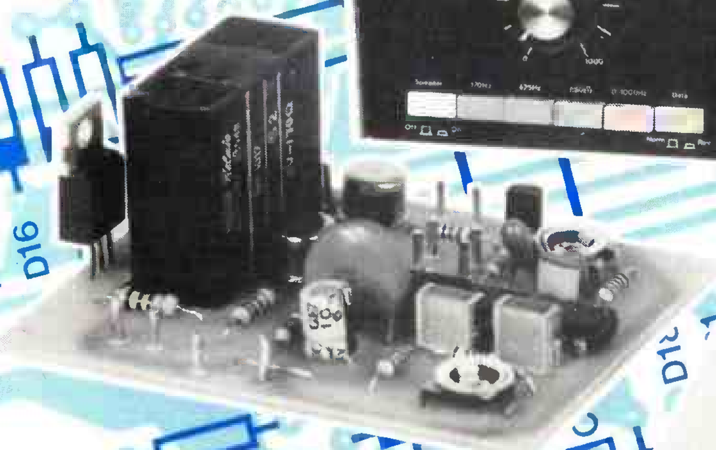
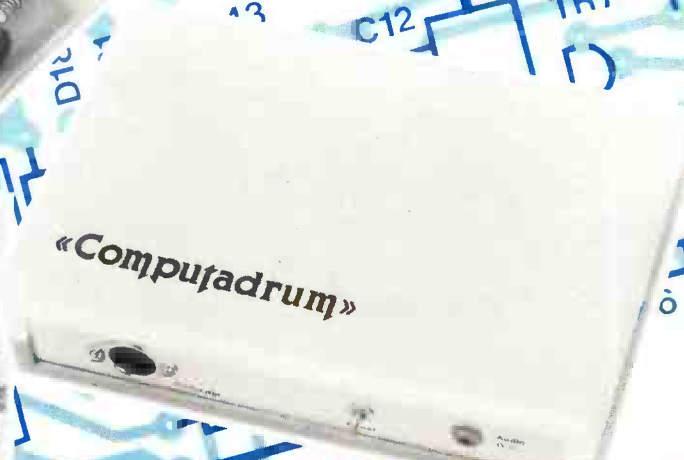
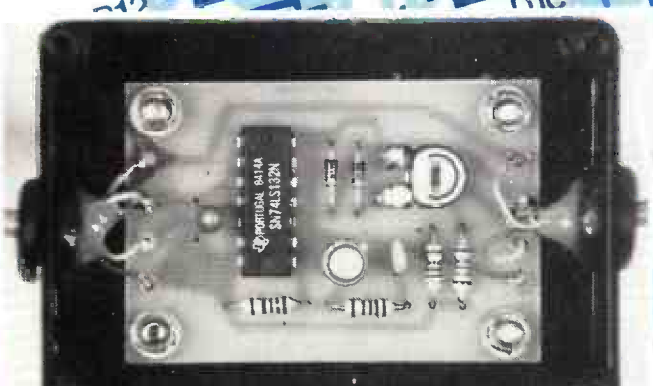
MAPLIN PROJECTS BOOK TWELVE

TU1000 RTTY TERMINAL
ZX81 & YOUR BOAT
LIGHT PEN
PWM MOTOR DRIVER
COMPUTADRUM
FIVE EASY PIECES







Electronics
THE MAPLIN MAGAZINE

PROJECT BOOK TWELVE

This Project Book replaces issue 12 of 'Electronics' which is now out of print. Other issues of 'Electronics' will also be replaced by Project Books once they are out of print. For current prices of kits, please consult the latest Maplin price list, order as XF08J, available free of charge.

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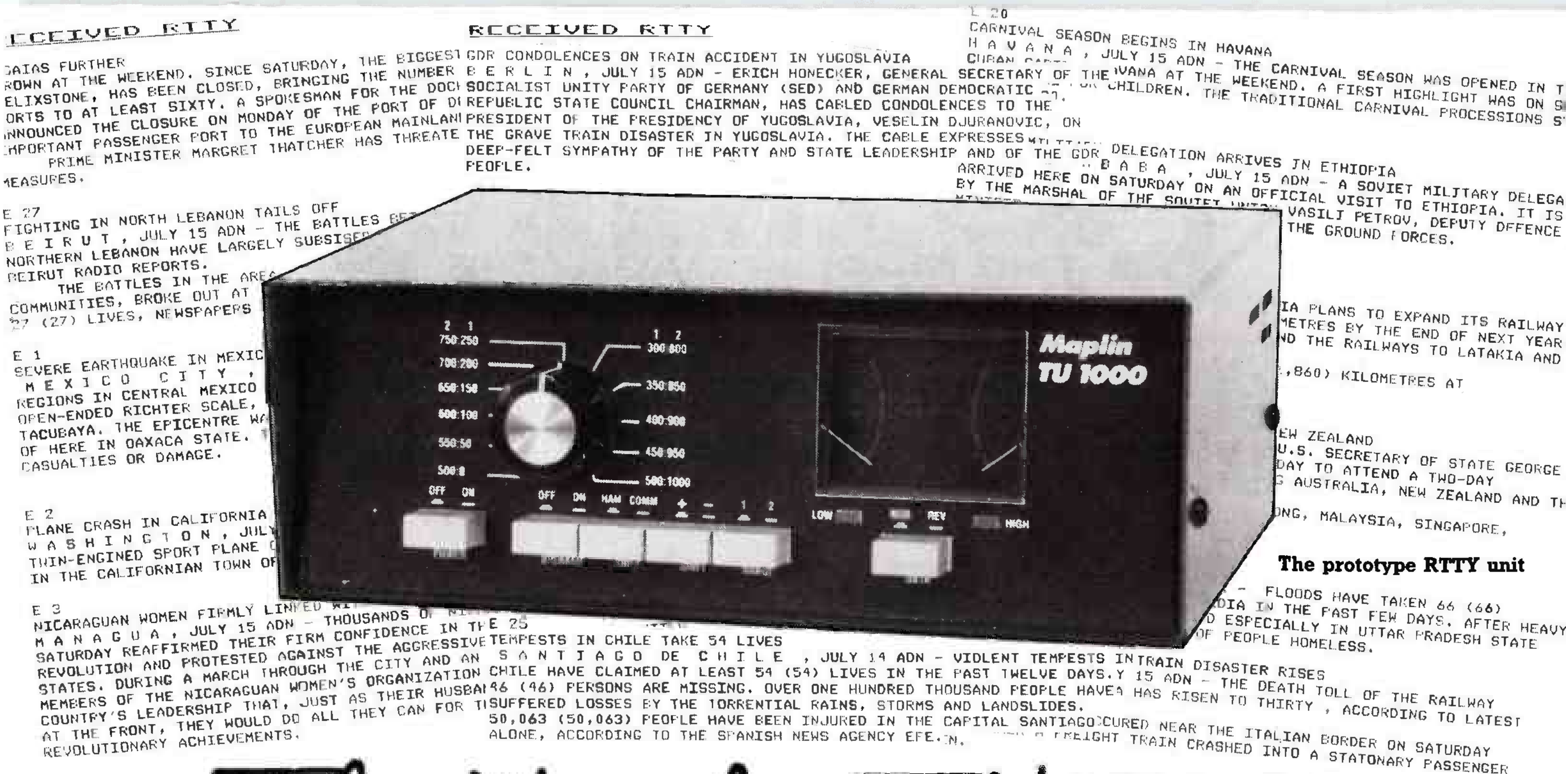


The prototype RTTY unit

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.

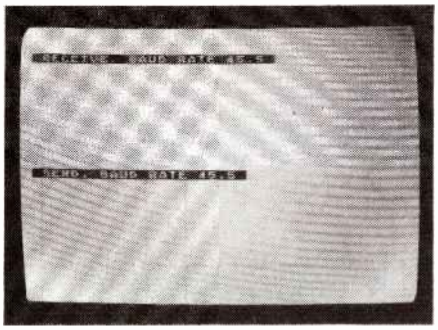
The Two-Tone System

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

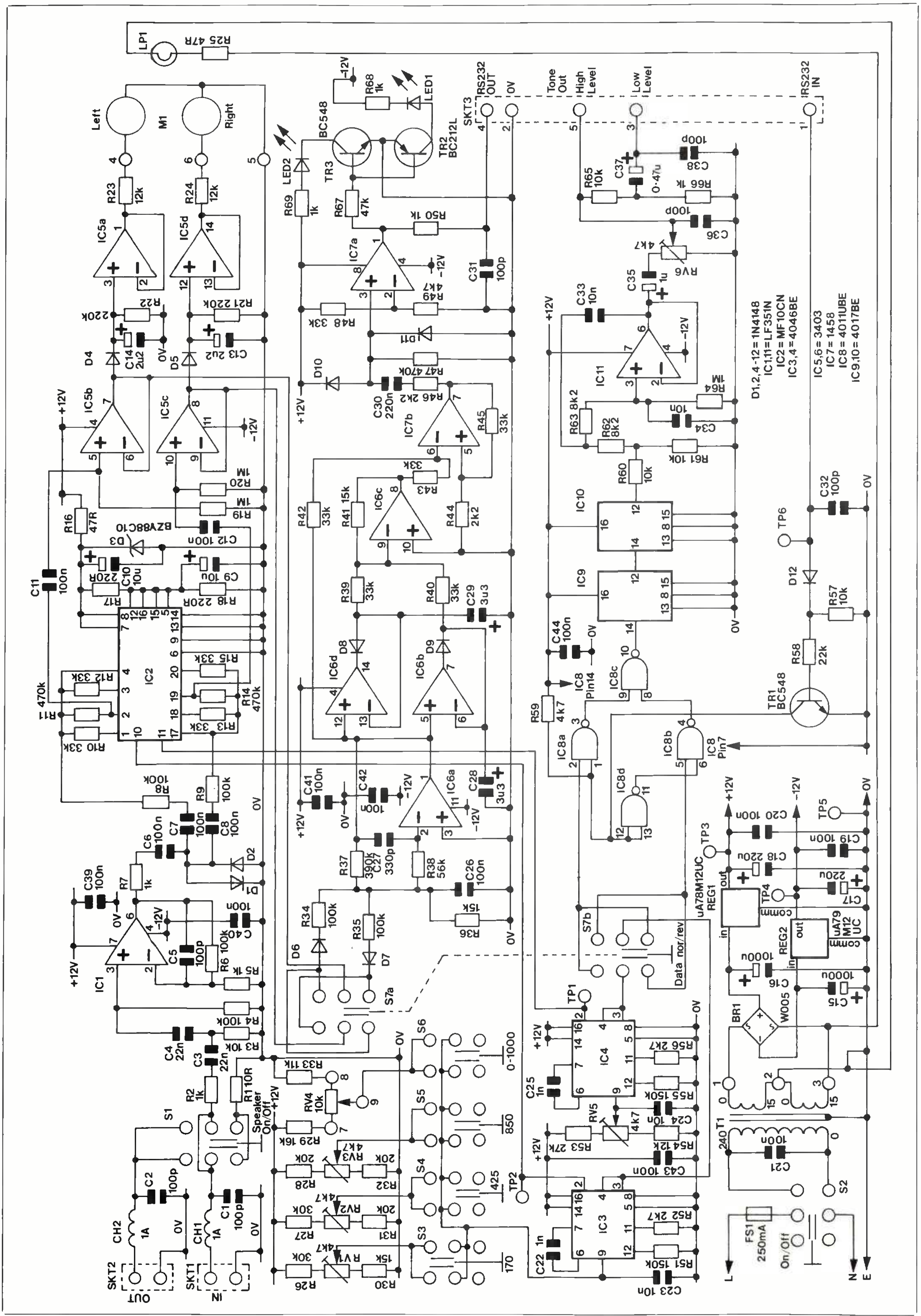
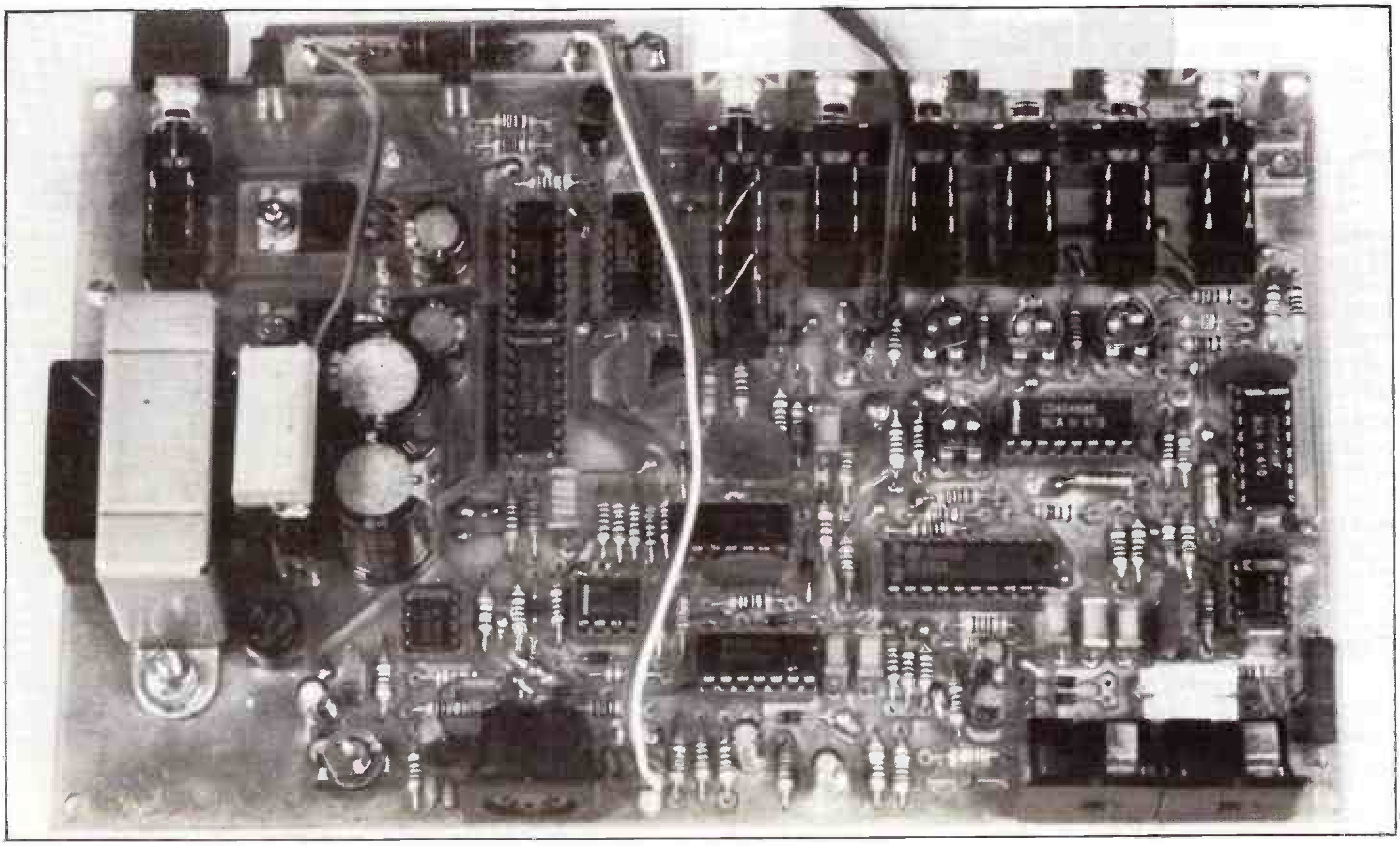


