45p (F)
QB10L	ACY19	79p (E)
QQ00A	ADC0804LCN	£5.95 (C)
YH93B	AM7910	£49.95 (A)●
HQ52G	AY-1-1320	£6.45 (C)●
HQ51F	AY-1-5050	£3.15 (D)●
YY98G	AY-3-1270	DIS (B)●
WQ19V	AY-5-2376	DIS (A)
QB27E	BA102B	42p (F)●
QB31J	BC107B	18p (G)
QB32K	BC108C	19p (G)●
QB37S	BC140	39p (F)
QB39N	BC142	39p (F)
QB49D	BC161	45p (F)
QB55K	BC182L	12p (G)
QB56L	BC183L	15p (G)
QB57M	BC184L	18p (G)
QB59P	BC209C	32p (G)●
QB60Q	BC212L	15p (G)
QB71N	BC441/461MP	£1.45 (E)●
QQ17T	BC558	15p (G)
QB74R	BC650	35p (F)●
QF00A	BCY70	23p (G)
QF01B	BCY71	22p (G)●
QF75S	BD136	42p (F)
WH16S	BD712	86p (E)
QF10L	BF167	45p (F)
QY53H	BF173	55p (F)●
QF18S	BF244	88p (F)●
QF17T	BF258	38p (F)
QF20W	BFW10	£1.68 (D)●
Page 335		
QF24B	BFX85	38p (F)
QF25C	BFX87	38p (F)
QF28F	BFY51	39p (F)●
QF31J	BRY39	87p (F)●
QF32K	BSX20	29p (F)
YH94C	BT149F	68p (E)●
QF43W	BY164	82p (E)
QF45Y	BZX61C4V7	17p (G)
QF46A	BZX61C5V1	17p (G)
QF47B	BZX61C5V6	17p (G)
QF48C	BZX61C6V2	17p (G)
QF49D	BZX61C6V8	17p (G)
QF50E	BZX61C7V5	17p (G)
QF51F	BZX61C8V2	17p (G)
QF52G	BZX61C9V1	17p (G)
QF53H	BZX61C10	17p (G)
QF54J	BZX61C11	17p (G)
QF55K	BZX61C12	17p (G)
QF56L	BZX61C13	17p (G)
QF57M	BZX61C15	17p (G)
QF58N	BZX61C16	17p (G)
QF59P	BZX61C18	17p (G)
QF60Q	BZX61C20	17p (G)
QF61R	BZX61C22	17p (G)
QF62S	BZX61C24	17p (G)
QF63T	BZX61C27	17p (G)
QF64U	BZX61C30	17p (G)
QF65V	BZX61C33	17p (G)
QF66W	BZX61C36	17p (G)
QF67X	BZX61C39	17p (G)
QF68Y	BZX61C43	17p (G)
QF69A	BZX61C47	17p (G)
QF70M	BZX61C51	17p (G)
QF71N	BZX61C56	17p (G)
QF72P	BZX61C62	17p (G)
QH26D	CA3046	£1.22 (E)
YH58N	CA3080E	£1.48 (E)●
QH28F	CA3130E	£1.38 (D)
WQ21X	CA3240E	£1.55 (D)●
YG37S	CL8960	£39.95 (A)●
QH30H	C106D	66p (F)
WQ23A	C126D	98p (D)
WQ24B	C206D	95p (D)
QQ01B	DAC0801LCN	£4.45 (C)
QQ21X	DV1202W	DIS (B)●
QQ22Y	DV1205W	DIS●
QQ23A	DV1210W	DIS (A)●
QQ24B	DV1220W	DIS (A)●
†QQ25C	DV1230W	£21.30 (A)●
QQ26D	DV1240W	DIS●
YY75S	ICL7660CPA	£6.98 (C)●
YY93B	ICM7045IPI	£17.98 (A)●
YY94C	ICM7216D1PI	£21.95 (A)
YH63T	ICM 7555	£1.95 (D)
BL36P	J02	£2.40 (D)
YY74R	L200	£1.82 (C)
WQ29G	LF347	£1.62 (D)
WQ30H	LF351	85p (E)
QY27E	LF411CN	£1.22 (E)
QY28F	LF412CN	£2.48 (D)●
QY29G	LF441CN	98p (E)
QY30H	LF442CN	£1.88 (D)●
QY31J	LF444CN	£2.98 (D)●
YY89A	LF13741	95p (E)●
QY09K	LM311N	£1.82 (E)
YY73Q	LM335Z	£1.32 (D)
QH40T	LM380	£1.82 (E)
QH41U	LM381	£1.80 (D)
WQ34M	LM384	£1.72 (D)
WQ35Q	LM387	£1.95 (D)
QY19V	LM1035	£3.95 (C)
QY33L	LM1037N	£2.30 (C)
QY34M	LM1038N	£4.65 (C)●
YY85G	LM1818	£1.98 (D)●
YY99H	LM1830	£2.95 (C)
QY36P	LM1851N	£2.20 (D)●
YY71N	LM1871	£2.24 (B)
WQ38R	LM2917	£2.20 (C)●
QH42V	LM3900	£1.36 (E)
WQ39N	LM3909	95p (E)●
WQ41U	LM3914	£3.95 (C)
YY96E	LM3915	£2.98 (C)
YY97F	LM3916	£2.98 (C)
YH64U	LM13700N	£1.95 (D)
Page 336		
HQ71N	M251	£15.95 (A)●
YH89W	MC1488N	£1.38 (E)
YH90X	MC1489N	£1.38 (E)
QH47B	MC1496	£1.95 (E)
QH48C	MC3302P	95p (E)
QH49D	MC3340P	£3.62 (C)
WQ42V	MCM4027 250ns	£2.48 (D)●
WQ44X	MC6802P	£5.95 (C)
WQ45Y	MC6810AP 450ns	£3.36 (D)●
WQ46A	MC6821P	£2.86 (D)
QQ03D	MC6845	£13.95 (B)
WQ48C	MC6850P	£3.45 (C)
WQ49D	MC6852P	DIS (C)
WQ50E	MC6875L	DIS (B)
QY23A	MC10116P	£1.32 (E)
QY35Q	MF10CN	£4.95 (C)
QH54J	MJE340	45p (E)
WQ51F	MJE350	£1.20 (E)
QH59P	MPF102	95p (E)
QH60Q	MPSA14	21p (F)
QH63T	MPS3638A	22p (G)
YH96E	MR751	58p (F)●
YH97F	MR754	95p (E)●

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WQ53H	MVAM115	£3.24 (C)
QH66W	NE 555	39p (G)
QH67X	NE 556	78p (E)
YY68Y	NE5534A	£2.48 (C)
QH70M	OA47	22p (G)
QH72P	OA91	10p (H)
QH73Q	OA95	12p (H)●
QH85G	OC72	DIS (F)
QH92A	OC171	DIS (E)
WQ58N	PW06	£1.20 (D)
QL05F	SC146D	£1.42 (D)
QL07H	SG3402	£4.98 (C)
★YH66W	SL490	£3.35 (C)
QY50E	SP0256	£9.95 (A)
QL10L	S04	68p (E)●
BL35Q	TBA 651	DIS (C)●
YY79L	TCA350Z	£3.85 (C)●
WQ64U	TCA4500A	£3.95 (C)
YY76H	TDA1024	£1.95 (D)
WQ71N	TIP33A	99p (E)●
WQ73Q	TIP122	95p (E)
QH55K	TIP2955	98p (E)
QL19V	TIS43	84p (E)
WQ75S	TL170C	95p (E)
WQ76H	TL172C	£1.24 (E)●
YY77J	TL430C	£1.22 (E)
YY78K	TL497A	£2.20 (D)
YY88V	TMS1121	£11.95 (B)
QY14Q	UAA170L	£3.95 (C)
QL27E	uA78L15AWC	38p (F)
QL29G	uA78M12UC	64p (E)
QL32K	uA7812UC	68p (E)
QL35Q	uA7815KC	£1.55 (D)●
WQ80B	uA78HO5KC	£7.86 (B)
WQ81C	uA78H12KC	£7.45 (B)
WQ83E	uA78HGKC	£9.95 (B)●
WQ84F	uA78PO5SC	£9.36 (B)
WQ86T	uA79L12AWC	62p (E)
Page 337		
QL36P	uA7915UC	78p (E)
WQ95Q	uA79HGKC	DIS (B)
QQ27E	VN10KM	95p (E)
WQ96E	VN46AF	£1.68 (D)●
WQ97F	VN66AF	£1.95 (D)●
WQ98G	VN88AF	£2.45 (D)●
QQ11M	VQ1000CJ	£7.24 (C)●
QL40T	W04	45p (F)
QY43W	XR2211CP	£3.64 (C)
QL43W	ZTX107	24p (G)
QL44X	ZTX108	18p (G)
QL54J	ZTX326	DIS (E)
QL60Q	ZTX500	22p (G)
QW00A	Z80-CPU	£3.98 (B)
QW03D	Z80-PIO	£5.30 (C)●
QL73Q	1N4001	7p (H)
QL74R	1N4002	5p (H)
QL80B	1N4148	5p (H)
QL82D	1N5401	13p (G)
QL84F	1N5404	22p (G)
QR10L	2N1893	72p (F)
QR11M	2N2219	37p (F)
QR12N	2N2369A	29p (G)
QR14Q	2N2646	95p (E)
QR15R	2N2647	95p (E)●
YH98G	2N3055	62p (E)
BL45Y	2N3055H	£1.10 (E)
QR25C	2N3525	£2.46 (D)
QR27E	2N3703	15p (G)
QR28F	2N3704	11p (H)
QR31J	2N3707	19p (G)
QR36P	2N3819	85p (F)
QR40T	2N3904	19p (G)
QR44X	2N4060	DIS (G)
QR45Y	2N4061	DIS (G)
QR47B	2N4871	82p (E)
QR49D	2N5458	62p (F)
QR50E	2N5459	39p (F)
QW08J	2N6609	£4.25 (C)
QY11M	2SC2547E = 2SC1775E	45p (F)
QQ34M	2SJ48	£4.49 (C)●
QW09K	2SJ50	£5.95 (C)●
QQ36P	2SK133	£4.98 (C)●
QQ37S	2SK134	£5.35 (C)●
QW10L	2SK135	£5.95 (C)
QW11M	2102 450ns	£2.85 (C)●
QW12N	2114 450ns	£1.99 (D)
QW13P	2708 450ns	£5.95 (C)●
QQ07H	2716 450ns	£5.75 (C)●
QQ08J	2732 450ns	£7.95 (B)
QQ09K	2764 450ns	£12.86 (B)
QR52G	3N140	£3.95 (D)
QH51F	3403	95p (E)
QX00A	4000BE	32p (F)
QX01B	4001BE	32p (F)
QL03D	4001UBE	32p (G)
QX02C	4002BE	32p (G)
QX03D	4006BE	72p (E)
QX04E	4007UBE	32p (G)
QW14Q	4008BE	99p (F)●
QX05F	4011BE	32p (G)
QL04E	4011UBE	32p (G)
QX06G	4012BE	32p (G)
QX07H	4013BE	41p (F)
QW15R	4014BE	68p (F)
QW16S	4015BE	89p (F)●
QX08J	4016BE	41p (G)
QX09K	4017BE	63p (F)
QX10L	4018BE	65p (F)
QW17T	4019BE	41p (F)
QX11M	4020BE	72p (E)
QW18U	4021BE	68p (E)
QW19V	4022BE	68p (F)
QX12N	4023BE	32p (G)
QX13P	4024BE	51p (F)
QX14Q	4025BE	32p (F)
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QX15R	4026BE	95p (E)
QX16S	4027BE	41p (G)
QX17T	4028BE	61p (F)
QW20W	4029BE	78p (E)
QW21X	4031BE	£1.16 (D)
QW22Y	4032BE	65p (E)●
QW25C	4035BE	65p (F)
QW27E	4040BE	69p (E)
QW28F	4041UBE	69p (F)
QX19V	4042BE	56p (F)
QW29G	4043BE	72p (E)
QW30H	4044BE	63p (F)
QW31J	4045BE	£1.15 (E)
QW32K	4046BE	77p (F)
QX20W	4047BE	98p (E)●
QW33L	4048BE	41p (F)
QX21X	4049UBE	58p (F)●
QX22Y	4050BE	41p (F)
QW34M	4051BE	57p (E)
QW35Q	4052BE	68p (E)●
QW36P	4053BE	72p (E)
QW37S	4054BE	98p (E)●
QW38R	4055BE	DIS (E)
QW39N	4056BE	95p (E)
QW40T	4060BE	80p (E)
QW41U	4063BE	83p (E)
QW42V	4067BE	£2.44 (C)
QX24B	4068BE	32p (G)
★QX25C	4069UBE	32p (F)
QX26D	4070BE	32p (G)
QX27E	4072BE	£1.10 (G)●
QW44X	4073BE	32p (F)
QW45Y	4075BE	32p (F)
QW46A	4076BE	74p (E)
QW47B	4077BE	32p (F)
QX28F	4078BE	32p (G)

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QW48C	4081BE	32p (G)
QW49D	4082BE	32p (F)
QW50E	4085BE	43p (E)
QW53H	4093BE	46p (G)
QW54J	4094BE	£1.22 (D)
QW57M	4099BE	96p (E)
QW61R	40103BE	£1.39 (D)
QW64U	40106BE	44p (E)
QW65V	40107BE	50p (E)
QW66W	40108BE	£3.98 (C)●
QW68Y	40110BE	£1.09 (D)
QW70M	40161BE	68p (E)
QW71N	40162BE	68p (E)
QW73Q	40174BE	63p (E)
QW74R	40181BE	£2.58 (C)●
QW75S	40182BE	79p (E)●
QW77J	40193BE	DIS (E)
QW78K	40194BE	79p (E)●
QW79L	40257BE	99p (D)●
QW93B	4116 250ns	£2.48 (D)
QW80B	4151	£1.15 (E)●
QQ06G	4164 250ns	£8.95 (C)
QY55K	MC14419	£4.48 (C)●
QW81C	4502BE	59p (E)
QW82D	4508BE	£1.52 (C)
QX31J	4511BE	73p (E)
QW84F	4512BE	68p (D)
QW85G	4514BE	£1.31 (D)
QX32K	4518BE	£1.10 (F)●
QX33L	4520BE	72p (E)
QQ42V	4521BE	DIS (C)
QQ43W	4522BE	85p (E)●
QQ44X	4526BE	98p (E)
QW89W	4532BE	78p (E)
QQ47B	4541BE	£1.98 (D)
QW90X	4555BE	47p (E)
QW91Y	4556BE	47p (E)
†YH31J	5101-L1	£3.48 (C)●
QR55K	634SS2	£6.95 (C)
QQ04E	6402	£7.74 (B)●
QQ02C	6502	£8.75 (B)●
QX37S	7400	39p (G)
YF00A	74LS00	39p (G)
QX38R	7401	39p (G)
YF01B	74LS01	39p (G)
QX39N	7402	39p (G)
YF02C	74LS02	39p (G)
QX74R	7403	39p (G)
YF03D	74LS03	39p (G)
QY24B	74S03	78p (F)
QX40T	7404	45p (G)
YF04E	74LS04	43p (G)
QX41U	7405	39p (G)
YF05F	74LS05	42p (G)
QX75S	7406	95p (F)
QX76H	7407	95p (F)
QX42V	7408	45p (G)
YF06G	74LS08	39p (G)
YF07H	74LS09	39p (G)
QX43W	7410	48p (G)●
YF08J	74LS10	39p (F)
QX44X	7411	39p (F)
YF09K	74LS11	39p (G)
YF10L	74LS12	39p (G)
QX45Y	7413	68p (F)
YF11M	74LS13	68p (F)
QX46A	7414	£1.10 (F)
YF12N	74LS14	£1.19 (F)
YF13P	74LS15	39p (G)
QX78K	7416	64p (F)
QX79L	7417	64p (F)
QX47B	7420	39p (G)
YF14Q	74LS20	39p (G)
QX48C	7421	85p (F)●
YF15R	74LS21	39p (G)
YF16S	74LS22	39p (F)
QX80B	7425	56p (F)
QX81C	7426	39p (G)
YF17T	74LS26	45p (F)
QX49D	7427	42p (F)
YF18U	74LS27	39p (F)
YF19V	74LS28	60p (F)●
QX50E	7430	68p (G)●
YF20W	74LS30	39p (G)
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QX51F	7432	68p (F)●
YF21X	74LS32	39p (G)
YF22Y	74LS33	42p (F)
YF23A	74LS37	98p (G)●
QX82D	7438	42p (F)
YF24B	74LS38	42p (G)
QX53H	7440	DIS (F)●
YF25C	74LS40	62p (F)
YF26D	74LS42	£1.24 (F)
QX55K	7447A	£1.95 (E)
QQ52G	74LS47	£1.49 (E)
★QQ53H	74LS48	£1.49 (E)
YF27E	74LS51	39p (G)
YF28F	74LS54	39p (F)
QX56L	7470	34p (F)
QX57M	7472	88p (F)●
QX58N	7473	69p (F)
YF30H	74LS73	54p (F)
QX59P	7474	69p (F)
YY83E	74ALS74	96p (E)
YF31J	74LS74	56p (F)
YF32K	74LS75	78p (F)
QX61R	7476	95p (F)
YF33L	74LS76	54p (F)
QX62S	7481	DIS (D)●
QX85G	7483	£1.95 (E)●
QX63T	7485	£2.42 (E)
YF35Q	74LS85	£1.82 (E)
YF36P	74LS86	65p (F)
QX65V	7489	£3.40 (C)
QX66W	7490	£1.15 (F)
YF38R	74LS90	95p (F)
QX86T	7491	£1.62 (D)
QX67X	7492	£1.15 (F)
YF39N	74LS92	95p (F)
QX68Y	7493	£1.20 (F)
YF40T	74LS93	95p (F)
QX70M	7495	£1.38 (F)
YF41U	74LS95	£1.20 (D)
QX87U	7496	£1.95 (E)
QX71N	74107	72p (F)
YF43W	74LS107	82p (F)
QX88V	74109	£1.18 (E)
YF44X	74LS109	82p (F)
YF45Y	74LS112	82p (F)
YF46A	74LS113	62p (F)
QX72P	74118	£2.15 (C)●
QX73Q	74121	82p (F)
QQ54J	74LS122	£1.20 (E)
WH01B	74123	£1.98 (F)●
YF48C	74LS123	£1.42 (E)
YF49D	74LS125	72p (F)
YF50E	74LS126	72p (F)
WH03D	74132	£1.22 (E)
YF51F	74LS132	£1.10 (F)
YF52G	74LS136	72p (F)
YF53H	74LS138	£1.20 (F)
YF54J	74LS139	£1.15 (F)
WH05E	74141	£1.62 (E)
WH06G	74145	£1.82 (E)
YF55K	74LS145	£1.82 (D)
QX89W	74150	£2.82 (E)
WH07H	74151	£1.42 (E)
YF56L	74LS151	£1.62 (F)
YF57M	74LS153	£1.62 (E)
YF58N	74LS154	£1.95 (E)
YF59P	74LS155	£1.20 (F)
YF60Q	74LS156	DIS (E)

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YF61R	74LS157	95p (F)
YF62S	74LS158	95p (F)
WH09K	74160	£1.95 (E)
YF63T	74LS160	£1.22 (F)
YF64U	74LS161	£1.22 (F)
YF66W	74LS163	£1.22 (F)
WH10L	74164	£2.32 (E)
YF67X	74LS164	£1.59 (E)•
YF68Y	74LS165	£1.95 (D)
YF69A	74LS166	£2.95 (D)
YF71N	74LS169	£1.84 (E)
YF72P	74LS170	£3.40 (D)
YF73Q	74LS173	£1.82 (E)
WH11M	74174	£1.95 (E)
YF74R	74LS174	£1.95 (F)
YF75S	74LS175	£1.42 (F)
YF76H	74LS181	£3.38 (C)
YF78K	74LS190	£1.52 (E)
YF79L	74LS191	£1.48 (E)
YF80B	74LS192	£1.62 (E)
QX90X	74193	£2.22 (D)
YF81C	74LS193	£1.62 (E)
WH13P	74194	£1.68 (E)
YF82D	74LS194	£1.22 (E)
YF83E	74LS195	£1.19 (F)
YF84F	74LS196	£1.62 (E)
YF85G	74LS197	£1.10 (E)•
YF86T	74LS221	£1.62 (E)
YF87U	74LS240	£2.26 (E)
YF88V	74LS241	£2.24 (E)•
YF89W	74LS242	DIS (D)
YF90X	74LS243	£1.95 (E)
QQ56L	74LS244	£2.32 (E)
YF91Y	74LS245	£3.42 (D)
YF92A	74LS251	£1.18 (E)
YF93B	74LS253	£1.64 (E)•
YF95D	74LS257	£1.19 (E)
YF97F	74LS259	£2.62 (E)
YF99H	74LS266	49p (F)•
YH00A	74LS273	£2.22 (D)
YH01B	74LS279	£1.19 (F)
YH02C	74LS283	£1.45 (E)
YH03D	74LS290	DIS (D)
QY39N	74LS292	£12.98 (A)
YH04E	74LS293	DIS (E)
QY40T	74LS297	£14.48 (A)•
YH06G	74LS298	£1.65 (D)•
YH11M	74LS365	79p (F)
YH12N	74LS366	89p (F)•
YH13P	74LS367	78p (E)
YH14Q	74LS368	79p (F)
YH15R	74LS373	£2.38 (E)
YH16S	74LS374	£2.42 (E)
YH18U	74LS377	£2.42 (D)
YH19V	74LS378	79p (D)
YH20W	74LS379	DIS (C)•
YH22Y	74LS393	£1.62 (D)
YH23A	74LS395	£1.15 (D)•
WH02C	74LS629 = 74LS124	£1.98 (D)
YH30H	74C917	£9.60 (B)
QY08J	74C925	£6.95 (B)
YH32K	76477	£5.95 (B)
YH34M	8T28	£2.74 (D)•
†YH35Q	8T95	70p (C)
YH38R	8038 CCPO	£4.98 (C)
YH39N	8069 DCQ	£2.95 (C)
YH40T	8080A	£6.45 (C)•
YH41U	8085A	£8.20 (B)
YH43W	8211 CPA	£2.95 (C)
YH44X	8212	£2.25 (D)
YH46A	8224	£3.98 (C)•
YH47B	8228	£8.25 (C)•
YH48C	8250	£13.25 (B)•
YH49D	8251	£4.95 (C)•
YH51F	8279	£8.95 (B)

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YY68Y	NE5534A	£2.48 (C)
QH51F	3403	95p (E)
QH42V	LM3900	£1.36 (E)

Page 364
QH28F	CA3130E	£1.38 (D)
WQ21X	CA3240E	£1.55 (D)•
YY69A	LF13741	95p (E)•
WQ30H	LF351	85p (E)
WQ29G	LF347	£1.62 (D)
QY27E	LF411CN	£1.22 (E)
QY28F	LF412CN	£2.48 (D)•
QY29G	LF441CN	98p (E)
QY30H	LF442CN	£1.88 (D)•
QY31J	LF444CN	£2.98 (D)•

Page 365
YH58N	CA3080E	£1.48 (E)•
YH64U	LM13700N	£1.95 (D)
QY09K	LM311N	£1.62 (E)
QH48C	MC3302P	95p (E)

Page 367
QH40T	LM380	£1.82 (E)
WQ34M	LM384	£1.72 (D)

Page 370
QH41U	LM381	£1.80 (C)
WQ35Q	LM387	£1.95 (D)

Page 371
QY19V	LM1035	£3.95 (C)

Page 372
QY33L	LM1037N	£2.30 (C)
QY34M	LM1038N	£4.65 (C)•
YY85G	LM1818	£1.98 (D)•

Page 373
QH49D	MC3340P	£3.62 (C)

Page 374
QY35Q	MF10CN	£4.95 (C)
HQ52G	AY-1-1320	£6.45 (C)•
HQ51F	AY-1-5050	£3.15 (D)•
HQ71N	M251	£15.95 (A)•

Page 377
YY79L	TCA350Z	£3.85 (C)•

Page 378
YH32K	76477	£5.95 (B)

Page 380
QY50E	SP0256	£9.95 (A)

Page 381
BL35Q	TBA651	DIS (C)•
WQ64U	TCA4500A	£3.95 (C)

Page 383
QY23A	MC10116P	£1.32 (E)
QH47B	MC1496	£1.95 (E)

Page 384
QL07H	SG3402	£4.98 (C)
QH26D	CA3046	£1.22 (E)
QQ11M	VQ1000CJ	£7.24 (C)•
★YH66W	SL490	£3.35 (C)

Page 386
BK66W	UM1286 Modulator	£11.90 (A)
YY71N	LM1871	£2.24 (B)
YQ69A	LM1871 Xmitter PCB	£1.25 (D)

Page 388
WQ76H	TL172C	£1.24 (E)•
WQ75S	TL170C	95p (E)
QR55K	634SS2	£6.95 (C)

Page 389
YY99H	LM1830	£2.95 (C)
YY73Q	LM335Z	£1.32 (D)
YG37S	CL8960	£39.95 (A)•
YY98G	AY-3-1270	DIS (B)•

Page 390
WQ41U	LM3914	£3.95 (C)
YY96E	LM3915	£2.98 (C)
YY97F	LM3916	£2.98 (C)

Page 391
QY14Q	UAA170L	£3.95 (C)
YH30H	74C917	£9.60 (B)
YY93B	ICM7045IPI	£17.98 (A)•

Page 393
YY88V	TMS1121	£11.95 (B)
QY08J	74C925	£6.95 (B)

Page 394
YY94C	ICM7216DIPI	£21.95 (A)

Page 395
QH66W	NE 555	39p (G)
QH67X	NE 556	78p (E)

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YH63T	ICM 7555	£1.95 (D)

Page 397
WQ39N	LM3909	95p (E)•
YY76H	TDA1024	£1.95 (D)

Page 398
QY36P	LM1851N	£2.70 (D)•
YH43W	8211 CPA	£2.95 (C)
YH39N	8069 DCQ	£2.95 (C)
YY78K	TL497A	£2.20 (D)
YY77J	TL430C	£1.22 (E)

Page 399
YY75S	ICL7660CPA	£6.98 (C)•
YY74R	L200	£1.82 (C)

Page 401
YQ39N	0.1A Reg PSU PCB	£1.45 (D)
YQ40T	0.5/1A Reg +V PS PCB	95p (E)
YQ41U	0.5/1A Reg -V PS PCB	95p (E)

Page 403
QQ02C	6502	£6.75 (B)•
WQ44X	MC6802P	£5.95 (C)
WQ46A	MC6821P	£2.86 (D)
WQ48C	MC6850P	£3.45 (C)
WQ49D	MC6852P	DIS (C)
WQ50E	MC6875L	DIS (B)

Page 404
QW00A	Z80-CPU	£3.98 (B)
QW03D	Z80-PIO	£5.30 (C)•
YH40T	8080A	£6.45 (C)•

Page 405
YH41U	8085A	£8.20 (B)
YH46A	8224	£3.98 (C)•
YH47B	8228	£8.25 (C)•
YH49D	8251	£4.95 (C)•
YH48C	8250	£13.25 (B)•
YH51F	8279	£6.95 (B)

Page 406
YH44X	8212	£2.25 (D)
YH34M	8T28	£2.74 (D)•
†YH35Q	8T95	70p (C)
YH89W	MC1488N	£1.38 (E)
YH90X	MC1489N	£1.38 (E)

Page 407
WQ19V	AY-5-2376	DIS (A)
QQ04E	6402	£7.74 (B)•
QQ03D	MC6845	£13.95 (B)
†YH31J	5101-L1	£3.48 (C)•

Page 408
QW11M	2102 450ns	£2.85 (C)•
WQ45Y	MC6810AP 450ns	£3.36 (D)•
QW12N	2114 450ns	£1.99 (D)
WQ42V	MCM4027 250ns	£2.48 (D)•
QW93B	4116 250ns	£2.48 (D)
QQ06G	4164 250ns	£8.95 (C)
QW13P	2708 450ns	£5.95 (C)•

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QQ07H	2716 450ns	£5.75 (C)•
QQ08J	2732 450ns	£7.95 (B)
QQ09K	2764 450ns	£12.86 (B)

Page 410
XY84F	Softy 2 System	£184.95 (A)•
XY83E	EPROM Eraser	£47.95 (A)•
YH38R	8038 CCPO	£4.98 (C)

Page 411
QW80B	4151	£1.15 (E)•
YH93B	AM7910	£49.95 (A)•

Page 412
QY43W	XR2211CP	£3.64 (C)
QQ01B	DAC0801LCN	£4.45 (C)

Page 413
QQ00A	ADC0804LCN	£5.95 (C)
WQ38R	LM2917	£2.20 (C)•

Page 415
WR29G	Transkt 3-Lead TO18	22p (G)
WR30H	Transkt 4-Lead TO18	42p (F)•

Page 416
HQ77J	DIL Socket 20-pin	18p (G)
BL20W	DIL Socket 24-pin	20p (G)
HQ38R	DIL Socket 40-pin	30p (F)
YG29G	Header 24-pin	£1.45 (D)
YX50E	ZIF Socket 24-Way	£4.95 (C)

Page 417
FG52G	Clip on TO220	31p (F)
FG55K	Powerfin plastic	59p (F)

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FG60Q	Heatsink TO220HP	88p (E)
FG63T	Dip Sink 40 pin	82p (E)
FL41U	Heatsink 4Y	£2.30 (C)
★FG64U	Coverslide 4Y	38p (B)

