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MARCH TO MAY 1986

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March to May 1986
Volume 5 Number 18

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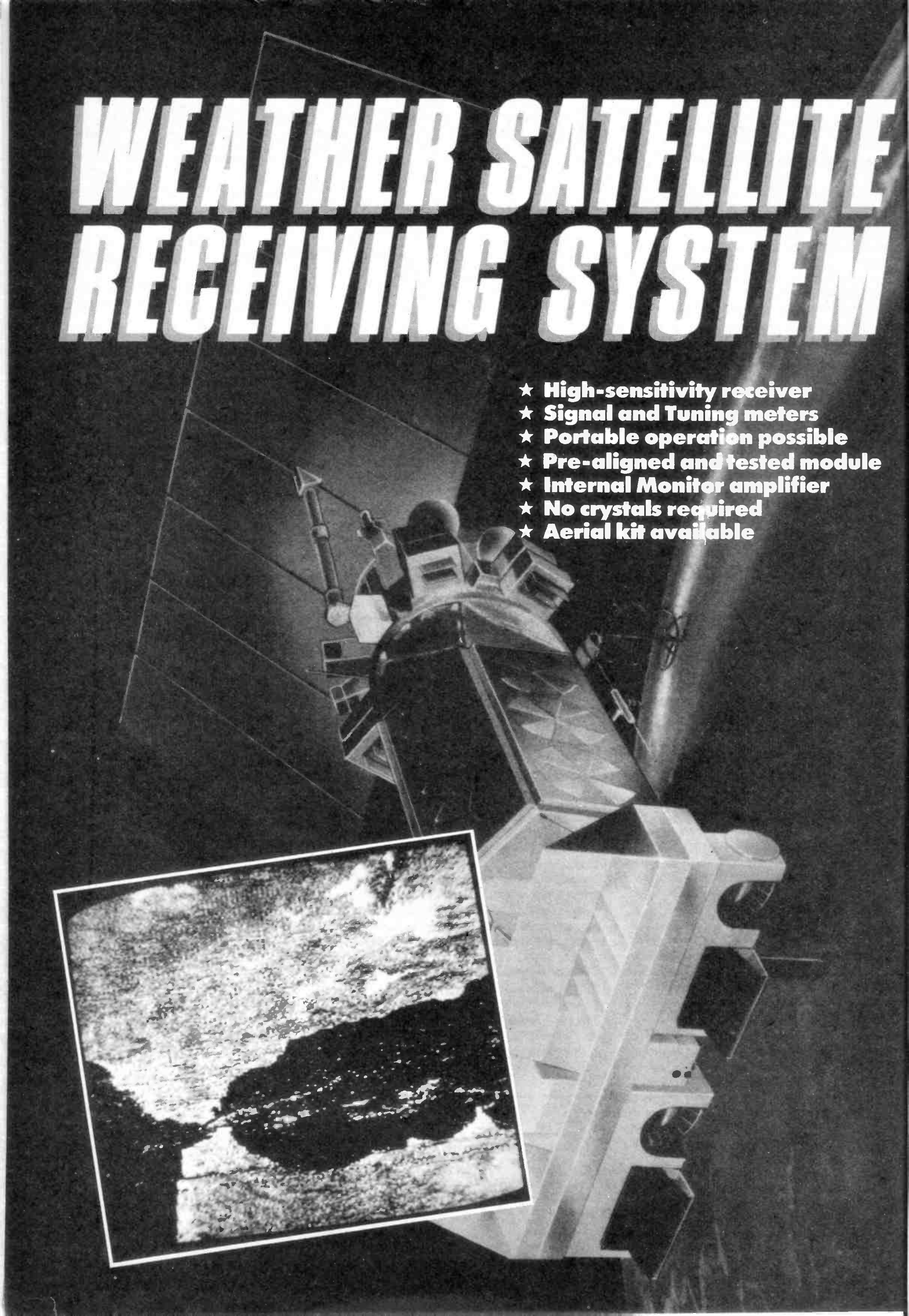

WEATHER SATELLITE RECEIVING SYSTEM
★ High-sensitivity receiver
★ Signal and Tuning meters
★ Portable operation possible
★ Pre-aligned and tested module
★ Internal Monitor amplifier
★ No crystals required
★ Aerial kit available


**by Robert Kirsch Part 1**

The idea of looking down upon the world from space appeals to many people. With the aid of Weather Satellites and the receiving system described in this series, it is possible to receive and display pictures of cloud formations, weather systems and land masses from many of the orbiting weather satellites that transmit in the 137-138MHz band.

This article describes the receiver, aerial and storage system to be followed by the Decoder and Frame Store. Pictures from the decoder may be displayed either by using the Frame Store, which is connected to an ordinary television or monitor, or by using a suitable home computer such as the BBC B or Amstrad.

**Opposite page: TIROS-N in orbit (Inset: The Straits of Gibraltar)**

The prototype system, when used with a fixed aerial of the type described later in this article, has regularly received pictures from as far away as North Africa to the South, and Iceland and Norway to the North.

| FREQUENCY | SATELLITE | APPROX TIME (ENGLAND) |
|---|---|---|
| 137 | MET 30 | 1015 – 1145 |
| | METEOR & COSMOS | VARIOUS |
| 137·5 | NOAA 6 | 0530–0730<br>1800–2000 |
| | NOAA 9 | 0000–0200<br>1230–1430 |
| | METEOR | VARIOUS |
| 138 | | |

**Receiving Times**

There are several satellites regularly orbiting the Earth and sending picture information both in the visible and infra-red spectrum, most of which can be decoded by the MAPSAT system. Satellites that are easily received in this country include the American TIROS-N series (NOAA 6 and 9) see Figure 1, and the Russian Meteor and Cosmos satellites. These satellites orbit the Earth roughly every 100 minutes but, due to the rotation of the Earth, a satellite travelling in a roughly north/south orbit will cross the equator 25 degrees further west on each orbit, thus enabling the whole of the Earth's surface to be covered. Due to this effect, a satellite of this type will only pass within usable range two or three times every 12 hours, making it

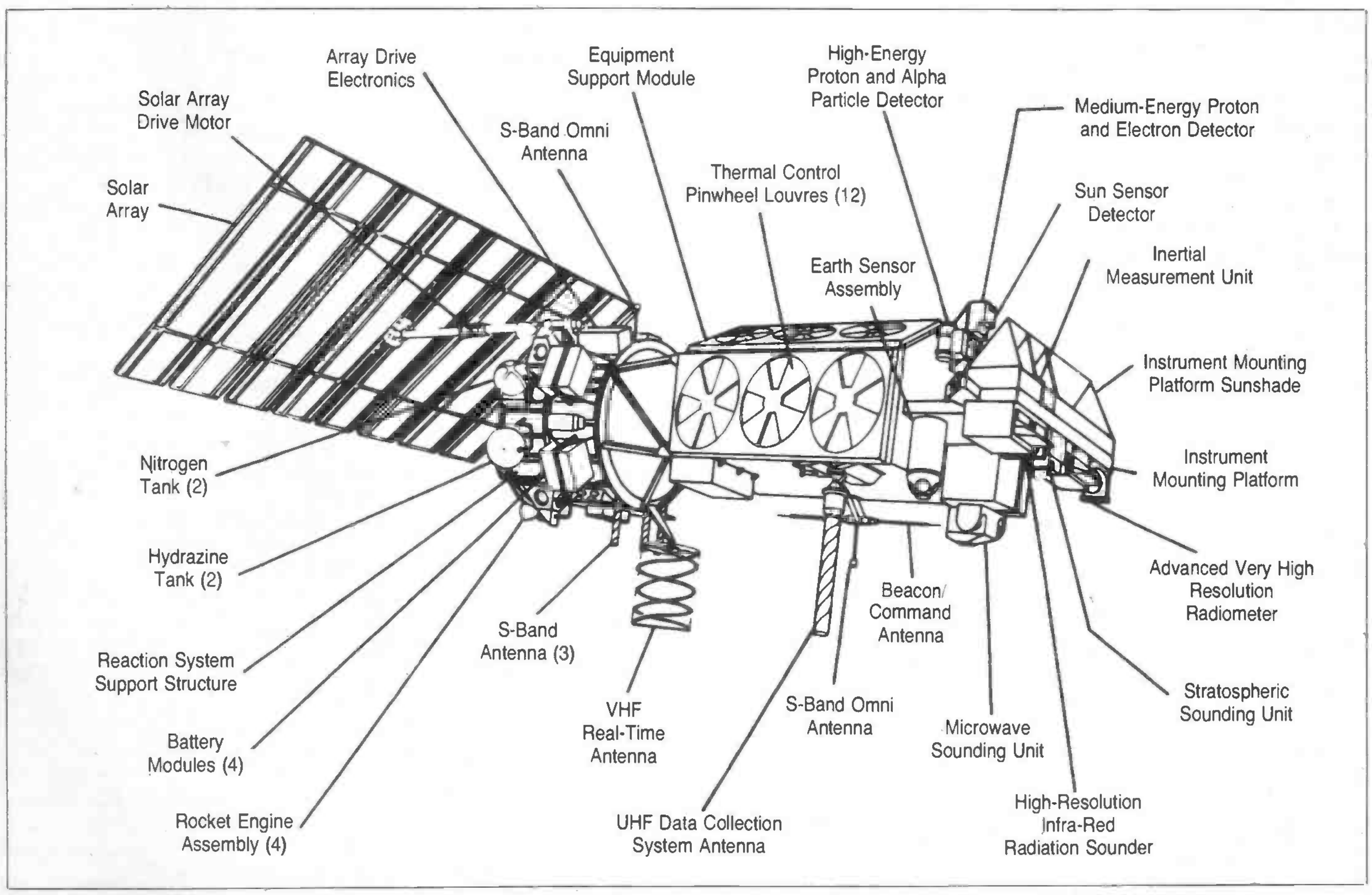



**Figure 1. TIROS-N Satellite**

necessary to refer to a prediction chart to enable a particular satellite to be received. Prediction charts for NOAA 6 and 9 and any other satellites for which data is available will be published in future editions of Electronics. The receiving system can also be used to receive geostationary weather satellites such as METEOSAT, by using a down converter with a suitable aerial system.

## The Complete System

Figure 2 shows a block diagram of the complete receiving, storage, decoding and display system. Incoming signals from the receiver are normally stored on tape before decoding, although it is possible to decode and display pictures as they are received immediately. Once stored on tape, a picture can be decoded at leisure and several runs can be made with various settings of the decoder to obtain the best results. The receiver, block schematic shown in Figure 3, includes interfacing for a standard mono or stereo cassette recorder via a DIN socket. A monitor amplifier is also provided that can be switched to the tape playback and decoder monitor points as well as receiver's output. The decoder is connected to the receiver by a DIN connector lead, and the decoder also provides 12 volts DC to supply the receiver. Connection to a computer or the Frame Store is made via a fifteen way D-range plug. The decoder also contains the mains power unit and a VU meter for setting the levels out of the tape system. The receiver may be run from any 12-14 volt supply such as a car battery or mains unregulated power supply (e.g. XX09K), in the absence of the decoder. Provision is also made to run the receiver from internal batteries for portable operation. This enables the receiver to be used outdoors in conjunction with a portable tape recorder and a directional aerial for tracking satellites, by using the SIGNAL meter to obtain maximum strength whilst aiming the aerial.

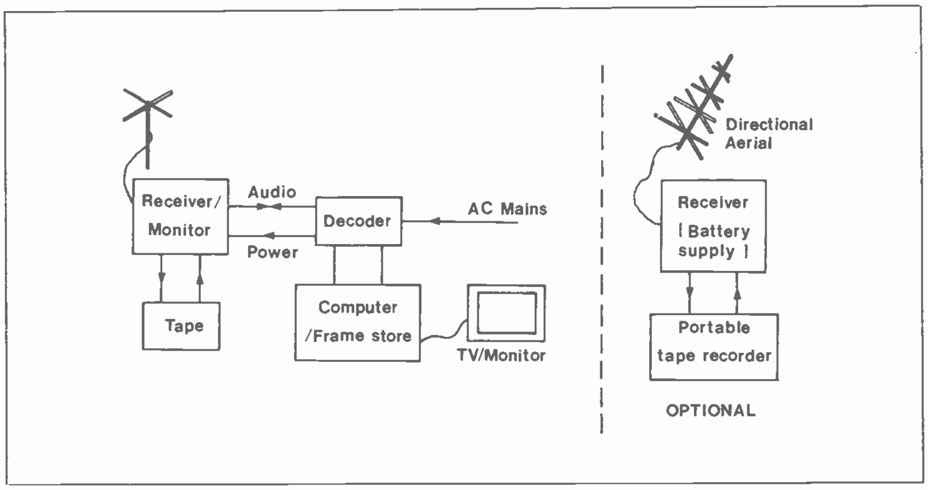



**Figure 2. Complete System**

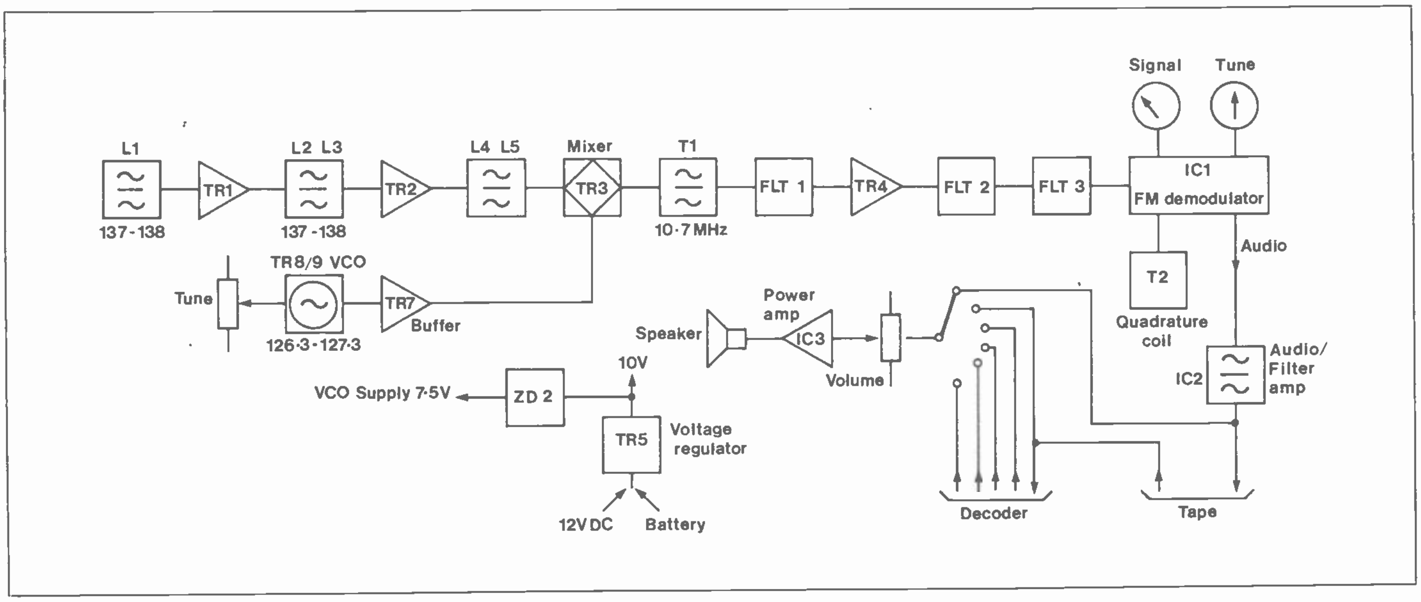



**Figure 3. Receiver Block Schematic**

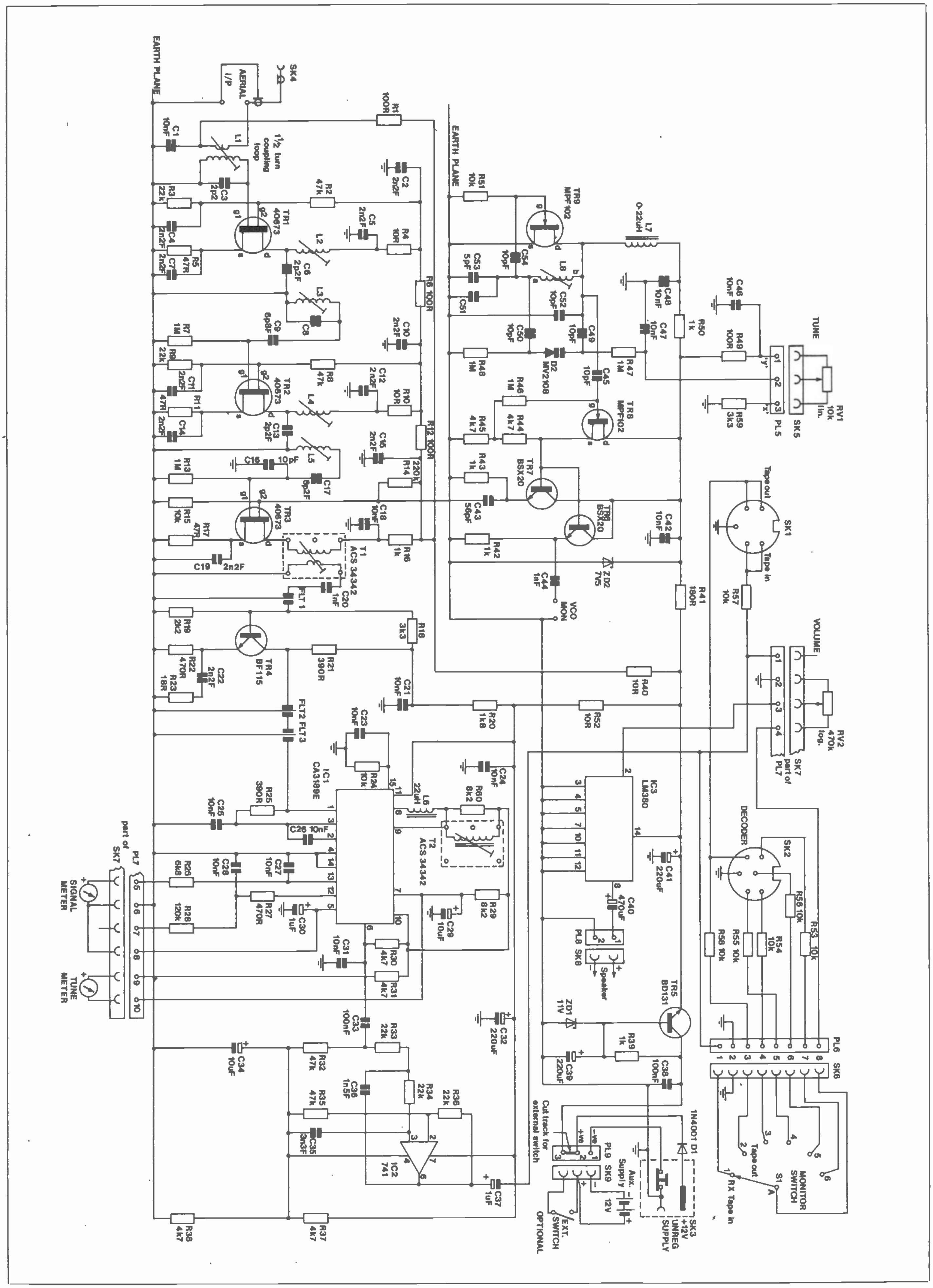



**Figure 4. Receiver Circuit**

## The Receiver - Circuit Description

Figure 4 shows the circuit of the receiver, monitor amp and switching. The 75 ohm aerial input is coupled to the first bandpass tuned circuit L1 by a 1½ turn coil, which, after being decoupled to ground by C1, is fed with 10 volts via R1. This supply, connected to the centre conductor of the aerial coax, is to power a masthead preamplifier (if used). The dual gate FET TR1 provides the first stage of amplification, with L2 and L3 in its output (drain) circuit to provide tuned coupling into TR2, the second RF amplifier. The output of TR2, via the third bandpass and coupling circuit, L4 and L5, is fed to gate 1 of the mixer FET TR3. Gate 2 of TR3 is fed from the VFO circuit, and the drain of this transistor is connected to the 10.7 MHz transformer T1.

The first of three ceramic filters is connected between the output of TR1 and the 10.7MHz amplifier, TR4. The output of TR4 is fed via the two remaining ceramic filters into IC1, the FM IF and demodulator sybsystem. This IC provides quadrature detection of the IF signal as well as providing outputs for the SIGNAL and TUNING meters and squelch (not used in this application). T2 is the quadrature inductor tuned to 10.7MHz. The output from pin 6 of IC1 is fed to the AF amplifier and filter formed by the op-amp IC2 and its surrounding circuitry. This filter limits the audio bandwidth to that required for satellite reception, attenuating all frequencies outside this band.

The audio signal is now fed to the DIN socket for connection to the tape recorder and to the switching for the monitor amplifier. The rotary MONITOR switch is connected via the VOLUME control RV2 to the input of the power amplifier IC3, which drives the loudspeaker.

The receiver is tuned by a voltage controlled oscillator, operating the range 126.3MHz to 127.3MHz, which is 10.7MHz below the input frequency of 137MHz to 138MHz (this provides an IF of 10.7MHz). The FET TR9 forms part of a Vacar type oscillator, whose tuned circuit L8 is tuned by the varicap diode D2. ZD2 stabilizes the power supply at 7.5 volts. This supply also feeds the tuning potentiometer RV1, whose wiper is connected via R47 to the cathode of the varicap diode. The anode of D2 is connected to 0 volts DC by R48.

The varicap diode is reverse biased and, as virtually no current flows through it, R47 and R48 can be of high resistance (i.e. 1MΩ), thus having little effect on the RF signal present across the diode. The output from the drain of the oscillator FET TR9 is taken to a source follower buffer FET TR8. The output from the buffer feeds two emitter follower transistors TR7 and TR6. TR7 feeds the mixer via C43, and TR6 connects to a monitor point that can also be used to feed a frequency

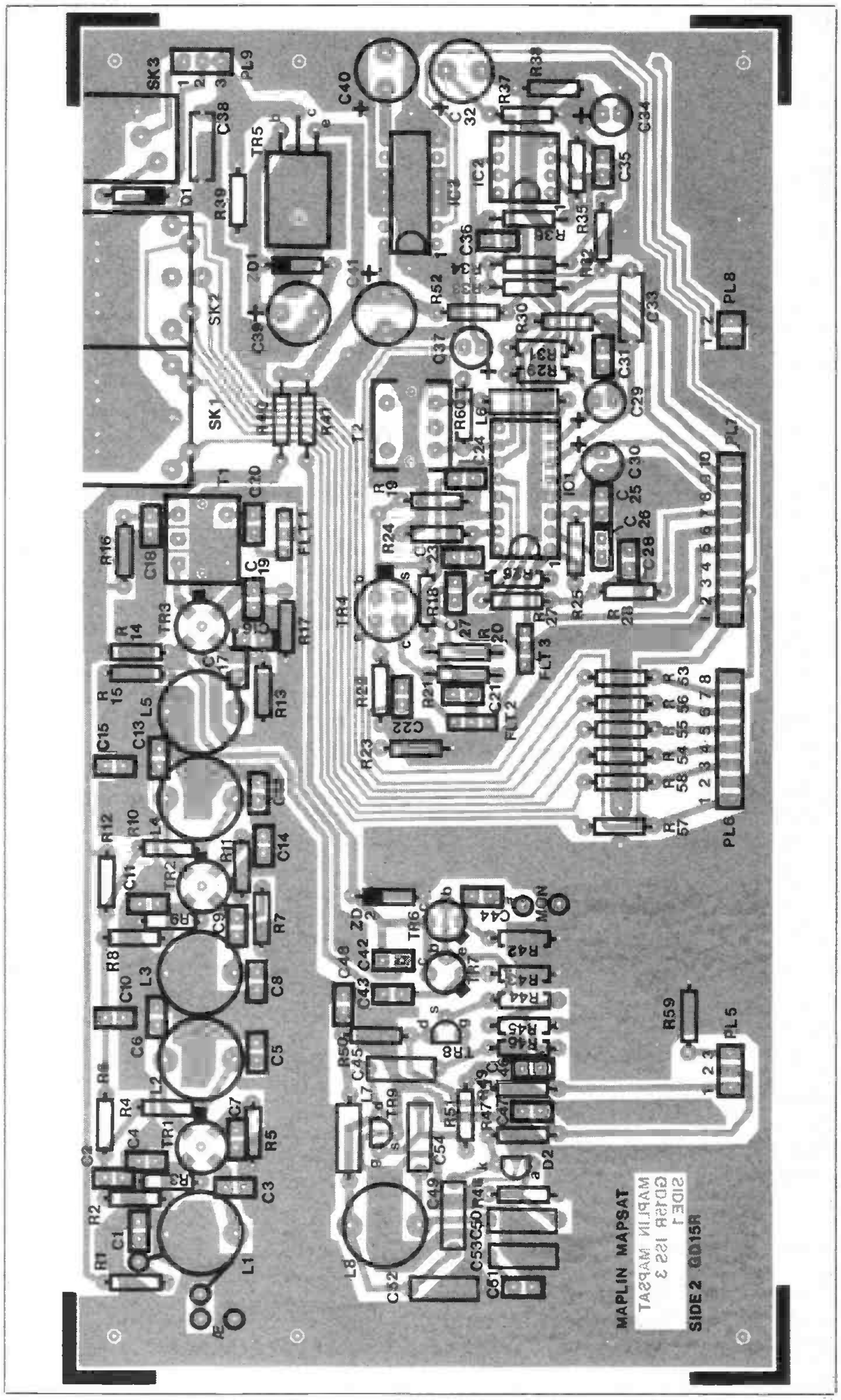
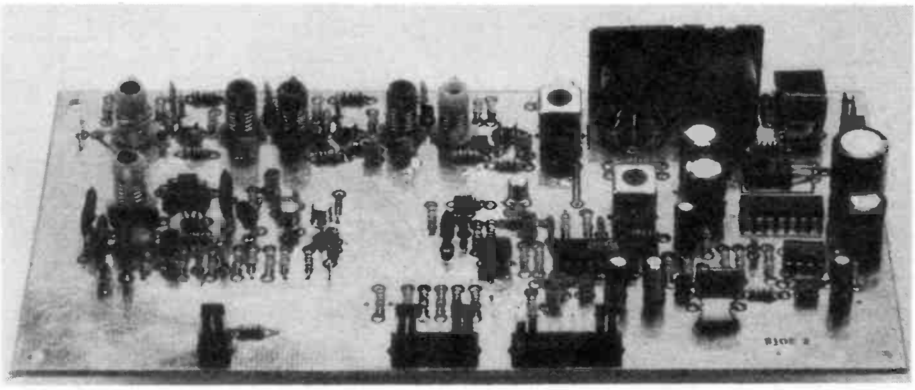