Figure 2. Circuit Diagram



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

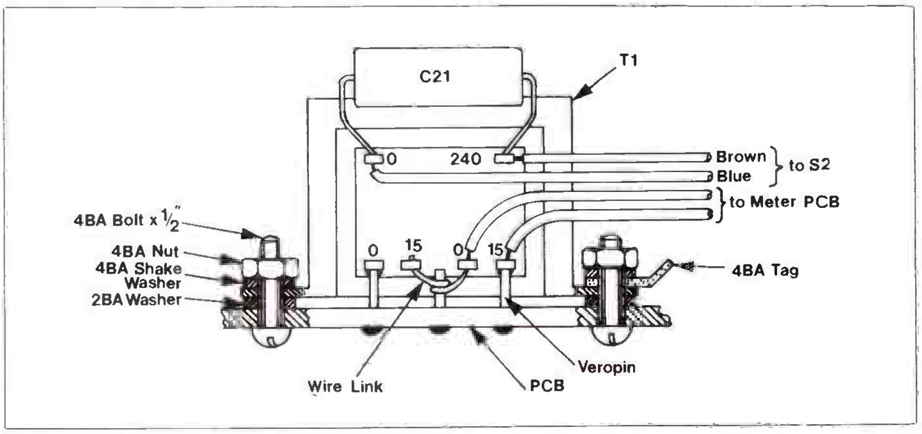


Figure 3. Transformer mounting

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.

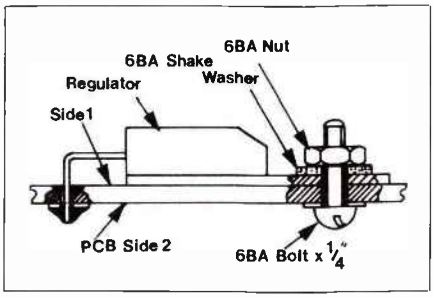


Figure 4. Fitting regulators

```
RECEIVED RTTY

YRYRYRYRYRYRYRYRYRYRYRYRYRYRYRYRYRYRYR 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

PS 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

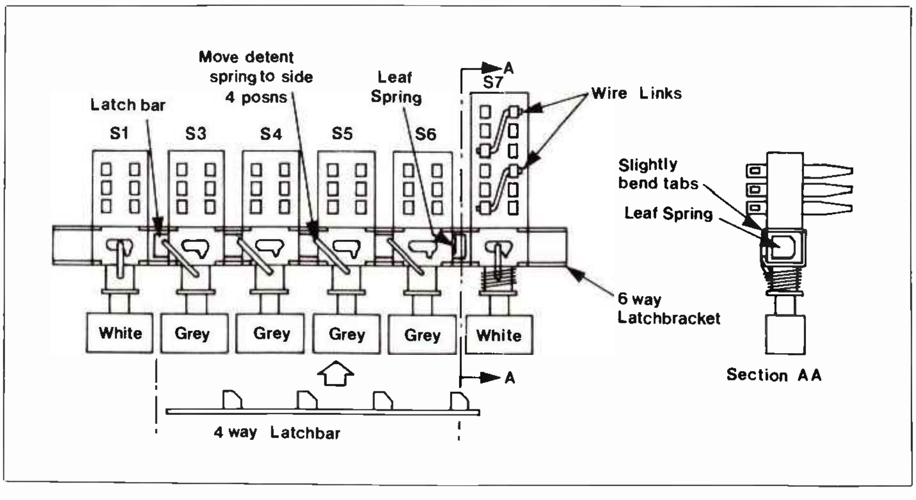


Figure 5. Switch sub-assembly

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.

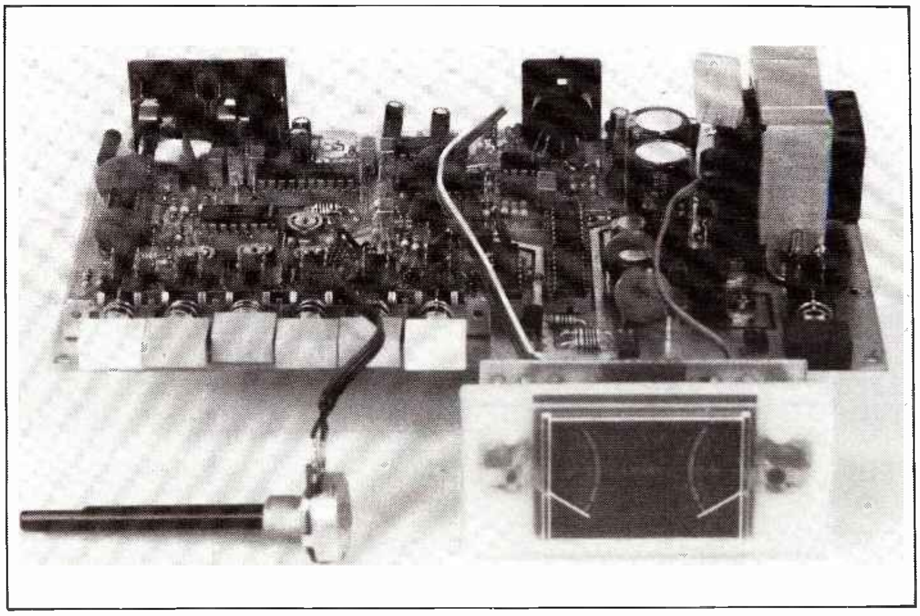
Install the Veropins on the meter PCB in the same manner as the main PCB. As you will see from Figure 6, the pins protrude through side one of the board. The lamp is mounted on side two. This board is now fitted to the back of the dual meter by carefully bending the lugs of the meter over the board and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



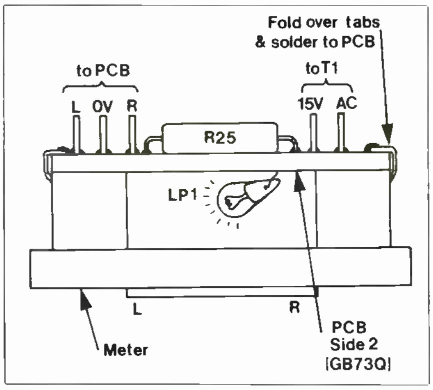


Figure 6. Meter illumination

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

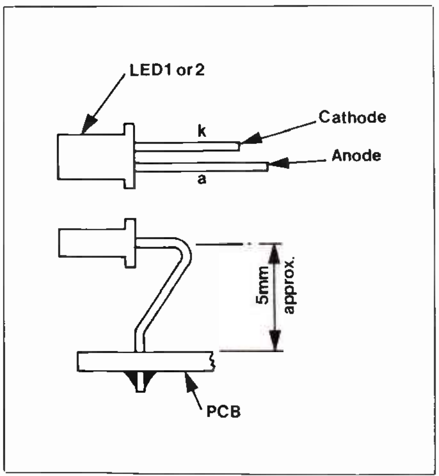


Figure 7. Fitting the LED's

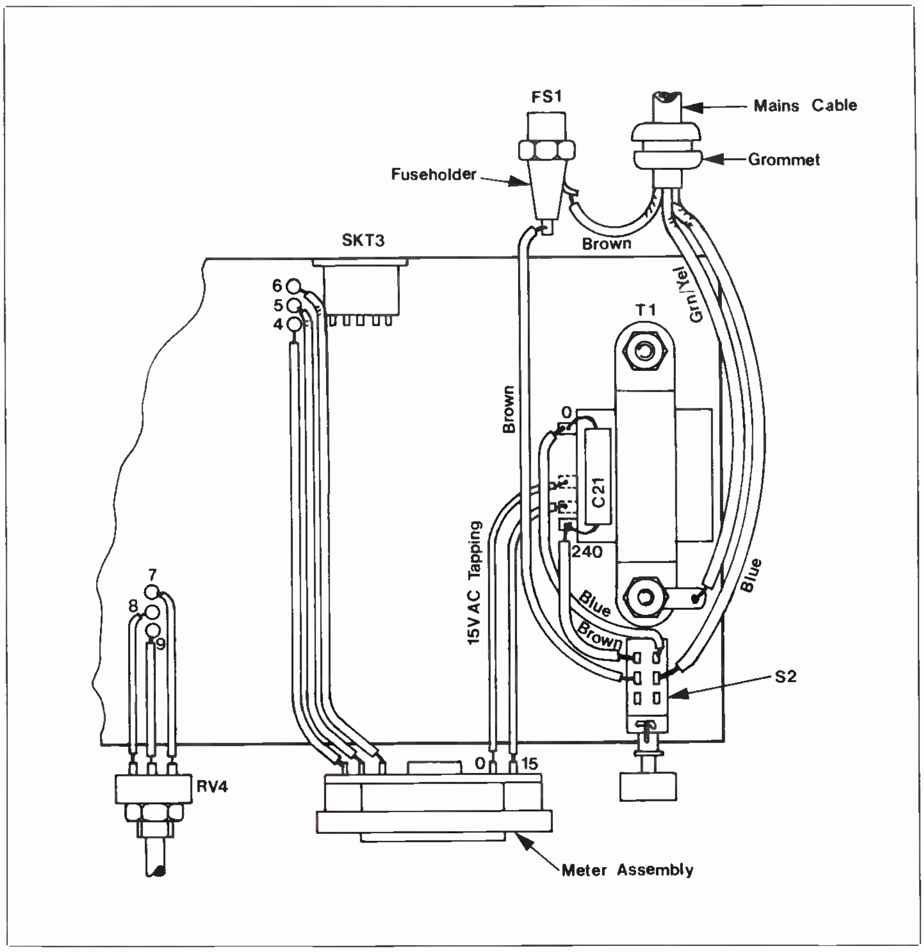


Figure 8. Wiring

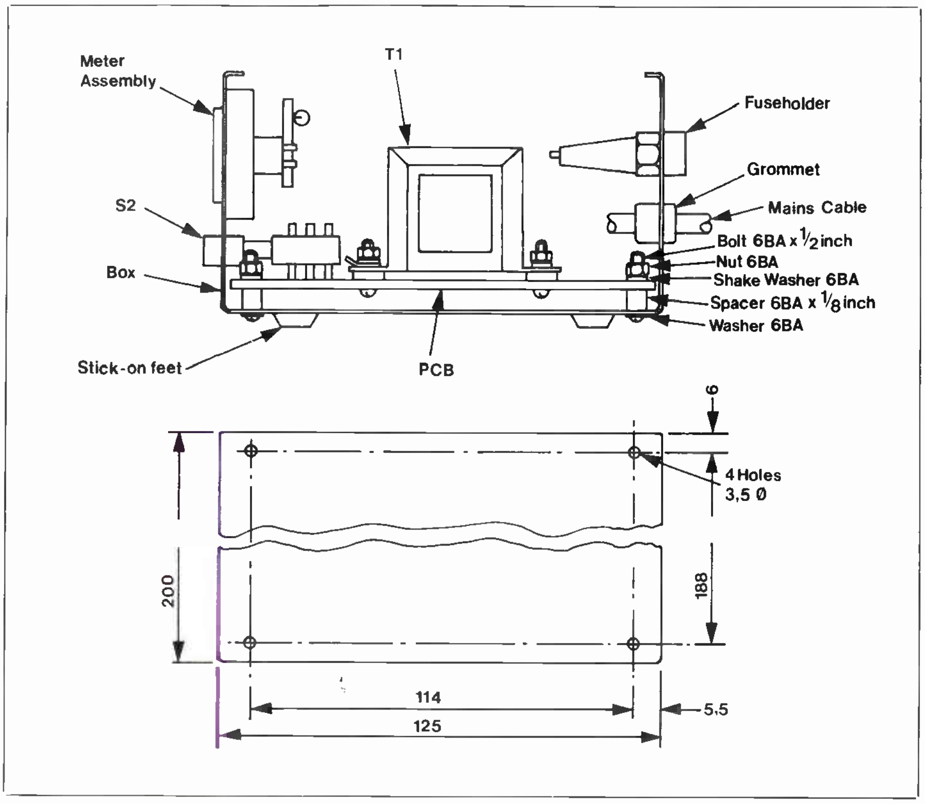


Figure 9. Case layout

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

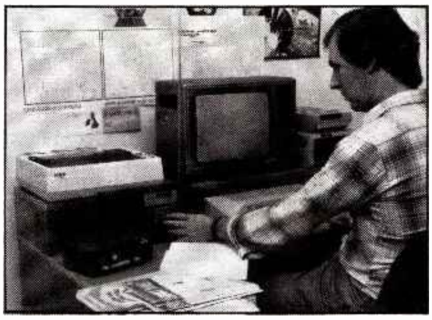
```
100 CLR :REM R.T.T.Y BY Chris Barlow.
200 REM 850 INTERFACE MODULE RS-232 PORT 1.
300 TRAP 10900:CLOSE #2:OPEN #2,4,0,"K:"
400 GRAPHICS 0:POKE 710,180:POKE 709,0:POKE 712,180:POKE 559,0
500 SOUND 0,80,10,5
600 REM **** BAUDOT TO ATASCII SET-UP ****
700 DIM BA$(7):DIM ATASCII(64):DIM BAUDOT(128):DIM RT$(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$="50.0 "
9600 IF KEY=51 THEN BA$="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 2,2,2,2,2,2,2,65,20,6
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.

