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NUCLEAR RADIATION MONITOR

by C.S. Barlow & Ms. M.A. McCarthy

★Portable ★Sensitive Wide Range Detector

★Low Power Consumption ★Easy To Read Display

Specification

Internal Supply Voltage:	9V Battery
External Supply Voltage:	7V to 14V DC
Min Supply Current at 9V:	0.5mA
Max Supply Current at 9V:	15mA
Radiation Detector:	Geiger Muller Tube
Tube Type:	Mica End Window
Gas Filling:	Neon, Argon
Quenching Agent:	Halogen
Detected Radiation:	Alpha, Beta, Gamma and X-Rays
Meter Ranges In Millirems per hour:	Range 1 = 0.5 mR/hr Range 2 = 5 mR/hr Range 3 = 50 mR/hr Battery Test
Audio/Visual:	Piezo Sounder Red Light Emitting Diode
Case Dimensions:	154 x 81 x 37.5mm
Weight (including battery):	257gm (9oz)

Main Introduction

Monitoring the environment is becoming a matter of great concern as the levels of pollution increase. One form of this pollution, which attracts a lot of media attention, is nuclear radiation. Having an independent method of measuring the natural background radiation and the level of individual items, will assist you to determine an acceptable level. However, radiation monitoring equipment is not commonly available through domestic retail outlets and professional, scientific instruments are very costly.

The radiation monitor described in this article has been designed with the following advantages: portability, compactness, light weight, extremely low power consumption and an easy-to-read display. The meter has three ranges displayed in millirems per hour (mR/hr), 0.5 mR/hr, 5 mR/hr and 50 mR/hr full scale deflection. In addition, an audio bleep or click, and a flash from a red light emitting diode (LED) can be selected to indicate each count event.

One consideration in the design of the unit was the ability to expand its versatility and performance. Provision has been made for an external power supply, remote detector and pulse output for counter or computer data recording. The unit runs on a 9 volt battery, but may be operated from a power supply of 7 to 14 volts DC.

To meet these exceedingly high specifications, several components had to be specially manufactured before a complete kit of parts was available.

The Radiation Detector

There are several types of detector available for radiation monitoring and one of the most commonly used, is the GEIGER-MULLER (G.M.) tube. It was a German physicist HANS GEIGER, in collaboration with MULLER, who perfected the counter tube in 1928 and since that time further refinements have been made. This has lead to a wide range of detector tubes, but they all work on the same, basic, principle.

The G.M. tube consists of a wire electrode, the anode, surrounded by a metal cylinder, the cathode, which forms part of the envelope (see Figure 1), inside which is a mixture of rare gases: neon, argon, and halogen. The end window of the tube is made from a very thin piece of mica which bows inward due to the reduced pressure inside the envelope.

For the G.M. tube to function, a high, positive, voltage must be applied to the anode pin via a high value resistor. The voltage produces a strong electric field around the anode electrode. The cathode is connected via a low value resistor to the 0 volt ground. Radiation ionizing events, accelerated by the electric field, ionize more gas atoms in multiple collisions, resulting in an avalanche of electrons. This effect is known as Gas Amplification and it will occur whenever

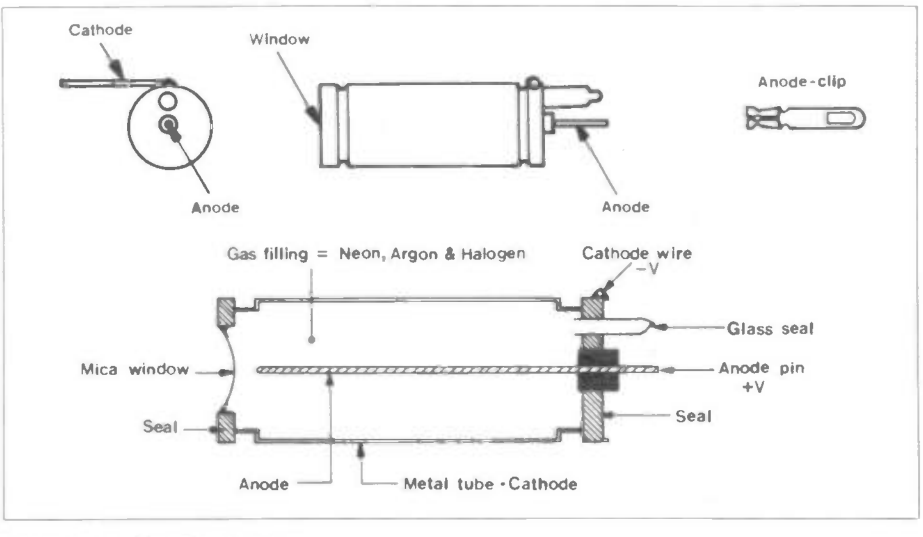


Figure 1. The Geiger-Muller Tube.


DANGER
Radiation risk

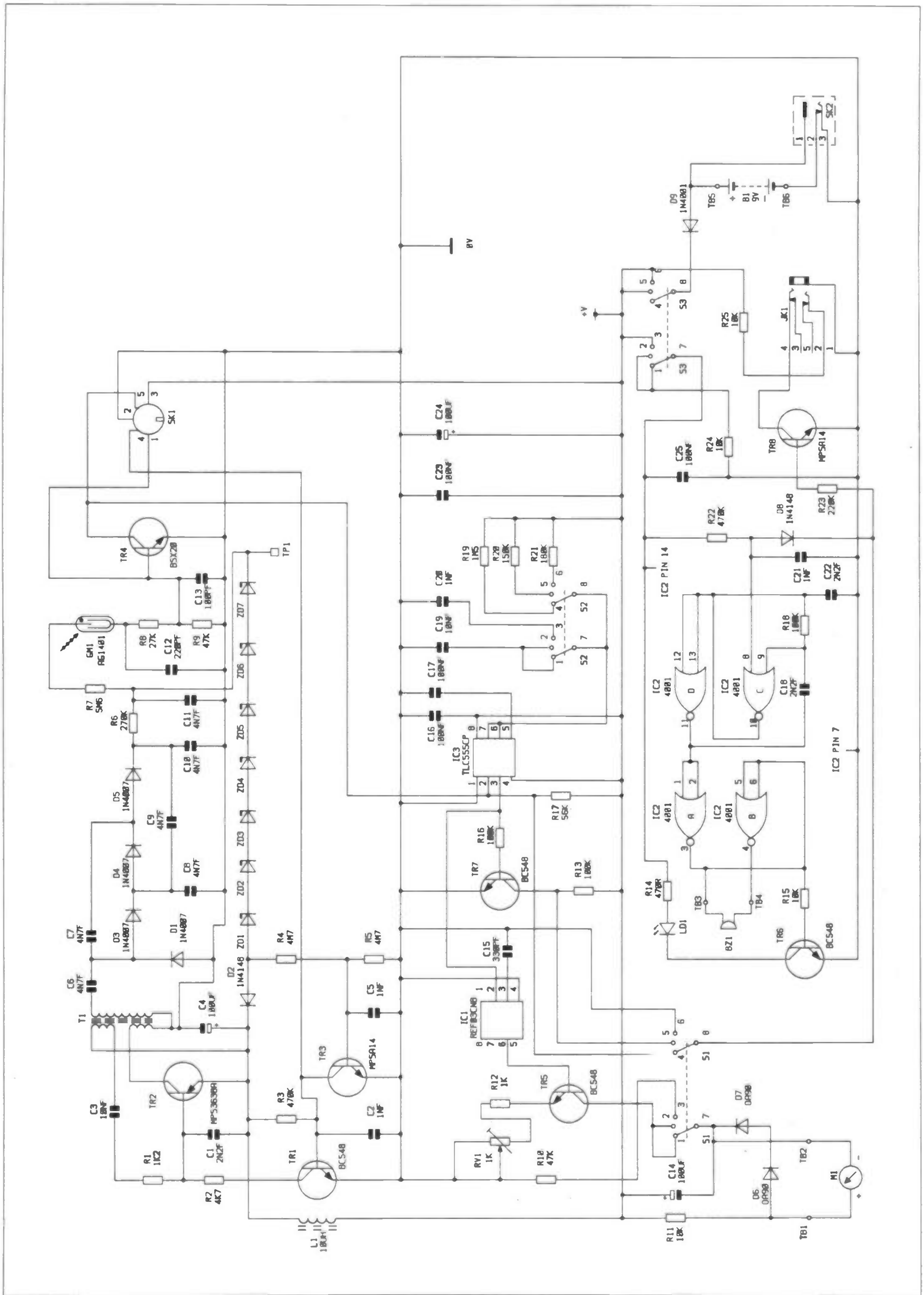


Figure 2. Circuit for the hand-held Radiation Monitor.

alpha/beta particles or gamma/X-rays enter the tube. Because of the low penetrating power of alpha particles, a very thin mica window is necessary to allow them to pass through. The G.M. tube has two basic electronic states; high impedance, when there are no radiation ionizing events, and low impedance when an event occurs.

Once avalanching has occurred, it may be sustained by positive ions reaching the cathode, releasing secondary electrons. To prevent this, a quenching agent, halogen, is present to absorb the energy from the positive ions leaving the G.M. tube ready for subsequent ionizing events. The quenching agent, which has been ionized, should recombine between events, but minute quantities will be chemically bonded and have no further effect. This will lead to a gradual deterioration until a continuous state of ionization is reached, rendering the G.M. tube inoperative. The ambient temperature during the operation of the G.M. tube is of prime importance and should be kept below 50 degrees centigrade. At temperatures above this, changes in the gas mixture may occur. However, if the G.M. tube is operated within the manufacturers specified electrical and environmental limits it should last for many years.

The handling and mounting of the G.M. tube is also important. To prevent electrical leakage between the anode pin and the cathode, the G.M. tube should be kept dry and clean. The fragile mica window must neither be touched, nor should the pressure outside the tube drop lower than 35 kPa (25 cm Hg) or rise higher than the atmospheric pressure. Any changes in pressure must be gradual to prevent possible damage to the mica window. Great care must e taken when fixing the G.M. tube because the thin walled envelope may be crushed or distorted out of shape. Soldering directly to the anode pin or the cathode wall may destroy the G.M. tube, so the electrical connection to the anode pin is made by a push on connector and the cathode has a lead or strap bonded to it.

Main Circuit Description

In addition to the main circuit shown in Figure 2, a block diagram of the complete system giving the power supplies and signal paths are detailed in Figure 3. This should assist you when following the circuit description or fault finding in the completed unit.

The internal DC power is provided by B1, a 9 volt PP3 type battery and when an external supply is plugged into SK2, B1 is switched out of circuit. Any DC supply entering the circuit must have the correct polarity, otherwise damage will occur to the semiconductors and polarized components. To prevent this, a diode, D9, has to have the positive supply voltage applied to its anode before the DC power can pass to the switch, S3. This switch has three positions: power off, power on and audio/visual (A.V.) on. Capacitor C24 provides the main decoupling and additional high frequency decoupling is supplied by C16,23,25.

All of the semiconductors run off the 9 volt DC supply but, the G.M. tube requires a +500 volt DC supply. This high voltage is generated by the oscillator circuit TR2 and T1. The transformer, T1 has three windings, the primary winding in the collector of TR2 and a feedback winding in its base circuit. The secondary winding has many turns providing an AC voltage step up. The oscillator runs at a frequency of approximately 40kHz and the voltage at the secondary is approximately 250 volts, peak to peak. To prevent electrical noise getting back to the main supply rail, a filter choke L1 and capacitor C4, decouple the oscillator supply.

The AC voltage is then rectified and multiplied by the capacitors C6 to C11 and diodes D1, D3 to 5. The high DC voltage across C11 is fed via the current limiting resistor R7 to the anode of the G.M. tube GM1. The only load on the supply is the few microamps of the G.M. tube present when ionizing events occur. Thus, if the oscillator was switched off, the high voltage across C11 would slowly leak away. The oscillator switching is controlled by the +500 volt monitoring circuit ZD1 to ZD7, and TR1, TR3. Only five, 100 volt, zener diodes are necessary when using the AG1401 Geiger tube so two diodes are linked out. When the voltage across C11 reaches the total zener break down of 500 volts, a DC bias, limited to less than +9.7 volts by D2, is fed to the base of TR3 via R4 and R5. When TR3 turns on, the voltage at its collector goes low removing the bias from the base of TR1 which then stops conducting, biasing off the oscillator until the

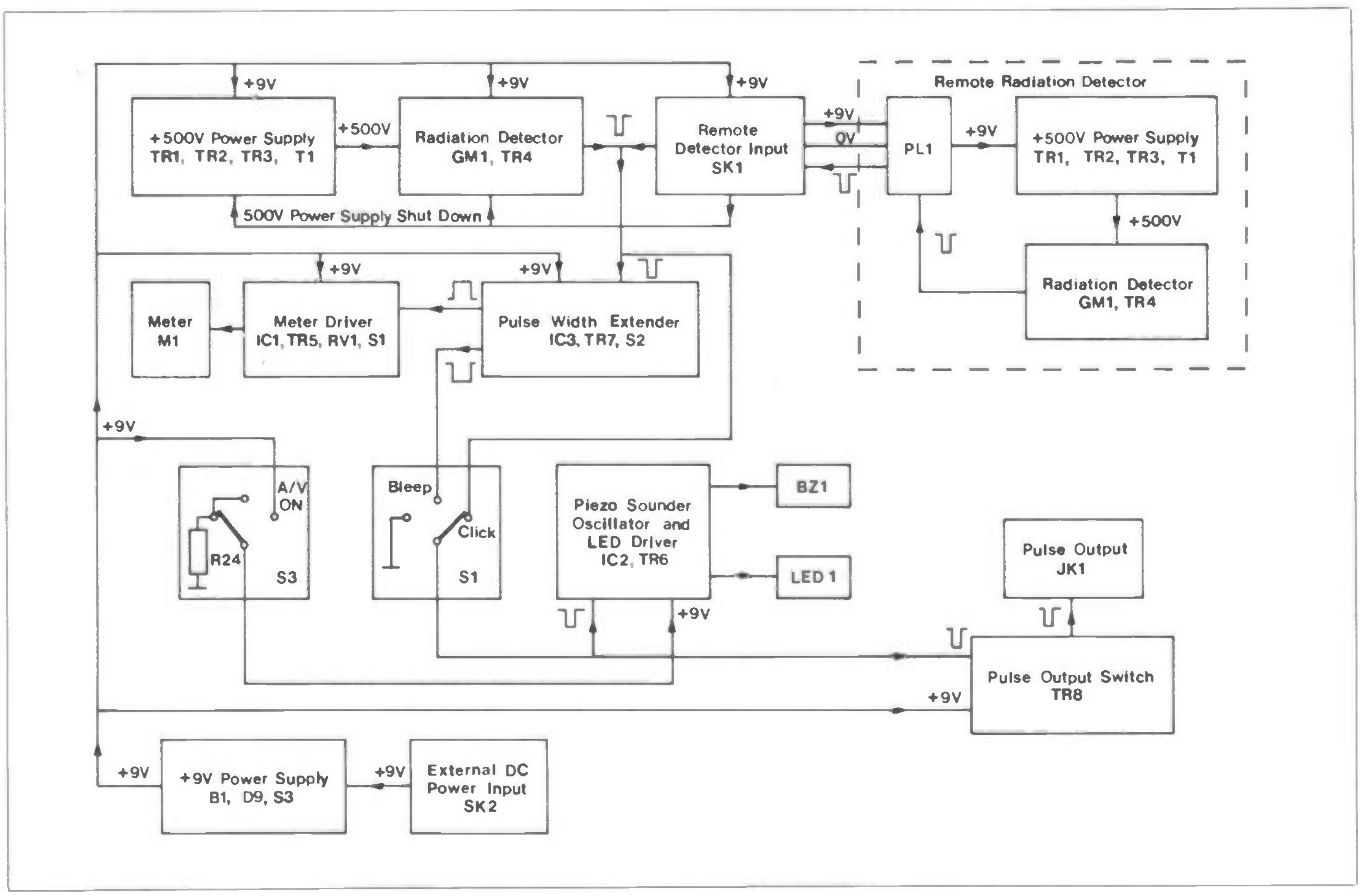


Figure 3. The complete system.

Inside the handheld unit.

voltage across C11 drops just below +500 volts. This regulates the output and a battery supply of 6 to 15 volts will only cause a small fluctuation of between 5 to 8 volts in the +500 volt supply. Having the oscillator interrupted means that the average current consumption from the 9 volt supply is greatly reduced, around 350 microamps at background radiation levels.

When GM1 detects a radiation ionizing event, the low impedance allows a small current pulse to flow through R8 and R9 in its cathode. This produces a positive going voltage pulse that feeds the base of TR4. The collector, held high by R17, goes low on each pulse for approximately 50μs. The base of TR4 is connected to SK1, pin 1, and its collector to pin 5. When using the remote radiation detector, if pin 1 is taken to pin 2, no pulses will reach TR4. Pin 5 is the remote signal input. Normally, both pins 1 and 4 are taken to pin 2 of SK1, shutting down the internal +500 volt supply to minimize power consumption.

The meter, M1, has a moving coil with a 280 microamp full scale deflection (FSD) and a multicoloured scale. This scale has three radiation ranges in mR/hr and a battery condition range. Diodes D6,7 provide over-range current protection for M1, and resistor R11 and capacitor C14 average out the current pulses. This reduces the amount of flicker shown by M1 when reading the level of random radiation ionizing events.

The meter function is selected by one half of switch S1. When M1 is switched to show the battery condition the current through the meter is set by R10. When displaying the radiation level, the current pulses pass through TR5 and R12. RV1 sets the amount of current flow for calibration of the meter. To maintain a constant current pulse over a range of supply voltages, a precise constant voltage pulse must be applied to the base of TR5. This is derived from a precision +2.5 volt reference source IC1. Its output pulse, on pin 6, will only vary by a small percentage for a change in supply from 7 to 14 volts.

If the number of pulses applied to IC1, pin 2, increase over a given period of time, the meter reading will rise until FSD is reached. If the width of each pulse was extended by an exact amount, then fewer pulses for the same period would reach FSD. This has the effect of increasing meter sensitivity and the wider they become, the more sensitive it will be.

The pulse width is controlled by IC3, a low power 555 timer, in its monostable mode. The high tolerance timing components C19, 20 and R19, 20, 21 are switched by S2 to provide three pulse width settings: 17ms, 2ms and 200μs. This corresponds to the three meter ranges 0.5 mR/hr, 5 mR/hr and 50 mR/hr FSD. IC3 is triggered by the pulses from the collector of TR4, and the extended output feeds IC1 and R16 in the base of TR7. The collector of TR7 is connected to S1 and goes low on each pulse. S1 selects the direct or extended pulses for the audio/visual and pulse output switch circuits. The third position of S1 is used in conjunction with the battery condition test, producing a constant low output to these circuits.

The audio/visual circuit comprises of a gated oscillator, IC2, which drives a piezo sounder and the LED control transistor, TR6. With S3 in its third position A/V ON, the supply is connected, but to prevent any spurious output when switched off, its supply rail is taken to ground by R24. When the cathode of D8 receives a negative going pulse from S1, IC2 will produce an output of approximately 3.7kHz. If the direct narrow pulses are selected, a click will be heard from the sounder and LED1 will flash momentarily. When the extended pulses are monitored the sound and light output will change, depending upon the meter range selected. In the 0.5 mR/hr range, the wider pulse produces a longer bleep sound and LED1 appears to flash more brightly. On the 5 mR/hr and 50 mR/hr ranges, the pulses become progressively narrower until the clicking sound returns.

Pulses from S1 also drive the base of the output switch, TR8. The stereo jack socket, JK1, can be set for Open Collector Switching or Voltage Pulse Output. When in the open collector mode, the output is on the ring of the jack and is normally low, going high, on each pulse. The output is for logic switching of only a few milliamps and the body of the plug provides the 0 volt return. If a voltage pulse is desired, an internal 10kΩ, pull-up, resistor on the tip of the jack is linked to the ring by the plug. See Figure 8a.

Main PCB Assembly

The PCB is a double-sided, plated-through hole type, chosen for maximum reliability and stability. However, removal of a misplaced component is quite difficult with this kind of board, so please double-check each component type, value and its polarity where appropriate, before soldering! For further information on component identification and soldering techniques please refer to the constructors' guide included in the kit.

The PCB has a printed legend to assist you in correctly positioning each item, see Figure 4. *Do not* fit the G.M. tube or the IC's until the initial testing stage!! The sequence in which the remaining components are fitted is critical, because of the high density of components on such a small board. It is easier to start with the smaller components. Begin with the resistors including the preset RV1 and set it as shown in Figure 5, then mount the resin-dipped and high voltage ceramic, polystyrene and electrolytic capacitors. The polarity for the electrolytic capacitors is shown by a plus sign (+) matching that on the PCB legend. However on some capacitors the polarity is designated by a negative symbol (−) in which case the lead nearest this symbol goes away from the positive sign on the legend. You must be very careful whilst bending the leads of choke L1, in order not to damage this component.

When fitting the transistors you must carefully match the case to the outline shown. The diodes all have a band at one end to identify the cathode connection. Be sure to position them accordingly. Please note: Only zener diodes ZD3 to ZD7 are fitted when using the AG1401 G.M. tube, ZD1 and ZD2 are linked out using component lead off cuts.

Next, install the slide switches making certain that they are pushed down firmly on to the surface of the PCB. Discard the fixing nut on JK1, and install this connector as carefully as you did the switches. The DC power input socket, SK2, and the remote detector socket, SK1, are mounted in a similar manner. The final PCB mounted sockets are for the IC's.

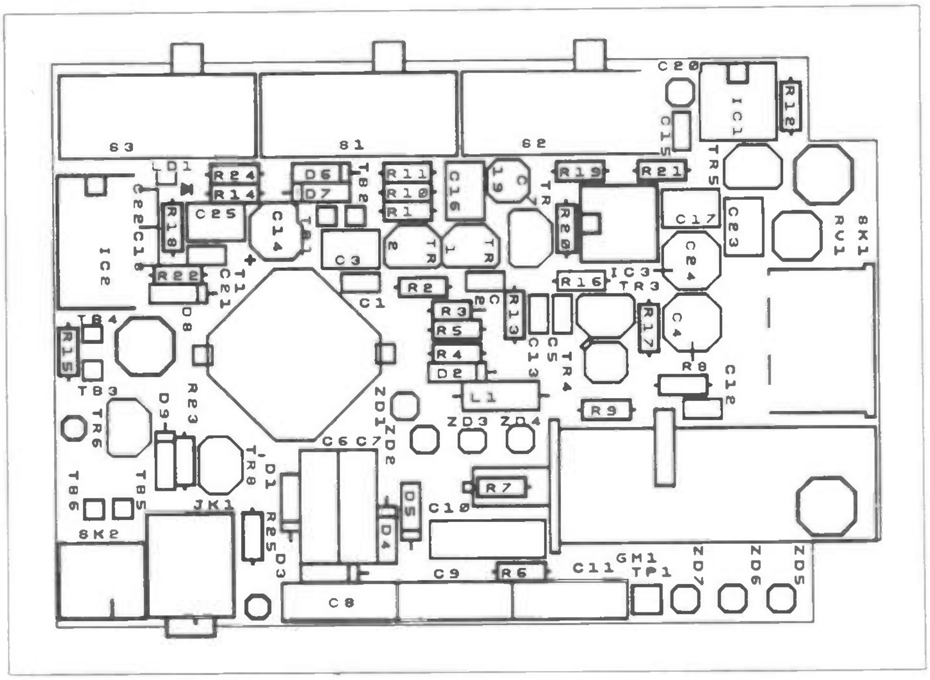


Figure 4. Main board legend.

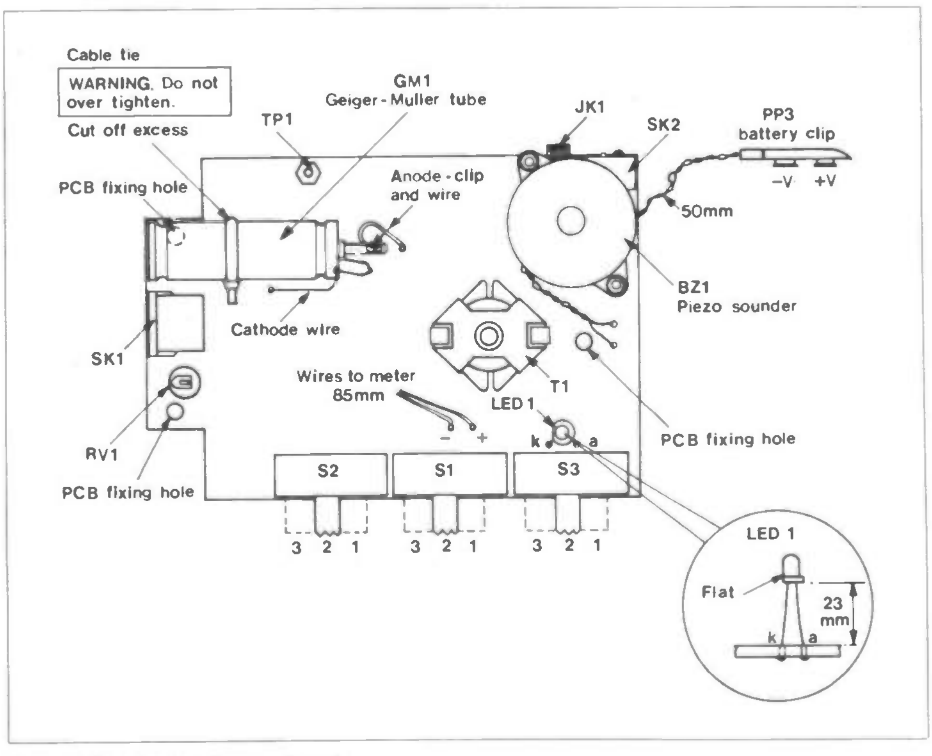


Figure 5. Constructing the main board.

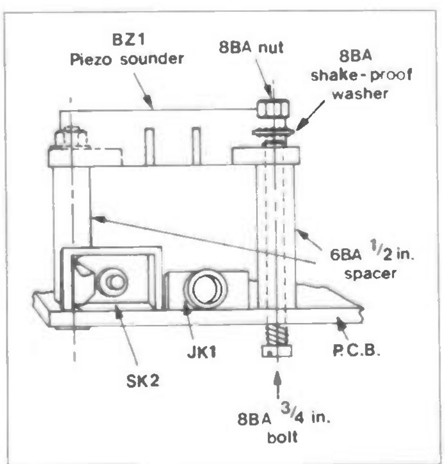
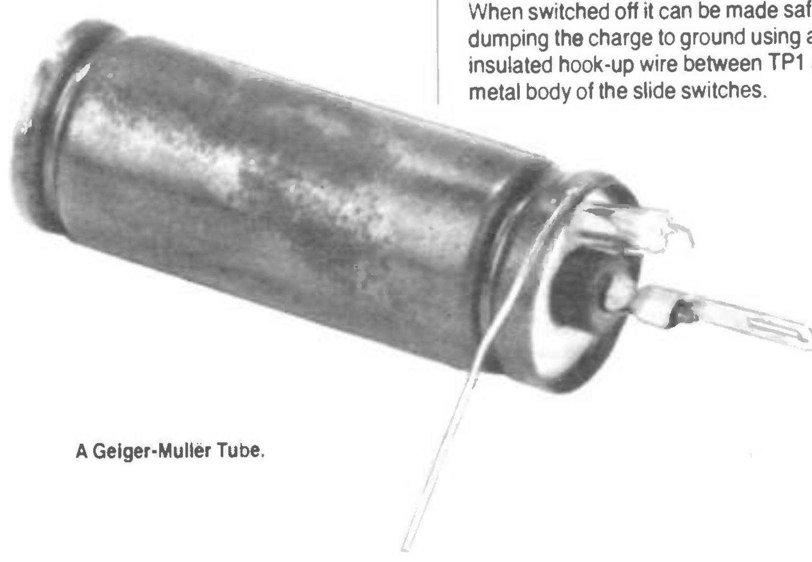


Figure 6. Mounting the sounder.



A Geiger-Muller Tube.

Ensure that you fit the appropriate IC holder in each position, matching the notch with the block on the legend. The transformer, T1, can only be fitted one way. The pot core is secured by soldering two pieces of tinned copper wire to the steel clips and through two holes in the PCB nearest each clip. The wire used can be some of the off cuts from other components. When mounting LED1 it must be 23 millimetres above the board and the flat indicates the cathode, see Figure 5.

The remaining components are connected to the circuit board by insulated wires. Cut the PP3 battery clip leads to 50 millimetres and solder the red lead to TB5 and the black to TB6. The piezo sounder is mounted on two 6BA, 0.5 inch spacers by the 8BA hardware. See Figure 6. The sounder may have different coloured leads but either can be taken to TB3 or TB4. The wires for M1 and the anode clip for GM1 are not fitted until the initial testing stage.

This completes the assembly of the PCB and you should now check your work very carefully ensuring that all the solder joints are sound. It is also very important that the bottom, track side of the circuit board does not have any trimmed component leads standing proud by more than 1mm.

Main Unit Initial Testing

All the initial tests can be made with a minimum of equipment. You will need a digital, or electronic, analogue, moving coil multimeter with an input impedance of not less than 10 MΩ on its voltage ranges. Other multimeters can be used, but some of the readings obtained may vary slightly depending on the type of meter.

Carefully lay the PCB assembly on a non-conductive surface, such as a piece of dry paper or plastic. Set all three slide switches to their Number 1 positions, see Figure 5.

The power for testing the unit can be a 9 volt PP3 battery or a regulated power supply unit (PSU). The external DC input socket, SK2, is a type commonly used on Japanese radio equipment, where the centre pin is the positive connection and the negative contact is the spring-loaded tag. When the circuit is running, or even after it has been switched off, treat the PCB with caution as the 500 volt supply circuit can make you jump if touched! When switched off it can be made safe by dumping the charge to ground using an insulated hook-up wire between TP1 and the metal body of the slide switches.

To monitor the supply current set your meter to read mA and place it in the positive line of the battery or PSU. When the power on/off switch, S3, is set to position 2, a current reading of approximately 0.35 mA (350 μA) should register on the meter. Remove the meter and set it to read 500 volts DC. Place its negative lead on the 0 volt ground and the positive to TP1. Reconnect the power supply and observe the reading which should be between 480 to 515 volts.

Now switch off. Disconnect the power supply and dump the 500 volt charge. Cut two pieces of hook-up wire to 85 millimetres and solder them to the PCB at the points shown in Figure 5. Temporarily solder the wires to M1. The polarity of the terminals is moulded on the body of the meter. See Figure 7, stage 3. Lay the meter face up off the PCB near the slide switches. Set S1 to position 3 and S3 to position 2. Reconnect the power supply and M1 should read approximately halfway on the green battery scale.

Switch off (S3 position 1). Dump the 500 volt charge and carefully install IC2, the 14 pin 4001BE, into its socket. Set S3 to position 3 (audio/visual on) and a continuous 3.7kHz tone from the piezo sounder should be heard. At the same time LED 1 should light and the current from the supply will increase to approximately 10mA.

To test the pulse output switch insert a 3.5 mm stereo jack plug, wired as in Figure 8a. When in the battery test position, S1 position 3, the supply voltage can be seen on the tip or ring of the plug. If S1 is set to position 1 or 2 then only 0.5 volts should be seen. Now remove the plug and set S1, S3 to position 1. Before proceeding to the next stage dump the 500 volt charge. Install IC1, the 8 pin precision +2.5 volt reference source, and IC3, the low power 555 timer. Switch on the power and A/V circuit, S3 position 3. The supply current should read approximately 0.5mA, and M1 display zero. Switch off and dump the 500 volt charge using a high value resistor, not a piece of wire! To properly test the pulse width extender and meter driver circuits, a TTL pulse generator must be connected to SK1. See *final assembly*. For the time being the background count pulses from the G.M. tube will provide an indication that the circuits are working.

Install the anode clip using a short 10mm length of hook-up wire, see Figure 5. Remember when handling the G.M. tube *not to touch the fragile mica end window*. Carefully unpack the G.M. tube and temporarily lay it on the PCB in the area shown by the legend. Solder the cathode wire to the PCB at the point shown, and push on the anode clip. Turn on the power, S3 position 3, and set S1/S2 to position 1. Each time a radiation ionizing event occurs the meter should read the pulse as one or two small divisions and the A/V circuit will respond with a click. When S1 is set to the bleep mode, position 2, the response of the A/V circuit will change according to the meter range setting of S2. At normal background radiation levels of between 5 to 30 pulses a minute the meter display on range 2 or 3 will show almost nothing. Switch off and dump the 500 volt charge as previously described. Carefully desolder the wires on M1, then the G.M. tube

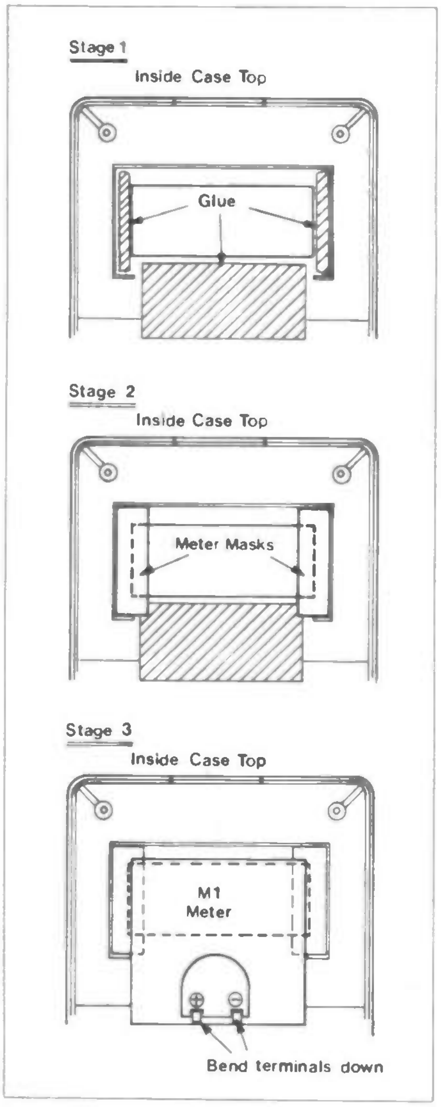


Figure 7. Mounting the meter.

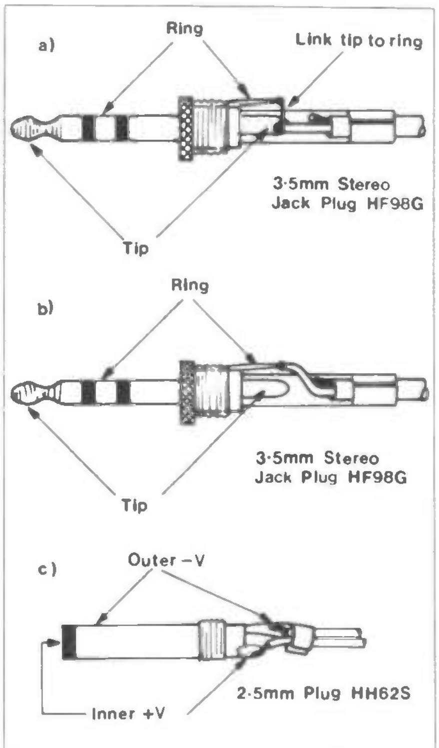


Figure 8.
(a) Wiring plug for use with a pulse counter.
(b) Wiring plug for use with computer.
(c) Wiring a DC Input Power Plug.

and repack it for safe keeping. This completes the initial testing of the main PCB assembly.

Main Unit Final Assembly

The calculator style, hand-held case is made in two halves. The top half has a window for the meter and two 5mm holes. One hole is for the LED to protrude through and the other for the output from the piezo sounder. Unfortunately, the window is fractionally too wide for the meter. To remedy this two black masking pieces cover the gaps at each end. The procedure for fixing the masks and the meter, M1, are shown in three stages. See Figure 7.

Stage 1: Apply a thin coating of impact adhesive at the two ends of the window, inside the case top. A thicker coating of adhesive is then applied over a larger area beneath the window.

Stage 2: Carefully position the two meter masks at each end of the window and press them down firmly.

Stage 3: Apply a coating of impact adhesive to the lower front of the meter, being careful not to get any glue on the raised scale area. Position the meter inside the case top and press it down. Finally bend down the meter terminals so they lay flat on the meter body.

In the lower part of the case top is a boxed-in area for the PP3 battery. Cut a 54mm length of sponge and glue it down across the centre of this compartment. This completes the assembly of the case top. Set it aside to allow the glue to set.

The bottom half of the case has various holes and slots cut into it. A piece of wire mesh is glued over the hole, in front of the G.M. tube, to protect the fragile mica window. Apply impact adhesive at the points shown in Figure 9 and carefully position the wire mesh so as not to cover the hole for the 5 pin DIN socket. There is a boxed-in area for the PP3 battery similar to the one in the case top except, it has

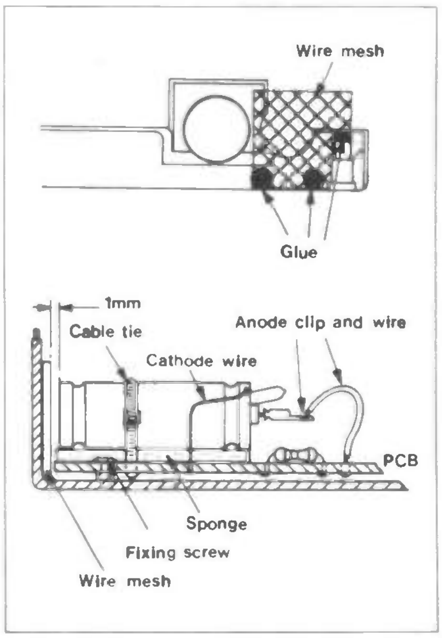


Figure 9. Mounting the Tube and fitting the mesh.

a detachable, slide-off cover. Cut a 54mm length of sponge and glue it down across the centre of this cover.

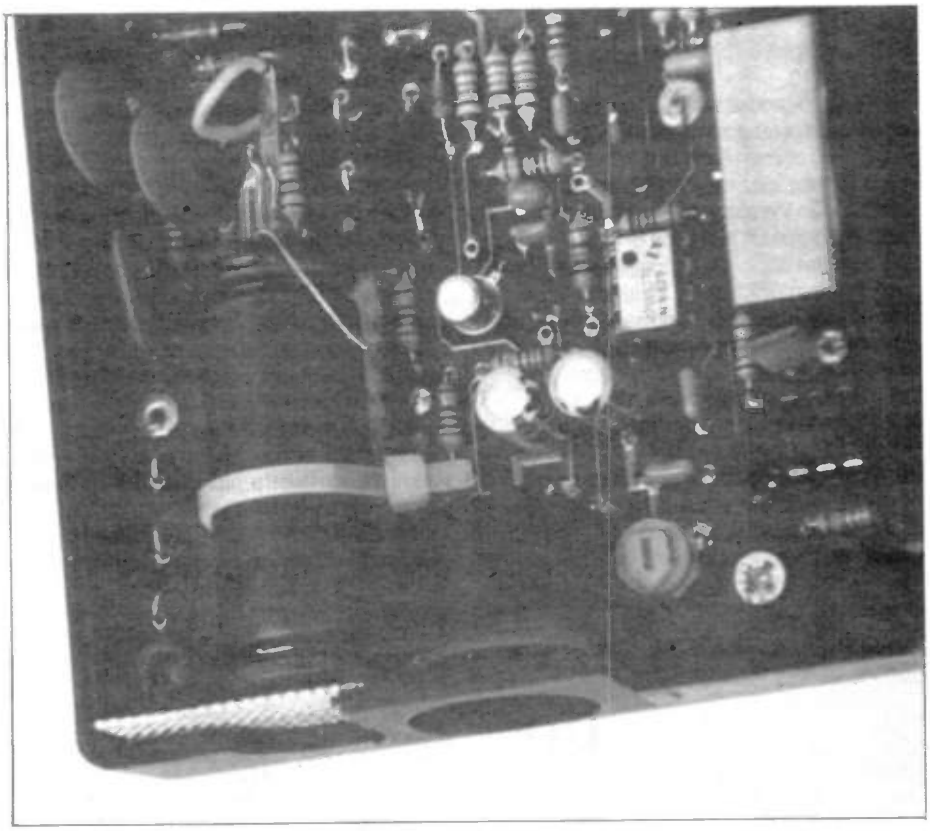
Before fixing the PCB assembly into the case, thread the cable tie through the two holes in the PCB, See Figure 9. Lay the assembly inside the case and secure it using three countersunk self-tapping screws at the positions shown in Figure 5. Cut a 39mm piece of sponge and lay it down where the G.M. tube outline is shown on the legend. Unpack the G.M. tube. Position it on the PCB, as shown in Figure 9, and tighten up the cable tie. ***WARNING!*** *Do not over-tighten* the cable tie and ensure that there is at least a 1mm gap between the front of the G.M. tube and the wire mesh. Solder the cathode wire into the hole in the PCB and push on the anode pin. Lay the battery clip in the battery compartment and position the wires through the slot in the case. Solder the two meter wires to the terminals on M1, ensuring that they are in the correct polarity. Lay the front case assembly face up alongside the switches of the main unit.

Alignment Without a Pulse Generator

If you do not have access to a TTL pulse generator to complete the calibration, then RV1 should be left in its centre position. This will provide a reasonable basic accuracy for most applications. Affix the front and back self-adhesive labels to the case in the recessed areas. Install the PP3 battery and test each switch function. Once these are successfully completed the bag of silica gel is placed over the PCB at IC2 and the case can be closed. When fixing the two halves of the case together ensure that the meter wires and terminals are not touching any other components. Secure the case with the four long self-tapping screws. The Nuclear Radiation Monitor is now ready for use.

Alignment With a Pulse Generator

To calibrate the unit a TTL pulse generator, set to produce positive going pulses, must be applied to pin 1 of SK1 via a 1000Ω resistor. The ground return for the generator is to pin 2 of this socket. The width of the pulses must be no more than 50μs at a repetition rate of 1.8ms (550Hz). Install the PP3 battery. Set the meter range switch, S2, to the 50 mR/hr scale, position 3 and turn on the power, S3, position 2. Adjust the preset control RV1 until a meter reading of exactly 40 mR/hr is displayed. Remove the generator and test each switch function. Once these tests are successfully completed, the bag of silica gel is placed over the PCB at IC2. The case can now be closed and secured using the four long self-tapping screws. When fixing the two halves of the case together ensure that the meter wires and terminals are in the clear and not touching any other components. Affix the three self-adhesive labels, one at the front and two at the rear, to the case in the recessed panels provided. The Nuclear Radiation Monitor is now ready for use.



Geiger Tube mounting position.

Using the Monitor

The DC power for the unit is supplied by the internal alkaline, PP3, 9 volt battery. However, external power can be fed into SK2 from a variety of sources, see Figure 9. The wiring for the 2.5mm DC power plug is shown in Figure 8c. For mobile use, a car battery voltage converter, or just a 12 volt cigarette lighter power lead is required. When used in the home, to save the battery, a mains adaptor supplying a regulated, 9 volt output is preferable. Due to the low power demand of the unit even a Solar panel, under moderate sunlight, will produce sufficient voltage output. If the unit is to be stored for long periods of time, remove the PP3 battery.

The meter of the Monitor is scaled in millirems per hour, (mR/hr). One mR equals one thousandth of a REM. The term REM stands for Roentgen Equivalent Man, a radiological unit. One REM is that quantity of radiation which when absorbed by a human being produces the same effect as the absorption by a human body of one RAD of Gamma or X-rays. The RAD unit is the absorbed ionizing radiation dose. One RAD is equal to an energy absorption of a hundred Ergs per gram of tissue. A new unit to measure absorbed dose, the Gray (Gy), will be used more in the future. To convert from RAD to Gy is simple, 1 Gy = 100 RAD, or 1 mGy = 100 mR. The Geiger Muller tube is capable of detecting Alpha, Beta, Gamma and X-rays.

Alpha Particles

An Alpha particle is the nucleus of a helium atom which has lost its two planetary Electrons, leaving it positively charged. Each Alpha particle consists of two Protons and two Neutrons. They do not have much penetrating power and can be blocked by a piece of paper.

Beta Particles

A negatively charged particle, an electron ejected at high velocity from the nucleus of the atom of a Beta emitter when one of its Neutrons changes into a Proton. Beta particles are more penetrating than Alpha particles and it takes several millimetres of aluminium to stop them.

Gamma and X-Rays

Gamma rays are electromagnetic radiation of nuclear origin, of very short wavelength, emitted by the nuclei of certain atoms in the course of their radioactive decay. Gamma rays are not composed of particles, but consist of high-energy Photons; they have the speed of light and have no electric charge. Their range, both in air and matter, is much longer than that of either Alpha or Beta particles, but their ionizing capacity is much weaker than that of either of the latter. The wavelength and penetration of Gamma rays occupies an intermediate position between X-rays and Cosmic rays. Lead screening must be used to block them.

There should be few, if any, sources of radiation in the home. The occasional ionizing events are mainly due to the background radiation in the environment. Some old clocks and watches have radium paint on the hands and dials which makes them glow in the dark. In modern timepieces, the radioactivity from the more commonly used Tritium, is too low to penetrate the glass lens. If you have a rock collection test each sample. Should you discover a particularly active one store it in an airtight metal container and take care not to inhale any dust or fragments which may rub off the specimen. If monitoring radiation in wet or dirty environments, the remote detector should be deployed by plugging it into SK1, See Figure 10.

The background radiation count is a combination of random events which can be from 5 to 30 counts in any one minute period. The G.M. tube will produce a background count even in the absence of any external radiation sources. This is due to Beta particles from contamination and impurities of the materials from which the G.M. tube is made. The AG1401 has a maximum self-background count of not more than ten counts in any one minute period. The majority of background count events in the environment are due to Gamma radiation and a smaller amount of Mesons from Cosmic radiation.

To obtain a clearer result from these random events, you should take the average of one minute counts, over one hour. The average background count will vary, depending upon the geology and other influences of your location. To manually record all this data is very tedious, an electronic recording device is preferable. A pulse counter set to record events over an hourly time period, then averaging out the result manually, is one method. However, if a computer is employed, automatic data recording with graphic output on the screen, or printer, can be achieved. It is not possible to cover all the available computer hardware and software for each machine however, two example programs are shown in Listings 1 and 2. One is for the BBC and the other for the AMSTRAD 464/6128. The BBC computer has an input port built in, but the AMSTRAD, like so many computers, has to have one added. A simple input port kit is available from MAPLIN for the AMSTRAD 464/6128 computers. Figure 11 shows the sort of display that can be produced on a computer.

When the Geiger counter is producing the 17millisecond pulses in the 0.5 mR/hr bleep mode, most computer hardware and BASIC software will register each event. However, at higher radiation levels when the pulse width is reduced in the 5 or 50 mR/hr ranges, events may be missed, giving a false, lower data recording. One method of overcoming this problem is to feed the pulses into a CMOS 4040 12-stage ripple counter and read the 8 bit data output, see Figure 12. The maximum number of count events is 255, all 8 bits high. To stop the 4040 at this point a 4068, 8-input nand gate removes the pull-up voltage from the input of the 4040. To reset the count to zero, pin 11 of the 4040 must be taken high and when low, counting can continue. This circuit is included for experimental use only. A PCB or kit is not available. Generally, when

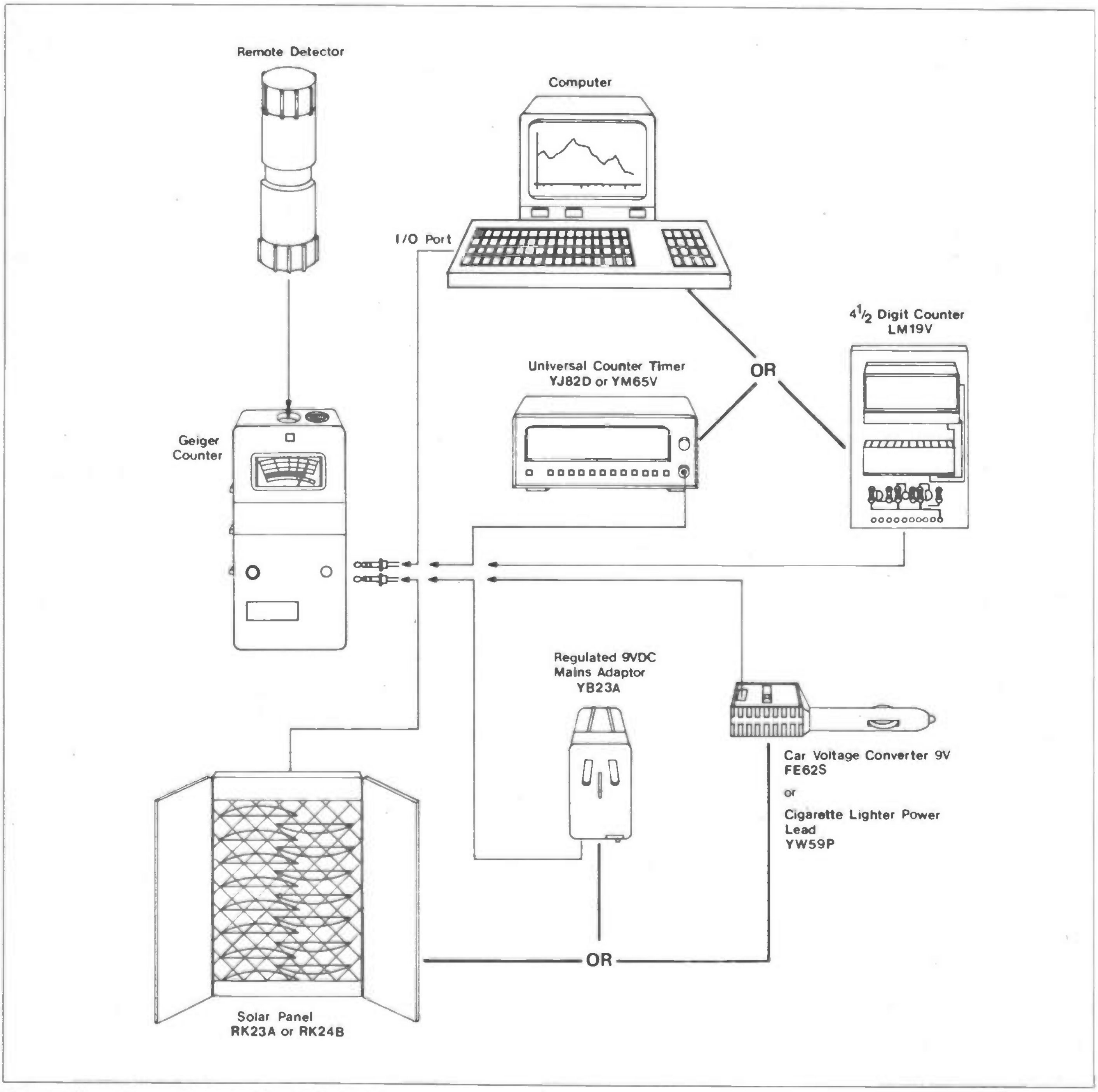


Figure 10. Many things can be plugged into the main unit.

```
10 REM MAPLIN GEIGER COUNTER
20 REM SET TO BLEEP MODE
30 REM SET METER RANGE TO .5mR/hr
40 REM BBC MICROCOMPUTER
50 REM USER PORT PIN 5-0V/PIN 6-PB0
60 MODE 1:VDU 23,1,0;0;0;0;
70 C%=0:T%=6000
80 SS%=1100:XY%=0
90 BS%=170:TT%=0
100 LS%=160:CU$="COUNT"
110 SI%=640:VN%=0
120 PRINT TAB(12,4);" * RADIATION * "
130 PRINT TAB(13,29);"TIME = 1 HOUR"
140 FOR CH%=1 TO LEN(CU$)
150 PRINT TAB(0,13+CH%);MID$(CU$,CH%,1)
160 NEXT CH%
170 FOR V%=26 TO 7 STEP -1
180 PRINT TAB(2,V%);VN%
190 VN%=VN%+5:NEXT V%:VN%=0
200 FOR V%=4 TO 38 STEP 5
210 PRINT TAB(V%,27);" ";VN%;
220 VN%=VN%+10:NEXT V%
230 GCOL  0,1
240 FOR XL%=LS% TO LS%+SS% STEP 36
250 MOVE XL%,BS%:DRAW XL%,BS%+SI%
260 NEXT XL%
270 FOR YL%=LS%+10 TO LS%+10+SI% STEP 32
280 MOVE LS%,YL%:DRAW LS%+SS%-16,YL%
290 NEXT YL%:GCOL 0,3
300 DRB=&FE60:DDR=&FE62
310 ?DDR=&00:TIME=0
320 PROCRADCOUNT
330 GOTO 320
340 DEF PROCGRAPH
350 IF C%>100 THEN C%=100
360 Y%=BS%+C%*6+C%/2.5
370 IF XY%=0 THEN MOVE LS%,Y%:DRAW LS%,Y%:GOTO 390
380 DRAW LS%+XY%,Y%
390 XY%=XY%+18:TT%=TT%+1
400 IF TT%>59 THEN TT%=0:XY%=0
410 C%=0:TIME=0
420 ENDPROC
430 DEF PROCRADCOUNT
440 REPEAT
450 X%=?DRB
460 IF TIME>T% THEN PROCGRAPH
470 UNTIL X%<255
480 REPEAT
490 X%=?DRB
500 IF TIME>T% THEN PROCGRAPH
510 UNTIL X%>254
520 C%=C%+1
530 ENDPROC
```

Listing 1.

```
10 REM AMSTRAD RADIATION PLOTER PROGRAM
20 REM MAPLIN GEIGER COUNTER
30 REM SET TO BLEEP MODE
40 REM METER SET TO .5mR/hr
50 REM MAPLIN AMSTRAD 8-BIT INPUT PORT LM140
60 REM ADDRESS LINK 1 = &F8F0
70 REM HEADER PLUG PIN 5=0V/PIN 6=D0
80 MODE 1:BORDER 1:CLEAR:DIM S%(60)
90 INK 0,0:INK 1,26:INK 2,13:INK 3,24
100 V%=0:C%=0:NN%=0:RA%=0:PA%=0
110 LS%=49:BS%=57:X%=LS%:PB%=100:XT%=1
120 PEN 1:PAPER 0:FOR P%=22 TO 3 STEP -1
130 LOCATE 2,P%:PRINT USING "##";V%:V%=V%+5:NEXT P%
140 LOCATE 1,P%:PRINT USING "###":V%:V%=0
150 FOR L%=LS% TO 640 STEP 10
160 PLOT L%,BS%-2,1:DRAW L%,BS%-6,1:NEXT L%
170 TAG:FOR P%=1 TO 12:READ DAT%
180 IF V%=0 THEN MOVE DAT%,BS%-10:PRINT V%+1;:GOTO 200
190 MOVE DAT%,BS%-10:PRINT V%;
200 V%=V%+5:NEXT P%:TAGOFF:PEN 3:PAPER 2
210 C$=" RADIATION COUNT ":FOR P%=1 TO LEN(C$)
220 LOCATE 1,5+P%:PRINT MID$(C$,P%,1):NEXT P%
230 LOCATE 3,24:PRINT " MINUTES "
240 LOCATE 14,1:PRINT " * RADIATION * "
250 PEN 1:PAPER 0:FOR L%=LS% TO 640 STEP 10
260 PLOT L%,BS%,2:DRAW L%,377,2:LL%=BS%+NN%
270 PLOT LS%,LL%,2:DRAW 640,LL%,2
280 NN%=NN%+16:IF NN%>320 THEN NN%=320
290 NEXT L%:EVERY 3010 GOSUB 340
300 REM * SAMPLE *
310 IF INP(&F8F0)<255 THEN 310
320 IF INP(&F8F0)>254 THEN 320 ELSE C%=C%+1:GOTO 310
330 REM * DRAW LINE *
340 IF C%>100 THEN C%=100
350 S%(XT%)=C%:RA%=RA%+C%:Y%=BS%+C%*3+C%\5
360 IF XT%=1 THEN PLOT X%,Y%,1
370 DRAW X%,Y%,1:X%=X%+10:XT%=XT%+1
380 IF XT%>60 THEN GOSUB 400
390 C%=0:RETURN
400 FOR M%=1 TO 60:NA%=S%(M%)
410 IF NA%>PA% THEN PA%=NA%
420 IF PB%>NA% THEN PB%=NA%
430 NEXT M%:LOCATE 14,24:PRINT "TOTAL COUNT";RA%;" "
440 RA%=RA%\60:LOCATE 8,25
450 PRINT "MAX";PA%;"MIN";PB%;"AVERAGE";RA%;"PPM "
460 XT%=1:X%=LS%:PA%=0:PB%=100:RA%=0:RETURN
470 DATA 25,65,108,156,208,256,308,356,408,456,508,556
```

Listing 2.

the Geiger unit is used with a pulse counter, the 3.5mm stereo jack plug is wired as shown in Figure 8a, or as in Figure 8b when used with a computer.