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FL42V	Flat Heatsink	£4.36 (C)
FL54J	Heatsink 10DN	£2.48 (C)
FL77J	Heatsink 6W-1	£7.38 (B)
★FG65V	Coverslide 6W	38p (D)

SPEAKERS

Page 420
WY08J	Standard Fan	£22.45 (A)•

Page 421
HY12N	Ultrasonic Transducr	£3.96 (B)

Page 422
YK58N	Large Dome Bell	£17.95 (A)
YB25C	Baby Siren	DIS (B)
LH98G	Hawaii Five-O Siren	DIS (A)
YK61R	Staccato Elctrnc Sdr	£9.95 (B)
†XQ71N	Re-entrant Horn Sndr	£26.50 (A)

Page 423
YW52G	2in Piezo Tweeter	£3.15 (C)•
WF09K	Piezo Horn Flush	£7.74 (B)•
WF55K	Piezo Horn Recessed	£7.74 (B)•
WF56L	Wide Angle Piezo	£10.45 (B)•
LB23A	Mag Earpiece 2.5mm	19p (F)
LB25C	Crystal Earpiece	62p (E)
YW57M	Stethoscope	95p (E)

Page 424
LH82D	Boom Mic Headphone	£15.45 (A)
LH83E	Stereophone OH150P	£5.25 (C)
WF13P	Stereophone HP110C	£6.45 (B)
WF14Q	Stereophone DH207	£8.95 (B)
LH84F	Stereophone M110B	DIS (B)

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LB13P	Headphone Adaptor	£3.45 (C)
YW54J	15W Cone Tweeter	£3.20 (C)
WF43W	Dome Tweeter	£5.95 (B)
WF44X	Rectangular Tweeter	£4.95 (B)

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XG34M	Bullet Tweeter	£22.60 (A)
YK71N	10in Speaker Grille	£2.98 (C)
YK72P	12in Speaker Grille	£3.95 (C)
WF48C	Hvy Duty Car Spkr	£6.98 (B)

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WF50E	Elliptcal Spkr CM641	£3.62 (C)
WF23A	Elliptcal Spkr CM852	£5.95 (B)
WF00A	Rd Speaker LT530	£8.95 (B)
†WF52G	Rd Speaker LT610	£5.95 (B)•
WF11M	Rd Speaker LT830	£8.45 (B)
XG02C	Loudspeaker 12in 35W	DIS (A)•
XQ77J	Fane 50 4R	DIS (A)

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XQ79L	Forte 1250TC 8R	£23.95 (A)
XQ80B	Forte 1250TC 16R	£23.95 (A)
XQ81C	Forte C1285TC 8R	£29.95 (A)
XQ82D	Forte C1285TC 16R	£29.95 (A)
XQ83E	C15 Bass 8R	£82.95 (A)•
AF35Q	15W Spkr Pair	DIS (A)•
AF32K	PA Spkr in Cab	DIS (A)•

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★XY79L	Ceiling Speaker	£12.45 (A)
YL15R	Bracket Minor 5	£9.95 (B)
YK54J	Wallclamps Duo 220	£16.20 (A)

SWITCHES & RELAYS

Page 430
FH99H	DPDT Ultra Min Tggle	78p (E)
FH00A	Sub-Min Toggle A	73p (E)
FF72P	Sub-Min Toggle L	£2.24 (C)
FH10L	Std Toggle SPST	52p (E)
FH11M	Std Toggle SPDT	59p (E)

Page 431
FH17T	H/D Toggle Type 4	£3.42 (C)
XX26D	DIL Switch SPST Dual	95p (E)
XX28F	DIL Switch SPDT Sgl	98p (E)
XX29G	DIL Switch SPDT Quad	£3.25 (C)

Page 432
FF73Q	Rotary SW12B	82p (E)
FH43W	Rotary SW6	72p (E)
FH45Y	Rotary SW3	92p (E)
FF83E	Thumbwheel Decimal	£4.55 (C)•
FF84F	Thumbwheel BCD	£4.55 (C)•

Page 433
FH35Q	Sub-Min Slide	18p (G)•
FF79L	Long Chrome Slide	19p (G)
FH36P	Std Slide Switch	19p (G)
FH59P	Push Switch	18p (G)
FH91Y	Motor-Start Press	45p (F)

Page 434
YW43W	Square Psh Lck Red	95p (E)
YW44X	Square Psh Lck Yllow	95p (E)
FH92A	Press Toe Sw Type 1	£2.42 (D)
BK31J	Press Toe SPST 2	£1.82 (D)
FH93B	Press Toe Sw Type 2	£2.24 (D)

Page 435
FF90X	Click Cap Green	DIS (G)
HY34M	Click Key Black	26p (F)
FF64U	Keytop 3 Position	75p (F)
BK72P	Membrane Switch	£9.95 (B)
BK73Q	Flat Flex Connector	75p (E)

Page 436
FL33L	Rd Latchbutton Grey	DIS (G)

Page 437
FH89W	Magiclight Bttn Drng	89p (F)•
BW15R	Latchbush Blue	89p (F)•
BW16S	Latchbush Green	DIS (F)
BW17T	Latchbush Orange	98p (F)•
BW18U	Latchbush Yellow	89p (F)•
LB91Y	Flasher Unit 2-Way	£8.72 (B)

Page 438
LQ01B	Professl Morse Key	£6.26 (B)
YR88V	Solenoid 12V	£6.82 (B)
BK48C	Ult-Mn Rlay 6V DPDT	£1.20 (D)

Page 439
YX98G	5A Mains Relay	£1.65 (C)•
★YX99H	12V 30A Relay	£3.24 (C)
FX23A	Open Relay 6V	£3.82 (C)
FX24B	Open Relay 12V	£3.96 (C)

Page 440
FX49D	Power Relay 230V AC	£4.45 (C)

Page 441
FX89W	Dil Reed Relay 1p12V	£1.98 (D)
FX90X	Dil Reed Relay 2p 5V	£2.95 (C)
FX91Y	Dil Reed Relay 2p12V	£3.45 (C)
FX71N	Magnet Small	48p (F)
FX72P	Magnet Large	£1.24 (E)

TEST GEAR

Page 442
HF22Y	Lo-Cost Test Probe	85p (E)
YR93B	Test Lead Kit	DIS (C)
FY73Q	Logic Probe	£12.45 (B)

Page 443
YB21X	Safebloc	£7.95 (B)
BW05F	Scope Probe BNC	£14.56 (A)
YR95D	Lo-Cost Scope Probe	AUG84 (C)

Page 444
XB82D	Crotech 3030	£195.95 (A)

Page 445
XB83E	Crotech 3132	£324.95 (A)
YK38R	Low-Cost Counter	£55.95 (A)
YB82D	LCR Bridge	£27.50 (A)
LH05F	Transistor Testr HFE	£16.95 (A)

Page 446
YW93B	Low Cost Multimeter	£5.95 (B)
FL60Q	Pocket Multimeter	£9.42 (B)

Page 447
YW68Y	Multimeter Type 320	£17.98 (A)
YB87U	100K Multitester	DIS (A)

Page 448
YB85G	Supertester 680G	£36.20
LH80B	Clamp Meter	£34.20 (A)

Page 449
YK32K	Multimeter DD601	£45.95 (A)
YK34M	Auto Range Meter	£69.95 (A)

Page 451
†WY21X	SWR Meter 178	£27.95 (A)•
YK01B	RF Frequency Meter	£55.95 (A)

Page 452
YB04E	Grid Dip Meter	£49.95 (A)

TOOLS

Page 453
BR50E	Trim TT5	68p (E)

Page 454
BR79L	Intrchgbl Scdrvr Set	DIS (D)
FY08J	Utility Set	£5.62 (C)
YX74R	Min Screwdriver	11p (G)
BR52G	Small Screwdriver	39p (F)
BR53H	Large Screwdriver	42p (F)
FY15R	Pozidriver P1	£1.98 (D)
FY17T	Pozidriver P2	£2.45 (D)

Page 455
FY19V	Low Cost Min Cutters	£5.45 (C)
FY22Y	Box JT Side Cutters	£8.98 (B)

Page 456
BR72P	Side Cutters S55	£4.95 (B)
BK41U	Hooked Pliers	£8.45 (B)
BR91Y	Electricians Pliers	£5.20 (C)

Page 457
BR76H	End Action Strippers	£6.95 (B)
BR93B	Wire Strippers 3A	£2.56 (C)
BR96E	Stripmaster	£17.50 (A)
FY32K	Hand Wrap Tool	£7.62 (B)

Page 458
FY40T	Box Spanner 2BA	£3.36 (D)
FY41U	Box Spanner 4BA	£2.99 (D)•
FY42V	Box Spanner 6BA	£2.95 (D)
FY43W	Box Spanner 8BA	£2.95 (D)
FY49D	Needle File Flat Wrd	£1.86 (D)
FG07H	8 Section Tool Roll	£4.65•
FY02C	Utility Knife	£1.69 (D)
★FY04E	Knife Blades	76p (E)

Page 459
YW64U	Snap-Off Blade Knife	£1.12 (E)
FY05F	Scalpel Handle	£2.86 (D)
FY06G	Scalpel Bld Type II	48p (E)
BR61R	Punch 1/2in	£5.24 (C)
BR62S	Punch 9/16in	£5.30 (C)
BR80B	Punch 5/8in	£5.36 (C)
BW00A	Punch 1 1/2in	£9.65 (B)
LH79L	Reliant Kit	£24.60 (A)
BW03D	Reliant Drill	£7.94 (B)

Page 460
BW02C	Titan Drill	£12.95 (A)
XB12N	Drill Stand	£17.95 (A)
BR84F	Reliant Collet	78p (E)
BW04E	Drill Power Supply	£15.95 (A)
BR65V	Twist Burr 0.8mm	45p (F)
BR66W	Twist Burr 1.4mm	44p (F)
BR85G	HS Twist Drill 0.8mm	82p (E)
BR86T	HS Twist Drill 1mm	82p (E)
BR87U	HS Twist Drill 1.4mm	78p (E)
YY28F	Long-Life Drill 1mm	£1.22 (D)
LH77J	20-Piece Tool Kit	£8.98 (B)
LH78K	40-Piece Tool Kit	£17.95 (A)
LH76H	Wishbone Sharpener	£7.42 (B)
HQ04E	HS Drill 3/32in	32p (F)

Page 461
HQ20W	HS Drill 11/32in	DIS (D)•
FY62S	Iron CS	£6.95 (B)
FY63T	Element CX	£3.95 (C)
FR30H	Bit 1106	£1.30 (E)
FY64U	Bit 1100	£1.30 (E)
FY65V	Bit 1101	£1.30 (E)
FR31J	Bit 7/1101	DIS (D)•
FY66W	Bit 1102	£1.30 (E)
FY67X	Bit 1103	£1.30 (E)
FR01B	Element Type CN	£3.25 (C)
FR02C	Handle Type CN	£1.65 (E)
FR03D	Bit 102	£1.30 (E)
FR04E	Bit 104	£1.30 (E)
FR05F	Bit 106	£1.30 (E)
FR06G	Bit 820	£1.30 (E)
FR07H	Bit 821	£1.30 (E)
FR08J	Bit 822	£1.30 (E)
FR12N	Iron XS	£7.25 (B)
FR13P	12V Iron MLXS	£9.49 (B)

Page 462
FR14Q	Element X25	£2.95 (C)
FR15R	Element MLX12	£3.45 (C)
FR16S	Bit No. 50	£1.30 (E)
FR17T	Bit No. 51	£1.30 (E)
FR18U	Bit No. 52	£1.30 (E)
FR20W	Stand ST4	£2.75 (C)•
RK33L	Sponge ST4	35p (F)
FR11M	Sponge ST3	24p (G)
FY68Y	CS Kit SK5	£9.95 (B)
FY69A	XS Kit SK6	£10.15 (B)•
WY05F	Rechargeable Iron	£33.95 (A)
YX68Y	B50 Bit Angled	£3.98 (C)
YX72P	B50 Sponge	35p (F)
FR10L	Heat Sink Tweezers	45p (F)
FR23A	Solder Sucker	£4.72 (C)

Page 463
FR26D	Desolder Tool	£6.45 (B)
BK40T	Replacement O rings	74p (E)
FR63T	Desldr Washer Type 2	52p (F)
FY71N	Aluminium Solder	85p (E)•
FY72P	Conductive Paint	£4.95 (B)
LH03D	Switch Cleaner	£1.95 (D)
LH02C	Aero-Klene	£1.95 (D)
YB73Q	Aero-Duster	£1.95 (D)

Page 464
YB75S	Plastic Seal	£1.95 (D)
YB76H	Foam Cleanser	£2.42 (C)
YB79L	Anti-Static Spray	£1.95 (D)
FL43W	Evostik Impact	£1.40 (D)
FL44X	Araldite Rapid	£2.82 (C)

Page 465
FL47B	PVC Tape Black	52p (F)
FL48C	PVC Tape Blue	52p (F)
FL50E	PVC Tape Green	52p (F)
FL51F	PVC Tape Red	52p (F)
FL52G	PVC Tape White	52p (F)
YR99H	PVC Tape Yellow	49p (F)•

WOUND COMPONENTS

Page 466
LB40T	9.5 Coil Former	DIS (E)
LB18U	Former 450	32p (G)
LB19V	Former 722/1	20p (G)•
LB41U	Dust Core Type 4	14p (G)
LB42V	Dust Core Type 6	14p (G)
LB43W	Dust Core Type 8	28p (G)
LB44X	Former-Base	18p (G)•
LB36P	Screening Can 10	15p (G)
LB39N	Screening Can 15	18p (G)
HX05F	Small Pot Core	£1.76 (D)

Page 467
HX14Q	Mtg System Type 4	£1.28 (D)
HX57M	GE Coil L8	DIS (C)
HW24B	GE Coil L14	£3.95 (C)
HX56L	GE Coil L7	DIS (C)
HW25C	GE Coil L12	£3.30 (C)•
HW26D	GE Coil L11	£3.30 (C)•
HX24B	Choke 0.5H	£1.40 (D)•
HX25C	Choke 1H	£1.40 (D)•
LR07H	Filter Pot Core	£2.40 (C)•

Page 468
HW27E	Choke 10H	£2.10 (D)
HW28F	Choke 5uH HC	DIS (E)•
HX15R	Choke 1.5mH	75p (E)
HX17T	Choke 5mH	68p (E)
WH25C	Choke 0.22uH	59p (E)
WH37S	Choke 22.0uH	55p (F)
HX42V	Toko YRCS 11098	69p (E)
YG30H	Toko YRCS12374	74p (E)•
HX43W	Toko YHCS 11100	68p (E)
YG31J	Toko CSK3464	75p (E)
YG32K	Toko YMCS17104	75p (E)
HX97F	Toko ACS 34342	£1.24 (E)
HX98G	Toko ACS 34343	88p (E)•
YG36P	Toko KAC8449	DIS (F)

Page 469
LB00A	IFT 13	£1.88 (D)•
LB01B	IFT 14	£1.86 (D)
LB05F	IFT 18	£2.36 (C)
HX82D	Min Tr LT44	58p (E)
LB14Q	Min Tr LT700	58p (E)
YR91Y	Mini Tr LT800	DIS (F)
LR06G	Mc Xfm Typ2 200-600R	£21.95 (A)
★YX84F	Z Changer	£6.40 (B)

Page 470
WB00A	Sub-Min Tr 6V	£1.65 (D)
WB01B	Sub-Min Tr 9V	£1.65 (D)
WB02C	Sub-Min Tr 12V	£1.65 (D)
WB11M	Min Tr 9V	£4.45 (C)
LY03D	Tr 10VA 15V	£5.45 (C)
WB15R	Min Tr 15V	£3.46 (C)
WB07H	Tr 34V 1A	£8.95 (B)
WB25C	Tr 12V 1A	£6.36 (B)
YK02C	Tr 32-0-32 2A	£13.62 (A)

Page 471
YK08J	Toroidal 30VA 6V	£9.24•
YK09K	Toroidal 30VA 9V	£9.74•
YK10L	Toroidal 30VA 12V	£9.55•
YK11M	Toroidal 30VA 15V	£9.55•
YK12N	Toroidal 30VA 18V	£9.95•
YK13P	Toroidal 50VA 6V	£11.55•
YK14Q	Toroidal 50VA 9V	£12.25•
YK15R	Toroidal 50VA 12V	£12.25•
YK16S	Toroidal 50VA 15V	£11.55•
YK17T	Toroidal 80VA 18V	£12.45•
YK18U	Toroidal 80VA 22V	£12.95•
YK19V	Toroidal 80VA 30V	£9.64
YK20W	Toroidal 120VA 30V	£13.48•
YK21X	Toroidal 160VA 35V	£15.55•
YK22Y	Toroidal 300VA 35V	£21.95•
YK23A	Toroidal 500VA 35V	£28.95•
WB12N	Tr 20V 1A	£9.95 (B)
WB17T	Tr 28V 1.1/2A	£10.98 (A)

Page 472
YG12N	Min Motor	£3.95 (C)•
YG13P	Small Motor	£1.68 (D)

TOP TWENTY KITS

THIS MONTH	LAST MONTH		DESCRIPTION OF KIT	ORDER CODE	KIT PRICE	DETAILS IN PROJECT BOOK
1.	(1)	♦♦	75W Mosfet Amp Module	LW51F	£15.95	Best of E&MM
2.	(2)	♦♦	Modem	LW99H	£44.95	5 XA05F
			Case also available: YK62S Price £9.95.			
3.	(3)	♦♦	Car Burglar Alarm	LW78K	£7.49	4 XA04E
4.	(5)	♦	Partylite	LW93B	£9.95	Best of E&MM
5.	(4)	♦	Spectrum Easyload	LK39N	£9.95	10 XA10L
6.	(8)	♦	8W Amp Module	LW36P	£4.45	Catalogue
7.	(10)	♦	VIC20/64 RS232 Interface	LK11M	£9.45	7 XA07H
8.	(–)	♦	Cautious Ni-Cad Charger	LK50E	£19.95	11 XA11M
9.	(6)	♦	Syntom Drum Synthesiser	LW86T	£12.95	Best of E&MM
10.	(12)	♦	Spectrum RS232 Interface	LK21X	£19.95	8 XA08J
11.	(7)	♦	Ultrasonic Intruder Detctor	LW83E	£10.95	4 XA04E
12.	(9)	♦	Logic Probe	LK13P	£10.95	8 XA08J
13.	(13)	♦♦	ZX81 I/O Port	LW76H	£10.49	4 XA04E
14.	(16)	♦	Harmony Generator	LW91Y	£17.95	Best of E&MM
15.	(17)	♦	Guitar Tuner	LW90X	£12.95	Best of E&MM
16.	(20)	♦	Burglar Alarm	LW57M	£49.95	2 XA02C
17.	(–)	♦	Keyboard for ZX81	LW72P	£23.95	3 XA03D
			Case also available: XG17T £4.95. Complete ready-built: XG22Y £32.50			
18.	(19)	♦	80m Amateur Receiver	LK41U	£15.95	10 XA10L
19.	(–)	♦	ZX81 Sounds Generator	LW96E	£13.49	5 XA05F
20.	(–)	♦	ZX81 Talkback	LK01B	£19.95	6 XA06G E&MM

Over 80 other kits also available. All kits supplied with instructions.
The descriptions above are necessarily short. Please ensure you know exactly what the kit is and what it comprises before ordering, by checking the appropriate Project Book mentioned in the list above.

CORRIGENDA

Vol. 1 No. 3

The specification of the 25W MOSFET Amplifier should read:- Magnetic pick-up input 2mV at 68k; Tape input 50mV at 1k2; Tuner input 50mV at 1k2; and Auxiliary input 50mV at 1k2. Also note that if you check the +15V rails on D5 and D6 you should obtain a reading below 30mV DC between the cases of the four MOSFET's and the chassis.

Vol. 2 No. 6

ZX81 Talkback: If you have a talkback module that suffers from 'slurred speech' when POKEing data from a string or REM line, then two simple component value changes can be made. Change R8 to 47Ω from 1k and C7 to 10μF 16V tantalum from a 0.1μF Disc ceramic. The +V lead of C7 must connect to pins 2 and 25 of IC5.

Vol. 2 No. 7

ZX81 Modem Interface: Some kits are being supplied with IC3 as an NEC D8255AC-5 type, in which case a small modification is required to improve access timing. Remove the track pin adjacent to IC1 pin 9 (which connects to MREQ). Re-connect IC1 pin 9 to IC1 pin 7 (0V). The MREQ line is left disconnected.

Digital Enlarger Timer/Controller: In the circuit diagram pin 10 of IC2b should go to +12V and not 0V.

Vol. 3 No. 9

TDA 7000 Radio: Improved reception can sometimes be obtained by decreasing the number of turns in L1 to 5.

Vol. 3 No. 10

Spectrum Easyload: In the circuit diagram, note that R5 and R15 are reversed. R5 is the resistor from the base of TR1 to −V, and R15 is the resistor from the base of TR1 to D1/IC3. Note the PCB layout is correct.

TOP TWENTY BOOKS

1. (3) How to Design & Make Your Own PCB'S, by R.A. Penfold (WK63T) cat. P40.
2. (2) Power Supply Projects, by R.A. Penfold (XW52G) cat. P41.
3. (10) IC555 Projects, by E.A.Parr (LY04E) cat. P42.
4. (11) International Transistor Equivalents Guide, by Adrian Michaels (WG30H) cat. P36.
5. (7) Understanding Telephone Electronics, by J. Fike and G. Friend (WK45Y) cat. P42.
6. (–) Audio Projects, by F.G. Rayer (WG46A) cat. P44.
7. (9) How to Build Your Own Solid State Oscilloscope, by F.G. Rayer (XW07H) cat. P45.
8. (20) Electronic Synthesiser Projects, by M.K. Berry (XW68Y) cat. P51.
9. (–) Atari Op-sys Users Manual (Technical Notes), (WA46A) cat. P62.
10. (8) Electronic Security Devices, by R.A. Penfold (RL43W) cat. P43.
11. (1) Remote Control Projects, by Owen Bishop (XW39N) cat. P45.
12. (14) How to Use Op-amps, by E.A. Parr (WA29G) cat. P38.
13. (–) Z80 IC's Data Sheets (4th Edition) (RQ54J) cat. P38.

14. (6) A Z80 Workshop Manual, by E.A. Parr (WA54J) cat. P57.
15. (16) Radio & Electronics Colour Codes & Data Chart (RH05F) cat. P34.
16. (–) How to Make Walkie-Talkies, by F.G. Rayer (RF18U) cat. P47.
17. (–) 68000 Assembly Language Programming, by Kane, Hawkins and Leventhal (WA04E) cat. P56.
18. (–) 30 Solderless Breadboard Projects Book 1, by R.A. Penfold (WA51F) cat. P35.
19. (–) Towers' International Transistor Selector Update 2, by T.D. Towers (RR39N) cat. P36.
20. (19) How to Build Advanced Shortwave Receivers, by R.A. Penfold (RB26D) cat. P47.

These are our top twenty best selling books based on mail order and shop sales during March, April and May 1984. Our own publications and magazines are not included. We stock nearly 700 different books, covering a wide range of electronics and computing topics. The full selection is shown on pages 33 to 70 of the 1984 catalogue, plus the new books sections in 'Electronics' Volume 3 issues 9, 10 and 11, and the new books in this issue.

Continued from page 28.

NEW BOOKS

ZX Spectrum Astronomy
by Maurice Gavin
A book aimed at Spectrum owners who wish to expand their computing knowledge to include astronomy. All aspects of the subject are introduced, including starcharts, star systems, tracking the orbit of a planet, satellites etc, plus much more. Great emphasis is placed on the high quality graphics that can be achieved, to display such things as the simulated movement of stars.
234x153mm, 229 pages, illustrated.
Order As WM84F (Spectrum Astronomy) Price £7.95*NV*

Artificial Intelligence on the Commodore 64
by Keith and Steven Brain
An interesting new book which explains Artificial Intelligence from first principles; all the important aspects of the subject are covered and fully illustrated with programs. The book will show you how to implement A.I. routines on the Commodore 64 and turn it into an 'intelligent' machine which can converse rationally.
233x155mm, 144 pages, illustrated.
Order As WM85G (A.I. Commodore 64) Price £7.65*NV*

The Commodore 64 Puzzle Book
by Brian Boyde-Shaw
The book is not about how to make up crossword puzzles or play games of snakes and ladders on the 64, rather it is a teaching system to help the reader learn how to write and enter programs and eventually be able to use the machine with confidence. Ideal for beginners, the 'puzzles' take the form of writing programs to solve problems for which solutions are also provided in case of difficulty or to double-check your progress. By the time you have solved the first few problems you will be confident that you can write programs that will for example, display text on the screen, just as YOU want it to look, carry out calculations, or play simple games. You will solve these problems and learn BASIC at the same time, and also learn to approach each problem in a logical fashion. Your success in solving a problem is used to reinforce what you already know, so that the next problem is solved more easily.
214x135mm, 130 pages, illustrated.
Order As WM91Y (64 Puzzle Book) Price £8.20*NV*

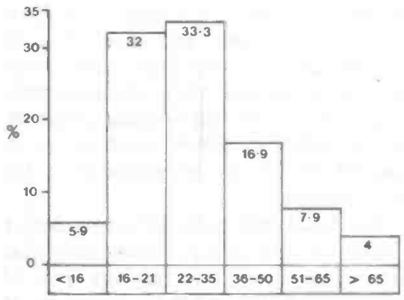
READERSHIP SURVEY

RESULTS RESULTS RESULTS RESULTS RESULTS

Most opinion polls rely on interviews with a minute cross-section of the population and assume that their responses can be extrapolated to the population as a whole. Usually about one to two thousand people are questioned and the response of twenty to thirty million people predicted from the result. Even with such a small percentage poll, the results can be extraordinarily accurate.

The results of our survey should be even more accurate, since we received 1657 replies, yet wish to use this as a guide to what only a little over 200,000 people (our customers) think about us. Before we begin though, let me tell you the winners of our Prize Draw. First out of the hat was Mr. R. Murphy, a student from Bourne in Lincolnshire who wins £50. The second and third prizes of £10 each went to Mr. A. Raja, a printer from London, and Mr. B. Harrington, an electronics engineer from South Ascot in Berkshire. Now to the actual results.

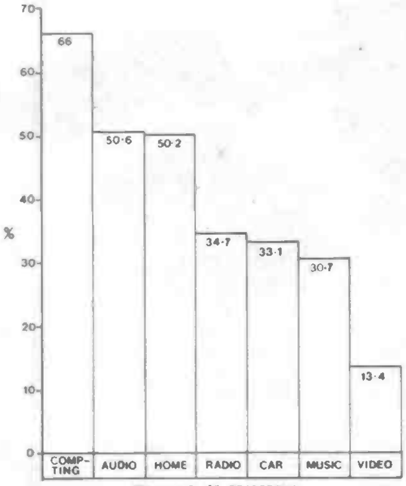
Nearly two-thirds of our readers are in the age-group 16 to 35 and well over a



AGES OF READERSHIP

EARNINGS

third are under 21. I would have thought that electronics would be a fascinating hobby for those who have retired, so it was disappointing to see such a low audience amongst the over 50's. Perhaps the content of the magazine doesn't appeal to them, (or as is much more likely, all the most enthusiastic, constructors have long since died, welded between the cathode and anode of an 807). Ah, those were the days, when men were men and the power rail would melt the end of your screwdriver if you weren't careful. Nowadays it's all 5V and CMOS. These youngsters can't remember the excitement of turning on a new project with its lethal voltages buzzing before you; the hairs on the back of the neck tingling and the smell of ozone rising from a bad joint.



INTERESTS OF READERSHIP

We were pretty certain that computing would be one of the main interests of our readers, so we were not suprised to see such a large figure here: nearly two-thirds of our readers. Lots of you mentioned security as another interest, but we really meant this area to be covered by "Home", so we've added these together, and still "Audio" just scraped in as second favourite. Fortunately, many people were interested in a wide range of subjects, which means we can please most of the people most of the time with our average content.

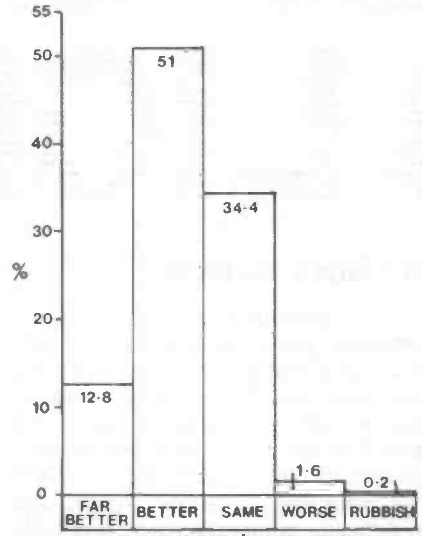
The only really sizeable vote for more coverage was for non-computer projects whilst over a third of you also wanted more educational articles and equipment reviews. However, since there was no really large vote for less of anything, this could be a problem.

A massive 91% of our readers, regularly build projects and the average project builder builds an astonishing 5.8 projects per year. (We must have been out of stock of something for the sixth one). Only a third of the projects you built were Maplin's, but we were pleased to see that 99% of them worked; 64.6% first time as well. Less than 8 in a thousand of our readers were unsuccessful.

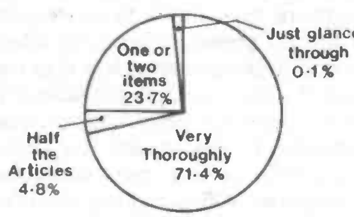
Of those who had built Maplin projects over 98% thought they were at least as good as other magazines' etc. and a very gratifying 64% of you thought they were better.