Figure 5. Receiver PCB Overlay



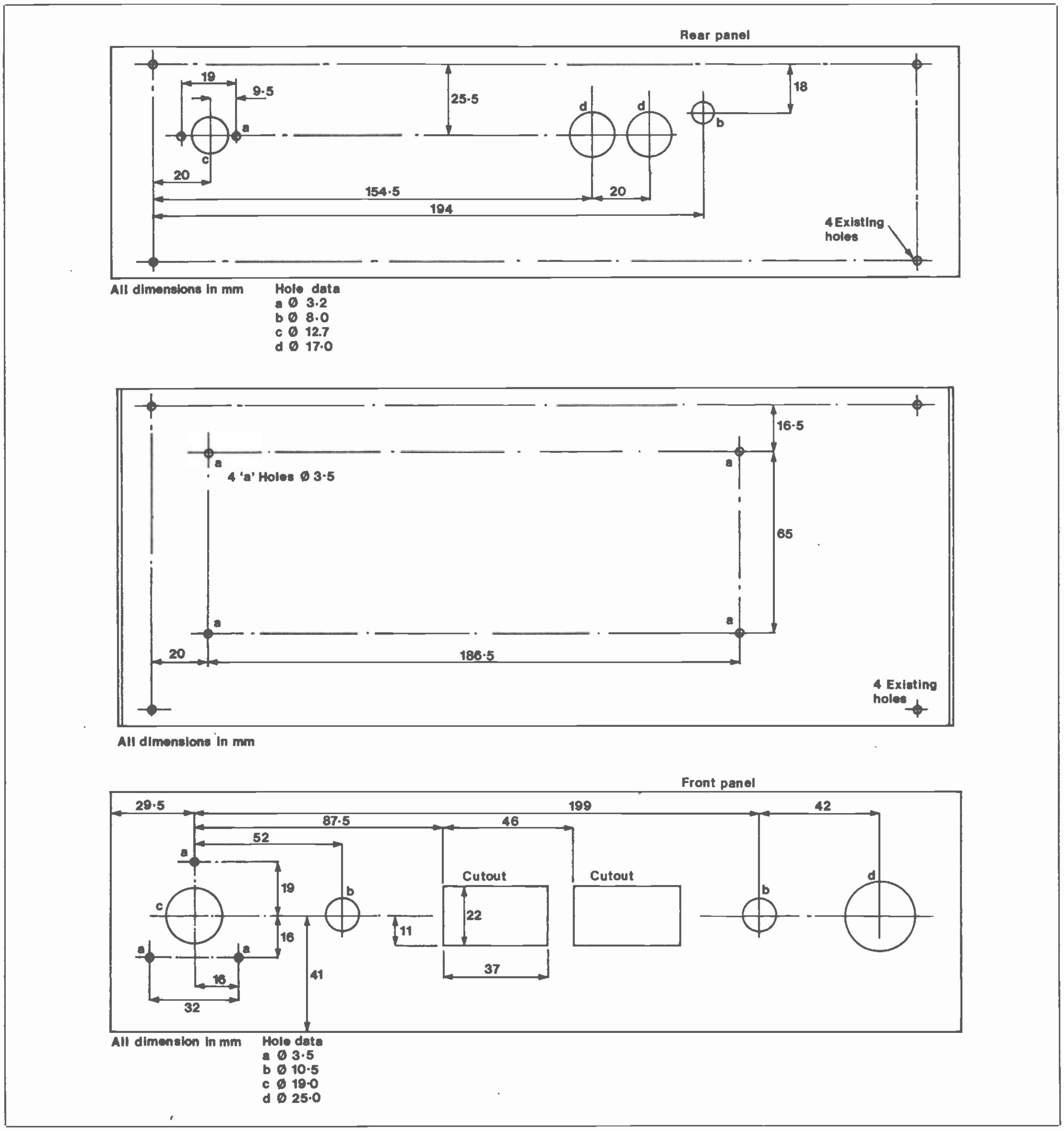



**Figure 6. Box Drilling**

synthesiser input (not used in this application).

The power supplies for the receiver are derived from an unregulated 12 volt input connected via the 2.5mm power socket on the pcb. D1 provides reverse polarity protection. Internal batteries may be connected via PL9 if required; this necessitates the provision of an external power switch, and the cutting of the track between pins 1 and 2 of PL9. The power transistor TR4 forms a simple series voltage regulator circuit, with ZD1 providing its reference voltage. The output from this regulator feeds various parts of the receiver, many via 10Ω and 100Ω decoupling resistors.

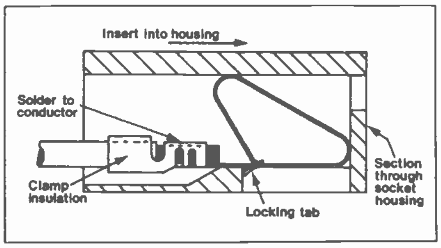



**Figure 7. Minicon Connectors**

## Construction

The receiver circuit board (the overlay is shown in Figure 5) comes ready-built, pre-aligned and tested making construction very simple. The receiver should be housed in an all-metal case, such as the Instrument Case NM2H (YM51F, see also New Products), for which drilling details (see Figure 6) and a stick-on front panel are provided.

Excluding the aerial, all connections are made to the pcb by Minicon connectors, and care should be taken to ensure the correct wiring of these. Details of how to make up these connectors are shown in Figure 7. *Carefully* crimp and solder the required number of minicon terminals onto the wires, making sure they all line up with each other, and then ensure that each is firmly fastened to its conductor and that nothing will foul the minicon socket on

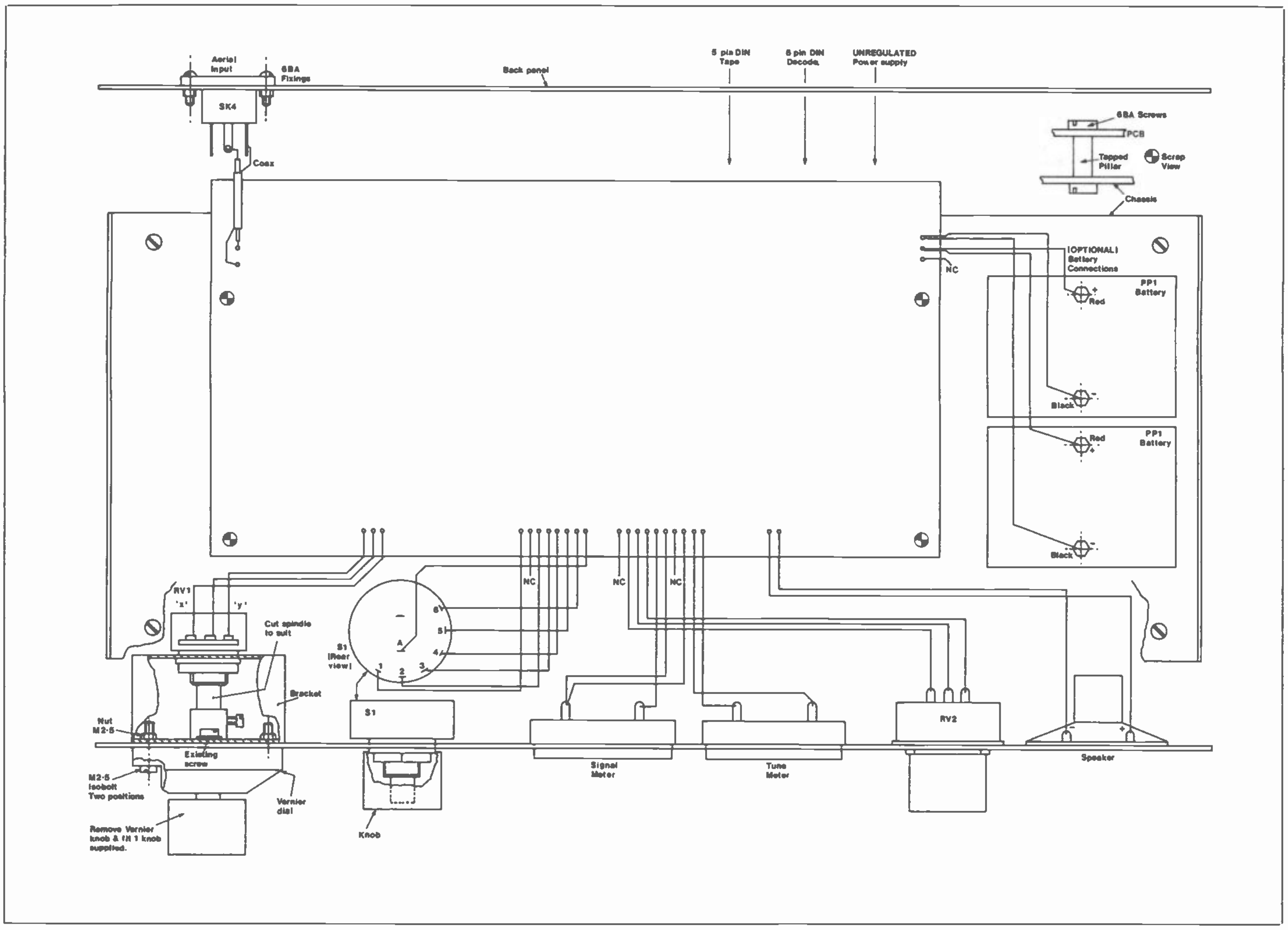
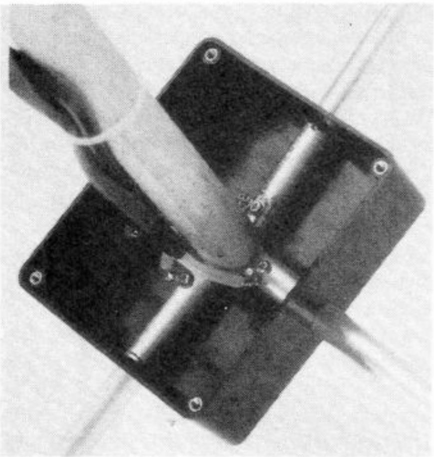
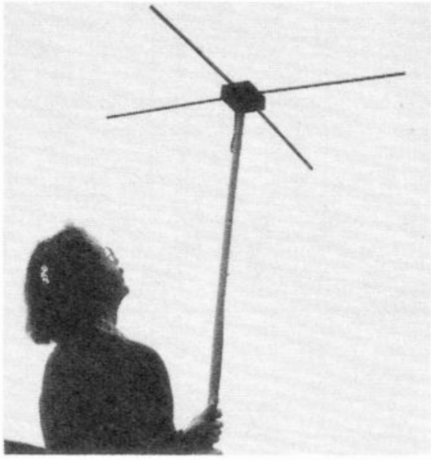



**Figure 8. Receiver Wiring**



**Aerial Junction Box**



**Aerial in use**

insertion. If all is well insert them into the socket the correct way round, and push them home until they click.
Refering to the wiring diagram, Figure 8, note that the short length of coax that connects from the board to the aerial socket has its screen connected to the ground pin on the pcb *and* the outer connection of the coax socket.

The meters and the loudspeaker may be held in position by using Araldite Rapid (FL44X), making sure that the metal surfaces are cleaned and roughened first to form a good bond. Note that if the recommended case and mounting method are not used, the pcb must be mounted 12mm above a metal plate to ensure correct operation.

When mounting the vernier dial, do not, at this stage, tighten the screw that locks the dial to the potentiometer spindle.

## Connecting Up and Testing

Carefully check and recheck all wiring; then connect a suitable 12 volt power supply to the receiver. Connect the positive lead of a voltmeter of 20,000Ω/volt sensitivity and set to 10V f.s.d or an equivalent range, to the point marked 'x' on the tune potentiometer (RV1), and the negative lead to 0 volts (e.g. the aerial screen connection). A reading of $0.7 \pm 0.2$ volts should be obtained.

Now transfer the positive lead to point 'y' on RV1. The reading at this point should be $7.25 \pm 0.3$ volts. The positive lead should now be connected to the wiper of RV1, and the shaft of the potentiometer rotated to obtain a reading of 4.5 volts (the shaft may be rotated using a screwdriver in the slot at the rear of the potentiometer housing). Set the Vernier dial to '5', making sure the correct voltage is still present on the wiper, and tighten the locking screw. Rotate the dial in both directions and check that about 4.5 volts is still obtained when returned to 5 on the scale.

Turn the MONITOR switch to its fully anti-clockwise position (RECEIVE-TAPE IN). Rotating the volume control clockwise should produce a rushing noise from the speaker. The reading on the SIGNAL meter should rise a small amount when power is applied, and the TUNE meter should remain near the centre of its scale.

Connect the receiver to a tape recorder via the DIN connector (the Maplin DIN pack A - RW14Q is suitable for connection to cassette recorders having a suitable DIN connection wired to the DIN standard). For tape recorders with VU meters, it should be possible to obtain a reading of 0dB or 100% when switched to record and input level controls adjusted. A short recording should now be made from the system. Turn the MONITOR switch to TAPE OUT, rewind the tape and press play. The recorded signal should now be heard from the monitor speaker.

The system is now ready for use when connected to a suitable aerial. The receiver has an input of 75Ω, and ordinary UHF television low loss coax cable is suitable for connection between the receiver and the aerial. A suitable fixed aerial is available in kit form from Maplin (LM00A). The aerial should be sited as high as possible and away from sources of electrical interference.

## Receiving Signals

Although pictures cannot be decoded at this stage, it is worth making recordings for future demodulation. Figure 9 shows a rough guide to the relationship between the received frequency and the dial reading. Signals from weather satellites can be easily identified by the 2.4kHz whistle that can be heard in the background of their transmissions, together with the characteristic synchronisation tones. The American NOAA satellites produce a 'clip-clop' type sound, and the Russian satellites a buzzing sound about once a second.

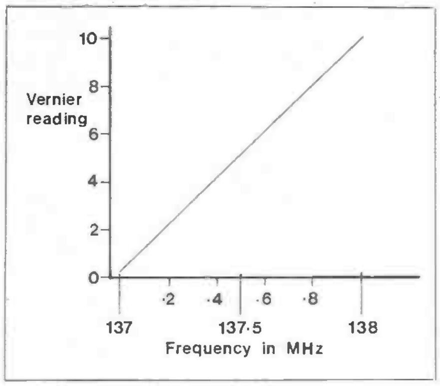



**Figure 9. Vernier Dial and Received Frequency Relationship**

The satellite signals can usually be heard some time before they are strong enough to produce a usable picture. The receiver should be tuned to obtain a maximum reading on the SIGNAL meter with the TUNE meter as near centre as possible. The receiver will probably need slight re-tuning during a satellite pass to compensate for Doppler shift of the signal as the spacecraft approaches and recedes. A good aerial system should give a reading of at least 4 on the SIGNAL meter for a close pass (within 10 degrees east or west).

Should it be found that the best reception does not coincide with the TUNE meter being in the centre position, a very careful adjustment to the core of T2 may be made.

## Coming Soon . . .

The decoder and optional synchronisation unit will be described in future issues, together with interfacing details and software for the BBC B and Amstrad computers. The Frame Store, which has a definition of 418 x 312 pixels, with 16 luminance levels per pixel, giving approximately twice the resolution of that obtainable using the BBC, will also be described.

Several associated projects are planned for the future including an aerial preamp, frequency scanner unit, and a computer interfaceable frequency synthesiser.

## Licence Requirements

There is no actual licence available for the reception of weather satellites, but it is necessary to obtain a 'Letter of Authority' from the Department of Trade and Industry for reception of NOAA and ESA satellites. There is no charge for this authorisation, and it can be obtained by writing to:-

Room 309, Radio Regularitory Division,
Waterloo Bridge House,
Waterloo Road,
LONDON SE1 8UA.

## SATELLITE RECEIVER PARTS LIST

| | | | |
|---|---|---|---|
| **RESISTORS** | | | |
| RV1 | Pot. Lin. 10k | 1 | (FW02C) |
| RV2 | Pot. Log. 470k | 1 | (FW27E) |
| **MISCELLANEOUS** | | | |
| S1 | Switch 2-Pole 6-W Rotary | 1 | (FF74R) |
| SK4 | Socket Flush Coax | 1 | (HH09K) |
| | Vernier Dial Small | 1 | (RX39N) |
| | Knobs K10B | 3 | (RK90X) |
| | Receiver PCB Assembled | 1 | (YM59P) |
| | Bracket MAPSAT | 1 | (FA92A) |
| SK5,9 | Minicon Latch Housing 3-Way | 2 | (BX97F) |
| SK6 | Minicon Latch Housing 8-Way | 1 | (YW23A) |
| SK7 | Minicon Latch Housing 10-Way | 1 | (FY94C) |
| SK8 | Minicon Latch Housing 2-Way | 1 | (HB59P) |
| | Minicon Terminal | 26 | (YW25C) |
| LS1 | Loudspeaker 8Ω | 1 | (WB04E) |
| M1 | Signal Strength Panel Meter | 1 | (LB80B) |
| M2 | Tuning Panel Meter | 1 | (LB79L) |
| | Miniature Wire Coax | ½mtre | (XR88V) |
| | Ribbon Cable 10-Way | 1 mtre | (XR06G) |
| | Bolt 6BA x 1in. | 1 pkt | (BF07H) |
| | Threaded Spacer 6BA x ½in. | 1 pkt | (LR72P) |
| | Nut 6BA | 1 pkt | (BF18U) |
| | Isobolt M2.5 x 12mm | 1 pkt | (BF55K) |
| | Isonut M2.5 | 1 pkt | (BF59P) |
| **OPTIONAL** | | | |
| | Instrument Case NM2H | 1 | (YM51F) |
| | Front Panel MAPSAT | 1 | (FA91Y) |
| | SPST Ultramin. Toggle | 1 | (FH97F) |
| | AC Adaptor Unregulated | 1 | (XX09K) |
| | Battery PP1 (6V) | 2 | (FM02C) |
| | Battery Clips PP9 | 2 | (HF27E) |
| | Araldite Rapid | 1 | (FL44X) |

A complete kit of all parts, excluding optional items, is available for this project:
**Order As LK99H (Satellite Receiver Kit) Price £59.95**
The following items included in the above kit list are also available separately, but are not shown in the 1986 catalogue:
Receiver PCB Assembled **Order As YM59P Price £44.95**
Instrument Case NM2H **Order As YM51F Price £14.95**
MAPSAT Front Panel **Order As FA91Y Price £3.95**
Ceramic Filter 10.7MHz/50kHz **UF71N Price 95p**
PCB 6-Pin DIN Socket **Order As FA90X Price 58p**
MAPSAT Bracket **Order As FA92A Price 80p**

## SATELLITE AERIAL PARTS LIST

| | | | |
|---|---|---|---|
| **MISCELLANEOUS** | | | |
| | ABS Box MB3 | 1 | (LH22Y) |
| | Aerial Rod | 4 | (YM58N) |
| | Hole Plug ⅜in. | 8 | (FW37S) |
| | Self Tap No.2 x 3/16in. | 1 pkt | (BF64U) |
| | Tag 8BA | 1 pkt | (LR02C) |
| | Low-Loss Coax Brown | 5 mtrs | (XR29G) |
| | Low C Cable | 1 mtre | (XR19V) |
| | Potting Compound 250g | 1 | (FT19V) |
| | Tie Wrap 186 | 5 | (BF93B) |
| | PVC Tape Black 20mm | 1 | (FM84F) |
| PL4 | Coax Plug Plastic | 1 | (YW08J) |
| **OPTIONAL** | | | |
| | Wooden Pole 1in. dia. | | |
| | Wood Screw | | |

A complete kit of all parts, excluding optional items, is available for this project:
**Order As LM00A (Satellite Aerial Kit) Price £10.95**
The following item in the above kit list is also available separately, but is not shown in the 1986 catalogue:
Aerial Rod **Order As YM58N Price 80p**

# THE CARE AND FEEDING OF VIDEO MODULATORS

**by J.M. Woodgate C.Eng., M.I.E.E., M.A.E.S., M.Inst. S.C.E.**

For many years, since the days of the Viewmaster and other DIY television receiver kits, the private experimenter or home constructor has generally not been very interested in video gadgets and circuitry. This must have been at least partly due to the use of the 'live-chassis' technique in almost all TV sets, where either one side of the circuit is connected directly to the mains, or, in later designs, a bridge rectifier is used in the power supply, so that whichever way round the mains lead wires are connected, the circuits are at half mains voltage to earth.

## Safety First!

The only safe way to use such a set for experiments is to connect it to the mains through a double-wound isolating transformer, which is a rather expensive component. It is possible, in some cases, to use opto-isolators instead, but one then has to take many more extra precautions, such as enclosing the opto-isolator circuits in a plastic box, and earthing the isolated circuits without fail to the mains earth. This is because most opto-isolators do not give enough protection in terms of breakdown voltage and separation between live and isolated circuits to allow the isolated circuits to be safely left not earthed. (For reference, the requirements are 3000V RMS (4240V DC) minimum breakdown voltage and 6mm separation, and the plastic box is still required, whatever the specification of the opto-isolator.)

## Video Equipment

We now have TV sets with isolated chassis, and even with video output sockets, together with computers, video recorders, video games and monitors. So there is no real problem in getting signals to experiment with and to feed into all those useful gadgets that have just been waiting to be built!

Many of these devices will be required to produce a signal that can be fed into the antenna (aerial) socket of a TV set of the live-chassis type, and this is where the video modulator comes in (at last!). Maplin offer a range of small and reasonably-priced modulator modules, made by one of the largest manufacturers in the field. The modulator takes the video signal (and, for the UM1286 and UM2301, audio as well), and impresses it on a UHF carrier, which is pre-tuned to Channel 36 (591.25MHz). The block of channels 35 to 38 cannot be used for broadcasting so they are available for feeding low-level local signals into TV sets without too much risk of 'patterning', or other indication of co-channel interference. Of course, two modulators on the same channel can interfere quite effectively with each other, so some 'tweaking' of the carrier frequency of one of the modulators may then be required.

This article looks at the UM1111, UM1233 and UM1286, together with a preview of the advanced UM2301, which uses surface-mounted components to achieve improved performance with extremely small size.

## The Video Signal

A video signal has a waveform, as seen on an oscilloscope, quite different from simple sine-waves or even music signals. In fact, it consists of three distinct parts, the picture signal itself, the DC component and the synchronisation or 'synch' signal, see Figure 1. The exact specifications of these signals vary with the TV system concerned, but this article will only be concerned with what is officially known as 'CCIR System I/PAL', which is used in the United Kingdom, Eire, South Africa and some other countries. 'PAL' (Phase Alternation Line) refers to the colour-encoding system, of which you will find a description in the tailpiece to the article on Digital Television Receivers in Volume 4 Number 15 of the Maplin Magazine. The 'I' means that the picture is composed of 625 lines, that 25 pictures are displayed per second, and that, when the signals are modulated on to carriers for broadcasting, the sound carrier has a frequency 6MHz higher than the vision carrier.

For System I, then, 625 lines are scanned in 1/25 second, so each line lasts $64\mu s$, of which about $58\mu s$ is actual picture signal, the rest being time allowed for the electron beam of the cathode-ray tube to 'fly back' to the left-hand side of the screen. During this time,

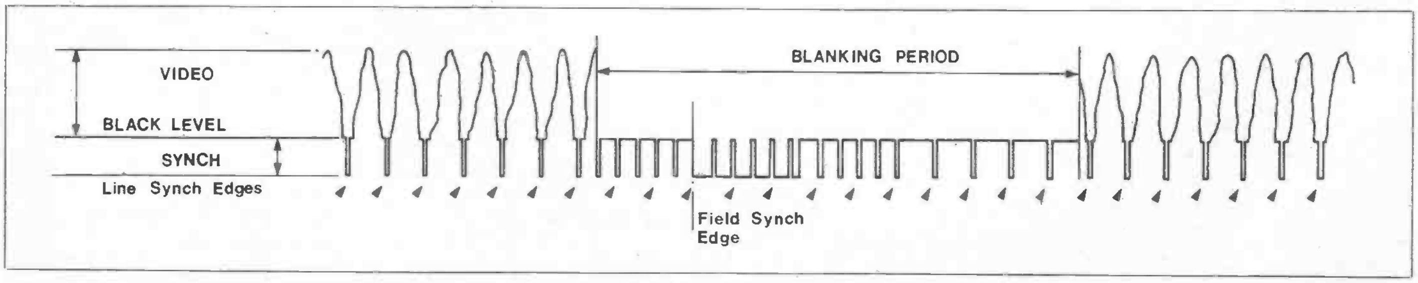



**Figure 1. Video signal waveform, showing the field synch edge. The short pulses between the line synch. pulses are known as 'equalising Pulses'.**

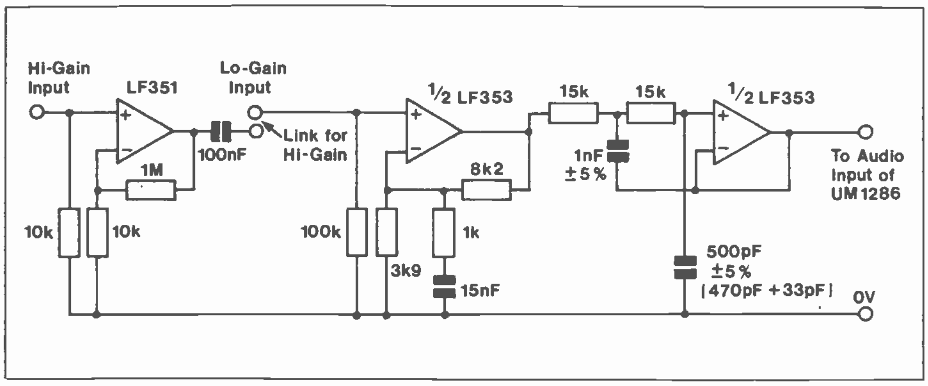



**Figure 2. Audio pre-emphasis and band-limiting filter. The supply voltage should be at least ±6V.**

the line-synch pulse and the 'back porch' appear in the signal waveform. The leading edge of the synch pulse triggers the horizontal (or 'line') time-base circuit in the TV set to fly-back. After 312.5 lines, or one field, the electron beam has reached the bottom of the picture and the synch pulses are modified in such a way that a synch signal for the vertical (or 'frame') time-base can be extracted in the receiver. The leading edge of this signal causes the electron-beam of the cathode-ray tube to fly back to the top of the screen. During this time, the video part of the signal is cut off, or 'blanked'. Because the fly-back begins after half a line has been scanned, and takes a whole number of line periods, the next sequence of 312.5 lines, or 'second field' falls between the previous set of lines on the screen. This technique is known as 'interlace', and is good for displaying pictures, but causes problems (interline flicker) nowadays when displaying text or graphics. The two fields, together made up of 625 lines, are known as one frame.