Remote Detector

Specification

Supply Voltage:	7V to 14V DC
Min. Supply Current at 9V:	0.5mA
Max. Supply Current at 9V:	4mA
Radiation Detector:	Geiger Muller Tube
Tube Type:	Mica End Window
Gas Filling:	Neon, Argon
Quenching Agent:	Halogen
Detected Radiation:	Alpha, Beta, Gamma and X-Rays
Case dimensions:	150 x 50mm
Weight (including 3 metre cable):	291gm (10.3oz)

The main unit is not suitable for use in wet or dirty environments because of the various openings in its case. To monitor radiation levels under these conditions, the remote detector is housed in a tough plastic tube with watertight screw-on end caps. The detector can be permanently mounted outdoors, or on an extension pole, if you wish to keep an appreciable distance from the object being monitored. The DC power is provided from the main unit and is fed to the remote detector by inexpensive, 3-core, mains cable. This cable also carries the signal pulses back to the main unit, which can be up to 100 metres away!

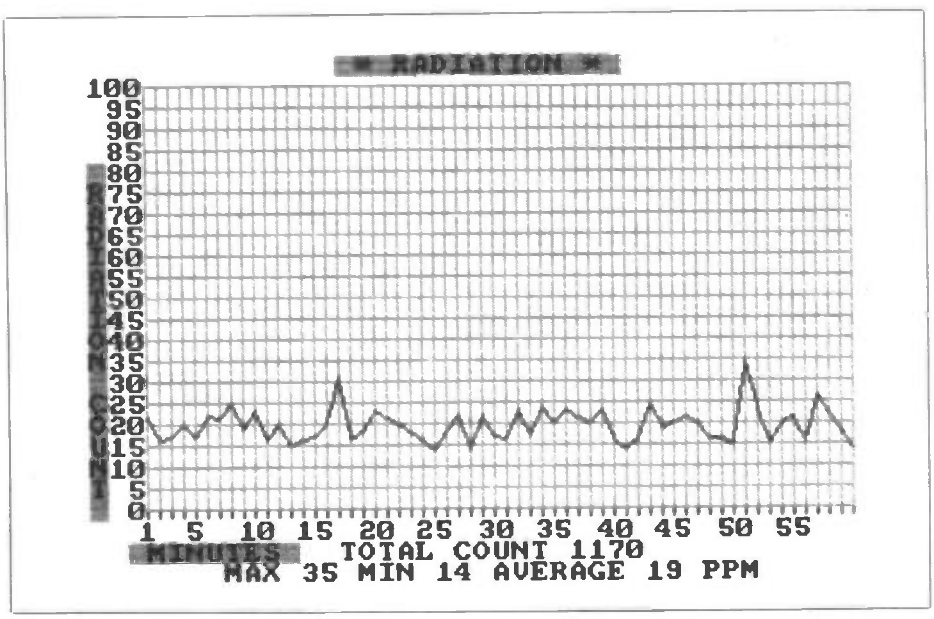


Figure 11. Typical computer display of daily radiation levels.

Remote Detector Circuit Description

In addition to the circuit shown in Figure 13, a block diagram of the complete system showing the main power supplies and signal paths is detailed in Figure 3. This should assist you when following the circuit description or fault-finding the completed unit.

The DC power is provided by the main unit through pin 3 of SK1/PL1 and is connected to the circuit board via three metres of 3-core mains cable. All of the semiconductors run off the 9 volt DC supply decoupled by C14. However, the G.M. tube requires a +500 volt DC supply. This high voltage is generated by the oscillator circuit TR2 and T1. The transformer T1 has three windings, the primary winding in the collector of TR2 and a feedback winding in its base circuit. The secondary winding has many turns providing an AC voltage step up. The oscillator runs at a frequency of approximately 40kHz and the voltage at the secondary is approximately 250 volts, peak to peak. To prevent electrical noise getting back to the main supply rail, a filter choke, L1, and capacitor, C4, decouple the oscillator supply.

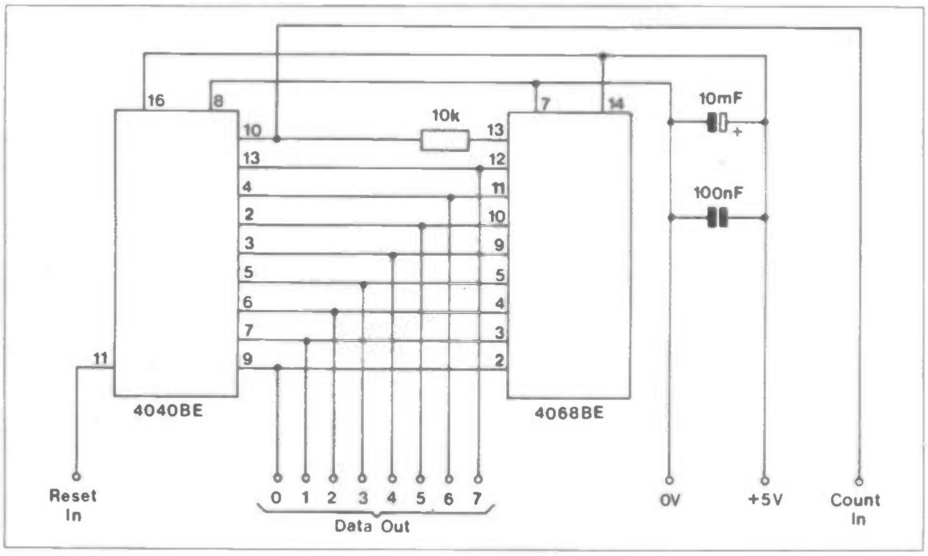


Figure 12. 8-bit pulse counter circuit.

The Remote Unit.

The AC voltage is then rectified and multiplied by the capacitors C6 to C11 and diodes D1, D3 - 5. The high DC voltage across C11 is fed via the current limiting resistor R7 to the anode of the G.M. tube GM1. The only load on the supply is the few μA of the G.M. tube present when ionizing events occur. Thus, if the oscillator was switched off, the high voltage across C11 would slowly leak away. The oscillator switching is controlled by the +500 volt monitoring circuit ZD1 to ZD7, and TR1, TR3. Only five, 100 volt, zener diodes are necessary when using the AG1401 Geiger tube so two diodes are linked out. When the voltage across C11 reaches the total zener break down of 500 volts, a DC bias, limited to less than +9.7 volts by D2, is fed to the base of TR3 via R4 and R5. When TR3 turns on the voltage at its collector goes low, removing the bias from the base of TR1 which then stops conducting, biasing off the oscillator until the voltage across C11 drops just below +500 volts. This regulates the output, and a battery supply of 6 to 15 volts will only cause a small fluctuation of between 5 to 8 volts in the +500 volt supply. Having the oscillator interrupted, means that the average current consumption from the 9 volt supply is greatly reduced, around 350 μA at background radiation levels.

When GM1 detects a radiation ionizing event, the low impedance allows a small current pulse to flow through R8 and R9 in its cathode. This produces a positive going voltage pulse that feeds the base of TR4. The collector, held high by R10, goes low on each pulse for approximately 50 μs. This signal is feed to pin 5 of PL1 by the 3 metres of mains cable and the 0 volt ground return is connected to pin 2. To shut down the detector and +500 volt power supply of the main unit, pins 1 and 4 of PL1 are linked to pin 2. If you wish to have both detectors active then these links can be left open.

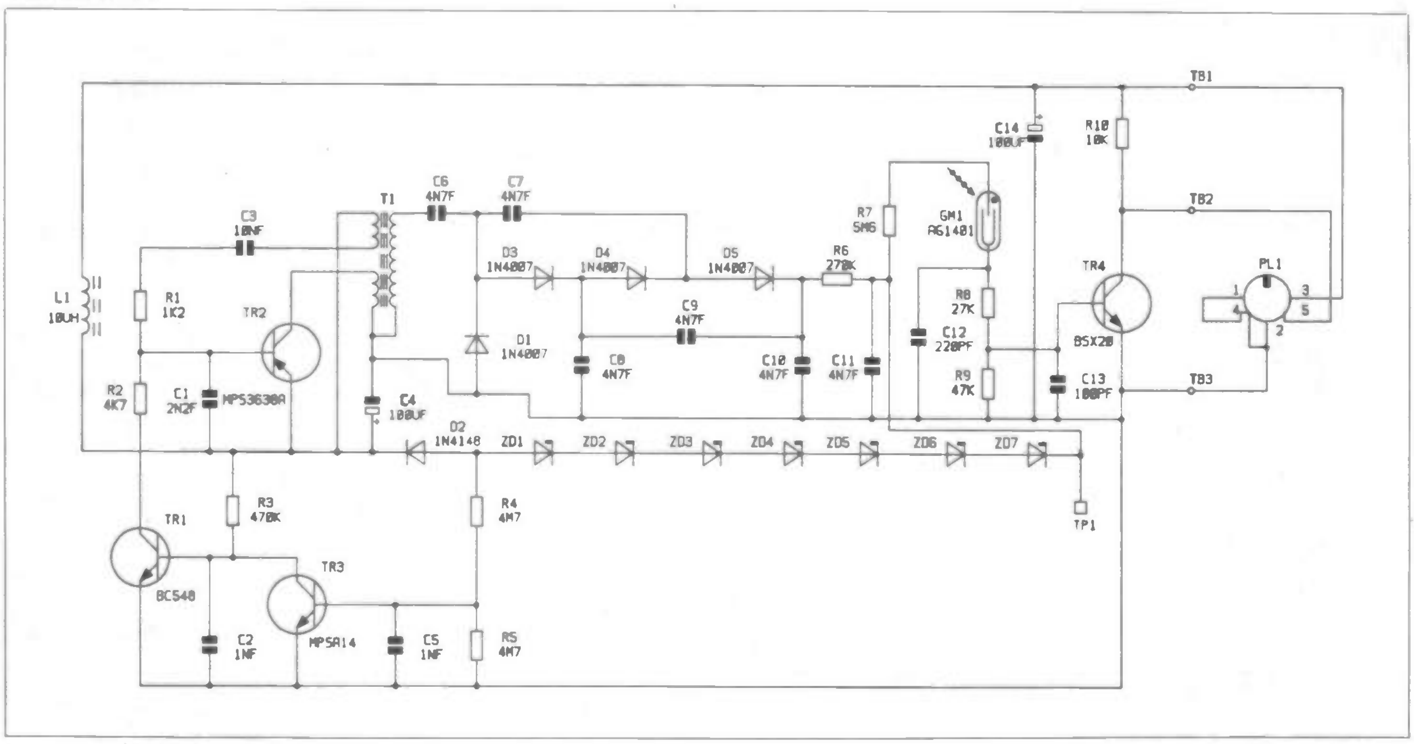


Figure 13. Remote Detector circuit.

Remote Detector PCB Assembly

The PCB is a double-sided, plated-through hole type, chosen for maximum reliability and stability. However, removal of a misplaced component is quite difficult with this kind of board, so please double-check each component type, value and its polarity where appropriate, before soldering!

The PCB has a printed legend to assist you in correctly positioning each item, see Figure 14. Do not fit the G.M. tube, anode clip or the 3 metres of mains cable to TB1, 2, and 3 until the initial testing stage!! The sequence in which the remaining components are fitted is critical, because of the high density of components on such a small board. Begin with the resistors, then mount the resin-dipped and high voltage ceramic, polystyrene and electrolytic capacitors. The polarity for the electrolytic capacitors is shown by a plus sign (+) matching that on the PCB legend. However, on some capacitors, the polarity is designated by a negative symbol (−) in which case the lead nearest this symbol goes away from the positive sign on the legend. You must be very careful whilst bending the leads of choke L1, in order not to damage it.

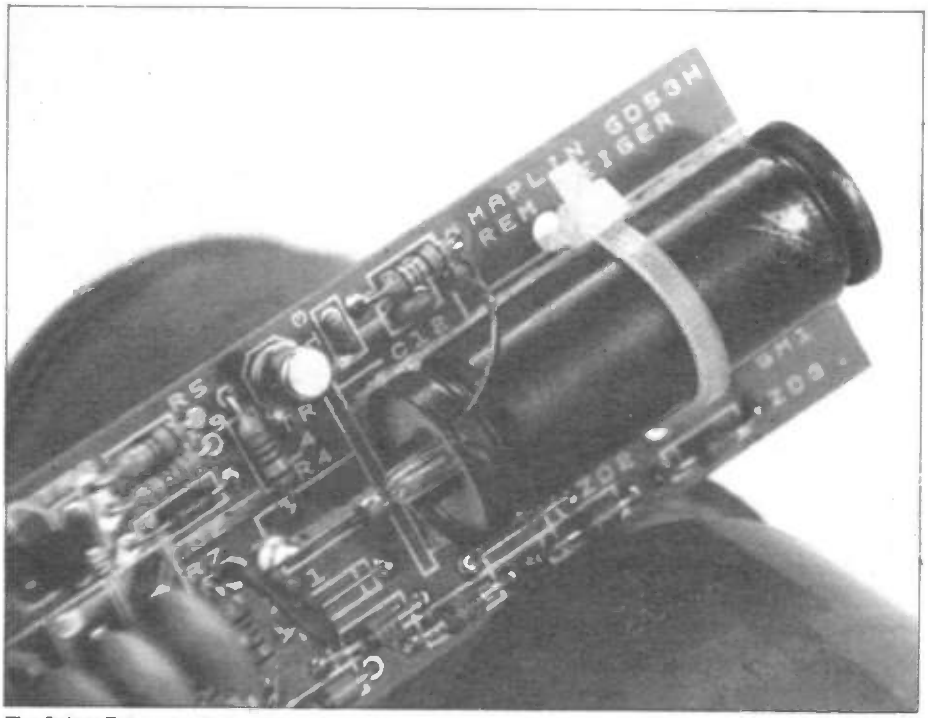
When fitting the transistors you must carefully match the case to the outline shown on the legend. The diodes all have a band at one end to identify the cathode connection. Please note only zener diodes ZD3 to ZD7 are fitted when using the AG1401 G.M. tube, ZD1 and ZD2 are linked out.

The transformer, T1, can only be fitted one way. The pot core is secured by soldering two pieces of tinned copper wire to the steel clips and through two holes in the PCB nearest each clip. The wire used can be some of the off cuts from other components.

This completes the assembly of the PCB and you should now check your work very carefully ensuring that all the solder joints are sound. It is also very important that the bottom track side of the circuit board does not have any trimmed component leads standing proud by more than 1mm.

Initial Testing

You will need a digital, or analogue moving coil, multimeter with an input impedance of not less than 10 MΩ. Other multimeters can be used but some of the readings obtained may vary slightly. An oscilloscope is also useful, if available.



The Geiger Tube mounted on the remote pcb.

Carefully lay the PCB assembly on a non-conductive surface, such as a piece of dry paper. The power for testing the unit can be a 9 volt, PP3 battery or a regulated power supply unit (PSU). When the circuit is running, or even after it has been switched off, treat the PCB with caution as the 500 volt supply circuit can make you jump if touched! When switched off, it can be made safe by dumping the charge to ground with an insulated piece of hook-up wire between TP1 and TB3.

To monitor the supply current, set your meter to read mA and place itin the positive line of the battery, or PSU, to TB1. When the power is applied a current reading of approximately 0.35mA (350μA) should register on the meter. Remove the meter and set it to read 500 volts DC. Place its negative lead on TB3 and the positive to TP1. Reconnect the power supply to TB1 and observe the reading, which should be between 480 and 515 volts. Remove the power and dump the 500 volt charge to ground.

Install the anode clip using a short 10mm length of hook-up wire. *Remember!* When handling the G.M. tube, not to touch the fragile mica end window. Carefully unpack the G.M. tube. Mount it on the PCB using a sponge strip cut to 39mm and a cable tie in the area shown by the legend. Ensure that the fragile front of the G.M. tube is set back from the edge of the PCB by approximately 1mm, and remember *not* to over-tighten the cable tie. Solder the cathode wire to the PCB at the point shown, and push on the anode clip. Power up the PCB and connect an oscilloscope to the output pulse terminal, TB2. At normal background radiation levels, a negative going pulse with a width of 50μs should be observed between 5 to 30 times a minute. This completes the initial testing of the remote detector PCB assembly.

Final Assembly

The housing assembly is constructed from a tube, two coupling pieces and two threaded, end cap fixings. There are three screw-on caps: a cable entry cap, a closed and an open detector covering cap. All three have threaded tube fixings but only two are required. The third can be discarded. The pieces are bonded together with epoxy resin glue, spread liberally around each threaded fixing and both ends of the tube, see Figure 15. As the pieces are pushed together the excess glue oozes out of the joints forming a watertight seal. The excess glue is then scraped off, before it sets, using a knife to leave a smooth finish both inside and out.

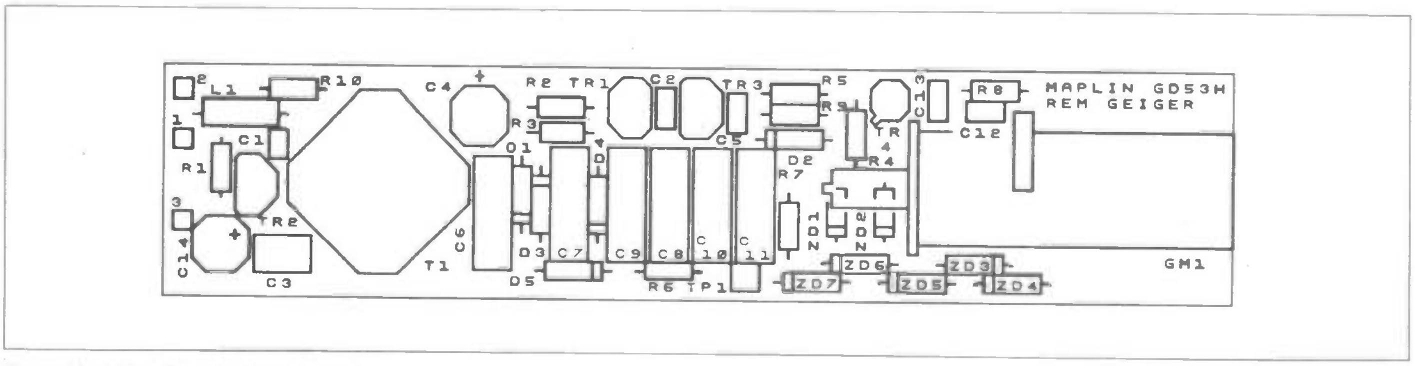


Figure 14. Remote Detector board legend.

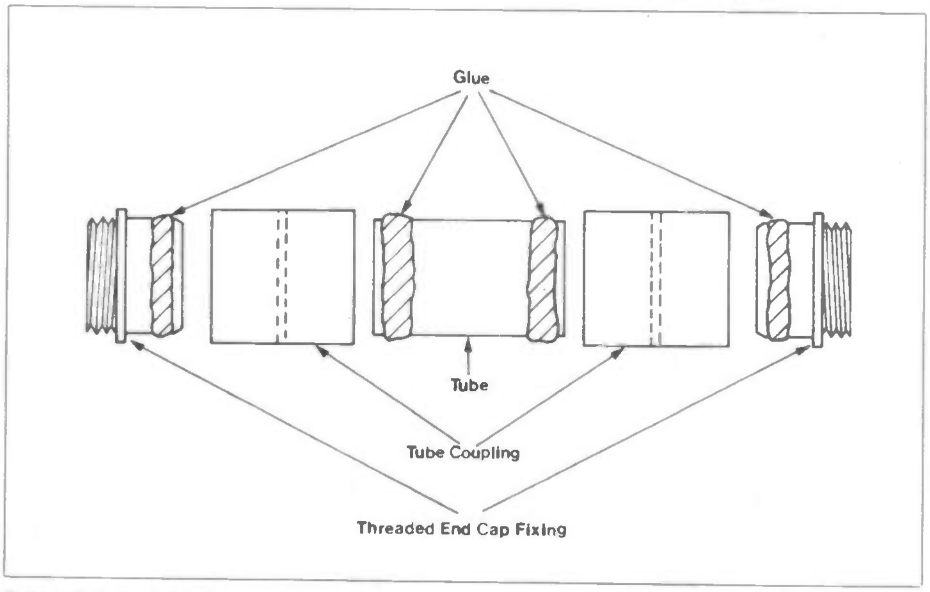


Figure 15. Assembling the remote housing.

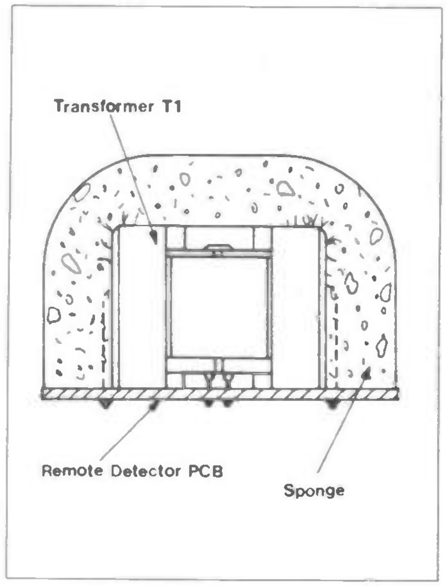
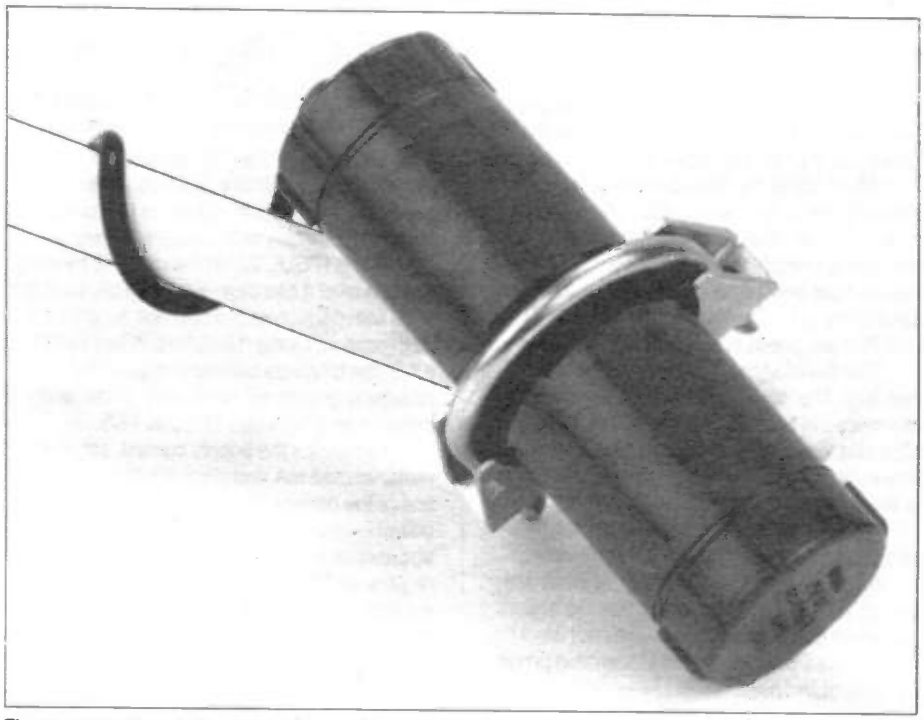


Figure 16. Making T1 shock resistant.

The 3 metres of mains cable has 45mm of outer sleeving removed from one end which goes through the strain relief grommet in the end cap. The grommet is a tight fit and grips the cable, but to ensure a watertight seal, flexible rubber sealant is smeared all over it. The other end of the cable has 15mm of sleeving removed for later connection to the 5 pin DIN plug.

Cut a 70mm piece of sponge strip and glue it around the transformer, T1, on the remote detector PCB, see Figure 16. This acts as a mechanical shock absorber for the rear of the PCB when inside the housing assembly. The three coloured wires emerging from the rubber sealant on the inside of the end cap must have 3mm of insulation removed and they are then tinned with solder. The brown wire goes to TB1, the 9 volt DC power input. The blue wire goes to TB2, the signal pulse output and the green/yellow wire to TB3 the 0 volt ground return.

The PCB assembly is then slid into the housing, see Figure 17 and the cable end cap is screwed on tightly to form a watertight seal.



The remote unit could be clamped to a pole.

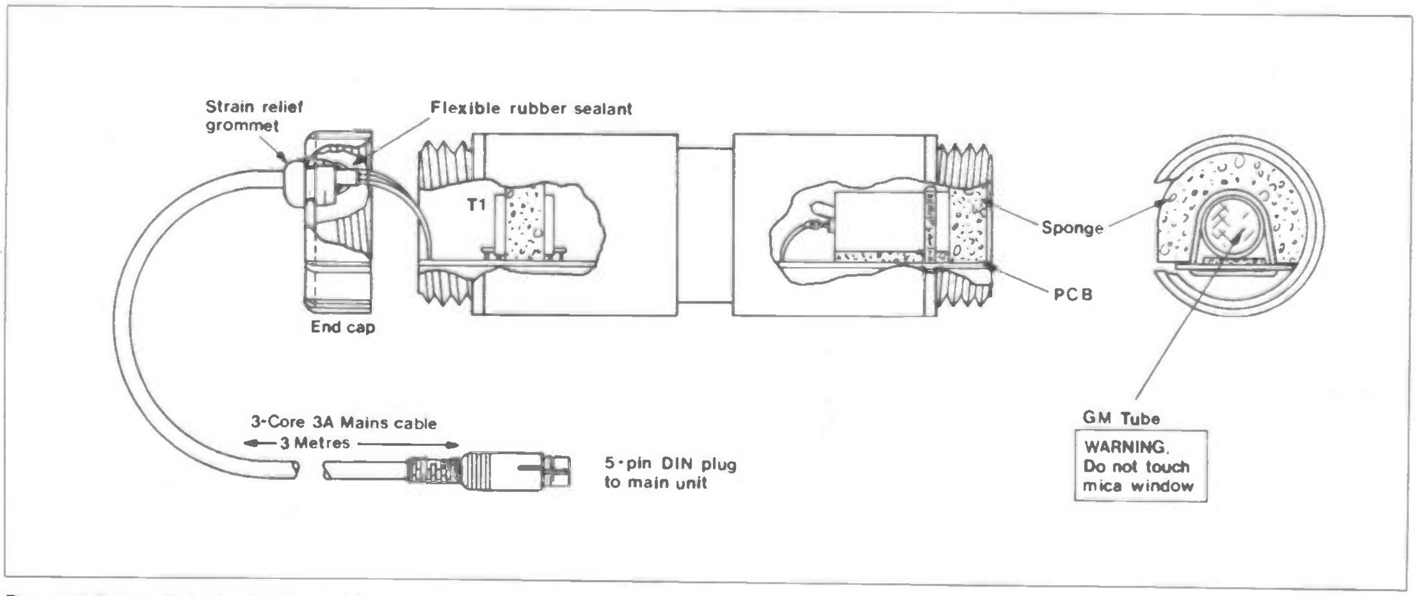


Figure 17. Remote Detector final assembly.

Position the PCB so that the front of the board is flush with the end of the tube. *WARNING! DO NOT TOUCH THE MICA WINDOW!!* Carefully drop the bag of silica gel past the G.M. tube, cut a 70mm length of sponge and gently position it as shown. Do not apply any glue to this piece of sponge as it will stay in position by itself and it may have to be removed at a later date. Take the end cap with the 20mm hole and using impact adhesive, glue the piece of wire mesh into the recessed area inside the cap. When dry, fit this or the solid end cap onto the remote detector assembly. Finally, fit the 5 pin DIN plug in the following manner; slide the plug cover over the cable, take the pin assembly and solder the brown wire to pin 3, blue to pin 5, green/yellow to pin 2. Link pins 1 and 4 to pin 2, the 0 volt return. Assemble the plug body, close the clamp around the cable and slide the cover over the plug.

Remote Detector Final Testing

Monitor the current in the 9 volt supply of the main handheld unit. When the remote detector is plugged into SK1, you should observe very little change in the reading and the background radiation count should remain the same. This completes the testing of the remote detector and it is now ready for use.

Using the Remote Detector

When using the unit in wet, or humid environments, the solid end cap must be fitted to completely seal the detector. This will block the Alpha particles, but Beta particles and Gamma rays will pass through. Since the majority of background radiation is composed of Gamma and Cosmic rays, the solid end cap will have no effect. To restore Alpha sensitivity, the open end cap with the wire mesh is used, but only in a dry and clean environment. Be extremely careful when changing the end caps, especially if the unit has recently been in a wet environment, as water can get trapped between the threads of the housing and the end cap.

The detector can be clamped to an extension pole, or mounted out-of-doors using aerial mounting brackets. An extension cable of up to 100 metres can be added to the detector, fitted with a DIN line socket at one end and a DIN plug at the other.

GEIGER COUNTER PARTS LIST

RESISTORS: All 0.6W 1% Metal Film			
R1	1k2	1	(M1K2)
R2	4k7	1	(M4K7)
R3,22	470k	2	(M470K)
R4,5	4M7	2	(M4M7)
R6	270k	1	(M270K)
R7	5M6	1	(M5M6)
R8	27k	1	(M27K)
R9,10	47k	2	(M47K)
R11,15,24,25	10k	4	(M10K)
R12	1k	1	(M1K)
R13,16,18	100k	3	(M100K)
R14	470Ω	1	(M470R)
R17	56k	1	(M56K)
R19	1M5	1	(M1M5)
R20	150k	1	(M150K)
R21	180k	1	(M180K)
R23	220k	1	(M220K)
RV1	1k Cermet Preset	1	(WR40T)
CAPACITORS			
C1,18,22	2n2F Monores	3	(RA40T)
C2,5,21	1nF Monores	3	(RA39N)
C3	10nF Monores	1	(RA44X)
C4,14,24	100µF 16V Min Electrolytic	3	(RA55K)
C6,7,8,9,10,11	4n7F 1000V Disc Ceramic	6	(HY18U)
C12	220pF Monores	1	(RA37S)
C13	100pF Monores	1	(RA36P)
C15	330pF Ceramic	1	(WX62S)
C16,17,23,25	100nF Monores	4	(RA49D)
C19	10nF Polystyrene 1%	1	(BX86T)
C20	1nF Polystyrene 1%	1	(BX56L)
SEMICONDUCTORS			
D1,3,4,5	1N4007	4	(QL79L)
D2,8	1N4148	2	(QL80B)
D6,7	OA90	2	(QH71N)
D9	1N4001	1	(QL73Q)
ZD1,2,3,4,5	ZPY100	5	(UH89W)
ZD6,7	Not Required		
TR1,5,6,7	BC548	4	(QB73Q)
TR2	MPS3638A	1	(QH63T)
TR3,8	MPSA14	2	(QH60Q)
TR4	BSX20	1	(QF32K)
IC1	REF03C	1	(RA84F)
IC2	4001BE	1	(QX01B)
IC3	TLC555C	1	(RA76H)
LD1	LED Red Hi Bright	1	(WL84F)
L1	10µH Choke	1	(WH35Q)
MISCELLANEOUS			
	Constructor's Guide	1	(XH79L)
SK1	PCB 5-Pin DIN	1	(YX91Y)
SK2	Power Skt 2.5mm	1	(FK06G)
B1	Min Piezo Sounder	1	(FM59P)
M1	Geiger Meter	1	(FP97F)
JK1	3.5mm Jack Socket Stereo	1	(FK20W)
S1,2,3	R/A DT3T Switch Slide	3	(FV02C)
T1	Transformer Module	1	(FP78K)
GM1	Geiger Muller Tube AG1407	1	(FP96E)
	PP3 Clip	1	(HF28F)
	Geiger Case Drilled	1	(YP26D)
	Sponge Rubber Block	3	(FS04E)
	Tie-wrap 200	1	(BF93B)
	Meter Mask	2	(UH91Y)
	Wire Mesh	1	(UH90X)
	P.C. Board	1	(GD49D)
	No.4 x ¼in. Self Tap Pozi/Csk Screws	1 Pkt	(FP98G)
	Label Front	1	(FS01B)
	Label Rear Small	1	(FS02C)
	Label Rear Large	1	(FS03D)
	Pillar 6BA x ½in.	1 Pkt	(FW35Q)
	Bolt 8BA x ¾in.	1 Pkt	(FP69A)
	Shake 8BA	1 Pkt	(LR01B)
	Nut 8BA	1 Pkt	(BF19V)
	Silica Gel	1 Pkt	(FS10L)
OPTIONAL			
B1	Battery PP3 Long Life Alkaline	1	(FK67X)
	Carrying Case	1	(YN71N)
	Impact Adhesive	1	(FL43W)

A complete kit of all parts, excluding optional items, is available for this project:
Order As LM24B (Geiger Counter Kit) Price £99.95
The following items included in the above kit list are also available separately, but are not shown in the 1987 catalogue:
Zener ZPY100 **Order As UH89W Price 24p**
Geiger Meter **Order As FP97F Price £1.98**
Geiger Transformer **Order As FP78K Price £1.95**
Geiger Tube **Order As FP96E Price £59.95**
Geiger Case Drilled **Order As YP26D Price £4.95**
Sponge Rubber Block **Order As FS04E Price £1.98**
Geiger Meter Mask **Order As UH91Y Price 98p**
Geiger Wire Mesh **Order As UH90X Price 58p**
Geiger Counter PCB **Order As GD49B Price £7.95**
No. 4 x ¼in. Self Tap Pozi/Csk Screws (Pack of 10) **Order As FP98G Price 15p**
Front Label **Order As FS01B Price 88p**
Rear Label Small **Order As FS02C Price 88p**
Rear Label Large **Order As FS03D Price £1.20**
Bolt 8BA x ¾ (Pack of 10) **Order As FP69A Price 60p**
Silica Gel **Order As FS10L Price 20p**

REMOTE GEIGER PARTS LIST

RESISTORS: All 0.6W 1% Metal Film

R1	1k2	1	(M1K2)
R2	4k7	1	(M4K7)
R3	470k	1	(M470K)
R4,5	4M7	2	(M4M7)
R6	270k	1	(M270K)
R7	5M6	1	(M5M6)
R8	27k	1	(M27K)
R9	47k	1	(M47K)
R10	10k	1	(M10K)

CAPACITORS

C1	2n2F Monores	1	(RA40T)
C2,5	1nF Monores	2	(RA39N)
C3	10nF Monores	1	(RA44X)
C4,14	100μF 16V Min Electrolytic	2	(RA55K)
C6,7,8,9,10,11	4n7F 1000V Disc Ceramic	6	(HY18U)
C12	220pF Monores	1	(RA37S)
C13	100pF Monores	1	(RA36P)

SEMICONDUCTORS

D1,3,4,5	1N4007	4	(QL79L)
D2	1N4148	1	(QL80B)
ZD1,2,3,4,5	ZPY100	5	(UH89W)
ZD6,7	Not Required		
TR1	BC548	1	(QB73Q)
TR2	MPS3638A	1	(QH63T)
TR3	MPSA14	1	(QH60Q)
TR4	BSX20	1	(QF32K)

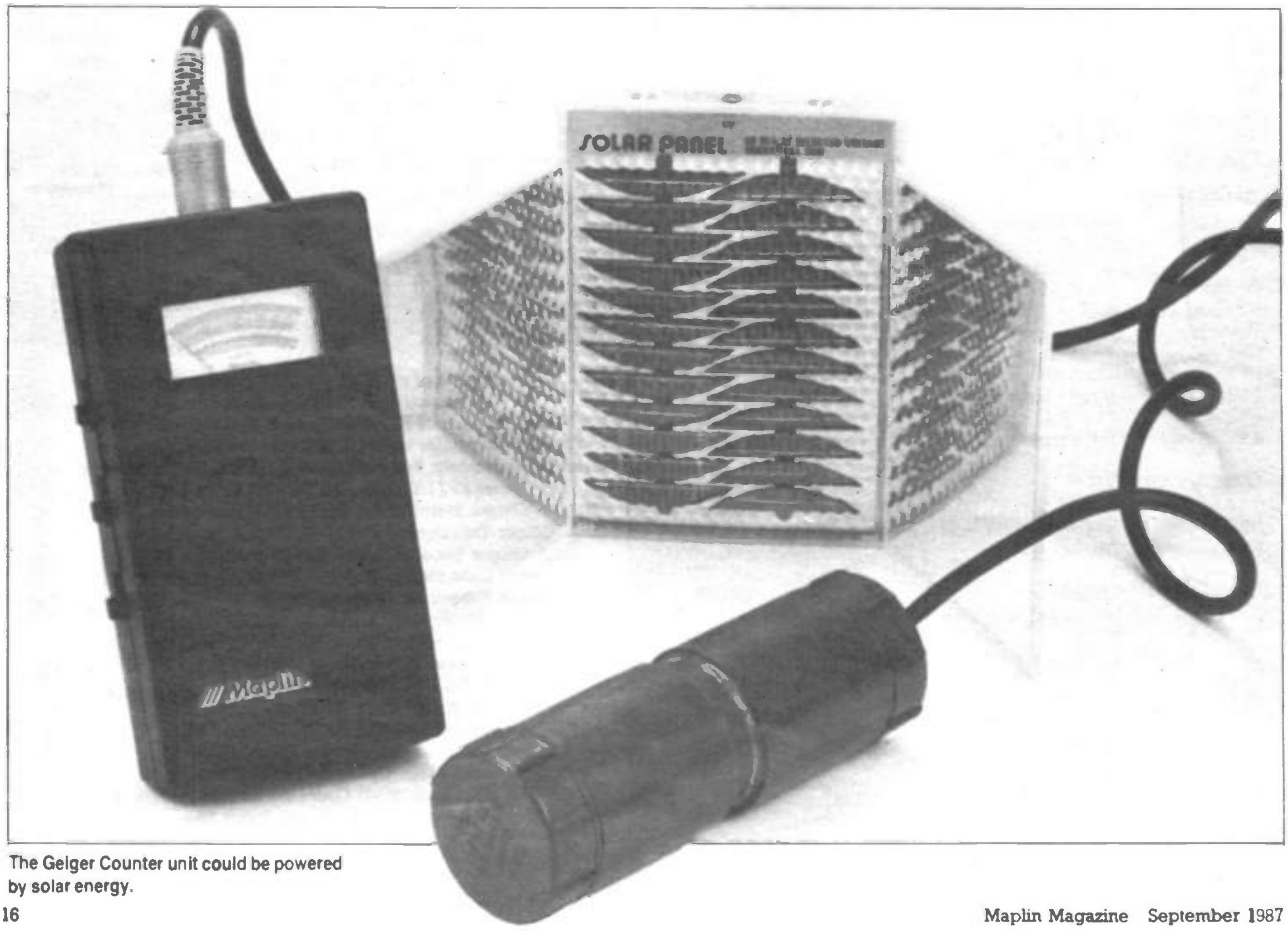
MISCELLANEOUS

	Constructor's Guide	1	(XH79L)
T1	Transformer Module	1	(FP78K)
L1	10μH Choke	1	(WH35Q)
GM1	Geiger Muller Tube AG1407	1	(FP96E)
	Sponge Rubber Block	3	(FS04E)
	Tie-Wrap 200	1	(BF93B)
	Wire Mesh	1	(UH90X)
	P.C. Board	1	(GD53H)
	Cable Min Mains Black	3 Mtrs	(XR01B)
	Silica Gel	1 Pkt	(FS10L)
	Grommet SR 5M-3	1	(LR48C)
	DIN Plug 5-pin A	1	(HH27E)
	Tube	1	(FS05F)
	Coupler	2	(FS06G)
	End Cap Plain	1	(FS07H)
	End Cap Cable Entry	1	(FS08J)
	End Cap Mesh Hole	1	(FS09K)

OPTIONAL

	Araldite Rapid	1	(FL44X)
	Impact Adhesive	1	(FL43W)
	Cable Min Mains Black	As Reqd	(XR01B)
	DIN Plug 5-pin A	1	(HH27E)
	DIN in-line 5-pin A Socket	1	(HH43W)
	Flex Rubber Sealant	1	(YJ91Y)

A complete kit of all parts, excluding optional items, is available for this project:
Order As LM25C (Geiger Remote Kit) Price £79.95
The following items included in the above kit list are also available separately, but are not shown in the 1987 catalogue:
Zener ZPY100 **Order As UH89W Price 24p**
Geiger Transformer **Order As FP78K Price £1.95**
Geiger Tube AG1407 **Order As FP96E Price £59.95**
Sponge Rubber Block **Order As FS04E Price £1.98**
Geiger Wire Mesh **Order As UH90X Price 58p**
Geiger Remote PCB **Order As GD53H Price £4.50**
Silica Gel **Order As FS10L Price 20p**
Plastic Tube **Order As FS05F Price 30p**
Coupler **Order As FS06G Price 98p**
End Cap Plain **Order As FS07H Price 98p**
End Cap Cable Entry **Order As FS08J Price £1.30**
End Cap Mesh Hole **Order As FS09K Price £1.20**



The Geiger Counter unit could be powered by solar energy.

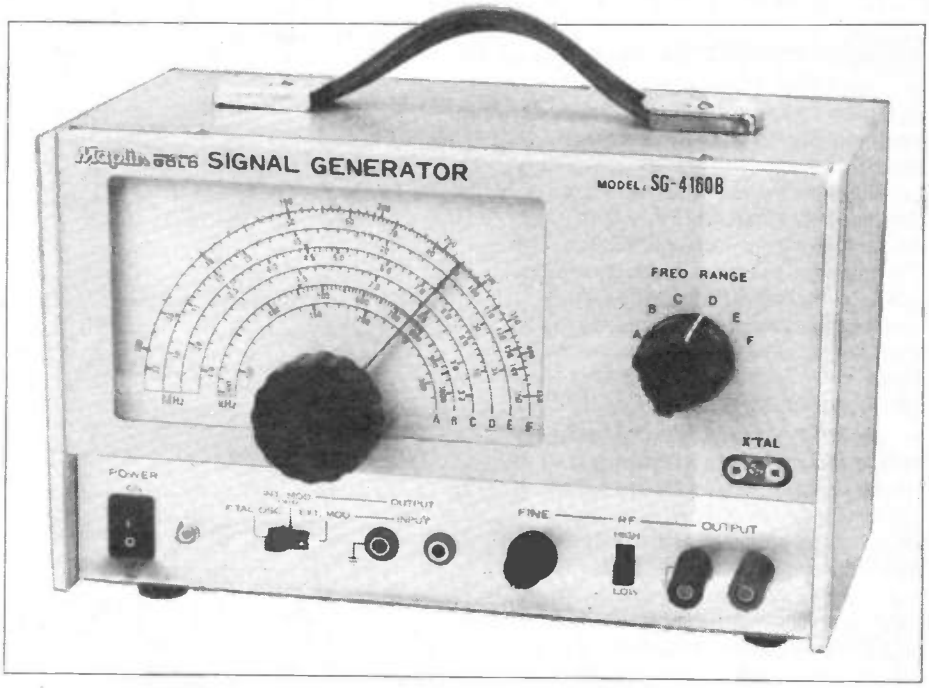
TEST GEAR AND MEASUREMENTS

by Danny Stewart
Part 6

Signal generators can be divided into two kinds: analogue and digital. The analogue ones usually generate a sine wave or several harmonics in the case of noise generators. Digital signal generators usually generate a square or rectangular waveform. And sawtooth waveforms, are they analogue or digital? It does not matter, as long as we can generate this very useful waveform for use in timebases for sweeping across TV and oscilloscope screens.

Let us deal with sine wave generators first. Among the most useful ones are the Wien Bridge, the Hartley oscillator and the Colpitts oscillator. These are basic oscillators that go into making up a signal generator. The Hartley and Colpitts use a tuned tank circuit (inductor and capacitor) and are useful in the frequency range 100KHz to 500MHz roughly. For frequencies of 1 Hz to 1MHz, the Wien Bridge is a useful oscillator. All these circuits provide the basic oscillations whereas a signal generator has the added ability to produce a modulated output.

Signal generators are used for tracing faults in equipment including radio and television receivers. They can also be used to measure the response of amplifiers and filters and align them by providing an input signal and monitoring the output with an oscilloscope.



Sine Wave Oscillators

The Wien Bridge was discussed in an earlier part and is reproduced here in Figure 1a for convenience. At balance the bridge yielded the following equations:

$$f = \frac{1}{2\pi CR}$$

$$\text{and} \quad \frac{R_3}{R4} = 2$$

if $R_1 = R2 = R$ and $C_1 = C_2 = C$

However, at balance Vout = 0 which is useless and a modification is required. The Barkhausen criteria for oscillation states that two conditions must be satisfied if oscillations are to be set up and maintained.

i) Voltage must be fed back from the output to the input and must be in phase with the input so that oscillations build up.

ii) The loop gain must be unity, i.e. the voltage gain around the combination of amplifer and feedback loop must equal one.

Figure 1b illustrates the above points. With the circuit modified so that Vout is not zero, the bridge can be used to provide feedback and hence oscillations. The bridge has good stability and is often used as an audio oscillator.

One of the easiest ways of producing oscillation is to inductively or capacitively couple some of the output back into the input. The Colpitts oscillator in Figure 2 uses

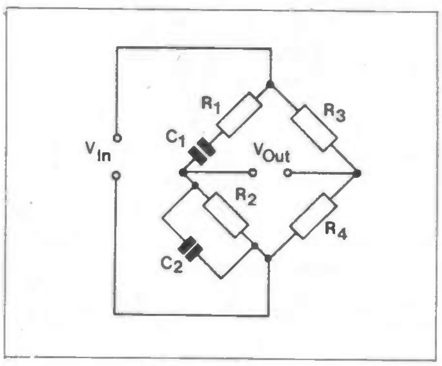


Figure 1a. A Wien Bridge.

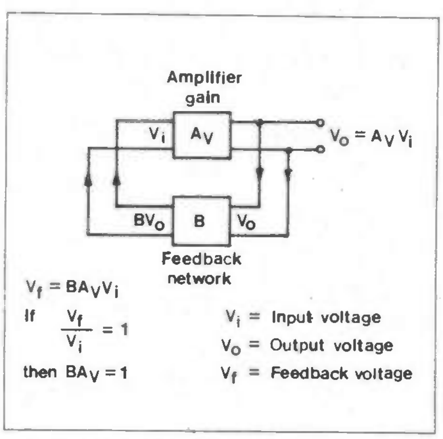


Figure 1b. Feedback for Oscillations.

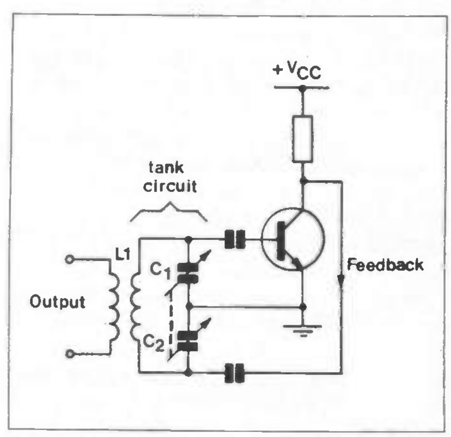


Figure 2. Colpitts Oscillator.

capacitive coupling and the Hartley oscillator in Figure 3 uses inductive coupling. Whichever method is used the oscillations build up in the LC circuit or 'tank' and the frequency is given by:

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

In the Colpitts oscillator C_1 and C_2 are ganged and therefore tuned together. Nevertheless, in the initial design, greater feedback can be achieved by making C_1 smaller than C_2. LC circuits can produce oscillations in the megahertz range. If oscillations in the gigahertz range are required then magnetrons and klystrons must be used.

Square Wave Generators

Here the title square wave is used to distinquish it from sine waves but rectangular waves are also included. There are two methods of generating square waves. The passive, pulse shaping circuit takes a sine wave and truncates (clips) it to give an approximate square wave, see Figure 4. The alternative is to use active, pulse generating circuits. Active generators charge and discharge a capacitor and are called relaxation oscillators. The most common relaxation oscillators are multivibrators and blocking oscillators.

We saw how the bistable (two state) multivibrator was used in counters and counting circuits. Here we require something free running and the astable multivibrator is used. Figure 5 shows a basic astable circuit. It is collector coupled since the collector of one is connected to the base of the other. At switch-on both transistors will start conducting but because of small differences in their characteristics let us assume that TR1 conducts more strongly than TR2.

The collector of TR1 drops towards zero, biasing TR2 negatively and driving it further into cut off. When a transistor conducts it is useful to think of it as an electrical switch that is closed. In this way it is easy to visualise C_1 charging to the supply voltage Vc via the emitter-base path of TR1. Since TR2 is off, it is an open switch and the full supply voltage appears at its collector. On the other hand, the collector of TR1 is at zero volts since it is conducting (switch closed). C_2 now starts to discharge from $-$Vc exponentially through R_2 reaching zero and tries to charge up to $+V_B$, the base supply. This immediately forward biases TR2 causing it to conduct and making its collector voltage drop to zero. The drop in collector voltage biases TR1 towards cut off. With TR1 cut off, its collector is at Vc potential and C_2 charges up to Vc via the low resistance of the base emitter path of TR2. The whole cycle then repeats and the waveforms can be seen in Figure 6. The waveform of the collector current is of opposite polarity to the corresponding voltage since when the transistor is ON ($V_{c1} = 0$) maximum current flows and with the transistor OFF ($V_{c1} = V_c$), the current is zero. For completeness, the waveform at the base is shown. The slope is the initial linear charging curve of the capacitor. Since $R_1 C_1 = R_2 C_2$, the waveform is a square wave at the collector. To get a rectangular wave, one of the time constants needs to be changed.

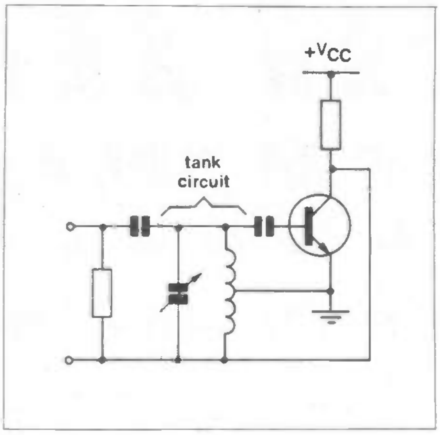


Figure 3. Hartley Oscillator.

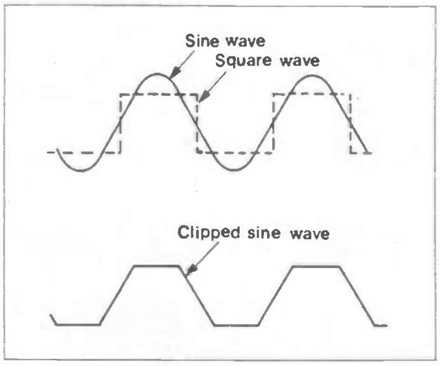


Figure 4. Pulse Shaping.

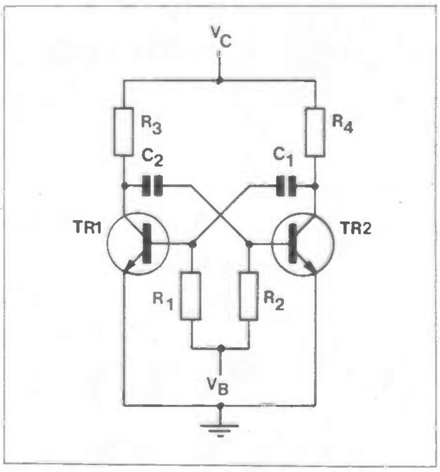


Figure 5. Astable Multivibrator.

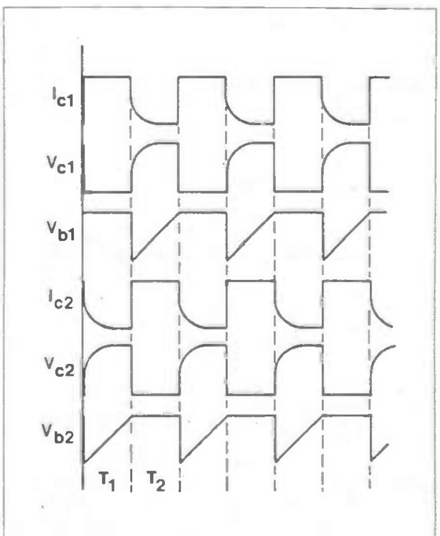


Figure 6. Astable Waveforms.

Let time constant $t_1 = R_1 C_1$
and let time constant $t_2 = R_2 C_2$

The period of each half of the waveform is then given by:

$$T_1 = t_1 \log e \left(\frac{V_B}{V_B + V_c}\right)$$

$$T_2 = t_2 \log e \left(\frac{V_B}{V_B + V_c}\right)$$

The whole period $T = T_1 + T_2$

Ramp Generators

The blocking oscillator is one of the best known ramp generators, see Figure 7. In addition the circuit produces pulses. These can be either a single pulse or a pulse train, i.e. the circuit is capable of both monostable as well as astable operation. The RC circuit permits free running operation. Without it, the blocking oscillator will be monostable. Feedback from collector to base is via a transformer. The dots on the transformer indicate the direction of the winding and hence the feedback is positive (regenerative). Since

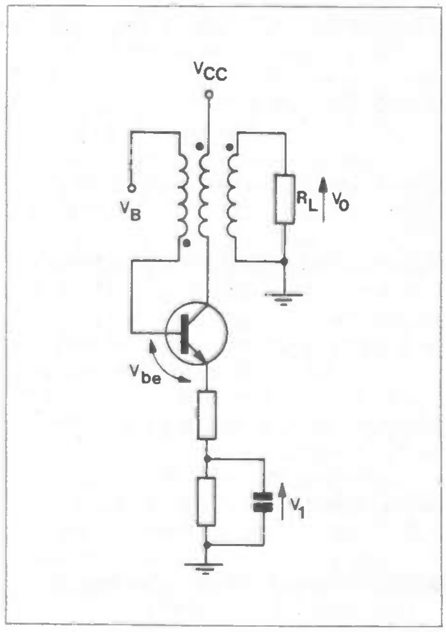


Figure 7. Blocking Oscillator.

there is a 180 degrees phase shift between base and collector signals, the transformer is wound in antiphase to provide a further 180 degrees shift and bring the feedback back into phase with the original input signal. A third winding connects to the load and the direction of winding can be chosen to give a pulse of either positive or negative polarity.

The ON-OFF operation of the transistor is controlled by the charge and discharge of C_1. When C_1 discharges sufficiently to permit the base-emitter junction of the transistor to be forward biased, the transistor switches ON. When the transistor is ON, current flows through it to charge up C_1. When C_1 has charged up sufficiently, the base-emitter junction is reverse biased and the transistor cut off. The cycle then repeats, see Figure 8. The overshoot in the output pulse is caused by oscillation in the coils when the current is interrupted. The oscillation occurs at the resonant frequency of the coils and can be damped by choosing coils with low Q and a suitable load.

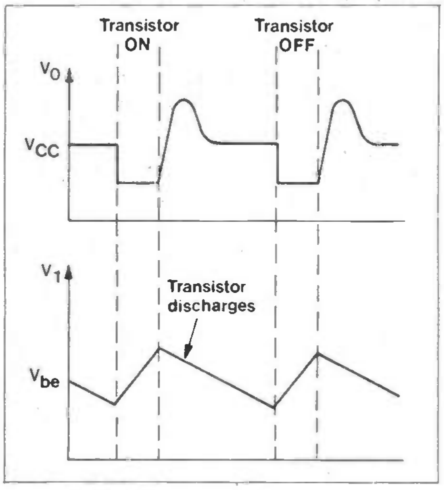


Figure 8. Blocking Oscillator Waveforms.