Another very pleasing result was that over 70% of you read the magazine very thoroughly, and over 97% keep the magazine for future reference.

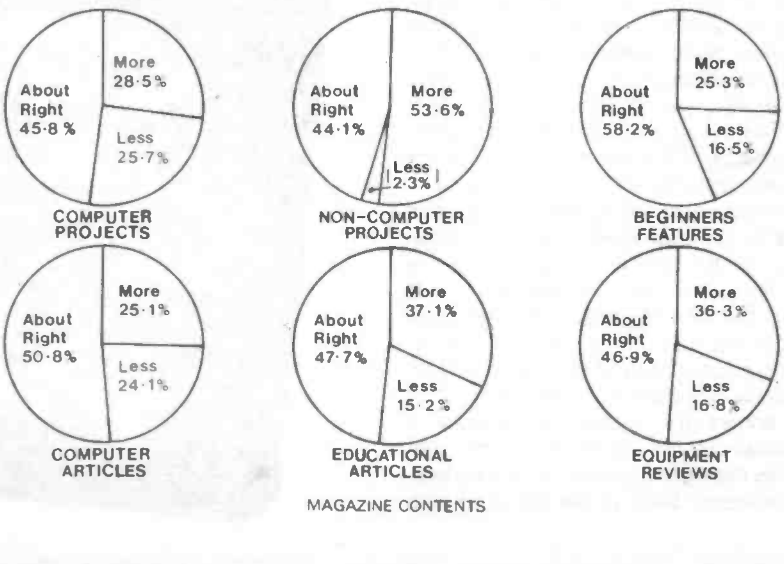
We haven't yet finished analysing what you thought of the monthly magazines, so we'll tell you about that in our next issue. And we'll answer some of the more interesting comments (good and bad) then as well.



MAPLIN'S vs OTHER'S PROJECTS (eliminating Don't Knows)



HOW THOROUGHLY IS MAGAZINE READ



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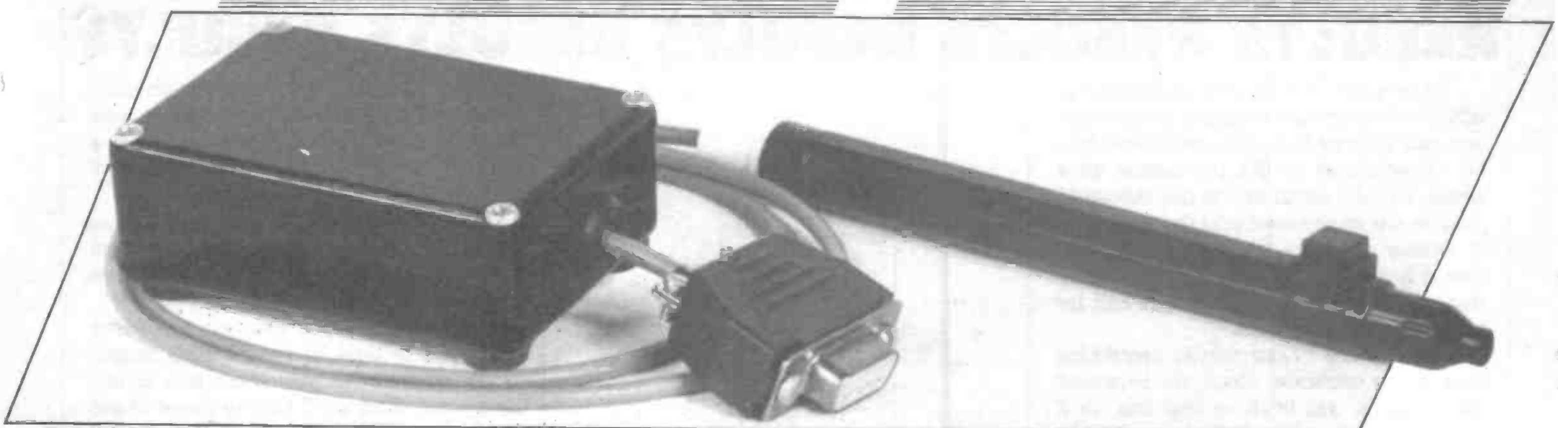


LIGHT PEN

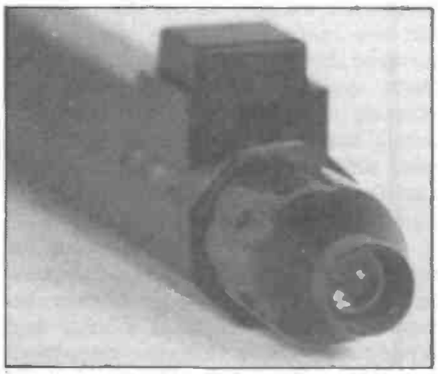
by Chris Barlow

for the Atari, VIC20, and Commodore 64

If you own an Atari, VIC20, or Commodore 64, you possess a computer with the ability to accept a light pen input. But if you have ever tried to obtain a ready-built unit, you will probably have been amazed at the cost even if you found a source at all. This is partly due to the lack of software that the device requires, and the difficulty in manufacturing a reliable piece of hardware. Some manufacturers have attempted to produce such a device, but due to marketing considerations (i.e. cost and potential sales), the resulting hardware leaves a lot to be desired. In this article I present a Light Pen which should cost in components, less than half the price of a commercially available unit, with, in my opinion, a considerably better performance. I have written the article with reference to my own computer, which is an Atari 800, but I have also tried the Light Pen on a VIC20 and a Commodore 64 and it works perfectly.

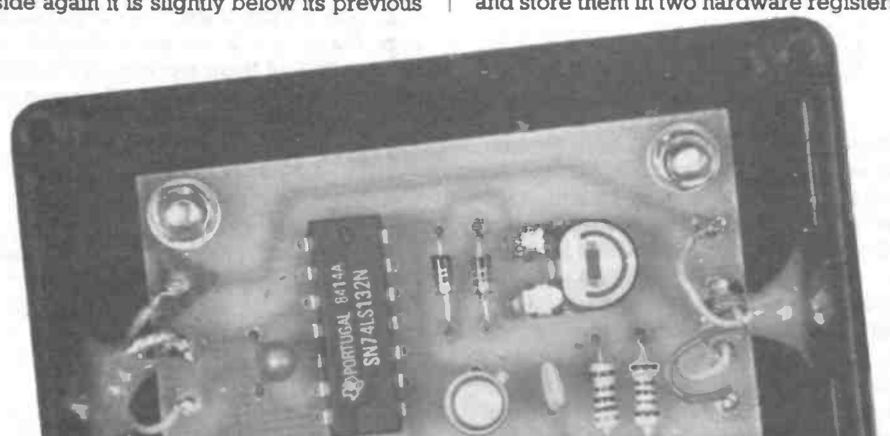
Method

To explain how a light pen works, you must first have an idea of how the television picture system is generated. A TV picture is basically constructed from a number of lines produced on the phosphor coating on the inside of the screen. The original TV system in this country used 405 lines, but today 625 lines is used. The phosphor on the screen glows when struck by the high speed electrons given off by the hot cathode wire (gun) in the tube. This is focussed by a magnetic field around the tube to produce a single spot of light on the TV screen. A set of electro-magnets called horizontal deflection coils are used to move the spot of light across the screen to produce a horizontal line (X axis). When the spot reaches the right-hand side of the screen, it is deflected back to the left-hand side



at high speed and during this period the gun is blanked to prevent spurious fly-back lines being generated. A vertical deflection coil is slowly moving the spot down the screen as well so that by the time the spot gets back to the left-hand side again it is slightly below its previous start position and thus ready to draw a new line. The downward scan (Y axis) continues until all 625 lines have been drawn, at which point the beam is made to return to its top left starting position. This is a highly simplified description; in a real TV set the actual procedure is far more complex.

The Light Pen is designed to detect the spot of light which moves over the screen. The computer has the job of determining the X and Y co-ordinates of the spot as it passes the pen. These values are obtained in an Atari from the internal register set of the 'Antic' display processor. Since the position of the light spot on the screen is directly related to the time it took to get there from the beginning of the first scan position, the hardware can determine X and Y values and store them in two hardware registers.



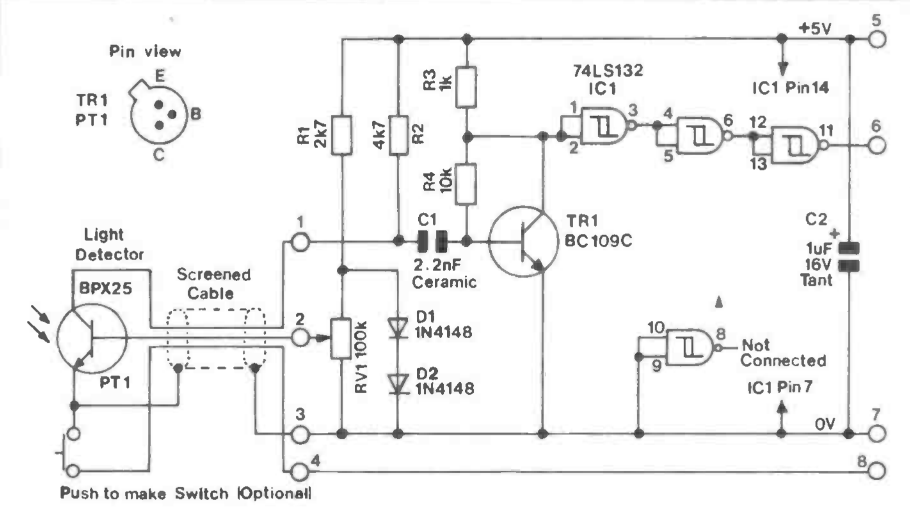


Figure 1. Circuit Diagram

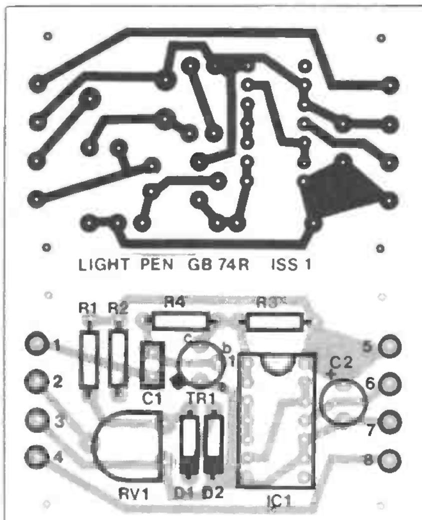


Figure 2. Artwork and Legend

When programming in BASIC, the X and Y values are obtained by PEEKing locations 564 for X and 565 for Y.

The user's software then has to interpret these values in order to obtain screen position related values. The horizontal or X location (564) will return a value of 78 for the extreme left-hand side of the screen, increasing by 1 up to a value of 227. Then something rather strange happens; the value jumps to 0 and then increments to a final value of 8 for the extreme right-hand side. Although this is a problem, it can be allowed for in the software. The vertical or Y location (565) will return a value of 16 for the extreme top of the display, incrementing by 1 to a value of 111 at the extreme bottom of the display. The values stored at these two locations are updated when any of the four joystick trigger inputs are used.

Circuit

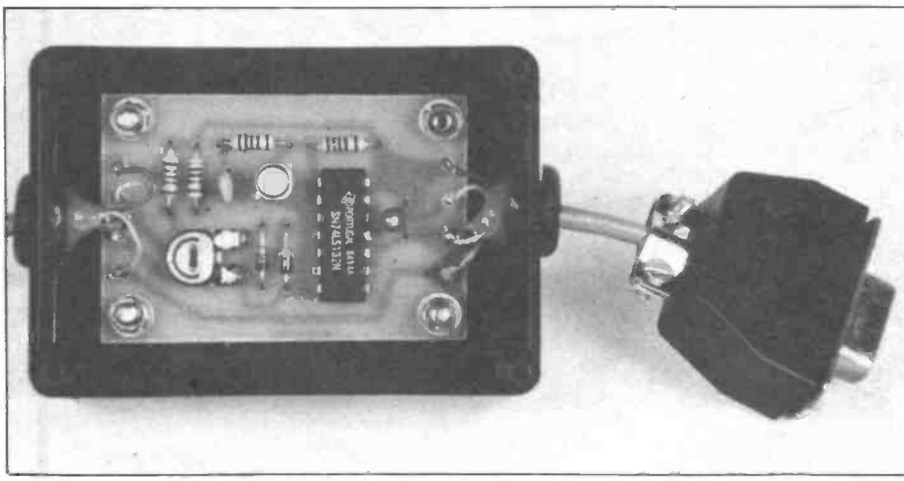
As can be seen in the circuit diagram (Figure 1), there are very few components necessary to obtain a working Light Pen. The most important is the light detector. It must have good sensitivity and fast reaction characteristics. The BPX25 phototransistor meets both requirements at a modest cost. This device is equipped with its own built-in optical lens which is made of glass. This point is worth noting, since, if direct contact is made with the glass of the TV screen, scoring may occur. To prevent this, the BPX25 should be recessed into a plastic tube of some description. To obtain maximum sensitivity and operating speed, it is necessary to bias the base of the transistor. The voltage required is quite small, about 0.5V. This voltage is adjustable with the 100k preset (RV1) from 1.2V down to 0V. In practice the preset wiper position comes out at about half way round its travel. The 1.2V at the top end of the preset is generated by two silicon diodes in series, and forward biased. The current through the diodes is limited by R1 connected to the +5V supply taken from pin 7 of the joystick port (PCB pin 5).

When the phototransistor detects a light pulse, the amount of current flowing through it changes. The current through the device is limited by R2 in the collector. These changes in current cause a voltage change at the collector of the phototransistor. The voltage pulses are then coupled by C1 into the base of a BC109C, TR1. This device performs the necessary voltage amplification to obtain TTL logic levels. The final stage of shaping the pulse is left to IC1, a quad 2-input NAND Schmitt trigger, 74LS132. As can be seen, only three of the four gates are used. The final component in the circuit is C2, a tantalum bead capacitor across the supply rails to remove any spurious noise on the rails. The output of the final gate is fed to pin 6 of the joystick port. The ground connection is made from PCB pin 7 to pin 8 on the joystick port.

In the prototype, a push-to-make switch was used as the trigger for the Light Pen. The switch was simply connected between pin 1 and pin 8 of the joystick port. The final construction and choice of housing is left to you, but an old Biro or felt-tip pen case is ideal for the pen itself, and the electronics can be housed in a small plastic box. The cable linking the phototransistor to the circuit board must be screened to prevent stray interference pick-up. The prototype used 4-core overall screened cable. Connection to the joystick port is via a standard D-type 9-way connector. Please note that if you have one of the Atari XL range of computers, due to the case moulding around the joystick ports, the standard D-range connector supplied in the kit will not fit and will either have to be modified or a suitable substitute found.

Programs

Included in this article are three very



simple programs for the Atari, the first of which is used to set up RV1 in the circuit. In all three programs we have used joystick port 1, because the Light Pen's switch controls the value of STICK (0). However, the Light Pen will work in any of the four joystick ports, except on the 400 where it will only work on port 4, so STICK(3) should be used in the programs in this instance. Program 1 is a simple drawing utility which will produce lines or dots depending on the state of the function keys. Holding Select down will put the drawing program into dot mode and the Option key will clear the screen and reset the starting position to the current pen position. Pressing the Light Pen's own button will produce continuous line drawing. To set a new starting point, simply place the pen on the screen and press the Select key. To adjust the preset to obtain the correct results simply hold the Light Pen against the screen, press the switch on the Light Pen and move the pen slowly. If the line does not trace the movement, adjust the preset until it does. If you cannot obtain a satisfactory result, try increasing the brightness and contrast controls on your TV. If there is still no response, recheck your soldering and construction.

Program 2 is an example of how a Light Pen can be used for menu-driven software. Position the pen over the number you wish to choose and press the Light Pen switch. If all is well, a tone will be heard and your selection will be shown at the bottom of the screen.

The final program (3) is a very simple musical instrument, in which you can select both volume and pitch. The sound will only be present whilst pressing the Light Pen switch. The display on the screen is a matrix of square dots with volume increasing down the screen and pitch increasing across the screen, right to left.

In conclusion I must point out that the programs shown are by no means good examples of what can be achieved, but are adequate for testing purposes and demonstrating the principles behind Light Pen Software implementation. When writing your own software, you must bear in mind where the screen is dark, no information can be detected by the Light Pen.

Atari Program 1

```
10 GRAPHICS 24:COLOR 1
20 X=PEEK(564):X=X-155+X:IF X<1 THEN X=1
30 Y=PEEK(565):Y=Y-30+Y:IF Y>190 THEN Y=190
40 IF PEEK(53279)=3 THEN GOSUB 80
50 IF PEEK(53279)=5 THEN PLOT X,Y
60 IF STICK(0)<>15 THEN DRAWTO X,Y
70 GOTO 20
80 GRAPHICS 24:COLOR 1
90 PLOT X,Y:RETURN
```

Atari Program 2

```
10 REM MENU
20 GRAPHICS 2+16:SETCOLOR 0,0,12:SETCOLOR 4,4,1
30 PRINT #6;" atari 1"
40 PRINT #6;" atari 2"
50 PRINT #6;" ATARI 3"
60 PRINT #6;" ATARI 4"
70 PRINT #6;" atari 5"
80 PRINT #6;" atari 6"
90 PRINT #6;" ATARI 7"
100 PRINT #6;" ATARI 8"
110 PRINT #6;" atari 9"
120 PRINT #6;" atari 10"
130 IF STICK(0)<>15 THEN 150
140 GOTO 130
150 LET I=PEEK(565)
160 IF I<18 OR I>94 THEN 150
170 IF I=18 OR I=19 OR I=20 OR I=21 OR I=22 THEN
 M=1:GOSUB 280
180 IF I=26 OR I=27 OR I=28 OR I=29 OR I=30 THEN
 M=2:GOSUB 280
190 IF I=34 OR I=35 OR I=36 OR I=37 OR I=38 THEN
 M=3:GOSUB 280
200 IF I=42 OR I=43 OR I=44 OR I=45 OR I=46 THEN
 M=4:GOSUB 280
210 IF I=50 OR I=51 OR I=52 OR I=53 OR I=54 THEN
 M=5:GOSUB 280
220 IF I=57 OR I=58 OR I=59 OR I=60 OR I=61 THEN
 M=6:GOSUB 280
230 IF I=65 OR I=66 OR I=67 OR I=68 OR I=69 THEN
 M=7:GOSUB 280
240 IF I=74 OR I=75 OR I=76 OR I=77 OR I=78 THEN
 M=8:GOSUB 280
250 IF I=82 OR I=83 OR I=84 OR I=85 OR I=86 THEN
 M=9:GOSUB 280
260 IF I=90 OR I=91 OR I=92 OR I=93 OR I=94 THEN
 M=10:GOSUB 280
270 GOTO 130
280 IF MM=M THEN RETURN
290 POSITION 4,11:PRINT #6;"ATARI=";M;" "
300 FOR V=15 TO 0 STEP -1:SOUND 0,M*10,10,V:NEXT
 V:LET MM=M:RETURN
```

Atari Program 3

```
10 GRAPHICS 4+16:COLOR 1
20 SETCOLOR 4,2,3:SETCOLOR 0,0,15
30 FOR Y=0 TO 47 STEP 4
40 FOR X=0 TO 70 STEP 4
50 PLOT X,Y
60 NEXT X:NEXT Y
70 IF STICK(0)<>15 THEN 90
80 SOUND 0,0,0,0:GOTO 70
90 SOUND 0,PEEK(564)/3,10,PEEK(565)/10
100 GOTO 70
```

PARTS LIST FOR LIGHT PEN

RESISTORS: All 0.4W 1% Metal Film

R1	2k7	1	(M2K7)
R2	4k7	1	(M4K7)
R3	1k	1	(M1K)
R4	10k	1	(M10K)
RV1	100k Hor Sub-Min Preset	1	(WR61R)

CAPACITORS

C1	2n2 Ceramic	1	(WX72P)
C2	1μF 35V Tantalum	1	(WW60Q)

SEMICONDUCTORS

TR1	BC109C	1	(QB33L)
D1,2	1N4148	2	(QL80B)
IC1	74LS132	1	(YF51F)
PT1	BPX25 Phototransistor	1	(QF30H)

MISCELLANEOUS

Printed Circuit Board	1	(GB74R)
Veropin 2145	1 pkt	(FL24B)
Cable Multi-Core 4-Way	2m	(XR25C)
Verobox 301	1	(LL12N)
D-Range Socket 9-way	1	(RK61R)
D-Range Cover 9-way	1	(RK62S)
Bolt 6BA ½inch	1 pkt	(BF06G)
Nut 6BA	1 pkt	(BF18U)
Shakeproof Washer 6BA	1 pkt	(BF26D)
Spacer 6BA ⅛inch	1 pkt	(FW33L)
Grommet Small	2	(FW59P)

A complete kit of parts is available.
Order As LK51F (Light Pen Kit) Price £10.95

The Printed Circuit Board in this project is also available separately.
Order As GB74R Light Pen PCB Price £1.25

FIRST BASE

by Mike Wharton **A Beginner's Guide To Logic Design.** **Part Seven**

CMOS Devices

As mentioned in the last article, there is available a range of logic devices based on a different type of technology from that of TTL devices. TTL chips have resulted from developments in bipolar transistors, that is the common or garden type like the ubiquitous BC109 and its ilk. The term bipolar is used to describe the manner in which the electrical current is carried through the transistor, which is by two charge carriers called electrons and 'holes'. The electron we are all familiar with, in a manner of speaking, being the basic particle carrying a unit negative charge; a 'hole', on the other hand, is simply the absence of an electron within the crystal structure of the semi-conductor material. It is really beyond the scope of this series of articles to delve further into the theory of semi-conductor action, but suffice to say that this type of device has certain electrical features which have been used to advantage in TTL devices.

Many readers will be quite aware that besides bipolar transistors there are the so-called FET's or Field Effect Transistors. In these devices the charge is carried only by electrons, there being no involvement with 'holes'. FET's have been developed along different lines to give several families, from Junction Gate FET's, (JUGFET's) to Insulated Gate FET's, (IGFET's). A widely used member of this last family is the MOSFET, or Metal Oxide Semi-conductor FET, and it is distantly related cousins of these that form the basis of the Complementary Metal Oxide Semi-conductor, or CMOS, logic devices. Figure 1 shows how CMOS transistors are fabricated on the surface of a silicon chip, whilst Figures 2a and 2b give an indication of the internal circuitry of typical CMOS and TTL devices.

As mentioned last time, there are a variety of advantages and disadvantages associated with both kinds of device, but it seems that many of the disadvantages with the CMOS variety are rapidly being overcome and they are poised to become the major type of logic element. Briefly, their most serious problem has been the low speed of operation as compared with TTL devices, but this may be off-set by their much reduced power consumption and wider operating voltage. For CMOS devices the supply positive is connected to Vdd (drain voltage), and supply negative to Vss (source voltage). The negative is connected to source since it can be regarded as the 'source' of negatively charged electrons. Practically all CMOS devices will tolerate a range of supply voltages from 3 to 15 volts, and hence may be operated quite happily from a standard TTL supply of 5 volts. If any difficulties are experienced, though, then it may be necessary to increase the supply to 9 volts or so.

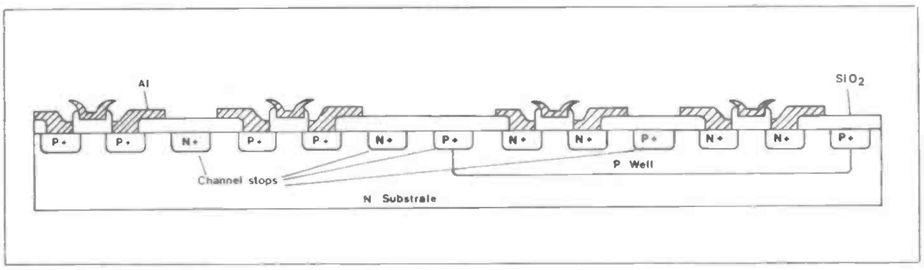


Figure 1. Conventional Metal Gate CMOS Structure.

Many of the logic elements available in TTL have direct equivalents in CMOS, indeed, some are even pin compatible replacements. A glance through the appropriate pages of the Maplin catalogue will give a very good idea of the range of devices commonly available along with their respective pinouts. Pretty well all of the circuits given so far in this series can be implemented using CMOS devices, and Figure 3 shows one of the earlier ideas but using a CMOS chip, the 4520. Because of the larger scales of integration possible with CMOS, this actually contains two four-bit binary counters within the 16-pin package, and the internal arrangement is a little different from the 7493 which was used in the original design.

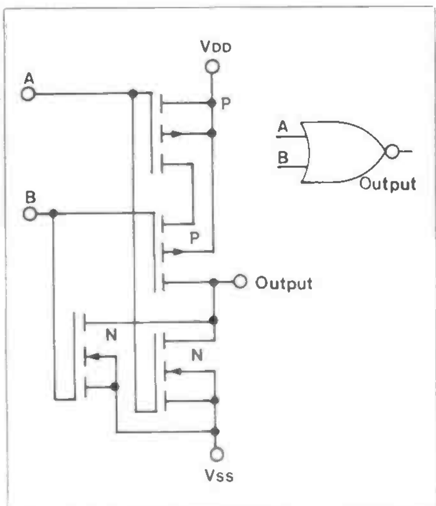


Figure 2a. CMOS 2-input NOR Gate.

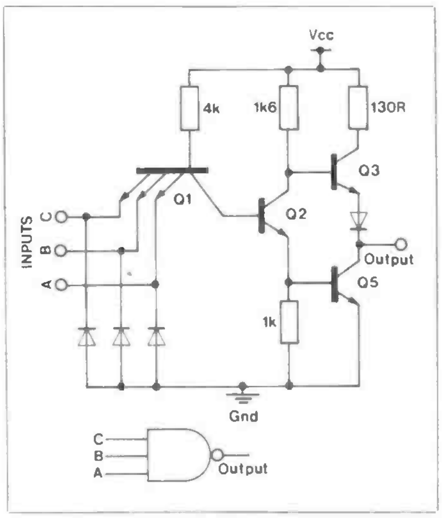


Figure 2b. TTL 3-input NAND Gate.

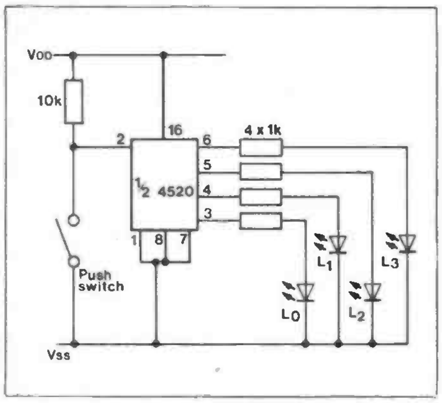


Figure 3. 4520 Dual 4-bit Binary Counter.

Beware of Static!

This point is perhaps a convenient one at which to mention one of the problems of using CMOS devices which is never encountered with TTL, that of sensitivity to static discharges. One may inadvertantly destroy a CMOS device by careless handling even before it is put into the circuit. The reason for this is due to the nature of the input to this type of device; the layer of insulating silicon dioxide, shown in Figure 1, is extremely thin, typically only a few microns thick. It is very easy to generate high static charges due to friction; for example by walking across a synthetic fibre carpet in rubber-soled shoes it is possible to produce a charge of 10,000 volts. Normally this would quickly leak away, but if applied to a CMOS chip then the thin oxide layer will break down and the device is effectively destroyed. Most of the devices produced nowadays have some form of protection against static discharge, usually in the form of internal zener diodes. However, the protection is not completely effective, and some care needs to be taken. The usual advice is to work on an earthed metal tray with all manner of other anti-static precautions, but for the common logic devices this is not really necessary. Provided you avoid touching the pins when handling them and resist the temptation to polish them up on your woolly jumper, no 'dead' chips should be produced. Also, it is a good idea to store them in their anti-static tubes or with the pins pushed into polystyrene foam which has been covered with aluminium cooking foil, so that the pins are all effectively shorted together.

One word of caution, don't adopt too much of a cavalier attitude to them or you might be tempted to treat a microprocessor in the same way, with expensive results!

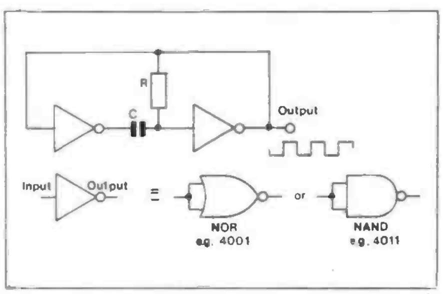


Figure 4. CMOS Astable Formed by 2 Inverters.

CMOS Logic Gates

One very useful effect of the insulated gate construction of these devices and its associated high input resistance is that some 'tricks' are feasible which would be difficult or impossible with TTL gates. For example, Figure 4 shows how a simple square wave oscillator, or astable flip-flop, may be obtained from just two gates. The frequency of operation is set by the values of capacitor and resistor chosen, but the exact frequency will be determined to some extent by the gate input characteristics, which will vary slightly from device to device. The approximate frequency of operation is found from the empirical formula:–

f = 0.6 / C x R where frequency, f, is in Hertz, capacitance is in Farads and resistance is in ohms and with an upper frequency set by the natural limitations of these devices. Similarly, Figure 5 shows a monostable flip-flop made up from two gates; due to the high input resistance long time constants can be achieved by the use of relatively small value capacitors in conjunction with large resistors. The period of this type of monostable is given by another form of the above expression:–

t = 0.6 x C x R where C and R are as before and t is the period in seconds.