Because of the presence of the regular line-synch pulses, the spectrum of the video signal (or of the monochrome or Y component of a colour video signal), which extends from zero-frequency (DC) to 5.5MHz, consists largely of harmonics of the line frequency of 15625Hz, around each of which are sidebands at harmonics of the field frequency of 50Hz. Between the harmonics of the line frequency, there is very little signal energy, and into these gaps the colour information can be inserted. The technique for this is described in the tail-piece mentioned above, and the colour signals are fitted into the gaps in the monochrome signal spectrum by choosing the colour sub-carrier frequency to be an odd multiple of one quarter of the line frequency, plus an offset equal to the frame frequency:

$$f_{mc} = (1135/4 + 1/625)f_H$$

For the I/PAL system, this gives a sub-carrier frequency of 4.43361875MHz.

The inherent DC component of the video signal arises from the fact that, while the amplitude of the synch pulses is constant, the amplitude of the actual picture signal varies with the brightness of the scene. If the video signal is passed through a coupling-capacitor, the average level of the signal drifts up and down according to the average brightness of the scene, which prevents the correct display of dark scenes. This can be overcome by using a 'clamp' circuit to clamp the black-level of the signal to a constant DC voltage, usually 0V. On the other hand, it may be necessary, for some reason, to add an additional DC component to the signal, and this is the case for all of the modulators except the UM2301. Luckily, most modern TV sets include their own black-level clamp, so that we can use AC coupling if necessary in add-on circuits, provided we do not lose too much of the low-frequency content of the signal.

It is usual to pass video signals from one piece of equipment to another at 'standard level', with a peak-white signal e.m.f. of 2V from a 75 ohm unbalanced source, the synch pulse amplitude then being 0.6V, negative-going. The total amplitude drops to 1V, of course, when the output is terminated in 75 ohm. Black level, and blanking level (which are the same for System I) are at 0V. However, as we shall see, the modulators require quite different video input signals.

| CHARACTERISTICS | | UM1111 | UM1233 | UM1286 | UM2301 | Units |
|---|---|---|---|---|---|---|
| | Supply voltage | 6.5 ±0.2 | 5.0 ±0.2 | 5.0 ±0.2 | 12.0 ±1.2 | V |
| EXTERNAL | Supply current | 1.0 | 6.0 | 9.0 | 25.0 | mA typ. |
| | Change of carrier freq. with supply voltage | – | 1.5 | 1.5 | 0.001 | MHz/V typ. |
| | Change of sound subcarrier freq. with supply V | – | – | 30 | * | kHz/V |
| INFLUENCES | Change of carrier freq. with temperature | – | 125 | 200 | 5 | kHz/deg.C |
| Video 3dB bandwidth (Rs = 470 ohm) | | 3.5 | 6.8 | 8.0 | * | MHz |
| Video modulator linearity | | – | 5 | 6 | * | % typ. |
| RF Output and carrier leak (75Ω load) | Vision Carrier, at synch. tips | 4 | 1.5 (±4dB) | 1.7 (±5dB) | 1.7 | mV |
| | Peak white, ref. synch. tips | −20 | −17 (±3dB) | −20 (±4dB) | * | dB |
| | Sound carrier, ref. synch. tips | – | – | −20 (±4dB) | * | dB |
| Sound/chroma beat, 1.54MHz ref. synch tips | | – | −45 | −50 | * | dB |
| Video input characteristics | Resistance, at peak white | 4.1 | 150 | 150 | * | kΩ |
| | Resistance, at synch tips | 0.7 | 1.5 | 1.5 | * | kΩ |
| | Parallel capacitance | 50 | 47 | 20 | * | pF |
| Audio input characteristics | Resistance | – | – | 64 | * | kΩ |
| | Series capacitance | – | – | 10 | * | nF |
| Spurious outputs, ref. synch tips | | – | −30 | −30 | −30 | dB (max.) |
| Sound sub-carrier fine tuning range | | – | – | 100±20 | – | kHz |
| Sound modulator deviation sensitivity | | – | – | 20±5 | 35.4 | kHz/V |
| Vision carrier frequency tolerance 25 deg.C | | 5 | 5 | 5 | 0.3 | MHz (max.) |

* Information not yet available.

**Figure 3. Modulator characteristics.**

## The Modulation Process

The video signal is impressed on to the high-frequency carrier by a form of amplitude modulation. However this does not operate in quite the same manner as AM radio transmission. In AM radio, the carrier amplitude is high when there is no modulation, (in the silences between programmes, for instance). But the video modulator produces only enough carrier amplitude to reproduce the video signal at whatever level it happens to be, so that the carrier amplitude is low when there is no modulation.

For System I, the video signal is applied to the modulator in such a sense that the carrier amplitude is at its highest at the tips of the synch pulses, and at its lowest when the picture signal corresponds to a brilliant white object, or 'peak-white'. Because the positive side of the envelope of the modulated carrier is an inverted copy of the video signal, this is known as 'negative modulation'. The old 405-line TV system, which closed down earlier this year, used positive modulation. With negative modulation, there is not much point in trying to tune the TV to the modulator unless there is some video modulation present and properly applied, because if there is no video, or too much, the modulation of the output from the modulator will be low or zero. The video amplitude is correct when a peak white signal reduces the carrier amplitude to 20% of the amplitude at the tips of the synch pulses – where the latter correspond to 100%. This 20% is the official value for System I, but other systems use a value of 10%. Too low a value of this characteristic, which is called 'carrier leak', can give rise to buzz on the sound channel and other more subtle effects. As the value approaches zero, the effect on the picture is to remove all detail from bright areas, producing a very distinctive, but almost indescribable visual effect, known as 'white crush'. If, on the other hand, the video signal amplitude is too small, the a.g.c. circuit of the TV set will not work correctly, and it will probably not be possible to tune the set properly, nor to produce a synchronised picture. We also have to remember that the video inputs of the modulators are DC coupled, and (except for the UM2301) have a standing DC voltage on the 'hot' terminal. So, if we feed the video in wrongly and disturb this DC voltage too much, the modulator may either produce no output, or it may produce a strong carrier with almost no modulation. For this reason it is quite important to follow fairly precisely the video feed arrangements which will be discussed later.

There is one other difference between the output of these modulators and the broadcast signal. To save power at the transmitters, one sideband of the vision signal is largely suppressed ('vestigial sideband transmission'), whereas the modulator produces both sidebands. This does not normally cause any problem, because the TV set does not need both sidebands, and the unwanted one is filtered out in the vision i.f. amplifier.

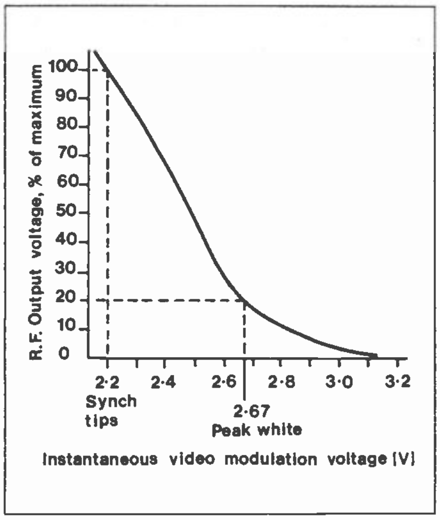



**Figure 4. Typical modulator linearity characteristic.**

## Adding Colour

We saw before that the video signal bandwidth extends up to 5.5MHz. Actually, while the top 2MHz is nice to have, household video recorders get along quite nicely without it , and without some of the low-frequency end as well! So we can take some liberties with the bandwidth, particularly if we are only handling monochrome signals (which may come out as green or amber on a monitor, of course). For these signals, a bandwidth of 3MHz or so is adequate. However, for colour we have to reproduce at least up to 4MHz, and preferably higher, without too much loss of amplitude nor too much phase-shift. These defects would distort the edges of objects in the picture and upset the alignment of the colour and brightness edges, which is most noticeable on red objects. If the circuits do not cope with the colour sub-carrier frequency too well, the colours will appear 'washed-out', or desaturated, so there must be a response at this frequency. If the response is too weak, the 'colour burst' (see the tail-piece again, or take it as read) will not be properly reproduced and the TV set will promptly shut down its colour circuits.

It is for this reason that the colour-capable modulators UM1233, UM1286 and UM2301 require a PAL-encoded colour video signal as input, and do not contain the colour sub-carrier and encoding circuits. They would also accept NTSC, or even SECAM, encoded signals, but other equipment is not readily available in this country for operation on these standards.

## Adding Sound

The sound is transmitted by frequency-modulation of the sound carrier, with a maximum deviation of 50kHz. The sound carrier frequency is 6MHz above the vision carrier frequency, and this is usually ensured by first frequency-modulating the sound signal on to a sub-carrier of 6MHz, and then to modulate the sound sub-carrier and vision signals separately on to the vision carrier. To improve the signal-to-noise ratio of the sound channel, the higher audio frequencies are boosted before transmission (pre-emphasised) with a time-constant of 50$\mu$s. This gives a response which is 3dB up at 3.18kHz, but a simple treble-boost circuit will probably cause difficulty if its response carries on rising well past the highest audio frequencies. It is advisable to add a band-limiting filter with a cut-off frequency of 15kHz to 20kHz to ensure that spurious signals do not upset the sound channel. A typical circuit is shown in Figure 2.

The modulators require a rather large sound signal input, so this filter has been designed to give a gain of 3.5 times. The output from the filter will thus be about 5V p-p when the filter is fed from the 0.5V r.m.s. signal available from the output of a cassette recorder or hi-fi preamp. To work from the DIN-standard (current-source) recording output of an audio system, more gain is required, and this can be obtained by changing to the high-gain input.

There is no direct way of measuring the deviation of the sound signal at the output of the modulator, unless you have access to a UHF deviation meter. The best way to check it is to compare the amplitude of the audio signal from a TV broadcast (measured with an oscilloscope or, even better, a proper peak-programme meter, if possible, at some convenient place in the TV set), with that produced by your own sound signal from the modulator. It is essential to have a correctly-applied video signal present for this test to ensure that the TV set's a.g.c. and sound-extraction circuits are correctly operating. You can assume that the peaks of music signals from the TV broadcast, especially of commercials, correspond to the full 50kHz deviation.

## Characteristics of Modulators

In order to get good results from the modulator, its characteristics should be understood. There are quite a few problems and strange effects which can occur if the modulator is misused. A table of the most important characteristics is given in Figure 3 and we can now look at these in detail.

### 1. External Influences

It may seem strange to start with these, but they are very important and a frequent source of unexpected effects. The three main influences are the supply voltage, temperature and magnetic fields.

It is important that the supply voltage is within the recommended range of values, and that it is stabilised. If

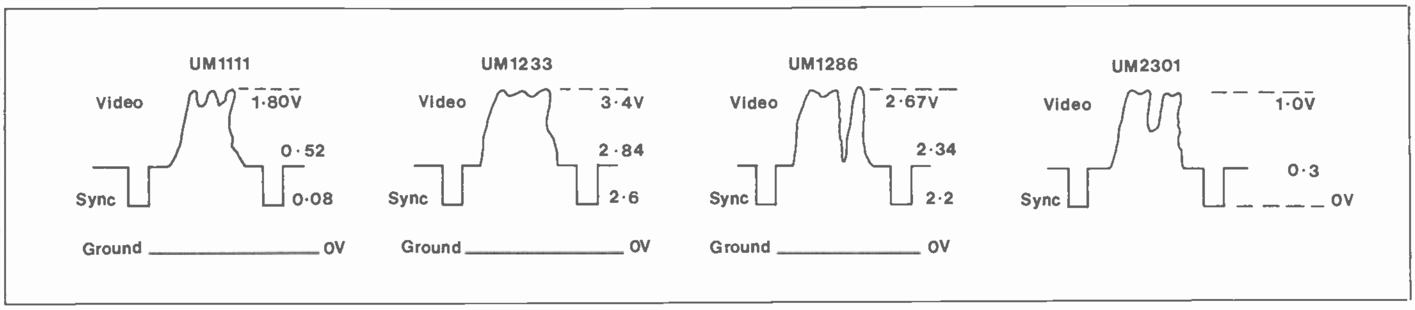


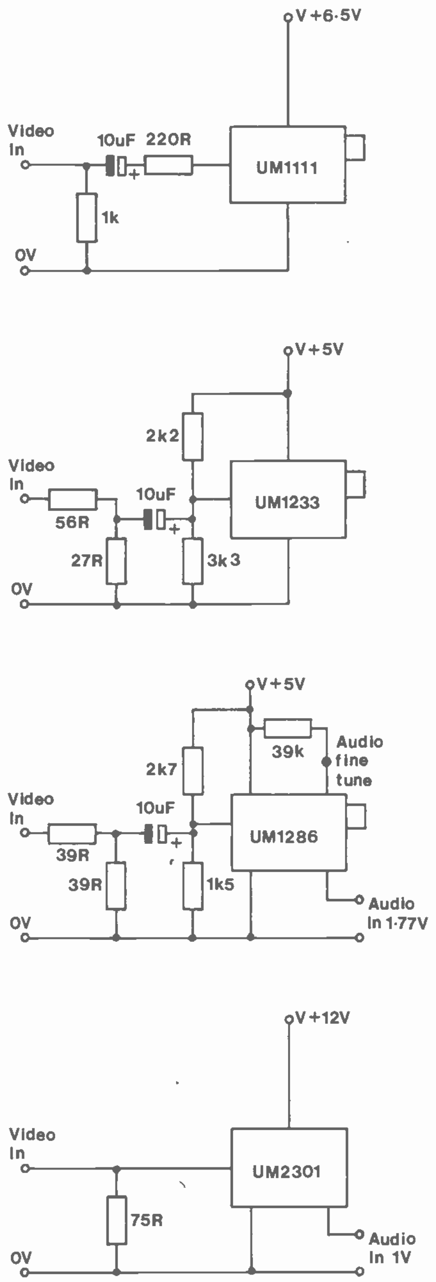

**Figure 5. Video input signal requirements.**

possible, the modulator should have its own 78L-type stabiliser whose output has a 10$\mu$F electrolytic and a 10nF ceramic capacitor in parallel. This will not only stabilise the DC voltage, but also remove hum (ripple) from the supply, provided that there is not too much of it on the input to the stabiliser. Low ripple is important in avoiding 'hum-bars', broad dark or light bands which drift slowly up or down the picture, which are caused by mains-frequency voltages getting into the video. For the UM1111, with its low current-drain of 1mA, a Zener diode stabiliser could be used, but it must be very well decoupled because Zener diodes can generate strong r.f. noise voltages.

There should not be any difficulty in providing the small supply currents required by these modulators, but it is worth noting that the UM2301 requires more than twice as much current as the UM1286, and becomes noticeably warm.

Temperature variations can cause the vision carrier frequency to drift, and the modulator sensitivity to change. There is not much self-heating in the larger modulators, and the UM2301 uses low-drift circuit techniques, so the main precaution is to keep the modulator away from outside sources of heat.

Magnetic fields can affect the modulators through the ferrite cores of some coils, and induction into the UHF circuit loops. The effects of permanent magnets show up as shifts in tuning or picture quality when the equipment is assembled. Alternating fields, from transformers etc., can cause hum-bars on the picture and/or hum on the sound channel. Again, the best way to avoid these effects is to know that they can occur and to keep the modulator away from sources of field.




a. The UM1111 requires 1.8$V_{p-p}$ input, which can be obtained by not terminating the video input with 75 ohm. This would not be a good idea if a long video cable is necessary. This very simple circuit is consistent with the rather basic, but effective, design of this module.

b. The UM1233 requires rather a small video input obtained from the input attenuator. For some samples of this unit, the 27 ohm resistor may need to be varied to get a good, contrasty picture without black-or white-crush. The DC bias voltage of 3.2V is obtained from a separate voltage divider. The AC coupling should not cause any problem.

c. The UM1286 obtains its 0.5$V_{p-p}$ video signal from the input attenuator, which also terminates the video cable. The DC bias voltage is set by the 2.7k and 1.5k resistors. The 39k resistor may be replaced by a 100k pre-set for fine tuning the sound sub-carrier to exactly 6MHz.

d. The UM2301 has an AC-coupled video input and its own DC restorer. The audio input requires 1V rms for ±50kHz deviation.

**Figure 6. Obtaining the required video signal from video at standard (1$V_{p-p}$) level.**

## 2. Vision Carrier Frequency Stability

Lack of carrier frequency stability is a most annoying problem because it means that you have to keep retuning the TV set as the modulator drifts, to avoid loss of picture quality, buzz on sound or other defects. But, provided that the supply voltage is stable and the temperature rise is kept down, these modulators do not drift much. However, particularly for the UM1111, the initial frequency may be rather different from the official Channel 36 frequency which can be a problem with modern TV sets with 'frequency-synthesis tuning'. It may be necessary to find the modulator signal on Channel 35 or Channel 37, in extreme cases.

## 3. Video Bandwidth

The UM1111 has sufficient bandwidth only for monochrome TV and video games. All of the other modulators have sufficient bandwidth for colour signals. Bandwidth is affected by the video source impedance (see Video input characteristics, below).

## 4. Video Modulator Linearity

The effect of non-linearity on video signals is nowhere near so easy to see on a picture as the effect of non-linearity on an audio signal is to hear (as distortion).

Severe non-linearity at the limits of modulation shows up as 'white-crush' or 'black-crush', with loss of detail and the appearance of 'flat' areas in the picture. Intermediate non-linearity can be seen on a grey-scale test-card, but is not usually a problem. An example of a modulator linearity characteristic is shown in Figure 4.

## 5. R.F. Output and Carrier Leak

The r.f. output signal must be strong enough to give a noise-free picture on the TV screen, but not so strong that it overloads the receiver or radiates sufficiently to cause interference with other transmissions. An output voltage of 1.5mV across 75 ohm is suitable, on the understanding that individual samples of modulator may vary by 5dB or so, either way. The UM1111 has a rather higher output of 4mV or so.

Carrier leak is controlled by the amplitude of the video signal input and the alignment of the balanced tuned transformers in the modulator. The effects of an incorrect value have already been described.

## 6. Sound Carrier Frequency Stability

This characteristic is important because the TV set expects the sound carrier frequency to be exactly 6MHz above the vision carrier frequency. It is difficult to use a quartz crystal in the sound modulator, because the requirement is for frequency-modulation, and even the best 'rubber-crystal' circuits will not allow linear ±50kHz deviation of a 6MHz crystal. The UM1286 is therefore, provided with an LC-oscillator which can be fine-tuned by means of a voltage applied to a vari-cap diode (actually the emitter-base junction of a transistor). The UM2301 uses a ceramic resonator, which is more stable than an LC-oscillator but can be frequency-modulated more easily than a quartz crystal can. It does not require fine-tuning.

## 7. Sound Deviation Linearity

This directly affects the distortion content of the reproduced sound, and consequently must be carefully controlled. There should be no problem if the input signal is not greater than 1.78V r.m.s. (5V p-p) for the UM1286, or 1V rms for the UM2301.

## 8. Cross-modulation

This is interference between the sound and vision signals caused by both signals encountering a non-linear circuit in the modulator. It can produce severe problems of streaking and patterning on the picture. With colour pictures, the sound and colour sub-carriers can beat together to produce a signal ('sound-chroma beat') at 1.57MHz, which covers the TV screen with vertical bars! Cross-modulation is minimised in these modulators by careful circuit design which prevents non-linear circuits affecting the combined vision and sound signal.

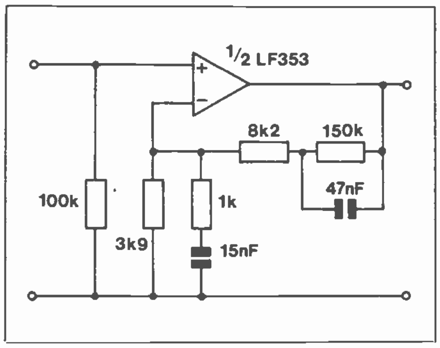



**Figure 7. Bass equaliser for the UM1286. This replaces the second stage of the circuit in Figure 2. The supply voltage should be increased, preferably to ±18V.**

## 9. Video Input Characteristics

This is the most intriguing part of the subject. Each modulator requires a different video input signal and, except for the UM2301, this signal requires an additional positive DC component. The reason for these differences is that the modulators are mainly intended to be fed with digitally-generated signals from computers or video games, and the modulators were designed to accept these signals directly. Consequently, they do not so easily accept picture signals at standard level, but can be arranged to do so. The input impedance at the video input looks like a non-linear resistor in parallel with a capacitor, so that to maintain both linearity and bandwidth, a low source impedance is necessary. The input signal requirements of the modulators are shown in Figure 5, and simple circuits for obtaining these signals from video at standard level are shown in Figure 6.

## 10. Audio Input Characteristics

There is not much difficulty in providing the required audio signal, especially if the pre-emphasis and band-limiting filter (Figure 2) is used. The audio input of the UM1286 looks like a resistance of 64kΩ in series with 10nF. This gives a low-frequency 3dB point of 250Hz which is rather high, but in most TV sets, the loudspeaker will not reproduce lower frequencies anyway. If a response down to 20Hz (−3dB) is required, the equaliser shown in Figure 7 could be used.

## 11. Supply Voltages and Currents

Most of this subject has already been covered under 'External Influences', but it must be emphasised that these units are very sensitive to supply voltage. Under no circumstances should they be operated from supply voltages different from the specified values.

## 12. Spurious Output Signals

It is very important that the modulator should not produce significant output at frequencies other than the wanted ones, as this can result in serious interference with other signals. The UM1111 is rather out of date in this respect, and might give a problem in certain, rather unusual, circumstances. The later products have been designed to meet much tougher specifications, in line with current interference regulations. However, care is required to ensure that a modulator is never connected to an antenna, as the radiated signal could interfere with neighbouring VCR's and TV sets!

## How the Modulators Work

The typical video modulator (Figure 8) consists of two stages. The first is the carrier-frequency oscillator, from the emitter circuit of which, a signal at 591.25MHz is transformer-coupled to the second stage, which is the modulator

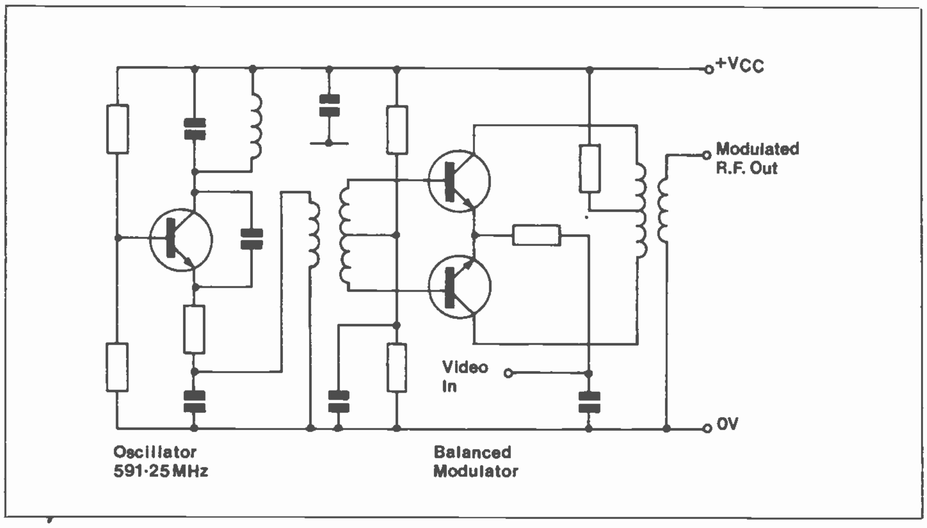



**Figure 8. Basic video modulator circuit.**

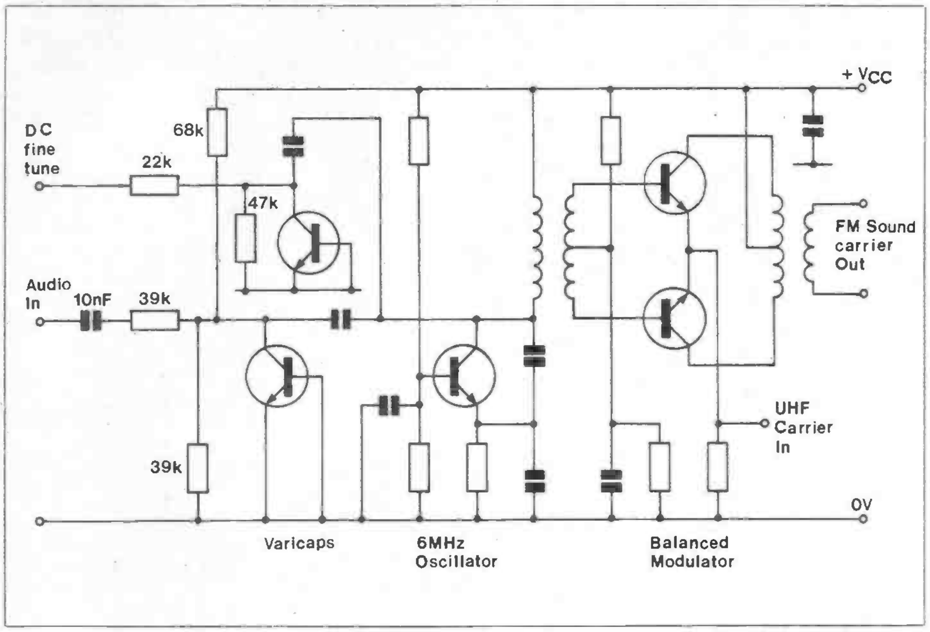



**Figure 9. Basic sound modulator circuit. The circuit values given are useful for designing peripheral circuits for the UM1286.**

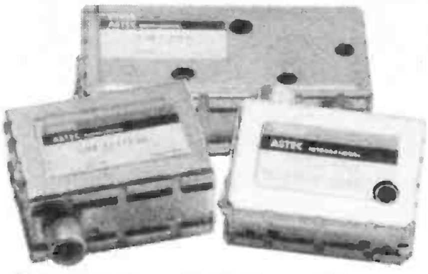


**Figure 10. Current Maplin modulator range.**

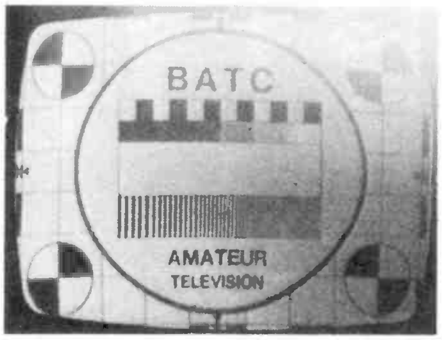



**Figure 11. Typical picture using the UM1286.**

proper. This consists of two matched transistors in a push-pull circuit, and the video signal is applied to the emitters of the transistors. The bases are biased to +4V, so that an emitter voltage of +3.4V, derived from the video signal, will just bring the transistors into conduction and allow a small amount of r.f. to appear at the output. This is the 'carrier leak' condition, corresponding to a peak-white signal. When the video signal brings the emitters down to 2.6V, the transistors are passing 0.7mA each, thus giving significant gain, and the r.f. output is high. This condition applies at the tips of the synch pulses. Note that, because of the emitter and collector resistors, the transistors will not be damaged if the video input is taken down to 0V, but the modulator will not work because the overall gain is almost independent of collector current at high currents.