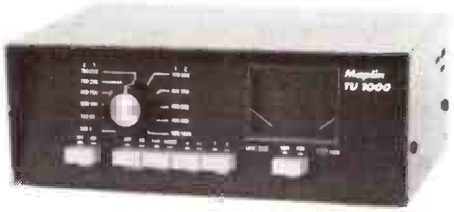
The connection to the TU1000 is made through the headphone or loudspeaker socket. Provision has been made on the TU1000 for muting the sound output by pressing S1. This switches off the loudspeaker and introduces a 10Ω resistor which acts as a dummy load for the receiver audio circuit. The initial tuning 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 I 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 IN 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 COMMITIED
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 IN 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. IT 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 0.6W 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)

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

FJ53H Front Panel
FJ54J Rear Panel
GB67X Main PCB
GB73Q Meter PCB

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 guess-work 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

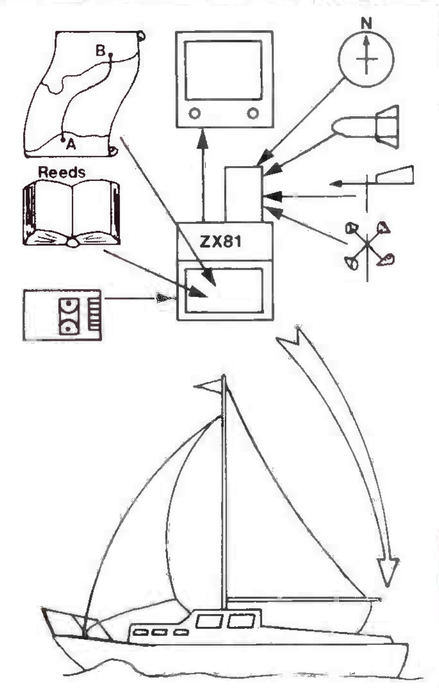


Figure 1. Block Schematic

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.

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.

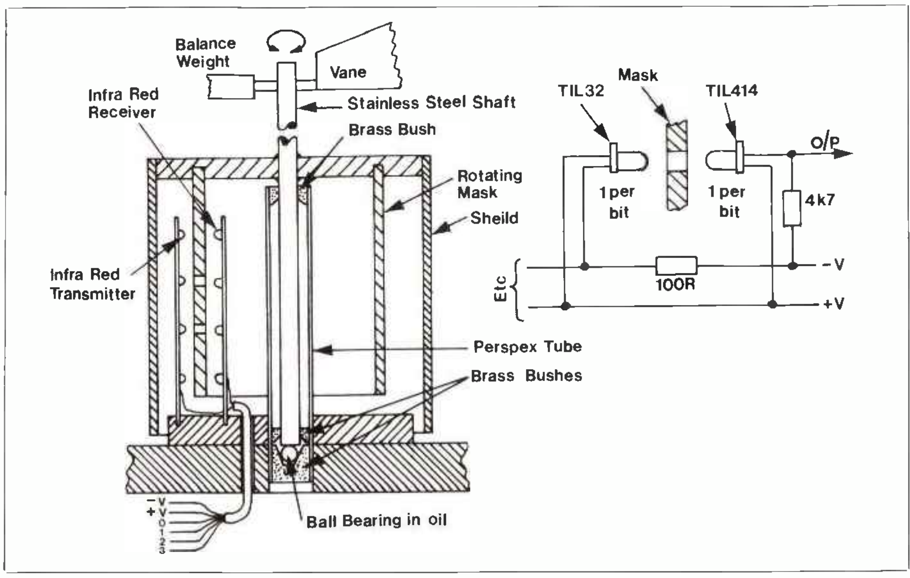


Figure 2. Wind Vane

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

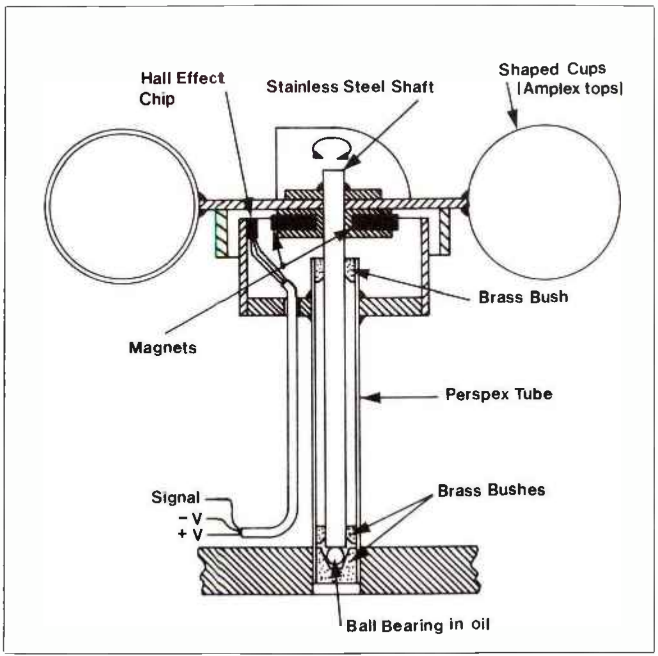


Figure 3. Anemometer

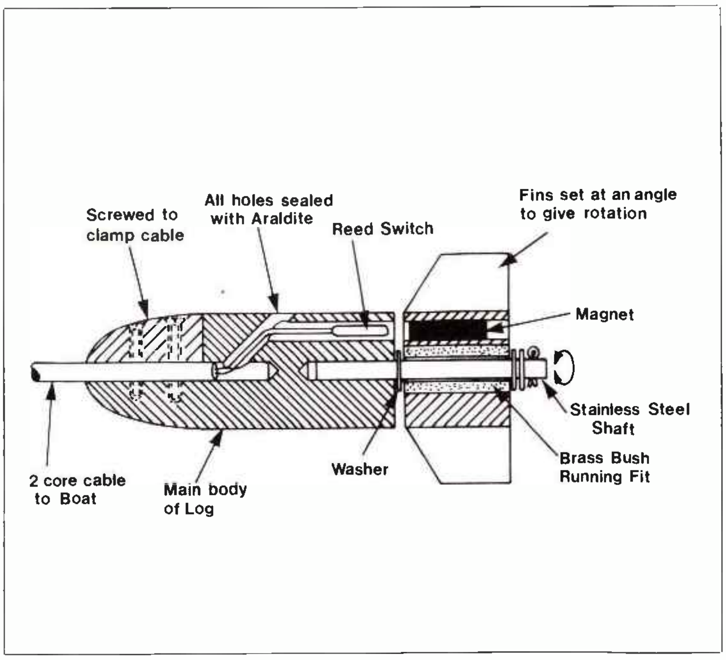


Figure 4. Log

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

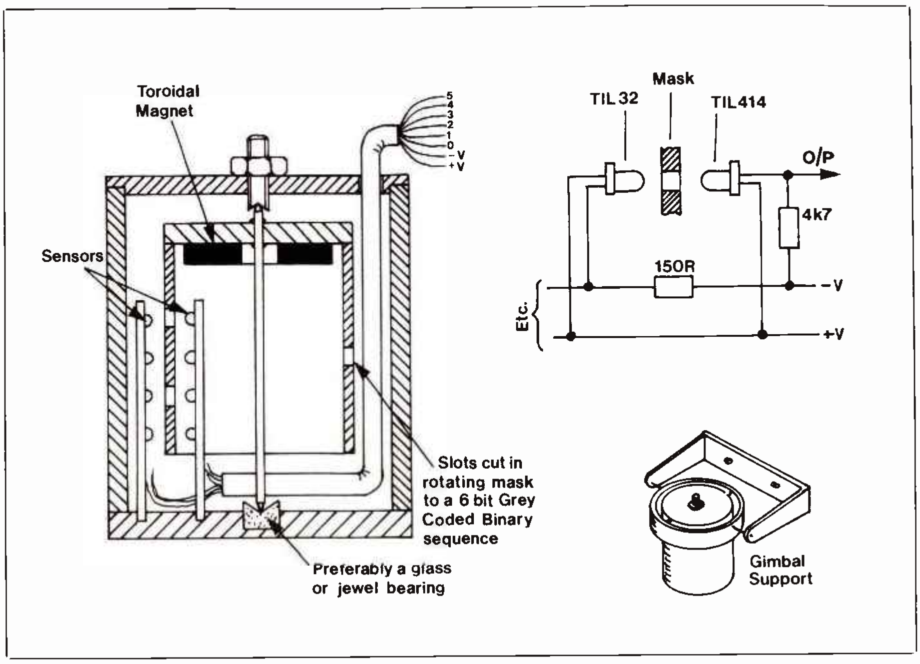


Figure 5. Compass

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.