A third type of flip-flop is shown in Figure 6. This is the bistable flip-flop, which is so called because it can adopt either of two stable states, and a suitable trigger pulse can flip it from one state to the other, where it remains until it is triggered to flop back.

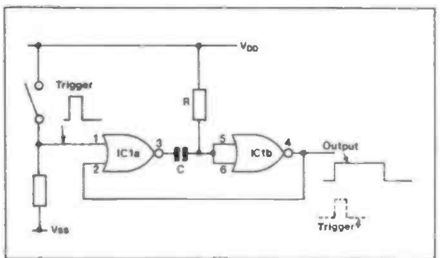


Figure 5. Monostable Formed by Two 2-input NOR Gates.

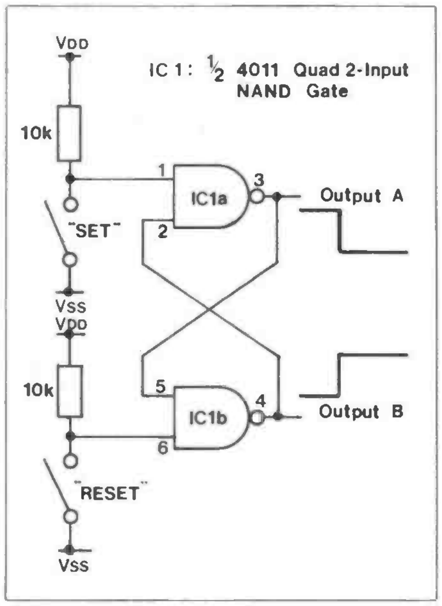


Figure 6. Bistable Formed by Two 2-input NAND Gates.

CMOS Counters

Some of the above ideas are brought together in Figure 7. If you have been following the series you should have some idea as to the function of the circuit, which is a simple timer to count up to 59 seconds and then reset to 00. The clock pulses are obtained from an astable flip-flop which has a period of about one second. Because of the simple nature of this part of the design the overall accuracy of the timer will not be very good; a much more accurate method of generating clock pulses will be discussed in a future article. The clock pulses are fed into one half of a 4518 binary coded decimal (BCD) counter. The outputs from this counter are then used to operate a 4511 BCD to seven segment decoder/driver for the 'units' LED display. The output from the most significant bit (MSB) of the first half of the 4518 is then used as the clock input to the second half of the counter, which produces the required output for the 'tens', via the second 4511 and LED display. The extra

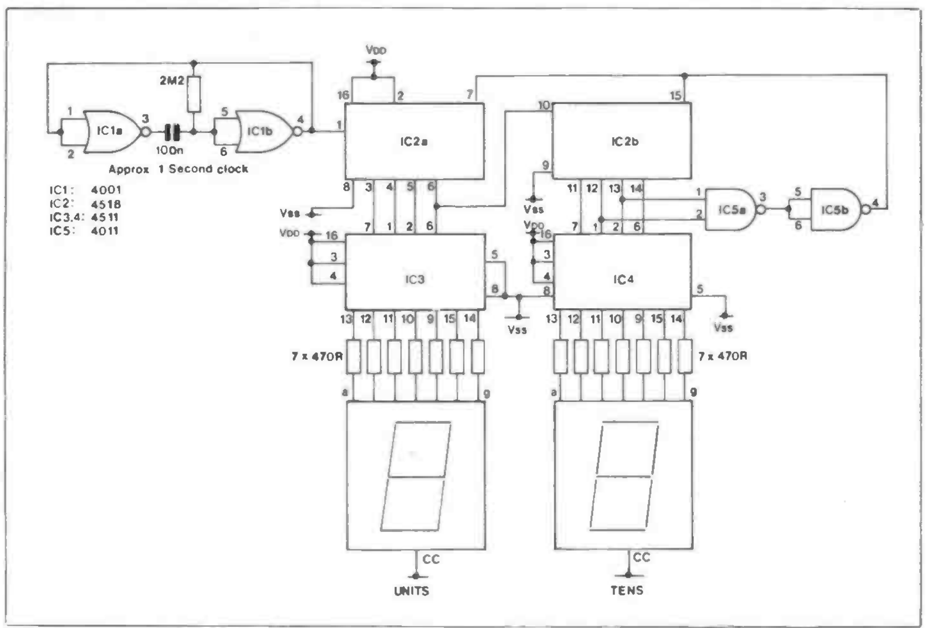


Figure 7. Simple Seconds Timer.

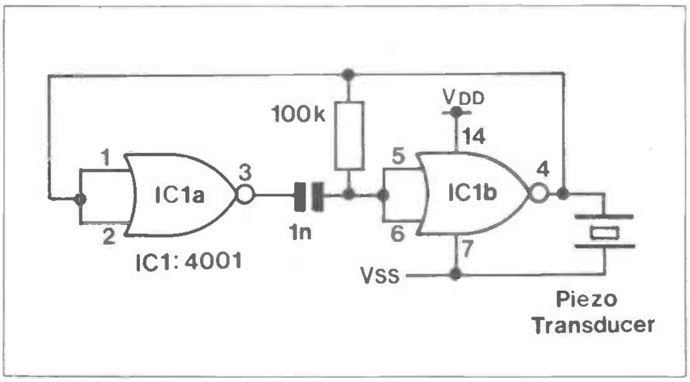


Figure 8. Astable used to operate a Piezo-Electric Sounder.

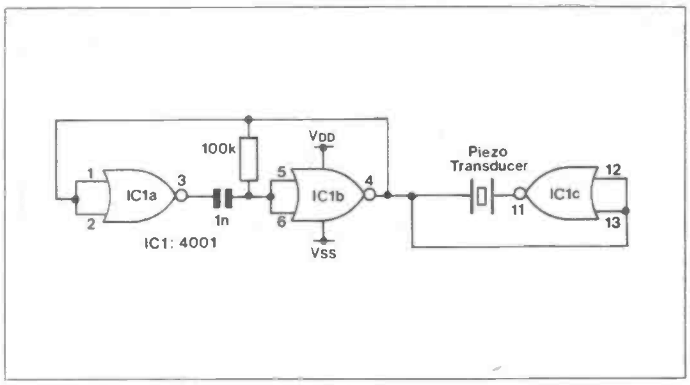


Figure 9. Circuit for Increased Output.

gating of IC5a and IC5b is to detect the presence of the value '6' on the output from the second counter, since it is desired only to count up to 59 and then reset to zero. The method of achieving this is to connect both the '4' and the '2' output lines to the inputs of a two-input AND gate, since the value of '6' is present when '4' AND '2' are both at logic 1. You may well be wondering, then, why two NAND gates are shown in the diagram. This is simply to avoid purchasing a chip containing AND gates when the job can be done with the more versatile NAND gates. The two NAND gates connected as shown, of course, produce an AND gate, as reference to previous Truth Tables will reveal.

The output from the AND gate is then fed to the Reset pins on both counters, so that counting is forced to re-commence from zero. Actually, a figure 6 will appear on the display, but only for the time it takes for the reset signal to be gated through the decoder and counter, which is of the order of a few nano-seconds, so you are unlikely to see it! Of course, it is possible to detect other values, so that instead of counting minutes some other number is counted. Without any reset logic, i.e. with the Reset pins connected permanently to Ground (or Vss), the circuit will count up to 99 before cycling round to zero again. The reader is left to experiment for himself, the only requirement being to AND all the unique values of the next highest count together to the Reset pins. For example, if it were desired to display the value '60', then 61 would need to be detected by ANDing '4' and '2' from the tens counter, along with '1' from the units counter. This could be achieved with a three-input AND gate or more conveniently with an equivalent array composed of two-input NAND gates. This kind of decoding can be done with this counter since it is of the synchronous type, described in the last article.

Jeepers Bleepers!

Returning to the simple oscillators made up from a couple of CMOS gates, and incorporating some of the ideas outlined above, brings us to the final portion of this issue's logic feast.

Although the output stages of CMOS gates are unable to drive even a small loudspeaker directly, they are ideal for operating the small piezo-electric sounders for producing an audible note. The type shown on page 421 of the current Maplin catalogue, order code QY13P, is the kind to use. It requires some care in soldering on a couple of connecting wires, but has the advantage of being cheap. Figure 8 shows a circuit which has an output of around 1kHz, which may be used to test the transducer. The audio output can be increased by the use of an extra gate, as indicated in Figure 9, but even then it will not be rock-crushing! By employing another set of gates operating at a much lower frequency it is possible to control the audio oscillator to produce a pulsating tone, as shown in Figure 10. Developing this idea further, it is then possible to control this circuit with yet another one, this time a monostable with a period of, say, 5 seconds. When initiated, the circuit of Figure 11 will produce a pulsed tone for this duration, and could be used as an audible warning device. Finally, Figure 12 shows how this last idea can be added to the simple timer outlined above, so that a warning note is sounded when a particular time is reached on the counters, in this case at every minute mark.

If you have a requirement for a simple timer of this nature, then the design could well be made up into a more permanent form, rather than being left as a breadboard experiment. In such a case it would be better if the features of the design were more versatile; for example, if the 'alarm time' could be set to any value over a wider range of times, to produce a high technology egg-timer! You may have some idea as to how this might be achieved, but the next article will include a suitable design, as well as probing deeper into the use of other interesting CMOS devices.

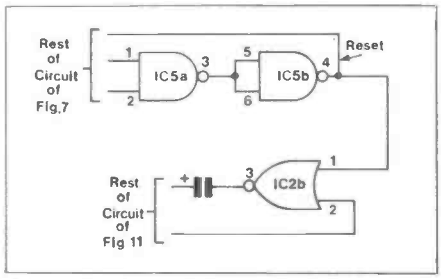


Figure 12. Reset Pulse used to Trigger Monostable for Audible Warning Device.

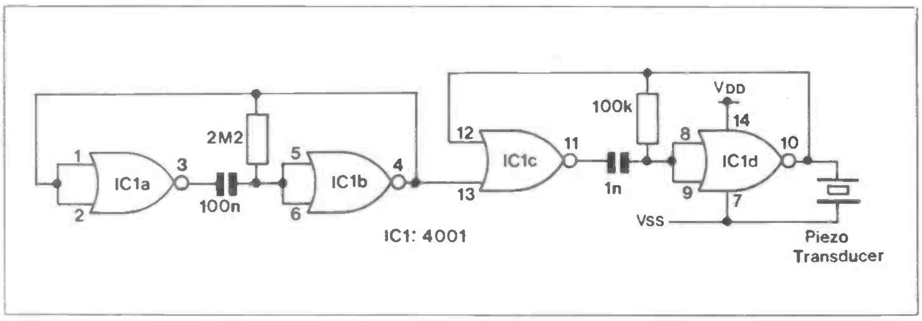


Figure 10. Gated Astable to produce Pulsating Tone.

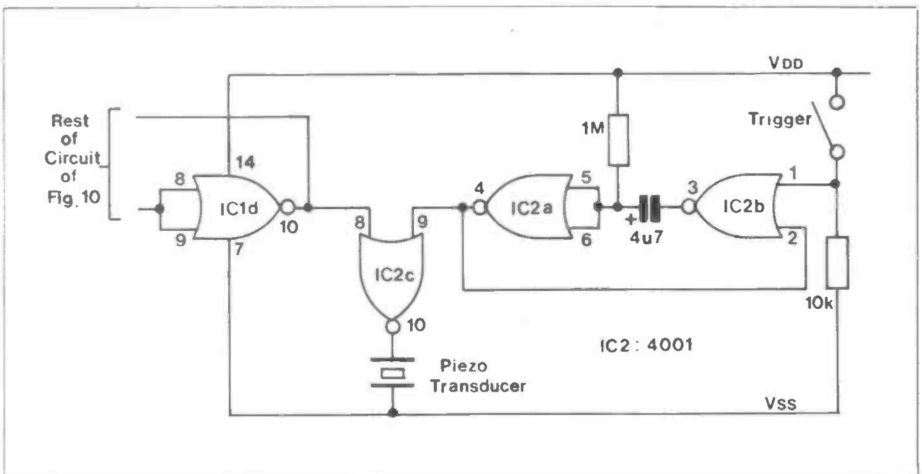
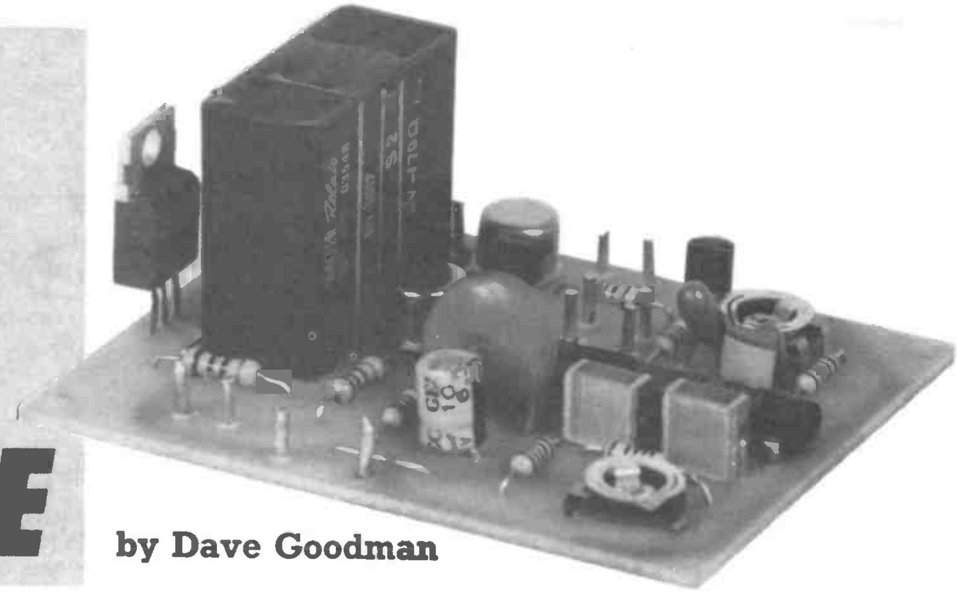


Figure 11. Monostable used to Gate Pulsed Astable.

PWM MOTOR DRIVE MODULE



by Dave Goodman

★ **6 - 12V Forward and Reverse Model Motor Driver**
★ **Proportional Control Offers Smooth Transition from Off to Full Speed**
★ **Ideal for Model Boats, Cars and Robotics**

Following on from the previous issues PWM Servo Driver, this model speed controller will drive low voltage electric motors from a suitably encoded pulse width modulated signal. Both 6V and 12V systems are catered for by the output drive circuitry which will handle motor stall currents up to 5 amps, while the front end decoding section connects separately to a low voltage 4.8 – 6V supply obtainable from radio control Rx battery packs for instance. Although primarily intended for Radio Control model use, the project also finds application in Robotics projects where computer control of movement and direction is required.

Proportional Control

Unlike servo's, the speed controller does not require positional feedback information. Essentially all that is required to start and stop an electric motor is to apply then disconnect power via a switch, and toggling the switch will alternately increase then decrease the speed at which the motor is running. If the switch could be held closed for a set time period and then held open for the same time, so that its MARK (closed) to SPACE (open) ratio becomes even, then the motor would be expected to run at approximately half power allowing for over-run and starting losses.

Lengthening the switch make time and reducing the switch break time repeatedly will therefore mean that power is applied for longer periods and the motor will increase its speed accordingly. Conversely, reducing the switch make time and lengthening the break time will slow the motor. This principle is applied in PWM systems as shown in Figure 7.

The repetition rate, or switch on and switch off cycle, is standardised at 20ms and each complete cycle is called a Frame. The reciprocal value from this (1 ÷ 0.02) produces the Frame Rate and is 50 frames per second. During each 20ms frame cycle the positive going pulse can be increased from a minimum width of 0.2/0.5ms, up to a maximum width of 2.0/2.5ms, the latter corresponding to maximum speed and the former to minimum. Obviously, manually operating a switch in the motor supply line at 50 times a second is slightly impractical and use of electronic switching IC's becomes desirable.

Circuit Description

In Figure 1, IC1 is a linear pulse width amplifier and expands the incoming signal at pin 14 into a pulse train whose MARK/SPACE ratio can be varied between zero (0V) and one (+V). Preset RV2 and C4 set the internal monostable timing period and input pulses less than or greater than this period determine motor speed. Because both forward and reverse drive are necessary, a 'no drive' or zero position is required and RV2 can be adjusted to determine this. RV1 sets the 'dead band' area, or the relationship between motor speed and control 'stick' movement. Along with the pulse expansion component, C3, this preset can be adjusted for maximum speed and zero positions. IC1 pin 4 output determines motor direction and has a high (+V) output in one direction and a low (0V) output in the other.

One of two links A or B are inserted for operating RLA via TR1, TR2, and IC2b or IC2c, and are fitted according to the required direction of rotation of the motor armature. Pins 5 and 9 are NANDed by IC2a and produce a positive pulse train which switches TR3, TR4 and TR5. Either pin 5 or pin 9 is active, but not both together, and each signal is complementary to the other depending on forward or reverse direction signals. TR5 must be capable of switching high currents to the motor and R10 will supply drive signals to external NPN transistors if larger current handling becomes necessary (pin 10). Pin 4 output is either high or low with a selected direction and could be buffered for reversing-lights on a model car for example. Both relay contacts reverse connections to the motor when operated by RLA from IC1 pin 4, so that the same drive signal at TR5

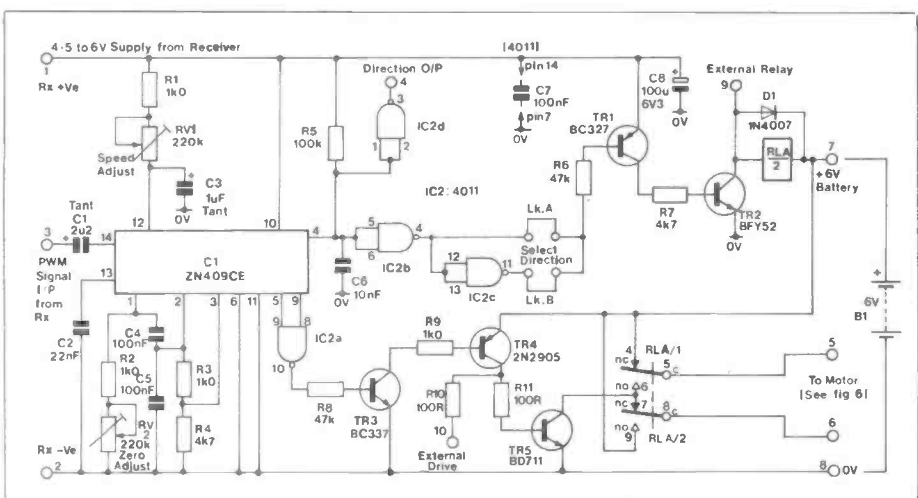


Figure 1. Circuit Diagram

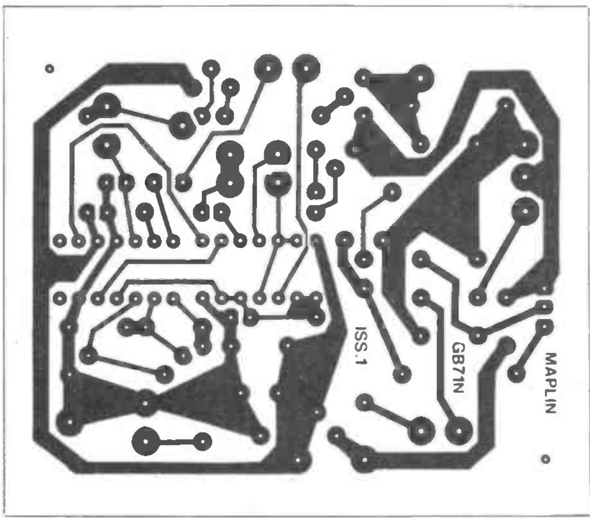


Figure 2. Artwork

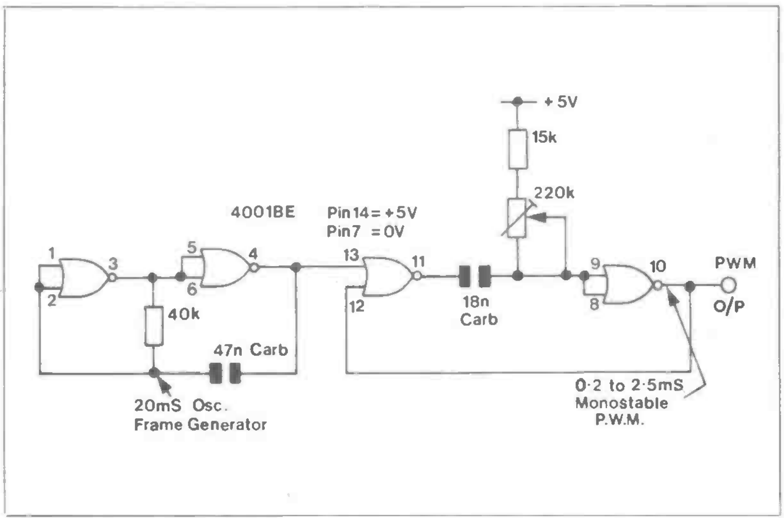


Figure 3. Test Circuit

collector is available for both forward and reverse modes. Output pin 9 may be connected to an externally mounted relay if larger current switching is required.

Construction

Two links are initially required to be inserted directly into the PCB and are best formed from 24swg tinned copper wire. Excess lengths removed from resistor leads could be utilised for this. Next fit R1 to R9 and standard resistors R10 and R11 followed by D1, which must be correctly aligned as per the PCB legend. It may be convenient at this stage to solder these components and cut off excess leads, thus avoiding the inevitable jungle that would otherwise result.

Fit the fourteen Veropins from the track side and push the heads down to the respective pads with a soldering iron and apply solder. Fit both presets RV1, RV2 and IC1, IC2. Be sure to fit IC's correctly by aligning the end notch with the legend otherwise they will be damaged in use and are not easy to remove after soldering! Fit all capacitors and note that C1 and C3 are polarised and must be fitted correctly with the +V markings in line. Polycarbonate capacitors C4 and C5 can have their terminals broken quite easily, so exercise care when fitting both to the PCB. Again, solder all components in place, remove surplus wires and fit RLA, which can only be inserted in one position.

The parts list offers both 6 volt and 12 volt versions for the relay and is a matter of choice to suit individual requirements, but note that only the 6V version is supplied in the kit. Next, mount the five transistors. TR5 is positioned with its mounting bracket facing outwards, away from the PCB and the plastic body facing inward towards RLA. Later on, it may be necessary to heatsink TR5, so ensure reasonable length leads between the PCB and bottom of TR5. This will allow it to be manoeuvred over the edge of the PCB for easier mounting.

Finally, solder all remaining components, clean the track surface with solvent, to remove flux and solder splashes, and inspect the work. When satisfied that all is correct, proceed with testing the module. It is worth pointing out that many problems develop from incorrect component recognition, poor soldering and messy track surfaces. Always carefully inspect and re-check parts for mistakes before applying power and this will ensure that any problems can be rectified before damage occurs.

Testing

Initial checks concern voltage and current measurements, and a multimeter is the minimum item of test equipment that should be available. Refer to Figure 4 connections diagram. Connect a 5V supply with −V to Pin 2 on the PCB, and +V to the + lead of a multimeter. Set the meter to measure DC current (100mA), connect its negative lead to Pin 1, and turn on the power. Set RV1 wiper to approx. 7 o'clock and RV2 wiper at approx. 11 o'clock as depicted by the arrows in Figure 4. A current reading of 5 - 6mA should be seen on the meter.

Remove power and meter, reconnect the supply +V to Pin 1 on the PCB and connect the meter with +V lead to Pin 1 and −V lead to Pin 7. Re-apply power and check the meter for a zero reading. Temporarily connect Link A and listen for a click in the relay. The meter should read approx. 10mA when using the 12V relay, or 55 - 60mA when using the 6V relay. Remove Link A. The meter should drop to zero and the relay should click as it releases. These checks should give an indication that the module is basically functioning, providing the above figures correspond to within a few percent.

With the absence of a suitable +V pulse PWM system, such as a radio control Tx and Rx, a simple CMOS test circuit is shown in Figure 3. This too requires a 5V supply and serves as a 20ms frame generator and variable monostable. Please note that the Figure 3

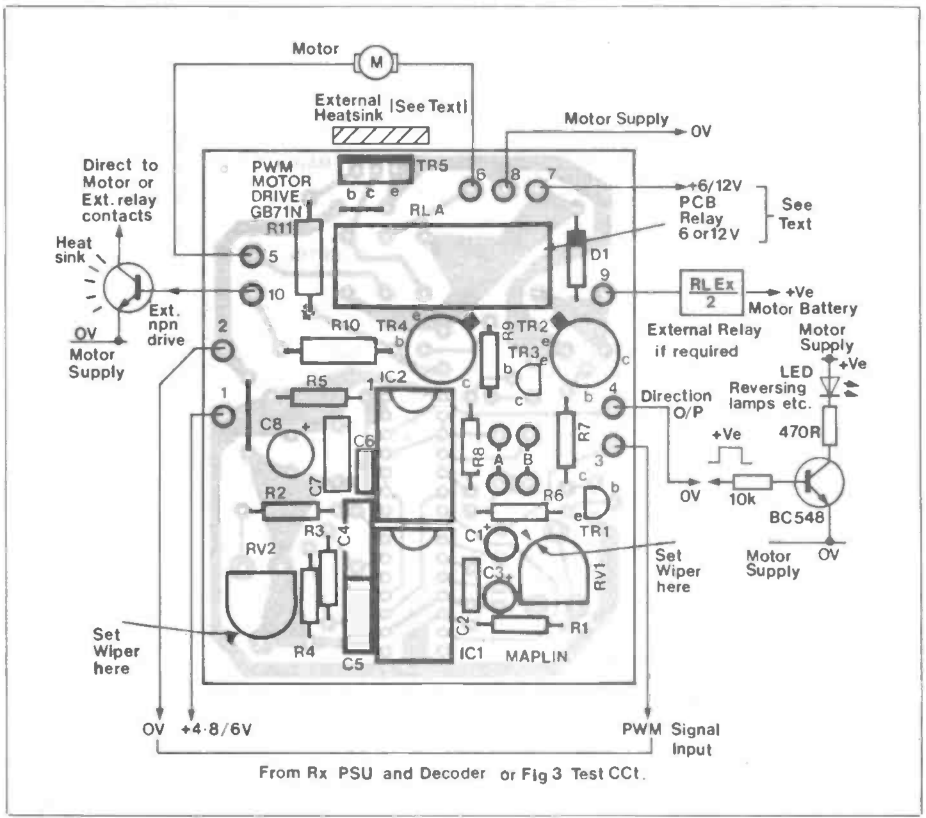


Figure 4. PCB Wiring & Legend

circuit is not a project or kit and exists solely as a guide to assist with testing the module. Whatever system is used, connect the PWM O/P to Pin 3 on the module, and ensure a signal return path exists along Pin 2 (0V) connection. Figure 8 can be used for reference. Fit Link B only onto the module and apply both low and high power supplies as shown.

It is certainly not advisable to take the motor supply +V from module input or receiver supplies, as large current surges will affect both, causing glitching at least, or battery failure at worst. In use, low power Nicads (4.8 - 6V) are perfectly adequate for the input supply, but larger battery packs (if used) will need to be either high power Nicads or Lead Acid/Cadmium varieties for driving the motor. Remember to choose the motor supply voltage to suit both relay and motor ratings (6 - 12V). Do not connect the motor just yet, but switch on all supplies. Adjust either the appropriate transmitter stick, or preset (in the case of Figure 3) from centre zero, which should correspond to an approximate 1.5ms frame pulse down to 0.5ms, whereupon the relay should operate with a click. Reverse stick or preset back through zero in the opposite direction, and the relay will release. When using Link A instead of Link B the relay will normally be in the operated state at first, and release during the test; this being the opposite condition. So Link A holds the relay operated for release mode and Link B holds the relay released for operate mode. In either case, connect a voltmeter adjusted to read 10 - 20V between 0V and PCB pin 4. The reading should be normal at 0V and +5V when moving the stick (pot!).

Connect a motor to PCB pins 5 and 6, and again with all supplies connected ensure full forward, zero and full reverse conditions can be established by varying the control stick or pot. It may be found necessary to re-adjust RV1 and RV2 on the module to ensure these conditions are met with a wide zero or motor off position, therefore trial and error settings will indicate optimum performance for your particular system.

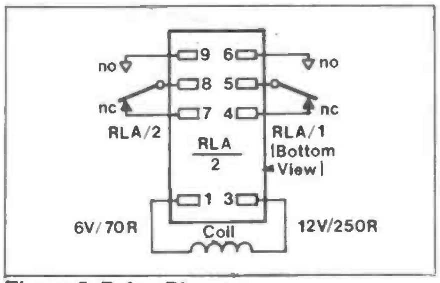


Figure 5. Relay Pinouts

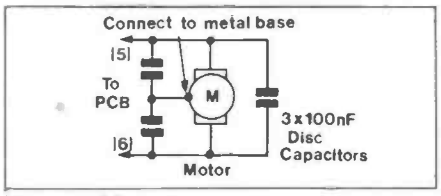


Figure 6. Motor Suppression

Motors

Owing to the wide variety of motors and applications that could be used, it would be best to examine the limitations of the module rather than discuss individual requirements. For instance, Bullett type motors used with large model aircraft can draw 30 Amps or more and relays, drive transistors and PCB tracks must be capable of handling this for long periods. On the module, RLA can comfortably switch 5 Amps although TR5 will dissipate large amounts of power, especially under low speed or stall conditions, so without extra relays and drive transistors fitted, smaller motors of 1 to 2 Amps only should be used. As explained previously, Pin 10 can supply a further three or four NPN power transistors, and Pin 9 a second relay, should it be required to drive larger motors. Simply connect the transistor's emitter to Pin 8, base to Pin 10, and collector to collector of TR5: in other words in parallel with TR5. Figure 6 offers a simple suppression circuit which should prove adequate for most motors without adversely affecting performance too much. Excessive capacitive loading will affect the pulse waveform at low speeds, so bear this in mind when using suppression.