The typical sound modulator (Figure 9) consists of a 6MHz oscillator, which has the reverse-biased base-emitter junction of a suitable transistor connected in parallel with the tuned circuit. As the reverse bias is varied by the sound signal, the capacitance of the reverse-biased junction, and thus the oscillation frequency, varies accordingly. Although the frequency shift is typically inversely proportional to the fourth-root of the voltage change, and is therefore very non-linear, we only need a deviation of 50kHz above and below 6MHz, so that the distortion is acceptably low. A second reverse-biased transistor is connected across the oscillator tuned circuit to allow fine-tuning of the sub-carrier frequency by means of a DC voltage, as mentioned before. The output of the 6MHz oscillator is passed to a balanced-modulator stage rather like the video modulator, but with the video input replaced by the vision carrier. The output of this stage consists of two frequency-modulated sound signals, at 6MHz above and below the vision carrier frequency. There is no vision carrier signal, provided that the modulator is accurately balanced. The unwanted lower-frequency sound signal is rejected by the receiver.

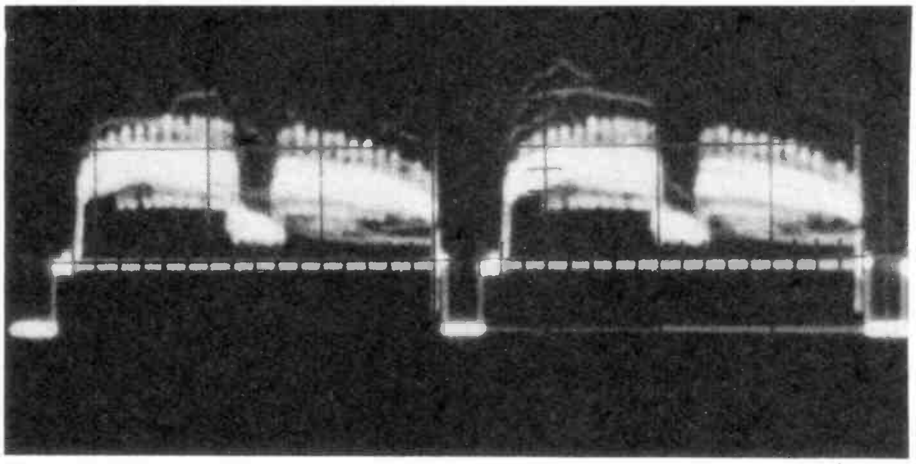


**Figure 12. Video waveform as seen on the oscilloscope, of a white picture with a black bar.**


**Figure 13. A camera control unit and modulator using the UM1286.**

In order to add the sound and vision signals from the two modulators linearly, thus avoiding cross-modulation, resistive mixing is used. This also allows the correct sound-to-vision carrier voltage ratio of 1:10 to be set. The r.f. output of the modulator appears on a phono-socket, which is a rather surprising use of an audio connector, at 75 ohms impedance. Don't try to insert a phono-plug with a long centre pin, as this might damage the modulator components.

## Summary and Conclusions

Video modulators, together with the spread of video recorders and changes in TV receiver technology, open up a new field for private experiments and the creative design of new equipment. They are quite easy to use, provided that their characteristics and requirements are understood.

## Acknowledgement

I would like to thank Mr J. Groves of Astec Europe, for valuable information.

# 'MIXING IT'

by Dave Goodman

## Part 2 — Using Maplin High Quality Mixer Modules

The Maplin range of HQ Mixer pre-amplifier modules serve as useful building blocks in audio circuits requiring high quality signal processing. General information and technical specifications are detailed here for a further four circuits, available in ready-built or kit form.

## PU or Mic Input Module

This module is available in either mono (single channel) or stereo (dual channel) versions; Figure 17 shows the left channel circuit only of the stereo version, but the circuit is common to both mono and stereo. It is suitable for use

**MODULE SPECIFICATIONS**

| | Mic | Mag' PU | Ceramic PU |
|---|---|---|---|
| Input Impedance | 56kΩ | 56kΩ | 200kΩ |
| Input Signal Level | 25mV | 5.5mV | 100mV |
| Max O/P before Clipping | 7.75V rms (22V Pk) | | |
| Total Harmonic Distortion | Better than 0.2% | | |
| Frequency Response | Flat (−3dB @ 40kHz) to RIAA ±1dB | | |
| Signal to Noise Ratio | Better than 90dB | | |
| PSU Max 30V DC | @ 12mA (stereo) @ 6mA (mono) | | |

with the following:

*a) High impedance microphone:* Often called dynamic or electret, with 47kΩ to 100kΩ impedance. This module should not be used with 80 to 200Ω low impedance microphones.

*b) Magnetic pick-up cartridge:* Most commonly used on record player pick-ups with 47kΩ impedance and 5mV sensitivity.

*c) Ceramic pick-up cartridge:* Often used, but not so common as magnetic pick-ups. Usually high output, high impedance in nature.

Any one input device can be used per channel (or board) and appropriate equalisation can be selected by fitting

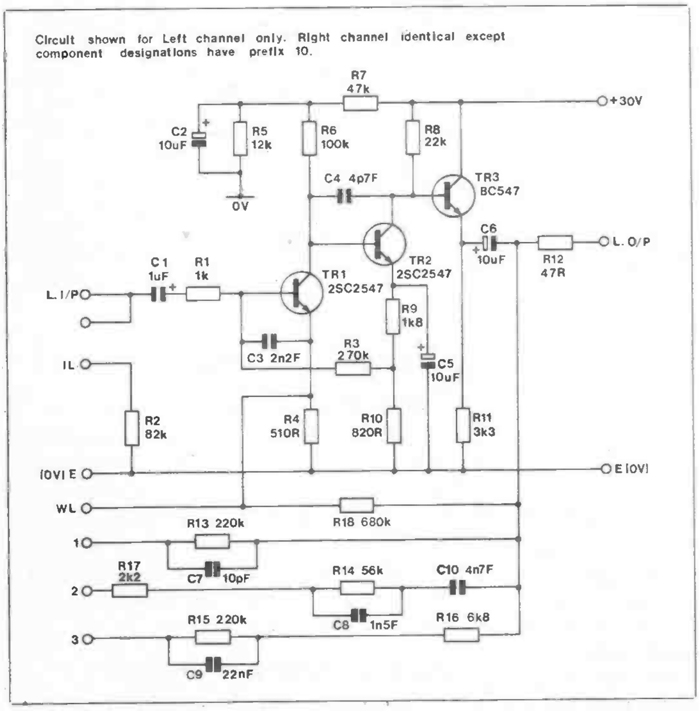



Figure 17. Mic Input Circuit

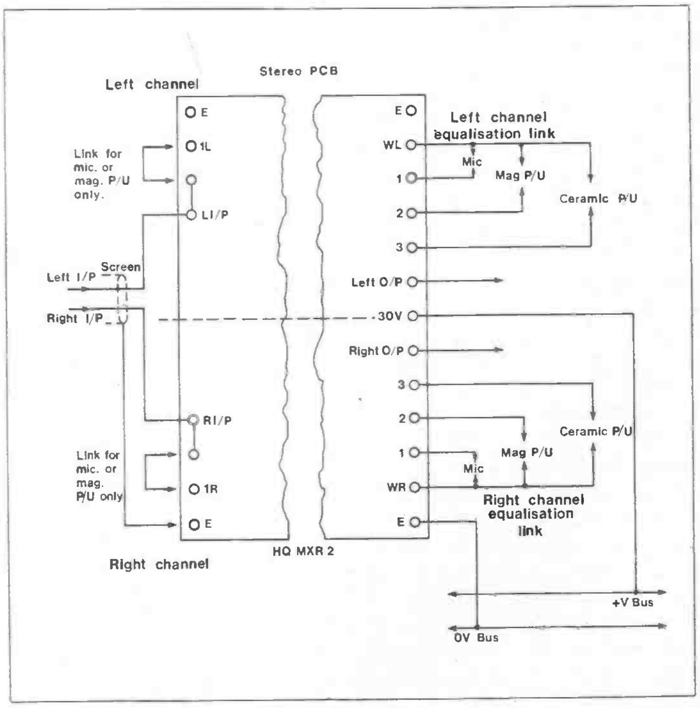



Figure 18. Equalisation link Selection

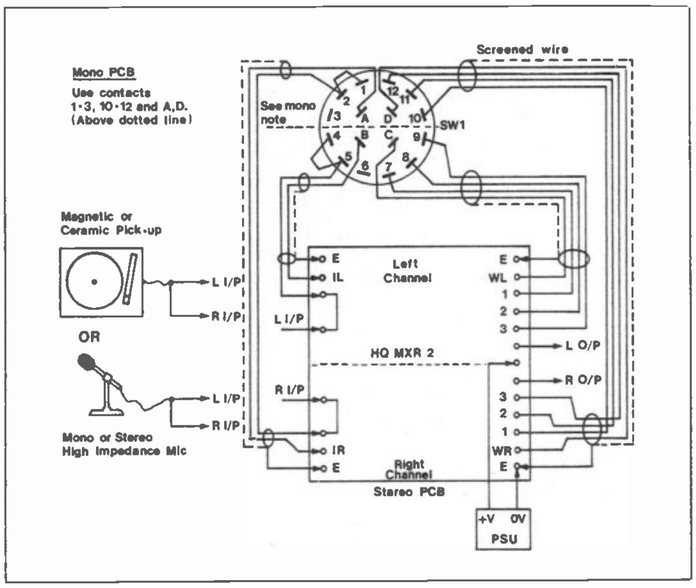



Figure 19. Using a switch for Selection

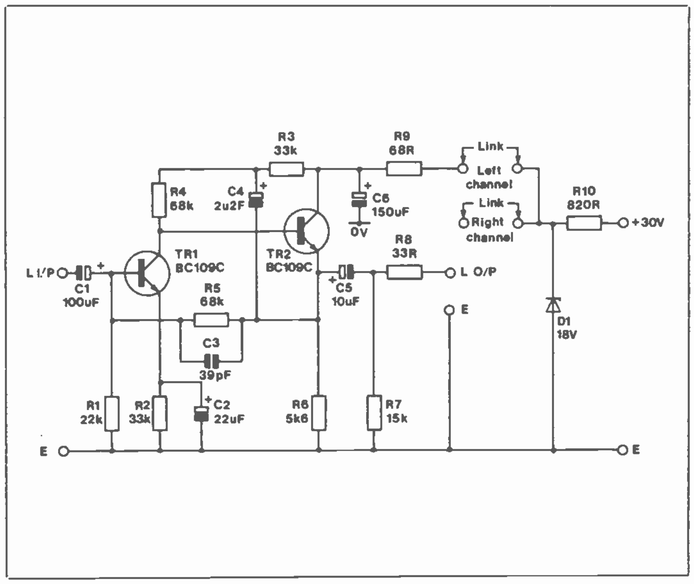



Figure 22. Mixer Circuit

links as shown in Figure 18. Alternatively, it may be found desirable to fit a switch selector instead of links and Figure 19 shows an example of this using screened wire for all signal connections and a 4-pole 3-way rotary switch on the stereo PCB version. Also, use screened wire for both input and output connections on the module, as hum pick-up and noise problems are greatly reduced this way.

The graph in Figure 20 shows the expected frequency response characteristic of the module when equalised for magnetic pick-up, and this closely follows the RIAA standard for replay. Records are manufactured with a boosted high frequency and attenuated low frequency signal content, effectively exhibiting a replay curve with an average rise of <6dB/octave with a small step in the mid-range, hence the replay characteristic for the pre-amp has to be the opposite to this. Ceramic pick-ups by nature exhibit increasing output levels at increasing frequencies; therefore with the ceramic pick-up equalisation selected, it can be seen (Figure 21) that low frequency signals are given a considerable amount of boost. In both instances, the object of equalising circuitry is for the final production of a flat frequency response from 20Hz to 20kHz. No plot is given for the module when used with a microphone, as the frequency response is flat throughout the useful audio range, dropping by 3dB at 40kHz.

The specifications given assume that a 30V DC power supply is used with the module. Lower voltage supplies will not unduly affect circuit performance, but will require lower input signal levels to avoid clipping the waveform.

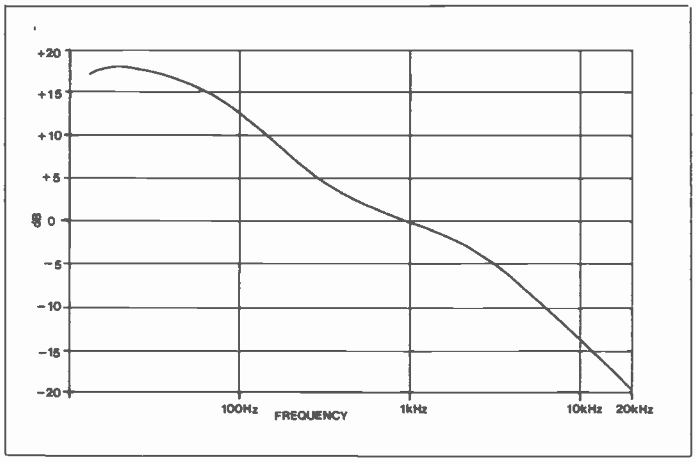



Figure 20. Magnetic PU Response Curve

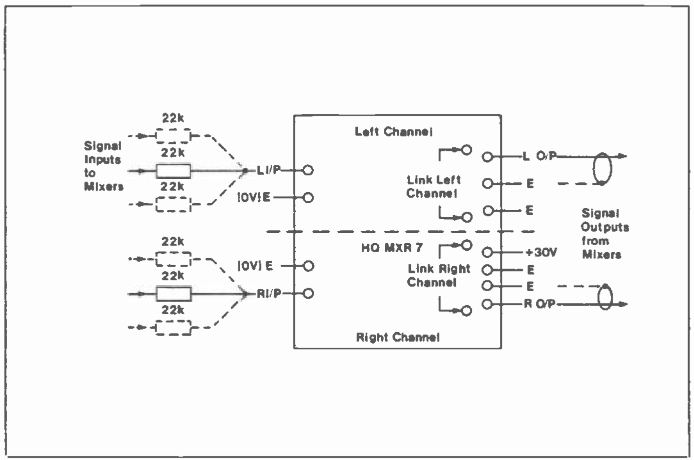



Figure 23. PCB wiring

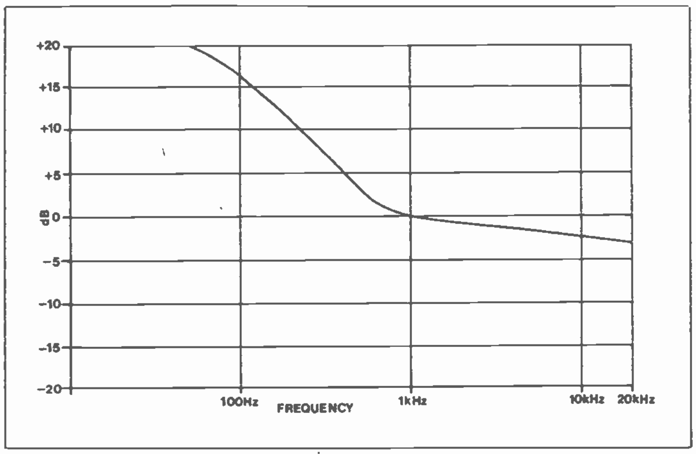



Figure 21. Ceramic PU Response Curve

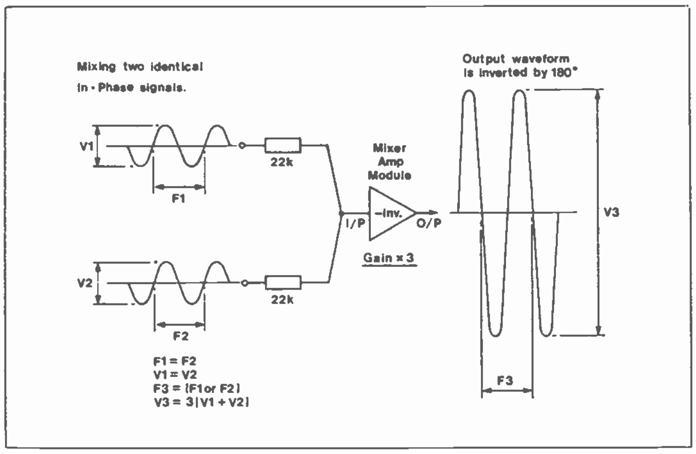



Figure 24. Mixing Identical in-phase Signals

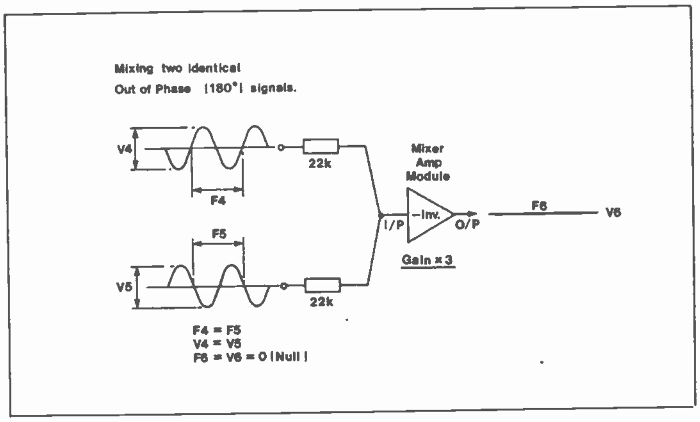



Figure 25. Mixing Identical out-of-phase (180°) Signals

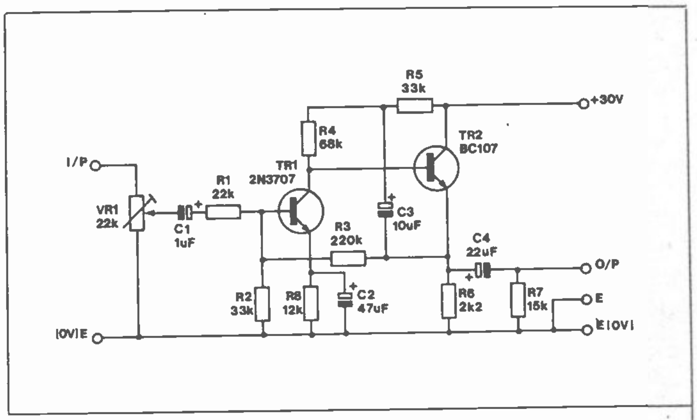



Figure 27. Line Amp Circuit

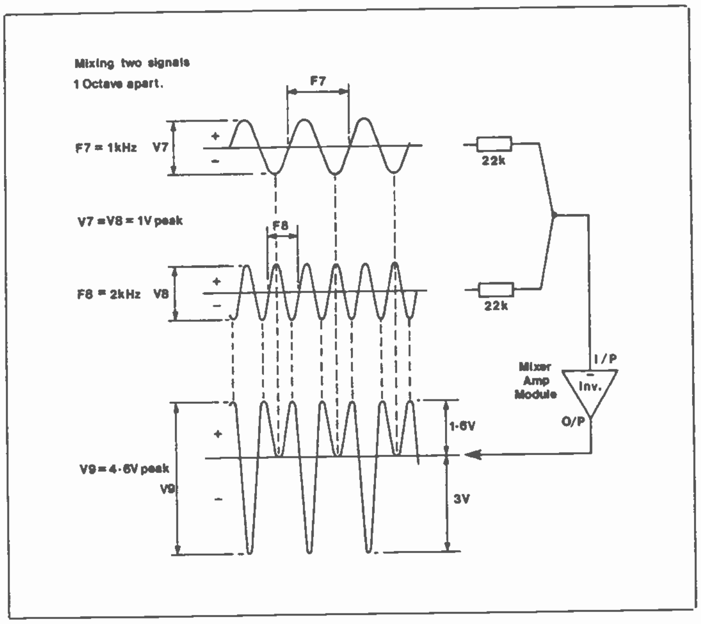



Figure 26. Mixing 2 signals 1 Octave apart

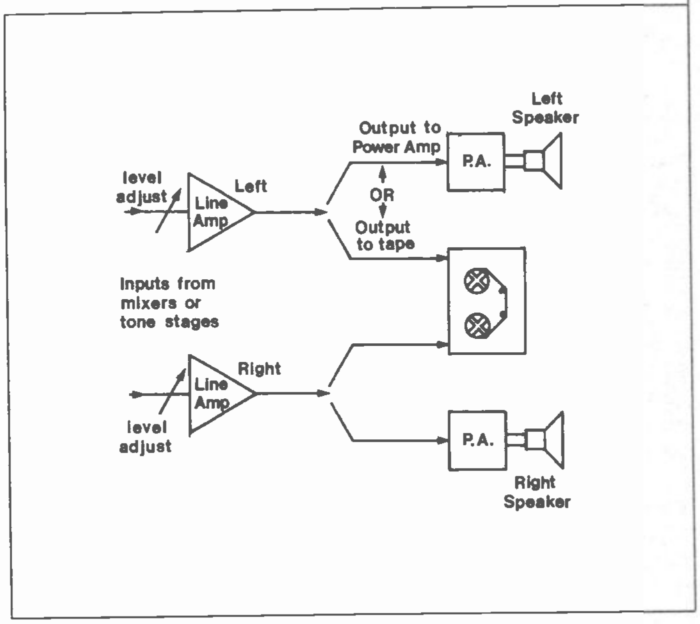



Figure 28. Driving Speakers or Tape Recorder

# Mixer Amp Module

## MODULE SPECIFICATIONS

| | |
|---|---|
| Frequency Response | 15Hz to 60kHz (−3dB) |
| Maximum Input Signal | 5V Pk into 22k |
| Maximum Output Signal | 15V Pk (Pre-Clipping) |
| Distortion (@ 1kHz) | 0.02% |
| Noise Level | 100$\mu$V |
| PSU 30V DC @ 14mA | |

The mixer amplifier is only available as a stereo (dual channel) module. Both circuits are identical, except for prefix numbers on the right hand channel, as usual. From the circuit diagram, Figure 22, it can be seen that the supply regulation comes from R10 and zener diode D1. This part of the circuit is not repeated on both halves of the PCB and regulated 18V DC is extended to each mixer via links, see Figure 23. TR1 and TR2 form a DC coupled amplifier with an overall gain of approximately x3.

Virtual earth mixing is effected by coupling input signals via a 22k resistor (Figures 23 to 26), therefore, as an example, if a 1kHz sinewave signal with a peak-to-peak amplitude of 1V is connected to a 22k resistor and then to the module input at C1, the output signal from R8 will be a 1kHz, 3V peak sinewave (overall gain = x 3). If several different signal sources are to be connected to the module input, each source must be coupled by a separate 22k resistor. One point to note is that the pre-amp inverts all input signals, so the final output waveform does not follow the input waveform exactly in time! The mathematics of mixing signals can be quite complex to both explain easily and understand, and a very general idea is given in Figure 24, 25 and 26. Basically, mixing two identical waveforms together produces a similar waveform (in the case of a sinewave) but with an increased peak-to-peak (amplitude) level. The maximum peak signal output from the module, before clipping occurs, is 15V which corresponds to a 5V peak input signal. Obviously, attempting to connect two 5V in-phase signals at the same frequency would effectively produce a 30V signal which cannot occur due to supply limitations, and therefore, heavy clipping of the output waveform will be evident. In theory, an infinite number of input signals can be applied via an infinite number of resistors as long as the sum total voltages do not exceed 5V, including all in-phase and out-of-phase products. In practice, it is probably advisable to connect no more than six inputs per channel, especially if high (1V peak or more) signal levels are envisaged.