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

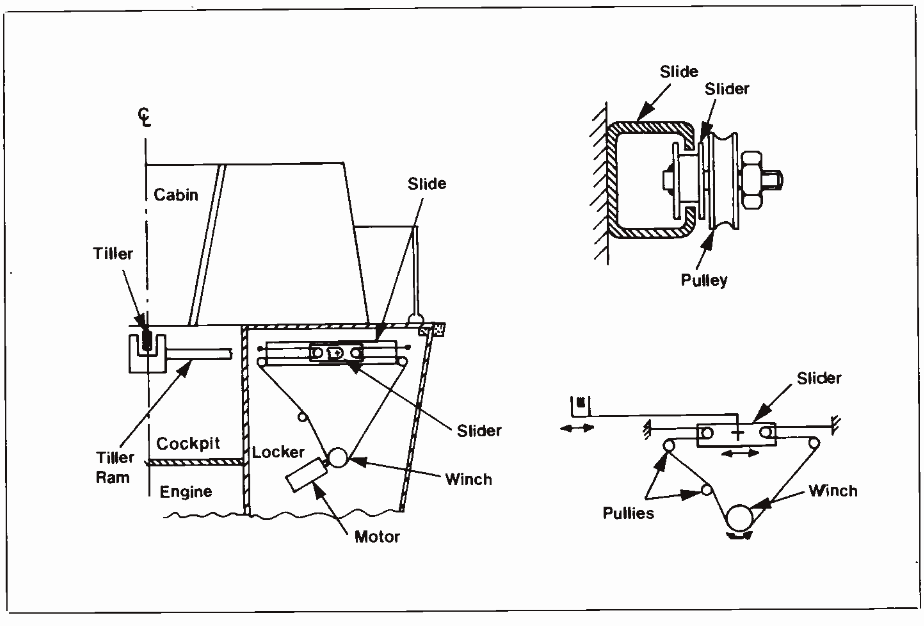


Figure 6. Tiller Servo

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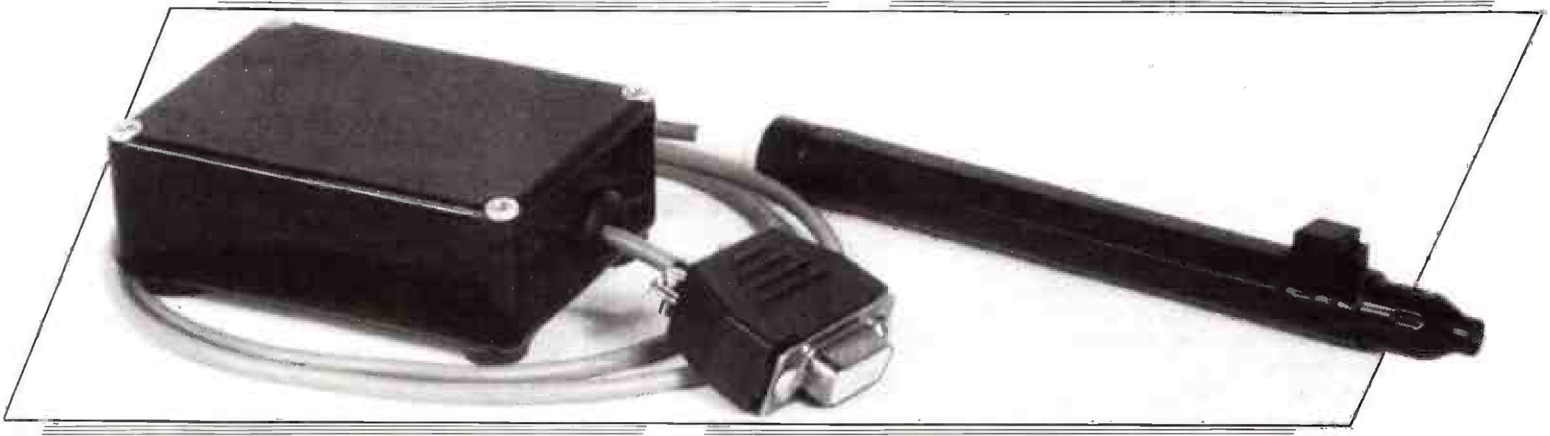


LIGHT PEN

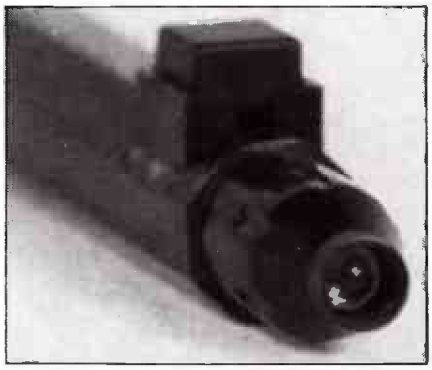
by Chris Barlow

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.

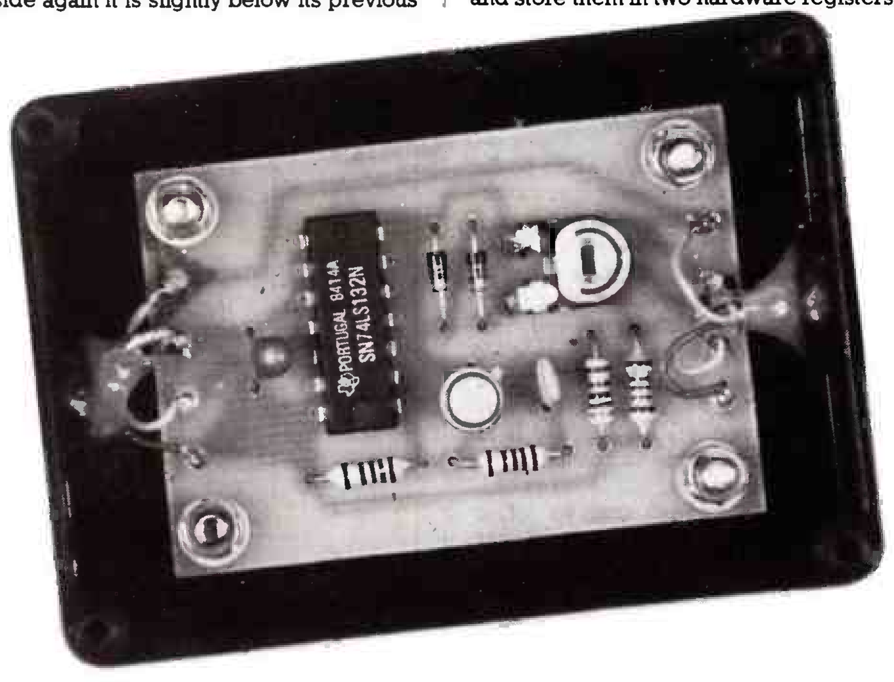
Method

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.



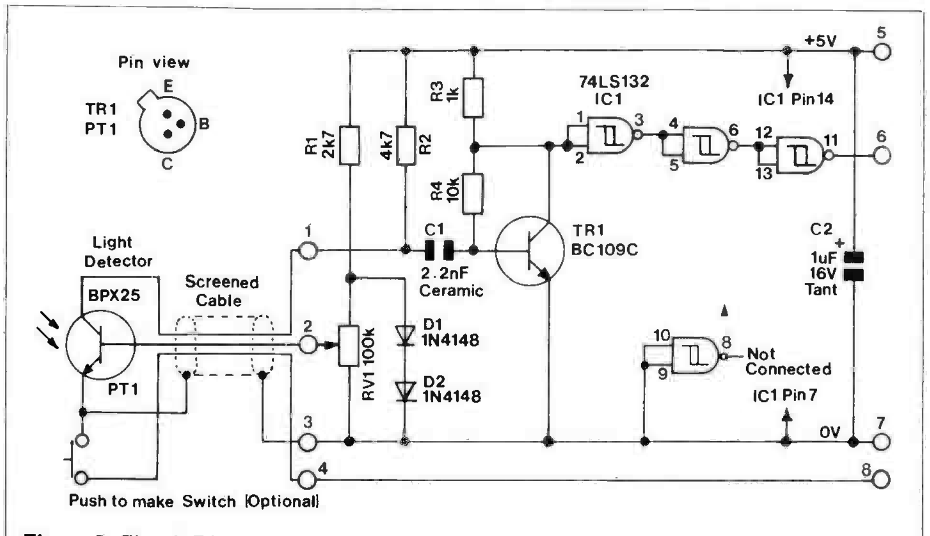


Figure 1. Circuit Diagram

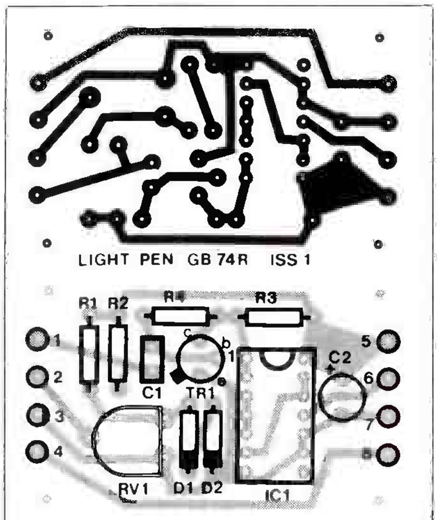


Figure 2. Artwork and Legend

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

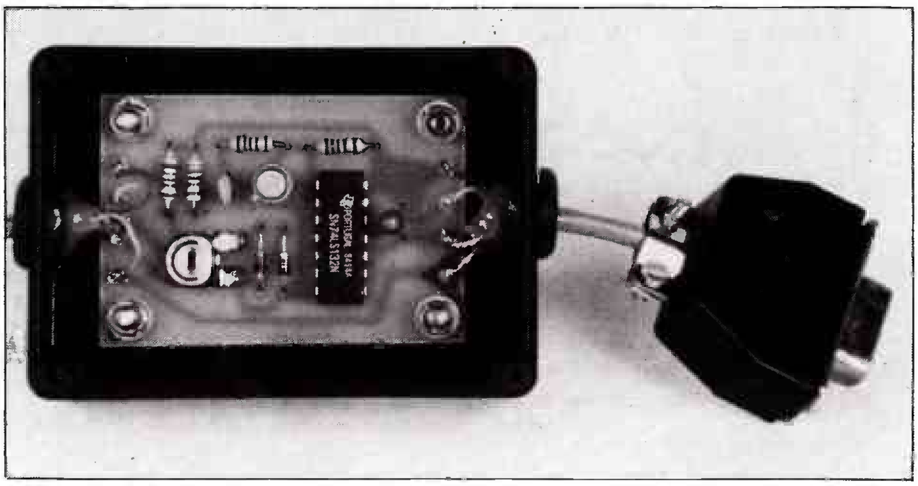
As can be seen in the circuit diagram (Figure 1), there are very few components necessary to obtain a working Light Pen. The most important is the light detector. It must have good sensitivity and fast reaction characteristics. The BPX25 phototransistor meets both requirements at a modest cost. This 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 0.6W 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	$1\mu F$ 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)
The Printed Circuit Board in this project is also available separately.
Order As GB74R Light Pen PCB