Heatsinks

TR5 may tend to run hot under heavy load conditions and heatsinking will have to be used to prevent damage or loss of power. Any method used will depend entirely on the space available, and the weight allowance within the model. Model boats generally have plenty of space and buoyancy, and a large heatsink may add ballast for stability. One eighth and half scale cars often have a metal chassis and this could be utilised for heatsinking, but plastic kits may melt around TR5 or its heatsink, so allow plenty of airflow to keep temperatures down.

In conclusion, always keep batteries for the motor drive supply and logic drive separate; only use low power 1 - 2 Amp motors unless adding further power transistors; ensure adequate heatsinking and ensure all supplies are switched off after use.

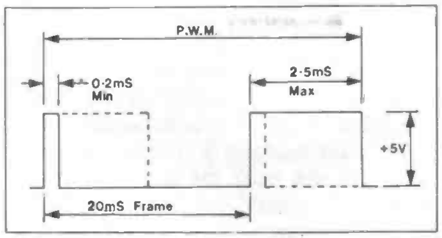


Figure 7. Control Waveform

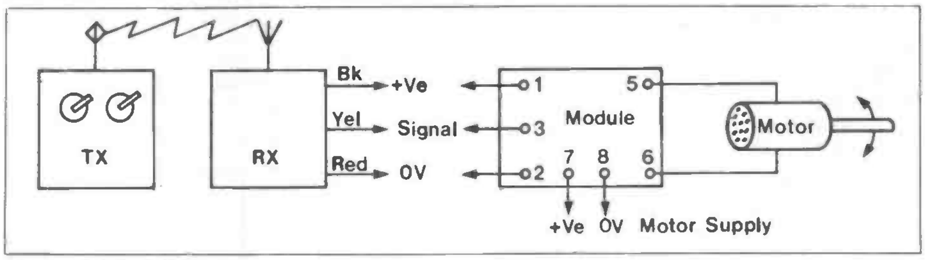


Figure 8. Block Diagram

PWM MOTOR DRIVE PARTS LIST

RESISTORS: All 0.4W 1% Metal Film unless stated.

R1-3,9	1k	4	(M1K)
R4,7	4k7	2	(M4K7)
R5	100k	1	(M100K)
R6,8	47k	2	(M47K)
R10,11	100Ω ½W 5% Carbon Film	2	(S100R)
RV1,2	220k Hor Sub-Min Preset	2	(WR62S)

CAPACITORS

C1	2µ2F 35V Tantalum	1	(WW62S)
C2	22nF Ceramic	1	(WX78K)
C3	1µF 35V Tantalum	1	(WW60Q)
C4,5	100nF Polycarbonate	2	(WW41U)
C6	10nF Ceramic	1	(WX77J)
C7	100nF Disc	1	(BX03D)
C8	100µF 6.3V Minelect	1	(RK50E)

SEMICONDUCTORS

D1	1N4007	1	(QL79L)
TR1	BC327	1	(QB66W)
TR2	BFY52	1	(QF29G)
TR3	BC337	1	(QB68Y)
TR4	2N2905	1	(QR17T)
TR5	BD711	1	(WH15R)
IC1	ZN419CE	1	(YH92A)
IC2	4011BE	1	(QX05F)

MISCELLANEOUS

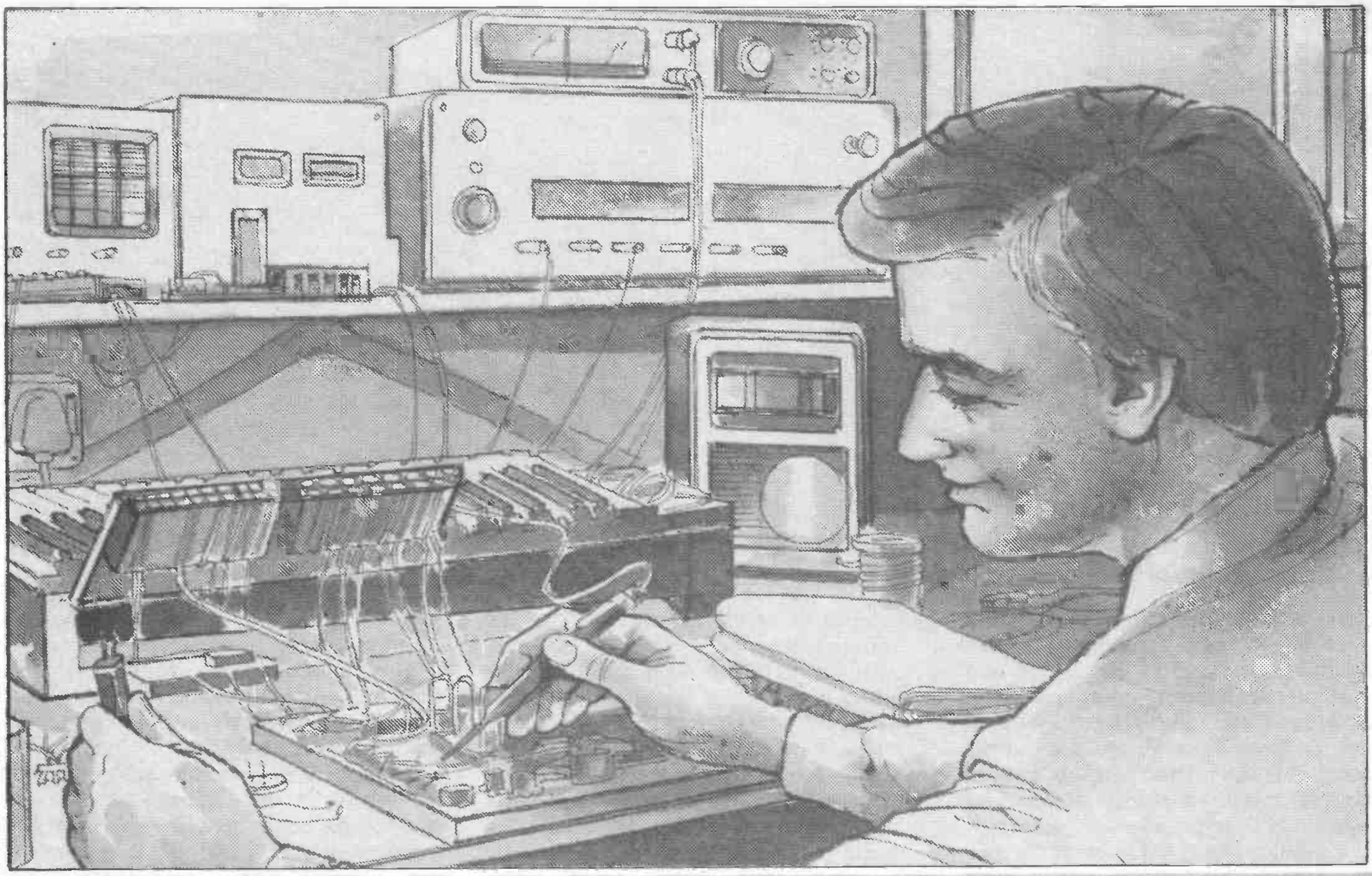
RLA	Min DPDT 6A 6V Relay	1	(FJ42V)
	Printed Circuit Board	1	(GB71N)
	Veropin 2141	1 pkt	(FL21X)

OPTIONAL

Ca,b,c	100nF Disc	3	(BX03D)
	Min DPDT 6A 12V Relay	1	(FJ43W)

A complete kit of parts (excluding Optional Items) is available.
Order As LK54J (PWM Motor Drive Kit) Price £9.50

The following parts used in this project are also available separately but are not included in our current catalogue.
FJ42V Min DPDT 6A 6V Relay Price £2.98
FJ43W Min DPDT 6A 12V Relay Price £2.98
GB71N Printed Circuit Board Price £1.75



PROJECT FAULT FINDING

by Robert Penfold Part One

Although the constructional information provided in electronics magazines and books is generally very concise and easy to follow, probably every electronics constructor is sooner or later faced with the problem of a newly constructed project that fails to work properly. Most projects these days (including virtually all the Maplin projects) are based on a custom printed circuit board, and these certainly help to greatly reduce the likelyhood of a new project failing. However, they are not as 'foolproof' as many people seem to imagine, and do not eliminate the problem.

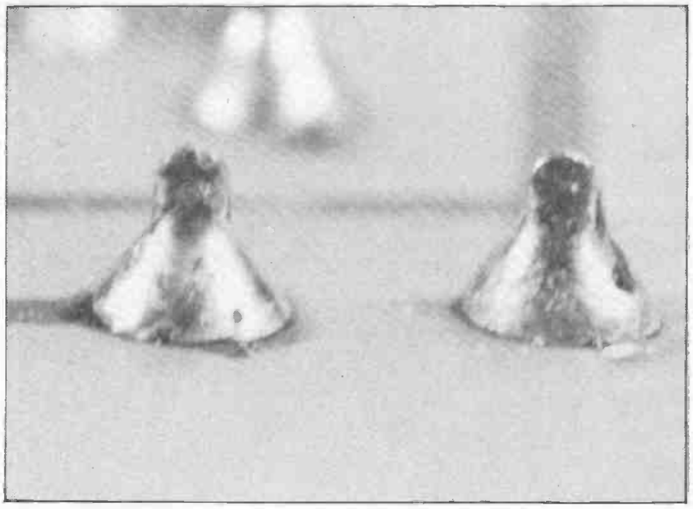
Ideally when fault-finding on a project one should understand the precise way in which each stage operates, and should have the necessary test equipment to methodically check each stage until the fault is located. Looking at things realistically, probably few constructors are in a position to undertake fault-finding in this way. However, even with the aid of little or no test equipment it should in most cases be possible to locate the fault. This is due to the fact that the majority of newly constructed projects that fail to operate do so because of an error in construction rather than a design error or a faulty component. At one time there was no shortage of genuine 'duds' in circulation, but at present it is very rare indeed for faulty components to slip through the battery of tests at the factory, or for unscrupulous dealers to sell faulty components as tested and operational components. Of course, it is not advisable to use untested components obtained cheaply unless you have the facilites to test them for yourself and discard any that fail to reach a suitable standard. All Maplin supplied components are of good quality and from reputable manufacturers.

With modern semiconductors it is possible to design repeatable projects that do not require a lot of experimentation with component values before they will operate properly. If a project fails to work properly first time it is only human nature to think that it is due to someone elses mistake, but this really is unlikely to be the case. Those who have checked faulty projects invariably find that more than nine times out of ten the problem is due to something like a component not fitted correctly, or a badly soldered joint.

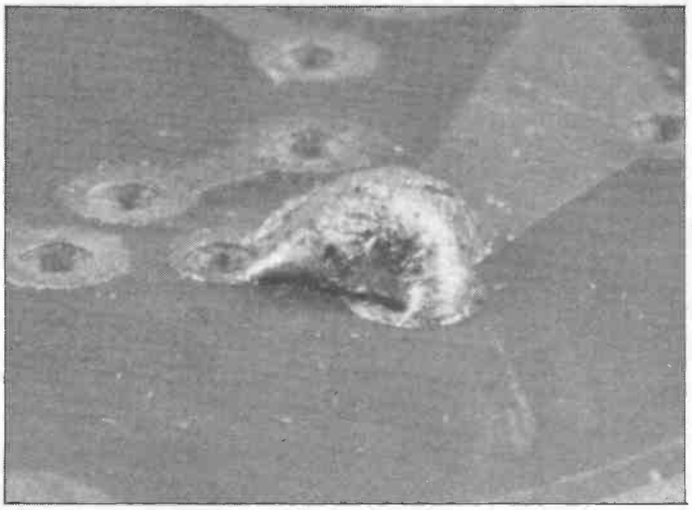
Checking

The inference of this is clear: if you construct a project and it does not work, the chances are very much in favour of it being possible to discover the error and rectify the fault without resorting to any test equipment at all. The first job is to read the description of the project thoroughly to make quite sure that you are using the unit correctly, and have not misunderstood something. This may seem a silly point, but as projects become increasingly complex and difficult to understand, the faulty project that isn't becomes less rare. Pay particular attention to any setting up or adjustment instructions, as this is where difficulties and misunderstandings are most likely to occur.

The next step is simply to check the unit against the construction diagrams to ascertain that there are no discrepancies



The correct appearance for soldered joints.



A joint of dubious quality.

here. In particular check that components which must fit onto the printed circuit board the right way round (e.g. most semiconductors, and polarised capacitors) are indeed fitted correctly. Few projects have all the components mounted on the printed circuit board, and it is easy to make a mistake in the wiring to off-board components such as switches, potentiometers, and sockets. There is a lot to be said in favour of using connecting wires of different colours or multicoloured ribbon cable when wiring up projects, since errors are then less likely, and any that do occur are easily spotted.

If a thorough check of the wiring etc. fails to show up the cause of the problem it is still quite likely that the fault is due to a mechanical problem of some kind, rather than a faulty component or design fault. With a project constructed on stripboard a common problem is that of minute blobs of excess solder producing short circuits between adjacent copper strips. With printed circuit boards the copper tracks are mostly much more spaced out, and this is a less common problem. It is not one that can be totally ignored though, and with most printed circuit boards there are areas of the board where the track spacing is minimal. This occurs principly around DIL integrated circuits.

The offending pieces of solder might be easy to spot with the naked eye, but often they are very small and difficult to spot. They can also be hidden under excess flux, of which there is usually no shortage on a completed printed circuit board. It is advisable to use a de-greasing solvent to remove any excess flux from the board prior to making a careful inspection of the underside of the board. Alternatively, a continuity tester can be used to check for short circuits between closely spaced printed circuit tracks, and this is the only certain way of finding any accidental short circuits.

With modern components and solders there is usually no difficulty in producing neat and effective soldered joints. Even so, 'dry' joints are not totally a thing of the past, and these inevitably occur from time to time. It can easily happen, for example, if a lot of flux is allowed to build up on the bit of the soldering iron, or if joints are made by using the bit to transfer solder to the joint rather than adding the bit and then the solder to the joint. It is often possible to find a 'dry' joint simply by looking at the board. A good connection should look like the illustration of Figure 1(a), but a 'dry' joint usually looks more like the shape in Figure 1(b). There is often a lot of excess flux around the joint as well. In fact the flux is often all that holds the board, solder, and leadout wire together.

With a fresh soldered joint the solder should have a shiny surface. A dark and dull surface to the solder is another tell-tale sign of a 'dry' joint. There can be two causes of this, one of which is movement in the joint as it solidifies. This causes the solder to crack and craze, producing an electrically poor connection as well as a mechanically weak one. The other main cause of this type of thing is having the iron applied to the solder for too long so that the flux burns away. This is also something that is likely to happen if soldered joints are made using the soldering iron bit to transfer molten solder to the joint.

To check for a 'dry' joint, a continuity tester (a multimeter set to a low resistance range will do) is used to check for a low resistance between the component's leadout wire and the appropriate printed circuit track. When a 'dry' joint is discovered the solder should be removed from the joint using a desoldering tool or solder wick. Clean the printed circuit track and the end of the leadout wire using something like fine sandpaper or a miniature file, and then solder the connection again. Do not simply try re-applying the soldering iron and some more solder to the joint as this is unlikely to produce a reliable connection.

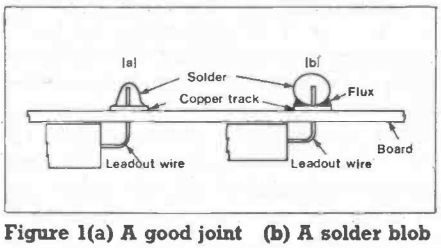


Figure 1(a) A good joint (b) A solder blob

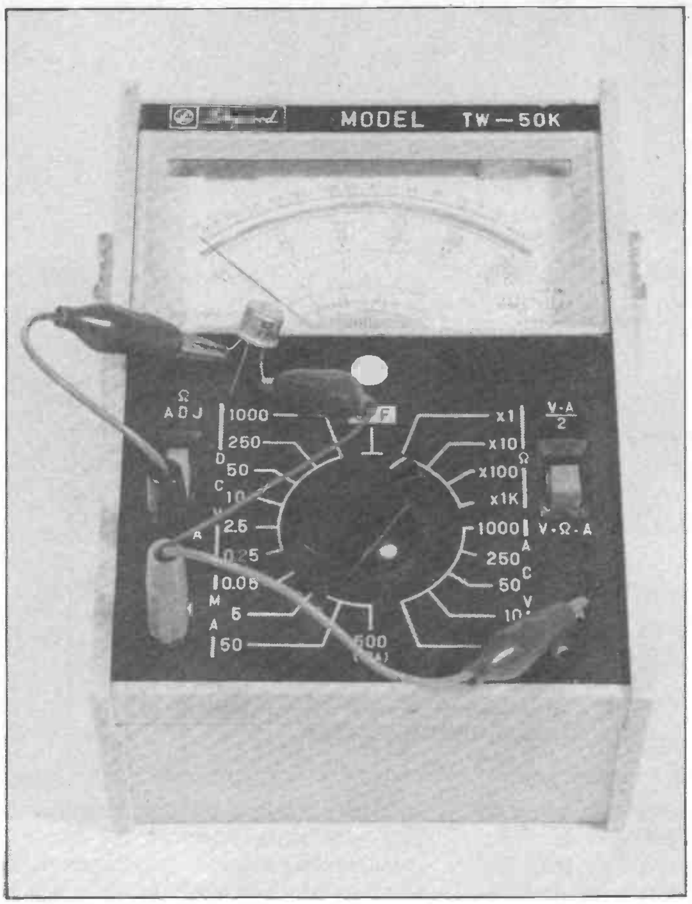
'Dry' joints do not only occur on the printed circuit board, and can also be produced when making connections to off-board components. In fact this is probably when they are most likely to be produced. Prevention is better than cure, and provided the tags of the components and the ends of the connecting wires are generously tinned with solder prior to making the connections, there should be no problems of this type. A continuity tester can be used to test for these 'dry' joints, and the tell-tale signs are again a dull surface to the solder and probably a lot of excess flux as well. Also as much as before, to remedy the situation the solder should be removed from the joint, and the component tag plus the end of the lead then cleaned and tinned with solder before remaking the connection.

Component Testing

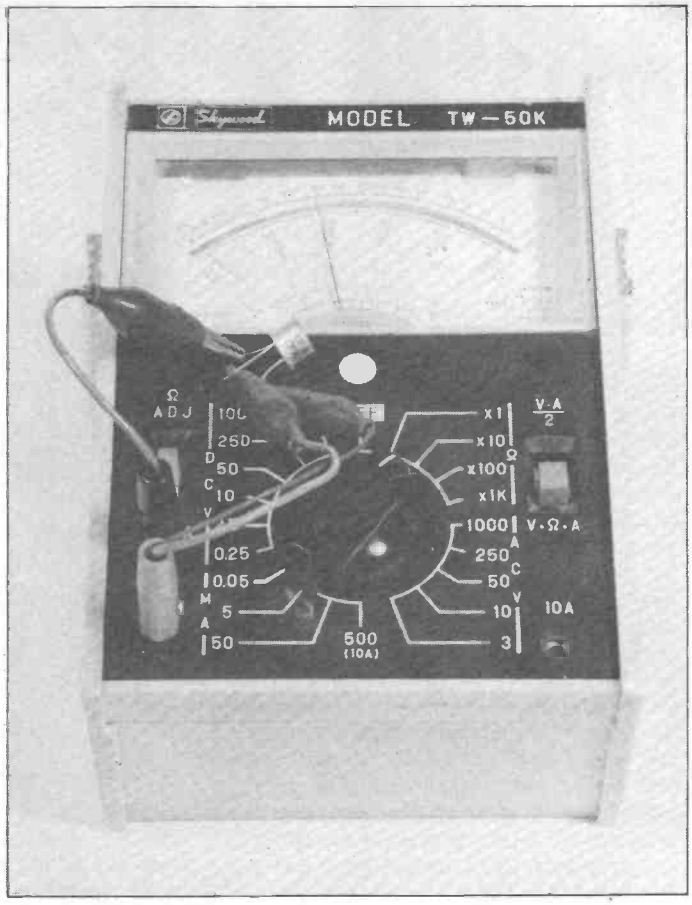
If a thorough check for mechanical faults fails to bring results, then a check for faulty components is the next step. A visual inspection of the components may show up a possible fault. For instance, a resistor or capacitor that has gone rather dark in colour might be indicative of overheating when it was soldered into circuit, with a consequent change in value.

Assuming that there is no clue of this type, it is then a matter of going through the components and testing them one by one. This task can obviously only be undertaken with the aid of some test equipment, but an ordinary analogue multimeter (which is something no electronics constructor should be without) is probably a little more versatile in this respect than most people realise.

Any multimeter should be equipped with a few resistance ranges, and should be capable of testing any resistance value within reason. An important point to bear in mind if you try measuring resistances with the component in-circuit is that other resistances in the circuit could shunt the component you are testing, and give a low resistance reading. If the reading obtained is higher than the marked value of the component then it is certainly faulty. If the reading obtained is much lower than the marked value try reversing the test prods. If a semiconductor junction was shunting the



Testing for Leakage.



Testing for Gain.

resistor and giving a low reading, reversing the test prods will reverse bias the junction so that it has a much higher resistance and does not significantly shunt the resistor. Of course, there could still be resistances in parallel with the resistor under test, but if the expected value is obtained with the test prods one way round or the other then the component is probably alright. If in any doubt, simply desolder one leadout wire so that the resistance can be measured in isolation from the rest of the circuit.

Potentiometers and preset resistors are also easily tested with a multimeter, but check that the resistance from the wiper terminal to each track connection varies properly, and do not merely check for a suitable track resistance. Bear in mind that the tolerances of potentiometers are quite high, being typically about plus and minus 20%, and that the track resistance may therefore be substantially different to the marked value.

Capacitors

Capacitors are difficult to test using just a multimeter, and low values cannot be checked properly. A check that can be made on any capacitor is a leakage test. Simply set the multimeter to a high resistance range and connect it across the capacitor. Apart possibly, from an initial 'kick' from the meter, a very high resistance reading should be obtained. In fact an infinite resistance reading should be obtained when testing non-polarised types. This test almost invariably has to be carried out with one leadout wire disconnected from the printed circuit as stray resistances in the circuit otherwise prevent a suitably high reading from being obtained.

With electrolytic and tantalum capacitors the test prods must be connected to the test capacitor with the correct polarity. Although one might expect the positive test prod to connect to the positive terminal of the multimeter's battery, it actually connects to the negative terminal. Therefore, connect the negative test prod to the positive leadout of the capacitor, and the positive test prod to the negative leadout of the capacitor. Due to the relatively high values of electrolytic and tantalum capacitors it may take some time for the capacitor to fully charge, and for the meter reading to reach a very high value.

Electrolytic types generally have small but significant leakage currents, and for low value types a reading of several megohms or more is satisfactory. For high value types a reading of about a hundred kilohms or more is satisfactory as these should never be used in a part of a circuit where low leakage is important. In order to give a reasonably short charge time when measuring high value capacitors it might be necessary to switch to a lower resistance range.

The 'kick' of the needle when a capacitor is connected to the multimeter can be used as a rough test of a capacitor's value. It is just a matter of first short-circuiting the capacitor to ensure it is fully discharged, and then connecting it to the multimeter (being careful to use the correct polarity where appropriate). Make a note of the peak reading obtained. You can gauge whether or not the component has roughly the correct value by subjecting capacitors of the same value to this test and comparing the peak readings obtained. This is admittedly only a very rough and ready check, and it will only work for capacitors of about 10nF or more in value, but it is better than nothing.

Semiconductors

Diodes and rectifiers are easily checked using a multimeter set to any resistance range. With an analogue type there should be a high resistance reading with the positive test prod connected to the anode and the negative test prod connected to the cathode (the leadout which comes from the end of the component having the coloured band). The reading should be infinity with silicon devices, but with germanium types a reading of a few hundred kilohms or more is acceptable. With the test prods reversed a much lower reading should be obtained, and the precise reading produced is of no importance.

The procedure is much the same with a digital multimeter, but initially a low resistance reading should be obtained, followed by a high resistance reading when the test prods are reversed. A few digital multimeters use an inadequate voltage for this test to work properly with silicon devices, but it will operate properly with the vast majority of digital multimeters.

Transistors

Some multimeters have a built-in transistor checker facility, but most transistors can be tested satisfactorily using an analogue multimeter that does not

Continued on page 57.

Five Easy Pieces

from Robert Penfold

Personal MW Radio

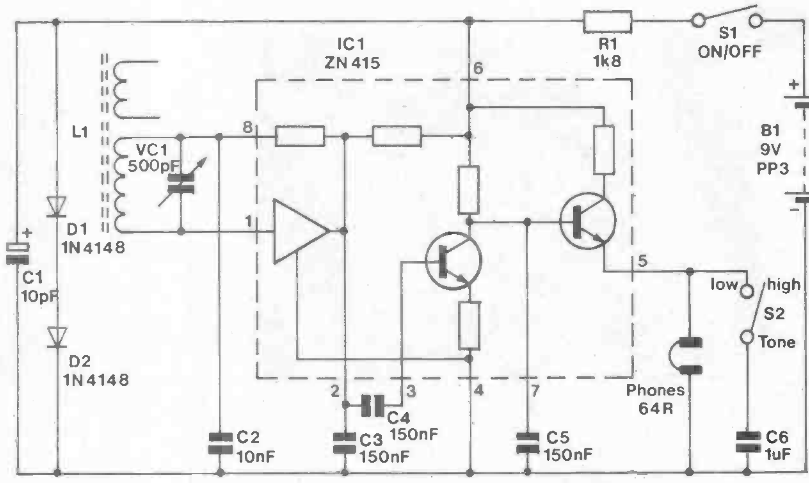
The ZN414 radio integrated circuit has been popular with the home-constructor for a number of years now, but recently two improved versions of the device have been released. One of these is the ZN415, which is basically just the familiar ZN414, but in an 8 pin DIL encapsulation, and including a built-in bias resistor, a load resistor, and a two transistor output stage. In the circuit diagram the area within the broken lines represents the ZN415.

VC1 and L1 are the medium wave ferrite aerial plus tuning capacitor, and the input of the device is biased through the aerial coil in order to minimise loading on the aerial (and give good selectivity). C3 is the RF filter capacitor at the output of the detector. Like the ZN414, a supply potential of about 1.2 to 1.6 volts is needed. This is provided from a small 9 volt battery via a simple voltage regulator which consists of D1, D2, and R1. Alternatively, a single 1.5 volt cell can be used as the power source, in which case D1 and D2 are omitted, while R1 is replaced with a shorting link. The current consumption of the circuit is only about 4 milliamps incidentally.

The output stage of the unit may seem a little strange, consisting of a very low gain common emitter amplifier followed by an emitter follower stage which provides only a modest maximum output current. It is in fact designed specifically to drive medium impedance headphones of the type used with personal stereo cassette players and radios. The maximum drive available is rather limited, and the very high volume levels that can be achieved using this type of headphone cannot be obtained from this circuit. However, the volume from any reasonably strong station is sufficiently loud for most requirements, and the audio quality is suprisingly good provided headphones of adequate quality are used. For best results the headphones should be connected in series and not in parallel.

C5 is an RF filter capacitor and is needed to prevent instability. The bandwidth of the receiver is quite wide, which helps to give good treble response and audio quality. On the other hand, this can often result in a quite high level of interference. Closing S1 shunts C6 across the headphones and gives a reduction in the treble response.

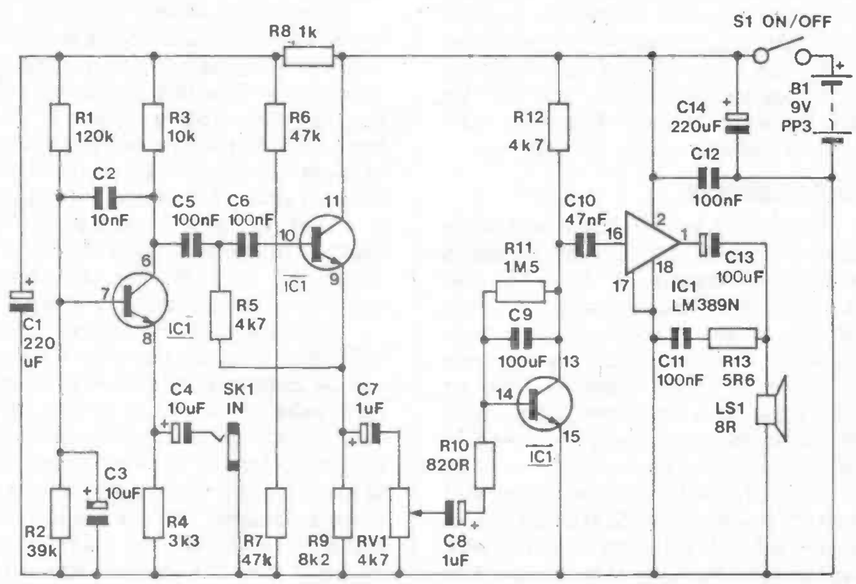
L1 can be any medium wave ferrite aerial. The position of the coil on the rod is adjusted to give full coverage of the medium waveband. Most aerials of this type have a low impedance coupling winding, but in this case the coupling winding is not needed and is either removed or just ignored. The specified aerial includes a longwave winding which is removed from the rod. It would be perfectly feasible to have a changeover switch to select either the medium or longwave winding, and thus provide dual band operation. However, the ZN415 is not at its most sensitive at the frequencies involved in longwave reception, and as reception conditions on this band are very poor in many areas anyway, this is probably not a worthwhile modification.