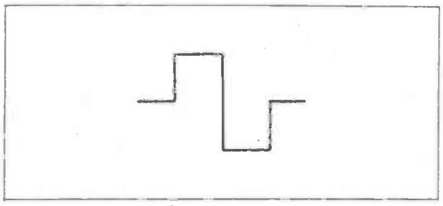


Figure 9a. Perfect Pulse.

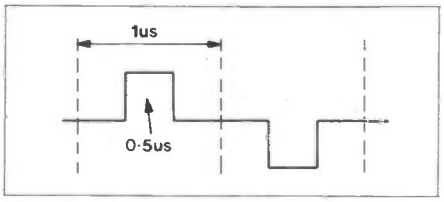


Figure 9b. 50% Duty Cycle.

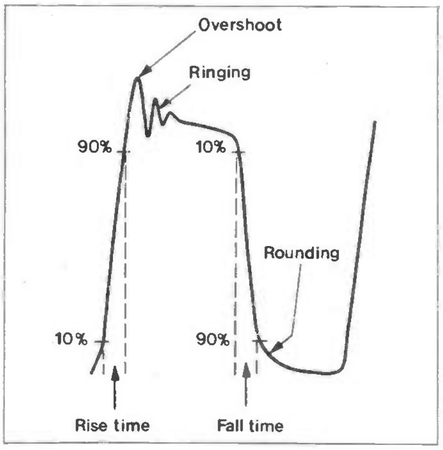


Figure 9c. Pulse Faults.

Pulse Characteristics

A perfect pulse is shown in Figure 9a. It has perfectly flat horizontals and verticals, i.e. the pulse rises to its full voltage instantaneously, holds this value for the required time and falls to zero or a negative value instantaneously. A pulse may not occupy the full period allocated to it. For instance a train of 1MHz pulses gives a period of 1 μs for each pulse. If the pulse occupies only 0.5 μs of this time slot it is said to have 50% duty cycle, see Figure 9b.

A non perfect pulse will not rise to its full value instantaneously. Instead, the rise time is defined as the time taken for it to increase from 10% to 90% of its full value, see Figure 9c. Similarly, the fall time is the time taken for it to drop from 90% to 10% of its full value. There may be other imperfections. The pulse may overshoot its full value, then oscillate about this value before coming to rest. Or it may approach the final value very slowly giving the pulse a round shoulder.

Signal Generators

Signal generators can be as varied as the need for them. They can be simply sine or square wave oscillators or both in the same box with a selector to switch between the two types of waveform. A signal generator may also be designed to produce various frequencies modulated by either a sine or square wave. An amplitude modulated sine wave for instance would be useful in troubleshooting a domestic radio receiver.

Various pattern generators also exist. For example a generator which produces a full composite video colour bars' signal is useful in a television laboratory or workshop. *No single generator will serve every need.* Even sine wave generators are divided into audio and high frequency applications.

A block diagram of a signal generator is shown in Figure 10. In this instance a radio frequency carrier is modulated by an audio signal. Two to one frequency dividers serve to step down the frequency of the RF signal if necessary. Sometimes, as tuning can be over a very wide range, rocker switches are provided on the front panel of the instrument, and selecting one of these operates a motor which drives the tuning capacitor. The indicator can be seen gliding across the dial and coming to a stop at the frequency selected. Further tuning can be achieved by a large rotary knob. Finally, fine tuning can be obtained from a second knob usually concentric with the large one. The second knob usually has a very limited range only, and needs to be set to the centre of this while the larger one is being used.

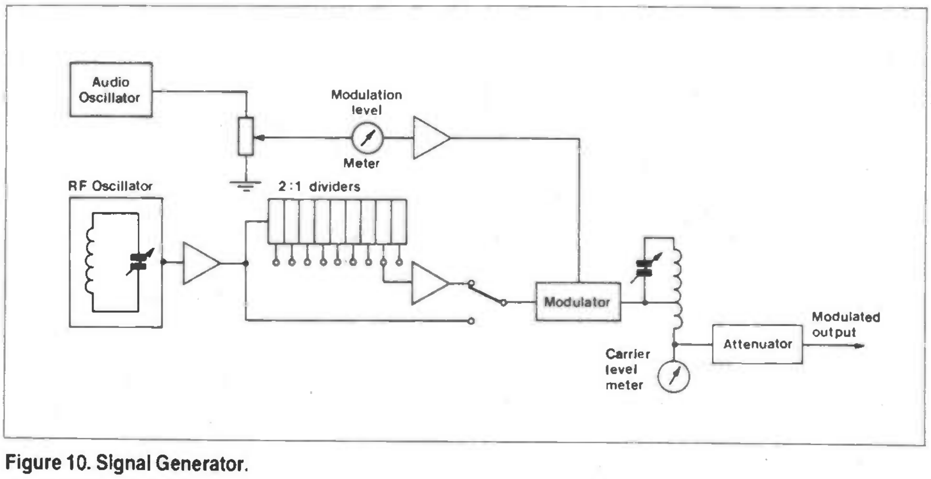


Figure 10. Signal Generator.

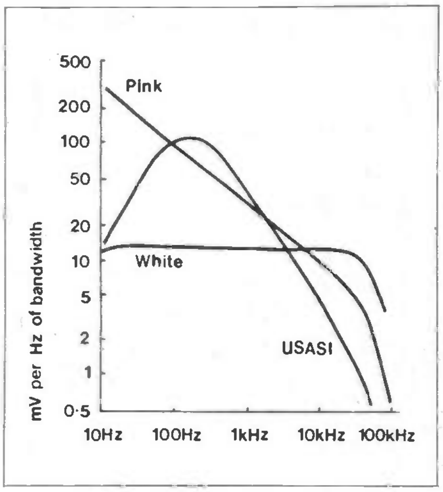


Figure 11. Noise Patterns.

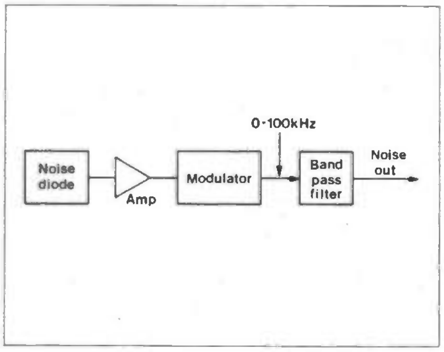


Figure 12. Noise Generator.

Noise Generators

The three most common noise patterns are pink noise, white noise and USASI noise and their spectral distributions are shown in Figure 11. White noise has random components uniformly across its bandwidth and because of this uniformity is often used to test telephone circuits. The upper slope is 12dB per octave and cuts off at 50KHz. The response is flat between 20Hz and 25kHz.

Random noise can be used as a test signal, as in telephone circuits where one circuit is loaded with noise and adjacent circuits tested for spill over of this noise. That is, in multiplex equipment, the amplifiers and filters are being tested to ensure that their design responses are correct. Random noise can also be used to cloud a signal when equipment is being designed to extract signals in the presence of noise.

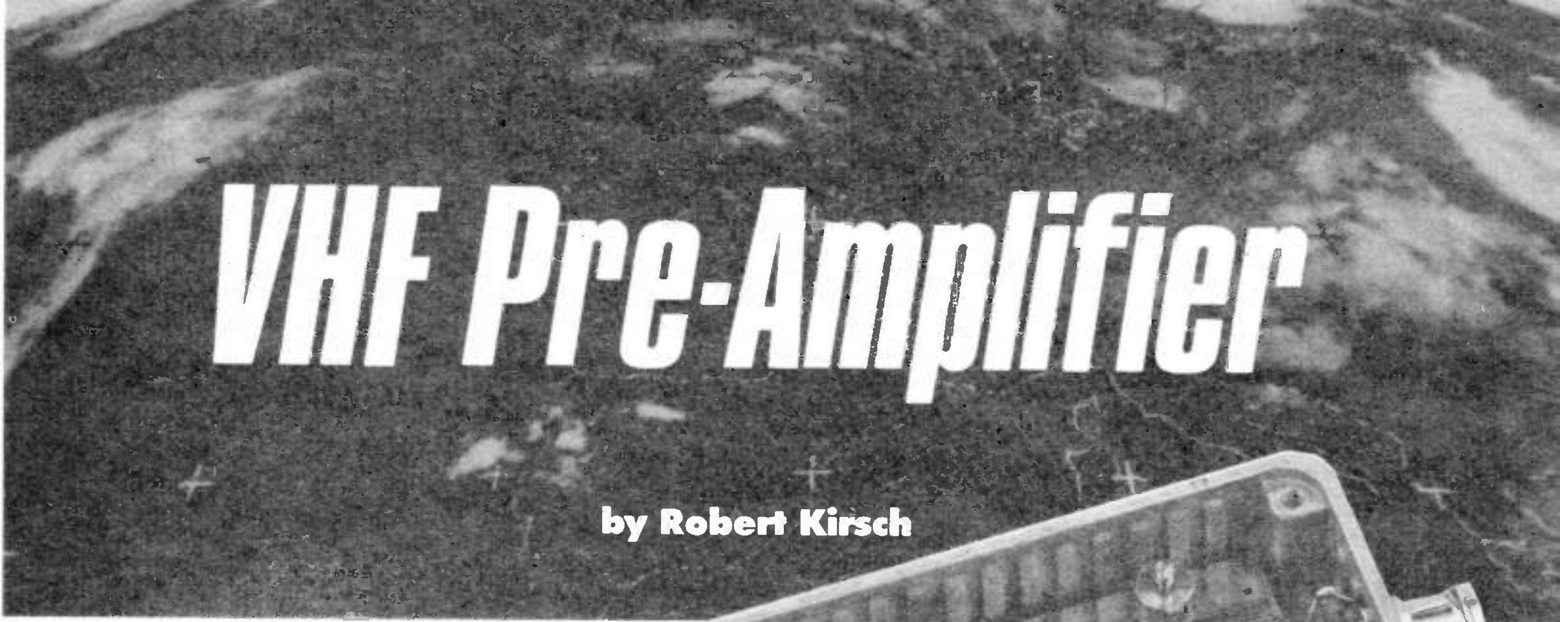
USASI noise is used for testing loudspeakers and audio amplifiers since the energy distribution is similar to that of music and speech.

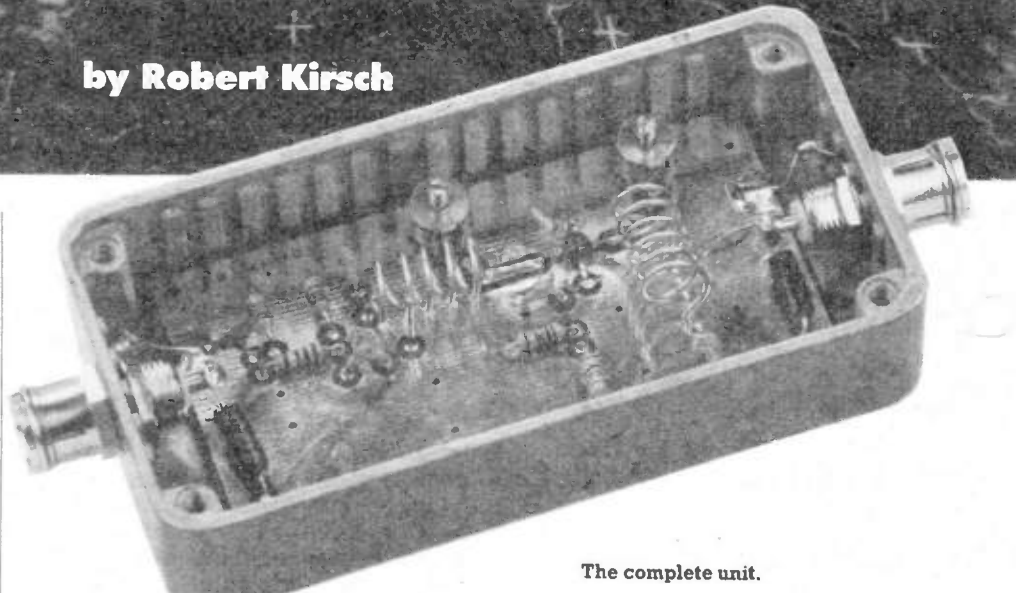
Pink noise is used in bandwidth analysis and is so called because the lower frequencies have larger amplitudes than the higher frequencies. Red light has the same power distribution.

Random noise is generated by a semiconductor diode whose output is 80KHz to 220KHz approximately. This is then modulated and filtered, see Figure 12, to give the required output.

VHF Pre-Amplifier

by Robert Kirsch





The complete unit.

This pre-amplifier has been primarily designed for use with the Mapsat VHF weather satellite receiving system although the basic design may be adapted for use for other purposes.

The main application for this amplifier in the Mapsat system is to compensate for long feeders between either the VHF aerial or the Down Converter and the Mapsat Receiver.

The amplifier also has the additional advantage that by raising the level of the wanted signal applied to the feeder, the effect of any interfering signals close to the feeder is reduced. This is particularly useful when the receiver is located close to a computer or printer which would otherwise cause interference to weak signals.

The power supply for this amplifier is fed via the coax cable that carries the signal to the Mapsat Receiver, and this supply is extended through the amplifier to feed such items as the Down Converter and its Pre-Amplifier, situated on the aerial, if these are being used.

The active element in this amplifier is a 3SK88 dual-gate MOS field-effect transistor which is designed to work up to about 900MHz and thus performs well in this application at 137 MHz. The amplifiers' gain is limited to about 14dB at which it produces a low noise figure when used in the Mapsat system.

Circuit Description

Refer to Figures 1 and 2. The incoming signal from SK1 is fed via C2 to a tap on L2 that matches the 75Ω feeder to the input tuned circuit formed by L2 and VC1. The trimmer VC1 is used to resonate this circuit at the desired frequency. Gate 1 of the dual gate FET TR1 is directly connected to the input tuned circuit which also provides a DC path for this gate to 0V.

Resistors R1 and R2 provide the bias for gate 2 of TR1 and this is decoupled by C3 to 0V. The source of TR1 is connected directly to 0V and its drain connects to the output tuned circuit formed by L3 and VC2. The output is taken from a tap on L3 via C6 to the output matching and attenuator circuit formed by R3, R4 and R5. The output is DC isolated by C7 and fed to SK2.

The power for the amplifier comes from the Mapsat Receiver which is connected to the output end of the Amplifier. The positive potential on the centre conductor of the coaxial cable is separated from the signal path by the inductor L4, which exhibits a high impedance to 137 MHz but has a low resistance to DC. The supply is fed to TR1 drain and gate 2 bias circuit, decoupled by C1, C4 and C5 and fed to the input socket SK1 via L1; this feeds the positive potential to the centre of the

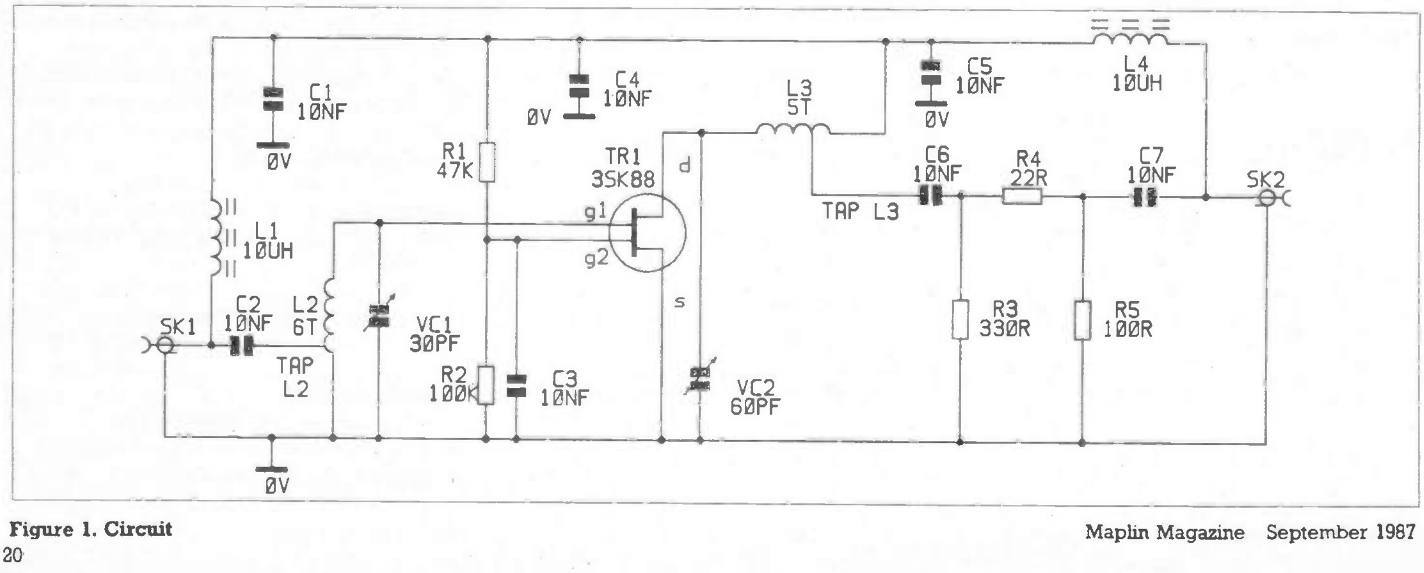


Figure 1. Circuit

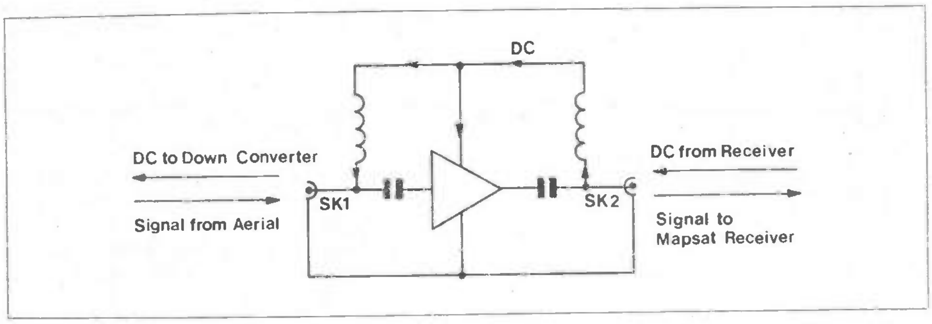


Figure 2. Signal path

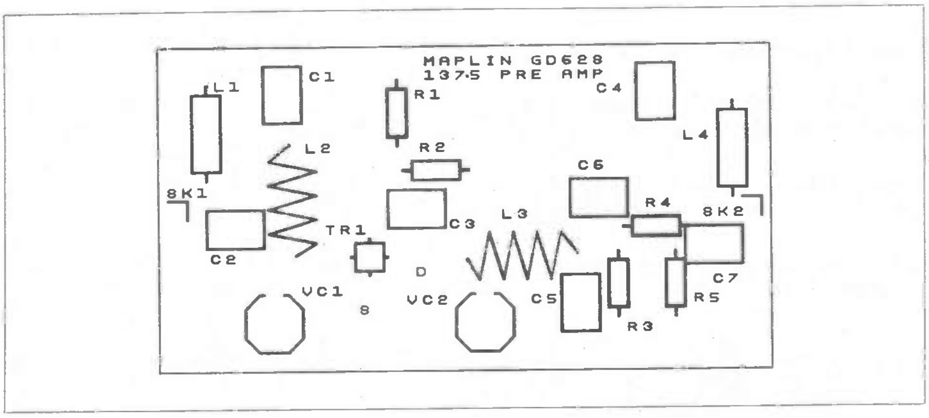


Figure 3. PCB overlay

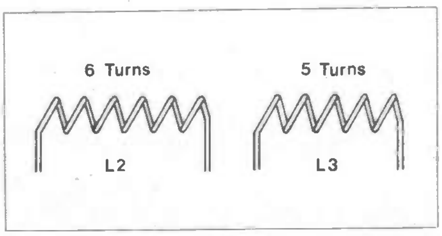


Figure 4. Winding the coils

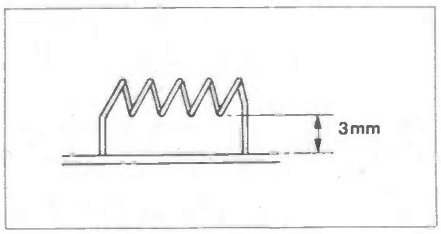


Figure 5. Mounting the coils

incoming coaxial cable for use by any other modules connected in line.

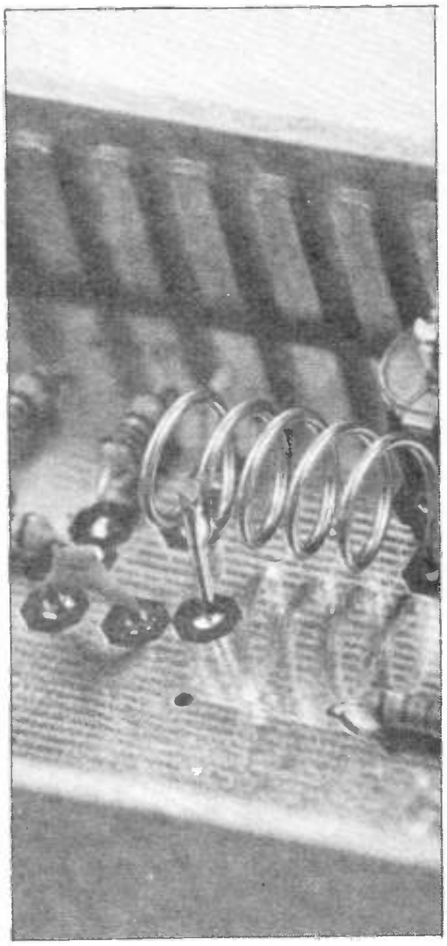
Construction

Note, if this amplifier is to be used with the Maplin crossed dipole aerial system, or any other aerial that presents a DC short circuit, *do not* install the inductor L1.

Referring to the board layout, Figure 3 and the Parts List, insert the five resistors and five disc ceramic capacitors on the circuit board and solder. Insert one end of each of the two inductors L1 and L4, through their appropriate holes and solder, leaving approximately 5mm of lead between the component body and the board, leave the unconnected end of these two inductors uncut at this stage.

Insert and solder one end of the capacitor C7 into the board leaving the other end free at this stage. Insert and solder the two trimmers VC1 and VC2. Using the trimming tool provided with the kit as a former, wind the two coils with the 20swg tinned copper wire provided, referring to Figure 4 and the photographs. Note that L2 has 6 turns and L3 has 5 turns. Carefully stretch the coils to the correct length to insert in their mounting holes, and insert and solder onto the board. Leave a gap of about 3mm between the lower edge of the coil and the surface of the PCB (see Figure 5).

Locate the hole for L3's tap in the PCB, towards the output end of L3 and solder a short length of the 20 swg tinned copper wire through this hole, leaving about 15mm above the board surface. Solder this wire to the second turn of L3 as shown in Figure 6, and trim off excess wire. Very carefully bend the four leads of TR1 so they will fit through the four holes in the PCB provided for them. Note CMOS precautions should be observed whilst handling this device, and also ensure that the transistor is *inserted in the correct position with the longest lead connecting to L3.* Carefully solder TR1 in place using the minimum amount of heat necessary to obtain a good joint. The circuit board is now complete and ready to insert in the die-cast box. Drill the box referring to Figure 7 and lay the completed PCB in position. Attach the two coaxial sockets with their solder tags on the inside of the box and tighten their fixing nuts. Solder a short length of the 20 swg wire between each solder tag and the upper earth plane of the PCB. Connect the free ends of both inductors to the centre connections of the appropriate sockets. Solder the last capacitor C2 between the centre tag of the input socket SK1 and the second turn of L2 (see



The tap on coil L3.

The tap on coil L2.

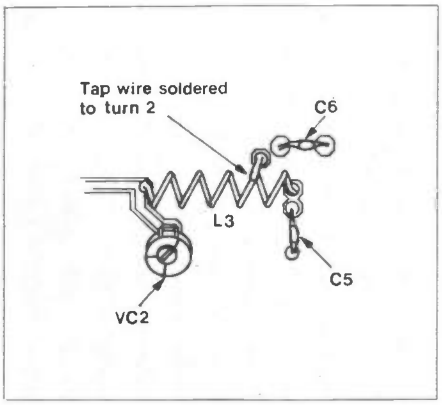


Figure 6. Making a tap on coil L3

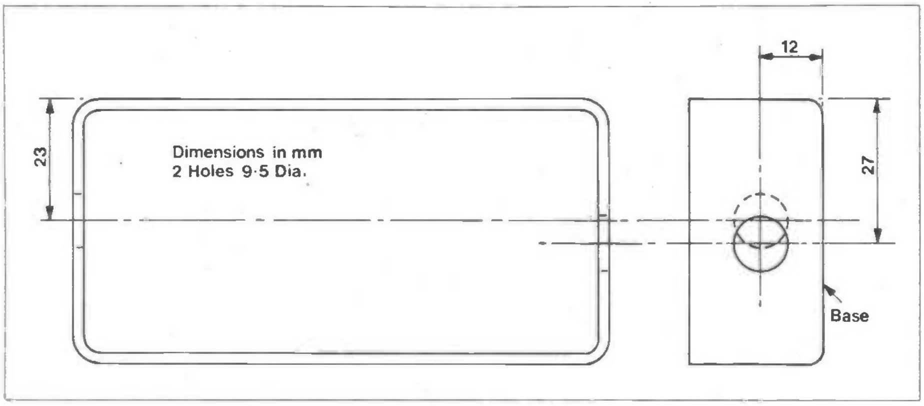
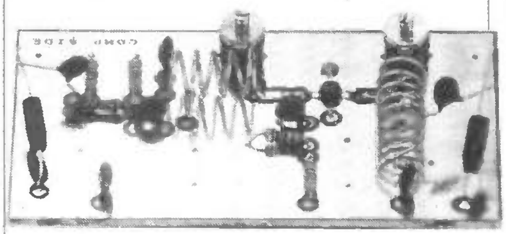


Figure 7. Box drilling

Figure 8) and attach the free end of C7 to the centre connection of the output socket SK2.

Testing and Using

Adjust both trimmers to the fully unmeshed (minimum capacity) position and connect the pre-amplifier between the Aerial feeder and the Mapsat Receiver (Note SK2 connects to the Receiver). With no signal tuned adjust both trimmers to give the maximum reading on the Signal meter of the Receiver. Tune in to a transmission from any satellite and finely adjust both trimmers for maximum signal strength on the meter. The Pre-Amplifier may now be transferred to its final position which should be as near to the Aerial or Down Converter as possible for best results. The unit may be waterproofed by sealing the lid with silicone rubber after final adjustments have been made, but it is preferable to mount the unit in a waterproof box.



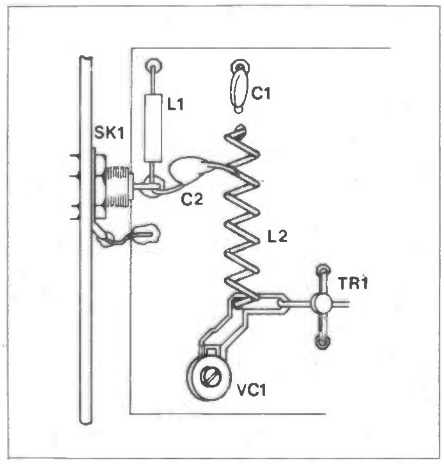


Figure 8. Capacitor tap to coil L2

VHF PRE-AMP PARTS LIST

RESISTORS: All 0.6W 1% Metal Film			
R1	47k	1	(M47K)
R2	100k	1	(M100K)
R3	330Ω	1	(M330R)
R4	22Ω	1	(M22R)
R5	100Ω	1	(M100R)
CAPACITORS			
C1,2,3,4,5,6,7	100nF Minidisc	7	(YR73Q)
VC1,2	65pF Trimmer	2	(WL72P)
SEMICONDUCTORS			
TR1	3SK88	1	(UH63T)
MISCELLANEOUS			
L1,4	10μH Choke	2	(WH35Q)
SK1,2	HQ Coax Socket	2	(FE10L)
	P.C. Board	1	(GD62S)
	Preset Trimmer Tool	1	(BR49D)
	T.C. Wire 0.9mm. 20 swg	1 rl	(BL13P)
	Box DCM5002	1	(LH70M)

A complete kit of all parts is available for this project:
Order As LM30H (137.5MHz Pre-Amp Kit) Price £9.95
The following item in the above kit list is also available separately, but is not shown in the 1987 catalogue:
137.5MHz Pre-Amp P.C.B. **Order As GD62S Price £2.95**

AMENDMENTS TO 1987 CATALOGUE

BLUE SEAL BATTERY R03B (Page 42). This is no longer available. FK54J is now being supplied as Silver Seal R03S.
TYPE C INDUSTRIAL NI-CAD BATTERY YG02C (Page 46). This banery now has a nominal capacity of 2000mAh.
PP3 NI-CAD BATTERY HW31J (Page 46). This battery has a nominal voltage of 8.4 volts.
SLOPING FRONT CASE XY60R (Page 78). Please note that this case does not have ventilation holes as described in the 1987 catalogue.
HEAVY DUTY HANDLE LH11M (Page 80). This item is now made of metal not plastic and its dimensions are: Cutout 235 x 120mm; Depth in cabinet 70mm; Bezel 161 x 280mm; Fixing centres 141 x 255mm; and fixing hole diameter 5.5mm.
4-CORE INDIVIDUAL SCREENED CABLE XR23A & PA18U (Page 87). The colours of the insulation are now Yellow, Black, Red and White.
0.1in. PC EDGCONN 2 X 20-WAY (Page 129). In the order code list, this should be stock code BK97F and not BK87F.
VIDEO COPYING KIT RK71N (Page 136). The second lead in the audio list should be 5-pin DIN socket to 2 phono plugs.
HOUSE-HOLD ELECTRICAL MAINS SWITCHES (Page 140). Switches HL87U, HL88V, HL89W, HL90X and HL92A all quote the wrong BS specification. They are all to BS3676 not BS3673.
SOLID ALUMINIUM KNOBS K8A YR64U (Page 176). The fixing nut on the pots sold by Maplin will not fit inside the recess provided in the knobs. This also applies to knob K10A (RK89W).
PLASTIC LENS FA95D (Page 201). This lens is not 'clear' but coloured red.
STYLUS CLEANER FLUID FV38R (Page 283). This is now supplied in a larger, new style bottle with an integral brush, but no instructions.
4K7 ENCLOSED PRESET UH15R (Page 293). In the description following the stock code for this item in the catalogue this is referred to as being horizontal mounting, whereas it is in fact vertical mounting.
ZTX750 to ZTX753 (Page 300). In the semiconductor list, these devices (UH50E to UH53H) are shown as NPN transistors, they are in fact PNP types.
74HC4511 (Page 327), cannot drive common anode LED's directly. It will drive common cathode LED's directly via a series resistor (same as the 4511BE). However for driving common anode LED's inverter/buffers are needed.
74HC4351 8-WAY ANALOGUE SWITCH UF14Q (Page 329). This is a 20 pin device, and not 18 pin.
LM1037 (Page 346). There are some changes to the diagram of the Dual 4-channel analogue switch (QY33L). Externally pin 5 is connected to C1 and +Vs. However, in the internal schematic representation of the IC, pin 5 should not connect to anything.
ICL7673 BATTERY BACKUP IC UH36P (Page 370). In the diagram for the high current system for the ICL7673, please note that the input is not 'Mains Supply' but should be 'Main supply' - *do not connect 240V AC to this chip.*
ICL7660 VOLTAGE CONVERTER YY75S (Page 370). Last line of description should read 'a supply voltage of +5V the output voltage will be −4.3V.' (not 15V).
MAX232C (Page 379). The 22μF capacitor which is shown connected between pin 2 and earth should instead be shown to connect to +5V (pin 16) with the capacitor positive to pin 2.
EPROM 27128 YH88C (Page 381). The text should read: 'with the address and data lines stable apply an active low pulse to pin 27.' (NOT a +5V pulse.)
SQUARE 3½in. MYLAR SPEAKER (Page 395). YN02C has an impedance of 4Ω, and not 8Ω.
FOOT SWITCH FH92A (Page 410). The description of the terminals and their operation for this switch are no longer correct. The description should be: SPDT switch. The common terminal is the centre of three solder tags. Rated 2A at 250V AC Body size: 36 x 12 x 15mm. Bush and knob length: 28mm.
15V MINIATURE TRANSFORMERS WB15R & LY03D (Page 457). Please note that the descriptions of these two items heve been transposed. WB15R is the 6VA version and LY03D is the 10VA type. This also applies to the physical dimensions given.
UHF MODULATORS UM1233, UM1286, FT30H & BK66W (Page 464). Types UM1233 and UM1286 have a wider and more linear bandwidth to cater for the chroma sub-carrier from a source video generator, they do not generate the chroma subcarriers internally. Same applies to the 6MHz sound carrier for the UM1286. The terminal designation leners A - D in the lower table apply to all units where the unit is turned label upwards and terminal wires are at left-hand side - UM1111 & UM1233 will have phono socket pointing away at top.

MACHINE CODE PROGRAMMING WITH THE Z80

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

Introduction

This, the concluding part of this series, will present some ideas in the form of a number of short programs. Since the subject of controlling or reacting to peripherals has been covered in some detail now, for a change this part will be concerned with internal events, that is register and memory operations. While a computer cannot do anything very useful without some interaction with the outside world, it is nonetheless true that such interactions give rise to processes within the computer itself. It is this type of process that is discussed here.

Code Conversion

Codes are important features of data handling. Binary itself is a code, the representation of familiar decimal numbers by strings of '1s' and '0s'. Binary Coded Decimal (BCD) is a variant that assigns four-bit binary groups to the decimal digits 0-9. Hexadecimal is a code in the sense that it is a specialised number system, virtually unknown outside the world of computing. Familiarity with this system is vital for programmers, since it will often be used for keyboard entry, leaving the processor to carry out the tedious task of converting into binary. Thus, since the op-codes and data of machine code programs will be entered into memory in hexadecimal, when it appears in another form, it often has to be converted. An obvious example is ASCII (American Standard Code for Information Interchange), which is the code normally found on full-size keyboards. In this code, the numerals 0-9, letters of the alphabet (both upper and lower case), all punctuation marks, plus a whole host of control characters, are represented by a pair of hexadecimal digits. The codes are shown in Table 1.

HEX (MSD) (LSD)	0	1	2	3	4	5	6	7
0	NUL	DLE	SPACE	0	@	P	-	p
1	SOH	DC1	!	1	A	Q	a	q
2	STX	DC2	"	2	B	R	b	r
3	ETX	DC3	#	3	C	S	c	s
4	EOT	DC4	$	4	D	T	d	t
5	ENQ	NAK	%	5	E	U	e	u
6	ACK	SYN	&	6	F	V	f	v
7	BEL	ETB	'	7	G	W	g	w
8	BS	CAN	(	8	H	X	h	x
9	HT	EM	)	9	I	Y	i	y
A	LF	SUB	*	:	J	Z	j	z
B	VT	ESC	+	;	K	[	k	{
C	FF	FS	,	<	L	\	l	
D	CR	GS	_	=	M	]	m	}
E	SO	RS	.	>	N	↑	n	~
F	SI	US	/	?	O		o	DEL

Table 1. The non-parity ASCII codes.

For example, the numerals 0-9 are represented by the ASCII codes 30-39. Thus, when the number 56 (decimal) is entered by two successive key presses, the codes 35 and 36 are generated. These digits, 5 and 6, are 'echoed' on the screen because the operating system ROM is able to recognise the ASCII codes and generate the dot matrix that the screen requires (that in itself is an example of a code conversion). If this keyboard data is entered into RAM, it will be found that the value of 56 in the appropriate memory location will be &38, showing that a conversion has taken place between the ASCII generated by the keyboard and the hexadecimal that the program requires. The first program presents an approach to indicate how this might be done. It is not intended as a 'utility' program in its own right, but as an illustration of problem solving in machine code, using one's knowledge of the available Z80 instructions.

To simplify the discussion, assume that the decimal numbers are limited to two digits. The process steps required to generate the number &38 from the key presses 5 and 6 are as follows:

(a) Get first key press (5 = 35 ASCII) and store it.

(b) Get second key press (6 = 36 ASCII) and store it.

(c) Form the decimal number (56) from (a) and (b).

(d) Convert this decimal number to hexadecimal.

The appropriate Z80 registers can be used to store the key presses and the necessary manipulations will be carried out on them. For example, when the first key is pressed, the resulting ASCII code can go into the A register; when the second key is pressed, this ASCII code can go into the B register. It then becomes necessary to combine the two separate register contents into a single register containing their decimal equivalent (56). This is much easier than it sounds. Look at the ASCII codes for 0-9; they are 30-39. The difference lies in the '3' that precedes all of these ASCII codes. If this can be 'masked off', the digits 5 and 6 will be left and it is then only necessary to manipulate the 5 so that it 'leads' the 6 to form the number 56. Here's the program segment to do it.

```
AND  A,&0F   ;Mask high nibble (A
             now holds 05)
RLC  A
RLC  A       ;Move low nibble to
             high nibble (A now
             holds 50)
RLC  A
RLC  A
AND  B,&0F   ;Mask high nibble (B
             now holds 06)
OR   A,B     ;Combine A and B (A
             now holds 56)
```

Here's how it works. In the first line the number in the A register (35 = 00110101 binary) is ANDed, bit for bit, with the specified number (0F = 00001111). Since, in the AND operation, the resulting bit will only be a '1' when both bits in the column are '1s', the high nibble automatically goes to 0000 since all of its bits are ANDed with '1s', causing 0101 (=5) to be produced. Diagrammatically, it looks like this:

```
    00110101 (35)
AND 00001111 (0F)
    00000101
```

In the next four lines, four rotations 'left' cause the lower nibble to enter the high nibble position, i.e. 00000101 becomes 01010000 (50). Next the same type of masking operation as before is performed to convert 36 into 06. However, no rotations are needed, since the nibble is correctly positioned. Finally, the OR operation combines the two numbers in the A and B registers, the result (56) appearing in the A register. Now it is necessary to convert this BCD number into hexadecimal.

Remembering that hexadecimal is a 'base sixteen' number system leads to the idea that all one has to do is find how many times 16 goes into the BCD number. This gives the higher HEX digit; the remainder (if any) will be the lower HEX digit. The result, 56 (BCD) = &38 can be anticipated to test the theory.

Divide 56 by 16 to get the high nibble '3'; the remainder is 56 − 48 = 8, the low nibble. Thus, the answer is &38. What is now needed is a simple division program that will do this job for us. The division can be done by counting the number of times 16 can be subtracted

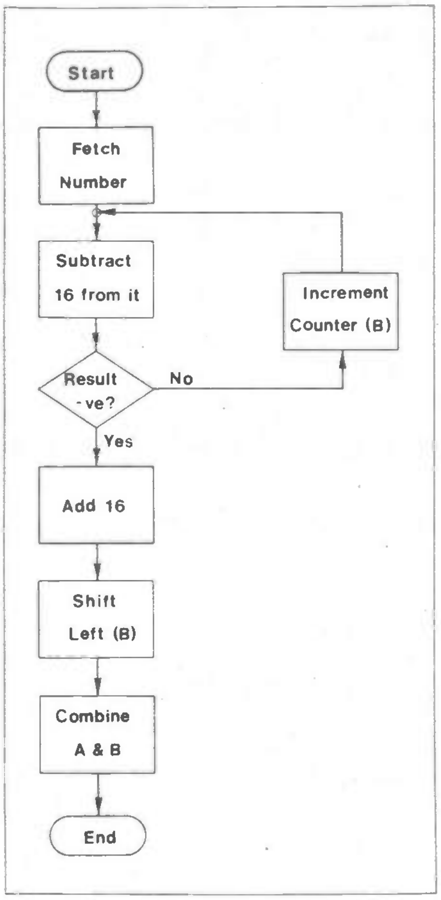


Figure 1. Initial flowchart for BCD to HEX conversion program.

from the BCD number before it goes negative. This last state can be easily detected, when 16 can be added back on to yield the remainder. The process is shown in the flowchart of Figure 1.

The B register is used as a counter, which is initially set to zero. The BCD number is then entered (into the A register) and 16 is subtracted from it. A conditional jump instruction tests whether the result is negative. If it is, then 16 is added back on to yield the remainder. In the example being considered the result will not be negative the first time round, in which case the B register will be incremented to record the first time that 16 was subtracted. The subtraction will be repeated, each time testing for a negative result and incrementing B when it isn't. The register contents will appear as follows:

Operation	**B register**	**A register**
Zero B register	00	00
Load A register	00	56
Subtract 16	01	40
Subtract 16	02	24
Subtract 16	03	08
Subtract 16	03	92 (i.e. −8)
Add 16	03	08

Easy, isn't it? Well, actually it isn't quite as simple as it seems, as would soon be found if one tried to assemble and run this program. Some numbers would convert correctly but others would just give answers that were complete nonsense. So, what's the problem? Actually there are two.

The first one concerns getting the wrong remainders. Suppose the number being converted is 56. This, as has been seen, gives the answer '3 remainder 8', which appears as 38 (hex). Quite correct. Now, suppose that we tried to convert 58 by this simple program. The B register would clock up 3 as the number of subtractions of 16 recorded and the remainder would be 10. The logical OR of 3(0) and 10 is 40, quite the wrong answer, which should be 3A. This arises because we are forced to use the Decimal Add Adjust (DAA) instruction after the 'ADD 16' block, since we are handling decimal numbers. This backfires on us in examples like that given, because it then returns a decimal value for 10 when what is wanted now is its HEX equivalent A. The same trouble will arise when the remainder is 11 (&B), 12 (&C), 13 (&D), 14 (&E) and 15 (&F). Fortunately there is a simple answer. All that is necessary to do is to know when one of these six cases has occurred and convert it back into HEX. The feature that is unique about these cases is that they all start with '1'. In terms of the byte representing the digit, this '1' lies in the 'bit 4' position. Thus, a *BIT 4,A* test can be used to detect a '1' in this position. If a *SUB &06* instruction is used on the cases found, the decimal will turn back into HEX; 10 becomes &0A, etc.

So what is the second problem? This concerns trying to convert the very largest numbers in the range 00-99, still assuming that we don't want to handle numbers with more than two digits. The problem occurs after the first subtraction of 16.

Suppose the number to be converted is 95. Subtracting 16 yields 79. The program works alright.

Now try converting 96. Subtracting 16 now yields 80 and the program no longer works, nor does it with the decimal numbers 97, 98 or 99! So what's the difference and why does the program break down?

The answer lies in the way that negative numbers are represented. Any binary number (whether representing HEX or BCD) in which bit 7 is '1' is identified by the Z80 as a negative number. The number 79 is 01111001 in binary (bit 7 = 0, hence positive), but the number 80 is 10000000 in binary and bit 7 is now a '1', i.e. appears to be negative. But, of course, in the arithmetic that we are doing it's actually supposed to be +80. The fact that the Z80 sees it as negative wouldn't matter too much if it weren't for the fact that we are testing to see if any of our subtractions yield a negative result. The poor old Z80 can't tell the difference between a genuinely negative result (obtained after a sufficient number of subtractions of 16) and a pseudo-negative result obtained when the inputs lie in the range 96-99.

Again, the solution lies in detecting the errant cases and correcting the result. This can be done by jumping

```
00002  5000  (5000)               ORG   &5000        ;program start address
00003  5000  06 00                LD    B,&00        ;initialise B
00004  5002  3E 56                LD    A,&56        ;fetch number (56)
00005  5004  D6 16      .SUB      SUB   A,&16        ;subtract 16
00006  5006  27                   DAA
00007  5007  CB 7F                BIT   7,A          ;is bit 7 a 1?
00008  5009  C2 10 50             JP    NZ,TEST
00009  500C  04         .INC      INC   B            ;record subtraction
00010  500D  C3 04 50             JP    SUB          ;go again
00011  5010  0E 04      .TEST     LD    C,&04        ;initialise C as counter
00012  5012  16 80                LD    D,&80        ;first non-minus code
00013  5014  BA         .LOOP     CP    D            ;does A = D?
00014  5015  CA 0C 50             JP    Z,INC        ;if yes go to INC
00015  5018  0D                   DEC   C            ;record time round
00016  5019  CA 20 50             JP    Z,ADD        ;last time round?
00017  501C  14                   INC   D            ;next non-minus code
00018  501D  C3 14 50             JP    LOOP         ;loop again
00019  5020  C6 16      .ADD      ADD   A,&16        ;result is -ve; add 16
00020  5022  27                   DAA
00021  5023  CB 67                BIT   4,A          ;is bit 4 of A reg. a 1?
00022  5025  CA 2A 50             JP    Z,SKIP       ;no, skip next line
00023  5028  D6 06                SUB   A,&06        ;yes, convert to HEX
00024  502A  CB 00      .SKIP     RLC   B
00025  502C  CB 00                RLC   B
00026  502E  CB 00                RLC   B            ;move B to high nibble
00027  5030  CB 00                RLC   B
00028  5032  B0                   OR    A,B          ;combine both nibbles
00029  5033  32 5F 50             LD    (&505F),A    ; store result
00030
```

Listing 1. Converting BCD numbers to hexadecimal.

whenever an apparently negative number is found and then testing to see whether the number is 80, 81, 82, or 83. If one of the latter cases is found, the program is, in effect, told to ignore the fact that it 'appears' to be negative and to go ahead and perform another subtraction. If it's not one of these numbers then it is obviously really negative and the program takes its normal course by adding 16 back on to yield the required remainder.

These points can now be seen in Listing 1, showing the fully assembled program. Here, briefly, is a line by line run down.

Line 3 sets the counter (B register) to zero. In lines 4-6 the number to be converted is loaded into the A register and 16 is subtracted from it; the DAA instruction returns a BCD result. Lines 7 and 8 carry out the test for bit 7 being either 1 or 0. If it is non-zero (i.e. = 1), a jump is made to TEST, a routine that establishes whether it is genuinely negative or one of the numbers 80-83. This test occupies lines 11 to 18, as follows.

Since there are four numbers (80-83) to be tested for, the C register is set up as a 'down counter' with an initial value of 4. The D register is used to hold the codes 80-83 in succession, the first (80) being loaded in line 12. A comparison is made in line 13 between the number in the A register and the value of 80 in the D register. All this does is condition various flags. If it sets the zero flag, this tells us that the two numbers are equal. If they are, the number is not negative and we jump to INC to record the first subtraction and then jump to SUB to carry out a second subtraction and then carry on as normal. If they are not equal, there are two possibilities. Either the number is 81, 82, or 83 or it is genuinely negative. We test the former possibility first by incrementing D (line 17) but we must also decrement C so that eventually we know when we have tested all four possibilities in the case when the number is actually negative. Since the D register now holds 81 it is now possible to test this against the A register by using the CP instruction again. Consequently, after incrementing D, the program loops back to LOOP at line 13.

In this way the four possibilities, 80-83, that cause the problem are tested in turn and appropriate action taken if any are found. Otherwise, when the C register reaches zero, the test in line 16 will cause the program to leave this loop and go to ADD, where 16 is added back on. In the ADD routine the BCD value is returned by the DAA instruction. Bit 4 of this is tested in lines 21 and 22 and, if it is found to be zero, no action is taken except to jump to line 24 to carry out four consecutive RLCs to move the contents of the B register (the high digit of the answer) to its correct position. Finally, an OR instruction combines the A and B register contents to give the answer.

It might at first be thought that the lines 21-23 can be avoided merely by omitting the DAA instruction in line 20. This is not so. The addition of 16 *must* be carried out in BCD because all previous arithmetic operations were carried out in BCD also. To add 16 back on in HEX to the A register, which holds a BCD number, will obviously yield a nonsense answer.

Look-up Tables

Another way of carrying out a conversion is by accessing a look-up table. This is especially useful if there is no convenient 'link' between the two codes. A case in point is a device that returns a code that has no direct relation to the required code, which we'll assume is for a seven-segment display. In this case the codes returned by the device are merely used as 'offsets' to a pointer to a look-up table that holds the appropriate seven-segment codes. For example, suppose the device returns the codes as follows:

Character Represented	Device Code	7-segment Code
0	CA	7B
1	CB	18
2	CC	B3
3	CD	BA
4	CE	D8
and so on ..... up to		
E	D8	E3
F	D9	E1

It is quite evident that there is no obvious relation between the device code and the code for 'common-anode 7-segment displays'. Provided that the device codes are consecutive, this produces no problem. A table is set up in memory starting from an address [BASE + OFFSET (the device code)] at which the first 7-segment code (that for 0) is stored.

Suppose this BASE address is &5800. The device code for 0 is CA, so the 'first' address of the table is &5800 + &CA = &58CA. In similar fashion the following addresses in the table will be &58CB, &58CC, etc. At these addresses we store the appropriate 7-segment codes. By using 'indexed addressing' the 7-segment codes can be fetched every time a device code is entered.

Figure 2 shows the principle. It is obvious that every code element needs a separate memory location but, unless there are many different possible codes, this is not really of much significance. This is a method commonly used to convert inputs from a variety of peripherals into common codes that the computer or another peripheral knows. The appropriate piece of assembler program looks like this. It is assumed that the A register has been loaded with the device code.

```
LD   DE,&5800  ;Load pointer with
                base address
LD   E,A       ;DE now points to
                table address
LD   A,(DE)    ;Fetch 7-segment
                code from table
```

That's all it takes, just three lines.

Finding the Largest Element in a Table

Talking of tables, there are occasions when data from some source is loaded into a table in RAM. As an example, it might be a data logging

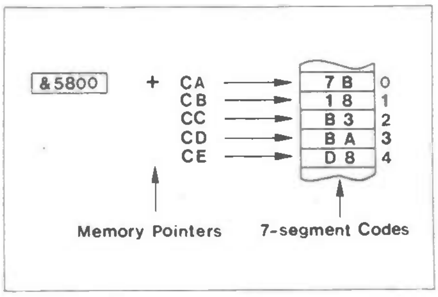


Figure 2. Code conversion using a 'look-up' table.

exercise, in which temperature is monitored at regular intervals throughout the day, and the values entered into consecutive memory locations (the table). It might be of value to know the highest temperature that was reached during the day (the largest element in the table) and when it occurred (the memory location in the table). The technique for this is to look at each value in the table in turn, and compare it with the previous one. If the new value is smaller it is discarded, if it is larger it is swapped with the previously larger value. The HL register pair is frequently used in applications of this type, that is as an address pointer. Combined with the INC HL instruction, it can be used to access a table in sequence. The comparison instruction, CP, can be used to compare the new value fetched from the table with the current value in the A register. Then a decision is made on their relative sizes and a swap made or not as a result. A program that will do this for positive integers is shown in Listing 2. The salient points are as follows.

The table is assumed to exist from address &5080 onwards. Line 3 loads the HL register pair with this base address. The first item in this table, at &5080, is the number of bytes in the table; this is fetched into the B register (line 4). Next the A register is set to zero to avoid a possible error. Line 6 moves the HL pointer onto the next address in the table, where the first byte of actual data is to be found. This is compared with the A register contents which are, of course, zero this time. As a result, the 'carry flag' is set and the comparison senses that this first byte is larger and loads it into the A register (line 9). Now we get down to business. Line 10 loads the locations &504E and &504F with the low and high bytes, respectively, of the table address at which the value in A was found. Lines 11 and 12 increment HL (to point to the next table address) and decrement B (to keep track of the number of comparisons done). Assuming B is not zero, the program now loops back to line 7 to make a comparison with the next element in the table. If this happens to be smaller, it skips lines 9 and 10 to go round again.

A memory dump for this program is also shown. The table is a short one, enough to prove the point. It has 14 data bytes, this being specified by the byte 0E at address &5080. The data bytes follow immediately. The largest data byte is 76 and this is seen to have been stored by the program at address &505F. The location for this byte appears, low byte first, in addresses &504E and &504F, giving location &5088, which can be seen to be correct from the table.

```
00002  5020  (5020)               ORG  &5020       ;Start address of program
00003  5020  21 80 50             LD   HL,&5080    ;Base of table
00004  5023  46                   LD   B,(HL)      ;Number of bytes in table
00005  5024  3E 00                LD   A,&00       ;Initialise A register
00006  5026  23                   INC  HL          ;First data byte address
00007  5027  BE         .LOOP     CP   (HL)        ;Compare entry
00008  5028  30 04                JR   NC,SKIP     ;Jump if smaller
00009  502A  7E                   LD   A,(HL)      ;Load new maximum
00010  502B  22 4E 50             LD   (&504E),HL  ;Store its address
00011  502E  23         .SKIP     INC  HL          ;Next data byte address
00012  502F  05                   DEC  B           ;Decrement counter
00013  5030  20 F5                JR   NZ,LOOP     ;Go again if not done
00014  5032  32 5F 50             LD   (&505F),A   ;Save maximum value
00015
```

Listing 2. Finding the largest positive value in a table.

```
5020  21 80 50 46 3E 00 23 BE  30 04 7E 22 4E 50 23 05  !.PF>.£>0.~"NP£.
5030  20 F5 32 5F 50 00 00 00  00 00 00 00 00 00 00 00   u2_P...........
5040  00 00 00 00 00 00 00 00  00 00 00 00 00 00 88 50  ...............P
5050  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 76  ...............v
5060  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00  ................
5070  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00  ................
5080  0E 62 23 02 71 13 03 04  76 63 35 55 21 65 53 37  .b£.q...vc5U!eS7
```

Memory Dump.

```
00002  5020  (5020)                  ORG   &5020         ;Start address of program
00003  5020  21 80 50                LD    HL,&5080      ;Base address of table
00004  5023  46                      LD    B,(HL)        ;Number of bytes in table
00005  5024  23                      INC   HL            ;First data byte
00006  5025  DD 21 4E 50             LD    IX,&504E      ;Low byte result address
00007  5029  3E 00                   LD    A,00          ;Initialise sum as zero
00008  502B  DD 77 00                LD    (IX + 0),A    ;Low byte result = 0
00009  502E  DD 77 01                LD    (IX + 1),A    ;High byte result = 0
00010  5031  7E             .LOOP    LD    A,(HL)        ;Get byte from table
00011  5032  DD 86 00                ADD   A,(IX + 0)    ;Form sub-total
00012  5035  DD 77 00                LD    (IX + 0),A    ;Store sub-total
00013  5038  30 03                   JR    NC,SKIP       ;Skip next if C = 0
00014  503A  DD 34 01                INC   (IX + 1)      ;Else add to high byte
00015  503D  23             .SKIP    INC   HL            ;Next data byte address
00016  503E  05                      DEC   B             ;Decrement counter
00017  503F  20 F0                   JR    NZ,LOOP       ;Go again if not done
```

Listing 3. Summing the bytes in a table.

```
5020  21 80 50 46 23 DD 21 4E  50 3E 00 DD 77 00 DD 77  !.PF£]!NP>.]w.]w
5030  01 7E DD 86 00 DD 77 00  30 03 DD 34 01 23 05 20  .~]..]w.0.]4.£.
5040  F0 C9 00 00 00 00 00 00  00 00 00 00 00 00 64 03  pI............d.
5050  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00  ................
5060  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00  ................
5070  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00  ................
5080  0E 3E 3E 3E 3E 3E 3E 3E  3E 3E 3E 3E 3E 3E 3E 3E  .>>>>>>>>>>>>>>>
```

Memory Dump.