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

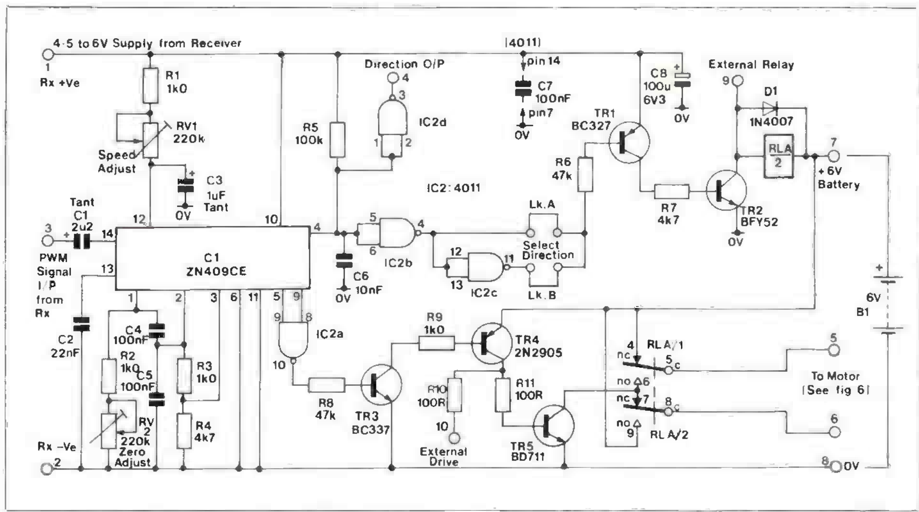


Figure 1. Circuit Diagram

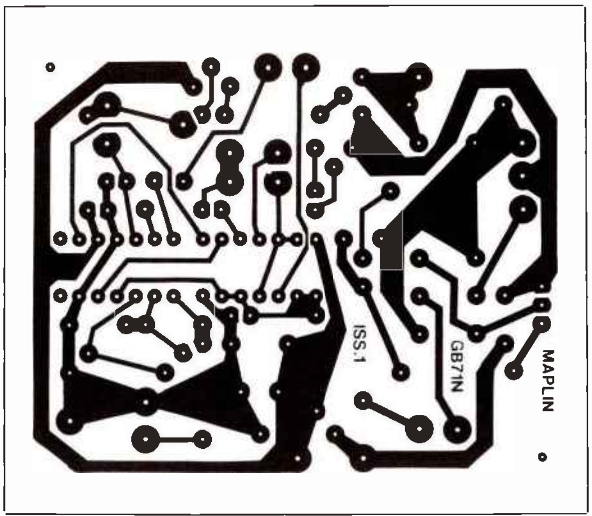


Figure 2. Artwork

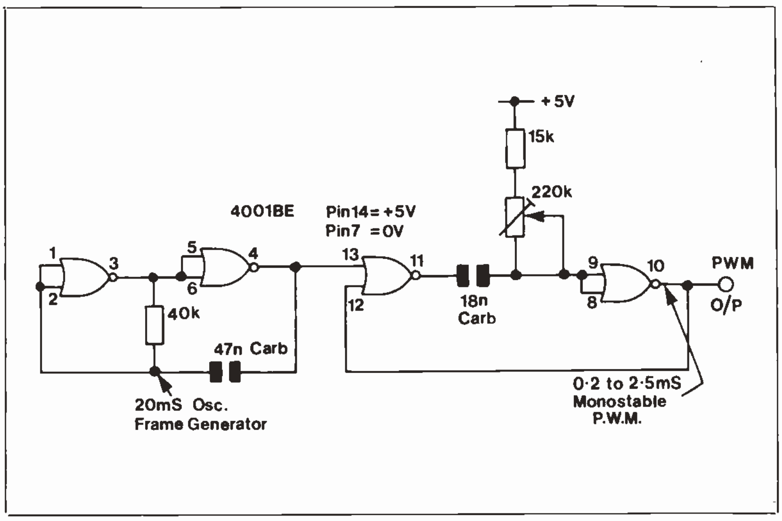


Figure 3. Test Circuit

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

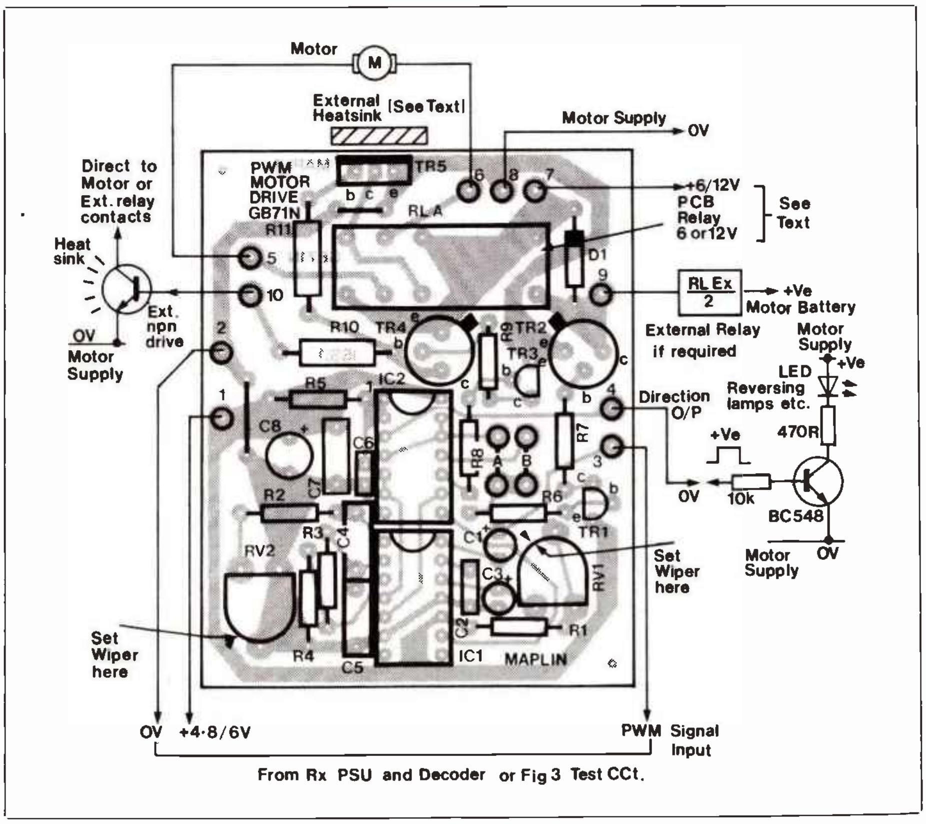


Figure 4. PCB Wiring & Legend

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.

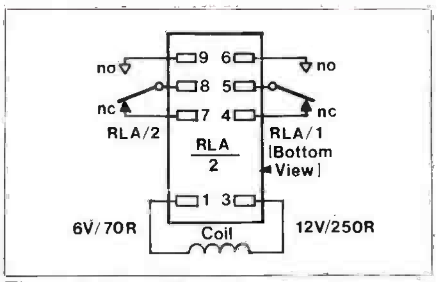


Figure 5. Relay Pinouts

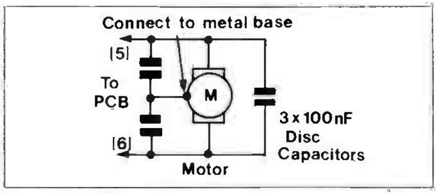


Figure 6. Motor Suppression

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.

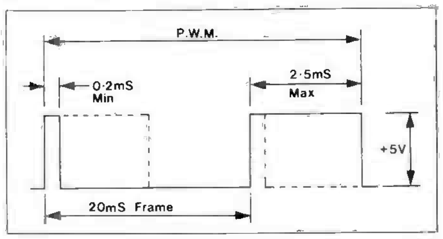


Figure 7. Control Waveform

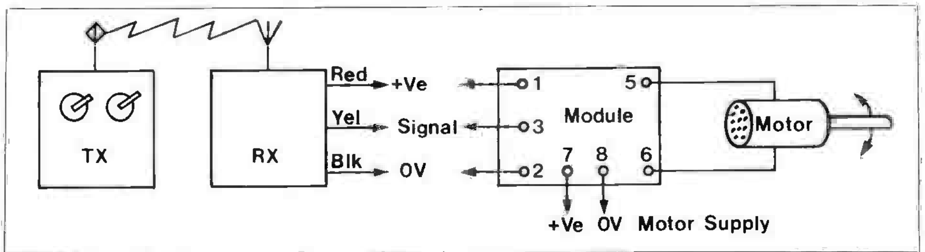


Figure 8. Block Diagram

PWM MOTOR DRIVE PARTS LIST

RESISTORS: All 0.6W 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)

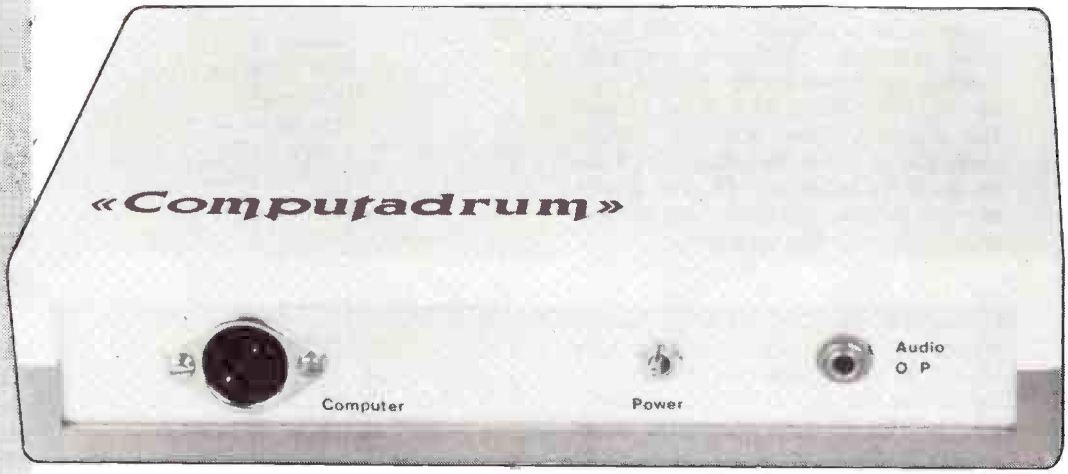
OPTIONAL

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)

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
FJ43W Min DPDT 6A 12V Relay
GB71N Printed Circuit Board

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

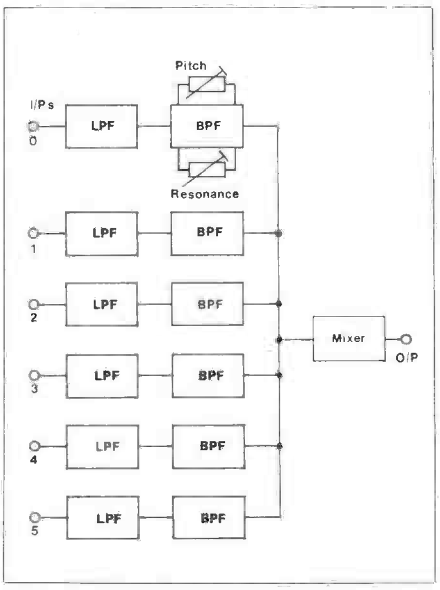


Figure 1. Block diagram

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.