# Line Amp Module

## MODULE SPECIFICATIONS

| | |
|---|---|
| Frequency Response | 10Hz to 100kHz Flat |
| Maximum Output Level | 26V peak (Pre-Clipping) |
| Minimum Input Signal for full Output | 2.6V Peak |
| Maximum Input Signal | Continuously Variable |
| Pre-amp Gain | x10 |
| THD | 0.02% @ 1kHz |
| PSU | Max 30V DC @ 14mA |

The line amp module circuit shown in Figure 27, is used as a high level buffer stage output drive to amplifiers or tape recorders, see Figure 28. Maximum gain of the circuit is ten times which makes it unsuitable for direct connection with microphones, and other low level input signal devices.

Wiring of the PCB is shown in Figure 29. In the typical application shown in Figure 30, line amp modules are shown in two output configurations, main output and unequalised output. The module is available in dual (stereo) version only and each input has its own level control which is infinitely variable from zero to maximum (see Specification).

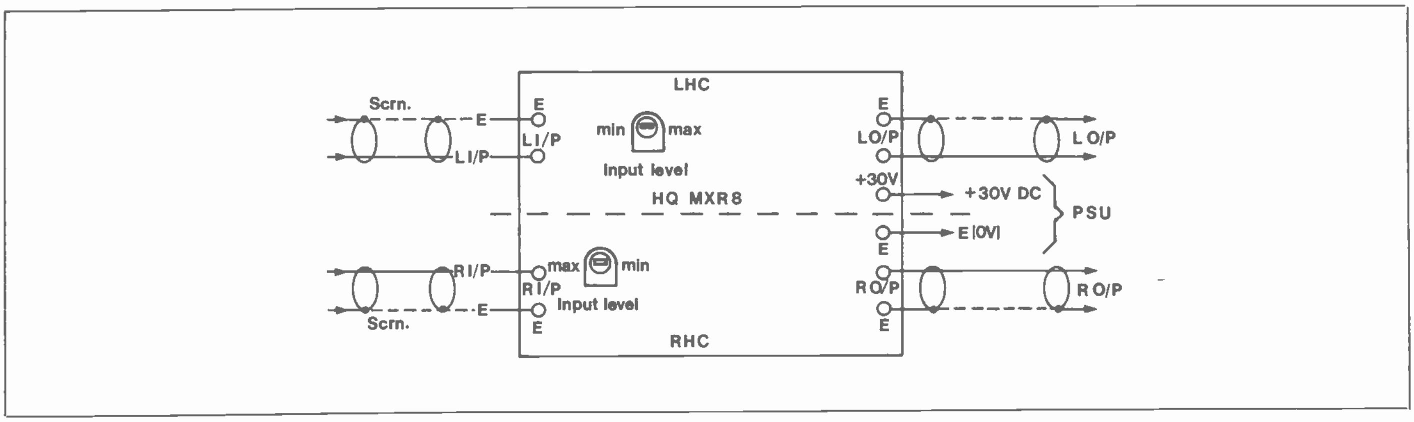



Figure 29. Line Amp wiring

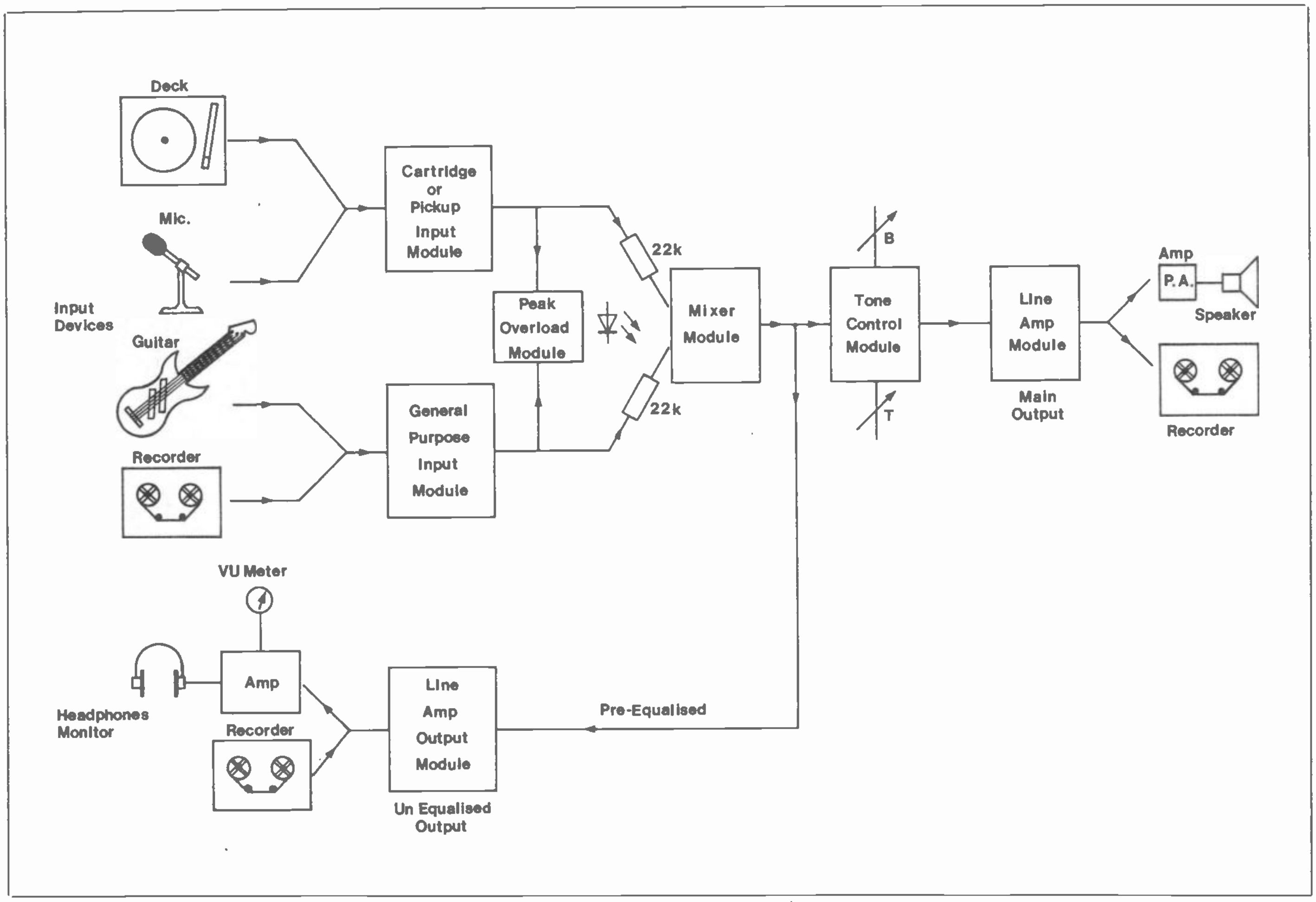



Figure 30. Typical Application

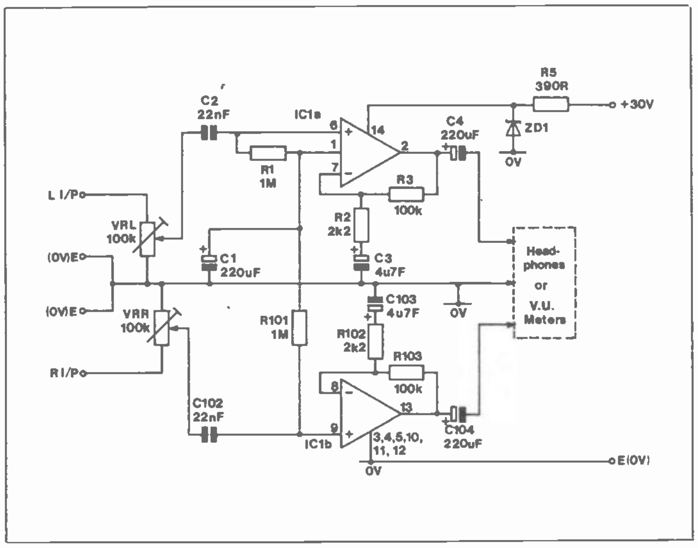



Figure 31. Basic Amplifier Circuit

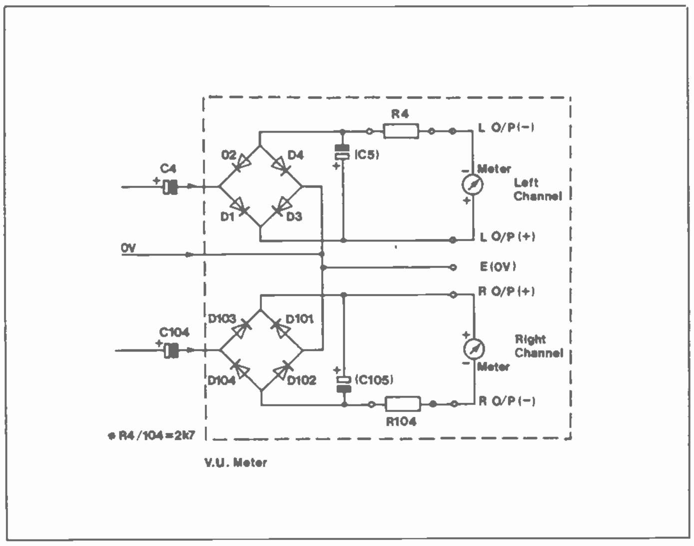



Figure 32. VU Meter Circuit

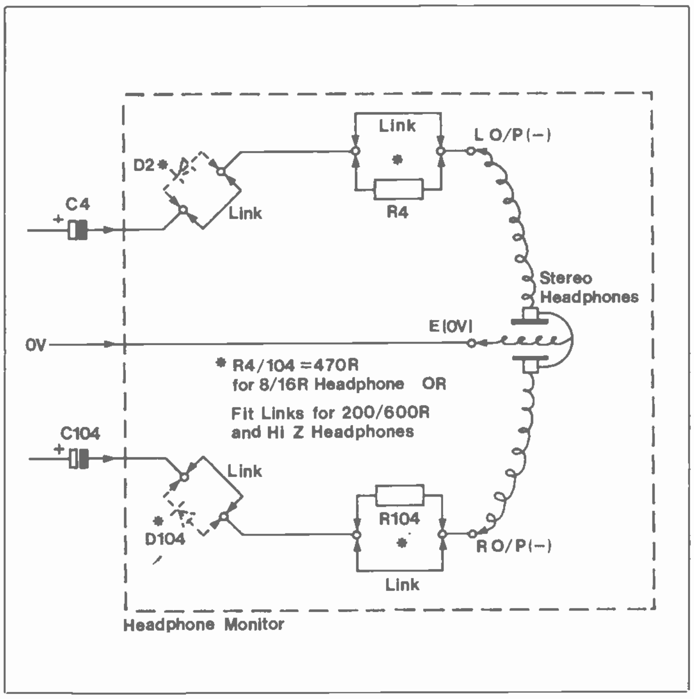



Figure 33. Headphone Monitor Circuit

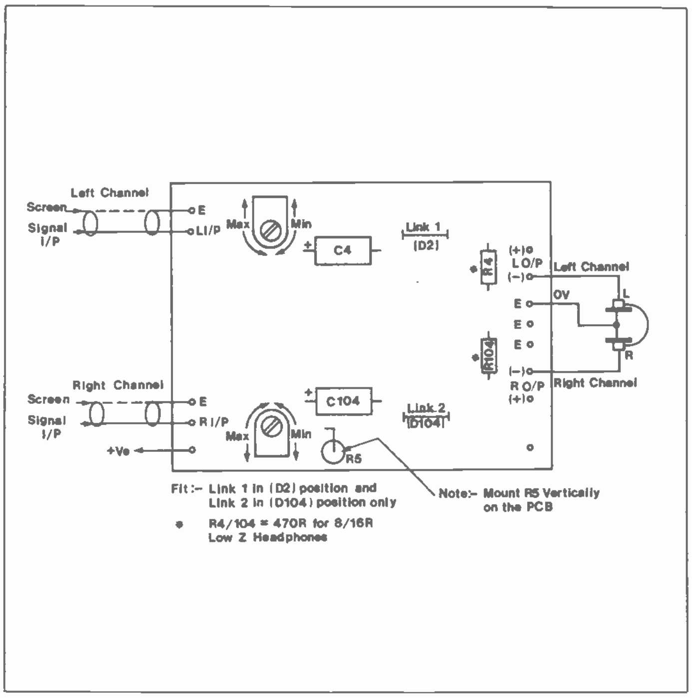



Figure 35. Headphone Monitor wiring

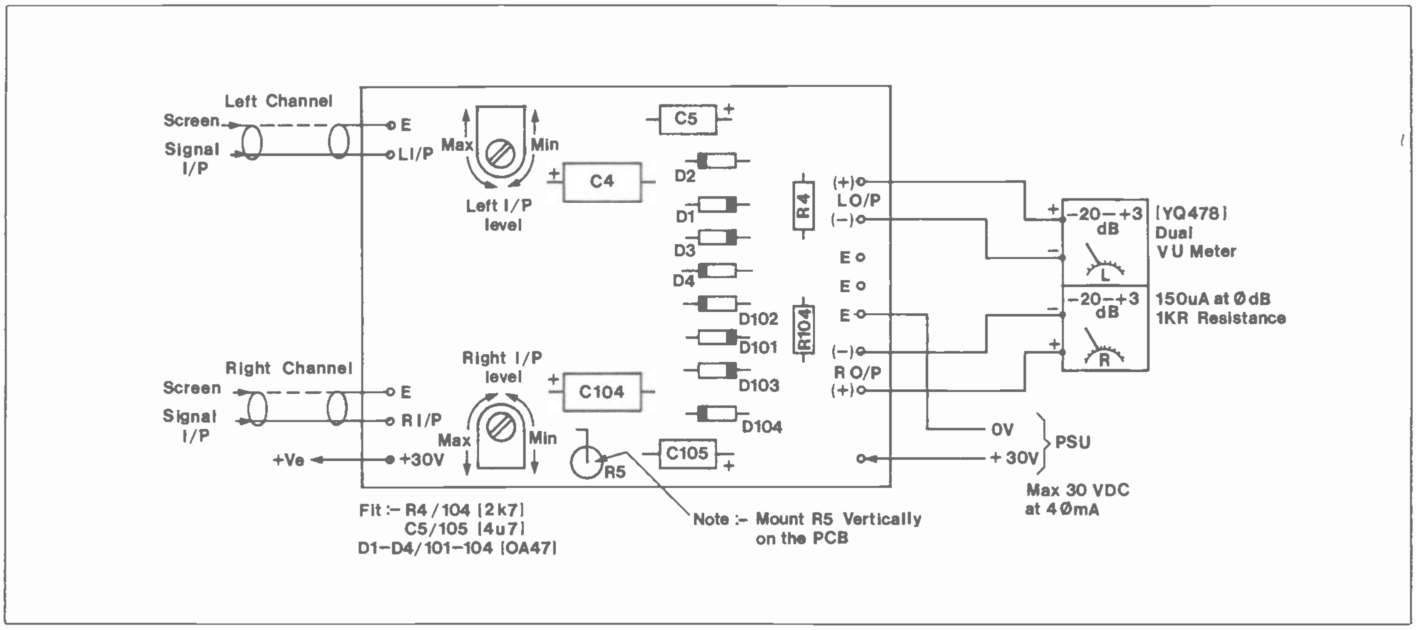



Figure 34. VU Meter wiring

# VU/Monitor Amp Module

## MODULE SPECIFICATIONS

Pre-Amp
Frequency
Response 50Hz-20kHz flat
Input
Sensitivity 75mV r.m.s. maximum, Continuously variable
Max Output
Level 10V pk (O/P open circuit)
150mV pk (into 8Ω 'phones)
VU Mode
Input Level 18mV r.m.s. for 0dB scale
PSU Max +30V DC @ 40mA

The VU/monitor module can be used in one of two ways: driving headphones or twin meter movements. Figure 31 shows the basic amplifier circuit, which is based around an LM377 power amp IC. Each channel input can be adjusted for the required output level via 'on board' presets, $VR_R$ and $VR_L$.

### VU Monitor

For VU meter mode, fit the additional components D1 to D4, D101 to D104, C5/105 and R4/104 (see Figures 32 and 34). With the specified components, a reading of 0dB on the meter scale is indicated with an 18mV r.m.s. input signal, and with the sensitivity presets (VR1, VR101) at maximum (both channels driven).

### Headphone Monitor

To use the module in this mode, use wire links in place of D2 and D104, and insert 470Ω resistors in R4 and R104 positions only (see Figures 33 and 35). *Do not* insert any of the components required for the VU version!

When driving 8Ω low impedance headphones, the maximum (pre-clipping) signal developed will be approximately 150mV, which should be loud enough for most applications. It may be necessary to insert links in place of R4/104 if medium impedance (200 – 600Ω) headphones are being used, or to reduce the 470Ω rating accordingly. The power amp IC can only drive loads above 200Ω in this circuit configuration, before overheating of the package begins to cause problems. Power supply requirements are in the range of 15V to 30V DC at 40mA.

This module would normally be used for monitoring all signal lines in a mixer or disco, each line being selected by suitable switching. Alternatively, it could be used as a low power/low cost stereo headphone driver for most audio applications.

# HI-Z MIC I/P (MONO) PARTS LIST

RESISTORS: All 0.6W 1% Metal Film

| | | | |
|---|---|---|---|
| R1 | 1k | 1 | (M1K) |
| R2 | 82k | 1 | (M82k) |
| R3 | 270k | 1 | (M270K) |
| R4 | 510Ω | 1 | (M510R) |
| R5 | 12k | 1 | (M12K) |
| R6 | 100k | 1 | (M100K) |
| R7 | 47k | 1 | (M47K) |
| R8 | 22k | 1 | (M22K) |
| R9 | 1k8 | 1 | (M1K8) |
| R10 | 820Ω | 1 | (M820R) |
| R11 | 3k3 | 1 | (M3K3) |
| R12 | 47Ω | 1 | (M47R) |
| R13,15 | 220k | 2 | (M220K) |
| R14 | 56k | 1 | (M56K) |
| R16 | 6k8 | 1 | (M6K8) |
| R17 | 2k2 | 1 | (M2K2) |
| R18 | 680k | 1 | (M680K) |

CAPACITORS

| | | | |
|---|---|---|---|
| C1 | 1μF 35V Tantalum | 1 | (WW60Q) |
| C2,5,6 | 10μF 63V Axial Electrolytic | 3 | (FB23A) |
| C3 | 2n2F Poly Layer | 1 | (WW24B) |
| C4 | 4p7F Ceramic | 1 | (WX40T) |
| C7 | 10pF Ceramic | 1 | (WX44X) |
| C8 | 1n5F 1% Polystyrene | 1 | (BX58N) |
| C9 | 22nF Poly Layer | 1 | (WW33L) |
| C10 | 4n7F 1% Polystyrene | 1 | (BX64U) |

SEMICONDUCTORS

| | | | |
|---|---|---|---|
| TR1,2 | 2SC2547 | 2 | (QY11M) |
| TR3 | BC547 | 1 | (QQ14Q) |

MISCELLANEOUS

| | | | |
|---|---|---|---|
| | Hi-Z Mic I/P (Mono) PCB | 1 | (GD11M) |
| | Veropin 2145 | 1 Pkt | (FL24B) |

OPTIONAL

| | | | |
|---|---|---|---|
| SW1 | 4 Pole 3-Way Rotary Switch | 1 | (FH45Y) |

A complete kit of all parts and a ready built module, excluding optional item, are available for this project:
**Order As LK92A (Hi-Z Mic Input Mono Kit) Price £4.95**
**Order As YM26D (Hi-Z Mic Input Mono Assembled) Price £5.95**

# HI-Z MIC I/P (STEREO) PARTS LIST

RESISTORS: All 0.6W 1% Metal Film

| | | | |
|---|---|---|---|
| R1,101 | 1k | 2 | (M1K) |
| R2,102 | 82k | 2 | (M82k) |
| R3,103 | 270k | 2 | (M270K) |
| R4,104 | 510Ω | 2 | (M510R) |
| R5,105 | 12k | 2 | (M12K) |
| R6,106 | 100k | 2 | (M100K) |
| R7,107 | 47k | 2 | (M47K) |
| R8,108 | 22k | 2 | (M22K) |
| R9,109 | 1k8 | 2 | (M1K8) |
| R10,1010 | 820Ω | 2 | (M820R) |
| R11,1011 | 3k3 | 2 | (M3K3) |
| R12,1012 | 47Ω | 2 | (M47R) |
| R13,15,1013,1015 | 220k | 4 | (M220K) |
| R14,1014 | 56k | 2 | (M56K) |
| R16,1016 | 6k8 | 2 | (M6K8) |
| R17,1017 | 2k2 | 2 | (M2K2) |
| R18,1018 | 680k | 2 | (M680K) |

CAPACITORS

| | | | |
|---|---|---|---|
| C1,101 | 1μF 35V Tantalum | 2 | (WW60Q) |
| C2,5,6,102,105,106 | 10μF 63V Axial Electrolytic | 6 | (FB23A) |
| C3,103 | 2n2F Poly Layer | 2 | (WW24B) |
| C4,104 | 4p7F Ceramic | 2 | (WX40T) |
| C7,107 | 10pF Ceramic | 2 | (WX44X) |
| C8,108 | 1n5F 1% Polystyrene | 2 | (BX58N) |
| C9,109 | 22nF Poly Layer | 2 | (WW33L) |
| C10,1010 | 4n7F 1% Polystyrene | 2 | (BX64U) |

SEMICONDUCTORS

| | | | |
|---|---|---|---|
| TR1,2,101,102 | 2SC2547 | 4 | (QY11M) |
| TR3,103 | BC547 | 2 | (QQ14Q) |

MISCELLANEOUS

| | | | |
|---|---|---|---|
| | HQ Mixer No.2 PCB | 1 | (LR13P) |
| | Veropin 2145 | 1 Pkt | (FL24B) |

OPTIONAL

| | | | |
|---|---|---|---|
| SW1 | 4 Pole 3-Way Rotary Switch | 1 | (FH45Y) |

A complete kit of all parts and a ready built module, excluding optional item, are available for this project:
**Order As LK91Y (Hi-Z Mic Input Stereo Kit) Price £8.50**
**Order As YM25C (Hi-Z Mic Input Stereo Assembled) Price £9.95**

# LINE AMPLIFIER PARTS LIST

RESISTORS: All 0.6W 1% Metal Film

| | | | |
|---|---|---|---|
| R1,101 | 22k | 2 | (M22K) |
| R2,5,102,105 | 33k | 4 | (M33K) |
| R3,103 | 220k | 2 | (M220K) |
| R4,104 | 68k | 2 | (M68K) |
| R6,106 | 2k2 | 2 | (M2K2) |
| R7,107 | 15k | 2 | (M15K) |
| R8,108 | 12k | 2 | (M12K) |
| VR1,101 | Vert S-min Preset 22k | 2 | (WR72P) |

CAPACITORS

| | | | |
|---|---|---|---|
| C1,101 | 1μF 100V Axial Electrolytic | 2 | (FB12N) |
| C2,102 | 47μF 16V Axial Electrolytic | 2 | (FB38R) |
| C3,103 | 10μF 63V Axial Electrolytic | 2 | (FB23A) |
| C4,104 | 22μF 25V Axial Electrolytic | 2 | (FB30H) |

SEMICONDUCTORS

| | | | |
|---|---|---|---|
| TR1,101 | 2N3707 | 2 | (QR31J) |
| TR2,102 | BC107B | 2 | (QB31J) |

MISCELLANEOUS

| | | | |
|---|---|---|---|
| | HQ Mixer No.8 PCB | 1 | (LR23A) |
| | Veropin 2145 | 1 Pkt | (FL24B) |

A complete kit of all parts and a ready built module are available for this project:
**Order As LK87U (Line Amp Kit) Price £3.95**
**Order As YM21X (Line Amp Assembled) Price £5.50**

# MIXER AMPLIFIER PARTS LIST

RESISTORS: All 0.6W 1% Metal Film

| | | | |
|---|---|---|---|
| R1,101 | 22k | 2 | (M22K) |
| R2,3,102,103 | 33k | 4 | (M33K) |
| R4,5,104,105 | 68k | 4 | (M68K) |
| R6,106 | 5k6 | 2 | (M5K6) |
| R7,107 | 15k | 2 | (M15K) |
| R8,108 | 33Ω | 2 | (M33R) |
| R9,109 | 68Ω | 2 | (M68R) |
| R10 | 820Ω | 1 | (M820R) |

CAPACITORS

| | | | |
|---|---|---|---|
| C1,101 | 100μF 10V P.C. Electrolytic | 2 | (FF10L) |
| C2,102 | 22μF 25V Axial Electrolytic | 2 | (FB30H) |
| C3,103 | 39pF Ceramic | 2 | (WX51F) |
| C4,104 | 2μ2F 100V Axial Electrolytic | 2 | (FB15R) |
| C5,105 | 10μF 25V Axial Electrolytic | 2 | (FB22Y) |
| C6,106 | 150μF 25V Axial Electrolytic | 2 | (FB56L) |

SEMICONDUCTORS

| | | | |
|---|---|---|---|
| TR1,2,101,102 | BC109C | 4 | (QB33L) |
| D1 | BZY88C18V | 1 | (QH20W) |

MISCELLANEOUS

| | | | |
|---|---|---|---|
| | Veropin 2145 | 1 Pkt | (FL24B) |
| | Mixer No.7 PCB | 1 | (LR22Y) |

OPTIONAL

| | | | |
|---|---|---|---|
| | 22k Input Resistor | | (M22K) |

A complete kit of all parts and a ready built module, excluding optional item, are available for this project:
**Order As LK86T (Mixer Amp Kit) Price £4.75**
**Order As YM20W (Mixer Amp Assembled) Price £6.50**

*Continued on page 25.*

# The Story of Radio

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

## *Part Two – The First Decade*

Having now proved to a doubting world that the Atlantic could be bridged by wireless waves, Marconi's next act was to establish a permanent station at Glace Bay, Cape Breton Island on the east coast of Canada. This station was augmented on December 21st 1902 and tests began straight away with transmissions between this new station, the one at Cape Cod and Poldhu in Cornwall. It was now vital to show that transatlantic contact was no freak occurrence but could be depended upon at all times. If this could be done, it would open up a whole new world of possibilities, of which the most obvious, at the time, seemed to be in the realm of marine communications.