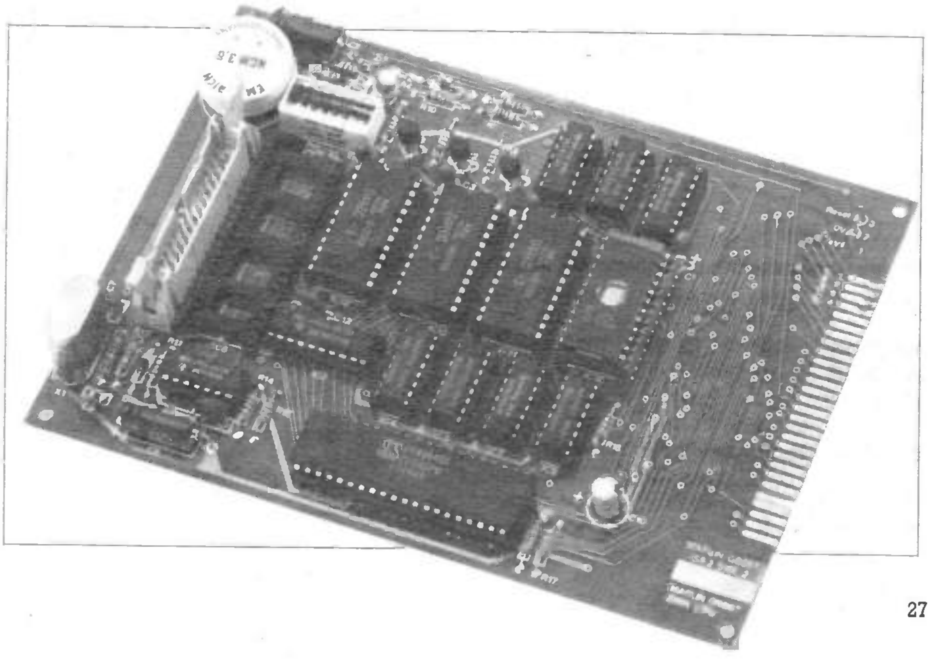
Summing the Bytes in a Table

And, finally, we have a program also to do with data tables. This time its aim is to find the sum of all the data in the table (perhaps to help find the average value). This program also uses the HL pair as a memory pointer but also makes use of one of the index registers, IX. The HL pointer is used to access the elements in the table, which starts at address &5080. The program is shown in Listing 3. The first item in the table is again the number of bytes in the table. So, the lines 3 and 4 are the same as in Listing 2. Having now got the number of bytes into the B register, the program loads the index register IX with the address at which the low byte of the result is to appear, namely &504E. Since the summation of a data table is likely to produce a substantial result, provision is made for a 16-bit answer. The high byte of this answer will appear in memory location &504F. Since IX holds the low-byte address &504E, an offset of zero added to it (IX + 0) will cause it to point to the low byte and an offset of 1 (IX + 1) will cause it to point to the high byte.

In line 7 the A register is loaded with zero and, by loading this into (IX + 0) and (IX + 1), in turn, both bytes of the answer are set initially to zero (lines 8 and 9). Now, in line 10, the first real byte of data is fetched from the table into the A register and, in line 11 it is added to the contents of (IX + 0) to form the first sub-total. This becomes a repetitive process until all elements of the table have been accessed (detected when B reaches zero). The only other point in the program worthy of discussion is in lines 13 and 14. First, the carry flag is tested to see if it is set. If it is, this implies that the addition of the two 8-bit bytes has given a 9-bit result. The 9th bit is the carry, which must be preserved. By incrementing the contents of location (IX + 1) it moves into its rightful position in the high byte of the result.

Conclusion

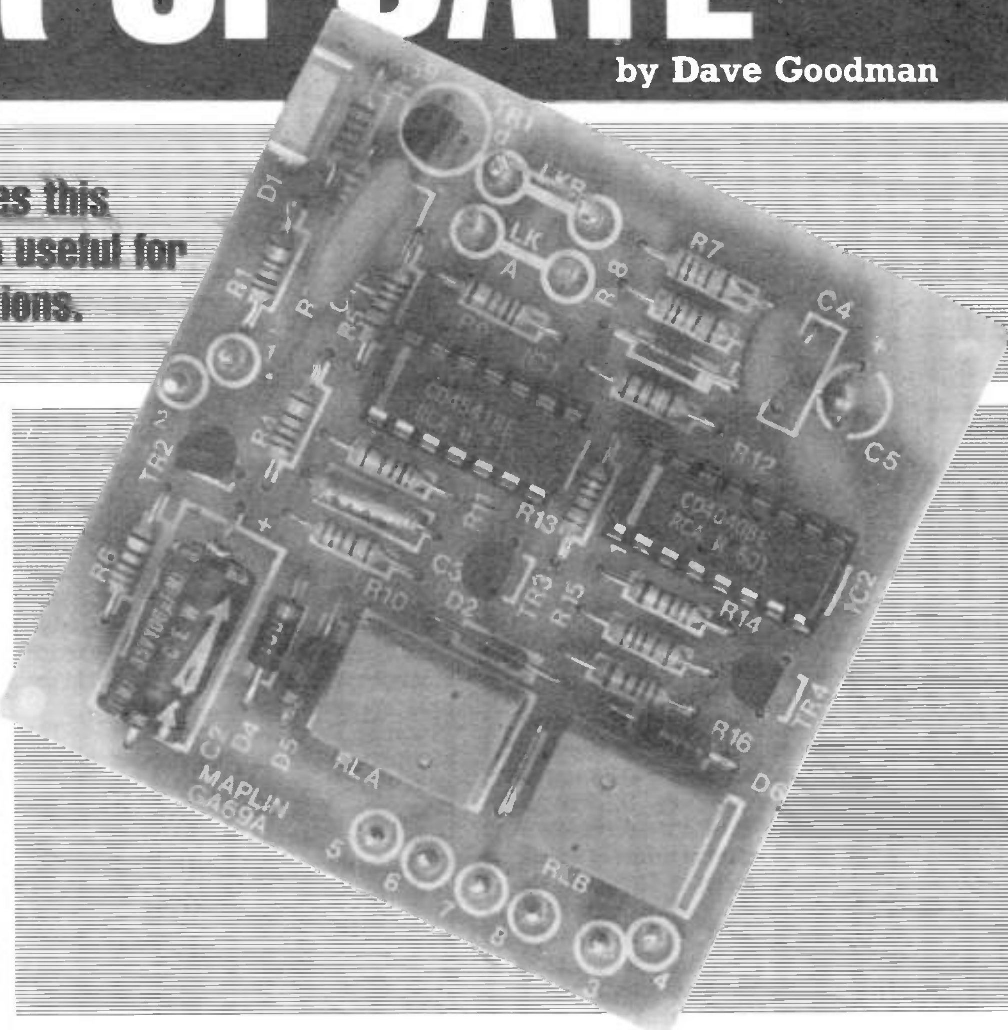
We have now come to the end of this series on programming the Z80 in machine code. It is hoped that it has opened a few hitherto closed doors for the readers of this magazine. I am aware that there is much unsaid, but there is so much that one can do once this type of programming has been mastered. It is only possible to put the readers on the right path and let them unravel a few more mysteries for themselves. If it has at least achieved that it will have been a well worthwhile exercise.



EXTERNAL HORN PROGRAMMABLE TIMER UPDATE

by Dave Goodman

★ A few modifications makes this specialised project more useful for general purpose applications.



Introduction

The external horn driver module featured in 'Electronics', Issue 5 (now available as Project Book 5), was originally designed to be used exclusively with the Maplin Home Security System. However, with a few component changes the same module can be triggered by any positive DC voltage from +3.5V minimum to +20V maximum. While the triggering voltage is present, the normal timer functions are in operation, whereas removing the triggering voltage (<+3.5V to 0V or open circuit) resets the module. When triggered, a horn or siren connected between pins 5 and 6 will sound for a pre-determined period, selected by various link combinations as follows:

Link	Time Period (Horn on)
Link A Only	30 Seconds
Link B Only	2 Minutes
No Links	17 Minutes
Link A & Link B	2 Hours 15 Minutes

After the time-out period has finished, the horn is turned off and a lamp flasher connected between pins 7 and 8 turns on. Only the lamp continues to operate indefinitely, or until the triggering voltage to the module is removed. Re-applying the trigger voltage repeats the timing function again.

The fixed time periods shown above could be increased or decreased by altering the oscillator timing components R10 and/or C3 as required, although the 'No Link' time period of 17 minutes should meet most Local Authority recommendations.

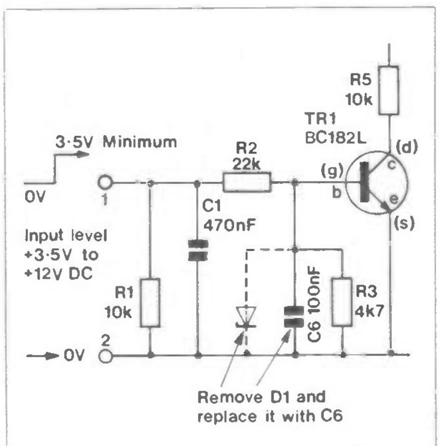


Figure A. Modifications to Figure 1 of the External Horn project.

Rules and Regulations

Before attempting to install any security system that is likely to become a nuisance or cause a disturbance by prolonged use of a high output sounding device, it is advisable to contact your local authorities on the matter. Some areas in Great Britain have local legislation covering the use of alarm bells and sounders in estates or built-up dwelling areas, so a visit to the local police or library should put you on the right lines on the matter.

Modifications

Complete details of the external horn project are to be found in Projects

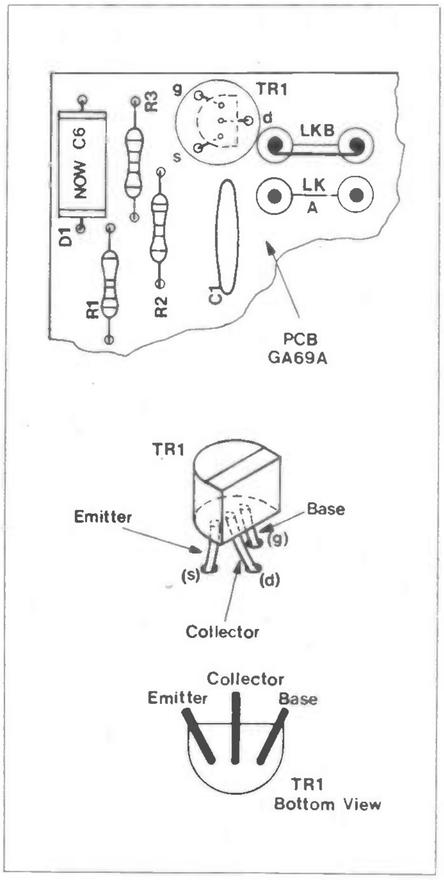


Figure B. Fitting replacement TR1.

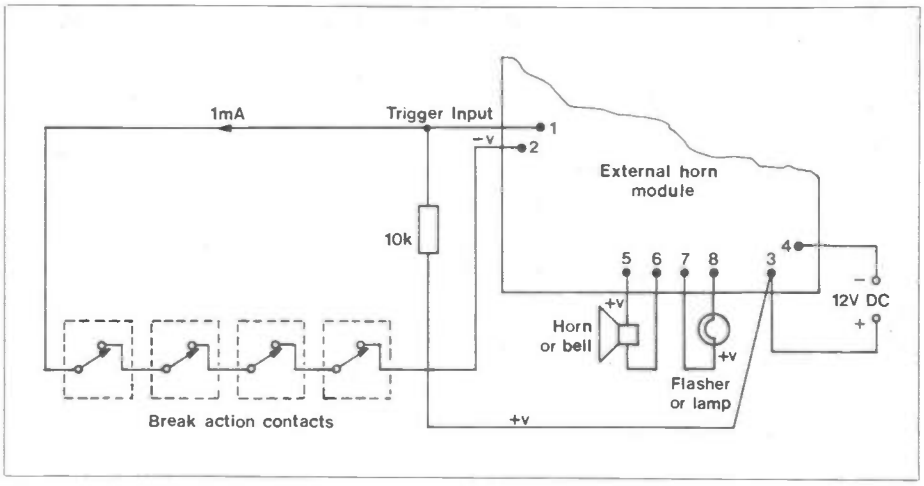
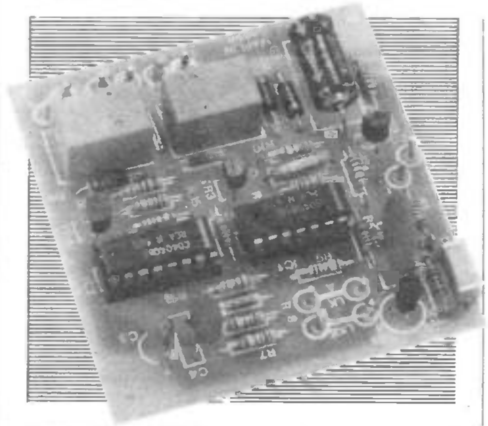


Figure C. Simple break action alarm.



Book 5. They are also supplied with the kit version of the module and therefore the details will not be provided here. However, it is necessary to show the modifications to the module, which are quite simple. Referring to Figure A, a circuit diagram showing 'a part of Figure 1' from the original external horn article, and also the modifications parts list, it can be seen that resistor R1 should be replaced with that of a value of 10k, and R3 replaced with 4k7. No other resistor values are changed. Capacitor C1 is replaced with a 0.47μF disc ceramic, and zener diode D1 is removed and replaced by C6, a 0.1μF disc ceramic. The final modification required is to remove the FET TR1 and replace this with transistor BC182L. The device is fitted a particular way around, as shown in Figure B, with the flat side of the package facing towards Links A & B. The centre lead (collector) goes to the hole marked 'd' which was the 'drain' on the previously fitted 2N3819 FET. The base lead now goes into the hole marked 'g', which was the 'gate' terminal, and the emitter goes to hole 's' for source.

Using the Module

The module could be used as a simple burglar alarm using standard 'break action' magnetic sensors. A typical example of this is shown in Figure C. Alternatively, 'make action' contacts could be wired as shown in Figure D.

Finally, Figure E shows an application using the external horn module with Maplin's 6-channel alarm panel, YN57M. The trigger contacts from terminals 19 and 20 on the 25-way contact block output 12V continuously when the alarm is triggered. The key must then be used to reset the alarm as the 'Auto Reset' does not effect this output. Pin 19 is the positive voltage and pin 20 the negative ground or return. The +12V regulated supply terminals, pin 17 (positive) and pin 18 (negative), could be used to supply the module if required. In this case, the second negative connection from terminal 20 to pin 2 is not necessary and can be left open circuit. If the module is to be used remotely from the panel, then two 6 volt batteries should be used to power the module and the horn, lamp devices and both terminals 19 and 20 are wired to the module as shown.

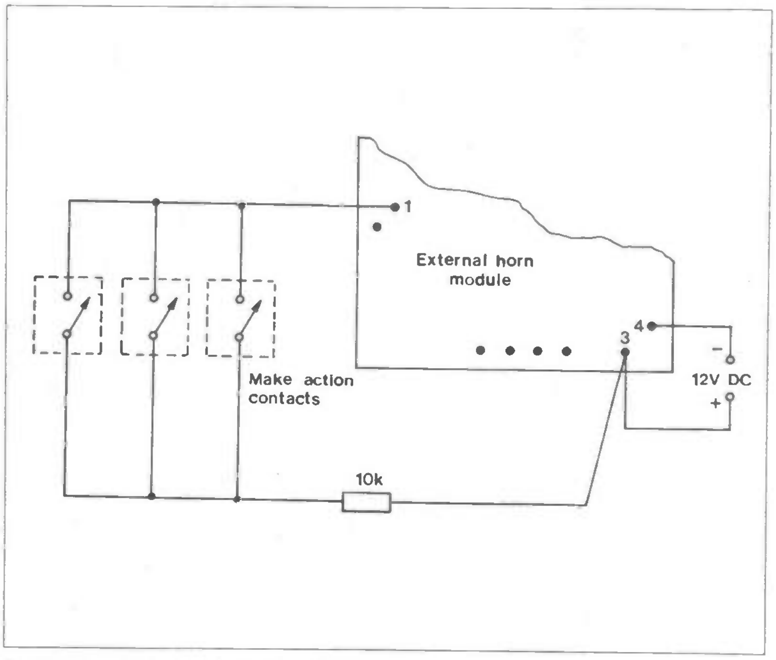


Figure D. Simple make action alarm.

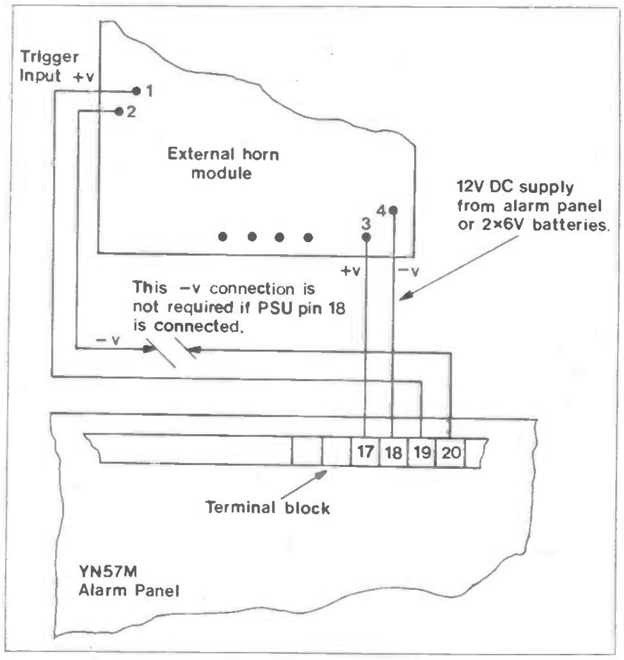


Figure E. Connections to 6-channel alarm panel.

Weather Satellite Prediction Table

Due to the great popularity of our Mapsat weather satellite reception system, it has been decided to include a regular feature inthis magazine which is intended to assist Mapsat system users and other interested parties in knowing when the NOAA series of polar orbiting satellites will be receivable by a station in the British Isles. Satellite news may also be included from time to time, as older satellites fail or are put out of service and new ones are launched to replace them.

Information regarding the geo-stationary satellite Meteosat 2 data transmissions will also be published as and when changes occur but, at the time of writing, the dissemination schedule S8510M01 published in issue 23 of this magazine is current.

The NOAA satellites in active service at present are NOAA 9, which transmits picture information over the British Isles at around mid-day and midnight each day, and NOAA10 which may be received in the early morning and early evening each day. These approximate timings are expected to apply to all future replacements for the current satellites to maintain a good overall coverage of the weather conditions each day between the two active satellites

The table shows Equator crossing times for all orbits which pass over the U.K. within 25 degrees longitude of the Greenwich meridian. It should be noted that times given are in Greenwich mean time so one hour should be added to the prediction times during British Summer Time. The satellite should come into reception range of the turnstile aerial used by the Mapsat system a few minutes after the Equator crossing time for ascending passes (south to north) and remain receivable for around ten minutes until it passes over the Arctic. It should be receivable around fifteen minutes before Equator crossing time for descending passes (north to south) for a similar period.

The Equator crossing times are predicted by means of a computer simulation of the satellites future orbits and are subject to a small but accumulative error caused by any inaccuracy in the reference orbit details and by deviation of the real satellites behaviour from their 'perfect orbit' computer models. In practice, this error amounts to no more than about five minutes in time and half a degree in longitude at the end of a three month period which has been found to be quite acceptable for reception purposes.

NOAA 9 APT PREDICTION CHART

Date	Time G.M.T.	Longitude	East/ West	Ascending/ Descending
01/09/87	04:13:05	0.81	E	DES
01/09/87	05:55:09	24.69	W	DES
01/09/87	14:03:32	22.40	E	ASC
01/09/87	15:45:36	3.10	W	ASC
02/09/87	04:02:08	3.67	E	DES
02/09/87	05:44:13	21.83	W	DES
02/09/87	15:34:40	0.24	W	ASC
03/09/87	03:51:12	6.53	E	DES
03/09/87	05:33:16	18.97	W	DES
03/09/87	15:23:43	2.61	E	ASC
03/09/87	17:05:48	22.89	W	ASC
04/09/87	03:40:15	9.39	E	DES
04/09/87	05:22:20	16.11	W	DES
04/09/87	15:12:47	5.47	E	ASC
04/09/87	16:54:51	20.03	W	ASC
05/09/87	03:29:19	12.25	E	DES
05/09/87	05:11:23	13.25	W	DES
05/09/87	15:01:50	8.33	E	ASC
05/09/87	16:43:55	17.17	W	ASC
06/09/87	03:18:22	15.11	E	DES
06/09/87	05:00:27	10.39	W	DES
06/09/87	14:50:54	11.19	E	ASC
06/09/87	16:32:58	14.31	W	ASC
07/09/87	03:07:26	17.97	E	DES
07/09/87	04:49:30	7.53	W	DES
07/09/87	14:39:57	14.05	E	ASC
07/09/87	16:22:02	11.45	W	ASC
08/09/87	02:56:29	20.83	E	DES
08/09/87	04:38:34	4.67	W	DES
08/09/87	14:29:01	16.91	E	ASC
08/09/87	16:11:05	8.59	W	ASC
09/09/87	02:45:33	23.69	E	DES
09/09/87	04:27:37	1.81	W	DES
09/09/87	14:18:04	19.77	E	ASC
09/09/87	16:00:09	5.73	W	ASC
10/09/87	04:16:41	1.04	E	DES
10/09/87	05:58:45	24.46	W	DES
10/09/87	14:07:08	22.63	E	ASC
10/09/87	15:49:12	2.87	W	ASC
11/09/87	04:05:44	3.90	E	DES
11/09/87	05:47:49	21.60	W	DES
11/09/87	15:38:16	1.37	W	ASC
12/09/87	03:54:48	6.76	E	DES
12/09/87	05:36:52	18.74	W	DES
12/09/87	15:27:19	2.84	E	ASC
12/09/87	17:09:24	22.66	W	ASC
13/09/87	03:43:51	9.62	E	DES
13/09/87	05:25:56	15.88	W	DES
13/09/87	15:16:23	5.70	E	ASC
13/09/87	16:58:27	19.80	W	ASC
14/09/87	03:32:55	12.48	E	DES
14/09/87	05:14:59	13.02	W	DES
14/09/87	15:05:26	8.56	E	ASC
14/09/87	16:47:31	16.94	W	ASC
15/09/87	03:21:58	15.34	E	DES
15/09/87	05:04:03	10.16	W	DES
15/09/87	14:54:30	11.42	E	ASC
15/09/87	16:36:34	14.08	W	ASC
16/09/87	03:11:02	18.20	E	DES
16/09/87	04:53:06	7.30	W	DES
16/09/87	14:43:33	14.28	E	ASC
16/09/87	16:25:38	11.22	W	ASC
17/09/87	03:00:05	21.06	E	DES
17/09/87	04:42:10	4.44	W	DES
17/09/87	14:32:37	17.14	E	ASC
17/09/87	16:14:41	8.36	W	ASC
18/09/87	02:49:09	23.92	E	DES
18/09/87	04:31:13	1.58	W	DES
18/09/87	14:21:40	20.00	E	ASC
18/09/87	16:03:45	5.50	W	ASC
19/09/87	04:20:17	1.27	E	DES
19/09/87	06:02:21	24.23	W	DES
19/09/87	14:10:44	22.86	E	ASC
19/09/87	15:52:48	2.64	W	ASC
20/09/87	04:09:20	4.13	E	DES
20/09/87	05:51:25	21.37	W	DES
20/09/87	15:41:52	0.21	E	ASC
21/09/87	03:58:24	6.99	E	DES
21/09/87	05:40:28	18.51	W	DES
21/09/87	15:30:56	3.07	E	ASC
21/09/87	17:13:00	22.43	W	ASC
22/09/87	03:47:27	9.85	E	DES
22/09/87	05:29:32	15.65	W	DES
22/09/87	15:19:59	5.93	E	ASC
22/09/87	17:02:04	19.57	W	ASC
23/09/87	03:36:31	12.71	E	DES
23/09/87	05:18:35	12.79	W	DES
23/09/87	15:09:03	8.79	E	ASC
23/09/87	16:51:07	16.71	W	ASC
24/09/87	03:25:34	15.57	E	DES
24/09/87	05:07:39	9.93	W	DES
24/09/87	14:58:06	11.65	E	ASC
24/09/87	16:40:11	13.85	W	ASC
25/09/87	03:14:38	18.43	E	DES
25/09/87	04:56:42	7.07	W	DES
25/09/87	14:47:10	14.51	E	ASC
25/09/87	16:29:14	10.99	W	ASC
26/09/87	03:03:41	21.29	E	DES
26/09/87	04:45:46	4.21	W	DES
26/09/87	14:36:13	17.37	E	ASC
26/09/87	16:18:18	8.13	W	ASC
27/09/87	02:52:45	24.15	E	DES
27/09/87	04:34:49	1.35	W	DES
27/09/87	14:25:17	20.23	E	ASC
27/09/87	16:07:21	5.27	W	ASC
28/09/87	04:23:53	1.50	E	DES
28/09/87	06:05:57	24.00	W	DES
28/09/87	14:14:20	23.09	E	ASC
28/09/87	15:56:25	2.41	W	ASC
29/09/87	04:12:56	4.36	E	DES
29/09/87	05:55:01	21.14	W	DES
29/09/87	15:45:28	0.44	E	ASC
30/09/87	04:02:00	7.22	E	DES
30/09/87	05:44:04	18.28	W	DES
30/09/87	15:34:32	3.30	E	ASC
30/09/87	17:16:36	22.20	W	ASC
01/10/87	03:51:03	10.08	E	DES
01/10/87	05:33:08	15.42	W	DES
01/10/87	15:23:35	6.16	E	ASC
01/10/87	17:05:40	19.34	W	ASC
02/10/87	03:40:07	12.94	E	DES
02/10/87	05:22:11	12.56	W	DES
02/10/87	15:12:39	9.02	E	ASC
02/10/87	16:54:43	16.48	W	ASC
03/10/87	03:29:10	15.80	E	DES
03/10/87	05:11:15	9.71	W	DES
03/10/87	15:01:42	11.88	E	ASC
03/10/87	16:43:47	13.62	W	ASC
04/10/87	03:18:14	18.66	E	DES
04/10/87	05:00:18	6.85	W	DES
04/10/87	14:50:46	14.74	E	ASC
04/10/87	16:32:50	10.76	W	ASC
05/10/87	03:07:17	21.51	E	DES
05/10/87	04:49:22	3.99	W	DES
05/10/87	14:39:49	17.60	E	ASC
05/10/87	16:21:54	7.90	W	ASC
06/10/87	02:56:21	24.37	E	DES
06/10/87	04:38:25	1.12	W	DES
06/10/87	14:28:53	20.46	E	ASC
06/10/87	16:10:57	5.04	W	ASC
07/10/87	04:27:29	1.73	E	DES
07/10/87	06:09:33	23.78	W	DES
07/10/87	14:17:56	23.32	E	ASC
07/10/87	16:00:01	2.18	W	ASC
08/10/87	04:16:32	4.58	E	DES
08/10/87	05:58:37	20.92	W	DES
08/10/87	15:49:04	0.67	E	ASC
08/10/87	17:31:09	24.83	W	ASC
09/10/87	04:05:36	7.44	E	DES
09/10/87	05:47:41	18.06	W	DES
09/10/87	15:38:08	3.53	E	ASC
09/10/87	17:20:12	21.97	W	ASC
10/10/87	03:54:40	10.30	E	DES
10/10/87	05:36:44	15.19	W	DES
10/10/87	15:27:11	6.39	E	ASC
10/10/87	17:09:16	19.11	W	ASC
11/10/87	03:43:43	13.16	E	DES
11/10/87	05:25:48	12.33	W	DES
11/10/87	15:16:15	9.25	E	ASC
11/10/87	16:58:19	16.25	W	ASC
12/10/87	03:32:47	16.02	E	DES
12/10/87	05:14:51	9.48	W	DES
12/10/87	15:05:18	12.11	E	ASC
12/10/87	16:47:23	13.39	W	ASC
13/10/87	03:21:50	18.89	E	DES
13/10/87	05:03:55	6.62	W	DES
13/10/87	14:54:22	14.97	E	ASC
13/10/87	16:36:26	10.53	W	ASC
14/10/87	03:10:54	21.74	E	DES
14/10/87	04:52:58	3.76	W	DES
14/10/87	14:43:25	17.83	E	ASC
14/10/87	16:25:30	7.67	W	ASC
15/10/87	02:59:57	24.60	E	DES
15/10/87	04:42:02	0.90	W	DES
15/10/87	14:32:29	20.69	E	ASC
15/10/87	16:14:33	4.81	W	ASC
16/10/87	04:31:05	1.95	E	DES
16/10/87	06:13:10	23.55	W	DES
16/10/87	14:21:32	23.55	E	ASC
16/10/87	16:03:37	1.95	W	ASC
17/10/87	04:20:09	4.82	E	DES
17/10/87	06:02:13	20.69	W	DES
17/10/87	15:52:41	0.90	E	ASC
17/10/87	17:34:45	24.60	W	ASC
18/10/87	04:09:12	7.67	E	DES
18/10/87	05:51:17	17.83	W	DES
18/10/87	15:41:44	3.76	E	ASC
18/10/87	17:23:49	21.74	W	ASC
19/10/87	03:58:16	10.53	E	DES
19/10/87	05:40:20	14.97	W	DES
19/10/87	15:30:47	6.62	E	ASC
19/10/87	17:12:52	18.88	W	ASC
20/10/87	03:47:19	13.39	E	DES
20/10/87	05:29:24	12.10	W	DES
20/10/87	15:19:51	9.48	E	ASC
20/10/87	17:01:55	16.02	W	ASC
21/10/87	03:36:23	16.25	E	DES
21/10/87	05:18:27	9.25	W	DES
21/10/87	15:08:55	12.34	E	ASC
21/10/87	16:50:59	13.16	W	ASC
22/10/87	03:25:26	19.12	E	DES
22/10/87	05:07:31	6.39	W	DES
22/10/87	14:57:58	15.20	E	ASC
22/10/87	16:40:03	10.30	W	ASC
23/10/87	03:14:30	21.98	E	DES
23/10/87	04:56:34	3.53	W	DES
23/10/87	14:47:01	18.06	E	ASC
23/10/87	16:29:06	7.44	W	ASC
24/10/87	03:03:33	24.83	E	DES
24/10/87	04:45:38	0.67	W	DES
24/10/87	14:36:05	20.92	E	ASC
24/10/87	16:18:09	4.58	W	ASC
25/10/87	04:34:41	2.18	E	DES
25/10/87	06:16:46	23.32	W	DES
25/10/87	14:25:09	23.78	E	ASC
25/10/87	16:07:13	1.72	W	ASC
26/10/87	04:23:45	5.05	E	DES
26/10/87	06:05:49	20.46	W	DES
26/10/87	15:56:17	1.13	E	ASC
26/10/87	17:38:21	24.37	W	ASC
27/10/87	04:12:48	7.91	E	DES
27/10/87	05:54:53	17.60	W	DES
27/10/87	15:45:20	3.99	E	ASC
27/10/87	17:27:25	21.51	W	ASC
28/10/87	04:01:52	10.76	E	DES
28/10/87	05:43:56	14.74	W	DES
28/10/87	15:34:23	6.85	E	ASC
28/10/87	17:16:28	18.65	W	ASC
29/10/87	03:50:55	13.62	E	DES
29/10/87	05:33:00	11.87	W	DES
29/10/87	15:23:27	9.71	E	ASC
29/10/87	17:05:32	15.79	W	ASC
30/10/87	03:39:59	16.48	E	DES
30/10/87	05:22:03	9.01	W	DES
30/10/87	15:12:31	12.57	E	ASC
30/10/87	16:54:35	12.93	W	ASC
31/10/87	03:29:02	19.34	E	DES
31/10/87	05:11:07	6.16	W	DES
31/10/87	15:01:34	15.43	E	ASC
31/10/87	16:43:39	10.07	W	ASC
01/11/87	03:18:06	22.20	E	DES
01/11/87	05:00:10	3.30	W	DES
01/11/87	14:50:38	18.29	E	ASC
01/11/87	16:32:42	7.21	W	ASC
02/11/87	04:49:14	0.44	W	DES
02/11/87	14:39:41	21.15	E	ASC
02/11/87	16:21:46	4.35	W	ASC
03/11/87	04:38:17	2.41	E	DES
03/11/87	06:20:22	23.08	W	DES
03/11/87	14:28:45	24.01	E	ASC
03/11/87	16:10:49	1.49	W	ASC
04/11/87	04:27:21	5.27	E	DES
04/11/87	06:09:25	20.23	W	DES
04/11/87	15:59:53	1.36	E	ASC
04/11/87	17:41:57	24.14	W	ASC
05/11/87	04:16:24	8.14	E	DES
05/11/87	05:58:29	17.37	W	DES
05/11/87	15:48:56	4.22	E	ASC
05/11/87	17:31:01	21.28	W	ASC
06/11/87	04:05:28	10.99	E	DES
06/11/87	05:47:32	14.51	W	DES
06/11/87	15:38:00	7.08	E	ASC
06/11/87	17:20:04	18.42	W	ASC
07/11/87	03:54:31	13.85	E	DES
07/11/87	05:36:36	11.65	W	DES
07/11/87	15:27:03	9.94	E	ASC
07/11/87	17:09:08	15.56	W	ASC
08/11/87	03:43:35	16.71	E	DES
08/11/87	05:25:39	8.79	W	DES
08/11/87	15:16:07	12.80	E	ASC
08/11/87	16:58:11	12.70	W	ASC
09/11/87	03:32:38	19.57	E	DES
09/11/87	05:14:43	5.92	W	DES
09/11/87	15:05:10	15.66	E	ASC
09/11/87	16:47:15	9.84	W	ASC
10/11/87	03:21:42	22.43	E	DES
10/11/87	05:03:47	3.07	W	DES
10/11/87	14:54:14	18.52	E	ASC
10/11/87	16:36:18	6.98	W	ASC
11/11/87	04:52:50	0.21	W	DES
11/11/87	14:43:17	21.38	E	ASC
11/11/87	16:25:22	4.12	W	ASC
12/11/87	04:41:53	2.64	E	DES
12/11/87	06:23:58	22.85	W	DES
12/11/87	14:32:21	24.24	E	ASC
12/11/87	16:14:25	1.26	W	ASC
13/11/87	04:30:57	5.50	E	DES
13/11/87	06:13:01	20.00	W	DES
13/11/87	16:03:29	1.59	E	ASC
13/11/87	17:45:33	23.91	W	ASC
14/11/87	04:20:01	8.37	E	DES
14/11/87	06:02:05	17.14	W	DES
14/11/87	15:52:32	4.45	E	ASC
14/11/87	17:34:37	21.05	W	ASC
15/11/87	04:09:04	11.23	E	DES
15/11/87	05:51:09	14.28	W	DES
15/11/87	15:41:36	7.31	E	ASC
15/11/87	17:23:40	18.19	W	ASC
16/11/87	03:58:07	14.08	E	DES
16/11/87	05:40:12	11.42	W	DES
16/11/87	15:30:39	10.17	E	ASC
16/11/87	17:12:44	15.33	W	ASC
17/11/87	03:47:11	16.94	E	DES
17/11/87	05:29:15	8.56	W	DES
17/11/87	15:19:43	13.03	E	ASC
17/11/87	17:01:47	12.47	W	ASC
18/11/87	03:36:15	19.80	E	DES
18/11/87	05:18:19	5.69	W	DES
18/11/87	15:08:46	15.89	E	ASC
18/11/87	16:50:51	9.61	W	ASC
19/11/87	03:25:18	22.66	E	DES
19/11/87	05:07:23	2.83	W	DES
19/11/87	14:57:50	18.75	E	ASC
19/11/87	16:39:54	6.75	W	ASC
20/11/87	04:56:26	0.01	E	DES
20/11/87	14:46:53	21.61	E	ASC
20/11/87	16:28:58	3.89	W	ASC
21/11/87	04:45:29	2.87	E	DES
21/11/87	06:27:34	22.62	W	DES
21/11/87	14:35:57	24.47	E	ASC
21/11/87	16:18:01	1.03	W	ASC
22/11/87	04:34:33	5.73	E	DES
22/11/87	06:16:38	19.76	W	DES
22/11/87	16:07:05	1.82	E	ASC
22/11/87	17:49:09	23.68	W	ASC
23/11/87	04:23:37	8.59	E	DES
23/11/87	06:05:41	16.91	W	DES
23/11/87	15:56:08	4.68	E	ASC
23/11/87	17:38:13	20.82	W	ASC
24/11/87	04:12:40	11.45	E	DES
24/11/87	05:54:45	14.05	W	DES
24/11/87	15:45:12	7.54	E	ASC
24/11/87	17:27:16	17.96	W	ASC
25/11/87	04:01:44	14.32	E	DES
25/11/87	05:43:48	11.19	W	DES
25/11/87	15:34:15	10.40	E	ASC
25/11/87	17:16:20	15.10	W	ASC
26/11/87	03:50:47	17.17	E	DES
26/11/87	05:32:52	8.33	W	DES
26/11/87	15:23:19	13.26	E	ASC
26/11/87	17:05:23	12.24	W	ASC
27/11/87	03:39:51	20.03	E	DES
27/11/87	05:21:55	5.47	W	DES
27/11/87	15:12:22	16.12	E	ASC
27/11/87	16:54:27	9.38	W	ASC
28/11/87	03:28:54	22.89	E	DES
28/11/87	05:10:59	2.60	W	DES
28/11/87	15:01:26	18.98	E	ASC
28/11/87	16:43:30	6.52	W	ASC
29/11/87	05:00:02	0.24	E	DES
29/11/87	14:50:29	21.84	E	ASC
29/11/87	16:32:34	3.66	W	ASC
30/11/87	04:49:06	3.10	E	DES
30/11/87	06:31:10	22.40	W	DES
30/11/87	14:39:33	24.70	E	ASC
30/11/87	16:21:37	0.80	W	ASC

NOAA 10 APT PREDICTION CHART

Date	Time G.M.T.	Longitude	East West	Ascending/ Descending
01/09/87	07:43:15	8.42	E	DES
01/09/87	09:24:32	16.89	W	DES
01/09/87	19:10:15	4.32	E	ASC
01/09/87	20:51:33	20.99	W	ASC
02/09/87	07:21:16	13.94	E	DES
02/09/87	09:02:33	11.37	W	DES
02/09/87	18:48:17	9.84	E	ASC
02/09/87	20:29:34	15.47	W	ASC
03/09/87	06:59:17	19.46	E	DES
03/09/87	08:40:35	5.85	W	DES
03/09/87	18:26:18	15.36	E	ASC
03/09/87	20:07:35	9.95	W	ASC
04/09/87	06:37:19	24.98	E	DES
04/09/87	08:18:36	0.33	W	DES
04/09/87	18:04:19	20.88	E	ASC
04/09/87	19:45:37	4.43	W	ASC
05/09/87	07:56:37	5.18	E	DES
05/09/87	09:37:54	20.13	W	DES
05/09/87	19:23:38	1.08	E	ASC
05/09/87	21:04:55	24.23	W	ASC
06/09/87	07:34:39	10.70	E	DES
06/09/87	09:15:56	14.61	W	DES
06/09/87	19:01:39	6.60	E	ASC
06/09/87	20:42:56	18.71	W	ASC
07/09/87	07:12:40	16.22	E	DES
07/09/87	08:53:57	9.09	W	DES
07/09/87	18:39:41	12.12	E	ASC
07/09/87	20:20:58	13.19	W	ASC
08/09/87	06:50:41	21.74	E	DES
08/09/87	08:31:58	3.57	W	DES
08/09/87	18:17:42	17.64	E	ASC
08/09/87	19:58:59	7.67	W	ASC
09/09/87	08:10:00	1.94	E	DES
09/09/87	09:51:17	23.37	W	DES
09/09/87	17:55:43	23.16	E	ASC
09/09/87	19:37:00	2.15	W	ASC
10/09/87	07:48:01	7.46	E	DES
10/09/87	09:29:18	17.85	W	DES
10/09/87	19:15:02	3.36	E	ASC
10/09/87	20:56:19	21.95	W	ASC
11/09/87	07:26:02	12.98	E	DES
11/09/87	09:07:20	12.33	W	DES
11/09/87	18:53:03	8.88	E	ASC
11/09/87	20:34:20	16.43	W	ASC
12/09/87	07:04:04	18.50	E	DES
12/09/87	08:45:21	6.81	W	DES
12/09/87	18:31:04	14.40	E	ASC
12/09/87	20:12:22	10.91	W	ASC
13/09/87	06:42:05	24.02	E	DES
13/09/87	08:23:22	1.29	W	DES
13/09/87	18:09:06	19.92	E	ASC
13/09/87	19:50:23	5.39	W	ASC
14/09/87	08:01:24	4.22	E	DES
14/09/87	09:42:41	21.09	W	DES
14/09/87	19:28:24	0.12	E	ASC
15/09/87	07:39:25	9.74	E	DES
15/09/87	09:20:42	15.57	W	DES
15/09/87	19:06:26	5.64	E	ASC
15/09/87	20:47:43	19.67	W	ASC
16/09/87	07:17:26	15.26	E	DES
16/09/87	08:58:44	10.05	W	DES
16/09/87	18:44:27	11.16	E	ASC
16/09/87	20:25:44	14.15	W	ASC
17/09/87	06:55:28	20.78	E	DES
17/09/87	08:36:45	4.53	W	DES
17/09/87	18:22:28	16.68	E	ASC
17/09/87	20:03:46	8.63	W	ASC
18/09/87	08:14:46	0.98	E	DES
18/09/87	09:56:03	24.33	W	DES
18/09/87	18:00:30	22.20	E	ASC
18/09/87	19:41:47	3.11	W	ASC
19/09/87	07:52:48	6.50	E	DES
19/09/87	09:34:05	18.81	W	DES
19/09/87	19:19:48	2.40	E	ASC
19/09/87	21:01:05	22.91	W	ASC
20/09/87	07:30:49	12.02	E	DES
20/09/87	09:12:06	13.29	W	DES
20/09/87	18:57:50	7.92	E	ASC
20/09/87	20:39:07	17.39	W	ASC
21/09/87	07:08:50	17.54	E	DES
21/09/87	08:50:07	7.77	W	DES
21/09/87	18:35:51	13.44	E	ASC
21/09/87	20:17:08	11.87	W	ASC
22/09/87	06:46:52	23.06	E	DES
22/09/87	08:28:09	2.25	W	DES
22/09/87	18:13:52	18.96	E	ASC
22/09/87	19:55:09	6.35	W	ASC
23/09/87	08:06:10	3.26	E	DES
23/09/87	09:47:27	22.05	W	DES
23/09/87	17:51:54	24.48	E	ASC

Date	Time G.M.T.	Longitude	East/ West	Ascending Descending
23/09/87	19:33:11	0.83	W	ASC
24/09/87	07:44:11	8.78	E	DES
24/09/87	09:25:29	16.53	W	DES
24/09/87	19:11:12	4.68	E	ASC
24/09/87	20:52:29	20.63	W	ASC
25/09/87	07:22:13	14.30	E	DES
25/09/87	09:03:30	11.01	W	DES
25/09/87	18:49:13	10.20	E	ASC
25/09/87	20:30:31	15.11	W	ASC
26/09/87	07:00:14	19.82	E	DES
26/09/87	08:41:31	5.49	W	DES
26/09/87	18:27:15	15.72	E	ASC
26/09/87	20:08:32	9.59	W	ASC
27/09/87	08:19:33	2.43	E	DES
27/09/87	18:05:16	21.24	E	ASC
27/09/87	19:46:33	4.07	W	ASC
28/09/87	07:57:34	5.54	E	DES
28/09/87	09:38:51	19.77	W	DES
28/09/87	19:24:35	1.44	E	ASC
28/09/87	21:05:52	23.87	W	ASC
29/09/87	07:35:35	11.06	E	DES
29/09/87	09:16:53	14.25	W	DES
29/09/87	19:02:36	6.96	E	ASC
29/09/87	20:43:53	18.35	W	ASC
30/09/87	07:13:37	16.58	E	DES
30/09/87	08:54:54	8.73	W	DES
30/09/87	18:40:37	12.48	E	ASC
30/09/87	20:21:55	12.83	W	ASC
01/10/87	06:51:38	22.10	E	DES
01/10/87	08:32:55	3.21	W	DES
01/10/87	18:18:39	18.00	E	ASC
01/10/87	19:59:56	7.31	W	ASC
02/10/87	08:10:57	2.30	E	DES
02/10/87	09:52:14	23.01	W	DES
02/10/87	17:56:40	23.52	E	ASC
02/10/87	19:37:57	1.79	W	ASC
03/10/87	07:48:58	7.82	E	DES
03/10/87	09:30:15	17.49	W	DES
03/10/87	19:15:59	3.72	E	ASC
03/10/87	20:57:16	21.59	W	ASC
04/10/87	07:26:59	13.34	E	DES
04/10/87	09:08:16	11.97	W	DES
04/10/87	18:54:00	9.24	E	ASC
04/10/87	20:35:17	16.07	W	ASC
05/10/87	07:05:01	18.86	E	DES
05/10/87	08:46:18	6.45	W	DES
05/10/87	18:32:01	14.76	E	ASC
05/10/87	20:13:18	10.55	W	ASC
06/10/87	06:43:02	24.38	E	DES
06/10/87	08:24:19	0.93	W	DES
06/10/87	18:10:03	20.28	E	ASC
06/10/87	19:51:20	5.03	W	ASC
07/10/87	08:02:20	4.58	E	DES
07/10/87	09:43:38	20.73	W	DES
07/10/87	19:29:21	0.48	E	ASC
07/10/87	21:10:38	24.83	W	ASC
08/10/87	07:40:22	10.10	E	DES
08/10/87	09:21:39	15.21	W	DES
08/10/87	19:07:22	6.00	E	ASC
08/10/87	20:48:40	19.31	W	ASC
09/10/87	07:18:23	15.62	E	DES
09/10/87	08:59:41	9.69	W	DES
09/10/87	18:45:24	11.52	E	ASC
09/10/87	20:26:41	13.79	W	ASC
10/10/87	06:56:25	21.14	E	DES
10/10/87	08:37:42	4.17	W	DES
10/10/87	18:23:25	17.04	E	ASC
10/10/87	20:04:43	8.27	W	ASC
11/10/87	08:15:43	1.34	E	DES
11/10/87	09:57:00	23.97	W	DES
11/10/87	18:01:27	22.56	E	ASC
11/10/87	19:42:44	2.75	W	ASC
12/10/87	07:53:45	6.86	E	DES
12/10/87	09:35:02	18.45	W	DES
12/10/87	19:20:45	2.76	E	ASC
12/10/87	21:02:02	22.55	W	ASC
13/10/87	07:31:46	12.38	E	DES
13/10/87	09:13:03	12.93	W	DES
13/10/87	18:58:47	8.28	E	ASC
13/10/87	20:40:04	17.03	W	ASC
14/10/87	07:09:47	17.90	E	DES
14/10/87	08:51:04	7.41	W	DES
14/10/87	18:36:48	13.80	E	ASC
14/10/87	20:18:05	11.51	W	ASC
15/10/87	06:47:49	23.42	E	DES
15/10/87	08:29:06	1.89	W	DES
15/10/87	18:14:49	19.32	E	ASC
15/10/87	19:56:06	5.99	W	ASC
16/10/87	08:07:07	3.62	E	DES
16/10/87	09:48:24	21.69	W	DES

Date	Time G.M.T.	Longitude	East West	Ascending Descending
16/10/87	17:52:51	24.84	E	ASC
16/10/87	19:34:08	0.47	W	ASC
17/10/87	07:45:08	9.14	E	DES
17/10/87	09:26:26	16.17	W	DES
17/10/87	19:12:09	5.04	E	ASC
17/10/87	20:53:26	20.27	W	ASC
18/10/87	07:23:10	14.66	E	DES
18/10/87	09:04:27	10.65	W	DES
18/10/87	18:50:10	10.56	E	ASC
18/10/87	20:31:28	14.75	W	ASC
19/10/87	07:01:11	20.18	E	DES
19/10/87	08:42:28	5.13	W	DES
19/10/87	18:28:12	16.08	E	ASC
19/10/87	20:09:29	9.23	W	ASC
20/10/87	08:20:30	0.38	E	DES
20/10/87	10:01:47	24.93	W	DES
20/10/87	18:06:13	21.60	E	ASC
20/10/87	19:47:30	3.71	W	ASC
21/10/87	07:58:31	5.90	E	DES
21/10/87	09:39:48	19.41	W	DES
21/10/87	19:25:32	1.80	E	ASC
21/10/87	21:06:49	23.51	W	ASC
22/10/87	07:36:32	11.42	E	DES
22/10/87	09:17:49	13.89	W	DES
22/10/87	19:03:33	7.32	E	ASC
22/10/87	20:44:50	17.99	W	ASC
23/10/87	07:14:34	16.94	E	DES
23/10/87	08:55:51	8.37	W	DES
23/10/87	18:41:34	12.84	E	ASC
23/10/87	20:22:51	12.47	W	ASC
24/10/87	06:52:35	22.46	E	DES
24/10/87	08:33:52	2.85	W	DES
24/10/87	18:19:36	18.36	E	ASC
24/10/87	20:00:53	6.95	W	ASC
25/10/87	08:11:53	2.66	E	DES
25/10/87	09:53:11	22.65	W	DES
25/10/87	17:57:37	23.88	E	ASC
25/10/87	19:38:54	1.43	W	ASC
26/10/87	07:49:55	8.18	E	DES
26/10/87	09:31:12	17.13	W	DES
26/10/87	19:16:55	4.08	E	ASC
26/10/87	20:58:13	21.23	W	ASC
27/10/87	07:27:56	13.70	E	DES
27/10/87	09:09:13	11.61	W	DES
27/10/87	18:54:57	9.60	E	ASC
27/10/87	20:36:14	15.71	W	ASC
28/10/87	07:05:57	19.22	E	DES
28/10/87	08:47:15	6.09	W	DES
28/10/87	18:32:58	15.12	E	ASC
28/10/87	20:14:15	10.19	W	ASC
29/10/87	06:43:59	24.74	E	DES
29/10/87	08:25:16	0.57	W	DES
29/10/87	18:10:59	20.64	E	ASC
29/10/87	19:52:17	4.67	W	ASC
30/10/87	08:03:17	4.94	E	DES
30/10/87	09:44:35	20.37	W	DES
30/10/87	19:30:18	0.84	E	ASC
30/10/87	21:11:35	24.47	W	ASC
31/10/87	07:41:19	10.46	E	DES
31/10/87	09:22:36	14.85	W	DES
31/10/87	19:08:19	6.36	E	ASC
31/10/87	20:49:37	18.95	W	ASC
01/11/87	07:19:20	15.98	E	DES
01/11/87	09:00:37	9.33	W	DES
01/11/87	18:46:21	11.88	E	ASC
01/11/87	20:27:38	13.43	W	ASC
02/11/87	06:57:21	21.50	E	DES
02/11/87	08:38:39	3.81	W	DES
02/11/87	18:24:22	17.40	E	ASC
02/11/87	20:05:39	7.91	W	ASC
03/11/87	08:16:40	1.70	E	DES
03/11/87	09:57:57	23.61	W	DES
03/11/87	18:02:23	22.92	E	ASC
03/11/87	19:43:41	2.39	W	ASC
04/11/87	07:54:41	7.22	E	DES
04/11/87	09:35:59	18.09	W	DES
04/11/87	19:21:42	3.12	E	ASC
04/11/87	21:02:59	22.19	W	ASC
05/11/87	07:32:43	12.74	E	DES
05/11/87	09:14:00	12.57	W	DES
05/11/87	18:59:43	8.64	E	ASC
05/11/87	20:41:01	16.67	W	ASC
06/11/87	07:10:44	18.26	E	DES
06/11/87	08:52:01	7.05	W	DES
06/11/87	18:37:45	14.16	E	ASC
06/11/87	20:19:02	11.15	W	ASC
07/11/87	06:48:45	23.78	E	DES
07/11/87	08:30:03	1.53	W	DES
07/11/87	18:15:46	19.68	E	ASC
07/11/87	19:57:03	5.63	W	ASC

Date	Time G.M.T.	Longitude	East West	Ascending/ Descending
08/11/87	08:08:04	3.98	E	DES
08/11/87	09:49:21	21.33	W	DES
08/11/87	19:35:05	0.11	W	ASC
09/11/87	07:46:05	9.50	E	DES
09/11/87	09:27:22	15.81	W	DES
09/11/87	19:13:06	5.40	E	ASC
09/11/87	20:54:23	19.91	W	ASC
10/11/87	07:24:07	15.02	E	DES
10/11/87	09:05:24	10.29	W	DES
10/11/87	18:51:07	10.92	E	ASC
10/11/87	20:32:24	14.39	W	ASC
11/11/87	07:02:08	20.54	E	DES
11/11/87	08:43:25	4.77	W	DES
11/11/87	18:29:09	16.44	E	ASC
11/11/87	20:10:26	8.87	W	ASC
12/11/87	08:21:26	0.74	E	DES
12/11/87	10:02:44	24.57	W	DES
12/11/87	18:07:10	21.96	E	ASC
12/11/87	19:48:27	3.35	W	ASC
13/11/87	07:59:28	6.26	E	DES
13/11/87	09:40:45	19.05	W	DES
13/11/87	19:26:28	2.16	E	ASC
13/11/87	21:07:46	23.15	W	ASC
14/11/87	07:37:29	11.78	E	DES
14/11/87	09:18:46	13.53	W	DES
14/11/87	19:04:30	7.68	E	ASC
14/11/87	20:45:47	17.63	W	ASC
15/11/87	07:15:30	17.30	E	DES
15/11/87	08:56:48	8.01	W	DES
15/11/87	18:42:31	13.20	E	ASC
15/11/87	20:23:48	12.11	W	ASC
16/11/87	06:53:32	22.82	E	DES
16/11/87	08:34:49	2.49	W	DES
16/11/87	18:20:32	18.72	E	ASC
16/11/87	20:01:50	6.59	W	ASC
17/11/87	08:12:50	3.02	E	DES
17/11/87	09:54:07	22.29	W	DES
17/11/87	17:58:34	24.24	E	ASC
17/11/87	19:39:51	1.07	W	ASC
18/11/87	07:50:52	8.54	E	DES
18/11/87	09:32:09	16.77	W	DES
18/11/87	19:17:52	4.44	E	ASC
18/11/87	20:59:09	20.87	W	ASC
19/11/87	07:28:53	14.06	E	DES
19/11/87	09:10:10	11.25	W	DES
19/11/87	18:55:54	9.96	E	ASC
19/11/87	20:37:11	15.35	W	ASC
20/11/87	07:06:54	19.58	E	DES
20/11/87	08:48:11	5.73	W	DES
20/11/87	18:33:55	15.48	E	ASC
20/11/87	20:15:12	9.83	W	ASC
21/11/87	08:26:13	0.21	W	DES
21/11/87	18:11:56	21.00	E	ASC
21/11/87	19:53:13	4.31	W	ASC
22/11/87	08:04:14	5.30	E	DES
22/11/87	09:45:31	20.01	W	DES
22/11/87	19:31:15	1.20	E	ASC
22/11/87	21:12:32	24.11	W	ASC
23/11/87	07:42:15	10.82	E	DES
23/11/87	09:23:33	14.49	W	DES
23/11/87	19:09:16	6.72	E	ASC
23/11/87	20:50:33	18.59	W	ASC
24/11/87	07:20:17	16.34	E	DES
24/11/87	09:01:34	8.97	W	DES
24/11/87	18:47:17	12.24	E	ASC
24/11/87	20:28:35	13.07	W	ASC
25/11/87	06:58:18	21.86	E	DES
25/11/87	08:39:35	3.45	W	DES
25/11/87	18:25:19	17.76	E	ASC
25/11/87	20:06:36	7.55	W	ASC
26/11/87	08:17:37	2.06	E	DES
26/11/87	09:58:54	23.25	W	DES
26/11/87	18:03:20	23.28	E	ASC
26/11/87	19:44:37	2.03	W	ASC
27/11/87	07:55:38	7.58	E	DES
27/11/87	09:36:55	17.73	W	DES
27/11/87	19:22:39	3.48	E	ASC
27/11/87	21:03:56	21.83	W	ASC
28/11/87	07:33:39	13.10	E	DES
28/11/87	09:14:57	12.21	W	DES
28/11/87	19:00:40	9.00	E	ASC
28/11/87	20:41:57	16.31	W	ASC
29/11/87	07:11:41	18.62	E	DES
29/11/87	08:52:58	6.69	W	DES
29/11/87	18:38:41	14.52	E	ASC
29/11/87	20:19:59	10.79	W	ASC
30/11/87	06:49:42	24.14	E	DES
30/11/87	08:30:59	1.17	W	DES
30/11/87	18:16:43	20.04	E	ASC
30/11/87	19:58:00	5.27	W	ASC

MAPLIN'S TOP TWENTY KITS

THIS MONTH	LAST MONTH		DESCRIPTION OF KIT	ORDER CODE	KIT PRICE	DETAILS IN PROJECT BOOK
1.	(1)	◆◆	Live Wire Detector	LK63T	£3.50	14 (XA14Q)
2.	(2)	◆◆	U/Sonic Car Alarm	LK75S	£16.95	15 (XA15R)
3.	(4)	◆	150W Mosfet Amplifier	LW51F	£17.95	Best of E&MM
4.	(5)	◆	8W Amplifier	LW36P	£5.50	Catalogue
5.	(3)	◆	Partylite	LW93B	£9.95	Best of E&MM
6.	(6)	◆◆	Car Burglar Alarm	LW78K	£7.95	4 (XA04E)
7.	(–)	◆	Car Battery Monitor	LK42V	£7.50	Best of E&MM
8.	(7)	◆	Ultrasonic Intruder Detector	LW83E	£11.95	4 (XA04E)
9.	(9)	◆◆	PWM Motor Driver	LK54J	£9.95	12 (XA12N)
10.	(11)	◆	27MHz Receiver	LK56L	£8.95	13 (XA13P)
11.	(8)	◆	I/R Prox. Detector	LM13P	£10.95	20 (XA20W)
12.	(10)	◆	Servo and Driver	LK45Y	£10.95	11 (XA11M)
13.	(12)	◆	27MHz Transmitter	LK55K	£7.95	13 (XA13P)
14.	(17)	◆	Car Digital Tacho	LK79L	£19.95	Best of E&MM
15.	(13)	◆	15W Amplifier	YQ43W	£6.50	Catalogue
16.	(15)	◆	Noise Gate	LK43W	£10.95	Best of E&MM
17.	(19)	◆	Stepper Motor and Driver	LK76H	£16.95	18 (XA18U)
18.	(–)	◆	50W Amplifier	LW35Q	£17.95	Catalogue
19.	(18)	◆	Xenon Tube-Driver	LK46A	£11.95	11 (XA11M)
20.	(20)	◆◆	Musical Announcer	LK57M	£13.95	13 (XA13P)

Over 150 other kits also available. All kits supplied with instructions.