Telephone Amplifier

A telephone amplifier is simply a device which boosts the audio output of a telephone to a sufficient level to drive a small loudspeaker at reasonable volume to enable several people to follow a telephone conversation. The normal method of connection to the telephone is via a special pick-up coil which receives the signal radiated by an inductive component inside the telephone. Apart from avoiding possible legal problems associated with direct connections to the telephone system, this is a very convenient way of doing things since the telephone amplifier can be set up ready for use in a matter of a few seconds. One slight problem with this system is the need for a high gain amplifier to boost the minute output signal of the pick-up coil to a sufficient level to drive a loudspeaker.

This telephone amplifier is based on the very useful LM389N audio amplifier device. This is very similar to the well-known LM380N integrated circuit, but it has three transistors in addition to the audio power amplifier section. This gives great versatility and the LM389N is



well-suited to an application such as this. To make the operation of the unit clearer the three transistors have been shown as if they were discrete components in the circuit diagram, but the pin numbers have been included alongside each one.

TR1 is used as a common base input stage. This effectively acts as a step-up transformer which takes the low level, low impedance output from the pick-up and provides a higher voltage, higher impedance output signal. This is coupled to the next stage of the unit which is a 12dB per octave highpass filter. There is little point in having a good low frequency response as these frequencies do not contribute to the intelligibility of a voice signal, and are unlikely to be present on the input signal anyway. The use of highpass filtering helps to give an improved signal to noise ratio, and in particular it helps to reduce any mains 'hum' that is picked up by the unit. The cut off frequency of the filter is about 300Hz.

The output of TR2 is coupled to volume control RV1, and then the signal is taken to the input of a high gain common emitter amplifier based on TR3. C9 provides a certain amount of low-pass filtering, as does C2 at the input stage, and this helps to give an improved signal to noise ratio with reduced background 'hiss'. The output from TR3 is coupled by C10 to the input of the power amplifier, which is a conventional class B type. An output power of about 200 to 300 milliwatts RMS into an 8 ohm impedance loudspeaker is available.

The pick-up coil is mounted on the base section of the telephone by means of the built-in suction cup. A little experimentation will soon determine the position that gives optimum signal pick-up, but for the current (standard style) telephones this will be roughly at the centre of the right hand side. Keep the loudspeaker reasonably well away from the handset and do not advance the volume control too far or there may be problems with acoustic feedback.

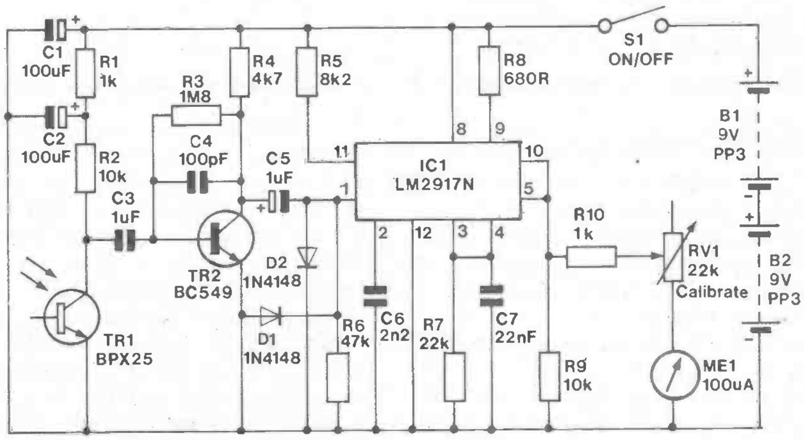
Opto-Coupled RPM Meter

Most RPM meters are designed for use in cars and obtain the input pulses from the ignition circuit of the car. This is obviously a technique which cannot be applied to most other applications where an RPM meter would be of use. There are two common ways of obtaining suitable timing pulses where none are produced by the machine being monitored. One is to use an optical circuit and the other is to use a system based on magnetic sensors (with suitable activating magnets positioned on the rotating shaft). The optical method is generally the more simple and inexpensive, and one that can be applied to virtually any set up.

The pulse counting section of this circuit is a conventional type based on the LM2917N frequency to voltage converter chip. With the specified values the circuit has a nominal full scale frequency of 333.33Hz. This corresponds to 20000 RPM with one pulse per revolution, or more realistically, 10000 RPM with two pulses and 5000 RPM with four pulses per revolution. However, the full scale frequency/RPM value can easily be modified by changing the value of C6 (reduced value giving a proportional increase in full scale frequency).

The sensor circuit consists of photo transistor TR1 and load resistor R2. The base terminal of TR1 is left unconnected, and the collector to emitter terminals are connected to form a sort of light dependent resistor. The BPX25 phototransistor has a built-in lens which makes the device highly directional and helps to avoid spurious trigger pulses from being generated. The Maplin 'Low Cost Phototransistor'(YY66W) also seems to work quite well in the circuit, and is a useful low cost alternative to the BPX25.

The output from the sensor circuit is likely to be far too small to directly drive IC1, and TR2 is therefore used as a high gain common emitter amplifier which boosts the signal to a suitably high amplitude. D1 prevents the input of IC1 from being taken strongly negative, which would cause a malfunction in the device.



The circuit is very sensitive, and in order to produce usable results it is merely necessary to have patches on the monitored shaft that contrast with the shaft itself. For instance, with a highly reflective metallic shaft, spots of matt black paint would be used. The reduction in the light level received by TR1 as these spots pass in front of it would then generate the required timing pulses. The circuit does not require a high light level in order to produce proper operation, but it obviously cannot operate in total darkness.

If the circuit proves to be over-sensitive, connecting a resistor of about 470Ω in series with the emitter of TR2 should cure the problem. An easy way of obtaining a calibration signal for the unit is to simply aim TR1 at a mains powered tungsten light. This gives a 100Hz calibration frequency.

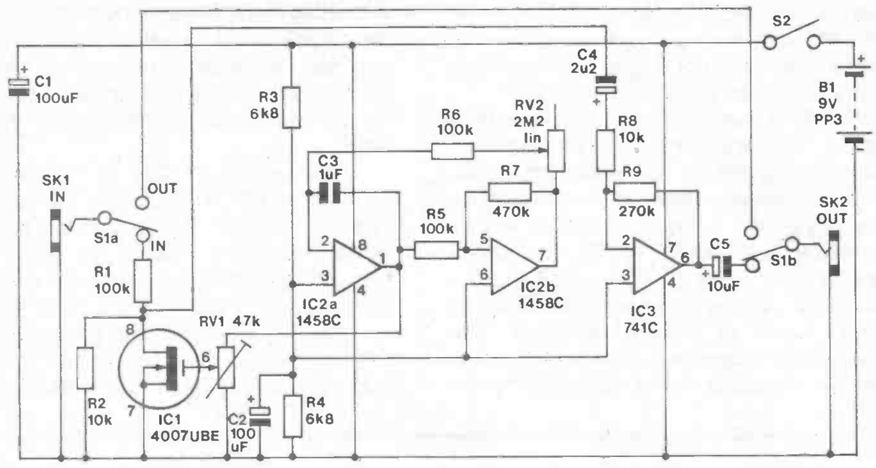
Tremolo Unit

A tremolo unit is one of the most simple types of musical effects unit, although one would probably not guess this from the prices of ready-made units. The design featured here can be built at low cost but it nevertheless has a high level of performance.

The function of a tremolo unit is to amplitude modulate an input signal, with the modulation frequency being variable from typically about 0.5 to 5Hz or so. The modulation waveform must be one that has a low harmonic content, such as a sine or triangular type, so that a smooth and pleasant effect is produced. In this circuit the modulation signal is generated by IC2 which is a dual operational amplifier used as a conventional triangular waveform generator. This is a form of relaxation oscillator which uses IC2a as a Miller Integrator, and IC2b as a Schmitt Trigger. This gives a squarewave output from IC2b, and the required triangular waveform from IC2a. Timing capacitor C3 charges and discharges via R6 and RV2, and the operating frequency of the oscillator can therefore be controlled using RV2. This gives an approximate frequency range of 0.5Hz to 10Hz.

The modulator uses MOSFET IC1 as a simple voltage controlled resistor. IC1 is a CMOS 4007UBE device, which contains two complementary pairs and an inverter. In this design, only one (N channel) transistor of one complementary pair is used and the other parts of the device are totally ignored. The drain to source resistance of IC1 forms an attenuator in conjunction with R1. However, R2 is connected in parallel with IC1, and this ensures that there is always a loss of 20dB or more through the attenuator. This is to keep the signal voltage across IC1 at a low level so that good distortion performance is obtained. The losses through the attenuator reach a maximum of about 50dB with IC1 biased into saturation. The gate of IC1 is driven from the output of the modulation oscillator via RV1. The latter is adjusted to give an input voltage range to IC1 that gives good symmetrical modulation, and this is really just a matter of adjusting RV1 to obtain what is judged to be the best effect, unless suitable test gear (an AF signal generator and an oscilloscope) is to hand.

IC3 is used as an amplifier and buffer stage which compensates for the losses through the attenuator and provides the unit with a low output impedance. S1 is a bypass switch, and in practice this is a heavy duty (latching) push button switch mounted on the top panel of the case so that it can be foot operated. The case must be a strong type, such as a diecast aluminium box. The current consumption of the circuit is very low at only about 4 milliamps.



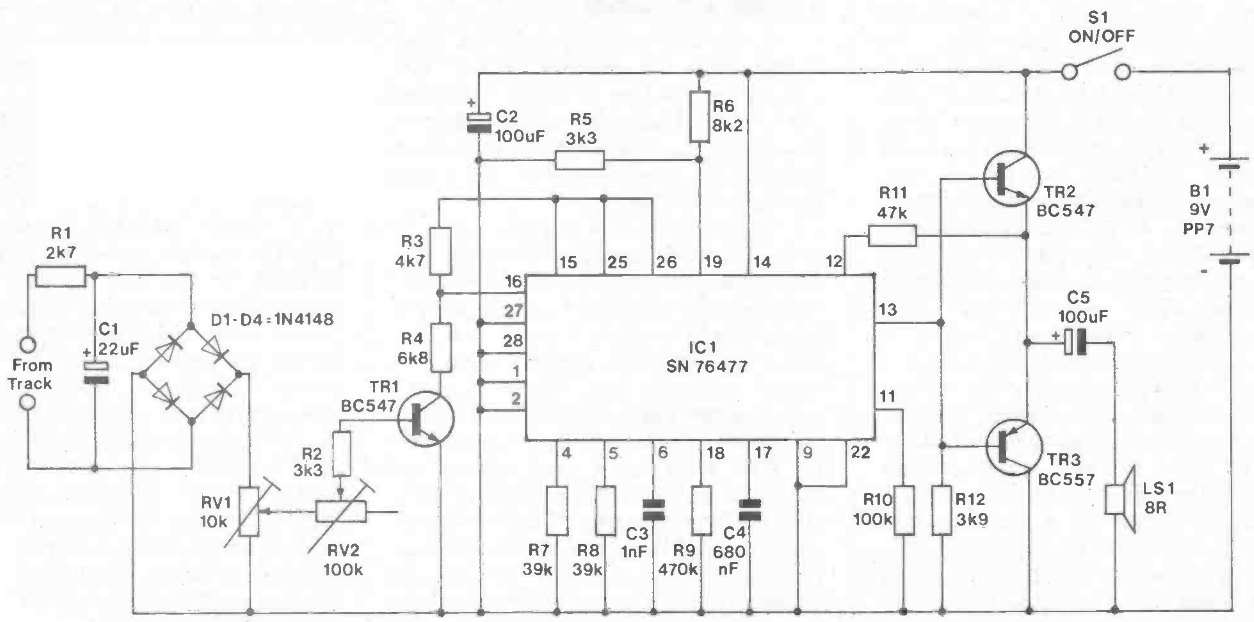
Model Train Chuffer

Sound effects can greatly enhance the realism of a model railway layout, and one of the most popular of these is the 'chuffer' effect. As its name suggests, it simply makes a 'chuffing' sound like a steam locomotive, but ideally a unit of this type should be designed so that the 'chuff' rate approximately matches the speed of the train. This is done by monitoring the track voltage and varying the 'chuff' rate in sympathy with this.

The 'chuffer' circuit shown here is based on the popular SN76477 sounds generator device, and this contains a number of stages including a VCO, super low frequency oscillator, noise source and filter, a mixer, a modulator and an envelope generator. In this case it is mainly the VCO, the noise source, and the modulator that are of interest. The noise generator gives the basic 'hissing' steam sound, while the VCO, in conjunction with the modulator, is used to amplitude modulate the noise signal to give the 'chuffing' effect.

The noise generator is a high quality digital type using a clock oscillator and shift register arrangement. R7 is part of the clock oscillator circuit, while R8 and C3 are discrete components in the noise filter. These give a small amount of low-pass filtering which gives a slightly lower pitched sound that is better for this application. R9 and C4 are the timing components for the VCO, and these have quite high values in order to provide a suitably low output frequency range. R10 controls the amplitude of the output signal while R5 and R6 control the timbre (the on to off ratio of the noise signal). The SN76477 has a built-in driver stage, but an external complementary output stage (TR2 and TR3) is required. R12 is the load resistor for the driver stage and R11 is a bias resistor. An output of around two or three hundred milliwatts RMS is provided into an 8 ohm impedance loudspeaker. The SN76477 has numerous control inputs, and these are either tied to earth or the stabilised 5 volt supply output at pin 15 in order to program the correct operating mode for this application.

The frequency of the VCO is controlled by the voltage fed to pin 16 of IC1. This voltage must be in the range 0 to 2.4 volts, with maximum voltage corresponding to minimum frequency. The track voltage, which may well be a pulsed DC signal, is smoothed by R1 and C1. D1 to D4 form a bridge rectifier which ensures that the voltage applied to the next stage is of the correct polarity. This stage is an inverter which uses TR1 in the common emitter mode. This converts the track voltage, which will be in the range 0 to about 15 volts, into a (roughly) 2.4 to 0 volt control voltage for the VCO. RV1 is adjusted so that the VCO switches on at the same track voltage that causes the train to start. Incidentally, there is a steady 'hissing' steam sound when the train is stationary and the VCO is cut off. RV2 is adjusted so that the VCO only just achieves maximum frequency with the train at full speed. After repeating adjustment of RV1 and RV2 two or three times the 'chuff' rate should vary realistically in sympathy with the speed of the train.



MODEL TRAIN CHUFFER PARTS LIST

RESISTORS: All 0.4W 1% Metal Film			
R1	2k7	1	(M2K7)
R2,5	3k3	2	(M3k3)
R3	4k7	1	(M4K7)
R4	6k8	1	(M6K8)
R6	8k2	1	(M8K2)
R7,8	39k	2	(M39K)
R9	470k	1	(M470K)
R10	100k	1	(M100K)
R11	47k	1	(M47K)
R12	3k9	1	(M3K9)
RV1	10k Sub-Min Hor Preset	1	(WR58N)
RV2	100k Sub-Min Hor Preset	1	(WR61R)
CAPACITORS			
C1	22μF Reversolytic	1	(FB08J)
C2,5	100μF 10V Axial Electrolytic	2	(FB48C)
C3	1nF Polystyrene	1	(BX35Q)
C4	680nF Polycarbonate	1	(WW51F)
SEMICONDUCTORS			
IC1	SN76477	1	(YH32K)
TR1,2	BC547	2	(QQ14Q)
TR3	BC557	1	(QQ16S)
D1,2,3,4	1N4148	4	(QL80B)
MISCELLANEOUS			
B1	9 Volt (PP7) Battery	1	
S1	Min SPST Toggle	1	(FH97F)
	Battery Clips	1 pr	(HF27E)
	28-pin DIL IC Socket	1	(BL21X)

TREMOLO UNIT PARTS LIST

RESISTORS: All 0.4W 1% Metal Film			
R1,5,6	100k	3	(M100K)
R2,8	10k	2	(M10K)
R3,4	6k8	2	(M6K8)
R7	470k	1	(M470K)
R9	270k	1	(M270K)
RV1	47k Sub-Min Hor Preset	1	(WR60Q)
RV2	2M2 Lin Pot	1	(FW09K)
CAPACITORS			
C1,2	100μF 10V Axial Electrolytic	2	(FB48C)
C3	1μF Polycarbonate	1	(WW53H)
C4	2μ2 63V Axial Electrolytic	1	(FB15R)
C5	10μF 25V Axial Electrolytic	1	(FB22Y)
SEMICONDUCTORS			
IC1	4007UBE	1	(QX04E)
IC2	1458C	1	(QH46A)
IC3	μA741C	1	(QL22Y)
MISCELLANEOUS			
S1	DPDT Push Button	1	(FH93B)
S2	SPST Min Toggle	1	(FH97F)
B1	9 Volt (PP3) Battery	1	
SK1,2	Standard Jack	2	(HF90X)
	14-pin DIL IC Socket	1	(BL18U)

TELEPHONE AMPLIFIER PARTS LIST

RESISTORS: All 0.4W 1% Metal Film			
R1	120k	1	(M120K)
R2	39k	1	(M39K)
R3	10k	1	(M10K)
R4	3k3	1	(M3K3)
R5,12	4k7	2	(M4K7)
R6,7	47k	2	(M47K)
R8	1k	1	(M1K)
R9	8k2	1	(M8K2)
R10	820Ω	1	(M820R)
R11	1M5	1	(M1M5)
R13	5.6Ω	1	(M5R6)
RV1	4k7 Log Pot	1	(FW21X)
CAPACITORS			
C1,14	220μF 10V Axial Electrolytic	2	(FB60Q)
C2	10nF Polycarbonate	1	(WW29G)
C3,4	10μF 25V Axial Electrolytic	2	(FB22Y)
C5,6	100nF Polycarbonate	2	(WW41U)
C7,8	1μF 63V Axial Electrolytic	2	(FB12N)
C9	100pF Ceramic	1	(WX56L)
C10	47nF Polycarbonate	1	(WW37S)
C11,12	100nF Ceramic	2	(BX03D)
C13	100μF Axial Electrolytic	1	(FB48C)
SEMICONDUCTORS			
IC1	LM389N	1	(WQ36P)
MISCELLANEOUS			
LS1	76mm dia 8Ω Speaker	1	(YW53H)
SK1	3.5mm Jack	1	(HF82D)
S1	SPST Sub-Min Toggle	1	(FH97F)
B1	9 Volt (PP3) Battery	1	
	Telephone Pick-up Coil	1	(LB92A)
	18-pin DIL IC Socket	1	(HQ76H)
	Battery Connector	1	(HF28F)

PERSONAL MW RADIO PARTS LIST

RESISTOR: 0.4W 1% Metal Film			
R1	1k8	1	(M1K8)
CAPACITORS			
C1	10μF 25V Axial Electrolytic	1	(FB22Y)
C2,5	10nF Polycarbonate	2	(WW29G)
C3,4	150nF Polycarbonate	2	(WW43W)
C6	1μF Polycarbonate	1	(WW53H)
SEMICONDUCTORS			
IC1	ZN415E	1	(QY61R)
D1,2	1N4148	2	(QL80B)
MISCELLANEOUS			
L1	Ferrite Aerial	1	(LB12N)
S1,2	SPST Sub-Min Toggle	2	(FH97F)
B1	9 Volt (PP3) Battery	1	
	Battery Connector	1	(HF28F)
	Headphones	1	(YK56L)
	8-pin DIL IC Socket	1	(BL17T)

The IC used in the MW Radio is not shown in our current catalogue.
Order As QY61R ZN415E Price £1.95

OPTO-COUPLED RPM METER PARTS LIST

RESISTORS: All 0.4W 1% Metal Film			
R1,10	1k	2	(M1K)
R2,9	10k	2	(M10K)
R3	1M8	1	(M1M8)
R4	4k7	1	(M4K7)
R5	8k2	1	M8K2)
R6	47k	1	(M47K)
R7	22k	1	(M22K)
R8	680Ω	1	(M680R)
RV1	22k Sub-Min Hor Preset	1	(WR59P)
CAPACITORS			
C1,2	100μF Axial Electrolytic	2	(FB49D)
C3	1μF Polycarbonate	1	(WW53H)
C4	100pF Ceramic	1	(WX56L)
C5	1μF 63V Axial Electrolytic	1	(FB12N)
C6	2n2 Polycarbonate	1	(WW24B)
C7	22nF Polycarbonate	1	(WW33L)
SEMICONDUCTORS			
IC1	LM2917N	1	(WQ38R)
TR1	BPX25	1	(QF30H)
TR2	BC549	1	(QQ15R)
D1,2	1N4148	2	(QL80B)
MISCELLANEOUS			
S1	SPST Sub-Min Toggle	1	(FH97F)
B1,2	9 Volt (PP3) Battery	2	
ME1	100μA Panel Meter	1	(RW92A)
	14-pin DIL IC Socket	1	(BL18U)

ALL ABOUT THE TELEPHONE

by Robert Kirsch

The telephone has for many years been something most people have taken for granted both at home and in the office. The recent loss of monopoly by British Telecom, (formally the Post Office) has generated a new interest in telephony by the general public as they may now buy and install their own approved telephone equipment.

This article describes briefly the history and operation of the telephone as we know it today. Information about the use of the new Line Jack units is also included although it must be noted that only British Telecom may install the Master Line Jack unit and no connections may be made to the P.S.T.N. (Public Switched Telephone Network) without British Telecom approval.

History

The origins of the telephone can be traced as far back as 1854 when a Frenchman called Charles Bourseul suggested that it was possible to transmit speech "by electricity". Phillip Reis, a German physicist, produced the first transmitter (microphone) in 1861 but it was not until 1875 that the first practical telephone was developed by Alexander Graham Bell. The principle of Bell's first instrument was that when sound waves vibrate a magnetic diaphragm in the field of an electro magnet, the current flowing through the coils of the electro magnet would vary in sympathy with the sound. The principle is still used today in the receiver (telephone earpiece). This device, although making a good receiver, was not very sensitive as a microphone. The problem was overcome by the invention, in about 1880 by the Reverend Hunnings, of the variable resistance microphone using carbon granules. This type of transmitter is still in use in many of the older telephones although the electret and dynamic microphone are now being used as their relatively low output can be amplified in the telephone by semiconductor devices powered from the line current.

How the Telephone Works

Figure 1. shows a basic telephone circuit using carbon microphones and electromagnetic receivers. This system will work, but there are several disadvantages. One problem is that direct current flows through the receiver which is undesirable. Another is that speech from one transmitter will be received at the same volume by both receivers, giving an unacceptable sound level at the sending end. This effect is called 'sidetone' and all telephones are fitted with an anti-sidetone circuit to reduce the level.

Figure 2 shows the block diagram of

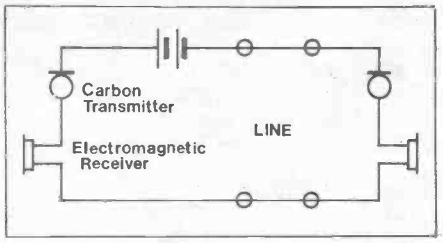
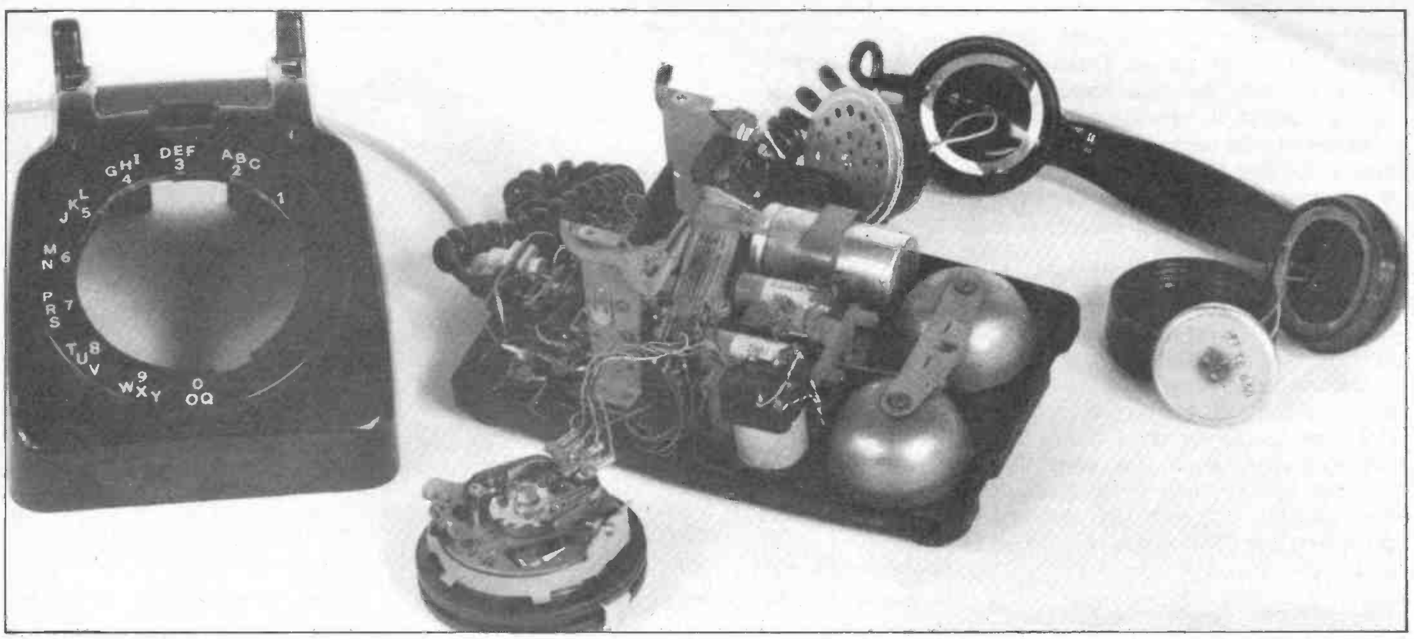


Figure 1. Simple Telephone Circuit



a practical telephone including transmitter, receiver and anti-sidetone circuit as well as the contacts, called the 'switch hook springs' operated by the handset when in its cradle. Figure 3 is the circuit of an actual telephone of older design.