Ever since man first set the bows of his vessel toward the open sea, he had had to accept the fact that once out of sight of land, he was totally isolated from humanity, unless he came across another seafarer of course. Now all that could be changed. Right across the breadth of the Atlantic he would be able to send messages to ports at both ends of his route, informing his employers as to his likely time of arrival, giving warning of bad weather or icebergs or some other emergency.

The first widespread use of marine wireless was the setting up of a long range news service for transatlantic liners, using the Glace Bay and Poldhu stations. This was an interim measure because it had been decided to build new, larger aerials at these stations in order to benefit more from the better service that longer wavelengths seemed to give. Until these new aerials were complete, some sort of practical use would presumably increase public confidence in the new technology. The commercial use of wireless at sea pre-dated this event by a couple of years because in 1900, the Marconi

Weekly Dispatch

PURE INDIAN TEA

BRITAIN'S BEST BEVERAGE.

No. 5,677.

109TH YEAR

SUNDAY, JULY 31, 1910.

SUNDAY SPECIAL EDITION.

ESMOLIN NEURITIS

ONE PENNY.

CRIPPEN'S LIFE AT SEA DESCRIBED BY 'WIRELESS.'

DETECTIVE INS^TR DEW

M^RS CRIPPEN — (MISS BELLE-ELMORE)

H.H. Crippen.

THE DOCTOR'S FIRST WIFE M^RS CHARLOTTE CRIPPEN

CAP^T KENDALL

MISS LE NEVE.

CRIPPEN'S LIFE AT SEA DAY BY DAY.

DESCRIBED BY CAPTAIN KENDALL OF THE MONTROSE.

FULL EXCLUSIVE "WIRELESS" TO "THE DAILY MAIL."

THE BOOKS CRIPPEN READS, AND THE SONG HE LIKED.

WHY HE FAILED TO ANSWER THE NAME "ROBINSON."

"ALL WALKED INTO THE SHOP."

NOTICE.

WHOSE REWARD?

*Photo supplied by Marconi Co Ltd.*

Company had installed untuned equipment in the German liner, Kaiser Wilhelm der Grosse. Such was the growth of this new service that, by the end of 1902, there were some seventy ships operating with wireless and twenty-five land stations available for their use, including several on the eastern seaboard of the North American continent.

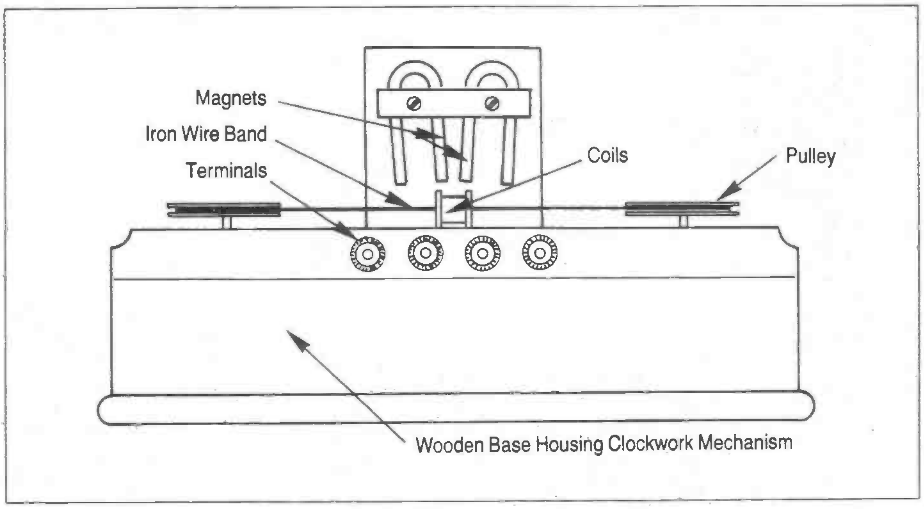
## Magnetic Detector

A significant technical development was made by the Marconi Company at this time. This was the superseding of the rather insensitive coherer with the new 'magnetic detector'; this also allowed higher signalling speeds and better discrimination against interference. The experimental prototype had been made by Rutherford in 1895 but Marconi developed it into a practical device. Its action was to use a high frequency bias to overcome the 'hysteresis' in magnetic materials, in much the same way that, in modern tape recorders, a high frequency current is superimposed on the signal current in the recording head. However, in the case of Marconi's magnetic detector, the end result was achieved in rather a different way.

An endless band of iron wires was driven past a system of permanent magnets by a clockwork motor, the speed being about 8cm/s. At the point of maximum magnetic field strength due to the permanent magnets, the iron wire band was surrounded by a pair of coils, one carrying the radio frequency energy from the aerial, the other being connected to the headphones. The signal itself consisted of bursts of energy recurring at an audio frequency. In the periods when no radio frequency energy was present, the permanent magnets had little effect, but when their action coincided with the bursts of radio frequency energy, an output, at audio rate, was produced in the headphones by way of the previously mentioned coil. This device remained in use for about twenty years and was known as the 'Maggie'.

## Radio for Hire

It is interesting to note that the Marconi Company did not actually sell their wireless equipment to the shipping lines, but hired it out instead – presumably the first example of 'radio rentals'! The installation came complete with a Marconi-trained operator, and the rental included the use of all of the shore stations in the Marconi network. There were naturally competitors at the time, and these were not allowed the use of the Marconi shore stations, since they had not paid the rental charge for their use. Obviously this restriction did not apply to distress calls. Furthermore, the ships equipped with Marconi wireless equipment were not allowed to communicate with ships equipped by their competitors. This may seem a strange state of affairs but should only be judged in the context of the times. The chief competitor of the Marconi company was the German firm of Telefunken, which was a government backed consortium of German radio expertise. It was this latter company who, in 1903, called an International Wireless Telegraphy Conference with the object of allowing all to have free intercommunication regardless of the source of the equipment carried. However, Marconi were not prepared to hand over their dominant position so readily and did not finally agree to this until 1912.




*Simplified diagram of Marconi's magnetic detector (the Maggie).*

## Licencing

An amusing and extremely significant event took place in 1903. The ability to tune the transmissions so that adjacent stations could operate without mutual interference had been developed to a practicable level. However, the case had been rather overstated because it had also been claimed that the medium of wireless allowed 'secret' communication between parties, free from

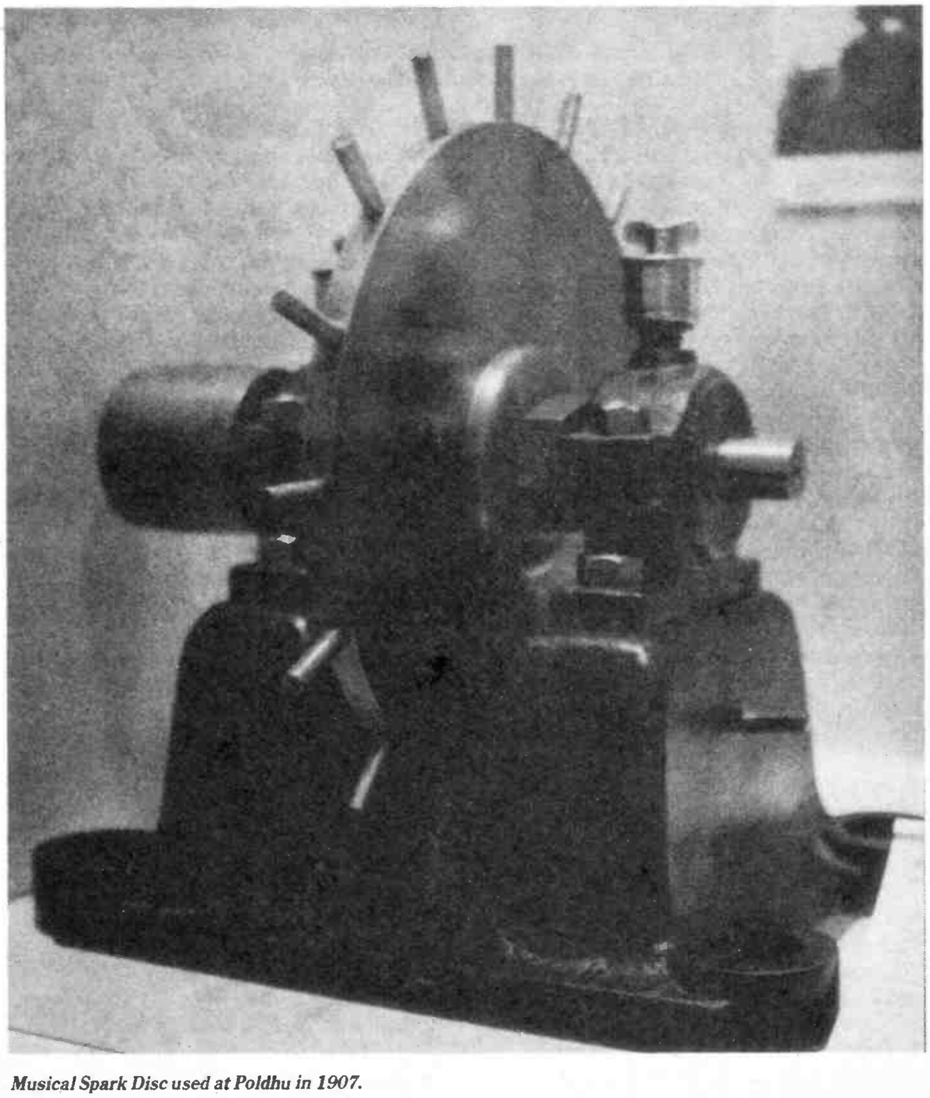


Photo courtesy of the Science Museum, London

*Musical Spark Disc used at Poldhu in 1907.*

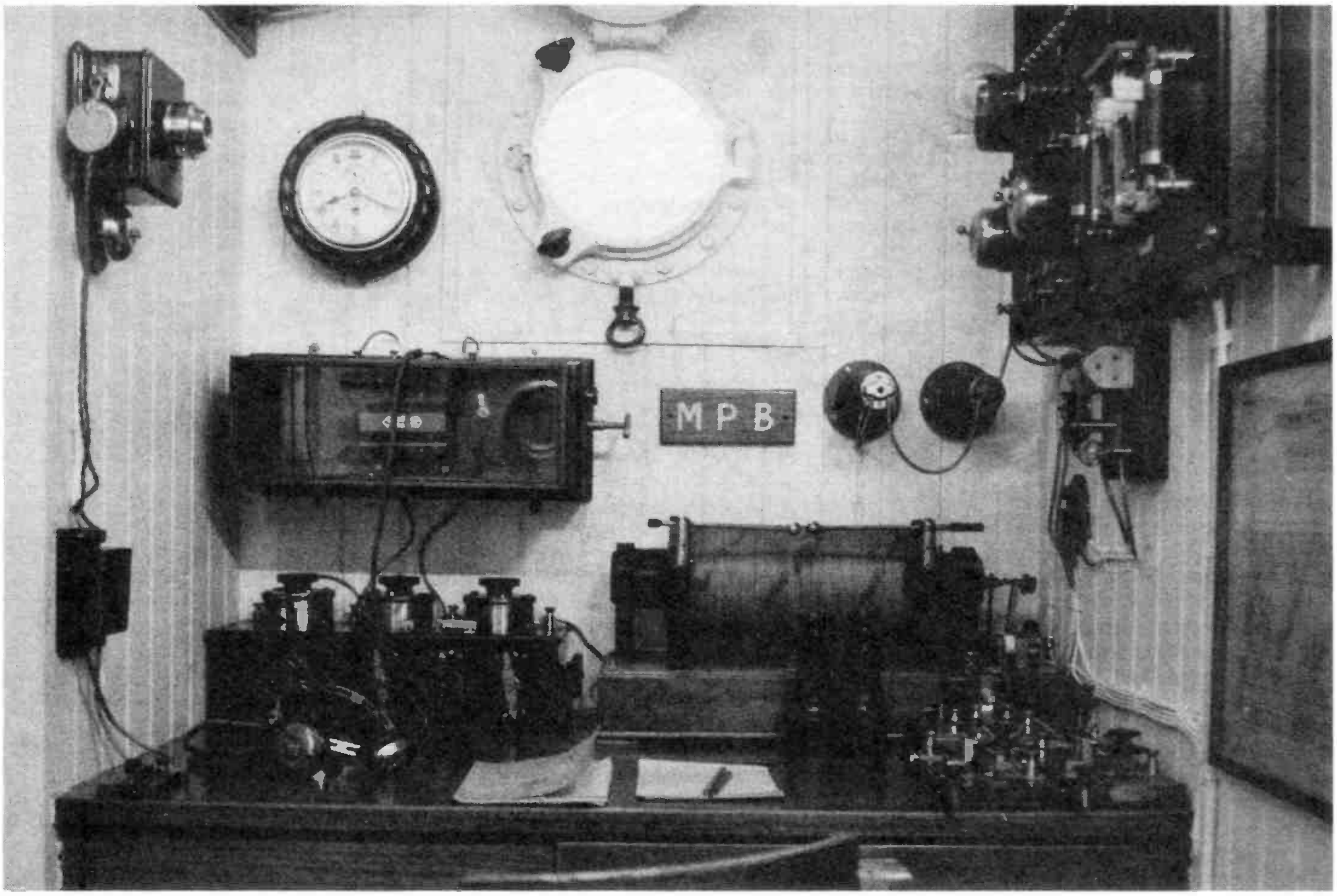


Photo courtesy of the Science Museum, London

*Ships wireless cabin, 1910. A 1.5kW installation that was standard for large ships.*

the possibility of interference by a third party. This clearly wasn't true, and one particular person was determined to demonstrate this in as public a manner as possible. The person concerned was Neville Maskelyne, son of the famous illusionist, whose father owned the Egyptian Theatre in Piccadilly, London. Neville Maskelyne had commercial interests in certain of Marconi's competitors, and it was in his interest to disprove unsound claims made by Marconi. This he did by setting up a transmitter on the roof of the Egyptian Theatre at the time that a demonstration was taking place at the nearby Royal Institution. A lecture was being given by professor Ambrose Fleming in the said Institution, which was to have, as its 'piece de resistance', the reception of a ceremonial message from the Marconi Company at Chelmsford. During the lecture Fleming's assistant was supposed to be receiving some test transmissions. To his surprise, indeed no doubt to his horror, rather odd messages began to come through, along the lines of, 'Rats', or 'There was a young fellow of Italy, who diddled the public quite prettily'. This had exactly the effect intended, since Maskelyne ensured that the episode attracted the maximum publicity.

The real significance of this episode was, of course, the fact that some form of control was needed for operators of wireless equipment. This led, in Britain, to the Wireless Telegraphy Act of 1904, which became effective the following year. This was to ensure that wireless was developed under direct government control, for the good of the country and the people, and to enforce international legislation. All stations had to have licences, which included Marconi's shore stations. The latter were supposed to have licences with an eight-year span but, by 1909, the British Post Office obliged Marconi to sell the stations to them. However, it now became possible to extend the Inland Telegrams service to ships at sea, where they became known as Marconigrams.

## New Directions

In 1905 Guglielmo Marconi married. He was considered an eligible bachelor, because of his fame and, to be fair, also because of his personality, which exuded self-confidence and a quiet determination. He had had a number of romances, including two engagements to American girls as a result of the many transatlantic crossings that he made. However, his bride was not American, but Irish, a 19-year old by the name of Beatrice O'Brien. Shortly after their marriage, Marconi took his new wife to the inhospitable site chosen in Nova Scotia as a replacement for the original Glace Bay station. Here a new aerial system had been built, which consisted of an inverted cone supported by four 64-metre towers, surmounted by an umbrella roof with a diameter of 615 metres! This gives a fair indication of the dimensions of the aerial required for the long waves in vogue at the time. Having seen to the tuning of the new station, Marconi set off by sea (leaving his wife behind!), to test the range. In daylight a range of 2,900 kilometres was achieved. This offered a significant but still insufficient improvement. However, Marconi then made the interesting discovery that, at the receiver, the signal received was much stronger when the aerial wire, as it lay on the ground, 'pointed away from the transmitter'. This led to the 'inverted-L' configuration, with the horizontal arm being much longer than the vertical one. As a result, the aerial at Glace Bay was modified by having three-quarters of the umbrella removed, the remaining quarter being that which faced away from the Poldhu transmitter. The received signal from England was substantially stronger.

Thus, the innovation that had improved the strength of the received signal showed also that an aerial could have the property of directionality. Put another way, a given aerial in which the directional property was enhanced, achieved a gain in signal strength. This invention was patented in 1905 and became the Company's standard long range aerial. Because the Poldhu site was too small for a directional aerial of any real size to be built, a new site was chosen. This was in the west of Ireland at Clifden, later to be famous as marking the end of Alcock and Brown's first flight across the Atlantic. A propitious choice indeed! The new station put out a power of three hundred kilowatts and generated its own electricity, the boilers often being fuelled with peat cut from the bog nearby; the Company built their own light railway to give access to the station, so remote was it.

A rather incredible feature of the site was the capacitor building, which was over one hundred metres in length, and housed a giant air-spaced capacitor in which the radio-frequency energy was temporarily stored, before being discharged through the aerial transformer!

## New Sparks

After the directional aerial came another important development. The spark suffered from the disadvantage of having too broad a bandwidth, which made nonsense of the selectivity that could be achieved with receivers. Also, the erratic nature of the spark meant that it was not always easy to distinguish it from the atmospherics that were a normal accompaniment of long range wireless communication. To overcome this, Marconi made the spark strike and extinguish in a more regular fashion, by means of a studded steel disc in which the length of the spark gap narrowed as each stud approached a stationary electrode producing the spark, and then widened as the stud passed on, thus extinguishing the spark. This gave the received signal a characteristic musical sound, much more easily distinguished against a background of static. Furthermore, the way in which the spark energy was transferred to the aerial reduced the bandwidth of the transmitted energy, so reducing the interference.

## Viable Service

With these two significant developments, Marconi was at last in a position to open a viable transatlantic service, which was done in October 1907. Within three months of opening the service, over 100,000 words had been transmitted. However, there were obviously some technical problems to be overcome, because some messages had to be repeated a number of times before they were understood. Notwithstanding, it was an excellent achievement.

***Within three months of opening the service, over 100,000 words had been transmitted.***

As a culminating achievement, in 1909, Guglielmo Marconi was jointly awarded the Nobel Prize in Physics. The other recipient of this honour was K.F. Braun of Telefunken, later to invent the cathode ray tube.

By the year 1910, there were a good many vessels on the high seas equipped with wireless. Marconi themselves had their own installations in about 250 of them. It was in 1910 also that the very fact of ship-borne wireless put paid to the plans of one particularly notorious character, whose name is still well enough known today. This was the murderer Dr. Crippen, who, with his mistress Ethel le Neve, was fleeing

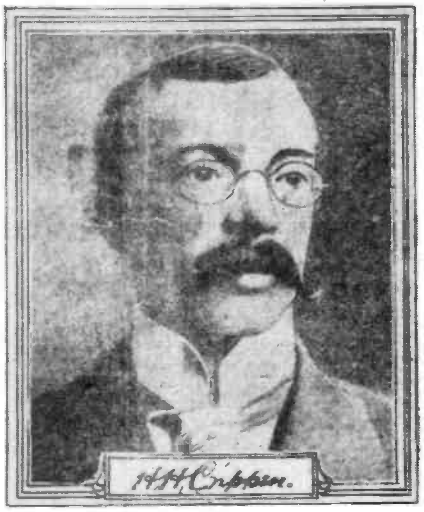



Photo supplied by Marconi Co Ltd

*Dr. Crippen*

westwards in the liner S.S. Montrose. The ship's captain was able to broadcast this fact back to England where Scotland Yard were alerted and were able, presumably also through the transatlantic wireless link, to arrange for the Canadian police to arrest him when the ship docked.

Also in 1910, Marconi's position in the further developments of wireless took a new turn. So much was happening that it was beyond one man to explore all the possibilities. From then on, he was to lead others to shape the future. In that future, very close at hand, lay the 'wireless valve'.

**MIXING IT** *Continued from page 21.*

## VU METER PARTS LIST

| | | | |
|---|---|---|---|
| **RESISTORS: All 0.6W 1% Metal Film unless specified** | | | |
| R1,101 | 1M | 2 | (M1M) |
| R2,102 | 2k2 | 2 | (M2K2) |
| R3,103 | 100k | 2 | (M100K) |
| R4,104 | 2k7 | 2 | (M2K7) |
| R5 | 390Ω 1W Carbon Film | 1 | (C390R) |
| VRL,VRR | 100k Hor Sub-min Preset | 2 | (WR61R) |
| **CAPACITORS** | | | |
| C1,4,104 | 220μF 35V Axial Electrolytic | 3 | (FB62S) |
| C2,102 | 22nF Ceramic | 2 | (WX78K) |
| C3,5,103,105 | 4μ7F 100V Axial Electrolytic | 4 | (FB18U) |
| **SEMICONDUCTORS** | | | |
| IC1 | LM377N | 1 | (QH38R) |
| ZD1 | BZX61C15V | 1 | (QF57M) |
| D1,2,3,4,101,102, 103,104 | OA47 | 8 | (QH70M) |
| **MISCELLANEOUS** | | | |
| | HQ Mixer PCB No.10 | 1 | (LR25C) |
| | 14 Pin DIL Skt | 1 | (BL18U) |
| | Veropin 2145 | 1 Pkt | (FL24B) |
| **OPTIONAL** | | | |
| | Dual VU Meter | 1 | (YQ47B) |

A complete kit of parts and a ready built module, excluding Optional item, are available for this project.
**Order As LK88V (VU Meter Kit) Price £8.95**
**Order As YM22Y (VU Meter Assembled) Price £10.95**

## HEADPHONE MONITOR PARTS LIST

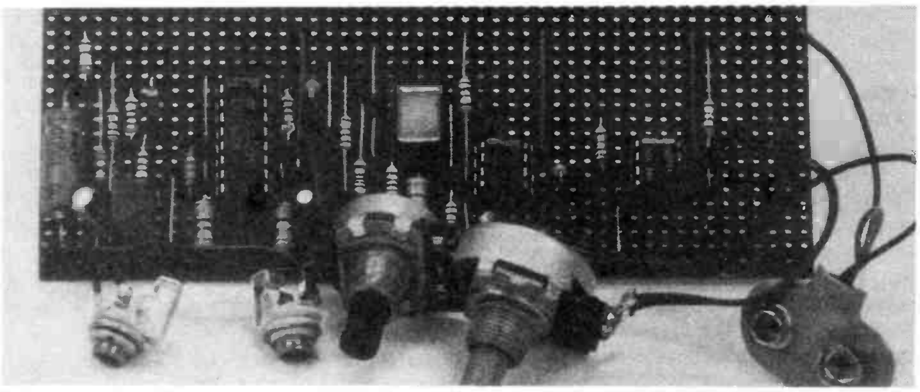
| | | | |
|---|---|---|---|
| **RESISTORS: All 0.6W 1% Metal Film unless specified** | | | |
| R1,101 | 1M | 2 | (M1M) |
| R2,102 | 2k2 | 2 | (M2K2) |
| R3,103 | 100k | 2 | (M100K) |
| R4,104 | 470Ω | 2 | (M470R) |
| R5 | 390Ω 1W Carbon Film | 1 | (C390R) |
| VRL,VRR | 100k Hor Sub-min Preset | 2 | (WR61R) |
| **CAPACITORS** | | | |
| C1,4,104 | 220μF 35V Axial Electrolytic | 3 | (FB62S) |
| C2,102 | 22nF Ceramic | 2 | (WX78K) |
| C3,103 | 4μ7F 100V Axial Electrolytic | 2 | (FB18U) |
| **SEMICONDUCTORS** | | | |
| IC1 | LM377N | 1 | (QH38R) |
| ZD1 | BZX61C15V | 1 | (QF57M) |
| **MISCELLANEOUS** | | | |
| | HQ Mixer PCB No.10 | 1 | (LR25C) |
| | 14 Pin DIL Skt | 1 | (BL18U) |
| | Veropin 2145 | 1 Pkt | (FL24B) |

A complete kit of parts and a ready built module are available for this project:
**Order As LK89W (Headphone Monitor Kit) Price £6.95**
**Order As YM23A (Headphone Monitor Assembled) Price £8.95**

# FANTASTIC FIVE

## Lowpass Filter Effects Unit

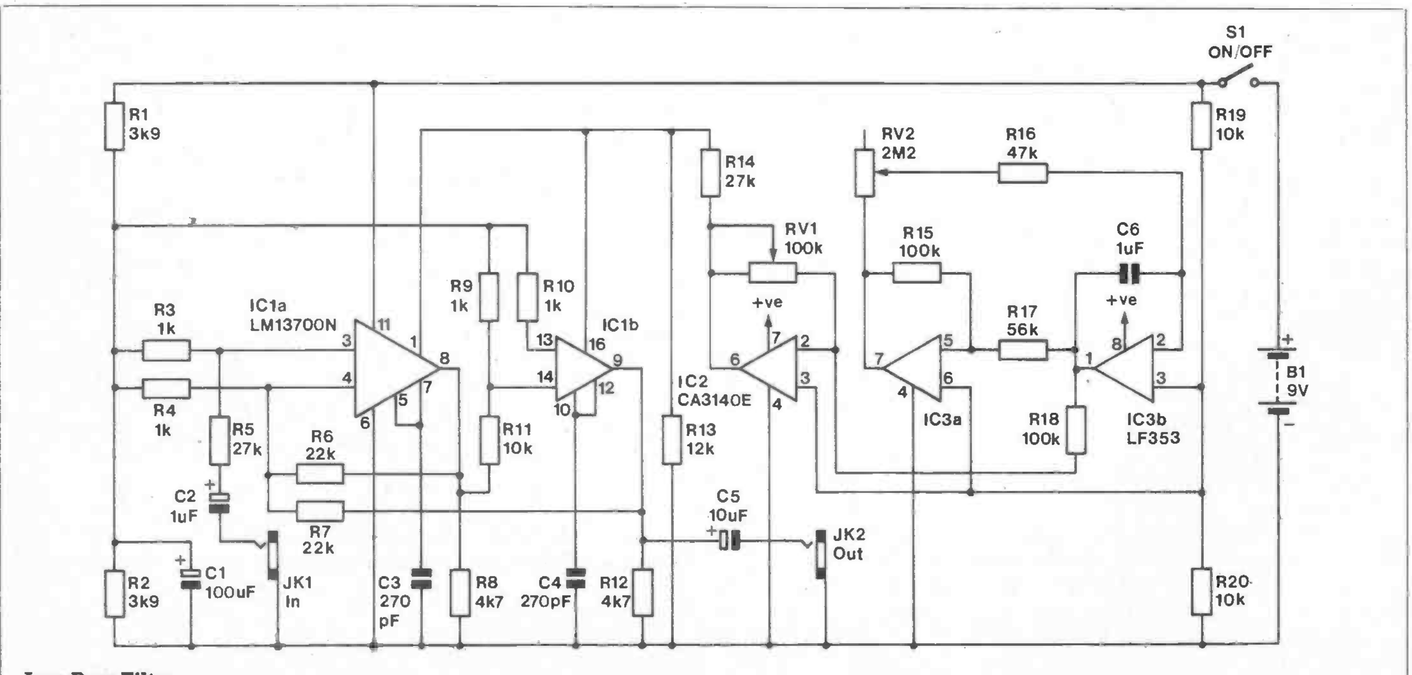
by Robert Penfold



There are a great many forms of musical effects unit, and most rely on some form of frequency selective filtering for their operation. The unit featured here is in this category, and it is basically just a 12dB per octabe lowpass filter which is swept by a low frequency oscillator. This gives a sort of tremolo effect on the high frequency content of the processed signal, producing a relatively mild but useful effect. It is an effect that is available on many synthesisers, but which seems to be something of a rarity as far as stand-alone effects units are concerned.