The descriptions above are necessarily short. Please ensure you know exactly what the kit is and what it comprises before ordering, by checking the appropriate Project Book mentioned in the list above – see inside back cover for details.

1987 CATALOGUE PRICE CHANGES

The price changes shown in this list are valid from 16th August 1987 to 6th November 1987. Prices charged will be those ruling on the day of despatch.

For further details please see 'Prices' on catalogue page 18.

Price Changes
All items whose prices have changed since the publication of the 1987 catalogue are shown in the list below. Those where the price has changed since the last Price Change Leaflet (dated 11th May 1987) are marked '•' after the price.
A complete Price List is also available free of charge – order as XF08J.

Key

NYA	Not yet available.
DIS	Discontinued.
TEMP	Temporarily unobtainable.
FEB	Out of stock; new stock expected in month shown.
‡	An additional £5.50 carriage charge must be added.
NV	Indicates that item is zero rated for VAT purposes.
★	See 'Amendments To Catalogue'. Note that not all items that require amendments are shown in this list.

1987 Catalogue Page No. — VAT Inclusive Price

AERIALS

Page 34
- XQ23A Mushkiller FM1083 £15.50•
- XQ25C Mushkiller FM1085 £23.95•
- ‡XQ27E Mushkiller FM1087 £31.50•
- XQ29G Trucolour TC10 Grp A £11.70•
- XQ30H Trucolour TC10 Grp B £11.70•
- XQ31J TrucolourTC10 GrpC/D £11.70•
- XG23A Trucolour TC10 Grp E £11.70•
- XQ32K Trucolour TC13 Grp A £13.80•
- XQ33L Trucolour TC13 Grp B £13.80•
- XQ34M TrucolourTC13 GrpC/D £13.80•
- XQ35Q Trucolour TC18 Grp A £16.95•
- XQ36P Trucolour TC18 Grp B £16.95•
- XQ37S TrucolourTC18 GrpC/D £16.95•
- XG24B Trucolour TC18 Grp E £16.95•

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- XQ38R Extragain XG5 £21.95•
- XQ39N Extragain XG8 GroupA £28.50•
- XQ40T Extragain XG8 GroupB £28.50•
- XQ41U Extragain XG8 GrpC/D £28.50•
- XQ42V Extragain XG8 Wdbnd £28.50•
- XQ43W ExtragainXG14 GroupA £54.50•
- XQ44X ExtragainXG14 GroupB £54.50•
- XQ45Y ExtragainXG14 GrpC/D £54.50•
- XQ46A Extragain XG14 Wdbnd £54.50•
- XQ50E Extragain XG21 Wdbnd £79.95•
- YM56L Hi-Tech TV Aerial £11.95•
- XQ51F Super-Set Top £9.45•
- XQ52G Caratenna £11.50•

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- XG82D H/Dty Aerial Rotator £89.95

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- BW51F Diplexer UF22 £7.50•
- BW52G Splitter CS1000 £7.50•

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- FE28F Splitter CS3000 £8.50•

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- YG41U 27MHz Rubber Duck £7.95•
- XX37S Car Aerial Booster £6.95•

BATTERIES & POWER SUPPLIES

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- FK56L Blue Seal R14B 34p•
- FK57M Blue Seal R20B 38p•
- FK58N Blue Seal PP3B 76p•
- FK60Q Silver Seal R14S 49p•
- FK61R Silver Seal R20S 57p•
- FK63T Gold Seal LR03 58p•
- FK64U Gold Seal LR6 58p•
- FK65V Gold Seal LR14 £1.05•
- FK66W Gold Seal LR20 £1.17•
- FK67X Gold Seal 6LF22 £2.19•

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- FK68Y Gen Purpose No.8 43p•
- FK69A Gen Purpose 1289 90p•
- YJ18U Gen Purpose PJ996 £2.65•
- YJ19V Gen Purpose 991 £7.49•
- YJ22Y Gen Purpose HP1 £11.99•
- YJ23A Gen Purpose HP992 £3.85•
- FK70M Gen Purpose 126 £2.35•
- FM02C Trans Pwr PP1 6V £1.89•
- FM03D Trans Pwr PP6 9V £1.59•
- FM04E Trans Pwr PP7 9V £1.59•
- FM05F Trans Pwr PP9 9V £1.59•
- FM13P Gold Seal LR1 60p•
- FM07H Photo Batt BLR121 £2.90•
- FM08J Photo Batt BLR122 £3.92•
- FM09K Photo Batt BLR154 £2.90•
- QY67X Photo-Test PX28 £3.50•
- FM14Q Merc Batt PX1/RMIN £1.26•
- FM18U Merc Batt PX/RM625 67p•
- FM20W Merc Batt PX675 56p•
- FM21X Merc Batt RM13H 37p•
- FM22Y Merc Batt BP401 £1.07•
- FM24B Merc Batt BP675 46p•

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- FM26D Zinc Air A675 68p•
- FM27E Zinc Air A13 64p•
- FM36P Silver Batt B-SR60L £1.10•
- FM33L Silver Batt B-SR58L £1.10•

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- FE09K Ni Cad AAA £1.80•

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- YG03D Ni-cad D 4000mAh £4.95•
- ★HW31J Nicad PP3 £5.95•
- YN28F AA Nicad Charger £3.50•

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- YN44X 13.8V 3A Reg PSU £13.95•
- FE62S Car Volt Conv 800mA £2.50•

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- FE54J DC/DC Conv +9V £7.40•
- FE55K DC/DC Conv +12V £7.40•
- FE56L DC/DC Conv +15V £7.98•
- FE57M DC/DC Conv -5V £7.40•
- FE58N DC/DC Conv -12V £7.40•
- FE59P DC/DC Conv -15V £7.40•
- FE60Q DC/DC Conv +/-12V £7.98•
- FE61R DC/DC Conv +/-15V £7.98•
- HF27E Clips PP9 28p•
- YX92A Dummy Battery 38p•
- XX33L PP3 Battery Holder £1.80•
- HY32K Large Batt Hldr £2.50•

BOOKS

Page 50
- RQ22Y Book NB245 £4.95 *NV*
- WA44X Undrstndng Auto Elec £13.50*NV*

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- WG11M Book JW748 £10.65 *NV*
- WK61R Electrnics for Techs £6.95 *NV*
- WP05F Pract Electronics £7.95 *NV*•
- WP07H Essentl Electronics £9.95 *NV*
- WP24B Telecom Circuits £13.50 *NV*

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- WP28F Data Communications £13.50 *NV*
- WM59P Linear Electronics £8.95 *NV*
- WG30H Book BP85 £3.50 *NV*
- RH35Q Book BP202 JAN88

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- WP39N Digital IC Equivlnts £5.95 *NV*
- WA11M TI Voltage Regulator DIS
- WP31J TI TTL Data Vol 2 £13.00 *NV*

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- RQ54J Z80 Data £4.80 *NV*
- WG23A Book JW568 £36.55 *NV*
- RR28F Book NB2028 £14.50 *NV*•

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- XW30H Cost Effectv Constrc £6.50 *NV*
- XW39N Book BP73 DIS
- XW66W Book BP79 DIS
- RL43W Book BP56 £2.50 *NV*•
- WG54J Book NB535 £4.95 *NV*•
- RB10L Book NB269 £6.95 *NV*

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- WG53H Book NB529 £4.95 *NV*•
- RH18U Book BP24 DIS
- LY04E Book BP44 £2.95 *NV*•
- XW38R Book NB480 £6.95*NV*•
- RB24B Book BP244 JAN88
- RL44X Book BP58 NOV87

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- WP00A Fib Op Laser Handbk £15.30 *NV*
- WP51F Audio Projects £7.50 *NV*

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- WG82D Book FT1364 £9.65 *NV*
- WP21X Hi Perfmnce L/Spkrs £16.00 *NV*
- XW26D Book NB336 £12.95 *NV*•
- XW83E Book AG512 DIS
- XW09K Book NB391 £4.95 *NV*•

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- WG95D Book FT1305 £10.10 *NV*
- WP57M DX Power £9.00 *NV*
- WG80B Book FT1185 £8.90 *NV*
- XW43W Book NB467 £6.95 *NV*•
- XW88V Book AG569 £3.95 *NV*

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- WM86T Elect Servicing £8.95 *NV*
- WM88V Fault Diag Dig Syst £8.95 *NV*
- RH27E Book BP34 NOV87
- RL23A Book NB137 £11.95*NV*
- WM99H Satellite TV Guide £10.60 *NV*

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- WG24B Book HD165 £17.95 *NV*•
- XW15R Book NB813 DIS
- XW98G Book FT1070 £16.10 *NV*
- WK29G Simple Interface Bk DIS

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- WA41U Advanced 6502 I/Face DIS
- WA02C Book MM495 £9.50 *NV*
- WM26D Disc Drives DIS

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- WM76H Programming M68000 £12.95 *NV*
- XW71N Book M4 £20.95 *NV*•
- WK81C Z80 Machine Code DIS

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- WA64U Learn Pascal Frm Bsc DIS
- WK98G Exploring Forth DIS
- WG25C Book JW609 £8.45 *NV*

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- XW60Q Book HD752 DIS
- WK04E BBC Micro Book DIS
- WP23A BBC Micro ROM Book DIS
- WM97F Intro Prog Amstrad £2.50 *NV*
- WP32K Amstrad User Guide DIS

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- WA39N Book JW593 £9.00*NV*

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- WM84F Spectrum Astronomy DIS
- WM40T Master ZX Microdrive DIS
- WM73Q Lang of Dragon 6809 DIS
- WM36P Oric Atmos Mach Cde DIS

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- WP06G Assembly Language QL DIS
- WA32K VIC Revealed DIS
- WG92A Book FT1341 £13.35*NV*
- WM37S Und Contrl Auto Syst £13.50*NV*

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- FT31J Small Narrow Box 98p•

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- LH90X Smll Remote Cntrl Bx £2.95•
- YK24B Calc-Style Verobox £3.95•
- WY03D ABS Box 2002 £1.40•
- LH60Q ABS Box 2004 £1.70•
- LH61R ABS Box 2005 £1.95•
- LH62S ABS Box 2006 £3.50•
- LH68Y ABS Console M8005 £4.95•
- LH69A ABS Console M8007 TEMP•
- YR72P Pcb Guide Adaptor 8p•

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- YN30H ABS Console 2802 £9.95•
- WY00A Metal Panel Bx M4003 £1.80•
- WY01B Metal Panel Bx M4004 £2.20•
- WY02C Metal Panel Bx M4005 £2.80•
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- YN18U Small PSU Box £1.60•

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- YN32K Case 3501 £6.50•

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- YM90X Small Waterproof Box £1.85•
- YM91Y Medm Waterproof Box £2.80•
- YM92A Large Waterproof Box £7.95•
- LF08J Box AB7 £1.25•
- LF14D Box AB13 £1.95•
- XB71N Box AB15 £3.65•
- LF15R Box AB23 £1.60•
- LF16S Box AB24 £1.95•

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- LH70M Box DCM5002 £2.40•
- LH71N Box DCM5004 £3.30•
- LH72P Box DCM5007 £4.50•
- LH73Q Box DCM5005 £4.20•
- LH74R Box DCM5006 £6.30•
- YN49D Box CAN80 £2.60•
- YN50E Box CCN80 £3.80•
- YN51F Box CCN160 £5.95•
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- FE39N Sink 40 80p•
- XR93B Rubber Foot £1.40•

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- XG84F 19" Rackmount 89 hgt £26.95•
- XG85G 19" Rackmount 133Hgt £29.95•
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- FW19V Feet Cab 12p•
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UB57M 74HC240 98p●
UB58N 74HCT240 98p●
UB59P 74HC241 98p●
UB60Q 74HCT241 £1.80
UB61R 74HC242 98p
UB62S 74HCT242 £1.80
UB63T 74HC243 98p
UB64U 74HCT243 £1.80
UB65V 74HC244 85p●
UB66W 74HCT244 £1.80
UH83E 74AC245 £1.95●
UB67X 74HC245 £1.10●
UB68Y 74HCT245 £1.10●
UB69A 74HC257 90p
UB70M 74HC259 £1.80
UB71N 74HC266 80p
UB72P 74HC273 98p●
UB73Q 74HC283 85p●
UB75S 74HC352 98p
UB76H 74HC354 £2.80
UB77J 74HC356 £3.00
UB78K 74HC365 98p
UB79L 74HC367 98p
UB81C 74HCT373 98p●
UB82D 74HC374 98p●
UB83E 74HCT374 98p●
UB85G 74HC393 80p
UB86T 74HC490 £2.40
UB87U 74HC533 £1.20●
UB89W 74HC534 £1.80
UB90X 74HCT534 £1.40
UB94C 74HCT541 98p
UB96E 74HC643 £1.80
UB97F 74HC4002 28p●
UB98G 74HC4016 35p
UB99H 74HC4017 80p
UF00A 74HC4020 80p●
UF02C 74HC4040 80p
UF03D 74HC4046 £1.95●
UF05F 74HC4050 58p●
UF06G 74HC4051 60p●
UF07H 74HC4052 60p●
UF09K 74HC4060 85p●
UF10L 74HC4066 35p
UF11M 74HC4075 30p●
UF12N 74HC4078 30p●
UF13P 74HC4316 £1.80
UF15R 74HC4352 DIS●
★UF17T 74HC4511 98p●
UF18U 74HC4514 £1.50
UF19V 74HC4538 60p
UH45Y 74HC4543 £1.80●
YH38R 8038 CCPD £6.50●
YH45Y 8216 £2.95

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YF03D 74LS03 28p●
UB02C 74HC03 48p
UB08J 74HC10 48p

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UB11M 74HC20 48p
UB30H 74HC133 28p
UB06G 74HC08 30p●
YF13P 74LS15 32p

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UB97F 74HC4002 28p●
UB13P 74HC27 48p
UF12N 74HC4078 30p●
UB15R 74HC32 48p

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UF11M 74HC4075 30p●
UB23A 74HC86 42p●
UB71N 74HC266 80p

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UB29G 74HC132 64p●
UB10L 74HC14 60p●

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UB03D 74HC04 28p
UB04E 74HCU04 28p●
UB78K 74HC365 98p
UB79L 74HC367 98p
UF05F 74HC4050 58p●
UB27E 74HC125 98p
UB28F 74HC126 48p●

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UB61R 74HC242 98p
UB62S 74HCT242 £1.80
UB63T 74HC243 98p
UB64U 74HCT243 £1.80
UB57M 74HC240 98p●
UB58N 74HCT240 98p●
UB59P 74HC241 98p●
UB60Q 74HCT241 £1.80
UB65V 74HC244 85p●
UB66W 74HCT244 £1.80
UB94C 74HCT541 98p
UH83E 74AC245 £1.95●
UB67X 74HC245 £1.10●
UB68Y 74HCT245 £1.10●
UB96E 74HC643 £1.80

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UB19V 74HC74 35p
UB45Y 74HC175 90p
UB44X 74HC174 90p●

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UB72P 74HC273 98p●
UB82D 74HC374 98p●
UB83E 74HCT374 98p●
UB89W 74HC534 £1.80
UB90X 74HCT534 £1.40
UB18U 74HC73 60p
UB21X 74HC76 58p
UB24B 74HC107 58p

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UB81C 74HCT373 98p●
UB87U 74HC533 £1.20●
UB70M 74HC259 £1.80

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UB51F 74HC195 98p
UB43W 74HC164 85p●

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UB46A 74HC190 90p●
UB48C 74HC192 £1.40
UB86T 74HC490 £2.40
UB99H 74HC4017 80p
UB41U 74HC161 85p●
UB42V 74HC163 60p
UB47B 74HC191 65p●
UB49D 74HC193 98p●
UB85G 74HC393 80p

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UF00A 74HC4020 80p●
UF02C 74HC4040 80p
UF09K 74HC4060 85p●

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UB35Q 74HC139 60p●
UB31J 74HC137 60p
UB32K 74HCT137 65p
UB33L 74HC138 65p
UB34M 74HCT138 £1.20
UB53H 74HC237 98p
UB54J 74HCT237 98p
UB55K 74HC238 50p
UB56L 74HCT238 70p
UB17T 74HC42 68p●

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UB38R 74HC154 £1.40
UF18U 74HC4514 £1.50
★UF17T 74HC4511 98p●
UH45Y 74HC4543 £1.80●

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UB39N 74HC157 60p●
UB40T 74HC158 78p
UB69A 74HC257 90p
UB37S 74HC153 98p
UB75S 74HC352 98p
UB36P 74HC151 65p●
UB76H 74HC354 £2.80
UB77J 74HC356 £3.00

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UF06G 74HC4051 60p●
UF07H 74HC4052 60p●
UF15R 74HC4352 DIS●

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UB98G 74HC4016 35p
UF10L 74HC4066 35p
UF13P 74HC4316 £1.80

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UB22Y 74HC85 85p●
UB73Q 74HC283 85p●

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WH00A 74122 80p●
UB26D 74HC123 60p
UB52G 74HC221 80p●
UF19V 74HC4538 60p

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UF03D 74HC4046 £1.95●
QH36P LM301A 45p●

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RA74R OP-27GNB £5.30●
QL22Y uA741C 8-pin DIL 25p

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QL25C uA748C 45p●
QH29G CA3140E 65p●
WQ21X CA3240E £1.40●

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RA70M TL081CP 52p●
YH58N CA3080E 80p●

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UH32K LM392 £1.50●
UH30H LM393 60p●

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QH38R LM377 £3.40●

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QH40T LM380 £1.10●
WQ34M LM384 £2.80●

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QH41U LM381 £2.20●

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UH57M DG211 £2.80●

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QY35Q MF10CN £3.95●

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YY81C M083 £5.95●
HQ51F AY-1-5050 £2.95●
HQ71N M251 £19.95●
WH21X M254 £11.95●

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YH86T M112 £29.95●

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- YY90X M108 £14.95●
- YY91Y M147 £9.95●

Page 351
- YY89W AY-3-1350 £4.50●
- WH20W TDA1022 DIS

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- RA90X AY-3-8912 £5.50●
- QY50E SP0256 £5.95●

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- QH45Y MC1310P £1.98●

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- QY61R ZN415E £1.70●

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- YH67X ML922 £5.50●
- QR57M ML926 £3.95
- QR58N ML927 £3.95

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- WQ55K NE 544 £2.80●

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- WQ75S TL170C 98p●

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- UH62S CS2012 DIS
- UH37S MPX100AP £13.95●

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- YY94C ICM7216DIPI £26.95●
- WQ56L NE 565 £1.50●

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- WQ39N LM3909 £1.50

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- QY36P LM1851N DIS

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- RA82D REF-01CT £4.98●
- RA84F REF-03CNB £2.70●
- WQ32K LM334 £1.60●

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- QQ02C 6502A £4.95●
- WQ44X MC6802P £4.50●
- WQ46A MC6821P £1.98●

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- UF25C 6522 VIA £6.50●
- WQ48C MC6850P £2.20●

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- WQ18U AY-3-1015D £3.70●

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- QQ03D MC6845 £9.95●
- YH45Y 8216 £2.95

Page 379
- ★FD92A MAX232C £7.50●

Page 380
- UF34M 6264 - 150ns £4.95●

Page 381
- QQ07H 2716 450ns £3.95●
- QQ08J 2732 350ns £5.95
- ★YH88V 27128 250ns £4.45●

Page 382
- FK48C Softy 2 Adaptor DIS●

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- YH38R 8038 CCPD £6.50●
- YH93B AM7910 £17.95●

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- UF46A ADC0831CCN £4.95●

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- UF47B DAC0832LCN £4.98●

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- UF39N ZN426E-8 £2.80●
- UF40T ZN427E-8 £8.95●
- UF41U ZN428E-8 £6.50●
- UF43W ZN448E £8.50●

Page 388
- WQ38R LM2917 £3.80●

Page 392
- FL42V Flat Heatsink £3.95
- FL79L Silicone Grease 10ml £1.65●
- HQ00A Silicone Grease Tube 80p●

SPEAKERS & SOUNDERS

Page 393
- HY12N Ultrasonic Transducr £4.95●
- FM59P Min Piezo Sounder 78p

Page 394
- FL38R AC Bell £3.50
- FL37S Bell Xformer £7.95●
- YK85G 12v Dome Bell TEMP

Page 395
- WF54J Direct Radiant Piezo £5.95●

Page 396
- LB23A Mag Earpiece 2.5mm 48p●
- LB24B Mag Earpiece 3.5mm 48p●
- FE73Q Earphone 4 Metre 60p●
- LB25C Crystal Earpiece 80p●
- YJ85G Stereo Mic Hdphone £19.95
- YM38R Low-cost Stereophone £5.95
- YM39N Adjustble Sterophone £6.95
- YM40T InnerEar Stereophone £7.95●
- YM41U SC Stereophone £8.95●
- YM42V SC Adjust Sterophone £9.95●

Page 397
- LB13P Headphone Adaptor £3.95●
- FM39N 3-Way H/Phone Adapt £5.95
- WF33L Free Stand Tweeter DIS●
- YJ01B Tweeter 50W 8R £22.95●

Page 398
- YJ02C Tweeter 70W 8R £26.95●
- YJ03D Crossover HPX2 £7.50●
- WF02C Crossover 2-Way £4.95●
- WF03D Crossover 3-Way £5.95●
- WF47B Low-Cost 4in Spkr 4R £2.50●
- YJ16S Low Cost 4in Spkr 8R £2.50●

Page 399
- WF23A Elliptcal Spkr CM852 DIS●
- WF12N Hi-Fi Spkr 50W 8inch £10.95●
- YN47B Hi-Fi Spkr 50W 8" EB £11.95

Page 400
- YN43W Hi-Fi Dome Tweeter £8.50●
- XG39N Speaker 5in 50W 8R £21.95
- XG40T Speaker 5in 50W 16R £21.95
- XG41U Speaker 8in 50W 8R £26.95

Page 401
- XG43W Speaker 8in 100W 8R £34.95
- XG44X Spkr 10in 50W TC 8R £29.95
- XG46A Spkr 10in 100W GP 8R £34.95
- XG47B Spkr 12in 50W GP 8R £29.95
- XG48C Spkr 12in 50W GP 16R £29.95
- XG49D Spkr 12in 100W GP 8R £34.95
- XG50E Spkr 12in 100W TC 8R £39.95
- XG51F Spkr 12in 100W TC16R £39.95

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- XG52G Spkr 15in 100W 8R £47.95
- XG53H Spkr 15in 200W 8R £64.95
- XG54J Spkr 18in 300W 8R £99.95
- AF33L Mini Speaker System DIS
- XY79L Ceiling Speaker £11.95●

Page 403
- YL15R 5kg Wallbracket DIS
- YL16S 25kg Wallbracket DIS

SWITCHES & RELAYS

Page 404
- FH97F SPST Ultra Min Toggle 88p●
- FH98G SPDT Ultra Min Tggle 98p●
- FH99H DPDT Ultra Min Toggle £1.50●
- FH00A Sub-Min Toggle A 80p●
- FH01B Sub-Min Toggle B 90p●
- FH02C Sub-Min Toggle C £1.40●
- FH03D Sub-Min Toggle D £1.20●
- FH04E Sub-Min Toggle E £1.20
- FF71N Sub-Min Toggle K £1.80●
- FH05F Sub-Min Toggle F £1.35●
- FH07H Sub-Min Toggle H £1.85●
- FH08J 4-Pole SM Toggle £2.20
- FA73Q R/A Tggl DPDT Lft/Rt £1.80●

Page 405
- FH17T H/D Toggle DPST Chrm £2.95

Page 406
- FF73Q Rotary SW12B 80p
- FF74R Rotary SW6B 80p
- FF75S Rotary SW4B 80p
- FF76H Rotary SW3B 80p
- FH42V Rotary SW12 80p
- FH43W Rotary SW6 80p
- FH44X Rotary SW4 80p
- FH45Y Rotary SW3 80p
- FT56L PCB R/A Rotary 1x12 £2.70
- FT57M PCB R/A Rotary 4x2 £2.70
- FT58N PCB R/A Rotary 2x5 £2.70
- FT59P PCB R/A Rotary 3x3 £2.70

Page 409
- RK82D Lge Red Push Button 78p
- YW41U Square Psh Lck Black £1.20
- YW43W Square Psh Lck Red £1.20

Page 410
- UF59P 6V Lamp + Holder 80p
- UF60Q 12V Lamp + Holder 80p
- UF61R 28V Lamp + Holder 98p
- FF87U Click Switch 32p●

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- UH58N Mod Sw Button Red 12p
- UH74R Mod Sw Button Grey 12p
- UH75S Mod Sw Button Blue 12p
- FP53H Mod Sw Plain Bezel 12p
- FP54J Mod Sw LED Bezel 12p
- FF61R Keyboard Switch 35p●

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- BW15R Latchbush Blue DIS
- LQ00A Beginners Morse Key £2.50
- LQ01B Professl Morse Key £5.95

Page 414
- YR89W Solenoid 240V AC £8.95●

Page 415
- FJ42V Min 6V 6A Relay £2.95●
- FJ43W Min 12V 6A Relay £2.95●
- FX23A Open Relay 6V £2.98
- FX24B Open Relay 12V £2.98
- FX26D 2p Sub-Min Relay 6V £4.50●
- FX27E 2p Sub-Min Relay 12V £4.50●
- FX30H 4p Sub-Min Relay 12V £4.50●

Page 416
- HY20W Relay Flat 12V £2.50●
- FX89W Dil Reed Relay 1p12V £2.50●

TEST GEAR

Page 418
- FA96E S-Min Probe Clip Set £3.95

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- FK21X 4mm Test Lead Kit £3.80●

Page 428
- YJ89W Fluke 77 Multimeter £129.95●
- YK79L Fluke Meter Case £12.95●

Page 430
- YK38R Low-Cost Counter £84.95●
- YK01B RF Frequency Meter DIS
- YJ82D MF100 Freq Counter £119.95

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- XG94C Hobby RF Sig Gen £79.95●

Page 433
- ‡XB82D Crotech 3031 £239.95
- ‡XB83E Crotech 3132 £339.95

Page 434
- XG90X Bench PSU 3A 30V £84.95●
- XG95D Bench PSU Dual 3A30V £134.95●
- YB21X Quick Mains Connectr £8.95

TOOLS

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- XJ00A Service Box £6.95
- XJ02C Insert Tray 14 £3.50●
- XJ01B Insert Tray 10 £3.50●
- XJ03D Transbox £5.50●
- XJ04E Organiser Box £5.50●
- FP55K Dividers W Pk of 12 80p
- XJ05F Multibox £6.95●

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- FP55K Dividers W Pk of 12 80p
- FP56L Dividers A Pk of 12 80p
- BR49D Preset Trimmer 80p
- BK44X 11 Pce S/Driver Set £5.95

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- YJ26D Universal Driver Set £6.95
- BR52G L/Duty Driver 75mm 30p
- FY10L Gen/Purp Driver 75mm £1.20
- FY12N Gen/Purp Drivr 150mm £1.50
- FV47B Robust Screwdriver £1.98
- BK35Q Screw Grip Driver £1.50
- BK36P Flex Driver £2.50
- FV49D Crosspoint Driver 0 98p
- FV50E Crosspoint Driver 1 £1.20
- FV51F Crosspoint Driver 2 £1.60

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- BK37S Crosspoint Grip Drvr £1.50
- BK38R Crosspoint Flex Drvr £2.50
- FT54J Size 0 Pozidriver £1.80
- FY15R Size 1 Pozidriver £2.20
- FY17T Size 2 Pozidriver £2.40
- BR71N Mains Tester 80p
- FY19V Min Lap-joint Cutter £7.95
- BR75S Min Box-joint Cutter £10.95
- BK42V Min Slant Edge Cuttr £10.95
- FG12N Min End Cutter £10.95
- FY21X Std Lap-joint Cutter £3.50
- BR74R Std Stripper Cutter £6.95
- BR72P Heavy Duty Cutter £8.50
- FY22Y Std Slant Edge Cuttr £10.95

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- YW67X Nylon Tweezers 40p
- FA65V Steel Tweezers 60p
- BK43W Pearl Catcher £2.40
- FV55K Min Lap Jt Pliers £6.95
- FV54J Min Long Nose Pliers £10.95
- BR77J Std Lap Jt Plier £4.95
- FY27E Heavy Duty Pliers £4.95
- BR92A H/Duty Combntn Plier £5.95
- BR91Y Electricians Pliers £5.95

Page 440
- BR76H End Action Strippers £8.95
- BR94C Wire Strippers 88 £2.48
- BR96E Singl Action Strippr £12.95
- BR97F Blade L5361 £8.95
- YK52G Helping Hands £4.95●

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- FA00A Telscpic Insp Mirror £10.95●
- YJ90X Antistatic Workmat £12.95●
- FY37S Min Spanner 68 £1.60
- FA66W Metric Spanner Set £6.95●
- FY39N Ring Spanner 46 £2.50
- FY45Y Adjust Spanner 150 £4.95●
- FY46A Adjust Spanner 200 £5.95●

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- FY40T Box Spanner 2BA £1.50
- FV56L Box Spanner M5 £1.50
- FY41U Box Spanner M4 £1.50
- FV57M Box Spanner M3 £1.50
- FY42V Box Spanner M2.5 £1.50
- FY43W Box Spanner 8BA £1.50
- YM32K 39-piece Socket Set £15.95●
- YM33L 52-piece Socket Set £34.95●
- FY49D Needle File Flat Wrd DIS
- FY50E Needle File Hand DIS
- FY51F Needle File Halfrnd £2.20
- FY52G Needle File Round £2.20
- FA67X Centre Punch 80p
- FA68Y Tacking Hammer £3.50●

Page 443
- FY02C Utility Knife £1.95●
- FY03D Retractable Knife £2.50
- FY04E Knife Blades 80p●
- YK27E Chassis Punch Set £19.95●
- FG09K Hand Nibbler £11.95●
- FG10L Nibbler Spare Blade £5.95
- FY53H Mini Vice £4.95●
- YJ83E 2 Inch Vice £8.95●
- YJ84F 3 Inch Vice £15.95●
- FT76H Mini G Clamp Set £4.95●

Page 444
- FV58N Spiral Hand Drill £9.95●
- YN56L Hand Drill £11.95●
- XB12N Drill Stand £15.95●

Page 445
- LH77J 20-Piece Tool Kit £8.95●
- LH78K 40-Piece Tool Kit £15.95●
- FV67X Masonry Drill 3/8 £1.20
- FM97F HSS Drill Set £7.95●
- FT75S 12" Stainls Stl Rule £3.50●

Page 448
- FR23A Sucksolder £4.50
- FV59P Sucksolder Tiplet £2.20
- FR26D Desolder Tool £4.95
- FM88V Desolder Nozzle 4 £1.20
- BK39N Desolder nozzle 3 £1.20
- BK40T Replacement O rings 80p
- FR29G Solda-Mop 80p●

Page 449
- FR21X Solder 22swg 10m pk 88p
- YJ92A 18 swg Solder Reel £9.95●
- FY70M 22 swg Solder Reel £10.95●
- YP01B Pipemaster 240V £39.95●
- FP36P Pipemastr 15mm Heads £9.95
- FP37S Pipemastr 22mm Heads £9.95●
- FP38R Pipemastr 240V Elemnt £17.95
- YM86T Nickel Screen Spray £7.95●
- LH03D Switch Cleaner £2.40●
- FM77J Switch Cleaner Pen £1.20●
- FM78K Contact Lubricant £2.98●
- YM37S Contact Grease £2.98●

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- LH04E Freezer Spray £2.20●
- LH02C Degreasing Spray £2.20●
- YB73Q Spray Duster £3.20●
- YB74R Silicone Grease £2.20●
- YB76H Foam Cleanser £1.40●
- YK91Y Safeclens £3.40
- YJ47B Permagard £1.98

Page 451
- YJ44X Aerosol Mech Oil £2.40
- FM80B Tube of Grease 80p●
- YJ91Y Flex Rubber Sealant £2.95●
- YJ48C Plastic Gloves 48p●
- FL43W Impact Adhesive 98p

WOUND COMPONENTS

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- LB41U Dust Core Type 4 24p●
- LB36P Screening Can 10 18p●
- LB39N Screening Can 15 20p●
- HX09K Type 3 Core £2.40●

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- HX11M Type 3 Clips 8p●
- HX12N Large Pot Core £1.95●
- HW25C GE Coil L12 £3.95●
- HW26D GE Coil L11 £3.95●
- LR07H Filter Pot Core £3.30●
- FQ91Y Suppressor Choke DIS
- HX15R Choke 1.5mH DIS
- WH25C Choke 0.22uH 35p
- WH27E Choke 0.47uH 35p
- WH29G Choke 1.0uH 35p
- WH30H Choke 1.5uH 35p
- WH31J Choke 2.2uH 35p
- WH32K Choke 3.3uH 35p
- WH33L Choke 4.7uH 35p
- WH34M Choke 6.8uH 35p
- WH35Q Choke 10.0uH 35p
- WH36P Choke 15.0uH 35p
- WH37S Choke 22.0uH 35p
- WH39N Choke 47.0uH 35p
- WH41U Choke 100uH 35p
- WH45Y Choke 470uH 35p
- WH47B Choke 1mH 35p

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- LB05F IFT 18 £2.50●
- FD23A Mic Xfmr 600/20 £4.95

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- LR06G Mc Xfm Typ2 200-600R £14.95
- YX84F Z Changer £5.95●
- HX81C Pulse Transformer £2.35
- YJ60Q Line Trans 30W £8.95
- YN12N Sub-Min Tr 3V £1.45
- WB01B Sub-Min Tr 9V £1.70
- WB02C Sub-Min Tr 12V £1.70
- YN13P Sub-Min Tr 15V £1.85

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- YJ50E Min Tr 0-6 0-6 1A £4.70
- WB11M Min Tr 9V £4.45
- YK28F Tr 12V 0.5A £4.70
- ★LY03D Tr 10VA 15V £3.60
- ★WB15R Min Tr 15V £4.50
- WB16S Min Tr 20V £3.10
- YJ52G PCB Tr 0-6 0-6 0.5A £3.95
- YJ53H PCB Tr 0-9 0-9 0.3A £3.95
- YJ54J PCB Tr 0-12 x 2 .25A £3.95
- YJ55K PCB Tr 0-15 x 2 0.2A £3.95
- WB22Y Tr 34V HP £7.95
- XG29G Inverter Transformer £19.95
- WB03D Tr 9V 1.1/2A £5.95
- WB12N Tr 20V 1A £7.95
- WB17T Tr 28V 1.1/2A £9.95
- YK02C Tr 32-0-32 2A £12.95
- XB38R TR 32032/6.1/2A £27.95

Page 458
- LW34M 15/22V Power Tran £13.95●
- LW33L Tr 240V Isotran £4.95
- YJ56L Auto Tr 50VA £9.95
- YJ57M Auto Tr 100VA £13.95●
- YM50E 100VA US Mains Trans £15.95●
- YJ58N Auto Tr 150VA £19.95
- YJ59P Auto Tr 250VA £24.95
- YK08J Toroidal 30VA 6V £9.95
- YK09K Toroidal 30VA 9V £9.95
- YK10L Toroidal 30VA 12V £9.95
- YK11M Toroidal 30VA 15V £9.95
- YK12N Toroidal 30VA 18V £9.95
- YK14Q Toroidal 50VA 9V £10.95
- YK15R Toroidal 50VA 12V £10.95
- YK16S Toroidal 50VA 15V £10.95
- YK17T Toroidal 80VA 18V £11.95
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BIGGEST CIRCULATION IN THE U.K.

The Story of Radio

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

Part Eight- The Post War Years

On 7th May 1945, at 1405 hours, Count Schwrin von Krosigk, Germany's foreign minister, newly appointed by Grossadmiral Dönitz, Hitler's successor, broadcast a statement from Flensburg to the effect that, "Germany has surrendered unconditionally". The war in Europe was finally over. The radio industry, hitherto operating in top gear for the war effort, could now begin to think again in more peaceful terms.

On July 29th 1945, the BBC introduced the Light Programme to provide light entertainment for an audience that badly needed relaxation after six years of war. All war contracts to manufacturers were cancelled and new licences issued to some seventy manufacturers for the production of a million or so receivers over the twelve-month period commencing December 1945. There was, of course, no shortage of components or materials now. Of the first post-war sets made, it is interesting to note that 400,000 were intended for export, no doubt in an attempt to re-vitalise the economy.

On September 24th 1946, King George VI opened an exhibition at the Victoria & Albert Museum, called 'Britain Can Make It'. It was meant, naturally, as a morale booster, an incentive to British industry to get cracking on new ideas for the post-war world. The Radio Industry was represented by 25 receivers, but they were largely 1939 designs resurrected.

The coming of peace marked a dividing line between old and new technologies. The valve, which had contributed so much to the history of radio and electronics would now begin to dwindle in importance in the face of the growth of the new 'semiconductors'. In a similar way television, put into cold storage by the recent conflict, would soon push radio into second place as the prime form of home entertainment. In fact television transmissions began again on June 7th 1946, the broadcast licence fee having been raised the previous week from 10s (50p) to £1.

Transistors

However, valves and semiconductors had existed side by side for the better part of half a century. The first silicon crystal detector was patented in Britain in 1904, coincidentally the very year of Fleming's valve. The first carborundum detector was patented in the U.S.A. in 1906. Various other crystals followed in quick succession. In general the crystal detectors did little to excite the imagination. They could neither amplify nor oscillate, and the job that they

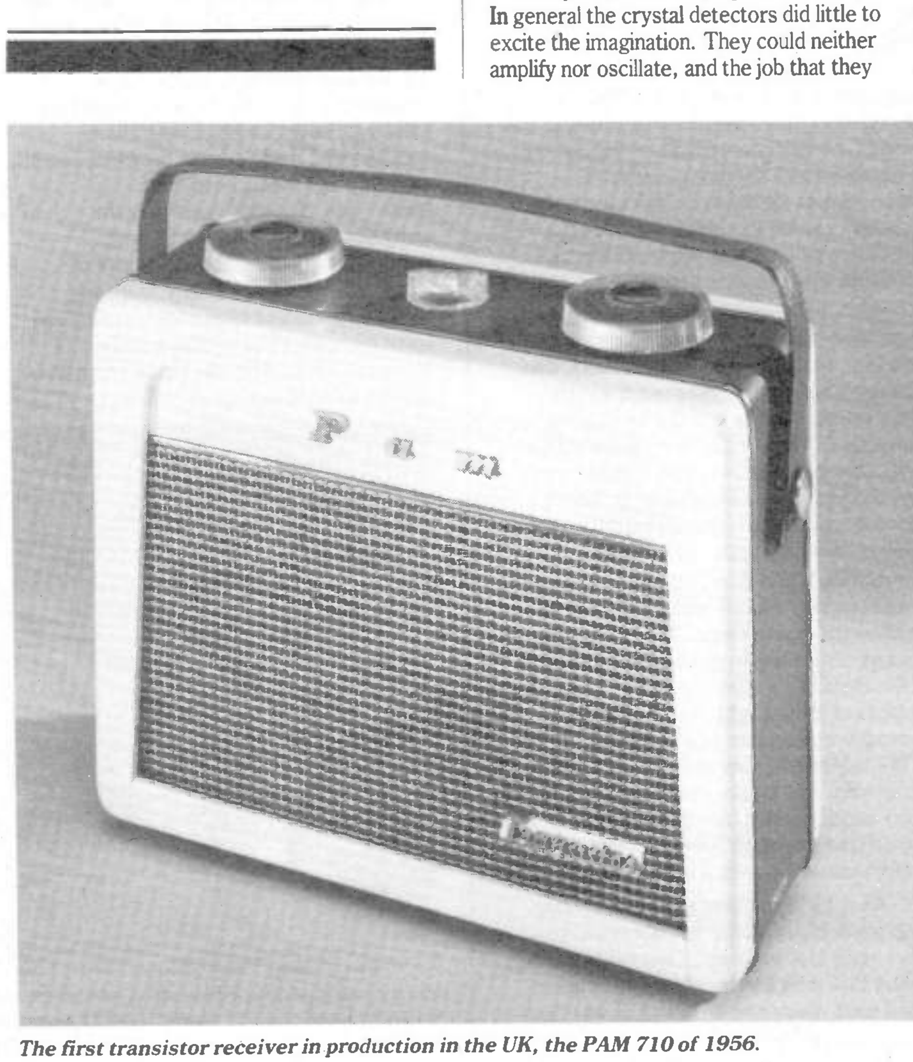


Photo courtesy of the Trustees of The Science Museum, London.

The first transistor receiver in production in the UK, the PAM 710 of 1956.

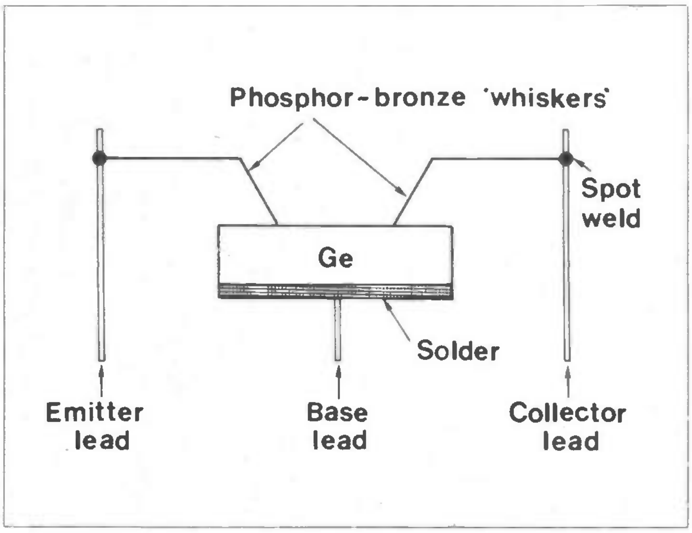


Figure 1. Construction of early point-contact transistor.

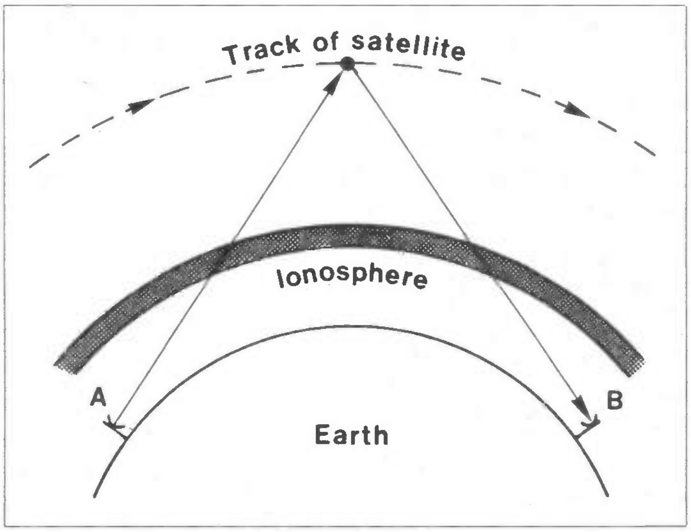


Figure 2. Effective 'line of sight' communication between two points, A and B, on the Earth's surface via orbiting satellite.

could do, detection or rectification, was often done by valves anyway. This was especially true in the field of communications.

In 1941 the semiconductor junction diode appeared, formed from the fusion of two crystals. On 23rd December 1947 the junction triode was born in the Bell Telephone Laboratories in the U.S.A. It could amplify and it could oscillate. It was called a 'transistor' (from transfer-resistor). Its discovery was an accident, made by a team of three men, whose names were, Bardeen, Brattain and Shockley. They were actually investigating an amplifying mechanism called the 'field effect' at the time. As with many new inventions, its likely role in the future was not fully appreciated. Why should it have been? It's always easy to be wise after the event. It was evidently a solid-state amplifier, but not one to compete with the thermionic valve, surely? But it did and more, because it was actually to sound the virtual death knell of the device on which the whole of radio and electronics had hitherto depended.

This first transistor was made of germanium (Ge) and was of a type now obsolete, the 'point-contact transistor'. The junction transistor followed and it was this new type that sparked off the 'semiconductor revolution'. Modern junction transistors are quite different in construction from the early types, which were either 'alloy' or 'grown' junction types. The construction of a point-contact transistor is shown in Figure 1.

During World War Two much development work had been carried out to improve the crystal diode. This may seem strange if it is thought of only in the context of the elementary crystal receiver. However, because of its small physical size, it was proving very useful as a detector and mixer at the high frequencies used in radar equipment. The crystal diode was itself, a point-contact device (cat's whisker and crystal), so it is hardly surprising that the first transistor was also a point-contact type.

As crude as the first transistors were, they obviously had a number of advantages. They were less bulky and consumed far less power than their thermionic counterparts. For a start, there was no heater; it was the heater-cathode assembly that consumed so much power, generated so much heat and invariably failed after a few thousand hours of operation. The transistor, by comparison, promised an unlimited life. Its small size ushered in the age of miniaturisation. One of the earliest commercial developments that it made possible was the personal, portable receiver, which quickly became universally known as the 'transistor radio', and with it the 'special' 9 volt 'transistor' batteries used to power it. The big mains-powered receivers in their polished wooden cabinets gradually began to disappear.

The early junction transistor made more of an impact in some fields than others. One field in which it failed to impress at first, was the computer field, where it was considered to be much too slow, bearing in mind that the device had to operate in common base mode even to be able to handle modestly high medium-wave RF frequencies. Nonetheless, wisely the computer industry kept an eye on its development because the failure rate of thermionic valves was so high that early computers suffered from poor reliability and spent more time 'down' than actually working! But, in 1958, the planar transistor, which combined high speed with high reliability, appeared on the scene. The computer people pounced on it and from then on it really took off. Within a year, Texas Instruments began talking about developmental 'integrated molecular devices'.

Now, almost thirty years on, the impact that integrated circuits have made in everyone's lives should be evident. The fundamental approach to the design of a wide range of electronic devices has changed from a 'circuit-orientated' one to a 'systems' one. In the field of radio and television, with which we are specifically concerned here, the impact has also been significant. Many former discrete functions have now been integrated into specific function chips. The systems approach mentioned has affected not only those who design the equipment but those who service it as well. One cannot help wondering what Guglielmo Marconi would have thought of it had he been alive today.

Television Thrives

As already stated, the coming of peace meant the re-emergence of television broadcasting. This brought with it a new phenomenon, the 'television party'. This would be given by the fortunate owner of a

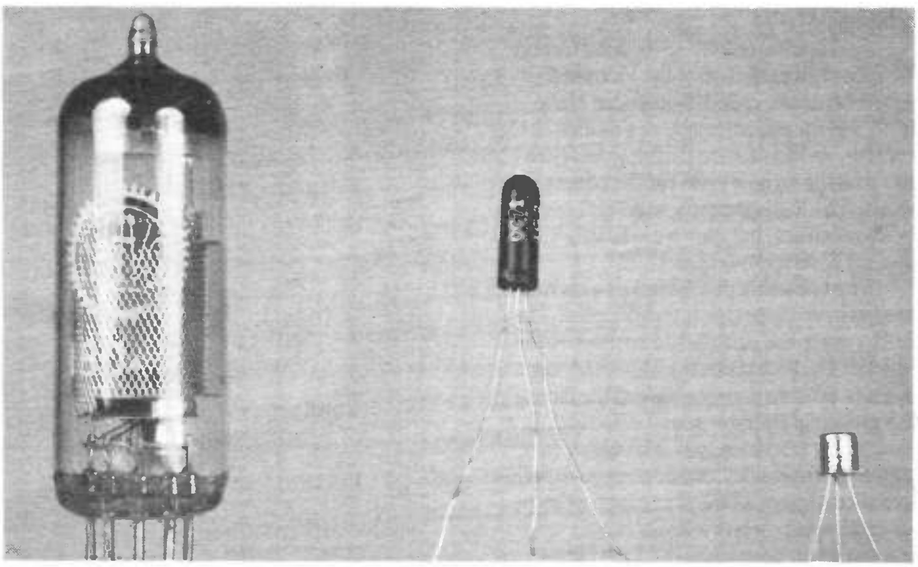


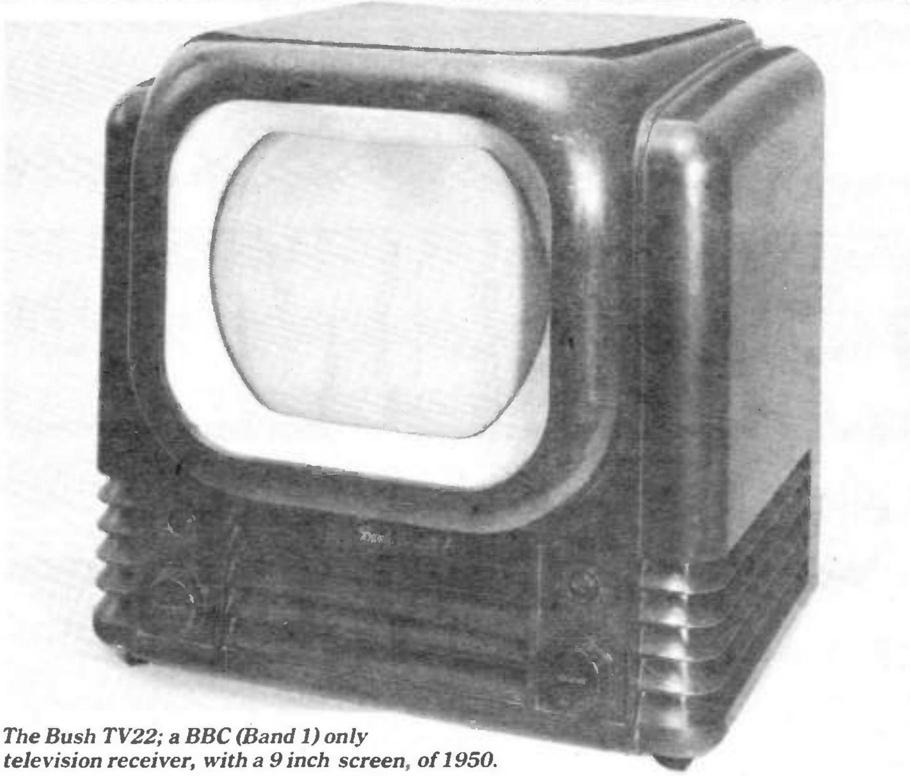
Photo copyright Graham Dixey.

Thirty years of development:- a miniature valve of the 1950s compared with the once popular Mullard OC71 (a germanium PNP device) and the Ferranti ZN414, a complete AM radio in a TO18 can.

television set (there weren't that many about at the time), for his neighbours and friends, and it comprised an evening with light refreshments with everyone sitting in a semi-circle peering at what was likely to have been about a 12 inch screen! But the new entertainment ousted other forms of home-made entertainment and was seen by some as a mixed blessing.

The growth of television as an entertainment medium was most impressive. In 1946 there were about one million receivers in use 'world wide'; by 1960 this figure had grown to 225 million. The televising of an important event could trigger off a demand for sets, as happened in 1953, when the coronation of Elizabeth II was televised.

The miniaturisation of components made possible the use of higher and higher frequencies. Television at this time used Band I (BBC) and Band III (ITV), both coming under the classification of VHF (Very High Frequencies, i.e. in the range 30-300MHz). However, the modern 625 line TV system operates in the UHF wavebands, at frequencies in excess of 470MHz.



The Bush TV22; a BBC (Band 1) only television receiver, with a 9 inch screen, of 1950.

FM Radio

One field where miniaturised radio equipment could obviously be applied was in the police force. Although some attempts (seen in a previous article) had been made in the 1930s to so equip them, the adoption had not been widespread and they continued to lack these vital communications. Development of relatively heavy VHF equipment began at the end of the war and continued for some years. There appears to have been little real progress for a long time after this, since there was still indecision over the specification when, in 1965, Pye pre-empted the whole situation by introducing their UHF Pocketphone. The experiments with VHF were then dropped.

However, there was a use of VHF that gave a boost to radio as an entertainment medium. This was FM, Frequency Modulation, especially since it allowed the transmission of stereo signals, although the initial advantage was that of a much superior sound quality compared with AM. Stereo reproduction of radio, disc and tape sources is taken very much for granted nowadays. However, only thirty years ago, many hi-fi systems were mono only, and having a stereo system (which one had probably built oneself) was definitely being one up on the 'Jones's'! But the advantage of FM radio, whether mono or stereo, as far as domestic use was concerned, was the possibility of a quality which could not be realised with medium or long wave broadcasting.

To back-track a bit, FM was put forward as a system of communication in the early days of radio, certainly before the 1920s. In 1925 a certain Major E.H. Armstrong, credited as being the pioneer of FM, began to take an interest in the idea. At first it was thought that small values of deviation would provide narrow-band FM, allowing stations to be spaced at 9kHz, as were the AM medium wave stations. However, it was soon appreciated that FM gave rise to many pairs of sidebands, especially at the low modulation frequencies. This made it impossible to use an FM system at the low carrier frequencies then in use. It was necessary to await the development of VHF operation before a practicable FM system could be realised. Experiments continued in the U.S.A. both before and during the Second World War, to the extent that it was actually used during the war for purposes of communication.

After the war the Americans adopted VHF FM domestically but things moved rather slower in Europe, where it was considered that an AM system could be developed to give the same quality. In Britain the problem was approached pragmatically and test transmissions were made from Wrotham in Kent. These tests compared directly the merits and demerits of the two systems, AM versus FM. As we know, FM won and was adopted as a means of high quality broadcasting; it is also used for UHF TV sound.

Radio from Space

It is a characteristic of radio waves that, when the wavelength is very short, the waves are not reflected back to Earth by the ionosphere but pass through it and travel on into space. This has the disadvantage that communication, of any sort, at frequencies from 'high VHF' upwards, has to be by line of sight, with repeaters if necessary, to allow the radio waves to bridge high ground, such as ranges of hills, or travel beyond the horizon. On the credit side, it means that radio waves can be directed out into space to control satellites, space probes, etc. A satellite orbiting the Earth (Figure 2) can be used to re-transmit signals from one location on the Earth's surface across vast distances to another location, a feat made possible by the two 'line of sight' links, transmitter to satellite, satellite to receiver. Signals that are handled in this way include high-quality speech and television pictures, thus making it possible for live broadcasts of significant events to be made available to a world-wide audience.

The first communications satellite was named Telstar 1 and was launched from an American base on the 10th July, 1962. Spherical in shape and 34.5 inches in diameter, Telstar weighed 170lb, contained 16,000 parts and was powered by a battery, which was kept charged by 3,600 solar cells. It orbited the earth at a height of about 100 miles.