Dialling is accomplished by disconnecting the loop through the telephone (when the handset is raised) for a short duration (67ms), for a number of times depending upon the number dialled. The telephone dial is a clockwork device that is wound by the clockwise rotation of the finger plate and is returned by the action of a spring, its speed being controlled by a governor. The dial, in its return direction, breaks a set of contacts a number of times, corresponding to the number dialled. Note that when 0 is dialled the circuit is interrupted 10 times. The dial also has contacts to short out the receiver,

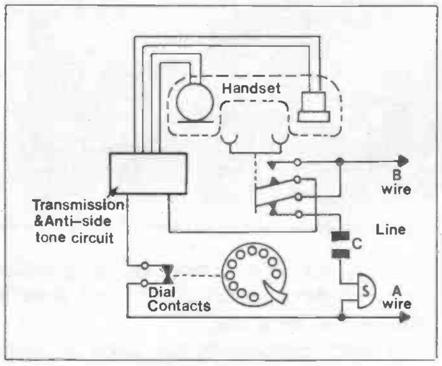
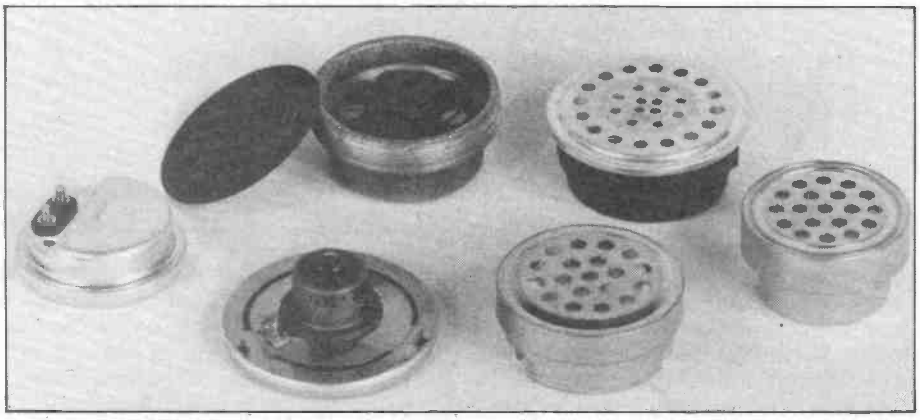


Figure 2. Simplified schematic of standard telephone



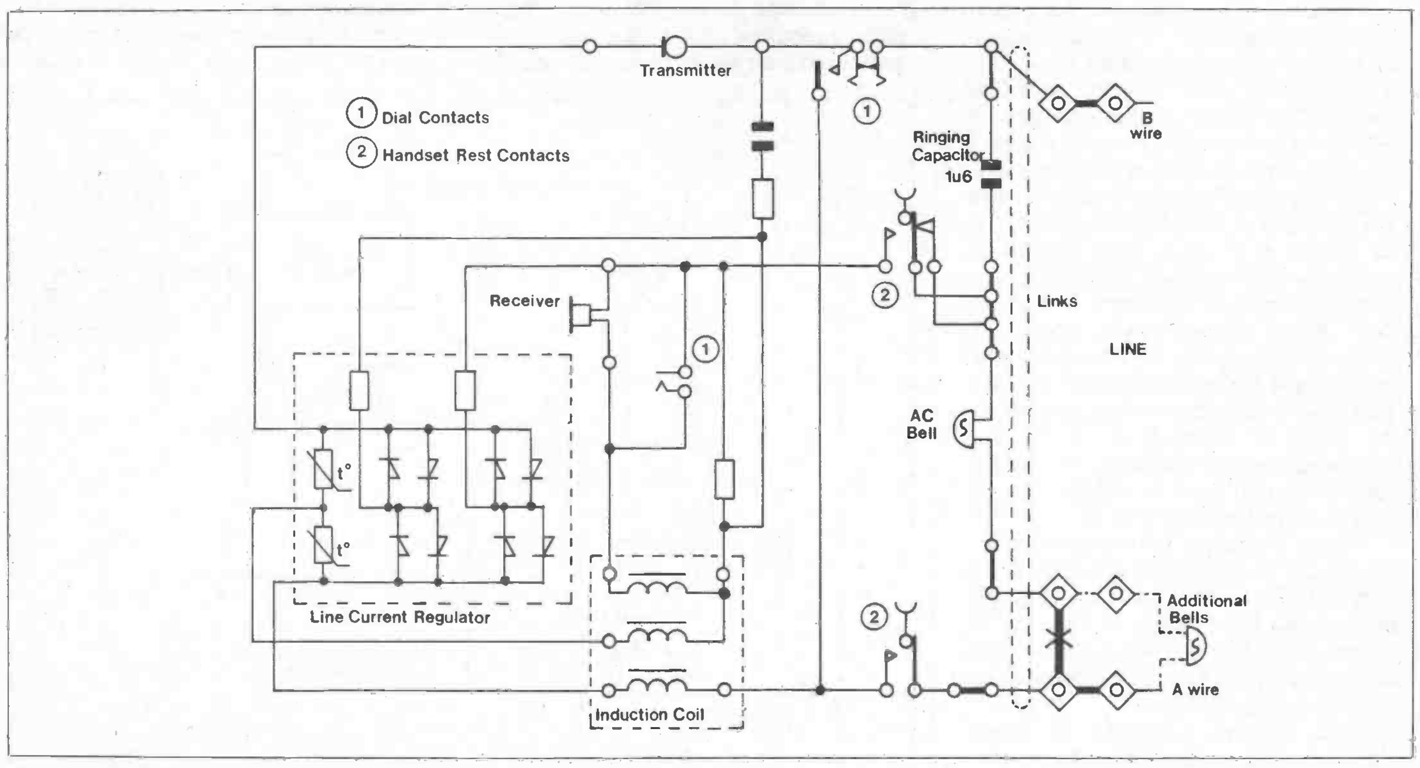


Figure 3. Circuit of telephone type 706

thus preventing an annoying clicking caused by the dial pulses. There are also contacts to short the transmission circuits during pulsing, to provide a lower loop resistance to the exchange during the 'on' time of the dial. The standard dial rate in this country is 10 pulses per second.

The telephone bell is rung by an A.C. signal of about 90 volts sent from the exchange. This relatively high voltage was used to provide sufficient energy to ring bells over long distances. The capacitor provided in the bell circuit presents a low impedance to A.C. ringing but prevents the bell causing a permanent D.C. loop across the line and thus calling the exchange, as in the case of the handset being lifted. When more than one telephone is used, one capacitor is provided and all the bells are wired in series.

Modern Developments

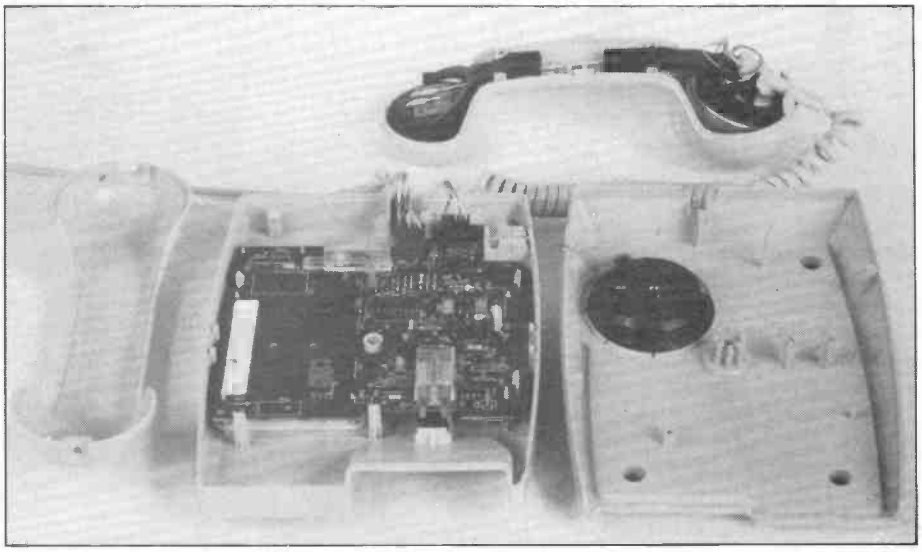
A telephone system designed today, would be very different from the present one, due to advances in technology. The existing system is so large that it would be impossible to change all the equipment at one time, although work has already begun on upgrading the system in some parts of the country. This means that modern telephones, used on the old system, use new technology to produce improved results, but must be compatible with techniques in use at the beginning of the century. There follows a brief description of areas in which new techniques have benefitted the performance of the telephone. Figure 4 shows a typical block diagram of a modern telephone.

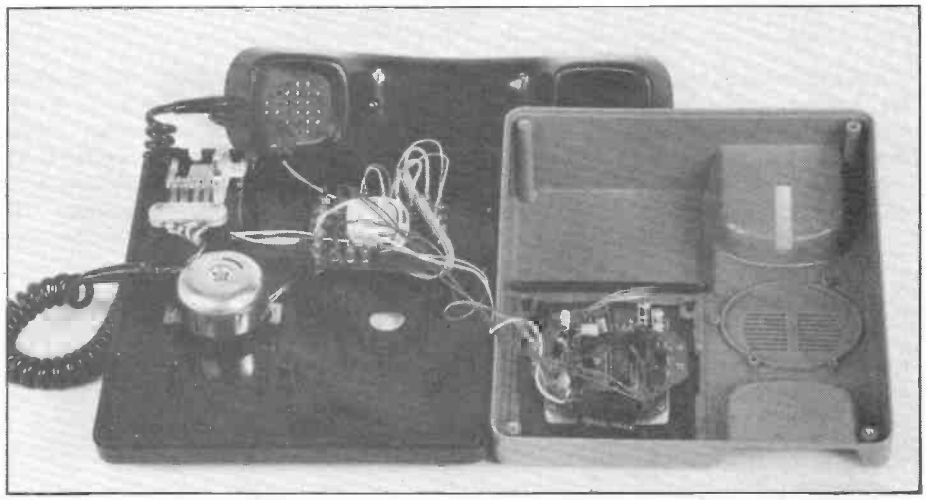
The transmission system has been greatly improved by the use of dynamic or electret microphones with solid state amplification and sidetone suppression within the telephone, powered by line current. This results in a better quality and level of speech even over long lines.

Most modern telephones have push button dialling. This is usually accomplished by using a dedicated IC (e.g.the AY-5-9158 or the Mullard PCD3320 series). This device converts the keypad information into loop disconnect pulses of the same form as those of the rotary dial. These IC's often have the facility to store the last number dialled and to re-dial it at the press of a single key. The actual pulsing is accomplished by a reed relay or a transistor in series with the telephone loop. When a transistor is used it is connected across the DC side of a bridge rectifier and the loop across the AC side. This is to ensure the correct polarity for the transistor irrespective of the line connection to the telephone. The bridge rectifier is also used to provide the DC supply for the internal circuits.

Tone Dialling is now slowly replacing the old loop disconnect system and it is called DTMF (dual tone multi-frequency) and has been in use in America for many years. This system enables rapid dialling and is particularly suited to microprocessor applications.

The modern telephone no longer uses a bell; instead another IC is commonly used to provide indication of an





incoming call. This IC also is usually fed from a bridge rectifier, but in this case the AC ringing is fed to it via a capacitor. The rectified output is then used to supply the ringer IC whose output is connected to a small loudspeaker or piezo sounder. Due to the relatively low current required for the electronic ringer compared with the conventional bell, the ringers are now connected in parallel, but a single capacitor is still used, fitted in the master jack unit.

Microprocessors are used in many modern telephones and these can provide many new features including multi-number storage and call metering; allowing the customer to know the cost of a call as it is being made. Figure 5 shows a

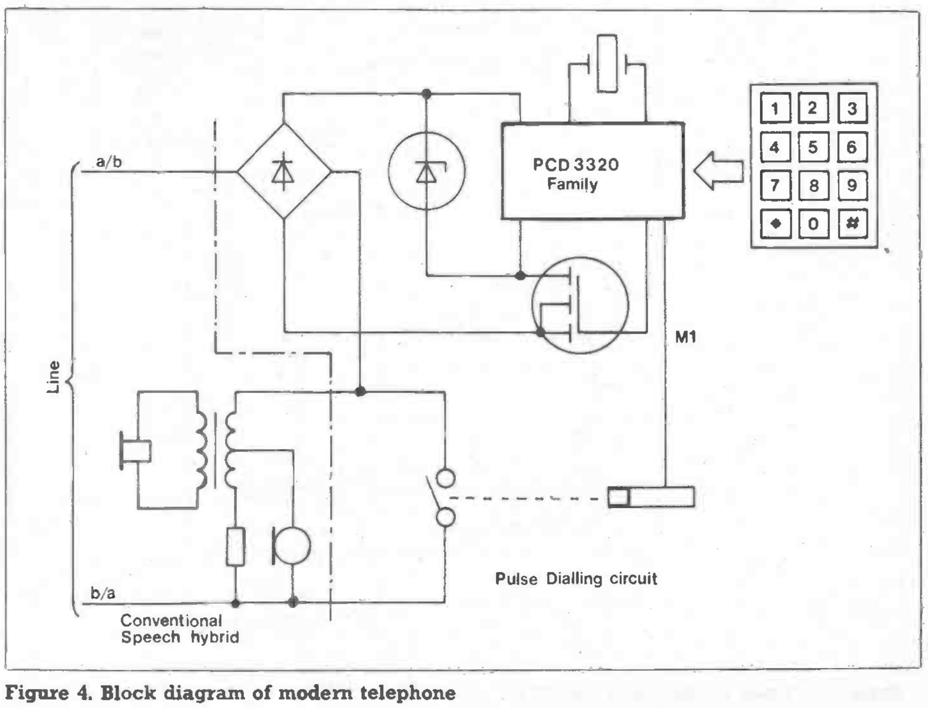


Figure 4. Block diagram of modern telephone

typical state of the art telephone using Mullard IC's.

Line Jack Units

Modern telephone installations use Line Jack sockets. This system has several advantages as customers may now buy and install their own (approved) telephone apparatus and simply plug it in. Also if several sockets are fitted, the customer can move the telephone from room to room or have as many instruments as he requires. This system also helps in the tracing of faults on an installation as customers equipment can be easily disconnected.

The Master Jack Unit is fitted by B.T. and contains the ringing capacitor and a discharge tube (for line and equipment protection against high voltages), see Figure 6. The two wires from the exchange are referred to as the A and B wires and it will be seen that all telephones are connected between A and B wire but all ringers are connected between the shunt wire (via the capacitor) and the A wire.

Several accessories are now available to plug into the line jack sockets including adaptors for various types of telephone and a dual outlet adaptor which is particularly suited for the use of direct connect modems where it is desirable to have the telephone and the modem in parallel.

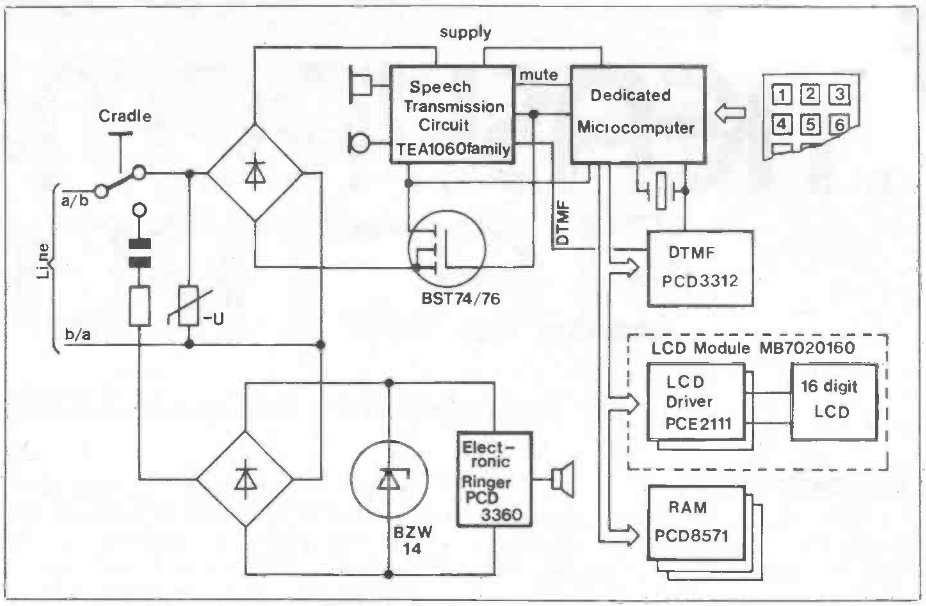


Figure 5. Microprocessor controlled telephone

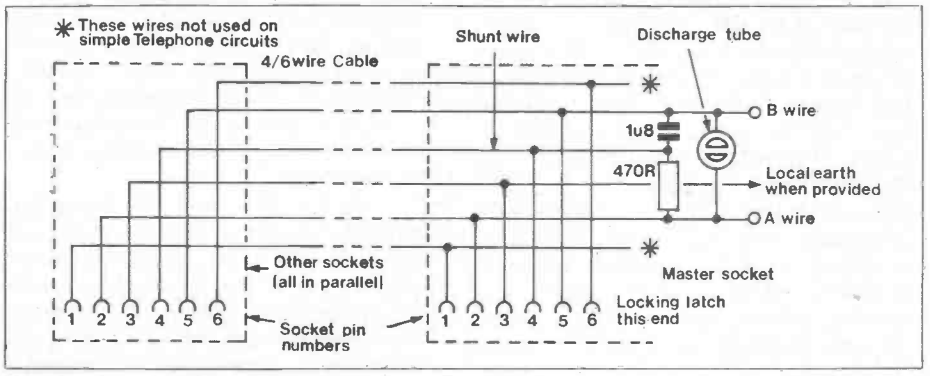


Figure 6. Line jack wiring

PROJECT FAULT FINDING *Continued from page 49.*

have this facility. To test npn transistors for leakage, set the multimeter to its highest resistance range, and then connect the emitter and collector terminals to the positive and negative test prods respectively. The test is basically the same for pnp transistors. The only difference is that the test prods are connected around the other way (positive to the collector, negative to the emitter). Silicon transistors should give an extremely high resistance reading, probably with no noticeable deflection of the meter at all, but be careful not to touch the base leadout wire when making this test or erroneous results could be produced. Germanium transistors often have significant leakage currents, and this test is of little worth with these devices.

It is easy to make a rough check to see if a transistor has a reasonable level of current gain, and the basic set-up is similar to that used for leakage tests. It is better to use a lower resistance range though, so that the transistor is tested at a reasonable collector current. A resistance range having a half scale value of around 100Ω to 1k should suffice. A resistor of about 100k in value is connected between the collector and base terminals of the transistor under test, and there should be no difficulty in making up a set of test leads which include this resistor. If the test device is serviceable the resistance reading obtained should be much lower than the 100k resistance of the base feed resistor. The lower the resistance reading obtained, the higher the gain of the device under test. A high reading of about 30k or more indicates that the transistor under test has little or no current gain, and is unusable. This test may not be effective with some germanium devices due to their high leakage currents, and it may not be effective with some power transistors as these are designed to operate at much higher currents than the test currents used with this set-up. This simple method of testing will work well with the vast majority of transistors though.

Most other semiconductor devices cannot be checked easily, and must be tested using in-circuit voltage checks or by building a simple test circuit. Assuming that you are unable to undertake this type of check, there is little alternative to replacing a semiconductor such as an integrated circuit, which is a suspected 'dud'.

Switches can easily be tested using a continuity tester or a multimeter set to a low resistance range. Due to their mechanical nature switches are amongst the components that are most likely to fail. Apart from checking for a fault, using a continuity tester also enables you to check whether or not you have correctly identified the tags of the component.

A multimeter set to a low resistance range can also be used to give transformers and inductors a rough check. With small inductors there should be no significant resistance through the components. Similarly, with RF coils there should be no significant resistance through each winding, but there should, of course, be an extremely high resistance between one winding and another. Things are much the same with large inductors and low frequency transformers, but a resistance of a few tens of ohms (or even a few hundred ohms) may be present across the windings. The most common fault in transformers and inductors is a break in the winding, and this should be readily shown up by a continuity check (and the lack of continuity). More complex faults such as shorted turns are not likely to be brought to light by a continuity check, unless a large winding has a suspiciously low resistance.

The methods of checking described here have the advantage of needing little or no test equipment, and a similar degree of technical knowledge. These methods are rather 'hit and miss' though, and if the fault is traced rapidly this is achieved by sheer luck. In the next article we will look at logical methods of fault finding which require slightly more equipment and technical know-how, but should give much speedier fault diagnosis.

MEASUREMENTS IN ELECTRONICS

By Graham Dixey C.Eng., M.I.E.R.E. Part Four

Introduction

The testing of digital equipment requires a slightly different approach from the testing of linear circuits. The approach still has to be a logical one, of course, and disciplined but there is unlikely to be the multiplicity of instruments to choose from. Therefore, it is not so much the correct choice of instrument that matters as knowing how to use the basic few that are normally accepted as being required. A real advantage of digital testing is that quite useful pieces of test equipment can be assembled at little cost; nonetheless they can be used to test a variety of circuits such as counters, registers, microcomputer inputs and outputs, indeed quite complex digital systems. Naturally, there are other more sophisticated items of test equipment such as logic analysers that can be very useful at times but most work can be done very simply. For this reason this article will include a number of circuits that can be made up cheaply but which will allow a variety of digital circuits to be examined for correct functioning.

Digital versus Analogue Signals

The clue to the differing degrees of complexity in digital and analogue test equipment lies in the 'signals' themselves. An anologue signal may occupy a wide range of amplitudes from a few micro-volts to many volts; its frequency may lie between a fraction of 1Hz and many MHz. For this reason a voltmeter of high sensitivity and wide bandwidth may be needed in order to measure it. Its waveform, if it is not a pure sinewave, may also be a complicating factor. Digital signals, on the other hand, occupy only one of two possible levels – in theory anyway. These levels may be continuous i.e. d.c. or may consist of pulses varying in length from a few seconds down to nanoseconds.

On the face of it the digital input signals to a system may be synthesised by either a switched level (to give either logic 0 or logic 1) or by a pulse generator. An output indicator has only to differentiate between these two levels and can be a simple two-state device such as an LED, rather than the costly moving-coil meter of the analogue system.

Inputs and Outputs

A desirable characteristic of any indicator is that it does not load the test point, a requirement met, in the case of an LED, by driving it from a high-gain transistor (Figure 1(b). The input resistance is, in this case, 33k, sufficiently high to avoid loading the test point. The two input levels, logic 0 and logic 1, can be developed using the circuit of Figure 1(a), consisting of no more than an SPST toggle switch and a pull-up resistor. This is about as simple as you can get so naturally there are limitations to what can be done with it. The switch, being a mechanical device with spring contacts, suffers from 'contact bounce' i.e. when the contacts close a short series of pulses is generated. These occupy only a very short period of time. Nonetheless, when the response times of TTL devices are measured in nanoseconds, the test circuit may well 'catch' all of the pulses. In the case of a counter the indication will be a false one. What is needed is a bounce-free switch and this is provided by the circuit of Figure 2. Half of a 7400 chip is wired as a simple latch. The SPCO switch 'sets' or 'resets' the latch giving either logic 1 or logic 0 levels at Q. The latch operates as soon as the switch closes either way and having flipped over into its new state then ignores the spurious pulses that follow. If the switch is a push-button type then regular operation generates a series of slow pulses, useful for studying counter operation, etc.

The indicator can also be improved. A simple logic probe can be made in which a positive indication of logic 0 or logic 1 is made on one or other of two separate LED's. Actually the design of logic probes is not as simple as may seem at first sight. The problem is that it actually has to recognise THREE separate conditions:

(i) probe connected to logic 1 (one LED lit).

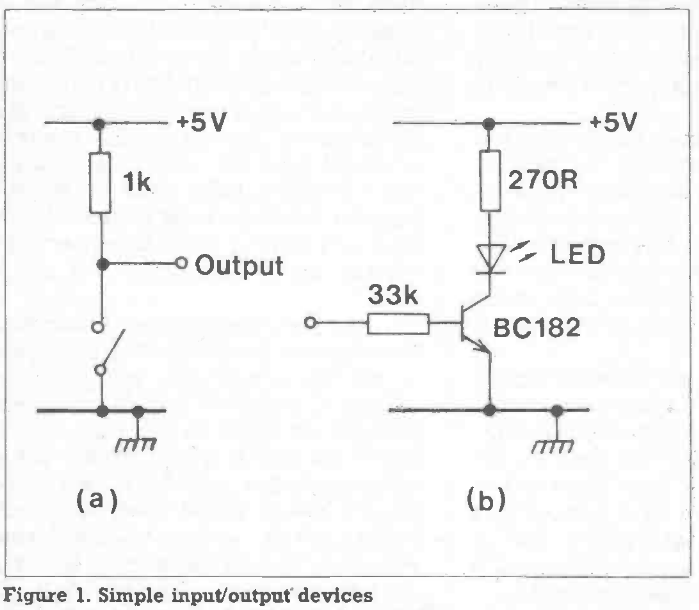


Figure 1. Simple input/output devices
(a) switched logic levels (b) logic level indicators.

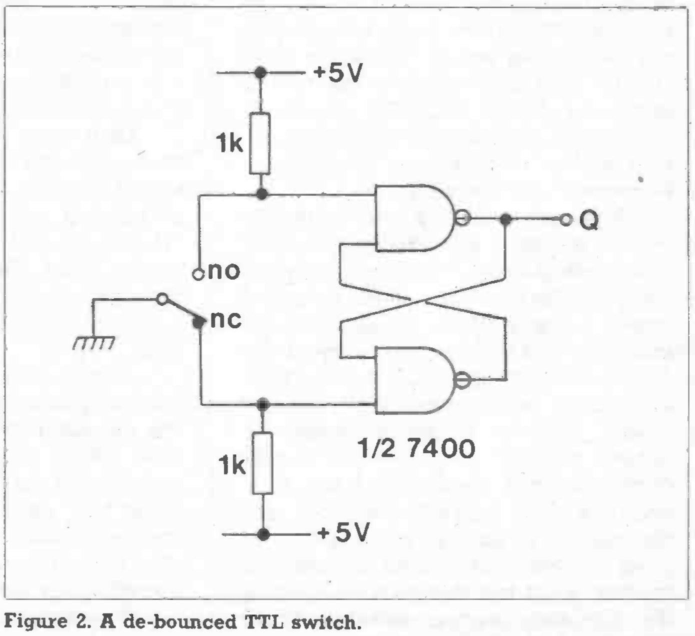


Figure 2. A de-bounced TTL switch.

(ii) probe connected to logic 0 (other LED lit).
(iii) probe not connected at all (neither LED lit).

The design of Figure 3 shows a simple circuit that meets all three of these conditions, which it does by a bit of honest cheating. Each of the NAND gates, G1 and G2, has an input held at logic 0 by the normally-closed push-button switch. Therefore, the outputs of both G1 and G2 are at logic 1, ensuring that both latches G5/G6 and G7/G8 are re-set i.e. neither LED is lit.

However, when the switch is pressed the above mentioned inputs to G1 and G2 rise to logic 1 level and either G1 or G2 will then have a logic 0 output, depending upon the logic level at the probe input. The appropriate latch will then be set, lighting one LED or the other. It is a simple three chip design with obvious limitations but justified by its extremely low cost.

A more useful probe would perform the following functions:

(i) indicate logic 0 and logic 1 levels within recognised thresholds e.g. logic 0 between 0V and 0.8V, logic 1 between 2.5V and 5V.
(ii) indicate the presence of a pulse train by flashing LED's at a constant rate, irrespective of the frequency of the pulse train.
(iii) incorporate a 'memory' LED to signify that a level transition has occurred; this is useful when the speed of the level change is too great to be detected with the human eye.

A probe incorporating all of these features can become quite sophisticated in design. There are a number of kits available for less than £20, that go some way towards meeting these requirements. In fact, a kit is available from Maplin (order no. LK13P) that at the moment sells for £10.95. It has the following features:

Detects HI, LO and Open Circuit (Floating Input) states and Pulse trains from 1Hz up. The display is novel in that a seven-segment display is used to indicate the states by the letters H, L, F or P, corresponding to those listed above.

Testing a System

Suppose that the items of Figures 1, 2 and 3 have all been constructed. How can they be used in practice? Figure 4 shows a circuit for a code converter; in fact it converts 2421 BCD numbers into their 8421 BCD equivalents. In this system the 2421 BCD number 1101 (ABCD) is equivalent to the 8421 BCD number 0111 (WXYZ), both equalling decimal 7. It is possible to check the logic of the unit by wiring in the switch units of Figure 1 (a) as inputs and the LED units of Figure 1 (b) as outputs. It is well worth making up two boxes – one with eight switches and one with eight LED's. This will cover the checking of almost any logic circuit including the input/output functions of

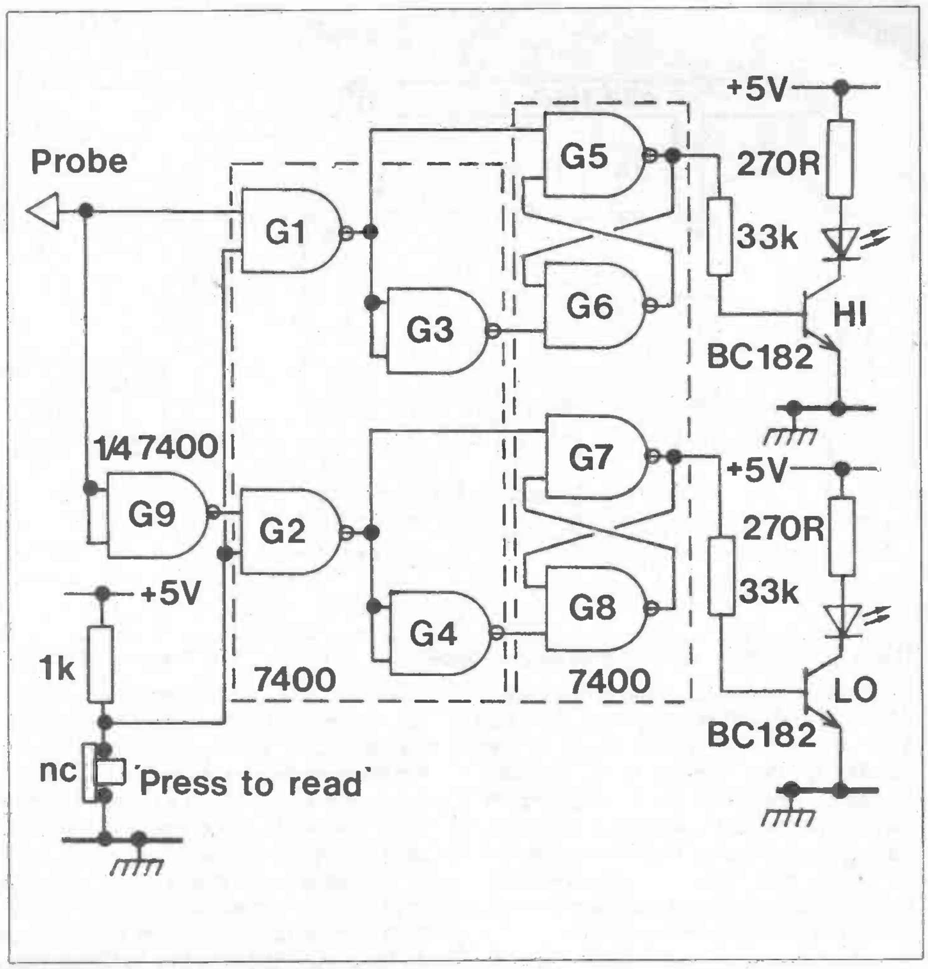


Figure 3. A simple HI-LO logic probe.