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**

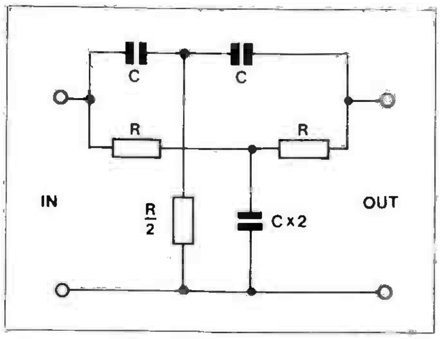


Figure 2. Twin T Filter

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 attenuation, 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.

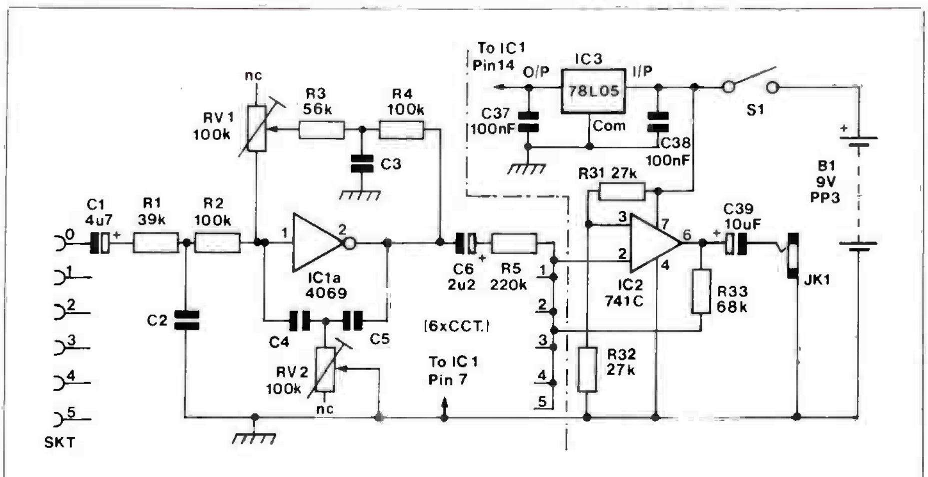
IC2 is used in the mixer circuit which is a standard operational amplifier summing mode type. The output from each filter circuit is quite high at a few volts peak to peak, and the mixer circuit has therefore been given less than unity voltage gain to prevent overloading if more than one drum is activated 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.

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



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

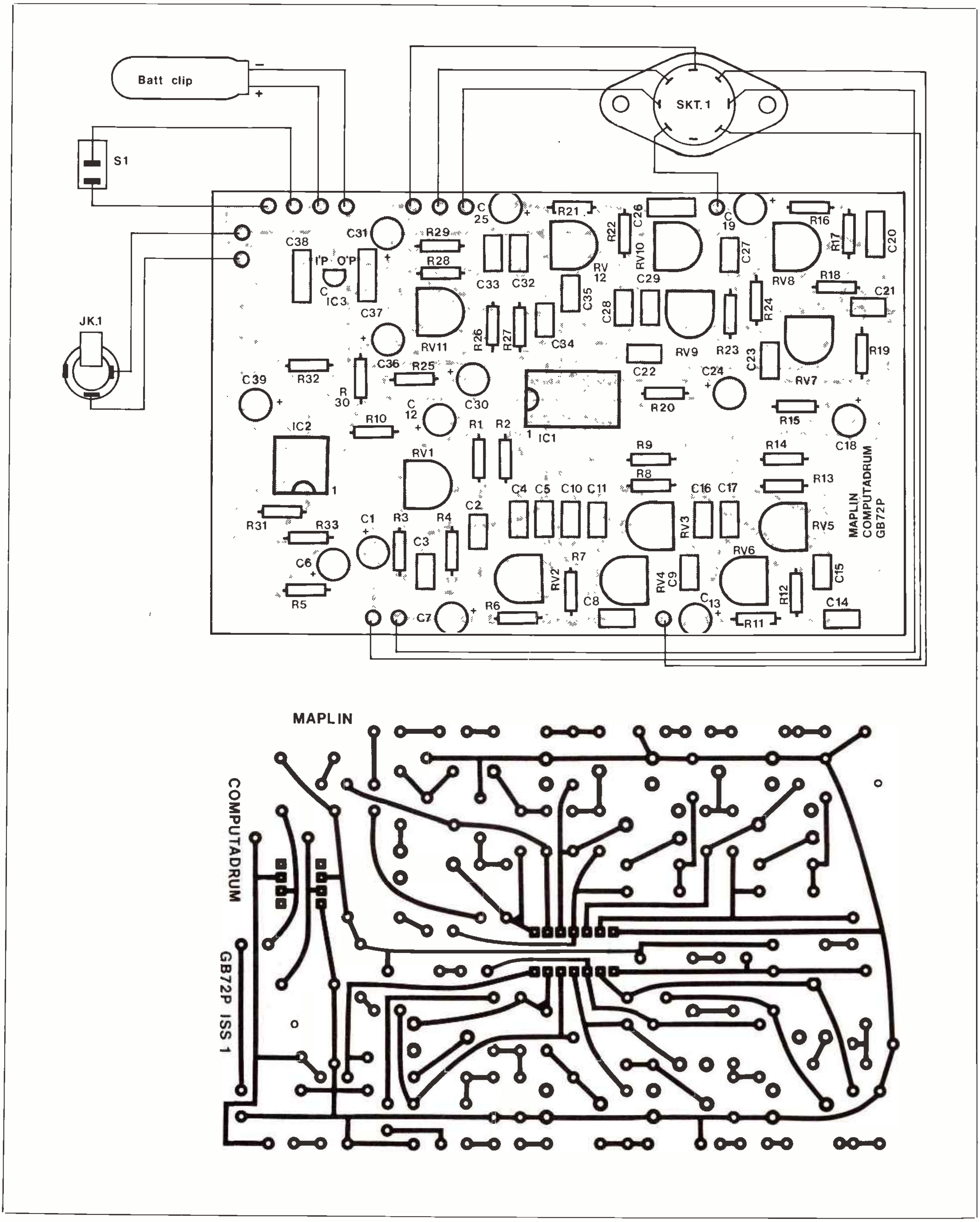


Figure 4. Artwork and wiring

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.

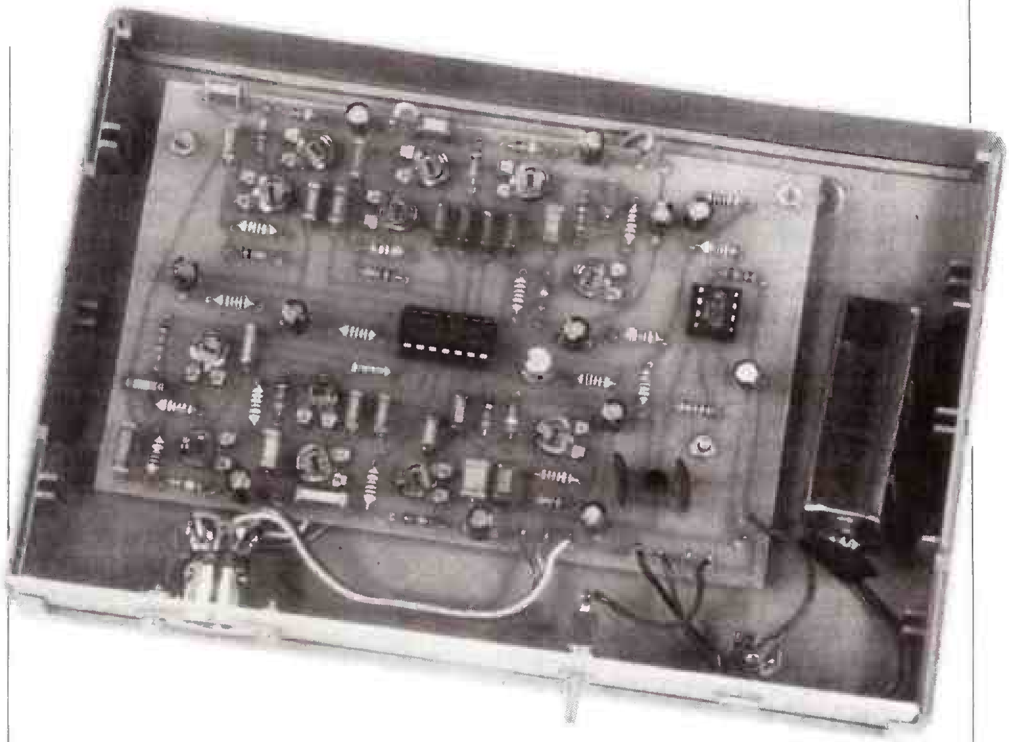
Connection

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



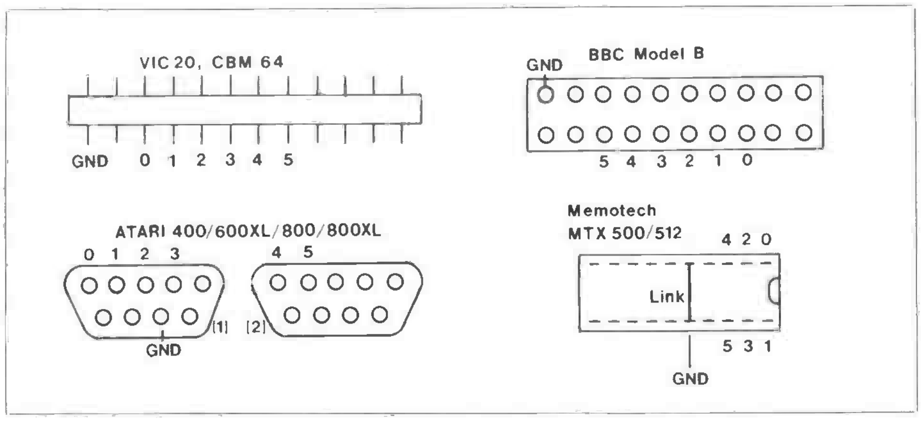


Figure 5. Connections to various computers

```
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
```