The circuit breaks down into two sections; the filter which is built around IC1, and the oscillator which is based on IC2 and IC3. Starting with the filter, this uses two transconductance operational amplifiers which are contained in a single LM13700N device. A darlington pair emitter follower output stage is also included for each amplifier, and these have discrete load resistors R8 and R12. The two amplifiers are connected in series, and in this application function more as voltage controlled resistors than amplifiers. They act as simple 6dB per octave lowpass filters in conjunction with C3 and C4, giving a combined attenuation rate of 12dB per octave. Feedback through R6 and R7 gives what is actually a bandpass response at pin 8 of IC1, and by taking the output signal from here a form of waa-waa effect can be obtained. IC1 is current rather than voltage operated, but the inclusion of R14 in series with the control inputs gives a current flow that is roughly proportional to the applied voltage, and effectively converts the filter to voltage controlled operation. R13 reduces the input voltage range from the oscillator slightly, bringing it into a more suitable range to drive the filter.

The oscillator uses IC3 in a well known configuration which is based on a Millier Integrator (IC3a) and a Schmitt




Low Pass Filter

Trigger (IC3b). This type of circuit gives both squarewave and triangular outputs. In this application a triangular waveform gives good results with a smooth sweeping of the filter frequency, and it is this output that is utilized. The operating frequency can be varied by means of RV2, and the nominal frequency range is from 10Hz at minimum resistance to 0.2Hz (one cycle every five seconds) at maximum resistance.

It is more than a little useful to have some control over the sweep range, and this is provided by RV1. This controls the feedback applied to IC2, and hence the voltage gain of this device. When set at a low value IC2 has only a low voltage gain, resulting in the cut-off frequency of the filter being varied over a narrow range of frequencies in the lower treble range. Higher resistance gives greater sweep width, with the cut-off frequency being swept over most of the audio frequency range with RV1 set at maximum value.

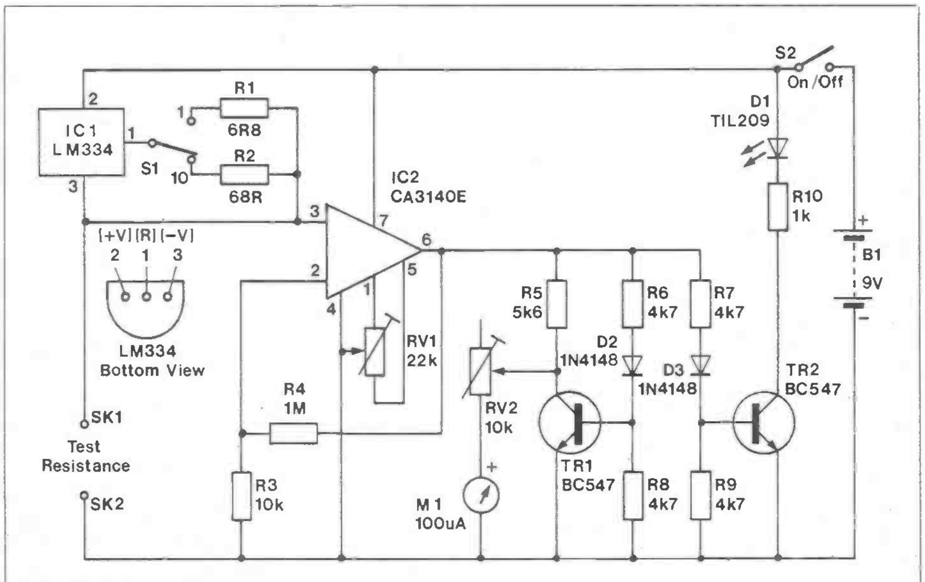
As with any effects unit, it is advisable to build the unit into a strong metal case such as a diecast aluminium type. If a bypass switch is needed a standard DPDT bypass configuration can be used, and the switch should be a heavy duty push button type mounted on the top of the case so that it can be operated by foot.

## Low Resistance Meter

Normal multimeters, including some quite expensive digital types, do not give very good results at low resistances. This is something that obviously varies from one instrument to another, but a resolution of one ohm or more is not uncommon, and this is obviously inadequate when testing very low value resistors. Open circuit or seriously overvalue components can be detected well enough, but it could prove to be impossible to distinguish between a closed circuit component and a serviceable one. This is often important as low value resistors are commonly used in applications such as current limiters in power supplies, where a faulty component could result in expensive damage.

This resistance meter has two ranges with full scale values of one ohm and ten ohms. It can therefore give an accurate assessment of resistances as low as a fraction of an ohm. It is an analogue instrument, but unlike conventional analogue resistance meters it has a forward reading linear scale. With an in-range resistance across the test prods, it uses a test voltage of no more than about 10 millivolts, and it will consequently not respond to semiconductor junctions. This can be useful when making continuity checks on circuit boards, where forward biased semiconductor junctions can often give misleading results by suggesting the presence of a short circuit where none exists.

The system used in this meter is to feed a constant current to the test resistance, and to measure the voltage developed across it. As this voltage is proportional to the resistance present, the meter can be calibrated dirctly in ohms using a forward reading linear scale, rather than the awkward reverse reading logarithmic type which is normally associated with analogue resistance meters. Here the constant current is provided by IC1 which is an integrated circuit designed specifically for current regulator applications. The current is controlled by a discrete resistor, and in this circuit two switched resistors (R1 and R2) give current options of 1 and 10 milliamps. M1, RV2, and R5 form the voltmeter circuit, and the nominal full scale value is 1 volt. However, IC2 boosts the sensitivity by a factor of about one hundred, giving a full scale value of 10 millivolts to the voltmeter circuit as a whole. Using Ohm's Law this gives full



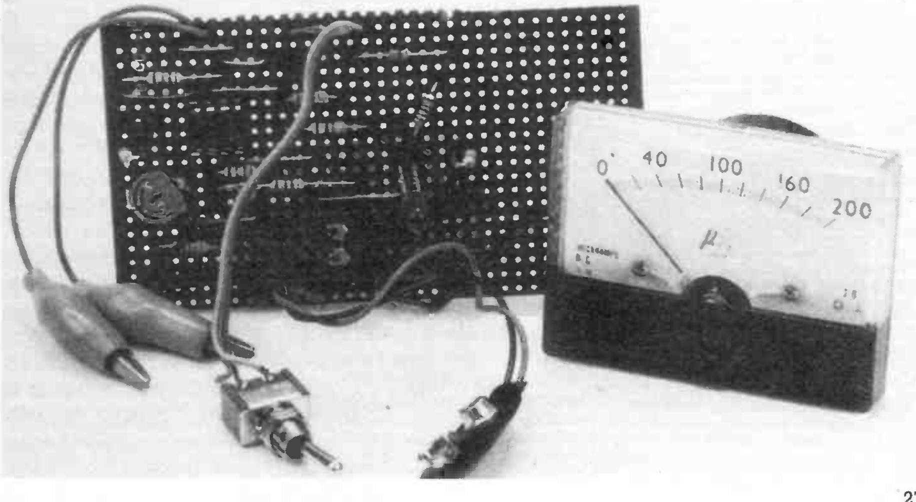
**Low Resistance Meter**

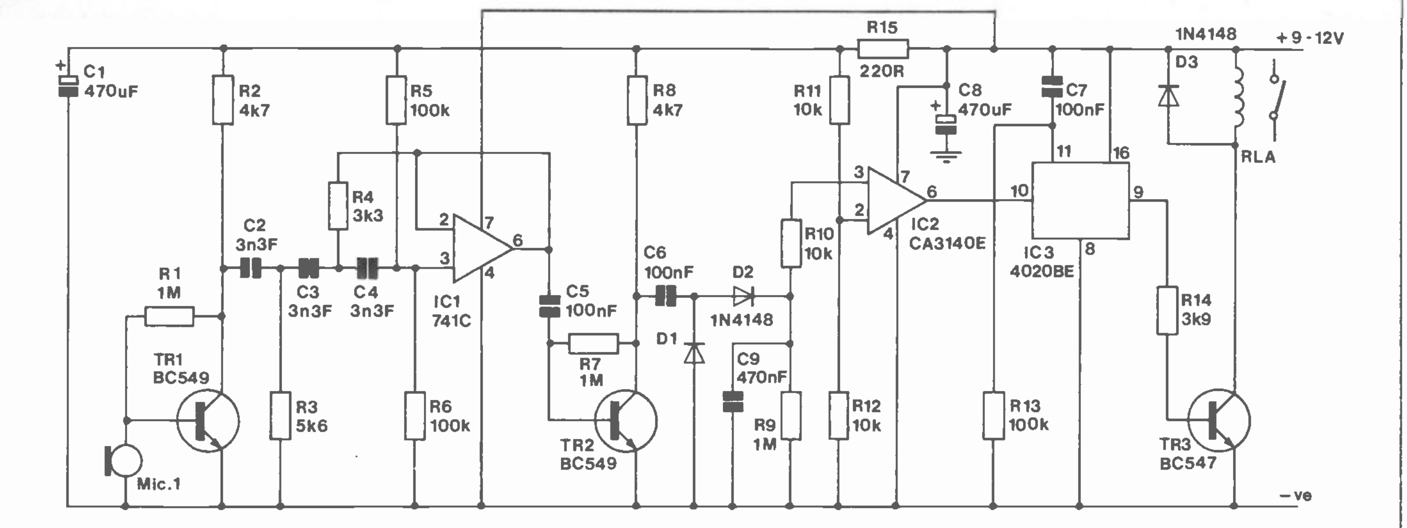
scale values of 1 ohm with a 10 milliamp test current, and 10 ohms with a 1 milliamp test current. RV2 is adjusted to give good accuracy, and RV1 compensates for offset voltages in IC2.

One problem with the basic circuit is that the meter would be driven hard against its end stop with no in-range resistance across the test prods. This is overcome by using TR1 as an electronic switch, which bypasses the meter circuit if the output of IC2 goes to more than about +1.2 volts. This prevents serious overloads of the meter, but makes it impossible to determine whether a valid reading or an overload is present. This is overcome by using TR2 to switch on LED indicator D1 if an overload is present. D1 switching off therefore indicates that a valid meter reading is present.

The unit is calibrated on the 10 ohm range using 1 and 10 ohm 1% resistors. First RV2 is adjusted for fsd with the 10 ohm resistor in circuit, after which the 1 ohm resistor is connected across the test prods and RV1 is adjusted for the correct reading of one tenth fsd. This procedure is repeated until no further adjustment is necessary.

In the interest of good accuracy it is important to keep resistances at the input of the circuit as low as possible. In particular, use short test leads of heavy gauge wire, and test prods that provide a low resistance (some spring types seem to be unsuitable).





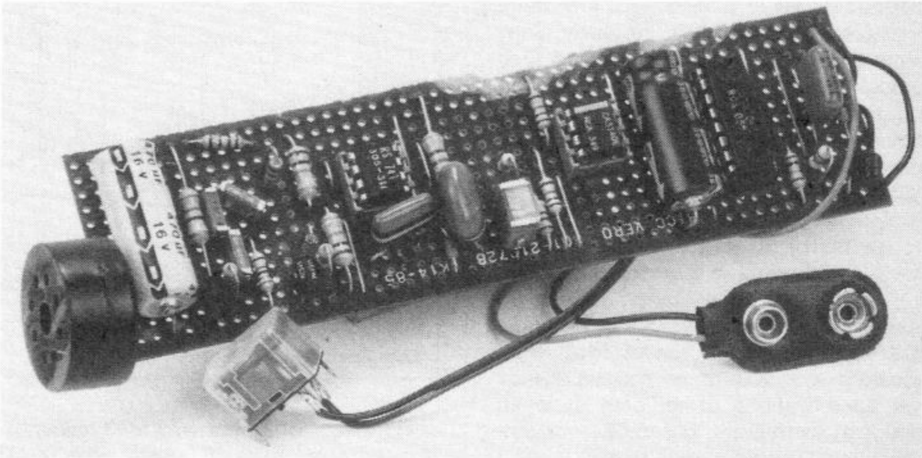

Clap Switch

# Clap Switch

This circuit was designed mainly as a novelty project, but although intended to be in the 'impress your friends' category, it could in fact be used as a practical alternative to simple ultrasonic and infra-red remote control systems. It is merely necessary to clap once in order to switch on the piece of controlled equipment, and to clap once more in order to switch it off again. Being a sound activated switch it is not totally immune to sounds other than handclaps, but a combination of moderate sensitivity and built-in filtering minimise the risk of spurious triggering.

TR1 operates as a high gain common emitter preamplifier, and its input is fed direct from a crystal microphone. This can be an inexpensive microphone insert, although many of these seem to give poor sensitivity, and a ceramic resonator was found to provide better results. A crystal microphone needs to feed into a very high load impedance in order to give a flat frequency response, and a fairly low input impedance (such as that of TR1) gives poor bass and middle frequency response. In this case though, we are only interested in the predominantly high frequency content of a handclap, and the lack of bass and middle frequency response is an advantage as it reduces the risk of spurious triggering. In fact, the input stage is followed by an active highpass filter based on IC1 which gives an 18dB per octave roll-off below about 7kHz. The output of the filter feeds the input of a second high gain common emitter amplifier, this time based on TR2.

The output from TR2 is rectified and smoothed by D1, D2, and C6, but under stand-by conditions there will be no significant output signal. However, a handclap will produce a strong positive DC bias across C6 that will decay over a period of a few hundred milliseconds. IC2 operates as a comparator which converts this signal into a pulse that will reliably drive the next stage, which is a CMOS divide by two circuit. In fact the



4020BE used for IC3 is a 14 stage type, but only one stage is used here. This drives the relay via switching transistor TR3, and the purpose of the divider circuit is to give the required successive type of operation, with alternate input pulses switching the relay on and off. C7 and R13 provide a reset pulse to IC3 at switch on, starting the relay in the off state. D3 is the usual protection diode.

The specified relay has a change-over contact with a rating of 5A at 240 volts AC. However, the unit should work properly using any relay having adequate contact ratings for your intended application, and a 6 volt coil with a resistance of about 200 ohms or more. Of course, a relay having a nominal 12 volt operating voltage is suitable if the unit is used with a 12 volt supply. If a mains load is controlled by the unit it is essential to observe all the normal safety precautions, and beginners would be well advised not to attempt control of mains powered equipment. The microphone must be reasonably well acoustically isolated from the relay if oscillation due to acoustic feedback is to be avoided. The current consumption is about 5 milliamps with the relay switched off, and around 40 milliamps when it is activated. In most cases battery operation will only be viable if some form of rechargeable type is used.

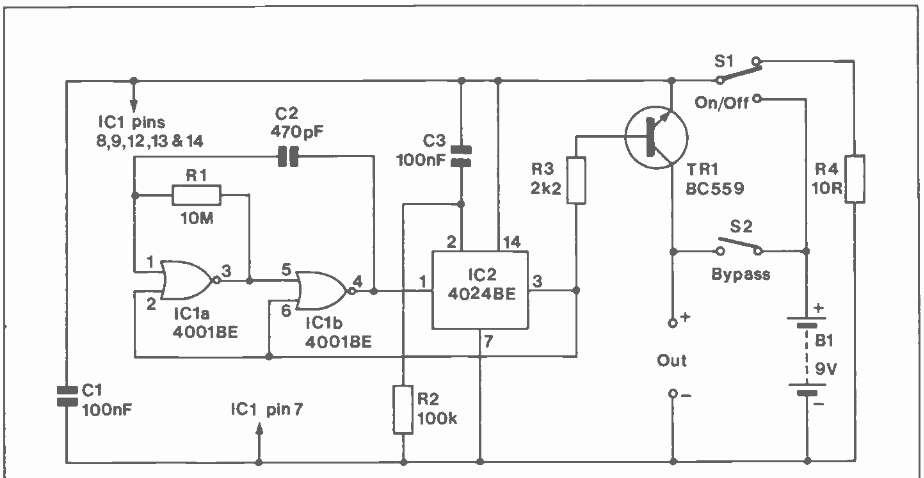
# Snooze Timer

Virtually all clock radios include a 'snooze' or 'sleep' facility which simply switches off the set after a preset time has elapsed. The general idea is to activate the timer when going to bed, and the radio then switches itself off when the user has become drowsy and is just dropping off to sleep. A somewhat simpler version of this feature (with non-adjustable delay) is sometimes found in other types of radio, ranging from cheap portable radios to expensive communications receivers, and it is quite easy to add a simple 'sleep' function to small battery operated radios. A suitable circuit is shown here, and this gives a switch-off delay of about 10 minutes. However, by changing the value of one component it is possible to obtain virtually any required delay time.

Simple C – R timing circuits work quite well when only short pulse lengths are required, but for periods of about a minute or more, the required values become impractically high. The standard solution to the problem, and the one adopted here, is to use an oscillator and divider chain arrangement. In this circuit two CMOS NOR gates (IC1a and IC1b) are used as inverters and connected in a standard CMOS astable configuration. IC2 is the divider, and is a CMOS 7 stage binary type, giving a total division rate of 128 with all seven stages used (as they are here). TR1 operates as a common emitter switch which is driven from the output of stage seven of IC2. TR2 is cut off when this output is high, and turned on when it is low. C3 and R2 provide a reset pulse to IC2 at switch-on, and this takes all seven outputs low, causing TR1 to turn on and supply power to the radio set.

After 64 clock pulses from IC1, the output of the final binary divider goes high, switching off both TR1 and the radio set. After a further 64 clock pulses the circuit would revert back to its original state, and it would continue to cycle indefinitely in this way. This problem is overcome by using a gated astable clock oscillator, with the gate input being fed from pin 3 of IC2. The clock is therefore muted when pin 3 of IC2 goes high at the end of the switch-off delay.

In order to reactivate the circuit it is merely necessary to switch off using S1, and then switch the unit on again. S1 and R4 ensure that the capacitors in the circuit discharge rapidly, leaving the circuit ready to operate from the beginning once again. S2 can be used to bypass the unit when normal operation of the radio is required. An important point is that the use of CMOS devices gives the circuit a very low quiescent current consumption so that the battery does not

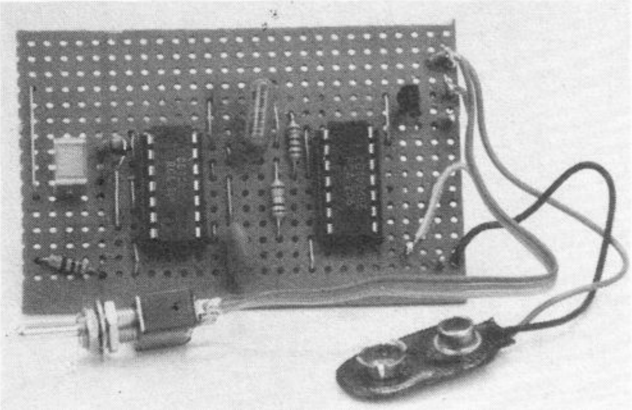


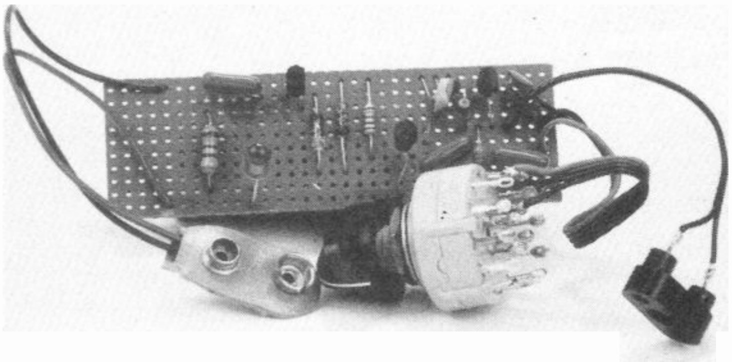
Snooze Timer

run down significantly when the radio is switched off. In fact, the quiescent current consumption is typically only a fraction of a microamp.

The unit should be quite easy to construct, and the only real complication is in taking the output of the unit to the battery connector of the radio. The output can be carried via an ordinary battery clip lead, but it will probably be necessary to make a small notch in the lid of the radio's battery compartment to enable the lead to pass through into the set. Be careful to connect the lead the right way round. The circuit can handle currents of up to 100 milliamps, and it will also work with a 6 volt battery. It will therefore function properly with the majority of transistor radios.

The switch-off delay is proportional to the value of C2, and also to that of R1. Different times can therefore be obtained by altering the value of one or both of these. For instance, a value of 220nF for C2 would give a delay of just under 5 minute, or using two 10M components in series for R1 would increase the delay to around 20 minutes.



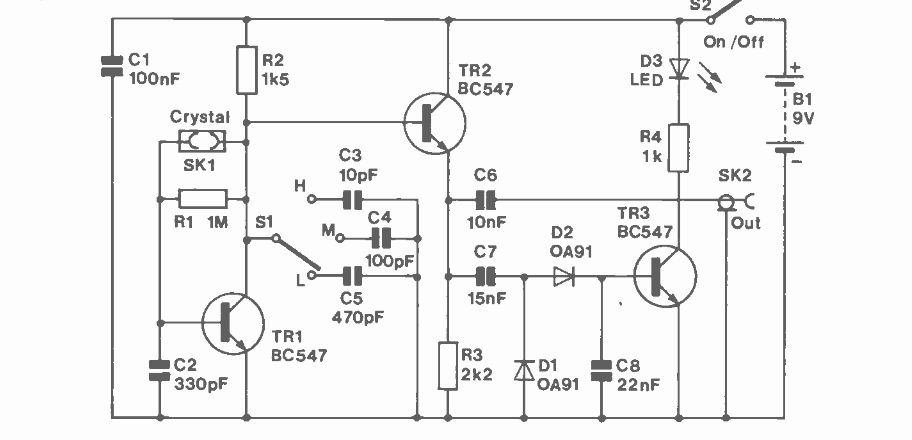


## Crystal Checker

Although at one time crystals seemed to be vanishing from the amateur electronics scene, with the revival in the popularity of radio and the increasing use of crystal oscillators in digital and micro circuits, these components are probably more widely used now than at any time in the past. Crystals are not components that can be checked properly using an ordinary multimeter, and a more elaborate system of testing is required. In its most simple form a crystal checker can consist of an oscillator circuit into which the suspect component is connected, and some form of detector circuit to indicate whether or not oscillation is present. An oscillator output socket is useful as it enables a check on the output frequency to be made with the aid of a suitable frequency meter or radio receiver.