Immediately after its launch an attempt was made to communicate using the satellite. This was not successful but, by evening of that day, events turned out better when the American President, John F. Kennedy, and other officials were able to transmit a message from Washington D.C. across to Goonhilly Down in Cornwall. There was also a transmission to France. During the evening of the same day a successful transmission was made in the opposite direction.

The low orbiting height of 100 miles of Telstar 1 raised certain problems. The rate of orbit was out of step with the rate of rotation of the Earth. Consequently, communication via the satellite could only take place at certain times, when the satellite occupied the correct position relative to both transmitter and receiver. The problem was solved by placing the next satellite into a much higher orbit, at a height of 2,300 miles, at which altitude it followed the Earth's rate of rotation perfectly.

Radio has played an important role in the, so far, short history of space exploration, in controlling the functions of in-space vehicles from the ground, in maintaining communications between manned space vehicles and base and in telemetering information back to Earth from distant space probes. For now it is worth remembering those often quoted words that came back to us out of space when man first landed on the moon on 20th July 1969. The first words that listeners on Earth heard the American astronaut, Neil Armstrong, say on that historic occasion were, "Contact light on, engine off, the Eagle has landed."

FRAME STORE

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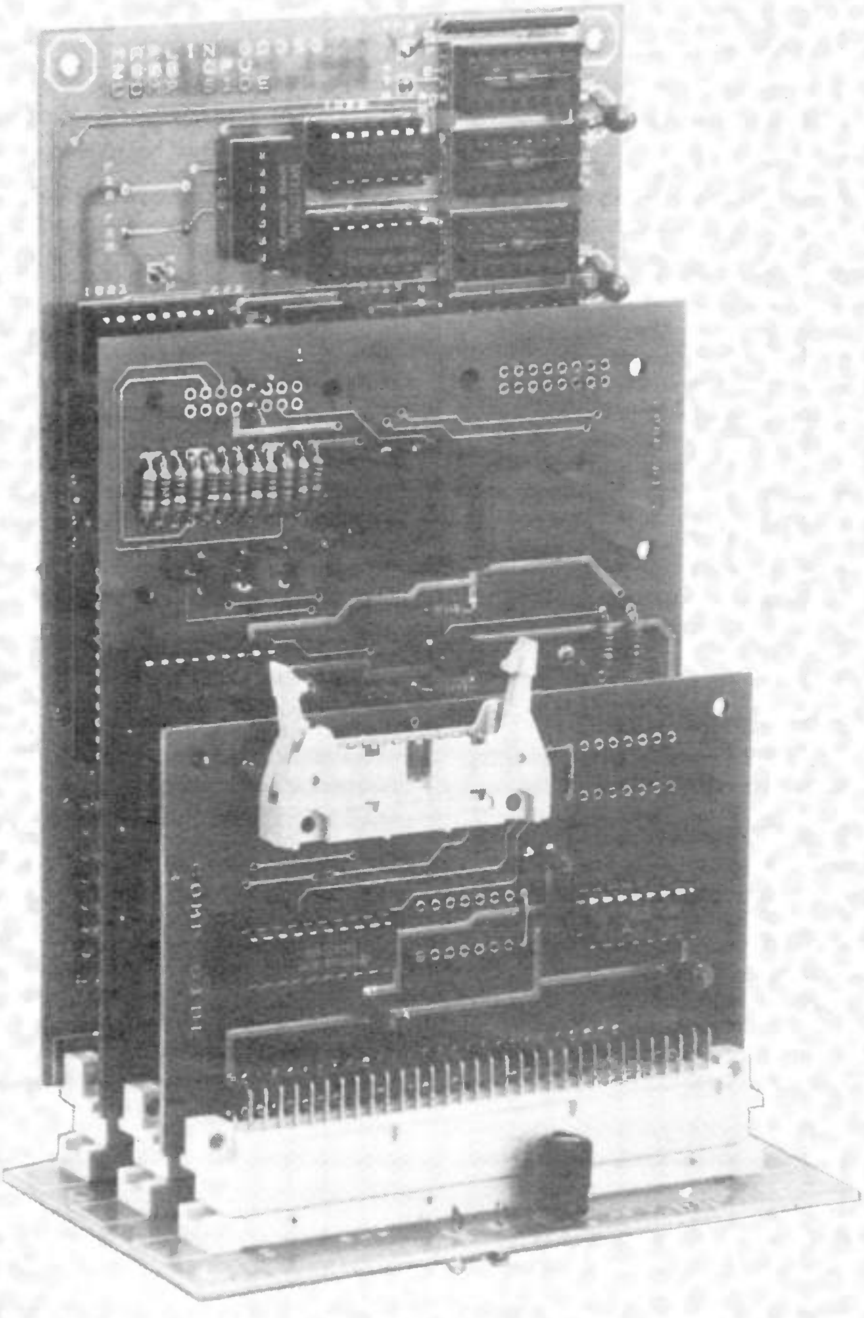
by Mark Brighton



The first part of this episode will describe a video graphics board for use with the Z80B CPU card described in the previous issue of this magazine and will explain in some detail the facilities available and potential applications of the video processor used in the design.

The remainder of the article deals with the additional circuitry necessary to complete the first of our applications for this system, the WEFAX Frame Store.

High Resolution Graphics Card

The circuit shown in Figure 1 is built around the V9938 video processor developed by Yamaha and Microsoft for the Yamaha MSX computer. This device is located within the I/O map of the Z80B card by fitting one of the links 0-7, addresses as Table 1. IC1b and IC1c gate the WRITE and READ lines with the I/O block selected to the V9938 (IC2). The Z80 A0 and A1 address lines are connected to pins 29 and 28 on IC2, splitting the I/O block selected into four effective addresses (ports) to the V9938. All data transfers between the CPU and V9938 are passed via four port addresses from the viewpoint of the CPU although there are 47 internal register addresses and 128K of RAM addresses from the viewpoint of the V9938, all data being 'pipelined' through the four CPU addresses as described later.

IC3, 4, 5 and 6 are 64K x 4 DRAMs, arranged to form a 128K x 8 block of RAM. This memory is used to store all screen images (up to 32 pages for text or pattern graphic modes and between 2 and 4 pages for bit-mapped graphics modes), character sets, and sprite graphics (if used). IC2 has a separate address and data bus for connection

I/O LINK	BASE ADDRESS
0	$0000
1	$0020
2	$0040
3	$0060
4	$0080
5	$00A0
6	$00C0
*7	$00E0

* Also used for DRAM block switching on CPU board where 256K RAM has been fitted.

Table 1. I/O block addresses.

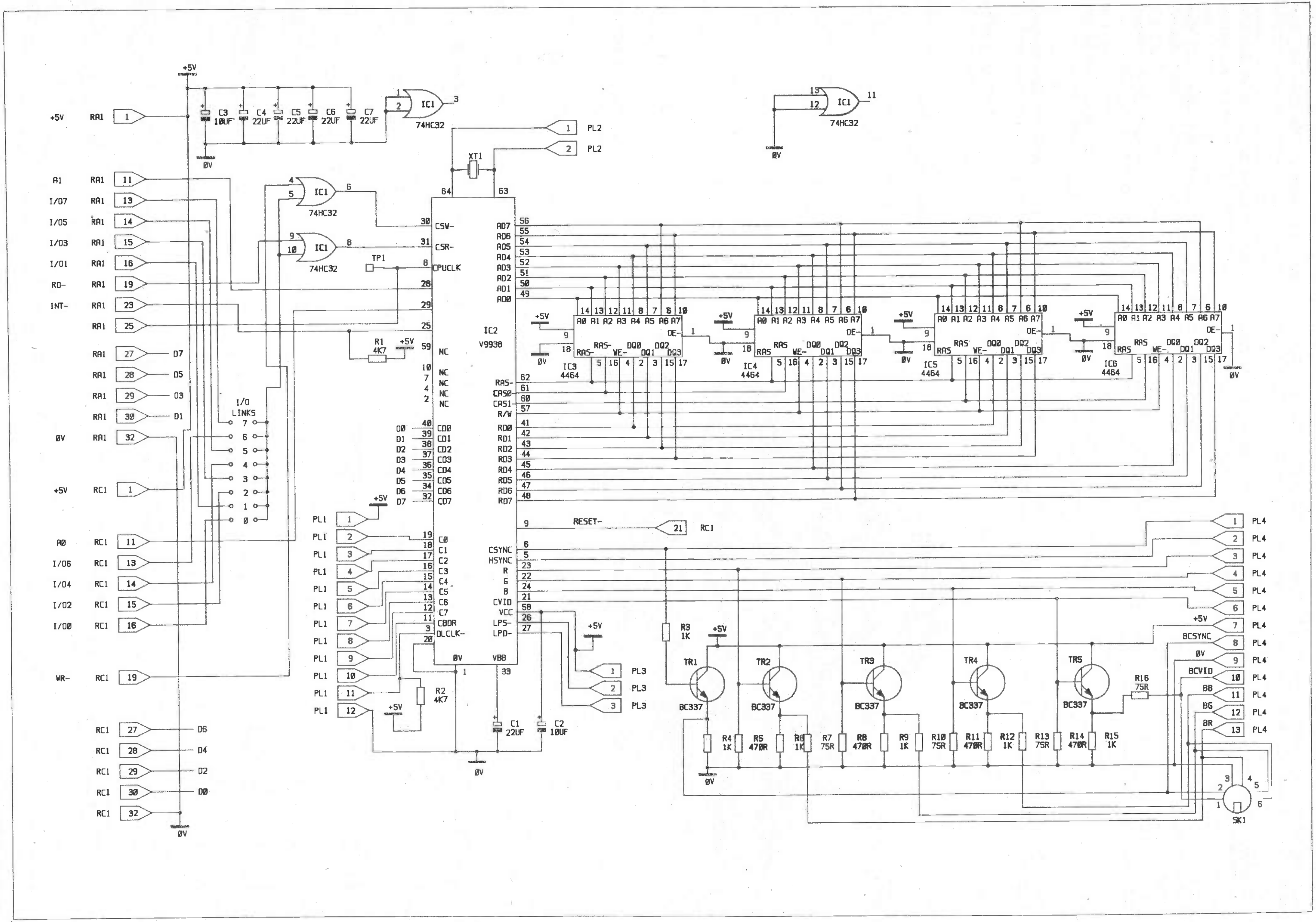


Figure 1. High Res circuit.

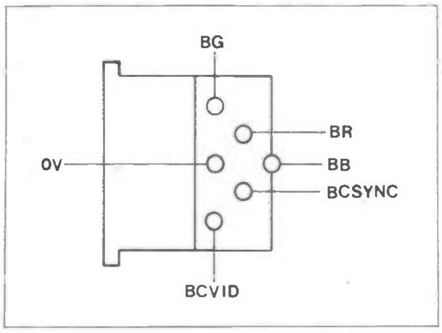


Figure 2. SK1 pinout.

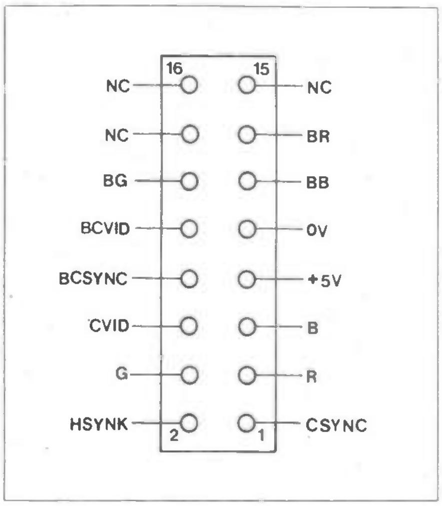


Figure 3. PL4 pinout.

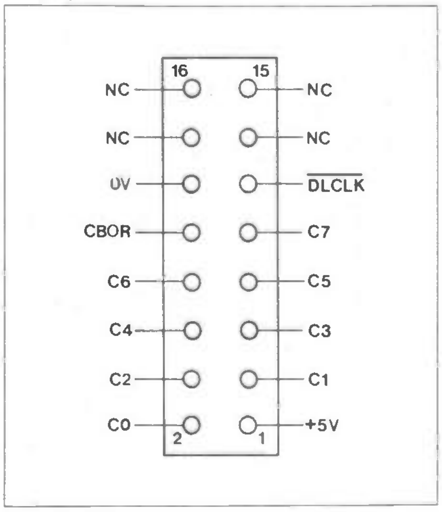


Figure 4. PL1 pinout.

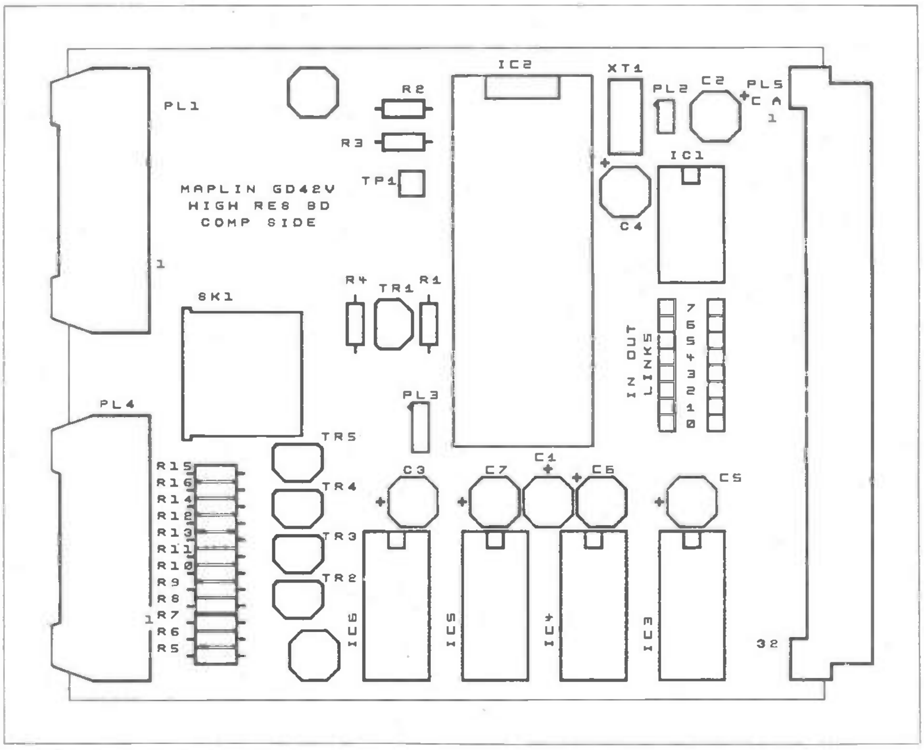
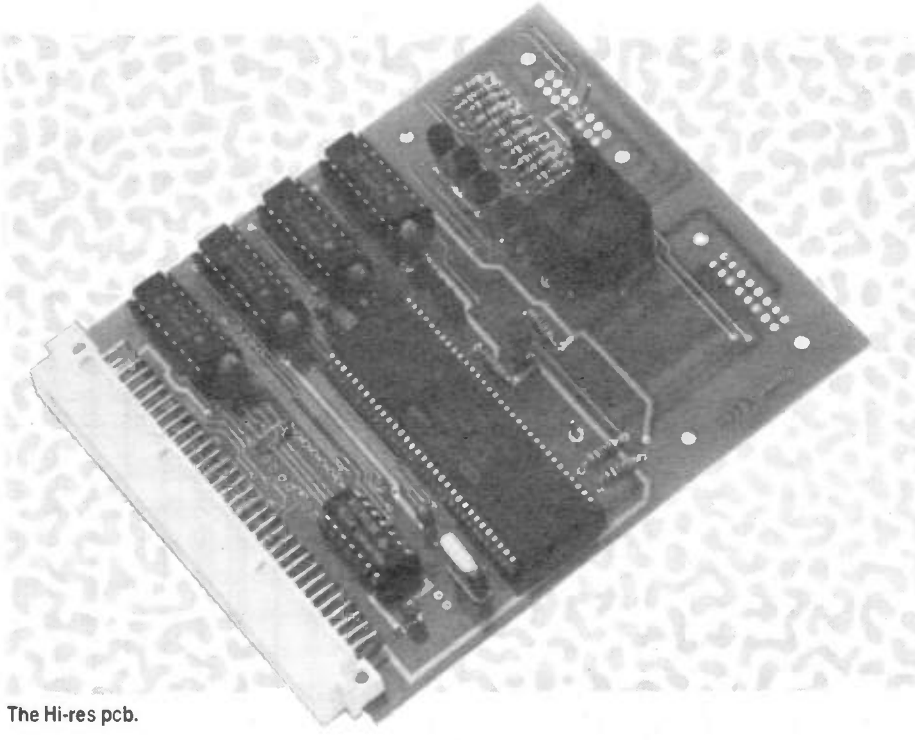


Figure 5. High Res board legend.



The Hi-res pcb.

to DRAMs and provides address multiplexing, RAS and CAS generation and full automatic refresh facilities.

The various video and synchronisation outputs are brought out to PL4, both unbuffered and buffered by emitter follower circuits TR1 to TR4 (whose outputs also go to a 6 pin DIN socket, SK1, as Figure 2). The pinouts for this IDC plug are shown in Figure 3. The buffered outputs (R, G, B, CVID, CSYNC) will drive any monitor with standard 75Ω composite video or RGB/composite sync inputs. **NOTE:** The composite video output of this card may be used in monochrome mode to directly drive any standard monochrome or colour monitor for black and white pictures only. The colour mode produces an NTSC standard colour composite video signal which will not display a colour picture on a PAL standard colour monitor. However, if a colour monitor has RGB inputs these may be connected to the corresponding outputs from the card to display a colour picture.

The data bus, C0 to C7, and associated signals CBDR and DLCLK, connected to PL1 (see Figure 4), along with LPS and LPD on PL3, provide an I/O channel for communication with special expansion devices related to the video picture, such as a mouse, light pen or external digital video inputs for mixing, digitizing, etc.

RESET on pin 9 of IC2 is provided by the reset circuit on the Z80B card, the only other signal line between the two boards being CLK. This is normally provided by an oscillator on the CPU board, but since the V9938 requires that the CPU is synchronized to its own clock the output CPUCLK on pin 8 is fed back to the CPU. **NOTE:** Link 7 on the CPU board should be removed, as should the crystal XT1.

Construction

Referring to the Parts List, legend (see Figure 5) and constructors guide, fit and solder all resistors and IC sockets, taking great care not to short circuit any of the pins on the 64 pin shrink DIP socket for IC2 and observing correct orientation of sockets. Fit and solder all transistors and capacitors ensuring that the transistors are aligned correctly with respect to the legend and that the positive leads of the capacitors are inserted into the holes nearest the '+' markings on the legend. The 64 way edge connector plug should be bolted onto the board using the

M2.5 hardware provided before soldering into place. Fit and solder the minicon plugs PL2 and PL3 into place. Lastly, fit one of the wire links as selected from Table 1 (for Frame Store fit link 0). Lastly insert the ICs into their sockets, taking special care when inserting IC2 to align the 'legs' carefully in the socket holes before pushing the chip fully home. It should be remembered that this IC will not be cheap to replace should a pin break off during assembly of the unit, its cost being a substantial proportion of the kit price. Should the IC be difficult to push fully home, closely examine every pin and its alignment with its respective socket hole and correct as necessary before using force. Also it would also be a good idea to take static damage prevention precautions, only removing the IC from it's conductive package at the last moment, after earthing yourself and the IC package momentarily to balance your potentials! In actual fact, the IC used in the prototype has proved to be a very sturdy device but with a price tag such as this chip bears, it does no harm to take every precaution to protect your investment.

Programming and Use

This section will cover the basic facilities provided by the graphics card and give an idea of the sort of control program necessary to use it, but is not a programmer's guide, since the rest of this issue could be filled with programming information and still leave some left over! Full programming information for the V9938 will be available soon, but in the meantime here is a brief overview of the graphic modes, features and commands.

TEXT MODE 1 is a pattern graphic mode allowing 40 columns by 24 lines of text or other character set patterns (6 x 8 pixels) in two colours out of 512 including the background colour. The memory requirement is 4K bytes per screen and since the patterns are mapped on to the screen by a simple pattern name table, 32 screen pages are possible in the 128K memory block.

TEXT MODE 2 is a pattern graphic mode allowing 80 columns by 24 or 26.5 lines of text (6 x 8) in two colours out of 512 (four if in 'blinking' mode) per screen. The memory requirement is 8K bytes per screen, giving up to 16 screen pages.

MULTICOLOUR MODE is a block graphic mode allowing 64 x 48 blocks in sixteen colours out of 512 and requires 4K bytes of RAM per screen, giving up to 32 screen pages. Sprite mode 1 activated (see Sprite graphics).

GRAPHIC MODE 1 is a pattern graphic mode allowing 32 x 24 patterns (8 x 8) in sixteen colours out of 512 and requires 4K bytes of RAM per screen, giving up to 32 screen pages. Sprite mode 1 activated.

GRAPHIC MODES 2 and 3 are pattern graphic modes similar to GRAPHIC MODE 1 in most respects except that the maximum number of patterns allowed is 768 as compared with 256 patterns for previous pattern modes. These modes therefore require 16K bytes of RAM, giving eight possible screen pages. Mode 2 enables sprite mode 1 and mode 3 enables sprite mode 2.

GRAPHIC MODE 4 is the first of the true graphics modes, being bit-mapped and supporting the graphic commands to be outlined later. The resolution is 256 (wide) by 192 or 256 (high), in sixteen colours. The memory requirement is 32K bytes, giving four screen pages. Sprite mode 2 activated.

GRAPHIC MODE 5 is a bit-mapped mode with a resolution of 512 x 212, each pixel being one of four colours. The memory requirement is 32K bytes per page, allowing up to four pages. Sprite mode 2 activated.

GRAPHIC MODE 6 is a bit-mapped mode similar to mode 5 except that pixels may be any of sixteen colours, therefore requiring 64K bytes per screen and only two pages are possible. Sprite mode 2 activated.

GRAPHIC MODE 7 is a bit-mapped mode with a resolution of 256 x 212, each pixel being any of 256 colours, requiring 64K bytes per screen. Sprite mode 2 activated.

COLOUR PALLETE as the name suggests, is a means of mixing the colours required for a screen page by combining chosen amounts of the (video) primary colours (red, green, blue) in each of the sixteen pallete registers. These are nine bit registers, divided into three bits for each of the primary colours. This allows eight levels of intensity for each primary colour in the mix, giving very fine tonal control of the composite colour created, which may be one of 512 colour/intensity combinations.

VIDEO OUTPUTS. There are several registers which control various aspects of the video output signals. The parameters which are under direct user control are as follows.

SCREEN PAGE. The user may select which one of the screen pages in memory (up to 32) is output as video, allowing multi-page text/graphics or comparison between pages, etc.

ALTERNATE PAGES. In the bit-mapped graphic modes, the user may alternate between certain graphic pages automatically, display time for each page being separately selectable from 166ms to 2053ms in 15 steps. It is also possible to alternate screens at frame rate (20ms).

INTERLACE. Video output may be interlaced or non-interlaced. In an interlaced picture alternate frames are offset by half a line (in the Y direction) which tends to fill the gaps between lines as far as the human eye is concerned when observing. The main disadvantage of this offset is that the display may appear to jitter annoyingly on some monitors (as owners of certain computers know well). By comparison, a non-interlaced picture is as solid as a rock but it is possible to see the gaps between lines. However, with this board, the user may choose the method employed.

COLOUR. A bit in one control register selects whether the device is operating in monochrome (up to 32 grey levels) or colour. In monochrome mode, the NTSC sub-carrier is removed from the composite video signal.

PAL/NTSC. Either frame timing may be selected and 312 or 262 lines per frame sent, although this feature is unlikely to be of much practical use in this country.

DISPLAY ADJUST. It is possible to move the active picture area both from side to side and up and down within the visible frame to exactly centre the picture on the monitor used.

Graphic Commands

The video processor has a range of built-in commands designed to reduce the demands on host processor time and soft are complexity when using bit-mapped graphic modes. The commands equipped are as follows:

PSET. Plots a point of a specified pallete colour on the screen.

POINT. Reads the colour code (pallete register number) present at the specified co-ordinate.

LINE. Draws a straight line of a specified colour between a given point and a relative offset co-ordinate.

SRCH. Searches to the left or right of a given point for a specified colour code and returns x location where colour is found, if any.

HMMC (High speed move CPU to video RAM (VRAM)). Transfers data from the CPU to video RAM within a specified rectangular area.

YMMM (High speed move VRAM to VRAM, Y only). Transfers a rectangular block of data defined by two basic points and the left or right hand edge of the screen up or down the screen.

HMMM (High speed move VRAM to VRAM). Transfers a rectangular block of data defined by a basic point and relative offset to another area.

HMMV (High speed move video processor (VDP) to VRAM). Used to paint a rectangular area defined as above with a specified colour.

LMMC (Logical move CPU to VRAM). Transfers data from the CPU to a rectangular area on the screen. Logical operations may be performed with data already present within destination area.

LMCM (Logical move VRAM to CPU). Transfers data from a rectangular area on the screen to the CPU. Logical operations may be performed on destination area.

LMMM (Logical move VRAM to VRAM). As HMMM but logical operations possible.

LMMV (Logical move VDP to VRAM). As HMMV but logical operations may be performed.

As previously mentioned, all data transfers including commmands from the CPU take place via one of four port addresses. The general format for this pipe-lining is to send the data byte first, followed by the internal register number or address that the data is destined for. It is also possible to set the VDP to auto-increment through its register addresses upon receipt of each new byte of data, further reducing host processor overheads. There are also a number of status registers within the VDP which allow the CPU to keep track of every aspect of what is going on within the video hardware. These status registers are accessed in a similar way to the control registers, keeping the external I/O map allocation low.

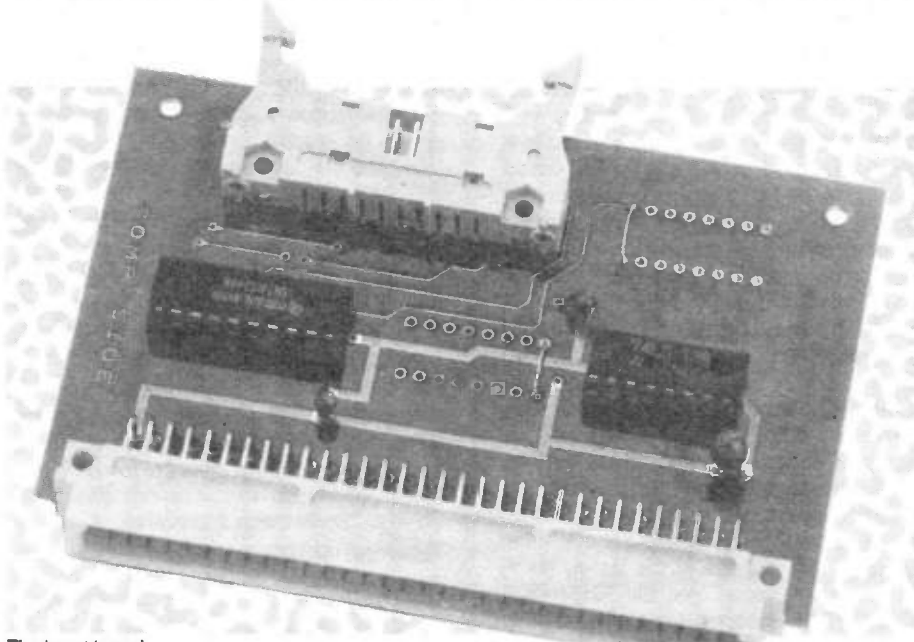
All logical moves are transferred in pixel units as opposed to bytes of VRAM and defined by (X,Y) co-ordinates, so that the host CPU does not have to spend time calculating which VRAM addresses correspond to particular positions on the screen. Another feature of these commands is that there is no need for the host program to keep track of the number of bytes sent to the VDP during block transfer since there are status registers within the VDP that may be simply checked between each data transfer until they indicate that the command has been executed. Together, these features and commands make graphic programming in machine language far less complex and tedious than would otherwise be the case.

Sprite Graphics

Up to 32 sprites, or movable object blocks (MOBs), as they are sometimes called, may be displayed, each sprite being a block of 8 x 8 or 16 x 16 pixels in size. There is also a sprite magnification feature which allows sprites to be displayed at twice the sizes previously mentioned. In sprite mode 1 up to four sprites may be displayed on any horizontal line. Any further sprites with lower priorities which overlap the same line will not be displayed where they overlap. Sprite mode 2 allows up to eight sprites on a line and also allows more than one colour per sprite. Within the limitations of these requirements, sprites may be independently positioned anywhere on the visible area of the screen, or below it (where they will not be displayed). They may be moved around without affecting information they pass over in any way.

Expansion Features

As previously mentioned the colour bus C0 to C7 is intended for connection to various expansion peripheral devices. A light pen may be connected to the system, or a mouse. However the external video facilities are potentially the most interesting feature as they allow real-time input of a digital video signal when the VDP is synchronized to the external video source. This opens possibilities for mixed video and graphics or a real-time colour digitizer, etc.



The input board.

WEFAX Frame Store

This section will deal with the extra hardware needed to go with the Z80B CPU board and the Video processor board to complete the basic weather satellite display application. There are three additional boards to build, an input port, a simple motherboard and a power supply/modulator board.

Input Port

This is an eight bit input port which provides an interface between any TTL compatible device and the I/O map of the Z80B CPU board. It has been provided with an input plug compatible with the BBC B user port to maintain a standard throughout our range of satellite display options (see Figure 6). The same interface cable (FD17T) may therefore be used for interconnection between the Mapsat Decoder and Frame Store.

Circuit Description

Refer to the input port circuit diagram (Figure 7) throughout this description. IC2 is

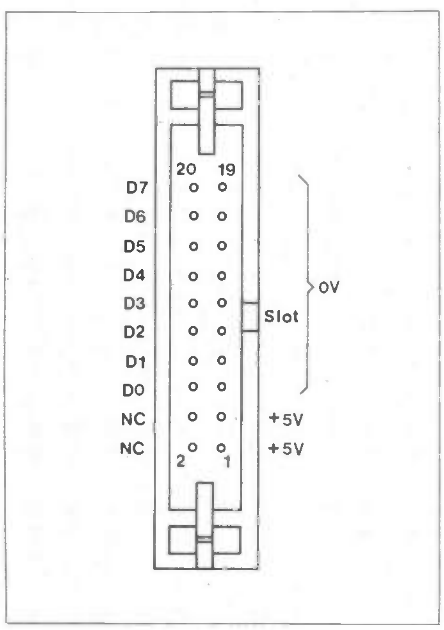


Figure 6. Input board IDC plug pinouts.

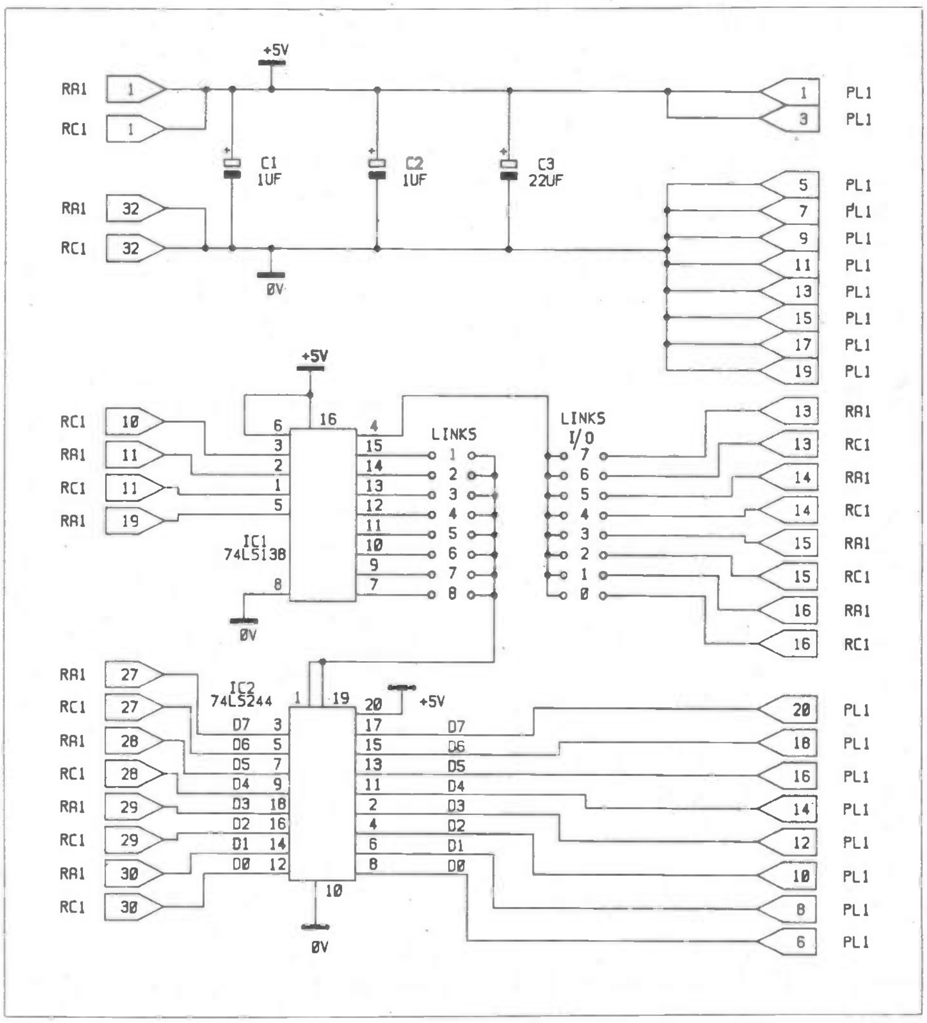


Figure 7. Input circuit.

an eight bit buffer which gates the levels present on its input bus through to the CPU data bus when enabled by IC1, an address decoder, via one of the links 1 to 8. For selection of link see Table 2. IC1 is enabled by the CPU READ line on pin 5 and one of the I/O select lines via one of the I/O links 0 to 7. This combination of link options makes it possible to locate each input port used at one of eight I/O addresses within the 32 byte I/O block selected by one of the I/O links 0 to 7. Link 1 selects the base address of the I/O block, link 2 selects the second address and so on until the eighth address. The port then 'ghosts', as just described, in eight byte blocks throughout the remainder of the I/O block, due to incomplete address decoding.

LINK	ADDRESS OFFSET
1	0
2	1
3	2
4	3
5	4
6	5
7	6
8	7

Input port links 1 to 8. Offsets from I/O block base address.

Table 2. Link offset addresses for Input Port.

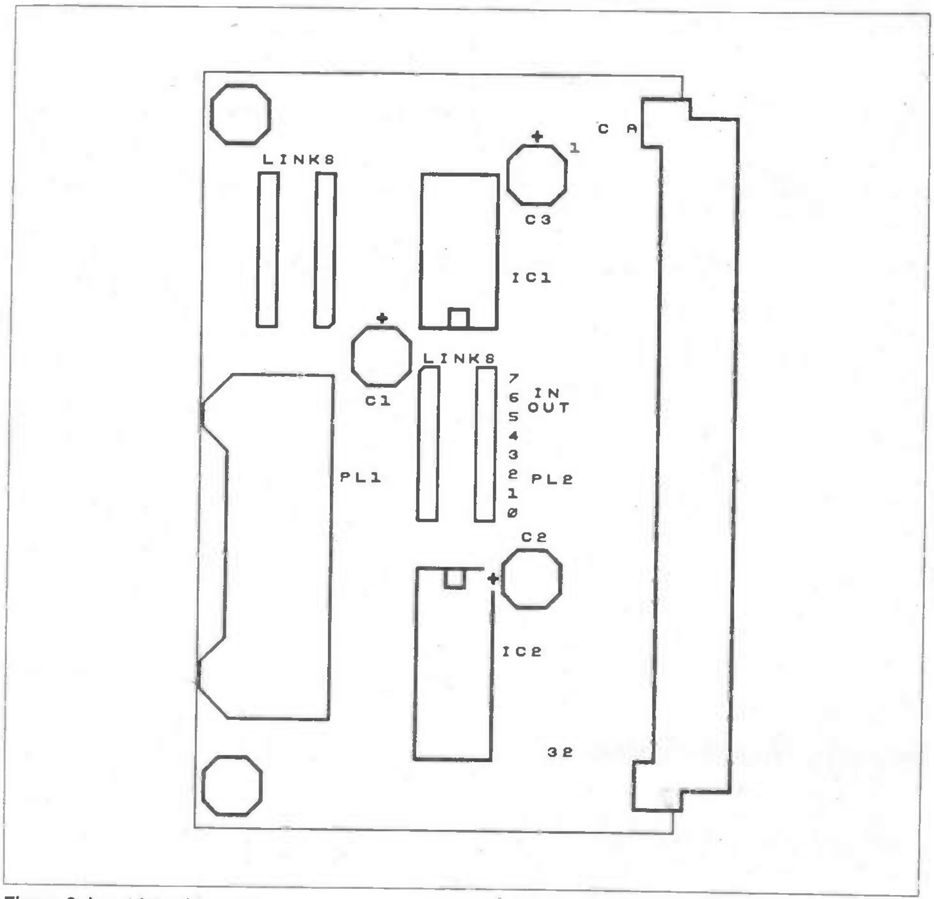


Figure 8. Input board legend.

Construction

Referring to the Parts List and legend (see Figure 8), fit and solder the IC sockets (ensuring that the cut-out on the sockets align with the markings on the legend) , PL1 and the edge connector plug, which should first be bolted into position using the M2.5 hardware provided. Insert the decoupling capacitors, noting correct polarity, and solder them into place. Insert the IC's into their respective sockets, noting correct orientation. Referring to Tables 1 and 2, fit and solder the links required (For frame Store fit link 1 and I/O link 6).

Motherboard

This board is merely a means of interconnection and mounting for the three digital boards. It has no active components and the only external connections to it are the power supply lines. The three sockets should be inserted so that the cut-outs in the corners of the sockets align with the markings on the legend (Figure 9) and bolted into position using the M2.5 hardware provided before soldering the pins into place.

NOTE: Failure to fit these sockets correctly will result in the power supply to all three main boards being reversed, with dire consequences!

Fit and solder the two pins and the decoupling capacitor, ensuring that the positive lead of the capacitor is inserted through the hole nearest the '+' marking on the legend. This completes assembly of the motherboard.

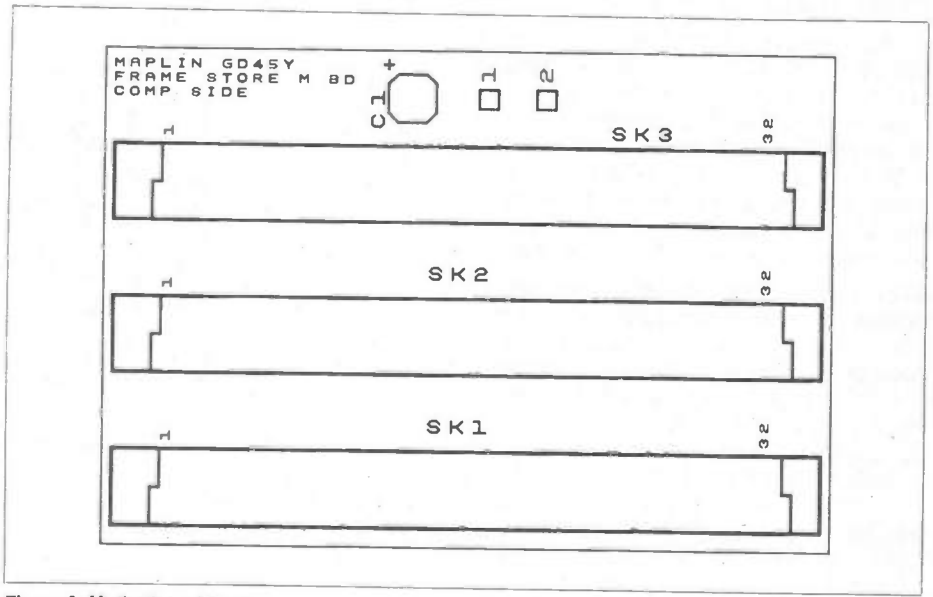
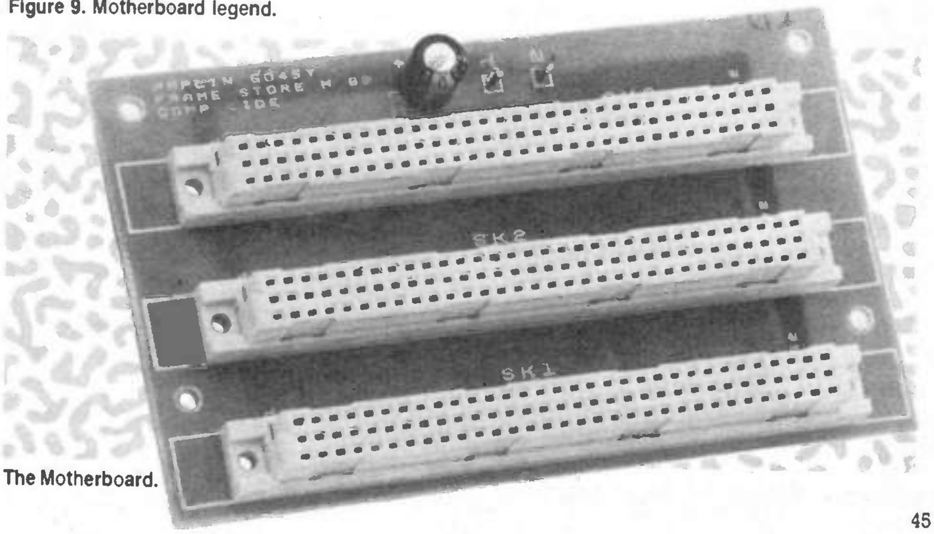


Figure 9. Motherboard legend.



The Motherboard.

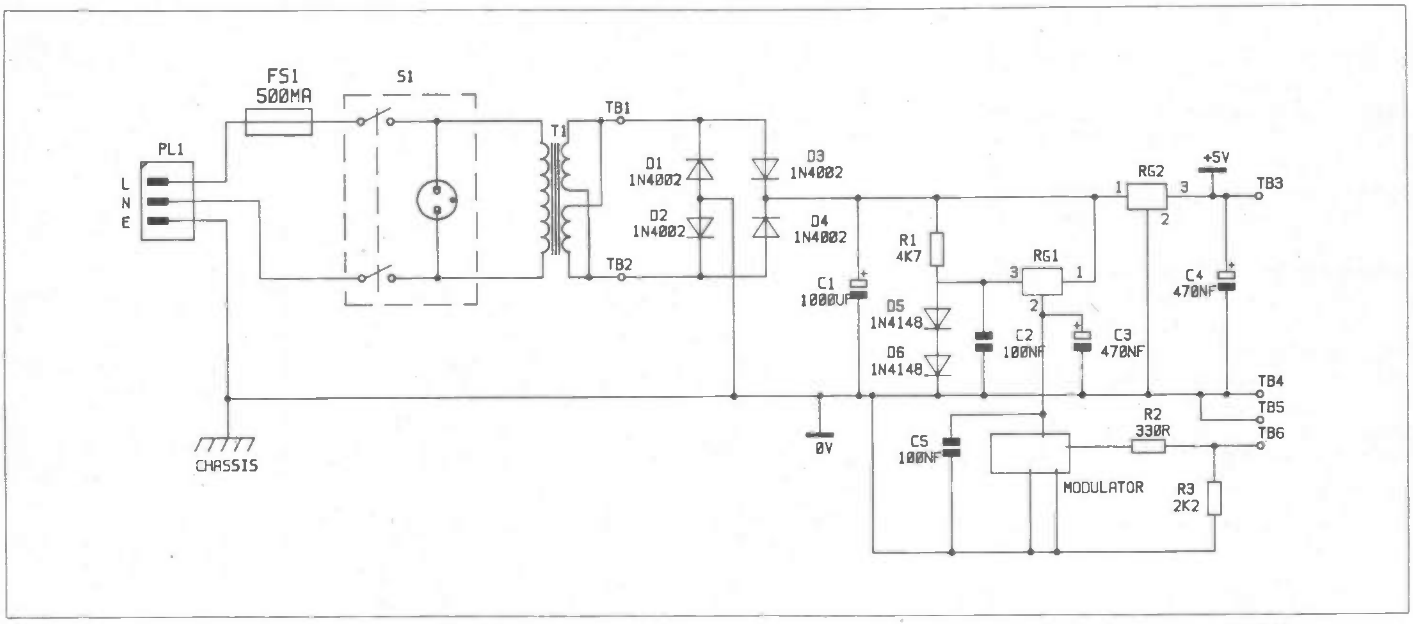


Figure 10. PSU/Modulator circuit.

Power Supply/Modulator

This circuit provides the 5V supply used throughout the unit and also has provision for a black and white UHF modulator for those who wish to use the system with a television reciever as opposed to a direct video monitor.

Circuit Description

Refer to Figure 10 throughout this circuit description. The mains transformer T1 steps the 240 volt mains voltage down to approximately 9 volts AC which is then rectified by a bridge rectifier formed by diodes D1 to D4, the resulting pulsating DC being smoothed by the 1000μF capacitor C1. RG2 is the main 5 volt regulator for the system, supplying the three logic boards with power via the motherboard.

NOTE: RG2 *must* be bolted to a substantial heatsink in order to dissipate the power generated as heat by the series regulation mode of the device. If the unit is to be mounted in a box, the regulator tab should be bolted to one of the box surfaces. No insulating washer is necessary since the tab is internally connected to 0 volts.

RG1 is a 5 volt regulator whose output is raised to approximately 6.4 volts with respect to the main 0 volt rail by raising its ground reference to around 1.4 volts above the 0 volt rail by means of the two forward biased diodes D5 and D6, which each drop about 0.7 volts when conducting. This 6.4 volt supply is required to run the UHF modulator, whose output may be connected to the aerial input of any domestic television set tuned to channel 36 via a phono plug to Belling-Lee co-axial plug lead (FV90X). The phono plug connects directly onto the modulator, which should be mounted in such a way that the phono socket protrudes through the rear of the box, if used.

Construction

Referring to the Parts List and legend (see Figure 11), insert diodes D1 to D6 into the board, ensuring correct type and polarity before soldering them into place. Insert and solder resistors R1 to R3. Next, insert and solder the veropins into place around the

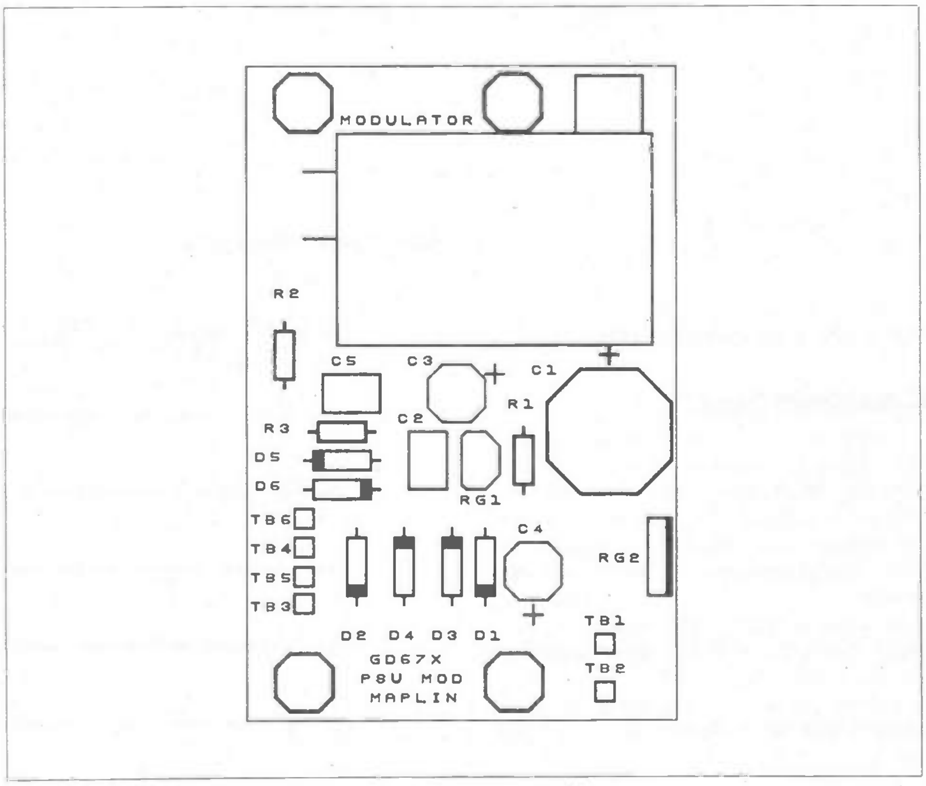
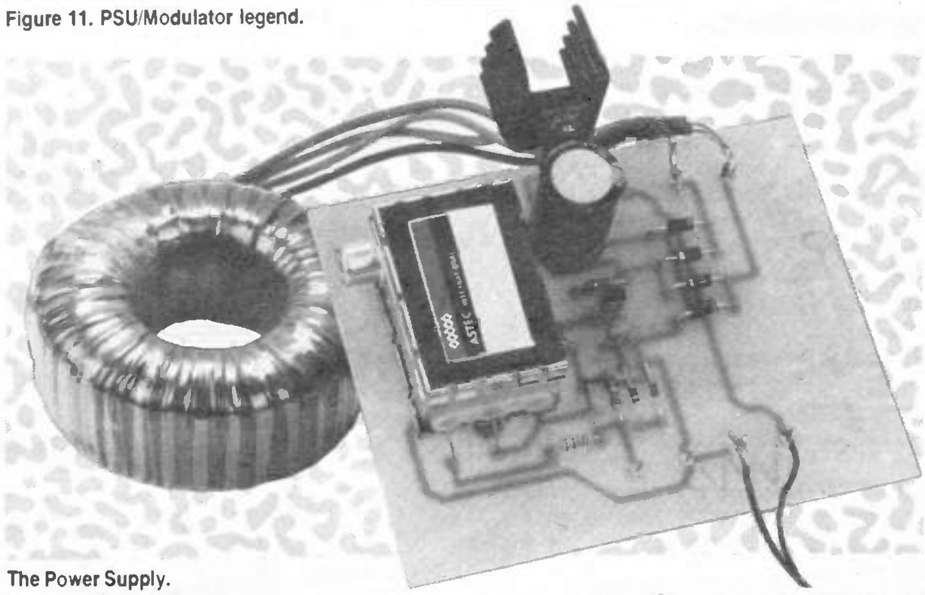


Figure 11. PSU/Modulator legend.



The Power Supply.

edge of the board. Finally insert and solder all capacitors (noting polarity), the modulator (taking care not to stress the wire leads unduly), and regulators, bearing in mind the need to mount RG2 in such a way as to allow it to butt up against the heatsink surface used.

Final Assembly

If a box is used, it should be drilled to mount all boards/components at this stage. While no lengths are given for the leads described below, they should be tailored by the user to fit neatly in the layout/box used. Refer to the wiring diagram (Figure 12) throughout for details of connections to the terminals on the various boards/components, etc.

Power Supply Wiring

The toroidal transformer should be mounted with the large rubber pads provided on either side and the large metal plate on the top of the transformer. Insert the fixing screw and fit a solder tag on the screw before fitting the washer and nut. The fuseholder should be mounted on the rear of the box, ensuring that the tags on the fuseholder clear all metal parts on the box and lid. The mains cable should be cut to the required length and one end stripped of its outer insulation for several inches. The cable should then be passed through a hole drilled in the rear panel of the box and a strain relief grommet fitted to anchor it. The brown wire should then be wired to the fuseholder and the other side of the fuseholder to the mains switch mounted on the front panel as shown in the wiring diagram. The blue wire from the mains lead should also be wired to the switch and the green/yellow earth lead to the solder tag previously fitted under the transformer mounting nut. The orange primary wires from the transformer should be wired to the other side of the mains switch. The insulating varnish on the transformer leads may be removed by *carefully* scraping with a sharp blade or by heating the wire ends with a well tinned soldering iron (mind the plastic insulation, though). The four transformer secondary wires should be cut to length, stripped and soldered to the terminals on the PSU/modulator board as shown. The red and black wires should be cut to lay neatly around the box and wired in to connect the power supply to the motherboard. The red wire should be used for the +5 volt line (DO NOT connect the red wire to TB3 on the PSU board at present) and the black wire for 0 volt line and earth wire back to the solder tag on the transformer mounting nut.

Video Wiring

A length of co-axial cable should be used to make two short video connection leads, one to carry the video from the processor board to the modulator board, and the other to run from the modulator board pins to the BNC socket mounted on the rear panel. Where the first lead terminates on the video processor board, the cable braid should be wired to the hole shown via a short length of wire, and the cable secured in some way to stop the braid fraying and shorting components on the PCB.

CPU Board Wiring

The RESET button mounted on the front

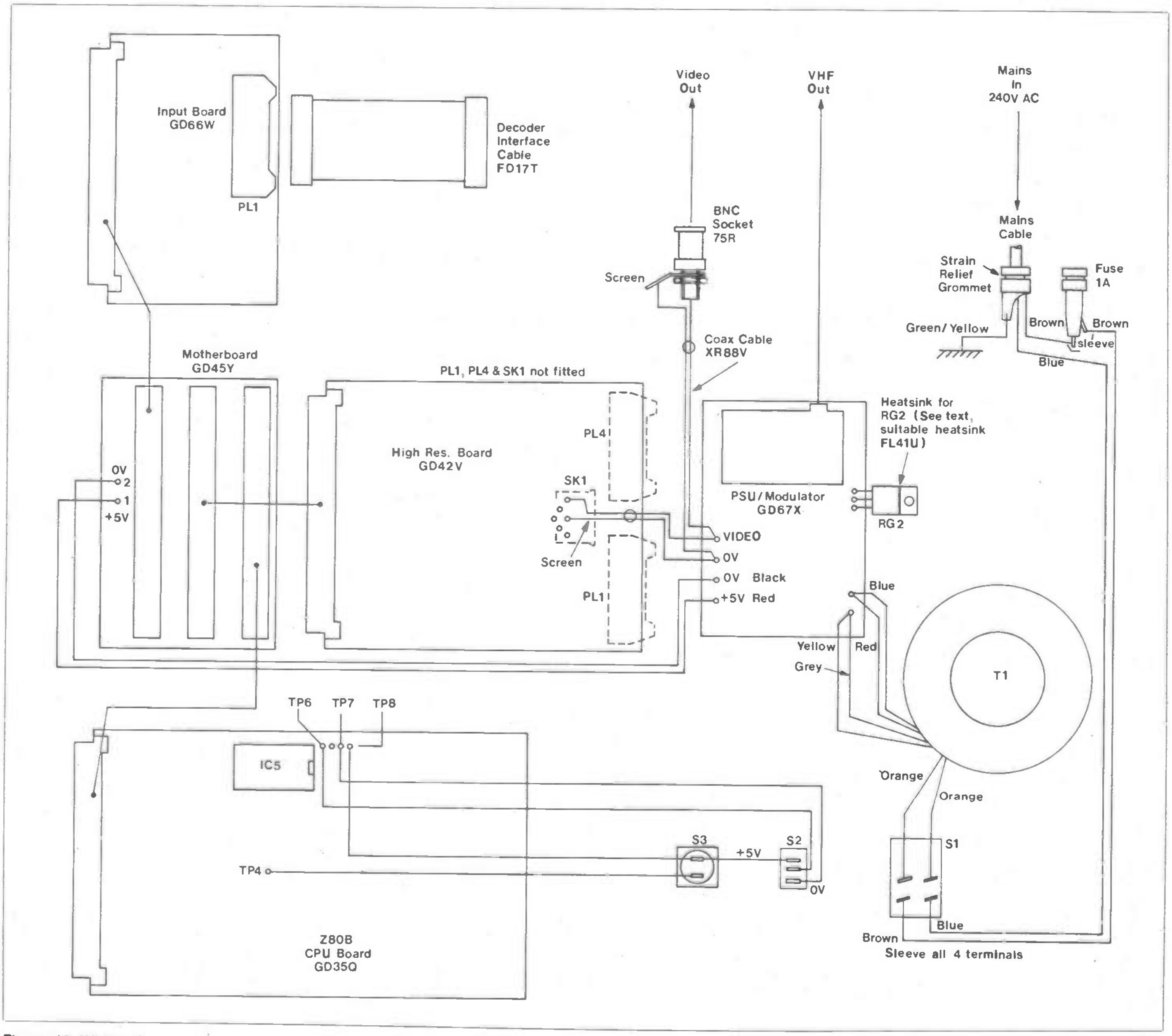


Figure 12. Wiring diagram.

panel should be wired to the RESET pin on the CPU board and +5 volts on the display select switch. The display select switch should be mounted on the front panel so that the two positions of the switch point up and down and should then be wired as follows. The centre terminal on the switch should be wired to the pin marked TP6 on the CPU board legend and the outer switch terminals to pins TP8 (+5 volts, this switch terminal to RESET button) and TP7.