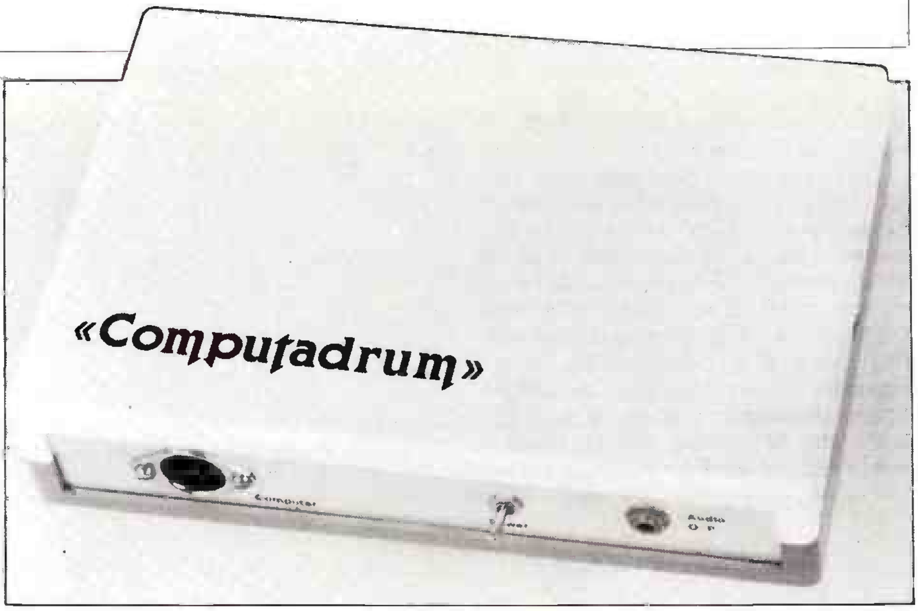
```
10 REM DRUMBEAT PROGRAM
20 REM FOR BBC MODEL B.
30 REM SETUP
40 DIM STORE (20)
50 ?&FE62=63
60 REM MAIN PROGRAM
70 REPEAT
80 PROCinput
90 PROCloop
100 UNTIL FALSE
1000 DEF PROCinput
1010 CLS
1020 INPUT "Number of drumbeats", N%
1030 FOR P=1 TO N%★2 STEP 2
1040 INPUT "Drum No.",STORE (P)
1050 INPUT "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.



COMPUTADRUM PARTS LIST

RESISTORS: All 0.6W 1% Metal Film

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

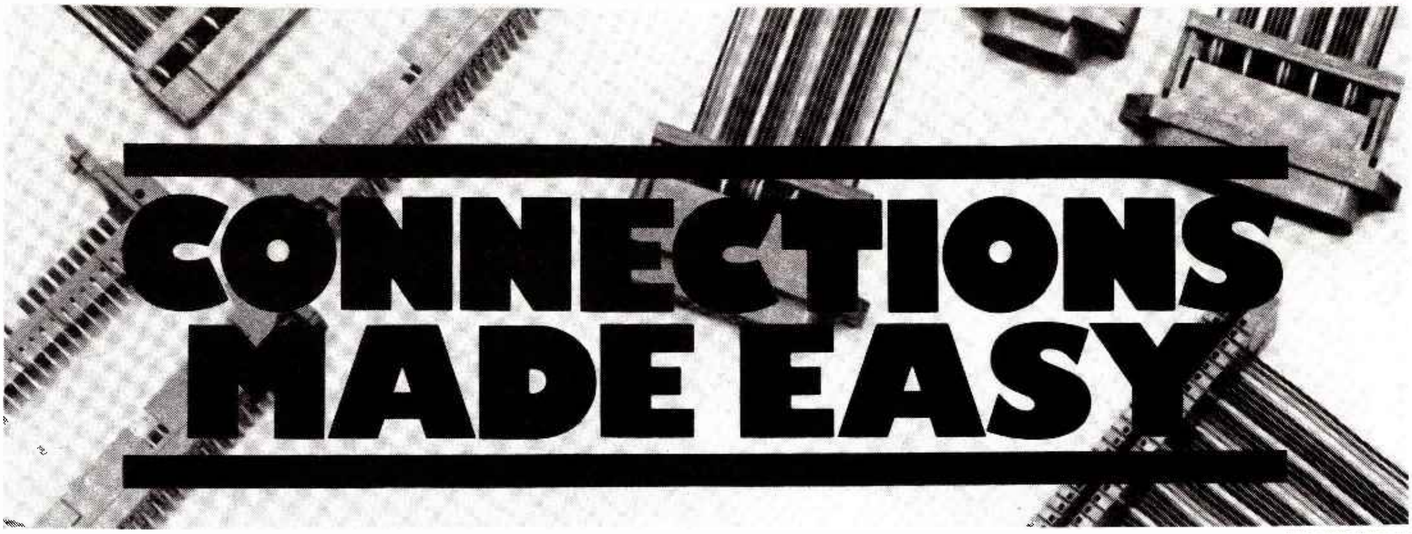
SKT1	DIN Socket 7 Pin	1	(HH37S)
JK1	Jack Socket 3.5mm	1	(HF82D)
S1	SPST Ultra-Min Toggle	1	(FH97F)
	Printed Circuit Board	1	(GB72P)
	Veropin 2145	1 pkt	(FL24B)
	PP3 Clip	1	(HF28F)
	DIL Socket 14-pin	1	(BL18U)
	DIL Socket 8-pin	1	(BL17T)
	Hook-up Wire	2m	(BL00A)

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)

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



CONNECTIONS MADE EASY

by D. H. Jennings
Marketing Director, H&T Components

ID Connector/Flat Cable, Design and Use

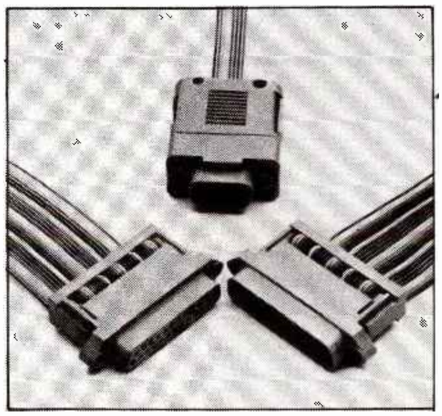
The development of flat cable technology in the early 1970's created problems of wire termination which remained largely unsolved until the introduction of insulation displacement termination techniques.

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.

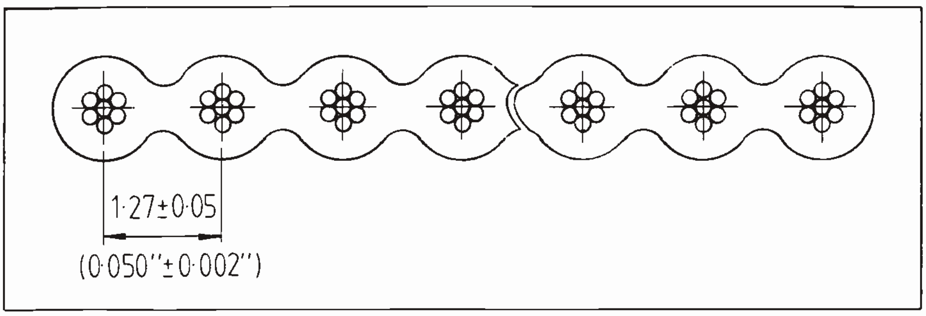


Figure 1. Cross section through flat cable

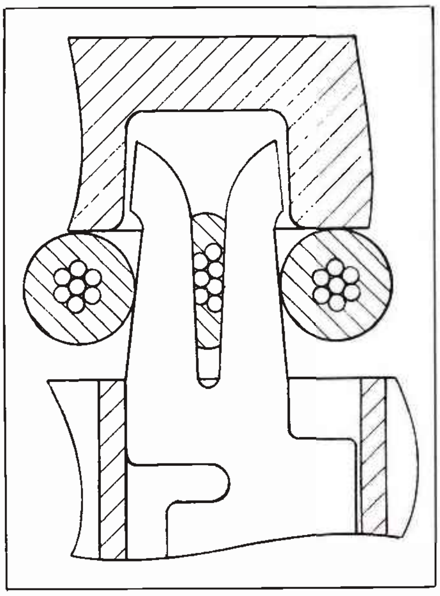


Figure 2. Contact point between forks and wire

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

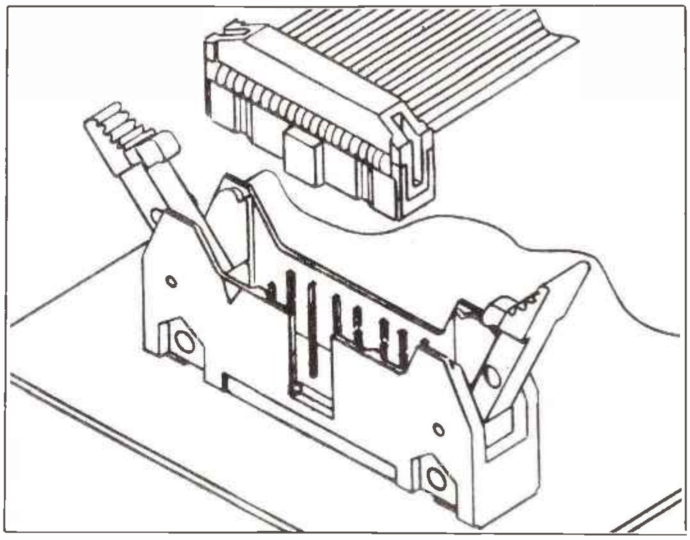


Figure 3. P.C. Board header/socket

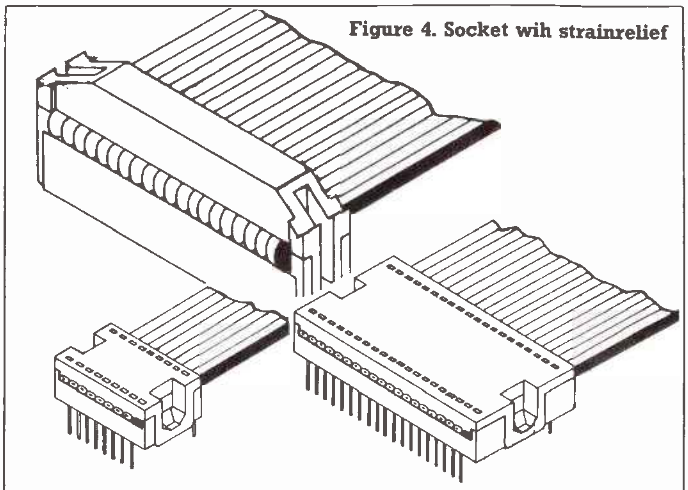


Figure 4. Socket wih strainrelief

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.

ZX81 & YOUR BOAT *Continued from page 15.*