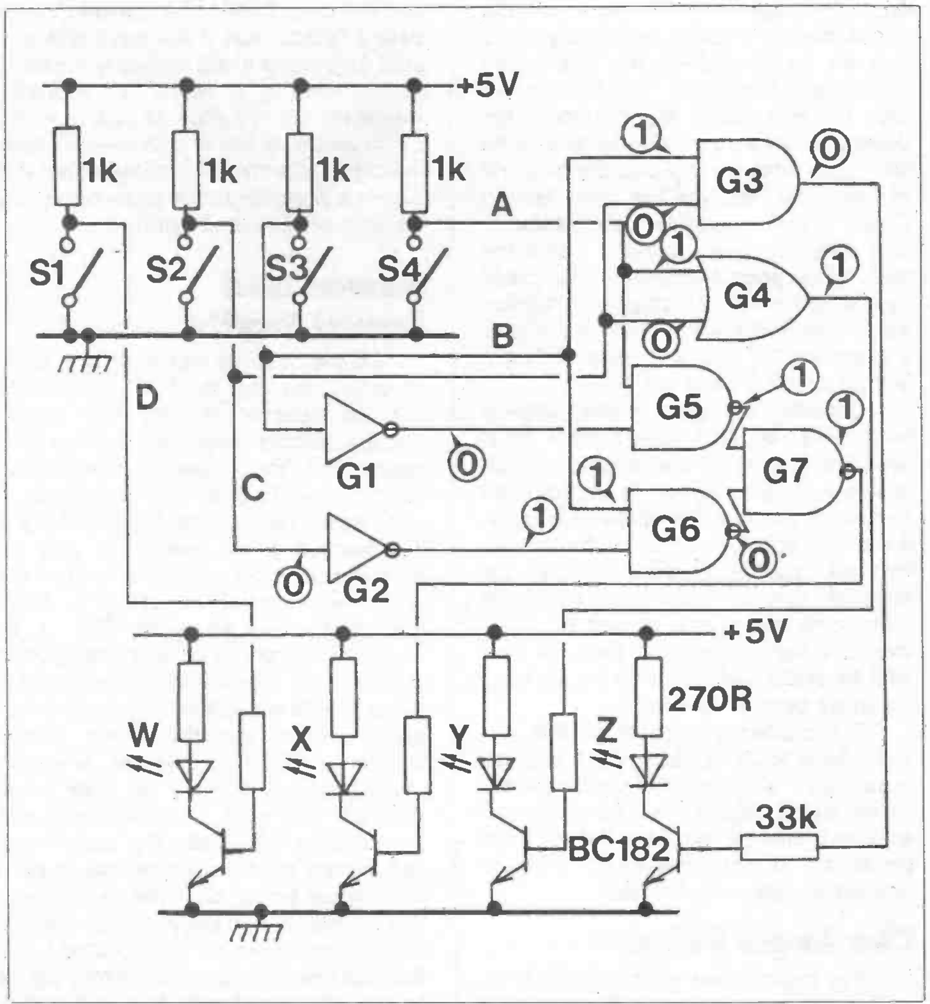


Figure 4. Checking the logic of a code converter.

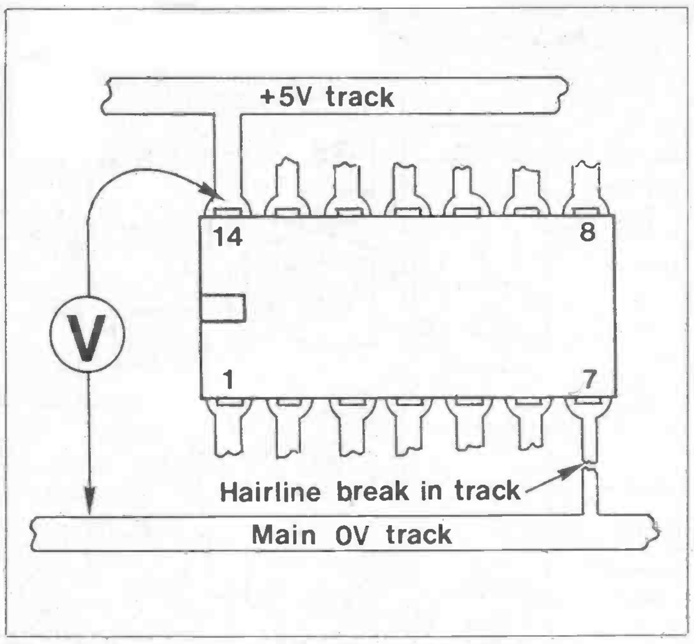


Figure 5. The wrong way of checking chip supplies.

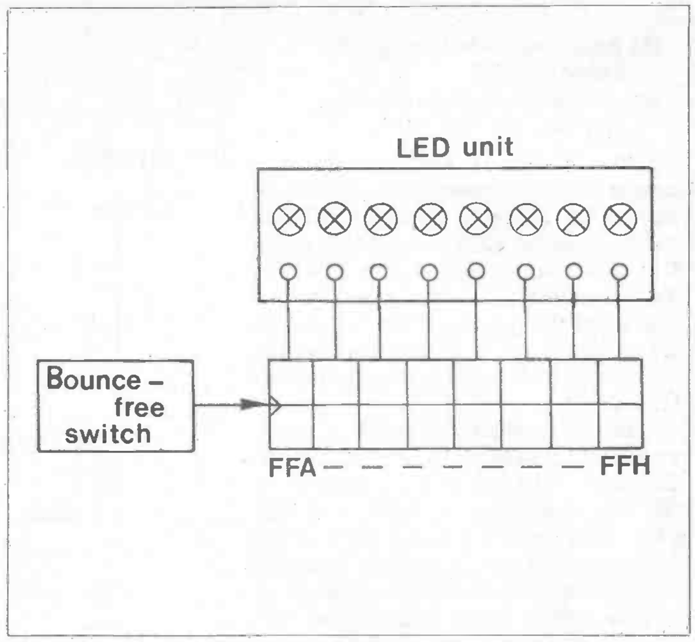


Figure 6. Testing the sequence of a counter manually.

8-bit microcomputers. The switches S1, S3 and S4 are closed to set up the 2421 BCD number 1101 as the input to the circuit. If the converter is working correctly then the LEDs will light up to give WXYZ = 0111. All other combinations in the set can be input in this way on S1 - S4 and the outputs checked. However, these will not be given here as this is just an illustrative example.

Suppose that the circuit doesn't work. There are several possibilities. The original design may be incorrect; the circuit may be wired up incorrectly; there may be a chip fault or the board may have a fault. Assuming that the first two can be eliminated by checking the design procedure and visually examining the circuit layout, this leaves the question of a physical fault. The test items used in Figure 4 have established the existance of a fault but do not actually locate the fault. At this point diagnostic testing takes over from functional testing. This implies some degree of knowledge – in this case a knowledge of the logic levels throughout the circuit for a given input.

Consider the input number already mentioned i.e. 1101. The correct logic levels at the inputs and output of each gate are shown circled. Enter the logic probe! By placing the probe at each of these test points in turn, the faulty area can be quickly found. Suppose, for example, that the input to gate G2 was found to be logic 0 (correct) and its output was also logic 0 (wrong), then G2 may well be faulty, possibly shorted, or have an errant earth at its output.

But another possibility is that the lower input to G6 is faulty. If the IC's are in sockets a quick substitution check will reveal which chip is faulty but if IC's are soldered straight into the board, this procedure is not convenient. What is needed is another instrument.

The Logic Pulser

The logic pulser may be thought of as the digital equivalent of the analogue signal injector. When it is applied to a test point in a circuit and a push-button switch depressed, it sends a very short, high-current pulse into the test point. This is sufficient to change the state of a working gate even when held in a given state by a fault. Thus, in Figure 4, the pulser will test gate G2 by sending a pulse into its input at the same time that a logic probe is applied to its output. If the probe's LED's flash momentarily, the gate is alright. A kit for a logic pulser is also available from Maplin (order no. LK19V) which at present costs £5.95. This design has the added feature that if the push-button is held depressed it will deliver a stream of pulses, making it useful for checking sequential circuits such as counters, etc. Furthermore, it has a built-in logic level indicator (effectively a simple probe) that makes a separate probe unnecessary for the type of test just described.

Power and Board Faults

Digital circuits tend to be fairly complex, leading to PCB's that have intricate patterns of very fine tracks, perhaps double-sided. In the event of a board failure the temptation to pull out all the IC's and 'twiddle with every pot' in sight should be resisted. The first thing to be checked is the power. It may be present at its entry point on the board but disappear somewhere along a track leading to one or more IC's. It is, therefore, necessary to check the power at every chip separately. On the face of it, this is simple enough to do; however, it is quite easy to get the wrong results without realising it. Imagine how you might proceed to carry out such a test yourself. You take your voltmeter, clip the negative lead onto the earth track and, in turn, put the positive lead on each plus supply pin on all of the chips. Every one shows a correct reading, yet the circuit doesn't work. You conclude that the fault lies elsewhere. Yet it may not be so at all. To see why not, look at Figure 5.

This particular chip has a minute break in the earth track right near the pin. By placing the negative lead on the main earth track, this break has been effectively 'bridged', thus allowing the voltmeter to read the supply voltage even though the chip actually lacks an earth return. If, however, the supply is checked directly between the IC pins (usually 14 and 7 on a 14-pin DIL TTL chip), any break like this soon shows up. Or at least the lack of supply to the chip is soon found, which should mean the same thing to the keen-eyed! The moral is – always check the supplies right at the chip pins. And that really means the pins of the chip themselves, not the track adjacent to the pins because another sort of break that can easily occur is a badly fitting pin in an IC socket. This also applies to the checking of logic levels at gate inputs and outputs.

Counters and Registers

These are examples of 'sequential' circuits i.e. those in which the current state of the circuit is dependent upon the number of inputs (pulses) received. After the design of a counter to a specified sequence, this sequence can be checked by noting the states that the Q outputs assume in turn, by using LED indicators of the type of Figure 1(b), while the input is being pulsed repeatedly by either the bounce-free switch of Figure 2 or the 1Hz TTL oscillator of Figure 7. This latter uses the well-known 555 chip and actually has two speeds. The 1Hz speed is used where the operation has to be slow enough to allow observation of the changing states of the LED's and the 1kHz speed is used when a CRO is used to look at the waveform at any stage in the counter.

Synchronous counters using extra gating can be more difficult to fault-find than simple 'ripple-through' counters because there is both sequential logic and combinational logic to deal with. If they seem to 'stick' or avoid some states completely, chip changes should be tried if at all feasible. If a JK flip-flop has both of

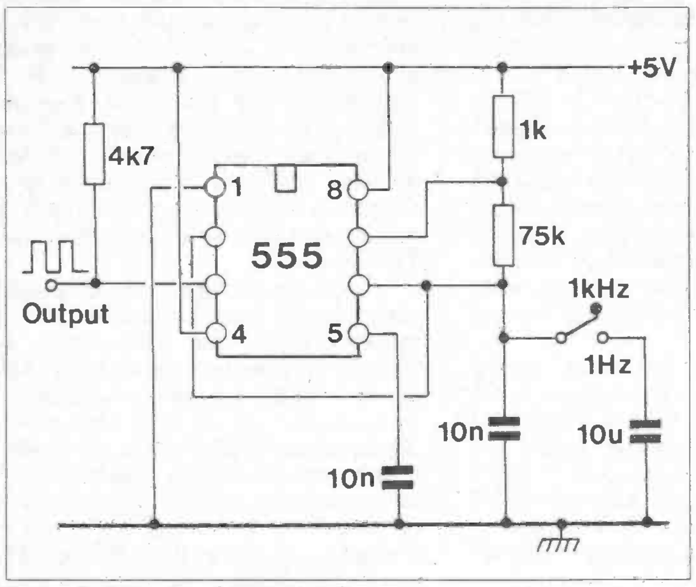


Figure 7. A two-speed TTL oscillator.

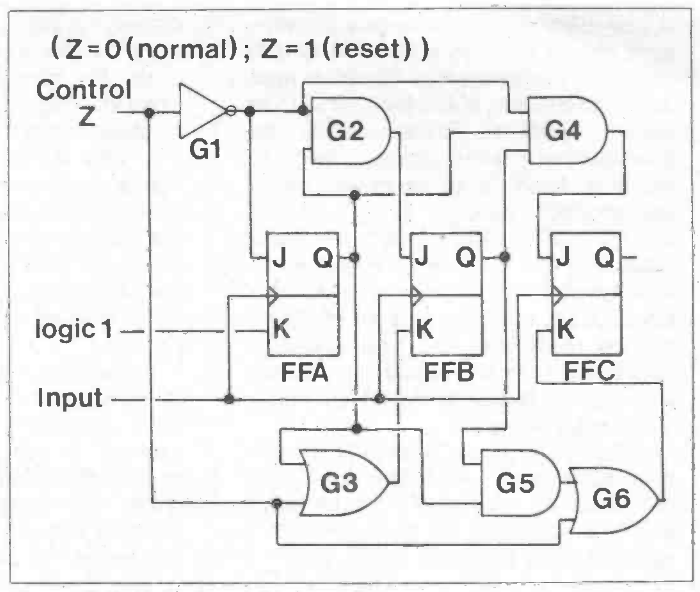


Figure 8. A divide-by-eight resettable counter.

its J and K inputs connected to logic 1, it should toggle whenever clocked. If it doesn't, try the logic pulser on the clock input to see if it responds; if it does, look for a missing clock pulse. An example of a gated synchronous counter is shown in Figure 8. A logic pulser, together with the LED indicators on the flip-flop Q outputs, will test the counter for correct sequencing. The pulser will provide the pulses to be counted at the input, and can also be used for checking the logic of the gates if the sequence is wrong.

Suppose that the counter gets to a state where flip-flop FFC is 'set', but taking the control input Z up to logic 1 fails to reset it. The question is whether gate G6 is receiving this transition or, if it is, whether it is responding to it. The logic pulser is applied to the input of G6, the logic probe is placed on G6's output and the integrity of this gate is thus checked.

It is possible to give numerous examples of digital circuits which can be analysed with the test items described in this article. However, what it usually comes down to is that one proceeds logically through the system testing power, checking logic levels with the logic probe and eliminating chips by substitution or by means of the logic pulser. Many quite complex digital circuits are nothing more than large-scale repeats of smaller ones. If you can trouble-shoot the latter, you can deal with the former. It just takes a little longer!

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DWELL ANGLE MEASUREMENTS

by R. Richards

With the increased price of petrol, it is now essential that the engine performance should be kept at its peak to give economical consumption. To obtain maximum combustion of the fuel, the ignition system must be maintained to the manufacturer's specification, the most important factor being the correct gap of the contact breaker points on the distributor. The most common method of measuring this gap is by a feeler gauge, which is not very accurate, because it does not allow for any wear or back lash on the distributor and can only give approximate results, which can be detrimental to engine performance, especially at higher speeds.

A more accurate method of measuring the gap is by using a dwell meter and measuring the number of degrees during which the contacts are closed, which is referred to as the dwell angle. Figure 1 illustrates the contact breaker points, cams, lobes and angles for points opened and closed as given for a Vauxhall Viva. This measurement is taken with the engine running which will compensate for any wear on the distributor components such as the spindle and cam lobes, thus averaging the error and obtaining the maximum results. The dwell angle varies with different ignition systems, but they are all designed with a dwell angle which will allow the ignition coil sufficient time to give maximum build up of the magnetic field, to produce the strongest spark at the plug points. The correct dwell angle for a particular make of car can be obtained by referring to the maker's Workshop Manual. For example:– Vauxhall Viva 1256 cc Engine number 1639738 onwards, the Cam Dwell Angle is 49 to 51 degrees.

In brief, the dwell meter measures the angle in degrees through which the cam rotates whilst the contacts are closed. This angle can be increased by closing the gap, or decreased by opening the gap. See Figure 1. A Dwell Meter could be purchased at a cost of £12 upwards, but the dwell angle can be measured using a multimeter in conjunction with the simple circuit shown in Figure 2. The principle on which the dwell angle is measured, is by observing the duty cycle of the voltage waveform across the points. When points are open, the multimeter will read zero and when the points are closed, the multimeter will read 90.

Therefore, with the engine running the needle will take up a position on the scale proportional to the number of degrees in which contact points are closed, which is the dwell angle. Figure 3 shows the multimeter adjusted to 90 divisions and an indication of the reading with the engine running (as for a Vauxhall Viva). The circuit consists of a 47k pot or preset connected in series with a diode BY127. Point (A) is connected to the C.B. terminal of the ignition coil and point (B) to the negative terminal of the multimeter. The multimeter is switched to 5 or 10 volts, and the positive lead of the multimeter is connected to the positive pole of the car battery. If the contacts are closed a reading will be obtained on the multimeter. If no reading is obtained the engine should be turned over until the contact points are closed. With the contact points closed and a reading on the multimeter, switch on the ignition and adjust (R1) until a reading of 90 is obtained on the multimeter. Start the engine at a normal tick over speed and you will note that the needle will drop back to a position on the scale proportional to the number of degrees in which the contact points were closed. i.e. The dwell angle.

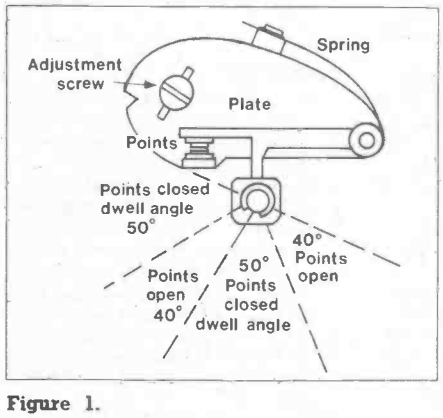


Figure 1.

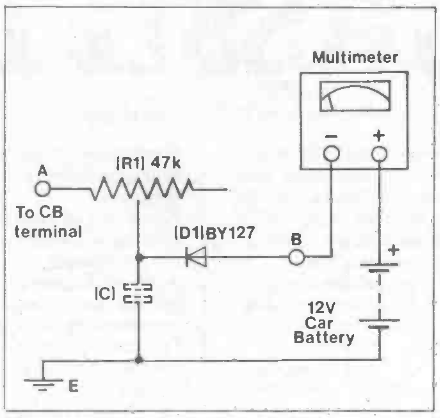


Figure 2.

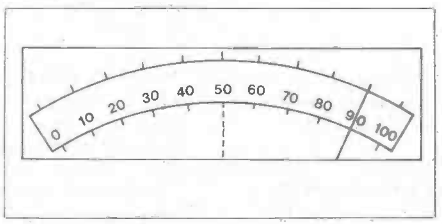


Figure 3.

If the dwell angle is not in accordance with the dwell angle stated in your repair manual, the points must be adjusted to give the correct dwell angle by closing the points to increase the dwell angle and opening the gap to decrease the dwell angle. If the reading is unsteady, you may be able to improve the condition by putting in a capacitor of about 0.047μF to smooth the circuit as shown by dotted lines (C) in Figure 2. The diode BY127 prevents any current from feeding back from the ignition coil, so it is essential that it is fitted the correct way round with the cathode to the 47k pot.

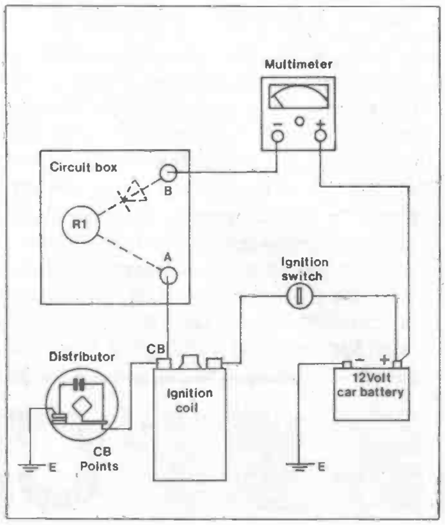


Figure 4.

The above circuit can be accommodated in a small box as shown in Figure 4. A knob is fitted to the 47k pot, and points (A) and (B) brought out on two terminals. The multimeter could also be used to carry out the following tests: Continuity Test, Circuit Tracing, Current Leakage, Battery Voltage and condition, together with testing for high resistance of any leads, switches or contacts. All of the examples shown applied to four cylinder engines. To measure the dwell angle on engines with more than four cylinders, the multimeter adjustment should equal the number of degrees between the lobes, which are as follows:

4 cylinder: 360 divided by 4 = 90 (adjusted reading on meter)
6 cylinder: 360 divided by 6 = 60 (adjusted reading on meter)
8 cylinder: 360 divided by 8 = 45 (adjusted reading on meter)

To complete the engine tune, the checking of the dwell angle is followed by checking the timing with a timing light, adjusting the valves, cleaning and adjusting the plugs and setting the carburettor with a Colortune, or similar appliance.

CONNECTIONS MADE EASY

by D. H. Jennings

Marketing Director, H&T Components

ID Connector/Flat Cable, Design and Use

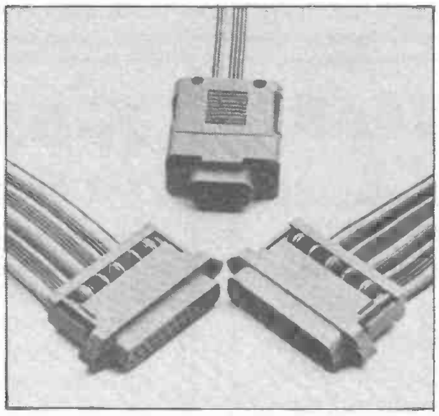
The development of flat cable technology in the early 1970's created problems of wire termination which remained largely unsolved until the introduction of insulation displacement termination techniques.

The requirement was to achieve simultaneous termination of a number of wires simply, quickly, cheaply and reliably. Insulation displacement connector technology or IDC as it is termed, has met all these requirements. This article attempts to help the reader to understand what it is, how it works and where and when it can be used. More ambitious readers can perform their own cable harness construction with relatively low cost tools but for the majority the quickest and simplest way is to purchase a ready made harness with the knowledge that it is easy to specify, well constructed and very reliable in use.

What is IDC?

To understand the what we need to consider the why; the evolution of IDC stems from the need to join together printed circuit boards and/or sub assemblies as well as peripheral equipment, with anything from five to sixty wires. The cables had to be compact and lightweight and to some extent replace co-axial and twisted pair as well as round harnesses. The superior mechanical and electrical performance of flat cable (Figure 1) as well as its improved flexibility made it ideal for use in interconnections in hitherto unattempted areas, including home computers, video games, hi-fi equipment, apart from the traditional commercial and military electronics applications.

Having established the cable suitable for these applications the need arose to terminate the ends with some form of connector. To strip and solder up to sixty wires at either end of a short cable is extremely time consuming and fraught with problems of quality. Likewise, stripping and crimping wires, or stripping and wire-wrapping is equally time consuming, added to which there is the further need to provide some form of strain relief to prevent the connector and cable termination interface being compromised during use.



The solution when it came seemed so obvious that many users questioned its originality. In fact the concept used a combination of many ideas including crimping, wire wrapping, and clamping wires onto terminals. What was significantly different was that the technique enabled reliable connections to be made between the wire and connector *without* pre-stripping the insulation. It also enabled all of the wires in the cable to be connected at the same time.

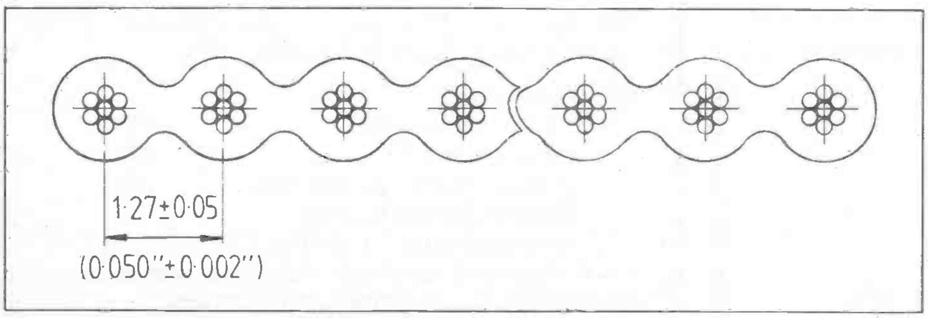


Figure 1. Cross section through flat cable

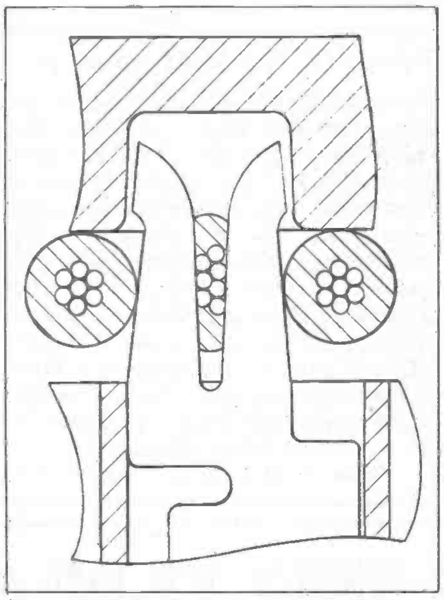


Figure 2. Contact point between forks and wire

The principle of the contact termination is a 'V' shaped slot into which the plastic coated stranded wire is forced. The insulation is displaced (hence the name) and the wire core is compressed between the forks of the contact, thus creating a number of contact points with the wire. The joint is similar in conception to a wire wrap termination, except in this case the contact surrounds the wire rather than the reverse (Figure 2).

In practical terms a connector, be it plug, socket, PCB transition, dip, card edge or input/output is identical in terms of termination and consists of a number of forks, a plastic cover, and in some cases a strain relief member. The flat cable is laid onto the back of the connector after which the cover is assembled. This sandwich is then placed in a press which is closed thus forcing the wires down into the forks and making an instant and complete termination.

Lest anyone think this technology low level; examination of the components will show precisely manufactured plastic and metal parts, which in themselves have to displace the insulation without shorting the wires together or creating open circuits (Figure 2).

Types of Connector

Differing needs inside and outside electronic equipment have generated a

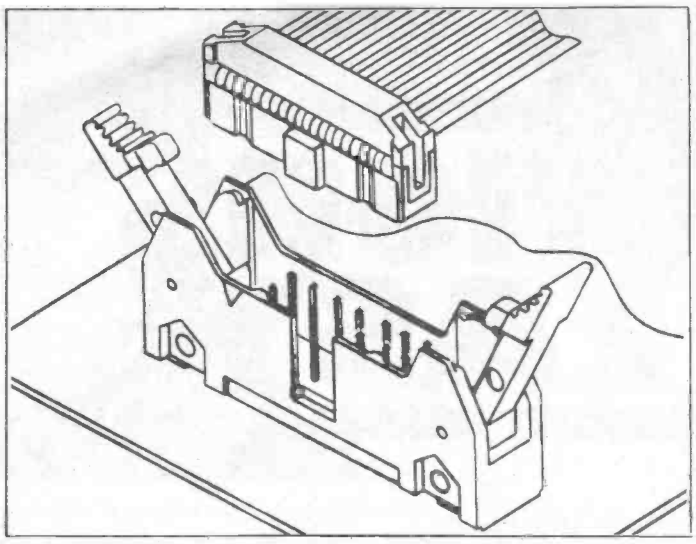
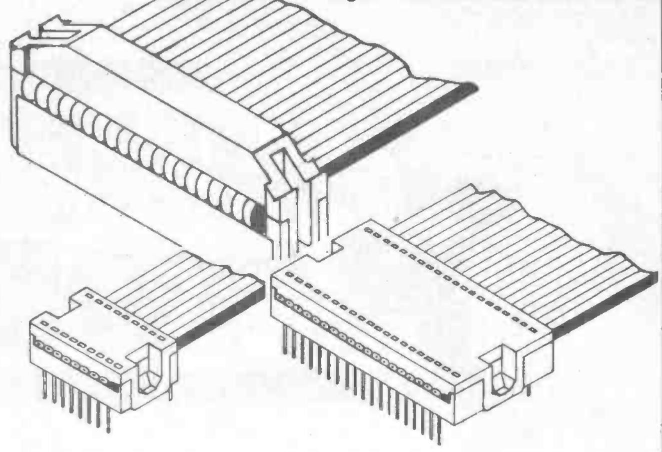


Figure 3. P.C. Board header/socket

Figure 4. Socket wih strainrelief



Dual in line plug (small) Figure 5. Dual in line plug (large)

whole family of connector shapes and sizes. The two most commonly used connectors are the header and its mating socket (Figures 3 & 4). The header is mounted on the end of the printed circuit board and has conventional solder terminations which connect with the tracks on the board. The mating end of the header consists of pins to which the socket is plugged and secured with end latches (Figure 3). The header and socket are polarised to prevent reversed mating which could have disastrous effects on the equipment being connected.

Other members of the family include PCB transition connectors which enable permanent connection to be made between flat cable and boards, dual in line plugs which provide a connection to the ubiquitous DIL socket (Figure 5), flat cable card edge connectors and the ever popular 'D' miniature complete the family.

IDC Benefits

In conclusion, ID connectors and flat cable harnesses provide a reliable means of interconnecting electronic equipment and sub assemblies whilst eliminating time consuming cable preparation and potentially unreliable connection points. The result is gas tight high speed termination interconnections, that can be relied upon to continue to give problem free service throughout their installed life. Furthermore they can be of particular help to the home constructor in providing a simple and reliable method of connecting flat multi-way cable to his PC board.

Maplin stock a wide range of IDC's, flat IDC cable and accessories (in 0.1 & 0.05 inch spacing), for full details please see pages 82, 179 and 185 of the 1984 Catalogue and the new products in the last issue of this magazine.

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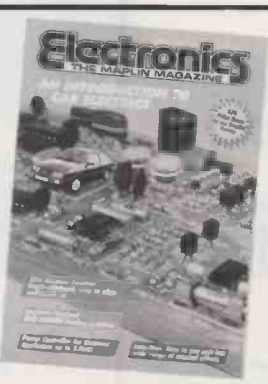

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