The unit is now fully built, and ready to test. Check all wiring and boards carefully for short circuits, mistakes, etc.

Testing

Having first installed a 1 Amp fuse in the fuseholder and a plug on the end of the mains lead, connect the unit to the mains. Switch on and measure between chassis and TB3 on the PSU board with a voltmeter set to 10 volt FSD or similar. A reading of +5 volts should be obtained, plus or minus about 0.1 volts. Measure between the positive lead of C3 on the PSU board and chassis for a reading of around 6.4 volts. If either of these readings differ from the values stated, switch off the unit and re-check your work. If all is well, this is a good point to connect a television set to the unit, if used, and tune until a blank screen is found at or near channel 36. Otherwise, connect a monitor to the BNC socket on the rear of the box via an appropriate lead. Switch the unit off, connect the remaining end of the red wire to TB3, and install a ROM into the IC5 position on the CPU board (see below). Connect the Frame Store to the Mapsat Receiver/Decoder, by means of the interface cable (FD17T). Whilst playing a recording of a satellite or receiving a live pass, switch the Frame Store on. You should observe a series of black and white horizontal stripes on the screen, which should be cleared over the next second or so. A picture of some sort should then commence to build up over the screen, starting at the bottom with lines building from right to left, i.e. the opposite to what might be expected. If nothing is to be seen depress the RESET button for a moment and release it. This should start the process again, although the stripes on the screen will only be observed if the CPU did not start up properly when power was applied. It should also be noted that the setting of the Decoder switches and controls may prevent a picture being seen as will be described next.

Use

Two ROMs are available for use in the Frame Store, a NOAA ROM and a METEOSAT ROM. Each ROM contains two similar display programs, the two ROMs being slightly different to compensate for display format differences between the pictures transmitted by the NOAA polar orbiting satellites and the METEOSAT geo-stationary satellite, although either ROM may be used to view a particular satellite with varying degrees of X compression or expansion. All the programs within the ROMs are variations of the program shown in Listing 1, which is the first of the METEOSAT ROM programs. No explanation of the program is included here, that being beyond the scope of this article, but it is hoped that the listing will provide the experienced machine code programmer with some idea of the use of the video processor board for a particular display application. The picture formats of the programs are as follows:

```
Hisoft GENA3.1 Assembler.

0100              10         ORG   £0100
0100              20         ENT   $
00F0              30 WEFAX:  EQU   £F0
0001              40 PORTB:  EQU   £01
0100  3E0A        50 INIT:   LD    A,10            ;GRAPHIC MODE 6
0102  D301        60         OUT   (PORTB),A
0104  3E80        70         LD    A,128
0106  D301        80         OUT   (PORTB),A
0108  C33B01      90         JP    COLSET
010B  000000     100 TABLO:  DEFB  0,0,0           ;GREYSCALE TABLE
010E  014000     110         DEFB  1,64,0
0111  020001     120         DEFB  2,0,1
0114  034001     130         DEFB  3,64,1
0117  040002     140         DEFB  4,0,2
011A  054002     150         DEFB  5,64,2
011D  060003     160         DEFB  6,0,3
0120  074003     170         DEFB  7,64,3
0123  080004     180         DEFB  8,0,4
0126  094004     190         DEFB  9,64,4
0129  0A0005     200         DEFB  10,0,5
012C  0B4005     210         DEFB  11,64,5
012F  0C0006     220         DEFB  12,0,6
0132  0D4006     230         DEFB  13,64,6
0135  0E0007     240         DEFB  14,0,7
0138  0F4007     250         DEFB  15,64,7
013B  210B01     260 COLSET: LD    HL,TABLO        ;SET PALLETE REGISTERS
013E  0630       270         LD    B,48
0140  0E01       280 COLOOP; LD    C,1
0142  EDA3       290         OUTI
0144  3E90       300         LD    A,144
0146  D301       310         OUT   (PORTB),A
0148  0E02       320         LD    C,2
014A  EDA3       330         OUTI
014C  EDA3       340         OUTI
014E  20F0       350         JR    NZ,COLOOP
0150  3E40       360         LD    A,64            ;SCREEN ENABLED
0152  D301       370         OUT   (PORTB),A
0154  3E81       380         LD    A,129
0156  D301       390         OUT   (PORTB),A       ;REG£1
0158  3E0B       400         LD    A,11
015A  D301       410         OUT   (PORTB),A
015C  3E88       420         LD    A,136           ;TO REG£ 8
015E  D301       430         OUT   (PORTB),A
0160  3E82       440         LD    A,130           ;PAL NO INT,212 LN,DLCLK
O/P
0162  D301       450         OUT   (PORTB),A
0164  3E89       460         LD    A,137           ;TO REG£ 9
0166  D301       470         OUT   (PORTB),A
0168  3E00       480         LD    A,0
016A  D301       490         OUT   (PORTB),A
016C  3E87       500         LD    A,135           ;TO REG£7.SET BACKGROUND
BLACK.
016E  D301       510         OUT   (PORTB),A
0170  3E3F       520         LD    A,63            ;SCN ADDR FOR ODD PAGE
0172  D301       530         OUT   (PORTB),A
0174  3E82       540         LD    A,130
0176  D301       550         OUT   (PORTB),A
0178  3E00       560         LD    A,0
017A  D301       570         OUT   (PORTB),A
017C  3E8D       580         LD    A,141           ;ZERO TO BLINK REG£13
017E  D301       590         OUT   (PORTB),A
0180  3E09       600         LD    A,9
0182  D301       610         OUT   (PORTB),A
0184  3E92       620         LD    A,146           ;SET HOR POS REG£18
0186  D301       630         OUT   (PORTB),A
0188  C39F01     640         JP    CLEAR
018B  00A400A5   650 TABL1:  DEFB  0,164,0,165
018F  00A600A7   660         DEFB  0,166,0,167
0193  FFA801A9   670         DEFB  255,168,1,169
0197  D4AA01AB   680         DEFB  212,170,1,171
019B  00AC00AD   690         DEFB  0,172,0,173
019F  0614       700 CLEAR:  LD    B,20
01A1  218B01     710         LD    HL,TABL1
01A4  0E01       720         LD    C,1
01A6  EDA3       730 LOOP:   OUTI
01A8  20FC       740         JR    NZ,LOOP
01AA  3E02       750         LD    A,2             ;SET STATUS POINTER
01AC  D301       760         OUT   (PORTB),A
01AE  3E8F       770         LD    A,143           ;TO REG£ 15
01B0  D301       780         OUT   (PORTB),A
01B2  3E80       790         LD    A,128           ;CLEAR SCREEN
01B4  D301       800         OUT   (PORTB),A
01B6  3EAE       810         LD    A,174
01B8  D301       820         OUT   (PORTB),A       ;TO COM REG
01BA  DB01       830 TEST:   IN    A,(PORTB)
01BC  1F         840         RRA
01BD  3015       850         JR    NC,START
01BF  C3BA01     860         JP    TEST
01C2  FFA400A5   870 TABL2:  DEFB  255,164,0,165
01C6  D3A600A7   880         DEFB  211,166,0,167
01CA  FFA800A9   890         DEFB  255,168,0,169
01CE  01AA00AB   900         DEFB  1,170,0,171
01D2  0CAD       910         DEFB  12,173
01D4  1ED3       920 START:  LD    E,211
01D6  21FF01     930         LD    HL,511
01D9  DBF0       940 LINE:   IN    A,(WEFAX)       ;WAIT FOR SYNC HIGH
01DB  CB77       950         BIT   6,A
01DD  28FA       960         JR    Z,LINE
01DF  DBF0       970 ENLIN:  IN    A,(WEFAX)       ;THEN WAIT FOR LOW
01E1  CB77       980         BIT   6,A
01E3  20FA       990         JR    NZ,ENLIN
01E5  7D        1000 NEWDOT: LD    A,L
01E6  D301      1010         OUT   (PORTB),A
01E8  3EA4      1020         LD    A,164
01EA  D301      1030         OUT   (PORTB),A       ;SET UP V9938 FOR
01EC  7C        1040         LD    A,H
01ED  D301      1050         OUT   (PORTB),A
01EF  3EA5      1060         LD    A,165
01F1  D301      1070         OUT   (PORTB),A       ;GRAPHIC COMMAND
01F3  3E00      1080         LD    A,0
01F5  D301      1090         OUT   (PORTB),A
01F7  3EAD      1100         LD    A,173
01F9  D301      1110         OUT   (PORTB),A       ;LOGICAL MOVE-
01FB  7B        1120         LD    A,E
01FC  D301      1130         OUT   (PORTB),A
01FE  3EA6      1140         LD    A,166
0200  D301      1150         OUT   (PORTB),A       ;CPU TO VRAM (LMMC).
0202  7A        1160         LD    A,D
0203  D301      1170         OUT   (PORTB),A
0205  3EA7      1180         LD    A,167
0207  D301      1190         OUT   (PORTB),A
0209  00        1200 SMPIN:  NOP
020A  DBF0      1210 SMPL:   IN    A,(WEFAX)       ;WAIT FOR SP HIGH
020C  CB7F      1220         BIT   7,A
020E  20FA      1230         JR    NZ,SMPL
0210  DBF0      1240 ENSMP:  IN    A,(WEFAX)       ;THEN WAIT FOR LOW
0212  CB7F      1250         BIT   7,A
0214  2BFA      1260         JR    Z,ENSMP
0216  DBF0      1270 GETLUM: IN    A,(WEFAX)       ;GET LUMINANCE SAMPLE
0218  E60F      1280         AND   15              ;DISCARD SYNC AND SP BITS
021A  D301      1290         OUT   (PORTB),A       ;SEND SAMPLE TO V9938
021C  3EAC      1300         LD    A,172
021E  D301      1310         OUT   (PORTB),A
0220  3E32      1320         LD    A,50            ;PSET COMMAND.
0222  D301      1330         OUT   (PORTB),A
0224  3EAE      1340         LD    A,174
0226  D301      1350         OUT   (PORTB),A
0228  2B        1360         DEC   HL              ;DECREMENT DOT COUNT
0229  7C        1370         LD    A,H
022A  B5        1380         OR    L
022B  20B8      1390         JR    NZ,NEWDOT       ;CHECK FOR END OF LINE
022D  1D        1400 NEWLIN: DEC   E               ;DECREMENT LINE COUNT
022E  21FF01    1410         LD    HL,511
0231  7B        1420         LD    A,E
0232  B7        1430         OR    A
0233  20A4      1440         JR    NZ,LINE         ;FULL SCREEN?
0235  C3D401    1450 FIN:    JP    START           ;IF SO,START AGAIN.
```

Listing 1.

Meteosat ROM

Program 1. Display size 512 wide by 212 deep with sixteen grey levels. One display screen shows about half of a transmitted Meteosat frame (in the Y direction). A small strip down the side of the frame is not displayed but this is not a problem in use. This display mode shows the full (X, Y) resolution of the transmitted WEFAX image.

Program 2. Display size 256 wide by 212 deep with sixteen grey levels. The display screen shows a complete Meteosat frame, but with half the (X, Y) resolution of Program 1. Gives a good result when viewing whole Earth pictures. This mode only uses half the available screen width.

NOAA ROM

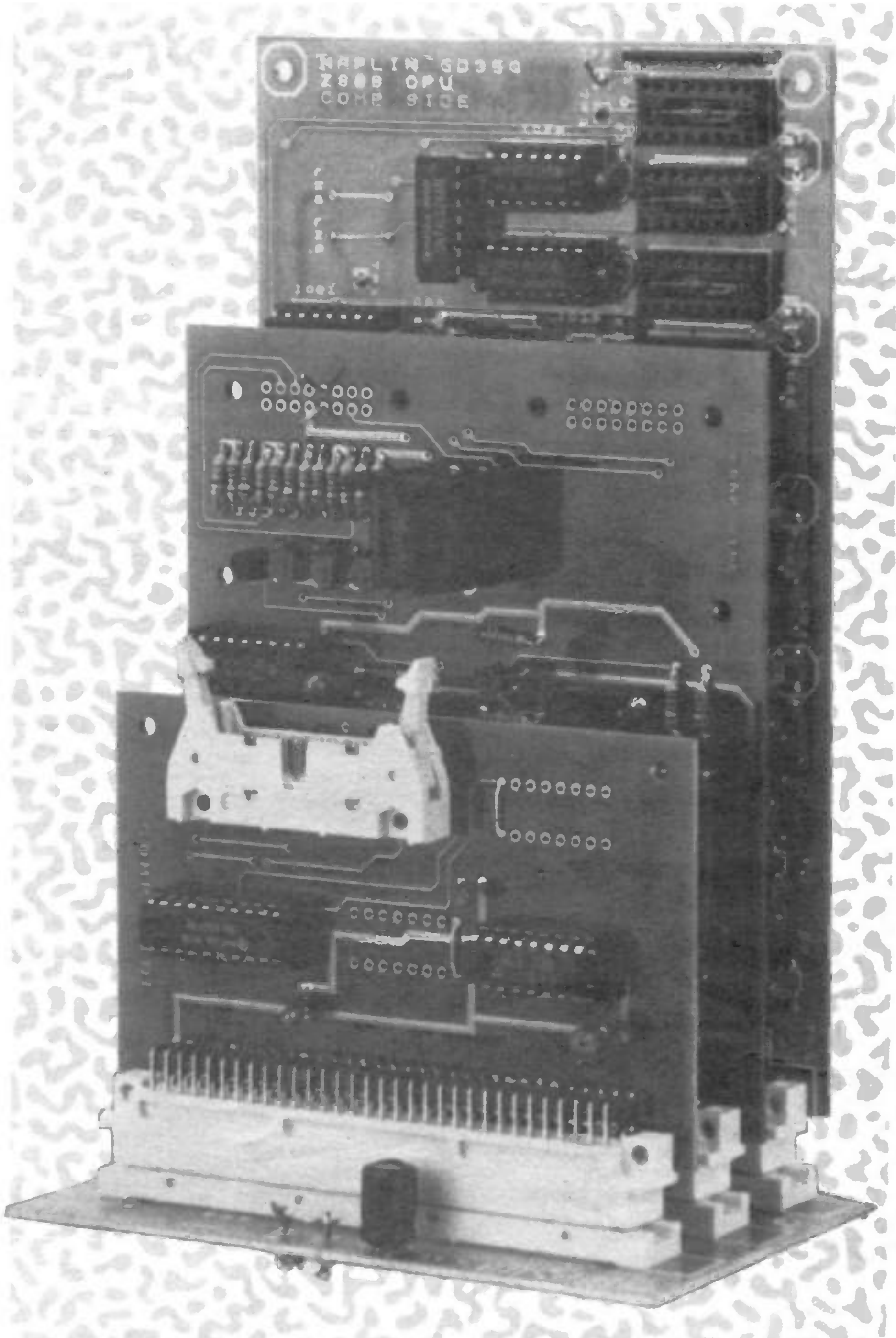
Program 1. Display size 256 wide by 212 deep with sixteen grey levels. This is a full width screen which shows about half the transmitted width of a NOAA picture at full resolution. The display may be shifted to view the other half of the picture using the slip control on the Decoder.

Program 2. Display size 512 wide by 212 deep with sixteen grey levels. This mode shows the full width of a transmitted NOAA picture with full X resolution and half Y resolution.

The display select switch on the front panel selects which of the two programs in the ROM fitted is running at any moment, although it is not possible to switch from one mode to another while a picture builds up. The program selected will run on power up or after the reset button has been operated.

Decoder Considerations

All controls on the Decoder will function as described in the decoder article, including the HOLD feature. Some experimentation will be necessary before the user finds the Level/Black level/White level control settings which give the best results. The lines per second switch should be left set to 2, although setting it to 4 whilst viewing Britain in Meteosat display mode 1 has the effect of (approximately) correcting the distorted view the satellite sees due to the curvature of the Earth.



The main boards mounted on the motherboard.

HIGH RES PARTS LIST

RESISTORS: All 0.6W 1% Metal Film

R1,2	4k7	2	(M4K7)
R3,4,6,9,12,15	1k	6	(M1K)
R5,8,11,14	470Ω	4	(M470R)
R7,10,13,16	75Ω	4	(M75R)

CAPACITORS

C1,4,5,6,7	22μF 16V Tantalum	5	(WW72P)
C2,3	10μF 16V Tantalum	2	(WW68Y)

SEMICONDUCTORS

IC1	74HC32	1	(UB15R)
IC2	V9938	1	(UH92A)
IC3,4,5,6	TMS 4464 DRAM 150ns	4	(UH93B)
TR1,2,3,4,5	BC337	5	(QB68Y)
XT1	21.47727MHz Crystal (HC18U)	1	(UH94C)

MISCELLANEOUS

PL5	64-way Plug Gold	1	(FJ61F)
	P.C. Board	1	(GD42V)
	Socket 64-Pin DIP	1	(FP99H)
	DIL Socket 18-Pin (Decoupled)	4	(FP80B)
	DIL Socket 14-Pin	1	(BL18U)
	Bolt M2.5 x 12mm	1 Pkt	(BF55K)
	Nut M2.5	1 Pkt	(BF59P)
	Shake M2.5	1 Pkt	(BF45Y)

A complete kit of all parts is available for this project:
Order As LM31J (High Res Kit) Price £74.95
The following items in the above kit list are also available separately, but are not shown in the 1987 catalogue:
High Res PCB **Order As GD42V Price £8.95**
64-Pin Shrink DIP Socket **Order As FP99H Price £2.98**
18-Pin Decoupled DIL Socket **Order As FP80B Price 78p**
V9938 Video Processor **Order As UH92A Price £29.95**
TMS 4464 DRAM 150ns **Order As UH93B Price £5.95**
21.47727MHz Crystal **Order As UH94C Price £2.40**

FRAME STORE INPUT PARTS LIST

CAPACITORS			
C1,2	1μF 35V Tantalum	2	(WW60Q)
C3	22μF 16V Tantalum	1	(WW72P)
SEMICONDUCTORS			
IC1	74LS138	1	(YF53H)
IC2	74LS244	1	(QQ56L)
MISCELLANEOUS			
PL1	20-way IDC Header R/A	1	(FT72P)
	PCB Plug Gold 64-way	1	(FJ61F)
	DIL Socket 16-Pin	1	(BL19V)
	DIL Socket 20-Pin	1	(HQ77J)
	P.C. Board	1	(GD66W)
	Bolt M2.5 x 12mm	1 Pkt	(BF55K)
	Nut M2.5	1 Pkt	(BF59P)
	Shake M2.5	1 Pkt	(BF45Y)

A complete kit of all parts, is available for this project:
Order As LM32K (Frame Store I/P Kit) Price £10.95
The following item included in the above kit list is also available separately, but is not shown in the 1987 catalogue:
Frame Store I/P PCB **Order As GD66W Price £5.95**

FRAME STORE MOTHER BOARD PARTS LIST

CAPACITORS			
C1	100μF 25V P.C. Electrolytic	1	(FF11M)
MISCELLANEOUS			
SK1,2,3	PCB Rec. Gold 64-way	3	(FJ47B)
	Veropin 2145	1 Pkt	(FL24B)
	Bolt M2.5 x 12mm	1 Pkt	(BF56K)
	Nut M2.5	1 Pkt	(BF59P)
	Shake M2.5	1 Pkt	(BF45Y)
	P.C. Board	1	(GD45Y)

A complete kit of all parts is available for this project:
Order As LM33L (Frame Store Motherboard Kit) Price £14.95
The following item in the above kit list is also available separately, but is not shown in the 1987 catalogue:
Frame Store Motherboard PCB **Order As GD45Y Price £3.50**

FRAME STORE PSU/MODULATOR PARTS LIST

RESISTORS: All 0.6W 1% Metal Film			
R1	4k7	1	(M4K7)
R2	330Ω	1	(M330R)
R3	2k2	1	(M2K2)
CAPACITORS			
C1	1000μF 35V P.C. Electrolytic	1	(FF18U)
C2,5	100nF Monores	2	(RA49D)
C3,4	470nF 35V Tantalum	2	(WW58N)
SEMICONDUCTORS			
D1,2,3,4	1N4002	4	(QL74R)
D5,6	1N4148	2	(QL80B)
RG1	μA78L05AWC	1	(QL26D)
RG2	μA7805UC	1	(QL31J)
	Modulator UM1111	1	(XX05F)
MISCELLANEOUS			
	P.C. Board	1	(GD67X)
	Vero Pin	1 Pkt	(FL24B)

A complete kit of all parts is available for this project:
Order As LM34M (Frame Store PSU/Modulator Kit) Price £9.95
The following item in the above kit list is also available separately, but is not shown in the 1987 catalogue:
Frame Store PSU/Modulator PCB **Order As GD67X Price £2.50**

FRAME STORE ADDITIONAL PARTS LIST

MISCELLANEOUS			
S1	Switch Dual Rocker Neon	1	(YR70M)
S2	Switch Sub-Min Toggle SPDT (A)	1	(FH00A)
S3	Square Push Black	1	(FF96E)
T1	Transformer Toroidal (30VA 15V)	1	(YK11M)
FS1	Fuse 1A A/S	1	(WR19V)
	Sleeving Heatshrink CP95	1 Mtr	(YR17T)
	Mains Warning Label	1	(WH48C)
	Safuseholder 20	1	(RX96E)
	Constructors Guide	1	(XH79L)
	HQ Co-ax Socket	1	(FE10L)
	S.R. Grommet 6W-1	1	(LR49D)
	EPROM 2732/M13 (NOAA)	1	(UH96E)
	EPROM 2732/M14 (METEOSAT)	1	(UH97F)
	Bracket	2	(FS14Q)
	Heatsink	1	(FS15R)
	Transformer Mounting Bracket	1	(FD09K)
	Instrument Case NM2H	1	(YM51F)
	Frame Store Front Panel	1	(FS16S)
	Decoder Interface Cable	1	(FD17T)
	Miniature Co-ax Cable 75Ω	1 Mtr	(XR88V)
	Hook-Up Wire	1 Pkt	(BL00A)
	Cable Min Mains White	1 Mtr	(XR02C)
	Grommet Small	1	(FW59P)
	2BA Tag	1 Pkt	(BF27E)
	Bolt 6BA x ½in.	2 Pkts	(BF06G)
	Nuts 6BA	2 Pkts	(BF18U)
	Washer 6BA Shake	2 Pkts	(BF26D)
	Washer 6BA	2 Pkts	(BF22Y)

The following items are available but are not shown in the 1987 catalogue:
EPROM 2732/M13 (NOAA) **Order As UH96E Price £9.95**
EPROM 2732/M14 (Meteosat) **Order As UH97F Price £9.95**
Bracket **Order As FS14Q Price 60p**
Heatsink **Order As FS15R Price 50p**
Frame Store Front Panel **Order As FS16S Price £4.50**

New Books

Transistor Selector Guide

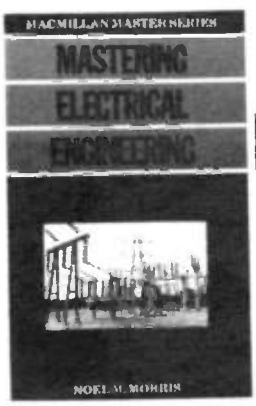
by J.C.J. Van De Ven

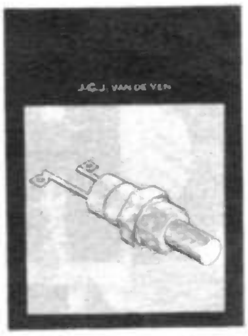
A comprehensive transistor selector prepared from a vast database with the aid of the latest computerised techniques forming a unique guide offering a range of selection tables, compiled so as to be of maximum use to all electronics engineers, designers and hobbyists.

The book is divided into four sections; the first being a detailed introduction to component markings, coding and standards, and explaining the symbols used and the arrangement of the tables. The second section actually comprises the tables in alpha-numeric order, of specifications of over 1,400 JEDEC, JIS, PRO-ELECTRON and brand specific designated devices. Section three tabulates the devices in 'case type' order, while section four can be used to find devices suitable for specialised and high power applications. FET's are included. The book finishes with device package outlines and pin-outs, and the latest Surface Mounting devices' conversion list.

178 x 130mm, 192 pages, illustrated.

Order As WP72P (Transistor Selector Guide) ***Price £4.95NV***





Power Selector Guide

by J.C.J. Van De Ven

Prepared from a vast database of device specifications, this guide offers a range of selection tables covering semiconductor power control devices, compiled so as to be of maximum use to all electronics engineers, designers and hobbyists. The book is divided into eight sections, comprising an introductory section explaining component markings, coding and standards, and the arrangement of the tables.

The devices are tabulated in alpha-numeric order, of which there are over 1,000 listed. Subsequent sections deal specifically with diodes and bridge rectifiers, thyristors and triacs finishing with technical specifications of power transistors, FET's, package outlines and pin-outs.

178 x 130mm, 160 pages, illustrated.

Order As WP73Q (Power Selector Guide) ***Price £4.95NV***

Mastering Electrical Engineering

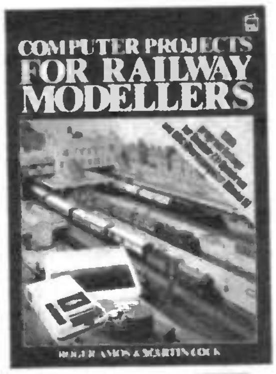
by Noel M. Morris

In this one book, all the essential information you may need to learn and master the principles of electrical engineering. is here. It is a complete, self-contained course for individual study or classroom use, with no previous knowledge of the subject required. Subject matter is suitable for all relevant GCSE, O-level, A-level and B/TEC courses.

This book reflects the modern thinking and needs of the *Electrical Technologist*, placing emphasis on practical circuits and systems. Mathematics is kept to a minimum consistent with the necessary back-ground theory. This is not a book to do with electronics and electronic circuitry, the science here is of the so called 'heavy current' electrical engineering practice, dealing with principles of electricity and sources of e.m.f, circuit theory, AC and DC machines, single and poly-phase, transformers, power distribution, instrumentation and power electronics.

206 x 136mm, 324 pages, illustrated.

Order As WP76H (Master Electrical Engineering) ***Price £3.50NV***



Computer Projects for Railway Modellers

by Roger Amos and Martin Cock

If you run a model railway *and* also own a home computer it's a fair bet that you have never thought of using them both together. In this book the authors, both life-long model railway enthusiasts, show how a computer can be used to add authenticity and enjoyment to your railway modelling. A wide variety of projects/software are described, for tasks such as displaying timetable information to computer aided design of track layouts and even controlling the layout. The program listings included are for two popular home computers, the BBC (model B), and the Sinclair Spectrum (48K), the majority of these being written in BASIC. Experienced programmers will be able to adapt these to suit other machines and languages.

206 x 158mm, 96 pages, illustrated.

Order As WP75S (Comp Proj for Railway Modellers) ***Price £4.99NV***

Modern Opto Device Projects

by R.A. Penfold

In recent years the range and variety of opto devices that have become available to the home constructor have expanded and changed radically. These devices are now representative of one of the more interesting areas of modern electronics in which the hobbyist can experiment, and many of these devices have useful practical applications too; they are not all just for show.

This book contains a number of practical designs which utilise a range of modern opto-electric devices, including ultra-bright LED's, IR detectors and fibre-optic cable. The projects are not all simple in construction but they should be within the capabilities of those with some reasonable experience of project building, and some of the more simple designs are suitable for beginners.

178 x 111mm, 104 pages, illustrated.

Order As WP74R (Modern Opto Device Projects) ***Price £2.95NV***

Building your own Working Fibre-Optic InfraRed and Laser Space-Age Projects

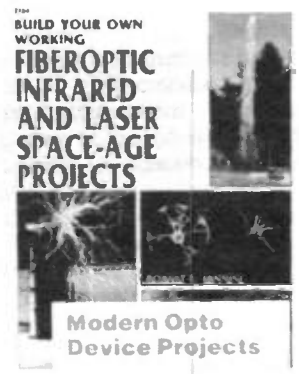
by Robert E. Iannini

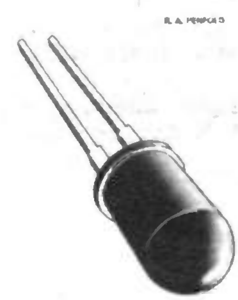
This American book contains many do-it-yourself projects for exploring the possibilities of the current laser technology, by building a variety of lasers including the gallium arsenide infra-red, optical helium-neon and ruby rod types, through to the carbon dioxide laser, complete with its collection of somewhat involved support equipment. This last type has been made much of lately due to the American 'Star Wars' laser weapon research. Apart from this, lasers have found applications on a scale and variety approaching that of electronics. The book provides details for such examples as a high sensitivity laser light detector, a high-voltage laboratory generator for use in all sorts of laser, plasma ion and particle applications including lightning displays and special effects; an infra-red viewer for night-time surveillance as well as a detector for a 4-30W infra-red laser; a voice modulated optical laser link, and several versions of a hand-held, visible-red laser light gun.

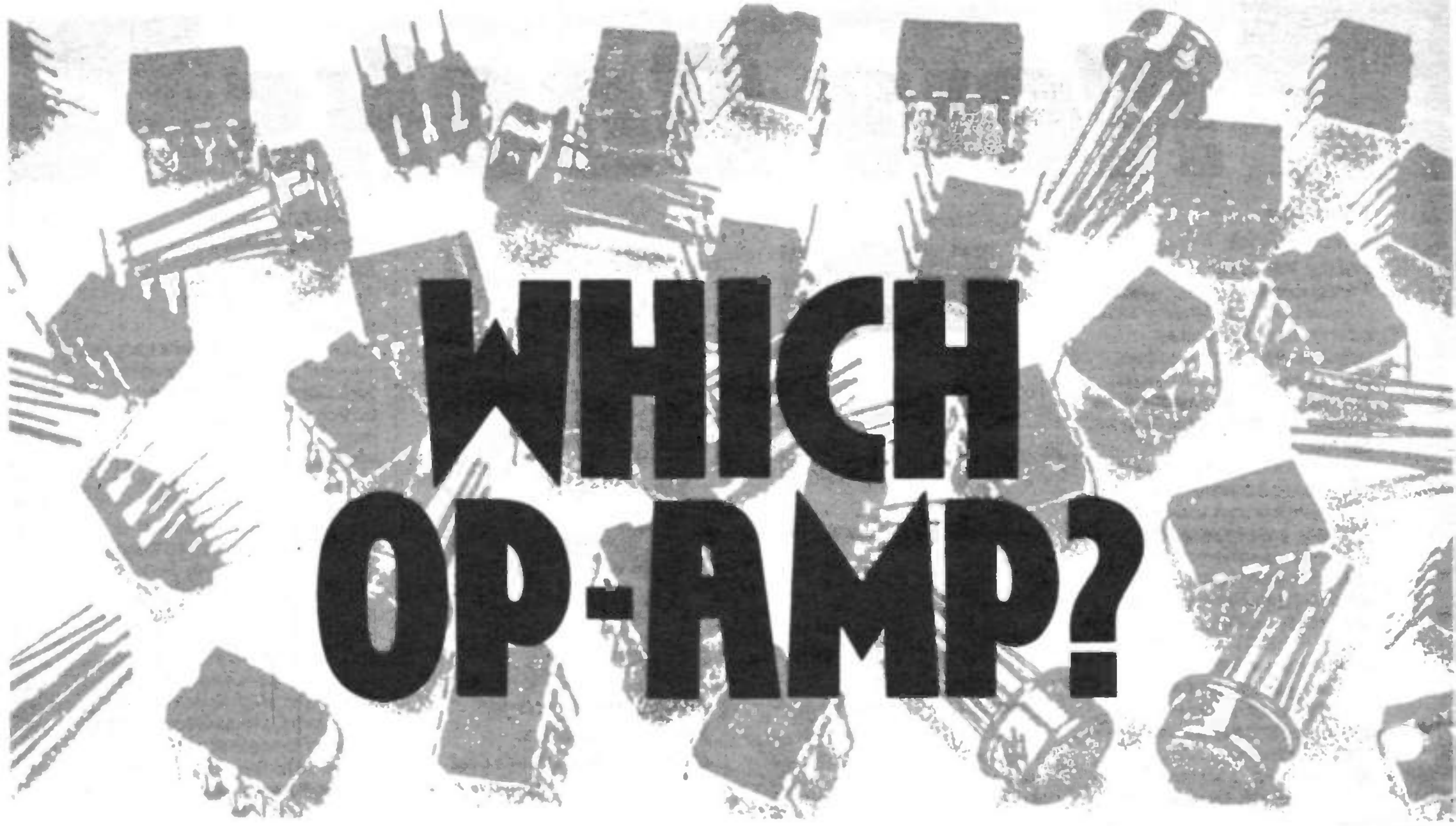
Also included are designs for 'plasma tornado' special effects generators, but bear in mind that any special items mentioned may not be available in the UK and suppliers mentioned are USA only. **Warning.** Note that all references in this book to a mains supply naturally mean the US standard of 110V 60Hz. If you intend to build any of the mains powered projects you must make sure to safely modify the mains input for compatibility with UK 240V mains, or use a suitable step-down transformer.

233 x 187mm, 264 pages, illustrated.

Order As WP77J (Build Fibreoptic I/R and Laser Projects) ***Price £12.85NV***







WHICH OP-AMP?

by J.K. Hearfield

Introduction

There was a time, not too long ago, when 'computer' meant 'analogue computer'. The analogue computer was developed as a means of simulating complex systems by modelling their behaviour in terms of their differential equations. It consists of a series of modules to perform the tasks of addition, multiplication, integration, and so on, wired together in such a way that the output voltage is an electrical analogue of the system property that is being simulated. At the heart of each module is a high-gain amplifier whose behaviour can be controlled precisely by negative-feedback networks; the amplifiers themselves became known as 'operational amplifiers', since their sole task was to perform mathematical operations. Technological advance has made analogue computation increasingly irrelevant as a problem-solving tool in most disciplines, but the concept of the operational amplifier has survived and flourished. An operational amplifier (op-amp) is today simply a high-gain wideband amplifier intended for use in networks of precisely defined characteristics, and capable of being used as a DC amplifier.

Ideal Amplifier

Consider for a moment the properties an ideal amplifier should possess. How large should its gain be, for example? Obviously, it should be just what the designer wants it to be: no more, and no less. But on reflection, there are advantages in having more gain than is needed. Gain can always be reduced by applying negative feedback, with all the added benefits of lower distortion, more stable behaviour, and so on. So perhaps a better answer is that an ideal amplifier should have *infinite* gain. It should also have infinite input resistance (so that it doesn't load its signal source), and infinite bandwidth (so that it can handle fast signals without distortion). The wish-list could be extended indefinitely, of course: an ideal amplifier would cost nothing, consume zero power, never fail under any operating conditions, and so on.

The ideal amplifier is a target for op-amp manufacturers to aim at, and one they approach more closely with each new family of devices. But the performance of real op-amps is now so good that the easiest way to understand an unfamiliar op-amp circuit is to take as a starting point the assumption that the op-amps are, in fact, ideal amplifiers.

Architecture

Op-amps have another very useful feature: they (mostly) have two input terminals. One is used for signals to be inverted by the amplifier (that is, phase-shifted by 180 degrees) and the other for signals which must not be inverted. The gain from each input terminal to the output is designed to be exactly the same.

The skeleton structure of an op-amp is illustrated in Figure 1. The device consists of three main units. First comes a balanced input stage, designed to amplify differential signals appearing as a voltage difference between its inverting (−) and non-inverting (+) inputs. The second stage provides virtually all the voltage gain. The output stage consists of a push-pull power amplifier.

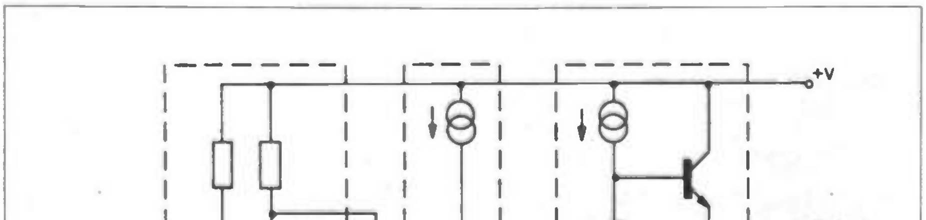


Figure 1. A skeleton Op-amp.

Input stage

One easy way of getting a balanced input is by the use of a long-tailed pair (Figure 2). The tail current (I) splits equally between the two transistors, as long as their input voltages are the same and the transistors are identical. But when one input is made slightly more positive than the other, the base-emitter voltage of that transistor becomes greater than the other's, and so it will try to take a larger share of the available current. The other is then obliged to take a smaller share. So the voltage across each collector load resistor changes: the voltage drop across R1 rises, whilst that across R2 falls.

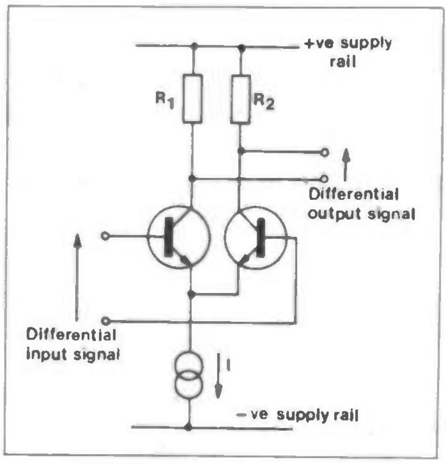


Figure 2. Long-tailed pair using bipolar transistors.

The circuit is symmetrical (with identical transistors and R1=R2), so the voltages dropped across the load resistors change by the same amount but in opposite directions. The single-ended input signal has been converted into a balanced (differential) output signal. And since the circuit is symmetrical, the input signal could equally well have been applied to the other input terminal, when it would have produced an output signal of exactly the same magnitude but phase-shifted by 180 degrees.

Since the two inputs have equal and opposite effects, any signal presented to both inputs at once will be cancelled out and will not appear at the output. Signals common to both inputs are known as common-mode signals (Figure 3).

Voltage-amplifier Stage

The voltage gain of a common-emitter amplifier is proportional to its collector load, so the easiest way to get lots of gain is to use a constant-current source as a load. This also avoids the need to use a high-value resistor which would occupy too much space on the chip. Many op-amps include a small feedback capacitor around this stage to ensure that the amplifier's frequency response rolls off smoothly and predictably over the full operating bandwidth. Some devices do not; the circuit designer must then add an external frequency-compensation capacitor. The output voltage of this stage can swing almost from the negative supply rail up to the positive rail.

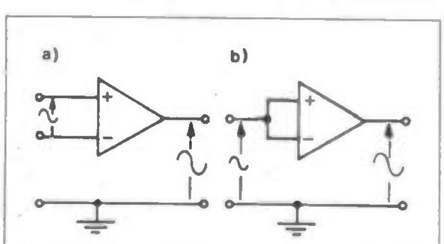


Figure 3. (a) Differential gain, (b) Common-mode gain.

Output Stage

The output stage functions as an impedance converter, transforming the high output impedance of the voltage amplifier stage into a low impedance suitable for driving the op-amp's load. This is achieved by means of a straightforward push-pull circuit, with the transistors biased such that both are just conducting (Class AB). Under no-signal conditions, the output voltage sits midway between the positive and negative supply rails; since these are usually equal and opposite (plus and minus 12V, for example), the output voltage is normally 0V. The transistors act as emitter followers, so the output resistance of the stage is very low.

Imperfections

A perfect DC amplifier would give an output of exactly 0V from an input of 0V. Real amplifiers can't quite manage this; the various small imbalances within the circuit combine to produce a small output voltage even when the input voltage is zero. These imbalances also cause the currents flowing into each input terminal to differ slightly from each other. (Of course, a perfect amplifier would not draw any input current, its input resistance would be infinite). The small differences are known as offsets, and op-amp manufacturers invariably define them in terms of additional voltage (or current) which would be needed at the input in order to drive the output to exactly 0V. For example:

INPUT OFFSET VOLTAGE is the voltage that must be applied between the input terminals to force the quiescent DC output voltage to zero. (Typical value: 1mV).

INPUT BIAS CURRENT is the average current flowing into an input terminal with the output at zero volts. (Typical value: less than $1\mu A$ for a bipolar op-amp).

INPUT OFFSET CURRENT is the difference between the two input currents (into the inverting and the non-inverting inputs) with the output at zero volts. (Typical value: 10nA for bipolar, or about 1% of the bias current).

Another consequence of imperfect balance is that a real op-amp is to some extent sensitive to ripple and noise on its supply rails, and to common-mode signals. The manufacturers' specifications cover these points:

SUPPLY VOLTAGE REJECTION RATIO is the ratio of the change in supply voltages to the resulting change in input offset voltage. (Typical value: 100dB).

COMMON MODE REJECTION RATIO (CMRR) is the ratio of differential voltage gain to common-mode voltage gain. (Typical value: 100dB).

Turning now to the performance of the op-amp as an amplifier, the important parameters are gain, input resistance, and output resistance. These are specified as follows:

LARGE-SIGNAL VOLTAGE GAIN is the ratio of the output voltage swing to the corresponding input voltage swing. This figure must be treated with care: it is the maximum gain the device manufacturer succeeded in getting from the op-amp under optimum conditions, and the gain at frequencies greater than a few Hz will almost certainly be less. (Typical value: 100dB).

INPUT RESISTANCE is the resistance between the input terminals with one input earthed. (Typical value: 1MΩ).

OUTPUT RESISTANCE is the resistance between the output terminal and earth. (Typical value: 100Ω).

The op-amp's gain begins to roll off at a very low frequency, 4Hz is not untypical, so its actual gain at high frequencies is very much less than the quoted DC figure. Manufacturers define the performance at high frequencies by means of the following parameters:

UNITY-GAIN BANDWIDTH is the frequency range in which the open-loop gain is greater than 1. (Typical value: 1MHz).

MAX PEAK-TO-PEAK OUTPUT VOLTAGE SWING is the maximum peak-to-peak output voltage swing that can be achieved without clipping when the quiescent output voltage is zero. Most devices can swing their output voltages almost up (and down) to the supply rails if the load resistance is sufficiently high and the frequency is no more than a few kHz.

FULL-POWER BANDWIDTH is the frequency range within which the maximum peak-to-peak output voltage swing is available. This figure is usually much smaller than the unity-gain bandwidth. (Typical value: 10kHz).

SLEW RATE is the average rate-of-change of the output voltage when a step input signal is applied (Figure 4). Slew rate is usually quoted for an op-amp connected as a unity-gain follower, and typical figures range from $0.5V/\mu s$ upwards.

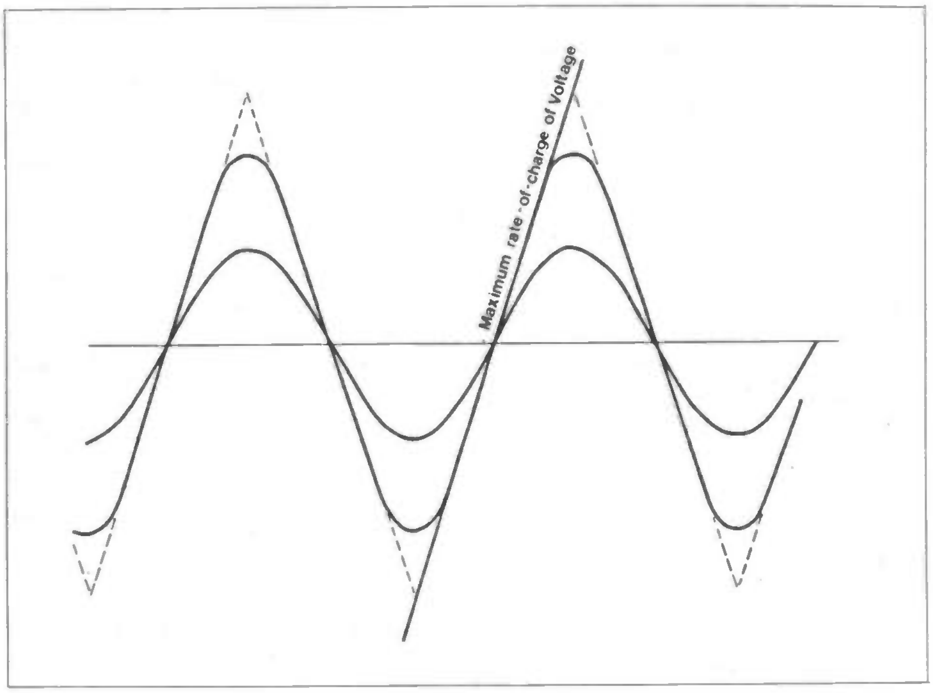


Figure 4. Slew-rate limiting turns sinewaves into triangles.

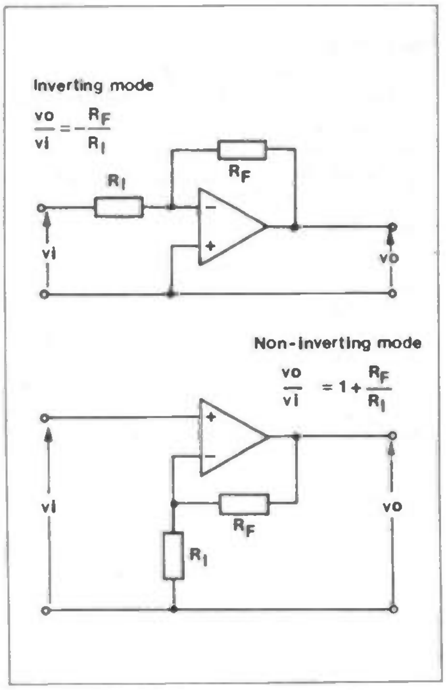


Figure 5. Basic Op-amp configurations.

Other Data Sheet Parameters

As for any other semiconductor device, the published data includes Absolute Maximum Ratings:

VOLTAGE SUPPLY RANGE (Vcc) is the range of values the supply voltages can take for the op-amp to function properly. Op-amps require two supply rails, one positive of earth and one negative, and they must usually be of equal value - for example, ±12V. Many op-amps will work over a wide range of supply voltage values, though their performance often depends on the actual value of supply voltage used; a lower voltage can mean a lower gain.

POWER DISSIPATION is the maximum dissipation allowed at a free-air temperature of 25 degrees C. Many op-amps are however specified to work properly over a wide temperature range, 0 to 70 degrees C is not uncommon, without derating being necessary, though as usual the hotter the device runs the shorter its life will be. Offsets and other properties are also usually temperature-dependent. The dissipation may be typically up to 0.5 watt.

DIFFERENTIAL INPUT VOLTAGE RANGE is the voltage difference between the inverting and non-inverting input terminals. This voltage in practice is usually very small indeed, though most op-amps allow it to be as high as the sum of the positive and negative supply voltages (perhaps 30V, positive or negative) if the need arises.

MAX INPUT VOLTAGE WITH ONE INPUT EARTHED. No harm usually results to the op-amp if one input is earthed and the other connected to either supply voltage.

SUPPLY CURRENT is the current flowing through each supply pin with no load and no input. Typical figures range from 0.2mA upwards.

Basic Op-Amp Circuits

Amplifier imperfections can of course be minimised by the use of negative feedback. The two basic circuits - of an inverting and a non-inverting amplifier - are shown in Figure 5. These circuits are very easy to analyse provided that:

(a) the amplifier's gain is very high, and

(b) the amplifiers input resistance is very high.

If both these conditions are met (and in a first look at the circuit, it is fairly safe to suppose they will be) then the argument goes like this. Since the amplifier's gain is very large, its input voltage (measured between the inverting and non-inverting input terminals) must be very small; to a first approximation, the amplifier's input voltage is zero. So the voltage across R_I is the stage input voltage, V_I. But since the amplifier's input resistance is very large, its input current is also (practically) zero, and so the currents flowing through R_I and R_F are identical.

In the case of the inverting amplifier, then, the output voltage V_o appears across R_F and the input voltage V_i appears across R_I. The same current flows through both resistors, so the stage voltage gain is just:

$A = -R_F/R_I$

(The minus sign is a reminder that the output signal is inverted relative to the input.)

For the non-inverting stage, the output voltage appears across R_F and R_I in series, whilst the input voltage is still across R_I. The same current flows through R_F and R_I though, so the stage voltage gain is:

$A = 1 + R_F/R_I$

The interesting thing about these very simple results is that they depend purely on the values of the external components. As long as the amplifier's gain and input resistance are large enough, their actual values don't matter at all.

Minimising Offsets

Input offset voltage and current (and bias current) are a particular nuisance in DC amplifiers, where the output voltage is supposed to be zero when the input voltage is zero. They can be modelled as shown in Figure 6. Fortunately, there is a simple circuit technique for minimising their effects, see Figure 7, which also helps to compensate for their variation with temperature.

By including an extra resistor R_B as shown, the bias and offset currents are forced to flow through both R_I and R_B. It can be shown by some rather tedious algebra that the effects of the input offset voltage V_{IO} and offset current I_{IO} cancel each other out if the value of R_B is chosen to be:

$R_B = V_{IO}/I_{IO}$

And it also turns out that the bias current does not affect the output voltage if the effective resistance from each amplifier input to earth is the same; this implies:

$R_B = R_F//R_I$

To see what this means in practice, consider an inverting amplifier stage using a 741 to get a gain of 10. For the 741C, V_{IO} is typically 1mV and I_{IO} typically 20nA, so:

$$R_B = \frac{(1000\mu V)}{(20nA)} = 50K\Omega$$

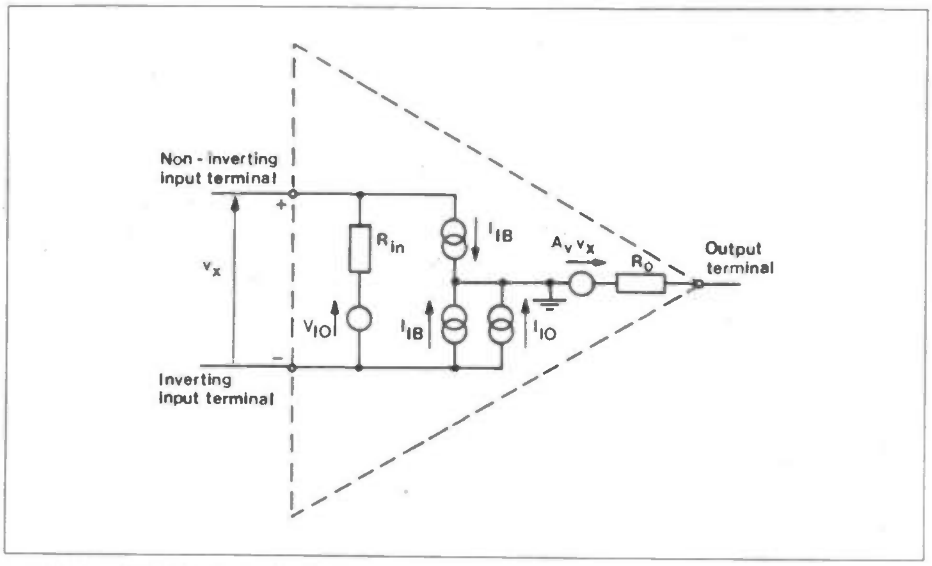


Figure 6. DC model of a real Op-amp.

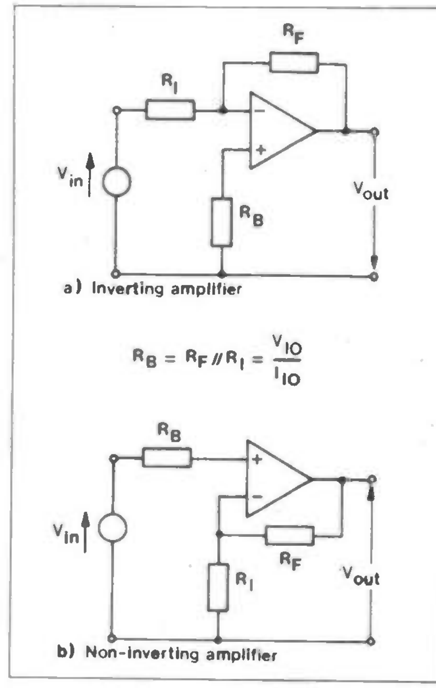


Figure 7. Basic amplifier circuits with offset compensation.

For a gain of 10,

$R_F = 10R_I$

and so the parallel combination of R_F and R_I is:

$R_F//R_I = 0.91R_I$

For this combination to equal 50KΩ,

$$R_I = \frac{50}{0.91} = 55K\Omega,$$

and $R_F = 55 \times 10 = 550K\Omega$.

The figures quoted for offset voltage and current are approximate, and prefer-red-value resistors are quite good enough in practice.

It is sometimes essential to trim the output voltage to exactly zero volts, and many op-amps include a means of doing so. Figure 8 shows how the 741 input stage (which incidentally can be seen to be rather more complex than a straight-forward long-tailed pair) makes available two internal nodes, allowing the circuit to be balanced manually by the adjustment of an external preset potentiometer.

Effects of Frequency-Dependent Gain

The simple analysis of the stage gain above was based on the assumption that the gain of the stage was much lower than the gain of the amplifier itself. It seems obvious that this assumption must be true for, say, a 741C with a quoted large-signal voltage gain of 200,000 (the so-called open-loop gain) used in a circuit with a gain of only 10 (the closed-loop gain). But appearances can be deceptive. The 741C's huge gain exists only at very low frequencies, as Figure 9 illustrates. Above a few Hz, the device's open-loop gain rolls off steadily at 20dB/decade; at a signal frequency of 10kHz, for example, it has fallen to just 100. Clearly, the assumption looks increasingly questionable at frequencies higher than a few kHz.

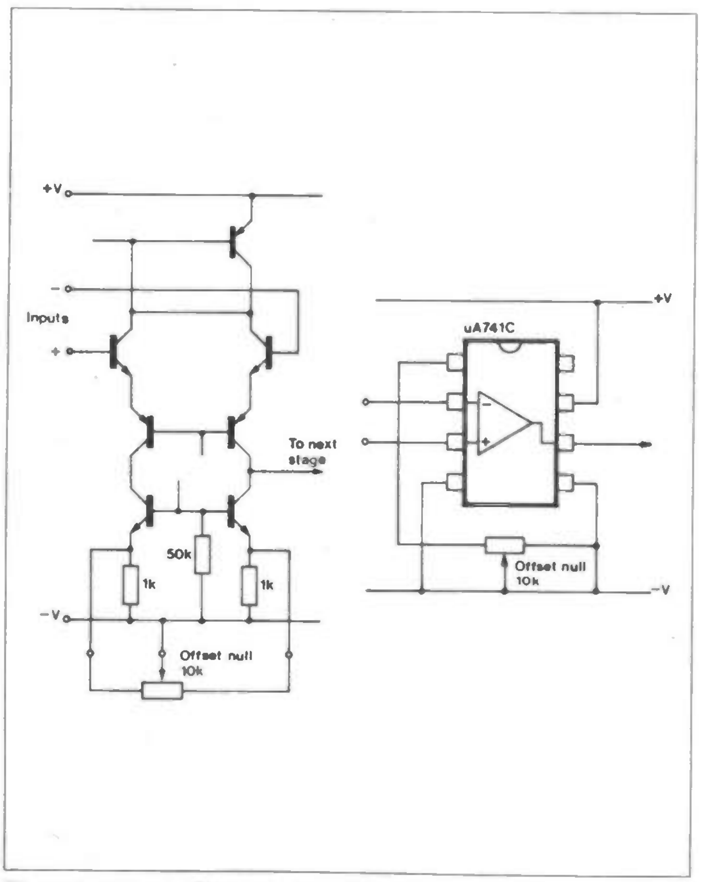


Figure 8. Offset nulling on a 741.