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.

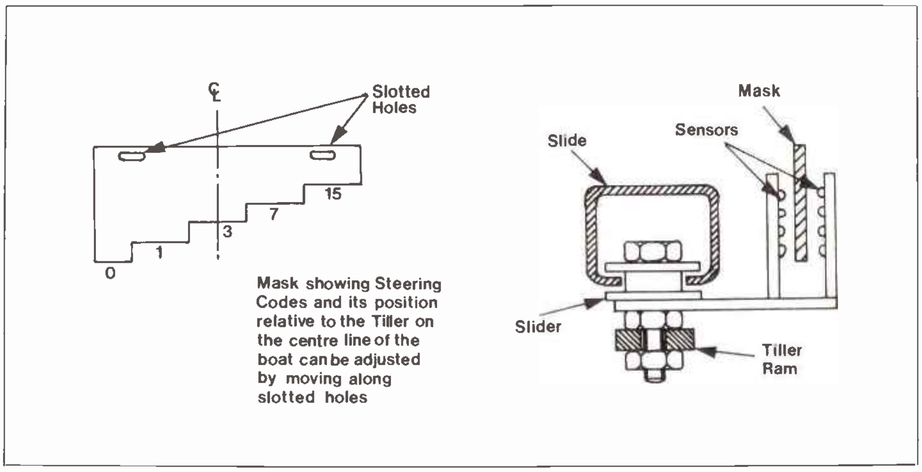
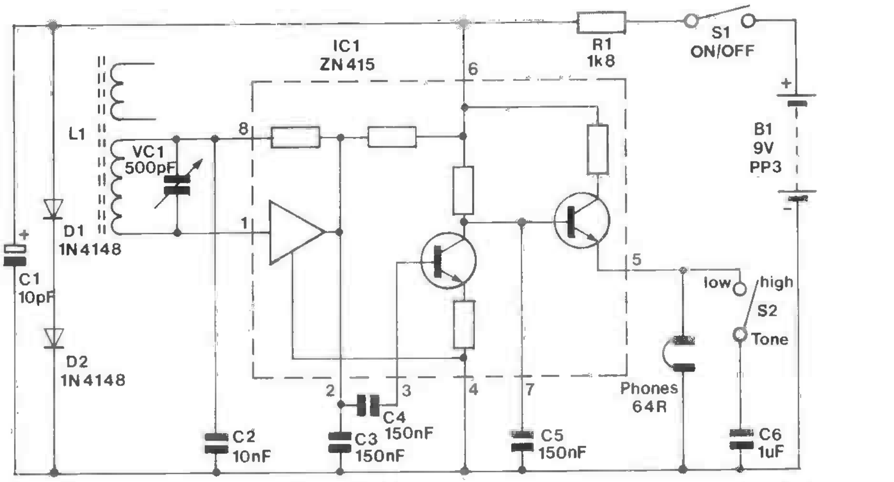


Figure 7. Tiller Follower

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.

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.

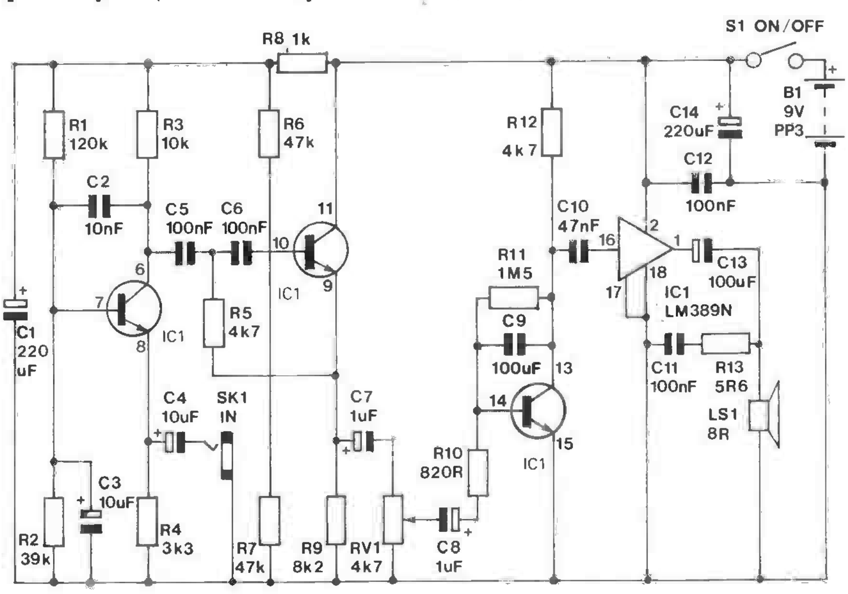
C5 is an RF filter capacitor and is needed to prevent instability. The bandwidth of the receiver is quite wide, which helps to give good treble response and audio quality. On the other hand, this can often result in a quite high level of interference. Closing S1 shunts C6 across the headphones and gives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

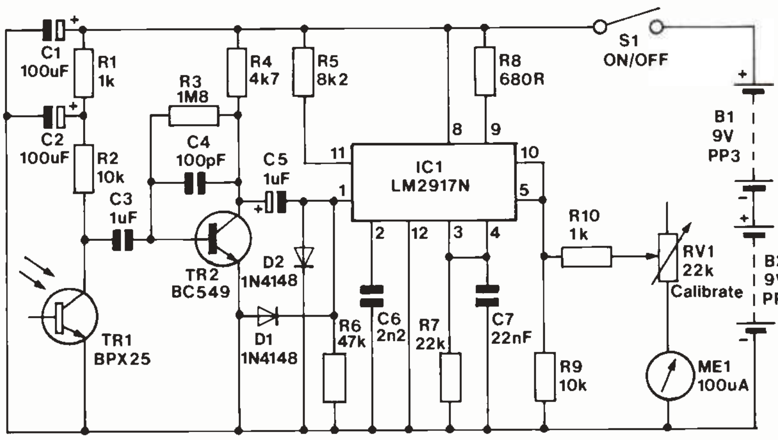
Opto-Coupled RPM Meter

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.

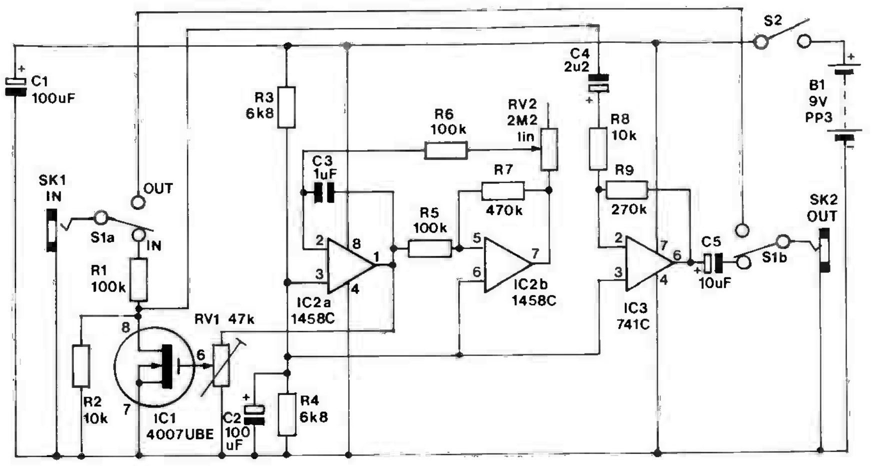
Tremolo Unit

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.



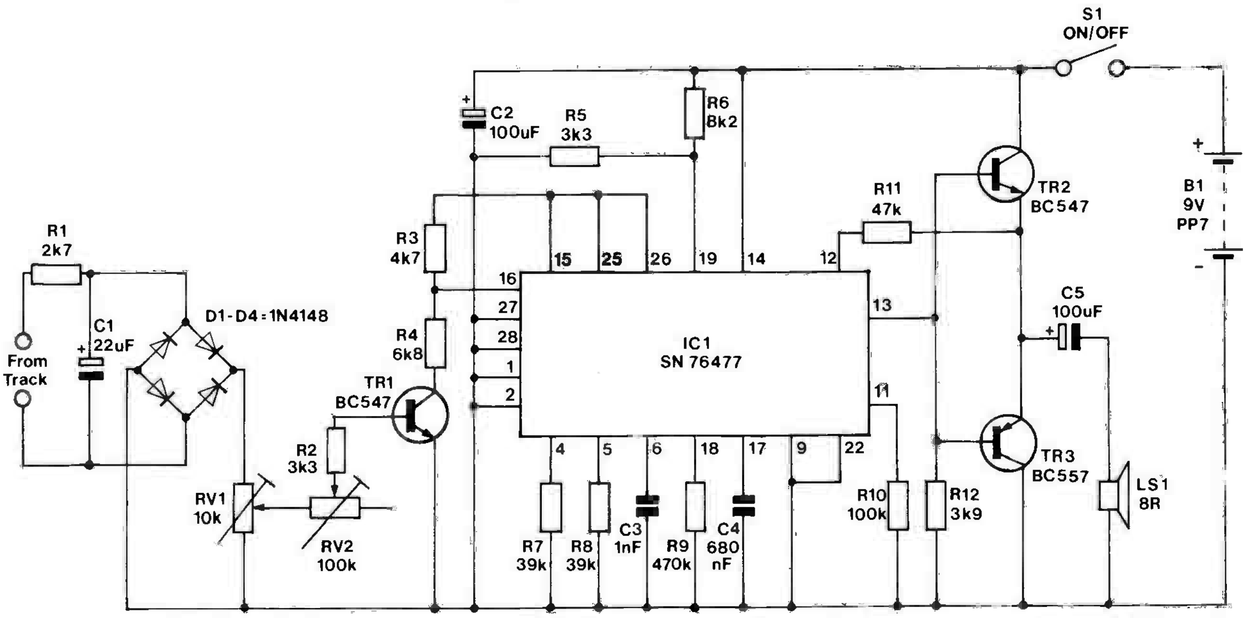
Model Train Chuffer

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 0.6W 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 0.6W 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 0.6W 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

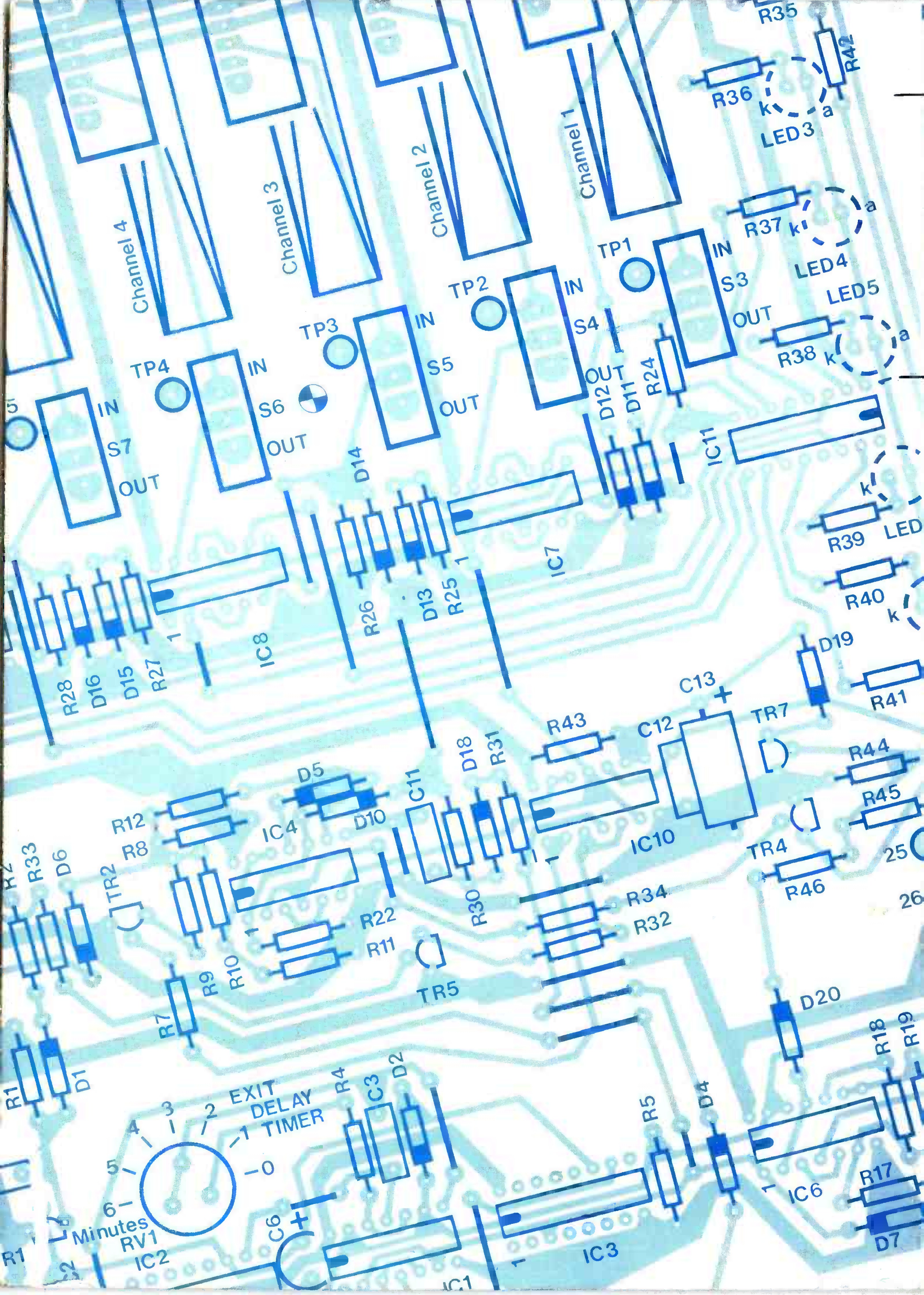
RESISTORS: All 0.6W 1% Metal Film

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)

OPTO-COUPLED RPM METER PARTS LIST

RESISTORS: All 0.6W 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)


R35
R42
R36
LED3
Channel 1
Channel 2
Channel 3
Channel 4
R37
LED4
TP1
IN
S3
OUT
LED5
R38
TP2
IN
S4
OUT
TP3
IN
S5
OUT
TP4
IN
S6
OUT
IN
S7
OUT
D12
D11
R24
IC11
D14
IC7
R39
R40
R26
D13
R25
IC8
R28
D16
D15
R27
D19
R41
C13
TR7
C12
R43
D18
R31
R44
R45
D5
R12
R8
IC4
D10
C11
IC10
TR4
R46
R2
R33
D6
TR2
R22
R11
R30
R34
R32
R9
R10
TR5
D20
R7
R18
R19
R1
D1
EXIT
DELAY
TIMER
R4
C3
D2
R5
D4
Minutes
RV1
IC2
C6
IC3
IC6
R17
D7
IC1