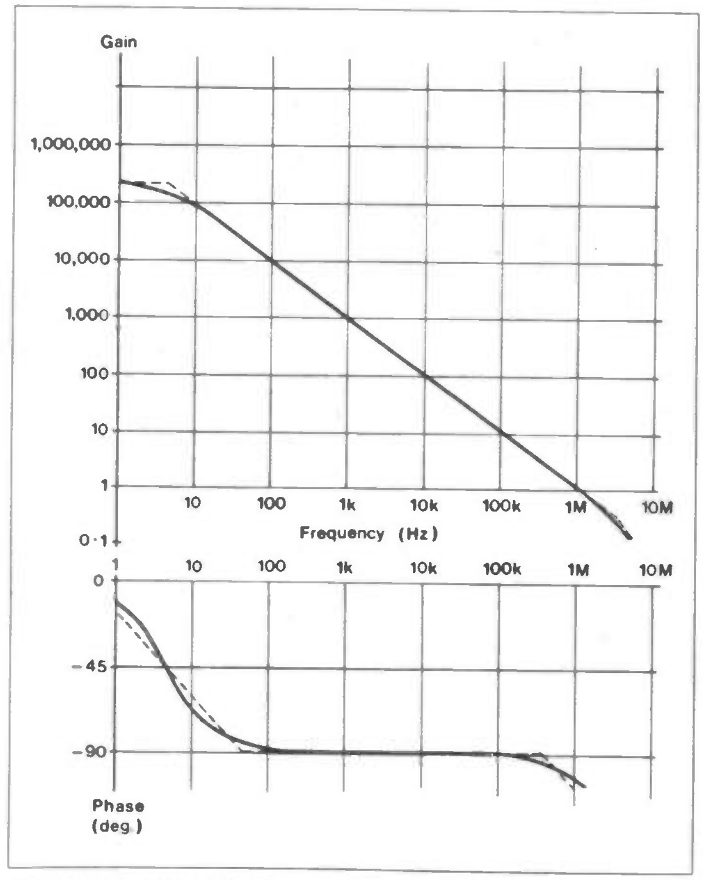


Figure 9. Open-loop gain frequency response of 741.

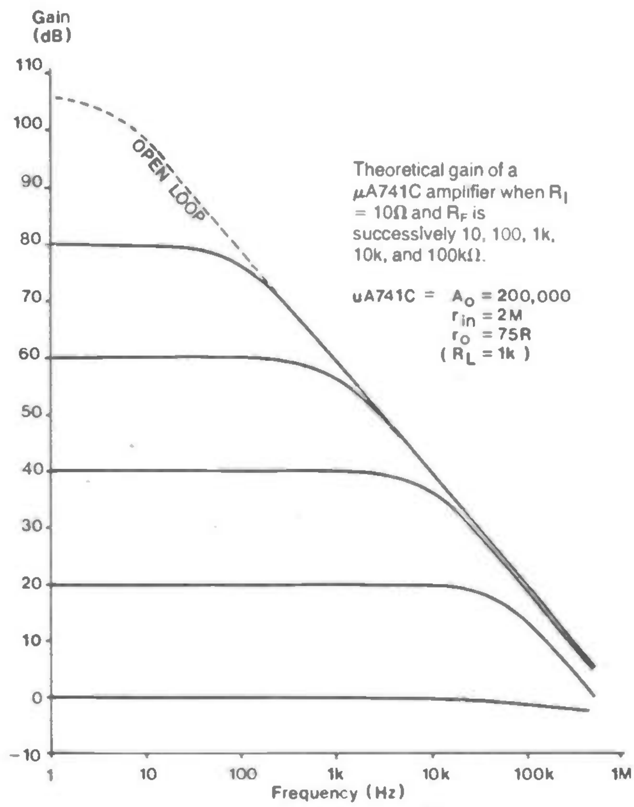
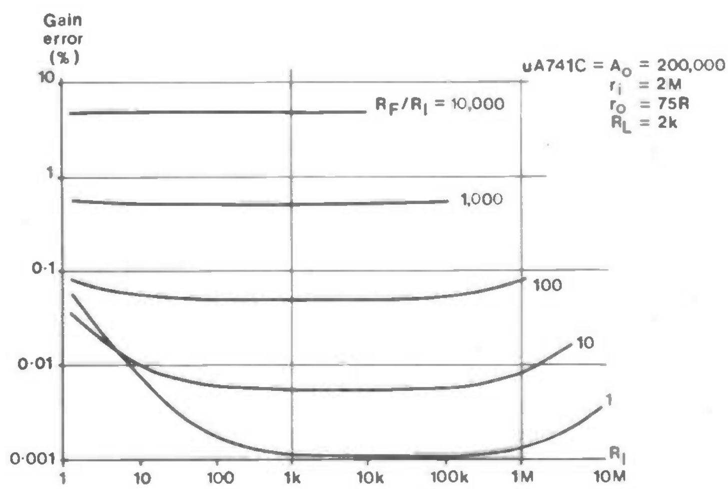


Figure 10. Theoretical gain of a 741.



The closed-loop gain is never quite *exactly* R$_F$/R$_I$, because the op-amp is not perfect.

The graph shows that R$_I$ should be between 1kΩ and 100kΩ for best results with a µA741C. The gain error is then nearly all due to A$_o$ being finite.

The graph is typical of many op-amps. For example, a TL071 with A$_o$ = 200,000 and r$_o$ of 130Ω but r$_i$ of 10^{12}Ω differs only in that the error does not rise at high values of R$_I$ but stays constant.

Figure 11. Closed-loop gain response of 741.

The graph of Figure 10 shows how the frequency response of a simple amplifier using a 741C depends on the desired value of closed-loop gain. At low frequencies the gain is close to the predicted value, even at a gain of 80dB. The gain of the stage cannot be greater than the gain of the amplifier, though, and so the higher the closed-loop gain must be, the smaller will the bandwidth become. The product of gain and bandwidth is (usually) constant for a given op-amp, as it is controlled by the value of the on-chip compensation capacitor. Some types though do allow the designer to choose the value of compensation capacitor most appropriate for the particular application; at high values of closed-loop gain, compensation is less important.

Effects of Op-Amp Input and Output Resistances

It must not be forgotten either that the amplifier's input and output resistances are finite, nor that the stage will presumably be driving a load of some sort.

The result of taking all these factors into account is that the simple expressions for stage gain obtained above are only approximately true, and then only under certain conditions. The graph of Figure 11 shows how the error in assuming the gain to be just ($-R_F/R_I$) varies with both frequency and R_I. It can be seen that the error is negligible only for low values of closed-loop gain and when the value of R_I is chosen to lie between 100Ω and 1MΩ.

Practical Considerations

The effects of supply rail ripple and noise can be minimised by decoupling each rail to earth close to the op-amp. It must be remembered that op-amps are wide-band devices, and the impedance of the supply lines at high frequencies can be critical. For this reason it is sensible to arrange that the resistance and inductance of the supplies is kept low, and that any large decoupling capacitor is bypassed by a suitable small capacitor.

Layout too needs some care. A very small degree of unwanted coupling between output and input can be enough to cause degraded circuit performance; even if oscillation is invisible on a scope, the circuit may still be oscillating at some high frequency.

Fet-Input Op-Amps

The 741 was the industry standard op-amp for many years. Recently, though, a new generation of devices have appeared which out-perform it in most respects. The breakthrough came when manufacturers discovered an efficient way of building op-amps which use matched field-effect transistors (FETs) in place of bipolar transistors in the input stage. Because of the mixture of bipolar and FET (or MOS) technologies on the same chip, such devices tend to be known as BIFET or BIMOS op-amps.

Field-effect transistors draw practically no input current. Their input resistance is thus almost infinite: a TL071 for example has a quoted input resistance of 1TΩ - that is, 1,000,000 MΩ! The corresponding bias current is a tiny 30pA. Unfortunately, the bias current is highly temperature-dependent; it increases by a factor of 10 for a temperature rise of 25 degrees C.

FET-input op-amps have other major advantages too. Their noise and distortion figures are often much better than those of bipolar devices, and they offer vastly better high-frequency performance. A TL071 has a full-power bandwidth 10 times greater than that of a 741, and it can slew more than 25 times faster than a 741.

Guidelines for Choosing an Op-Amp

Table 1 lists op-amps available in the Maplin catalogue, arranged in ascending order of price. The specifications for each parameter have all been expressed in the same units (for example, all offset currents are given in pA) to emphasise the differences between devices; for the same reason, the large signal gain figures are given in volts per millivolt instead of in dB.

The Table shows the clear superiority of BIFET and BIMOS op-amps over the earlier bipolar types. Input bias and offset currents are often ten thousand times smaller for the fet-input types, though offset voltages are much the same for both. The much greater full-power bandwidth figures for fet-input op-amps also mean less distortion, particularly at high frequencies.

Whilst op-amps packaged singly possess spare pins that can be used for offset nulling or external frequency compensation, dual and even quad devices allow a much higher PCB packing density. Most op-amp circuits use more than one device anyway, and it's cheaper to buy in bulk.

Op-amps are of course optimised for different applications.

Reference to the Table shows that:

CA3130E has the smallest bias and offset currents,

NE531 has the fastest slew rate,

LM592 has the highest unity-gain bandwidth and full-power bandwidth,

OP-27G has the smallest offset voltage,

OP-27G also has the highest large-signal gain and CMRR, and, not surprisingly,

μA741C is the cheapest. For how much longer, though?

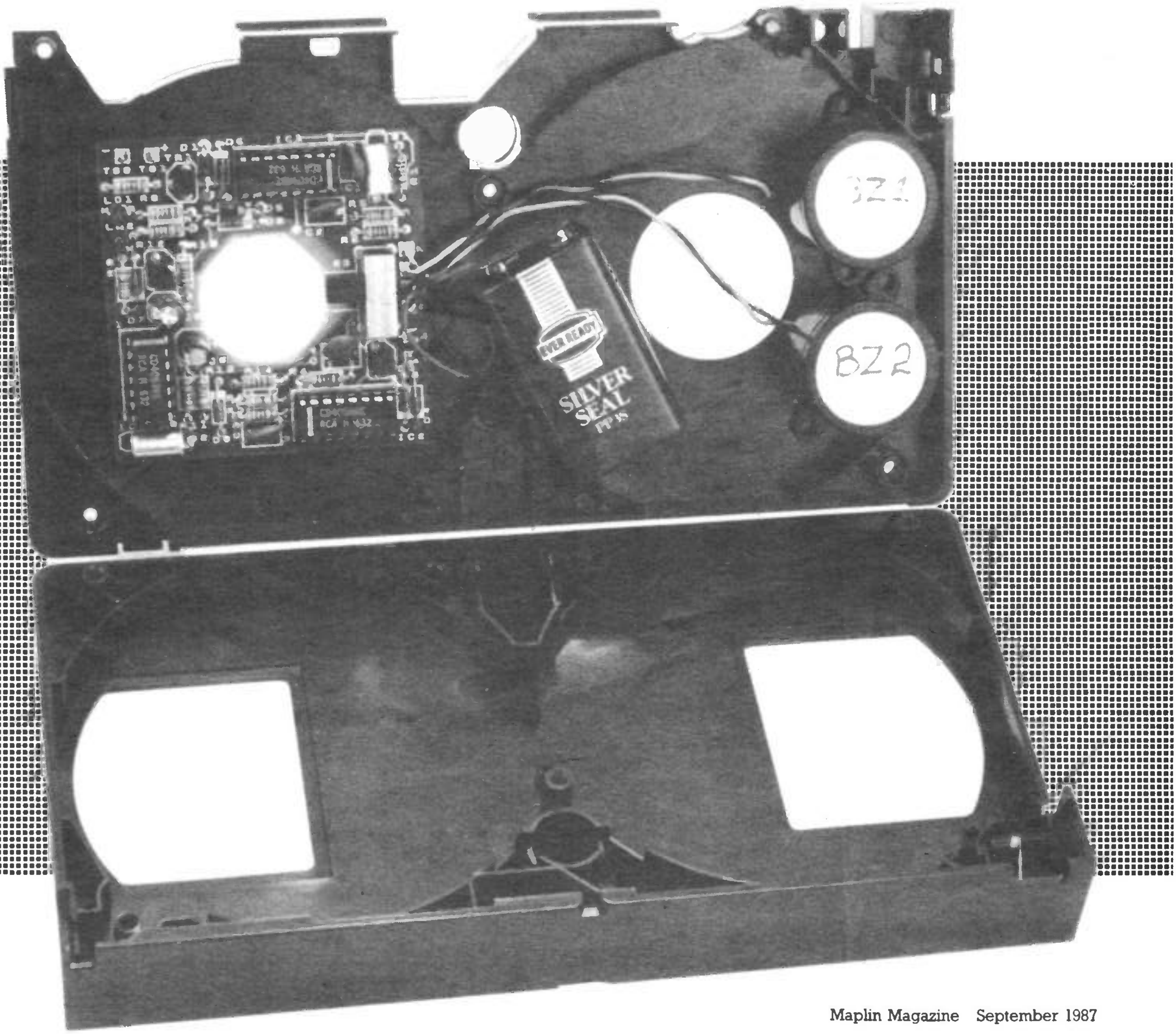
Device	Price (p)	Input Bias Current (pA)	Input Offset Current (pA)	Input Offset Voltage (mV)	Input Res. (Ω)	Large Signal Gain (V/mV)	Slew Rate (V/μs)	Unity Gain B/W (MHz)	Full Power B/W (kHz)	CMRR (dB)	Freq. Comp: Int/Ext	Optimised for:
Single:												
μA741C	18	200000	30000	1	1M	160	0.5	1	10	90	I	(GP)
LM301A	36	70000	3000	2	2M	160	0.4	1	10	90	E	(GP)
μA748C	40	120000	40000	1	800k	160	0.5	1	10	90	E	(GP)
TL081	44	30	5	5	1T	200	13	3	100	76	I	(GP)
μA709C	45	300	100000	2	250k	45	0.3	5	200	90	E	(GP)
TL071	46	30	5	3	1T	200	13	3	100	76	I	Noise
CA3140E	52	10	0.5	5	1.5T	100	9	4.5	100	90	I	(GP)
LF351	68	5	25	5	1T	100	13	4	100	100	I	Noise
LM308	86	1500	200	2	40M	320	0.2	1	10	100	E	I/P Current, Pwr
CA3130E	96	5	0.5	8	1.5T	320	10	15	100	90	E	(GP)
LF13741	120	50	10	5	500M	100	0.5	1	10	90	I	(GP)
LF441	125	10	5	1	1M	100	1	1	15	95	I	Power
NE5534A	135	500000	20000	0.5	100k	100	13	10	200	100	E	Noise
LM592	140	9E6	400000		4k	0.4		120	20000	86	E	Bandwidth
LF411	145	50	25	0.8	1T	200	15	4	100	100	E	Offset
OP07C	198	1800	800	0.06	3.3M	400	0.2	0.5	3.4	120	I	Offset, Noise
NE531	220	400000	50000	2	20M	63	35	1	500	100	E	Bandwidth
OP27G	320	15000	12000	0.03	4M	1400	2.8	8	34	120	I	O/S, Noise, B/W
LH0042C	995	15	2	6	1T	100	3	1	40	80	I	Offset, Noise
Dual:												
1458C	40	200000	80000	1	1M	160	0.5	1	10	90	I	(GP)
μA747C	69	200000	80000	1	1M	160	0.5	1	10	90	I	(GP)
TL082	62	30	5	5	1T	200	13	3	100	76	I	(GP)
TL072	80	30	5	3	1T	200	13	3	100	76	I	Noise
LF353	100	50	25	5	1T	100	13	4	100	100	I	Noise
CA3240E	115	10	0.5	5	1.5T	100	9	4.5	100	90	I	(GP)
LM833	145	500000	10000	0.3		320	7	9	120	100	I	Noise
NE5532	170	200000	10000	0.5	300k	100	9	10	140	100	I	Noise
LF442	195	10	5	1	1T	100	1	1	15	95	I	Offset, Power
LF412	275	50	25	1	1T	200	15	4	100	100	I	Offset
Quad:												
LM324	50	45000	5000	2		100	0.5	1	15	70	I	(GP)
3403	95	150000	30000	2		100	1.2	1	40	90	I	Bandwidth
4136	98	40000	5000	0.5	5M	320	1	3	25	100	I	Noise
TL064	100	30	5	3	1T	6	3.5	1	30	76	I	Power
TL084	115	30	5	5	1T	200	13	3	100	76	I	(GP)
TL074	125	30	5	3	1T	200	13	3	100	76	I	Noise
LF347	135	50	25	5	1T	100	13	4	100	100	I	Noise
LF444	325	10	5	3	1T	100	1	1	15	95	I	Power

Table 1. Op-amp comparison Chart.

VHS VIDEO RECORDER ALARM

by Dave Goodman

★ Protect your Video Player.
★ Includes Alarm set-up Delay.
★ Blank Case included.
★ Simple construction.



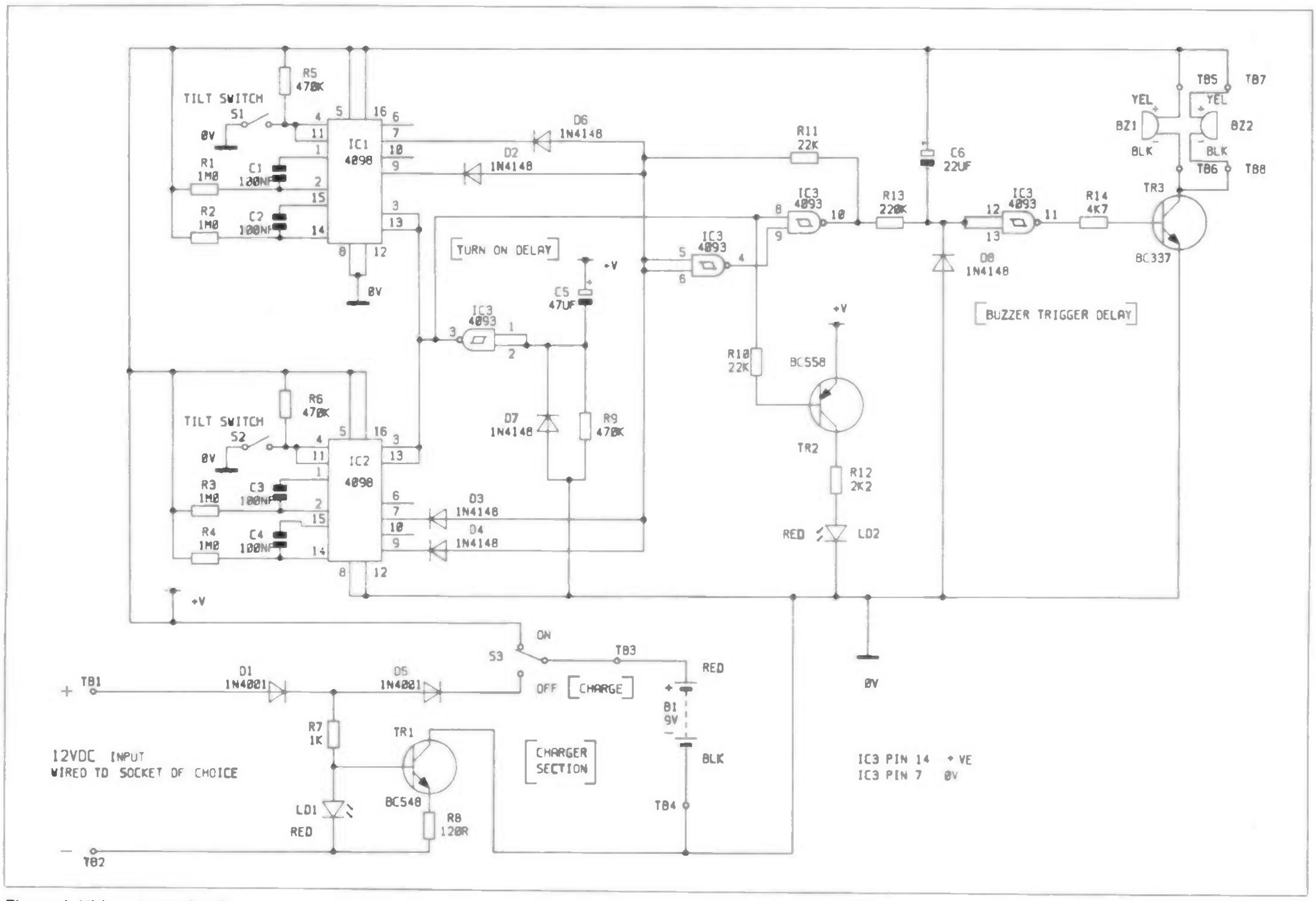
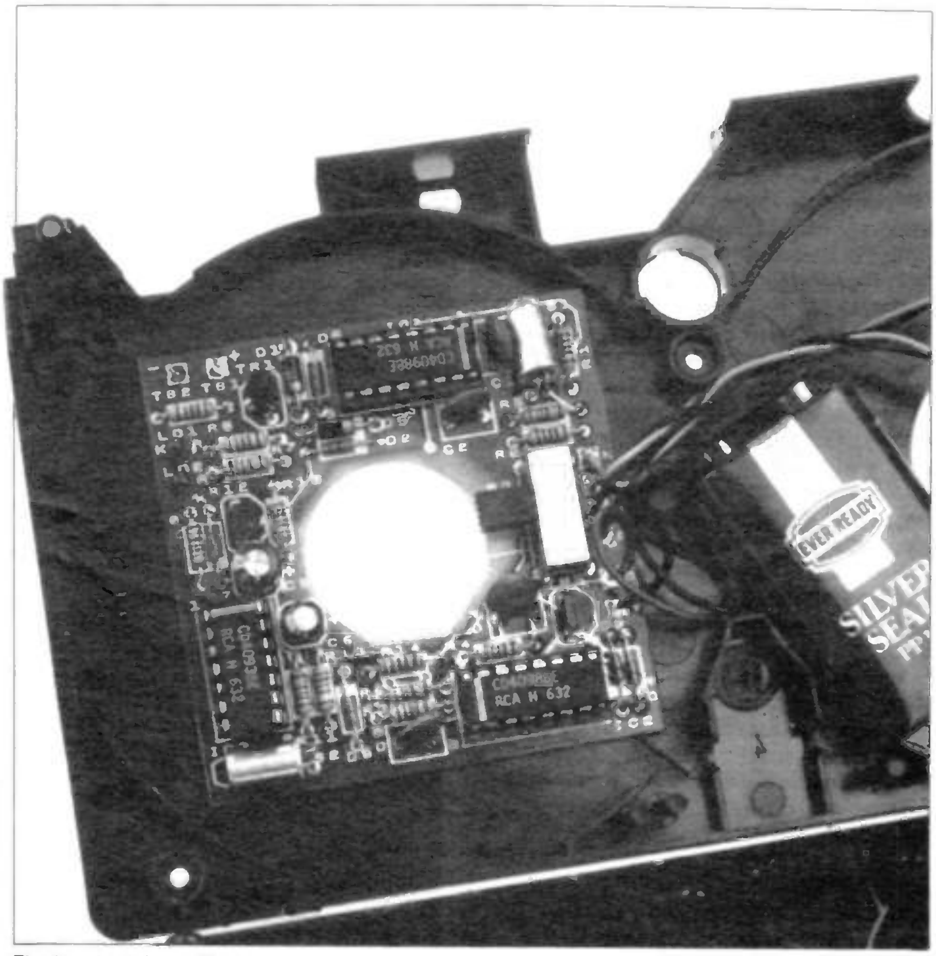


Figure 1. Video alarm circuit.

Described here is a portable, self-contained, alarm system disguised as a video cassette tape which detects movement from any pre-determined position. The cassette can be inserted into front or top loader VHS video players and will give an audible warning if the machine is moved or the cassette ejected. In addition, the cassette could be placed on top of a Video, TV or Hi-Fi or mixed with other tapes in a library situation and indeed in any position where a video cassette will not appear obtrusively 'out of place'.

The module is powered by 9V PP3 type batteries, either dry-cell or nicad types may be used. In case a nicad battery is fitted, the module has a constant current charger (approximately 10mA) circuit included which requires a separate 12/15V DC supply for re-charging the battery in-situ. With the addition of a case mounted socket wired to the charging circuits, the nicad can be re-charged at any time without taking the cassette apart, as would be the case when using dry cells. Ordinary battery life expectancy should be quite long, and when 'armed' the module's quiescent current is some 0.00002A (20μA) at 9V DC.

When the module is first switched 'on' an LED lights for approximately 10-12 seconds, this being the 'arm delay' time-out period. After this time, the LED extinguishes and the system is 'armed' for detecting movement. When moved, the module delays the alarm sounders for approximately 6 seconds and then triggers two electronic buzzers, which will sound continuously until either the module is switched off, or the battery supply runs down.



The Alarm pcb in position.

Operating Principle

Movement detection using mercury tilt switches relies on a 'make' or 'break' operation which limits the device to a single plane of movement in one direction only. The device could only be used by correct positioning to begin with! For a portable alarm system, the criteria for movement detection has to be for 360° rotation in all directions no matter where the device is placed, or at what angle. To achieve this effect, two tilt switches are used, one operating vertically and the other operating horizontally. By sensing a change of state from either sensor, rather than looking for make or break action alone, the system may be placed at any angle at the outset and movement from this position into a different plane can then be detected. Such a system can be made quite precise by accurately positioning the sensors, or less sensitive just by altering the incidence angle to suit requirements.

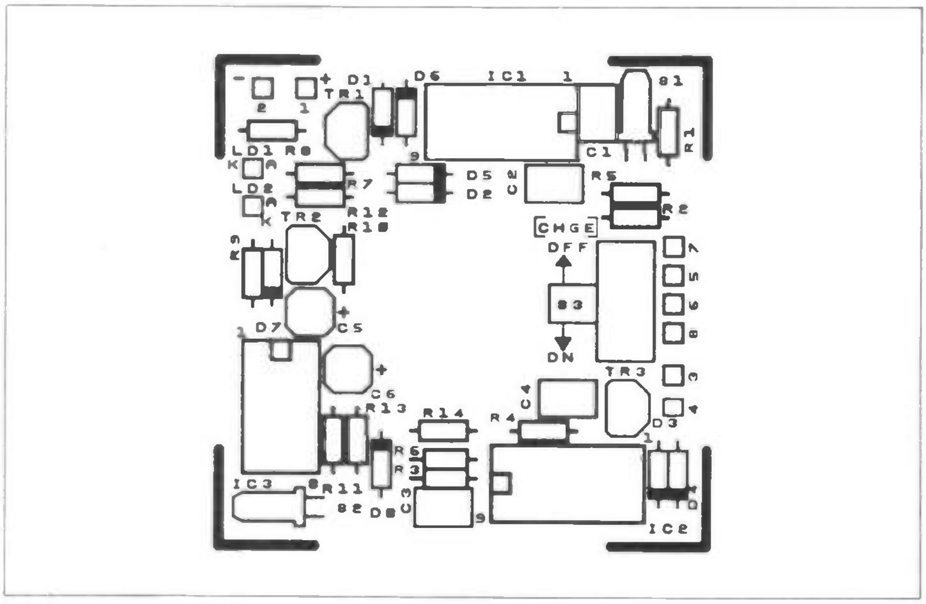


Figure 2. PCB layout.

How It Works

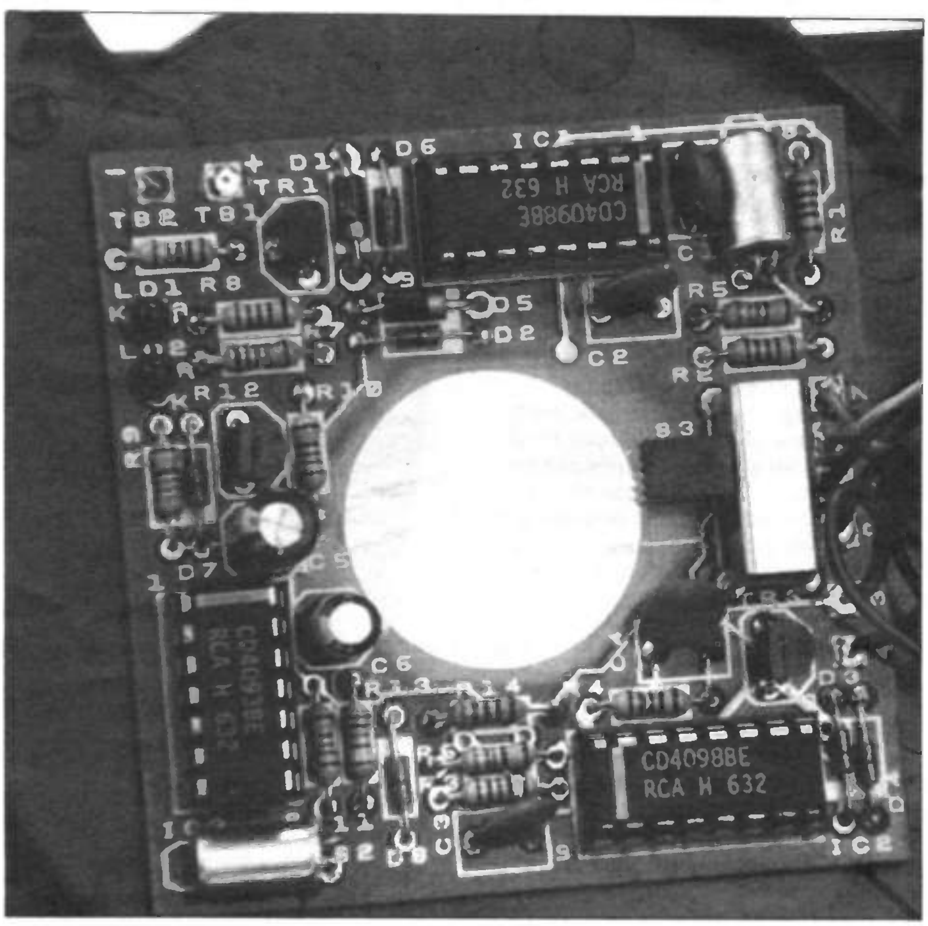
The two tilt switch sensors are shown in Figure 1 as S1 and S2, and each triggers a dual monostable, IC1 and IC2. IC1 has two monostables contained within the package, one of which is configured for positive edge triggering and the other is configured for negative edge triggering. Both trigger inputs are commoned at pins 4 and 11, and held high by R5. Triggering on the negative edge occurs upon S1 closing, and on the positive edge on S1 opening. Timing components R1 and C1 (R2, C2) determine the width of the triggered pulses which are output to D2 or D6 from IC1 pins 7 and 9 (IC2 and S2 circuitry is identical to IC1).

The four diodes D2, 3, 4 and 6 serve as a simple logic OR gate to trigger the latch formed around IC3. When a switch is activated, negative going trigger pulses, output from IC1/IC2, forward bias one of the OR gate diodes from R11. IC3 input pins 5 and 6 drop towards 0V, while pin 4 (connected to pin 9 of a second NAND gate input) goes high. Providing pin 8 on this gate is also high, the output from pin 10 goes low.

The feedback resistor R11 connected between pin 10 and the latch input gate will hold the LATCH in this new state until power is removed. A turn on delay is included for two reasons. Firstly, to prevent instant triggering when the power is switched on and secondly, to allow the user time enough to install the unit into a Video Player. At power on, capacitor C5 holds the inverter input pins 1 and 2 high while charging via R9. The inverter output pin 3 remains low at this time preventing IC1 and IC2 from being triggered and also disabling the latch. TR2 conducts and LED2 illuminates.

As C5 continues to charge up, current through R9 gradually decreases and hence the potential across R9 also decreases until the trigger threshold of the inverter is reached. The full CR time of a 47μF capacitor and a 470k resistor is some 22 seconds, but after 10 seconds, the inverter output snaps high thus enabling IC1/2, the latch circuitry, and turns off LED2. When triggered, IC3 pin 10 goes low and capacitor C6 discharges through R13, and the voltage at inverter input pins 12 and 13 slowly drops. This timing circuit allows a short, five second delay before the buzzers are activated, in other words while ejecting the unit from a Video and switching off the power. The buzzers, BZ1 and BZ2 are used for loud output and modulating tone. Sound output level will inevitably be reduced when the unit is inside a Video Player, but is quite loud in open air.

If rechargeable PP3 batteries are to be used for the supply, then it is convenient to be able to re-charge them in-situ. This can only be performed with the 'power-on' switch S3 in the 'off' position, and the alarm becomes inoperative while charging. A 12 to 15V DC supply connected to pin 1 and pin 2 operates LED1, and charging current flowing through the battery via S3 and TR1 collector is determined by R8. LED1 will not come on for a supply voltage of less than 12V, and at 15V will give maximum illumination. Some unregulated supplies may produce 15 to 18V, but this is not a problem as R8 determines a constant current of 10 to 12mA, suitable for nicad charging. D5 prevents the battery from discharging through R7 and TR1, with external supply removed, and D1 prevents reverse supply connections from damaging the generator and battery.



Centre the pcb so that it fits over the video player spindle.

Construction

Refer to the constructor's guide supplied in the kit for component recognition and assembly techniques. Space on the PCB (Figure 2) is very tight and components should be mounted neatly and flat onto the board. LED1 and 2 should be pushed home as far as possible and not left standing up above the board. Take note of polarity markings on electrolytic capacitors and diodes, and do not fit sensors S1 or S2 at this stage. As the PCB is double-sided, all holes are therefore plated through, so before soldering components, re-check your work as errors are very difficult to correct on this type of board. IC holders must be fitted also!

Carefully solder all component leads and cut off the excess wire ends close to the board, *without damaging tracks while doing so.* Clean excess flux and solder splashes with a suitable PCB cleaner and inspect the module.

Refer to Figure 3 for sensor mounting. Insert the sensor leads and leave a clearance between sensor base and PCB of 5mm. Solder both leads and gently bend the sensor back over the legend ensuring that the metal case *does not short out on any lead.* As contact within the sensor is made by liquid mercury bridging internal contacts, S1 and S2 should be angled for more than (or less than) 20° to ensure fully open, or closed, contacts - whichever is required (see Figures 4 and 5).

Mounting the sensors horizontally flat onto the board will make the switches over sensitive to the slightest vibration, which, apart from being as desirable as it may seem, may actually lead to all sorts of false triggering problems. If the sensor is left standing vertically as in Figure 3, then it can be appreciated that a far greater degree of rotation is required to break contact. Therefore, adjust the sensor between 0 and 90° for best results. Manufacturers data recommends 20° movement for activation.

Take the PP3 battery clip and cut the wires to a length of 6cm. Strip and tin 2mm from the ends and insert the black wire (negative) into PCB pin 4 and red wire (positive) into pin 3, as shown in Figure 6.

Do not reduce the length of the wires for each buzzer. Fit the yellow wire of one buzzer (BZ1) into pin 5, and the black wire into pin 6 of the PCB. For the second buzzer (BZ2), fit the yellow wire to pin 7 and the black wire to pin 8. Place the power switch, S3, into the OFF (charge) position.

Testing

Lay the completed module, component side up, onto a non-conducting surface with both buzzers standing upright. Connect a PP3 battery to the clip and switch on by placing S3 in the ON position. LED2 should glow brightly. If it is dim then LED2 and LED1 may be reversed. LED2 is a high brightness device and should not be replaced with standard mini LED's. After approximately 10 seconds, LED2 will extinguish; the module is now armed. Do not move the module for a minute or so and ensure that the buzzers are not activated. Now move the module and after approximately 6 seconds the buzzers will sound continuously. LED2 does not operate during the trigger delay period, only during the turn on delay period. If all is well, adjust the sensors S1 and S2 for required movement detection and install the module into the blank case.

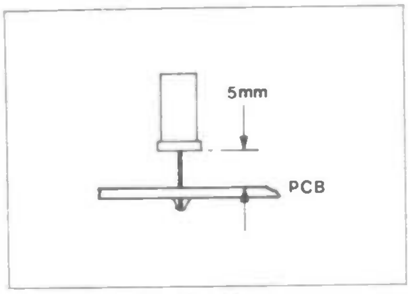


Figure 3. Mounting tilt switches.

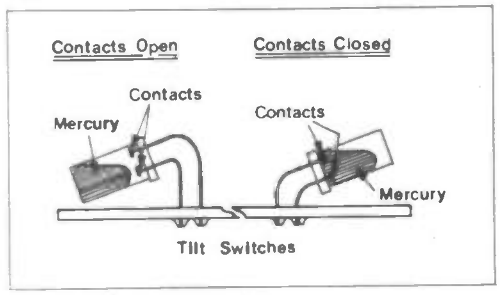


Figure 5. Tilt switch operation.

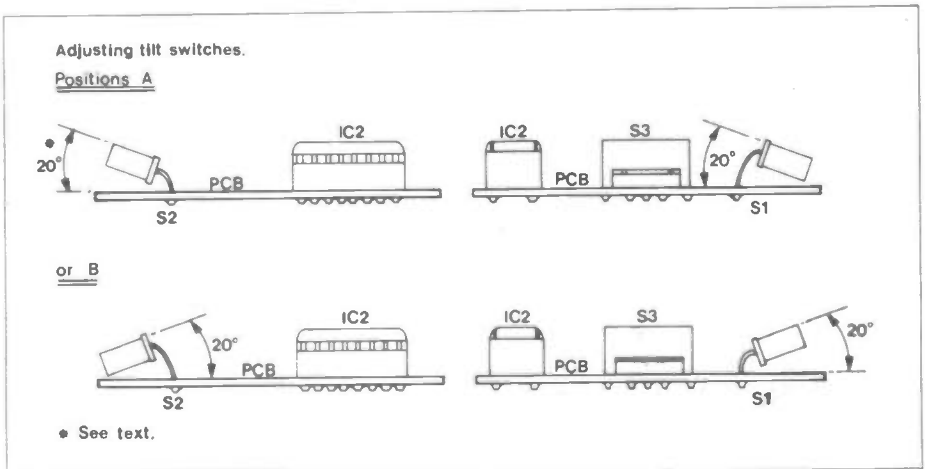


Figure 4. Adjusting tilt switches.

Case Assembly

Refer to Figure 7 and Figure 8. Place the blank video cassette case bottom up and remove the five screws with a small Philips/Pozi-drive screwdriver. Carefully separate both halves of the case, taking care not to lose the return spring fitted onto the front flap. Place the top section (large D shaped cut-outs) to one side, and position the base section as in Figure 8.

Mount four double-sided sticky pads around the spindle hole (left-hand side), remove the four paper strips from the pads and carefully place the PCB into position. The hole in the PCB must be placed centrally over

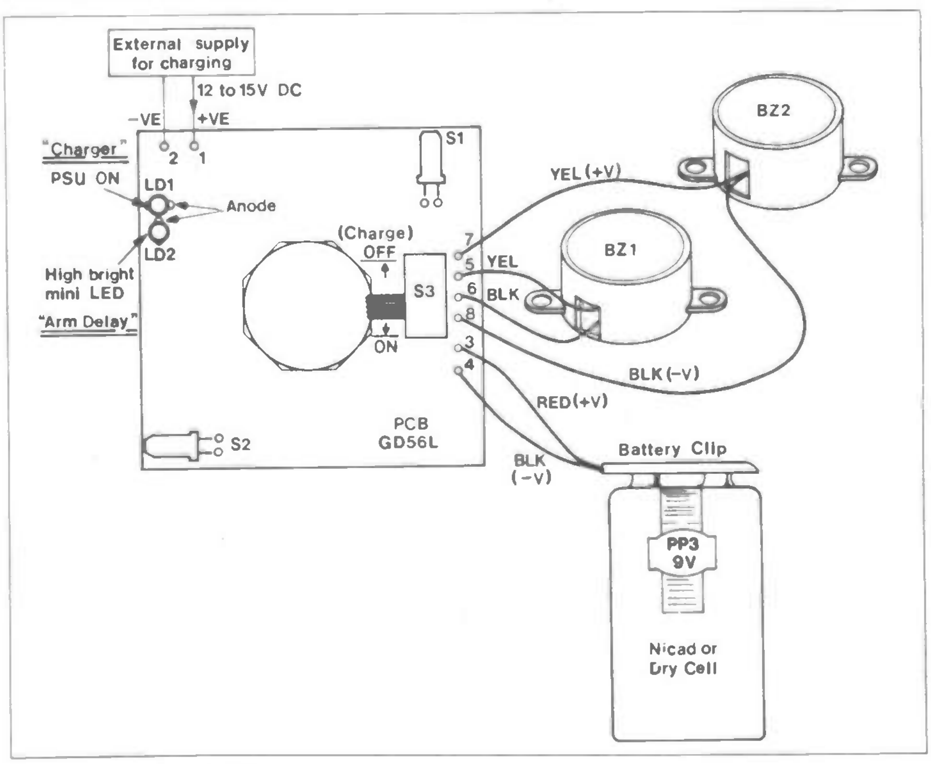
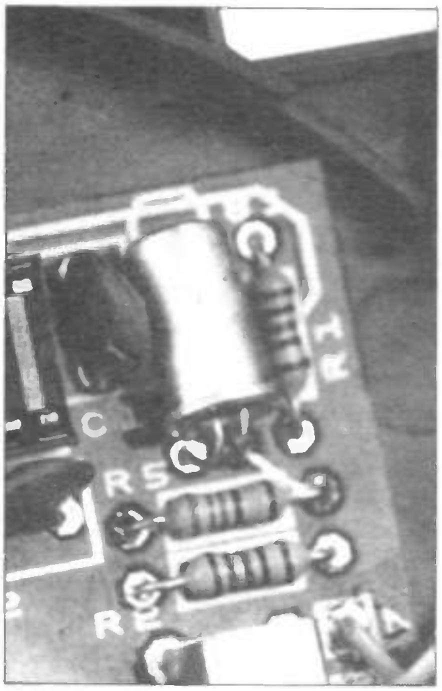


Figure 6. Connections to PCB.



A mercury switch.

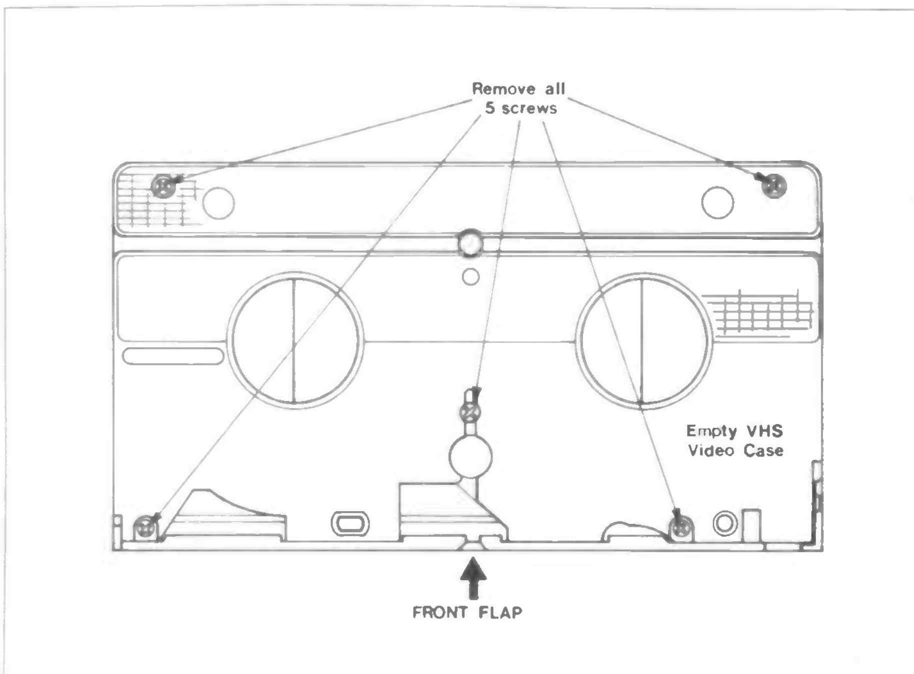


Figure 7. Opening the Video Case.

the hole in the case, otherwise the video drive spindle will foul on the board and may jam inside the machine! Final position of the board should be approximately 15mm from the inside edge of the case. Figure 8 also shows the PCB hole centred on the case hole with 5mm between edges. Press the PCB down onto the four pads to ensure good grip.

Position the two buzzers as shown ensuring the connecting wires *do not* cross over the spindle hole (for the reasons just mentioned), and use sticky pads to hold them in place. The battery should be placed in a position where it does not overlap the hole and this too is held with a sticky pad. If you require re-charge facilities, then fit a socket suitable to take your supply plug into the case at this stage. Many battery eliminator supplies have multiple plug connectors from 2.1, 2.5 to 3.5mm sockets. Use the smallest possible socket and fit it into the position shown above PCB pins 1 and 2 on Figure 8. *Do not* allow too much of the socket to protrude through the case as the majority of video machines usually have a vertical guide in this area! Suitable sockets can found in the 'connectors' section of the Maplin catalogue, if required. Re-assemble the case halves and replace the five screws.

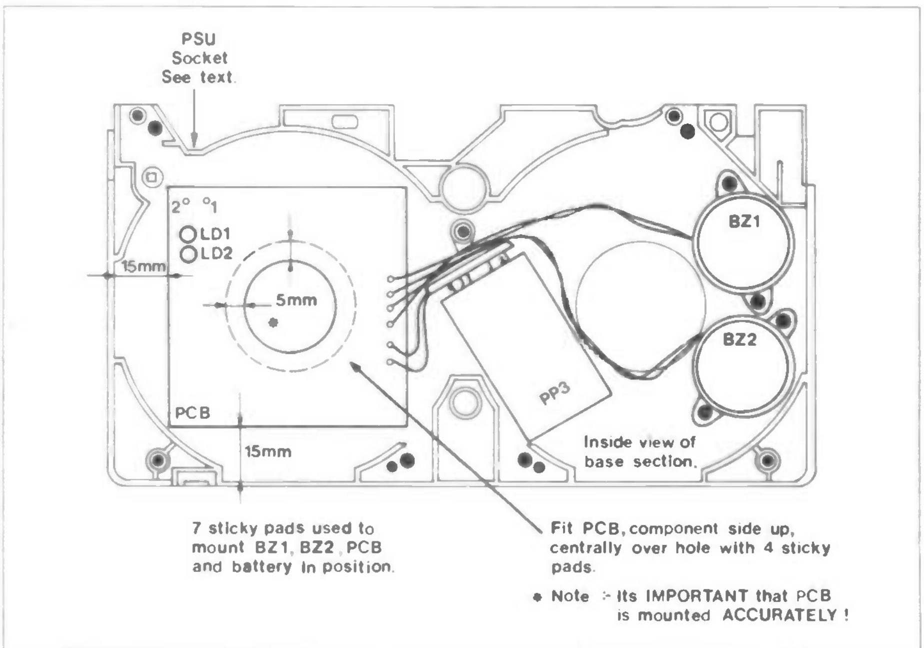


Figure 8. Video alarm assembly.

Using the Alarm

Powering up the alarm is achieved by inserting a finger through the base hole and the PCB. The unit is not automatically switched on when inserted into a Video. During turn on delay, insert the cassette into a Video Player. If the cassette is immediately rejected, check the recording tabs are intact on the back edge of the box and replace with tape if they have been broken. If the alarm continuously triggers after timing out, then sensors S1 and S2 may need further adjustment. Any attempt to move the Video Player or eject the cassette, once it has been armed, will trigger the sounders after a few seconds. Alternatively, the cassette can be placed in a sleeve and left on top of a cassette library or a TV or wherever it is not likely to look out of place, giving other security uses.

Activating the unit is a simple task.

VHS VIDEO ALARM PARTS LIST

RESISTORS: All 0.6W 1% Metal Film

R1,2,3,4	1M	4	(M1M)
R5,6,9	470k	3	(M470K)
R7	1k	1	(M1K)
R8	120Ω	1	(M120R)
R10,11	22k	2	(M22K)
R12	2k2	1	(M2K2)
R13	220k	1	(M220K)
R14	4k7	1	(M4K7)

CAPACITORS

C1,2,3,4	100nF Minidisc	4	(YR75S)
C5	47μF 25V P.C. Electrolytic	1	(FF08J)
C6	22μF 16V P.C. Electrolytic	1	(FF06G)

SEMICONDUCTORS

IC1,2	4098BE	2	(QX29G)
IC3	4093BE	1	(QW53H)
LD1	Red LED Mini	1	(WL32K)
LD2	Red LED Hi Bright	1	(WL83E)
TR1	BC548	1	(QB73Q)
TR2	BC558	1	(QQ17T)
TR3	BC337	1	(QB68Y)
D1,5	1N4001	2	(QL73Q)
D2,3,4,6,7,8	1N4148	6	(QL80B)

MISCELLANEOUS

BZ1,2	Buzzer	2	(FK83E)
S1,2	Tilt Switch	2	(FE11M)
S3	R/A SPST slide	1	(FV01B)
	P.C. Board	1	(GD56L)
	Vero Pin 2145	1 Pkt.	(FL24B)
	PP3 Battery Clip	1	(HF28F)
	Quickstick Pads	1 Strip	(HB22Y)
	DIL Skt 14-Pin	1	(BL18U)
	DIL Skt 16-Pin	2	(BL19V)
	VHS Video Case (blank)	1	(YP27E)
	Constructors Guide	1	(XH79L)

OPTIONAL

	PP3 Battery	1	(FK62S)
	PP3 Ni-Cad Battery	1	(HW31J)
	Power Socket	If req.	*see text*

A complete kit of all parts, excluding optional items, is available for this project:
Order As LM27E (VHS Video Alarm Kit) Price £11.95
The following items included in the above kit list are also available separately, but are not shown in the 1987 catalogue:
Printed Circuit Board **Order As GD56L Price £3.95**
Blank VHS Video Case **Order As YP27E Price £1.50**

TOP TWENTY BOOKS

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2. (2) MIDI Projects, by R.A. Penfold. (WP49D) Cat. P61.
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4. (4) International Transistor Equivalents Guide, by Adrian Michaels. (WG30H) Cat. P52.
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10. (14) How to Design and Make Your Own PCB's, by R.A. Penfold. (WK63T) Cat. P55.
11. (12) Practical Electronic Calculations & Formulæ, by F.A. Wilson. (RQ23A) Cat. P53.
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14. (19) Easy Add-on Projects for Commodore 64, VIC-20, BBC Micro & Acorn Electron, by Owen Bishop (WP29G) Cat P70.
15. (5) Introduction to Electronics, by Pam Beasant. (WP50E) Cat. P55.
16. (17) 50 Simple LED Circuits Book 2, by R.N. Soar. (WG43W) Cat. P59.
17. (18) Audio Projects, by F.G. Rayer. (WG46A) Cat. P59.
18. (13) How to Use Op-amps, by E.A. Parr. (WA29G) Cat. P54.
19. (–) Micro Interfacing Circuits Book 1, by R.A. Penfold (WM79L) Cat. P64.
20. (–) Electronic Household Projects, by R.A. Penfold (XW44X) Cat. P56.

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HYBRID OSCILLOSCOPE Philps PM3230 dual channel, complete with manual and Maplin probe kit. £100. Redruth, Cornwall 0209 821463.

BI-PRE-PAK Mk II television crosshatch generator with instructions and circuit. £10 plus postage & packing. R.M. 44 Blackshaw Drive, Buttershaw, Bradford, West Yorkshire BD6 2AY.

CHANGING HOBBY hundreds of new and used components for sale. Resistors, caps, opto devices, all sorts of IC's, transistors, etc. Contact Pete (0382) 738089 after 6p.m.

COPPER CLAD BOARD approximately 300 pieces, mainly 6in x 3in, mainly double-sided, fibre-glass base, £100, will separate/swap for test equipment/hand tools, can deliver within 70 miles. Portsmouth. Mike (0705) 697-258.

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HC1400 2m FM Tx/Rx £100. JR599CS, £100. Icom IC2E c/w case, speaker/mic. and base charger, £120. DX160, £60. Regency Scanner, £80. All o.n.o. contact Phill, 0742 420650.

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VIC 20 PERSONAL COMPUTER with manuals and data recorder, £35. D. Egerton, 42 Beech Ave, Greenacres, Oldham, Lancs. OL4 2EE.

MAXELL SSDD 5.25in. disks, box of 10, brand new, formatted for BBC, £8. M.J. Edmonds, Richings Cottage, East End, Fairford, Gloucestershire, GL7 4AP.

ATARI 520ST both B/W and colour monitors, dual drives, voltage regulator, 'C', assembler, BASIC and logo languages. A number of technical/reference books, ideal for educational/development purposes, excellent condition. Worth over £1200. Will accept £1000 o.n.o. G.T. Hindmarsh, 38 Totteridge Road, High Wycombe, Bucks.

1541 DISC DRIVE latest model, unused, cost £200, offers or swap for electronic video. Also unused, Commodore sound sampler disk version, offers? Mr. Simon Parker, Tel: 494 2087 (Manchester).

ZX81 I/O PORT 16K RAM pack. Both unboxed. £15 or offers. Please inquire to John Scullard, 12 Higher Holcumbe Close, Teignmouth, South Devon, TQ14 8RE.

QL 512K RAM Miracle Systems. Makers' packing, £80. Tarbell blank S100 cards, highest quality, gold plated contacts. £15 each (four available - £50 all four). Prices include postage. Porthtowan (0209) 890688.

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BRAND NEW 150W guitar amplifier kit, £50. For details please send SAE to Peter Burch, 'Woodhaye', Ivybridge, Near Plymouth, Devon, PL21 0AH.

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5600S SYNTH first offer over £125 secures. Unfinished project in case with metal work and most boards. Will deliver. Tel: Norwich (0603) 665388 after 5pm.

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WANTED KEYBOARD FRAME for matinee organ. Offers to: Mr. E.E. Matthews, 63 The Oval, Otley, West Yorkshire, LS21 2EE.

SOFTWARE FOR 16K ZX81 wanted, also require printer, books, etc. Please contact Ian, 01-505-6336. Will collect.

RETIRED ELECTRO-MECH. engineer wishes to aquire geiger tubes or complete wartime units for experimentation. Please contact K.M. Twamley, 25 Davena Drive, Wedley Castle, Birmingham B29 5UL.

ELECTRONIC IGNITION AUTO-ADVANCE circuit diagram wanted, or details of electronic advance/retard system to replace mechanical system. Vehicle is twin cyl. 4-stroke motorcycle. Contact A.G. Witham, 21 Whitehouse Road, Sheffield, S6 2WB.

YASHICA FR instruction manual wanted for copying, will return plus postage. L. Stewart, 23 Strode Road, Wolverhampton, WV2 3ES.

WANTED CIRCUIT DIAGRAMS for Newbrain motherboard and power supply. Write to S.B. Temple, 9 Elton Road, Sale, Cheshire, M33 4LA.

WANTED CONNECTION DETAILS demos, programs etc for Maplin video digitiser and Atari 800xl. Please contact Simon Brownlee, 9 Canterbury Road, Farnborough, Hants. GU14 6NS.

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£10 REWARD for a copy of the Maplin Matinee organ construction manual or copies of E & MM which covered the project. Can be photocopied. Tel: 04024 40420 or 0836 704438.

LOAN OR BUY instructions manual for printer Epson FX80. Please contact on Tel: 0533 730710.

WANTED DRAGON 64K or Tandy TRS80 64K info on where to buy games for these two computers. Contact Kevin Sheppard, 22 Crayford Road, Alwaston, Derby.

WANTED ELECTRONICS The Maplin Magazine issues 13, 14, 15. Contact A. Johnson, 48A Leggatts Wood Avenue, North Watford, Herts., WD2 5RP. Tel:(0923) 51102 evenings.

MAPLIN LEAFLET XH59P 600-note sequencer, and Electronics - The Maplin Magazine issue 2 (NOT the project book). I urgently need one copy of each of these to replace lost copies and will pay £5 for the first clean and complete copy of each to arrive here. Send to D. Parsons, 62 Mill Lane, Woodhall Spa, Lincs. LN10 6QZ.

WANTED KIND PERSON with EPROM programmer (in Grimsby area) to program a 2K CMOS EPROM. Please contact Rhonda on Immingham 75345 between 10am and 5pm. (P.S. I'm broke).

WANTED MAINS ADAPTOR for Dragon 32 or details of the adaptor. A. Beecroft, 91B Dowell Close, Taunton, Somerset, TA2 6AU.

SERVICE MANUALS FOR SONY C6 and C7 video recorders wanted. Reply to G.E. Curzon, 11 Grizedale Close, Keswick, Cumbria. Tel: Keswick 74526.

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