This checker is of the basic type outlined above, and it has a LED indicator

Crystal Checker




which switches on if the test component is producing oscillation. The circuit will work with crystals having fundamental frequencies from around 100kHz to about 20MHz or so. Most crystals are in this category since those having marked frequencies of more than 20MHz are usually overtone types which have fundamental frequencies at typically only a third or a fifth of the marked frequency. This checker will not work with very low frequency crystals having operating

# HIGH FREQUENCY TREMOLO PARTS LIST

| | | | |
|---|---|---|---|
| RESISTORS: All 0.6W 1% Metal Film | | | |
| R1,2 | 3k9 | 2 | (M3K9) |
| R3,4,9,10 | 1k | 4 | (M1K) |
| R5,14 | 27k | 2 | (M27K) |
| R6,7 | 22k | 2 | (M22K) |
| R8,12 | 4k7 | 2 | (M4K7) |
| R11,19,20 | 10k | 3 | (M10K) |
| R13 | 12k | 1 | (M12K) |
| R15,18 | 100k | 2 | (M100K) |
| R16 | 47k | 1 | (M47K) |
| R17 | 56k | 1 | (M56K) |
| RV1 | 100k Lin. Pot | 1 | (FW05F) |
| RV2 | 2M2 Lin. Pot | 1 | (FW09K) |
| CAPACITORS | | | |
| C1 | 100μF Axial Electrolytic 10V | 1 | (FB48C) |
| C2 | 1μF Axial Electrolytic 100V | 1 | (FB12N) |
| C3,4 | 270pF Ceramic | 2 | (WX61R) |
| C5 | 10μF Axial Electrolytic 25V | 1 | (FB22Y) |
| C6 | 1μF Poly Layer | 1 | (WW53H) |
| SEMICONDUCTORS | | | |
| IC1 | LM13700N | 1 | (YH64U) |
| IC2 | CA3140E | 1 | (QH29G) |
| IC3 | LF353 | 1 | (WQ31J) |
| MISCELLANEOUS | | | |
| SK1,2 | Jack Socket | 2 | (HF90X) |
| S1 | SPST Ultra-Min Toggle | 1 | (FH97F) |
| B1 | PP7 9V Battery | 1 | (FM04E) |
| | Battery Clips | 1 | (HF27E) |
| | DIL Socket 16-pin | 1 | (BL19V) |
| | DIL Socket 8-pin | 2 | (BL17T) |

# LOW RESISTANCE METER PARTS LIST

| | | | |
|---|---|---|---|
| RESISTORS: All 0.6W 1% Metal Film | | | |
| R1 | 6R8 | 1 | (M6R8) |
| R2 | 68R | 1 | (M68R) |
| R3 | 10k | 1 | (M10K) |
| R4 | 1M | 1 | (M1M) |
| R5 | 5k6 | 1 | (M5K6) |
| R6,7,8,9 | 4k7 | 4 | (M4K7) |
| R10 | 1k | 1 | (M1K) |
| RV1 | 22k Sub-min Hor Preset | 1 | (WR59P) |
| RV2 | 10k Sub-min Hor Preset | 1 | (WR58N) |
| SEMICONDUCTORS | | | |
| IC1 | LM334 | 1 | (WQ32K) |
| IC2 | CA3140E | 1 | (QH29G) |
| TR1,2 | BC547 | 2 | (QQ14Q) |
| D1 | Red LED | 1 | (WL27E) |
| D2,3 | 1N4148 | 2 | (QL80B) |
| MISCELLANEOUS | | | |
| SK1,2 | 1mm Socket | 2 | (WL59P) |
| S1 | SPDT Ultra-Min Toggle | 1 | (FH98G) |
| S2 | SPST Ultra-Min Toggle | 1 | (FH97F) |
| M1 | 100μA Panel Meter | 1 | (RW92A) |
| B1 | PP7 9V Battery | 1 | (FM04E) |
| | Battery Clip | 1 | (HF27E) |
| | DIL Socket 8-pin | 1 | (BL17T) |

# CLAP SWITCH PARTS LIST

| | | | |
|---|---|---|---|
| RESISTORS: All 0.6W 1% Metal Film | | | |
| R1,7,9 | 1M | 3 | (M1M) |
| R2,8 | 4k7 | 2 | (M4K7) |
| R3 | 5k6 | 1 | (M5K6) |
| R4 | 3k3 | 1 | (M3K3) |
| R5,6,13 | 100k | 3 | (M100K) |
| R10,11,12 | 10k | 3 | (M10K) |
| R14 | 3k9 | 1 | (M3K9) |
| R15 | 220R | 1 | (M220R) |
| CAPACITORS | | | |
| C1,8 | 470μF Axial Electrolytic 10V | 2 | (FB71N) |
| C2,3,4 | 3n3F Poly Layer | 3 | (WW25C) |
| C5,6,7 | 100nF Polyester | 3 | (BX76H) |
| C9 | 470nF Poly Layer | 1 | (WW49D) |
| SEMICONDUCTORS | | | |
| D1,2,3 | 1N4148 | 3 | (QL80B) |
| TR1,2 | BC549 | 2 | (QQ15R) |
| TR3 | BC547 | 1 | (QQ14Q) |
| IC1 | μA741C | 1 | (QL22Y) |
| IC2 | CA3140E | 1 | (QH29G) |
| IC3 | 4020BE | 1 | (QX11M) |
| MISCELLANEOUS | | | |
| Mic 1 | Min-Piezo Sounder | 1 | (FM59P) |
| RLA | Open Relay 6V | 1 | (FX23A) |
| | DIL Socket 8-pin | 2 | (BL17T) |
| | DIL Socket 14-pin | 1 | (BL18U) |

# SNOOZE TIMER PARTS LIST

| | | | |
|---|---|---|---|
| RESISTORS: All 0.6W 1% Metal Film | | | |
| R1 | 10M | 1 | (M10M) |
| R2 | 100k | 1 | (M100K) |
| R3 | 2k2 | 1 | (M2K2) |
| R4 | 10R | 1 | (M10R) |
| CAPACITORS | | | |
| C1,3 | 100nF Disc Ceramic | 2 | (BX03D) |
| C2 | 470pF Ceramic | 1 | (WX64U) |
| SEMICONDUCTORS | | | |
| IC1 | 4001BE | 1 | (QX01B) |
| IC2 | 4024BE | 1 | (QX13P) |
| TR1 | BC559 | 1 | (QQ18U) |
| MISCELLANEOUS | | | |
| S1 | SPDT Ultra-Min Toggle | 1 | (FH98G) |
| S2 | SPST Ultra-Min Toggle | 1 | (FH97F) |
| B1 | PP9 9V Battery | 1 | (FM05F) |
| | Battery Clips | 1 | (HF27E) |
| | DIL Socket 14-pin | 2 | (BL18U) |

# CRYSTAL CHECKER PARTS LIST

| | | | |
|---|---|---|---|
| RESISTORS: All 0.6W 1% Metal Film | | | |
| R1 | 1M | 1 | (M1M) |
| R2 | 1k5 | 1 | (M1K5) |
| R3 | 2k2 | 1 | (M2K2) |
| R4 | 1k | 1 | (M1K) |
| CAPACITORS | | | |
| C1 | 100nF Disc Ceramic | 1 | (BX03D) |
| C2 | 330pF Ceramic | 1 | (WX62S) |
| C3 | 10pF Ceramic | 1 | (WX44X) |
| C4 | 100pF Ceramic | 1 | (WX56L) |
| C5 | 470pF Ceramic | 1 | (WX64U) |
| C6 | 10nF Polyester | 1 | (BX70M) |
| C7 | 15nF Polyester | 1 | (BX71N) |
| C8 | 22nF Polyester | 1 | (BX72P) |
| SEMICONDUCTORS | | | |
| TR1,2,3 | BC547 | 3 | (QQ14Q) |
| D1,2 | OA91 | 2 | (QH72P) |
| D3 | Red LED | 1 | (WL27E) |
| MISCELLANEOUS | | | |
| SK1 | Crystal Socket | 1 | (HX61R) |
| SK2 | Coaxial Socket Flush | 1 | (HH09K) |
| S1 | 3-way 4 pole Rotary | 1 | (FF76H) |
| S2 | SPST Ultra-min Toggle | 1 | (FH97F) |
| B1 | PP3 Battery | 1 | (FK58N) |
| | Battery Clips | 1 | (HF28F) |

*Continued on page 39.*

# 1986 CATALOGUE PRICE CHANGES

**The price changes shown in this list are valid from 17th February 1986 to 10th May 1986. Prices charged will be those ruling on the day of despatch.**

For further details please see 'Prices' on catalogue page 15.

**Price Changes**
All items whose prices have changed since the publication of the 1986 catalogue are shown in the list below.
A complete Price List is also available free of charge – order as XF08J.

**VAT**
If the rate of VAT changes during the life of this price changes list then the new rates will take effect immediately.

**Key**

| | |
|---|---|
| NYA | Not yet available. |
| DIS | Discontinued. |
| TEMP | Temporarily unobtainable. |
| FEB | Out of stock; new stock expected in month shown. |
| † | To be discontinued when stocks are exhausted. |
| *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. |

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## AERIALS

**Page 30**
- XQ23A Mushkiller FM1083 £14.50
- XQ25C Mushkiller FM1085 £22.30
- XQ27E Mushkiller FM1087 £29.50
- XQ29G Trucolour TC10 Grp A £11.25
- XQ30H Trucolour TC10 Grp B £11.25
- XQ31J TrucolourTC10 GrpC/D £11.25
- XG23A Trucolour TC10 Grp E £11.25
- XQ32K Trucolour TC13 Grp A £13.35
- XQ33L Trucolour TC13 Grp B £13.35
- XQ34M TrucolourTC13 GrpC/D £13.35

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- XQ35Q Trucolour TC18 Grp A £15.85
- XQ36P Trucolour TC18 Grp B £15.85
- XQ37S TrucolourTC18 GrpC/D £15.85
- XG24B Trucolour TC18 Grp E £15.85
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- XQ40T Extragain XG8 GroupB £27.50
- XQ41U Extragain XG8 GrpC/D £27.50
- XQ42V Extragain XG8 Wdband £27.50
- XY30H Toptenna £4.95

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- BW49D Masthead UP1300/V £14.95
- BW50E Power Unit PU1240 £18.95

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- BK06G Amp VX1B £23.50
- YQ22Y Xtra Set Amp £23.50
- BK76H TV Amp XB12 £17.95

## BOOKS

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- RH53H Book BP160 £2.50 *NV*
- WA10L TI Linear Circuits £9.00 *NV*
- WA14Q TI TTL Data £10.00 *NV*
- WG58N Book FT1199 £14.20 *NV*

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- WM60Q Mastering Electronic £3.95 *NV*

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- RH25C Book BP32 DIS
- XW52G Book BP76 £2.50 *NV*

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- WG18U Book HD748 DIS

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- XW07H Book BP57 DIS

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- LY05F Book BP45 £1.95 *NV*
- RH38R Book BP205 DIS

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- XW40T Book BP74 £2.50 *NV*

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- WG92A Book FT1341 £14.20 *NV*
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- PA57M 100m Bell Wire Blu £2.00
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- PA59P 100m Bell Wire Grn £2.00
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- YJ72D 10 D/S Q/D Disk 5.25 £18.95

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- BG38P Bug Attack Cassette DIS

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- KS04E M5 Step Up DIS

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- KK10L Crsh & Cmp + 16K Cass DIS
- BC22Y MM Data 1 DIS

## CONNECTORS

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- RW66W Cas Lead Telefunken 58p

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- HT27E Heathkit SW-7800 £299.95
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- HT30H Heathkit HD-1986 £44.95

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- HK23A HD-1250 Dip Meter £89.95

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- HC91Y Heathkit CD-1015 £279.95
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## MICROPHONES

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- YW78K Mic Hldr Adhesive TEMP

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- XB45Y 5-Foot Mic Stand TEMP

## OPTO-ELECTRICAL

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- BY65V Red Bargraph Dslpy £2.25
- YG33L Green Bargraph Dslpy £2.25

**Page 207**
- HY19V 5KV Laser PCB £4.98

## ORGAN COMPONENTS

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- YL17T Reverb PSU Module £4.95

## PROJECTS & MODULES

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- GA46A Break Contact PCB £2.20
- LW57M Burglar Alarm Kit £59.95
- LW58N Ext Horn Kit £44.95

**Page 225**
- GA81C Channel/PSU PCB £1.80
- GA82D Extra Channel PCB £1.20
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- LW84F Usonic Interface Kit £3.45

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- LW97F Panic Button Kit £4.45

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- GA64U Timer Front Panel £4.50

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- GA25C Power Control PCB £1.10
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- QY25C 2716/M4 £9.95
- QY60Q 2716/M5 £9.95
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- GB06G T/E Motherboard £24.95
- GB07H T/E PSU PCB £6.95
- LW81C Digi-Tel Connect Kit £11.95
- LW82D Digi-Tel Main Kit £129.95
- LK37S Digi-Tel Expdr Kit £139.95

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- XX47B Train Cnrl Front Pnl £3.30
- GA72P Train Common PCB £3.30
- GA75S Train Receiver 2 PCB £1.20
- LW61R Train Common/PSU Kit £31.95
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- LW64U Train Rcvr2 ML926Kit £11.95
- LW68Y Train Rcvr1 ML927Kit £9.95
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- GA86T Data Decoder PCB £2.80
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- GA88V IR Rx PCB £1.80
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- FT40T Cntrl-A-Train Fr Pan £1.95
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- GA19V Batt Mon PCB £1.30
- LK42V Car Batt Monitor £7.50
- LK79L Car Digtl Techo Kit £17.95
- XX40T Ignition PCB £1.80
- XX41U Ign Mtg Plate £1.10

**Page 236**
- GA98G Car Burglar Alrm PCB £1.40
- LW78K Car Burglr Alarm Kit £7.95
- GA40T Car Aerial Bster PCB £1.60
- GB93B U/Sonic Car Alrm PCB £3.95

**Page 237**
- GA76H MPG Meter Main PCB £2.20
- GA77J MPG Meter Disply PCB £1.60
- YQ69A LM1871 Xmitter PCB £1.40
- LK55K 27MHz Transmittr Kit £7.95
- GB83E 4 Ch Servo Cntrl PCB £8.95
- LK61R 4 Ch Servo Cntrlr Kt £27.95

**Page 238**
- LK45Y Servo & Driver Kit £14.95
- FJ54J TU 1000 Rear Panel £2.50
- GB67X RTTY Terminal PCB £9.95
- LK53H TU1000 RTTY Kit £54.95

**Page 239**
- GB50E TDA 7000 Radio PCB £2.60

**Page 240**
- XG15R Stereo Amp Chassis £6.95
- GA71N Stereo Amp PCB £7.95
- GA78K Stereo Amp Sw PCB 60p
- LW71N 25W Stereo Amp Kit £79.95
- LW77J Amp Remote Cntrl Kit £34.95

**Page 241**
- XX03D 10-Channel G.E. PCB £2.20
- LR13P HQ Mixer PCB No.2 £2.50

**Page 242**
- LR15R HQ Mixer PCB No.4 £2.20
- LR34M HQ Mixer PCB No.24 £2.80
- LR16S HQ Mixer PCB No.5 £1.80
- LR35Q HQ Mixer PCB No.25 £2.40
- LR22Y HQ Mixer PCB No.7 £2.40

**Page 243**
- LR24B HQ Mixer PCB No.9 £2.40
- LR25C HQ Mixer PCB No.10 £2.40
- LR26D HQ Mixer PCB No.14 £2.80

**Page 244**
- GA00A D.I.Box PCB £1.10
- FJ36P Mapmix Front Panel £4.95
- LK49D Mapmix Kit £39.95
- GA43W Noise Gate PCB £1.50
- LK43W Noise Gate Kit £10.95

**Page 245**
- GA30H Compander PCB £3.50
- LK38R Mk II N/R Unit Kit £44.95
- GB44X Stereo DNL PCB £1.98

**Page 246**
- LK69A Active Crssvr Kit £19.95
- LK70M 3 Channel Amp Kit £21.95

**Page 247**
- BY73Q 8W Amp PCB 90p
- LW36P 8W Amp Kit £5.95
- YQ38R 30/2 PSU PCB £2.20
- YQ43W 15W Amp Kit £6.50

**Page 250**
- LW32K 150W Power Amp Kit £22.95

**Page 251**
- GA28F 100W MOSFET Amp PCB £2.20
- LW51F MOSFET Amp Kit £17.95
- GA41U Combo Amp PCB £7.95
- XG03D Combo Amp Frnt Panel £4.95
- GA17T MOS-Amp Bridge PCB £2.95
- LK03D MOSFET Bridging kit £11.95

**Page 252**
- BB81C Disco Pre-Amp Tn PCB £5.50
- BB19V Disco PSU PCB £2.95
- BB26D Motor Switch PCB £1.50

**Page 253**
- GA42V Partylite PCB £2.20
- BB41U Synth Mixer PCB £8.50
- BB44X Synth VCA PCB £2.50
- BY90X Synth Smpl & Nse PCB £5.50
- BB43W Synth Trns Gen 1 PCB £4.95
- BB45Y Synth Trns Gen 2 PCB £4.95
- BY82D Synth Rvrb & Phs PCB £4.50
- BY83E Synth VC Pn & AncPCB £11.95
- BB48C Synth Ext I/P's PCB £2.20
- BB85V 3600 VCF PCB £3.30
- BB47B Synth Otpt Stge PCB £6.95

**Page 254**
- GA03D Spectrum PSU PCB £2.60
- GA36P Spectrum VCD PCB £8.95
- GA55K Spectrum Cntrllr PCB £3.30
- LW85G Hexadrum Kit £22.95

**Page 255**
- GB72P Computadrum PCB £3.30
- LK52G Computadrum Kit £11.95
- GA05F Syntom PCB £1.10
- LW86T Syntom Kit £13.95
- LW87U Synwave Kit £13.95

| 1986 Catalogue Page No. | | VAT Inclusive Price |
|---|---|---|

1986 Catalogue Page No. VAT Inclusive Price
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|---|---|---|
| LK15R | Synchime Kit | £14.95 |
| LW55K | Synclock Kit | £23.95 |
| LW88V | Volume Pedal Kit | £28.95 |

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| | | |
|---|---|---|
| LW89W | Auto Swell Kit | £12.95 |
| GB54J | Auto-Wea PCB | £2.40 |
| LK36P | Auto-Wea Kit | £13.95 |
| LK74R | Guitar Equaliser Kit | £29.95 |

**Page 258**

| | | |
|---|---|---|
| BB72P | Sine/Square Gen PCB | £4.95 |

**Page 259**

| | | |
|---|---|---|
| LK63T | Live Wire Det Kit | £3.50 |
| GB21X | CMOS Xtal Clbrtr PCB | £3.30 |
| LK10L | CMOS Xtal Clbrtr Kit | £23.95 |

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| | | |
|---|---|---|
| LK06G | Sweep Osc Kit | £25.95 |
| GB30H | Probe Upper PCB | £1.10 |
| GB31J | Probe Lower PCB | £1.10 |
| LK13P | Logic Probe Kit | £14.95 |
| GB36P | Pulser PCB | £1.60 |

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| | | |
|---|---|---|
| RK39N | Freq Cnt Front Panel | £2.95 |
| GB02C | Freqency Counter PCB | £6.95 |
| GB03D | Freq Ctr Display PCB | £2.80 |
| GB40T | Frqncy Mtr Adptr PCB | £1.60 |

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|---|---|---|
| GB09K | Modem Main PCB | £5.95 |
| GB10L | Modem PSU PCB | £1.80 |
| LW99H | Modem Kit | £54.95 |

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| | | |
|---|---|---|
| LK68Y | Mains Tx/Rx Drvr Kit | £34.95 |
| LK17T | RS232/TTL Cnvrtr kit | £8.50 |

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| | | |
|---|---|---|
| LK67X | Z80 CPU Module Kit | £29.95 |
| GB39N | BBC Motherboard PCB | £5.95 |
| LK47B | BBC Motherboard Kit | £27.95 |
| GB37S | Dragon I/O PCB | £5.50 |
| LK18U | Dragon I/O Port | £19.95 |

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| | | |
|---|---|---|
| GB45Y | Oric Talkback PCB | £4.95 |
| LK28F | Oric Talkback Kit | £21.95 |
| GB55K | Oric Ma-Mo I/F PCB | £4.50 |
| LK40T | Oric Maplin Mo IFace | £12.95 |
| QY72P | 2716/M9 EPROM Shp IF | £9.95 |
| LK71N | Sharp Serial IF Kit | £29.95 |
| LK39N | Spctrm Easyload Kit | £12.95 |

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|---|---|---|
| QY57M | 2716/M7 | £9.95 |
| LK21X | Spctrm/RS232 Intf kt | £24.95 |
| LK65V | Spctrm I/O Cntrlr Kt | £17.95 |
| LK72P | Spect Pallel/Srl Kit | £17.95 |

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|---|---|---|
| LK26D | Spectrum ADC Kit | £32.95 |
| GB34M | DAC PCB | £3.30 |
| LK25C | Spectrum DAC Kit | £18.95 |
| GB47B | Spectrum Kbd Pcb | £11.95 |
| GB48C | Spectrum Kbd Con Pcb | £2.20 |
| LK29G | Spectrum Kybd Kit | £39.95 |
| LK30H | Sptrm Kybd Adptr Kit | £8.95 |

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|---|---|---|
| LK22Y | VIC20 Extendiboard | £34.95 |
| GB17T | VIC 20 Talkback PCB | £3.95 |
| GB28F | VIC20/RS232 Intfce | £3.50 |

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|---|---|---|
| GA83E | ZX81 Ext Kyboard PCB | £3.95 |
| LW72P | ZX81 Keyboard Kit | £27.95 |
| GA90X | I/O Port PCB | £2.80 |
| LW76H | ZX81 I/O Port Kit | £10.95 |

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| | | |
|---|---|---|
| GB11M | ZX81 Sound Gen Pcb | £2.20 |
| GB14Q | TV Snd/Inv Vid PCB | £2.95 |
| LK02C | ZX81 TV snd/inv vid | £24.95 |
| GB23A | ZX81 Mod/Intface PCB | £5.50 |
| QY52G | 2716/M6 | £9.95 |
| LK08J | ZX81 Modem Intfce Kt | £34.95 |

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|---|---|---|
| QY58N | 2716/M8 | £9.95 |
| GB43W | ZX81 Hi Res Grph PCB | £14.95 |
| LK23A | ZX81 Hi-Res Graphics | £34.95 |
| GB90X | Trundle Sensor PCB | £2.60 |

## RECORD, TAPE & VIDEO

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| | | |
|---|---|---|
| ★HR39N | BSR TC8 | 65p |
| ★HR51F | Ronette BF40 | 98p |
| ★FV27E | BSR ST4 | 98p |
| ★HR25C | Acos GP91-1SC | 98p |
| ★HR87U | Philips AG3306 | 98p |
| ★HR60Q | Sonotone 9TAHC | 98p |
| ★HR42V | BSR ST10 | 98p |
| ★YX27E | Sony NO15P | £5.95 |
| ★FV26D | Acos GP91-1 | 98p |
| ★HR53H | Garrard KS40A | 98p |
| ★HR31J | Acos GP104 | 98p |
| ★HR47B | BSR ST17 | 98p |
| ★HR74R | BSR ST21 | 98p |
| ★FQ45Y | Garrard GDD1 | 98p |
| ★HR81C | Vacco Luxor | 98p |
| ★FV19V | Shure N75-6 | £8.95 |
| ★FV30H | Shure N75-ED | £14.95 |
| ★FV31J | Shure N75-EJ | £11.45 |
| ★HR45Y | BSR ST15 | 98p |
| ★YX06G | ADC RSQ30 | £5.95 |
| ★FV25C | ADC RSQ33 | £12.50 |
| ★FV24B | Fuji Onkyo | £3.95 |
| ★FV22Y | Sanyo STG6 | 75p |
| ★HR90X | Philips GP400 | £3.95 |
| ★FM76H | Hitachi HN-ST6 | 98p |
| ★FV33L | Shure N95-ED | £17.95 |
| ★FV20W | Tetrad T30MS | 95p |
| ★FV34M | Shure N97-HE | £34.95 |
| ★FQ51F | Tenorel 2001D | £2.95 |
| ★FQ52G | Tenorel 2001ED | £8.95 |
| ★BK19V | Stanton D5107AL | £5.95 |
| ★HR89W | Philips GP205 | 78p |
| ★FM70M | Garrard GKS25 | 98p |
| ★HR97F | Sanyo 2611K | £4.95 |
| ★HR48C | Goldring D110SR | £3.45 |
| ★HR77J | Goldring D110H | £2.95 |
| ★HR76H | Goldring D110E | £5.95 |
| ★HR49D | Goldring D120SR | £3.45 |
| ★FV29G | Panasonic EPS36 | £3.50 |
| ★HR61R | Sonotone V100 | £4.95 |
| ★HR95D | Sansui SN28 | £2.95 |
| ★HR99H | Sharp STY717 | £4.95 |
| ★FV32K | Shure N70-B | £6.50 |
| ★HR79L | Hitachi ST103 | £5.95 |
| ★FV28F | Sharp STY104 | £3.95 |
| ★FV23A | Panasonic EPS270 | £1.95 |
| ★BK12N | Audio Tech ATS10L | £3.75 |
| ★FV21X | Audio Tech ATN3401 | £5.75 |
| ★BK07H | Audio Tech ATN3400 | £6.95 |
| ★FG94C | Sharp STY123 | £8.95 |

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|---|---|---|
| RB07H | Rota-Rack | TEMP |

## RESISTORS

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| | | |
|---|---|---|
| YY13P | Resnet 220R | 68p |
| YY14Q | Resnet 470R | 68p |
| YY15R | Resnet 1k | 68p |
| YY16U | Resnet 10k | 68p |

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|---|---|---|
| FW44X | Sw Pot Lin 47k | £1.35 |

## SEMICONDUCTORS

**Page 294**

| | | |
|---|---|---|
| QF10L | BF167 | DIS |
| YY75S | ICL7660CPA | £2.85 |

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| | | |
|---|---|---|
| YY73Q | LM335Z | £1.65 |
| WQ42V | MCM4027 250ns | £1.25 |
| RA81C | SAA1099 | NYA |
| QL22Y | $\mu$A741C 8-pin | 18p |
| QL19V | TIS43 | 64p |
| QL37S | W005 | 25p |
| QL38R | W01 | 28p |
| QL39N | W02 | 32p |
| QL40T | W04 | 35p |

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|---|---|---|
| QR46A | 2N4062 | DIS |
| QW13P | 2708 450ns | £4.50 |
| QQ09K | 2764 350ns | £2.30 |
| YH88V | 27128 | £3.45 |
| QY75S | 27256 - 250ns | £5.50 |
| QX04E | 4007UBE | 28p |
| QX21X | 4049UBE | 40p |
| QW81R | 40103BE | £2.25 |
| QY74R | 41256 - 150ns | £5.50 |
| QW83E | 4510BE | 63p |
| QX31J | 4511BE | 63p |
| QW84F | 4512BE | 63p |
| QW85G | 4514BE | £1.20 |
| QQ44X | 4526BE | 68p |
| UF33L | 6116 (446) 150ns | £1.70 |
| UF34M | (6264-150ns) | £4.50 |
| QX37S | 7400 | 25p |
| YF00A | 74LS00 | 25p |
| QX38R | 7401 | 25p |
| YF01B | 74LS01 | 25p |
| ★QX39N | 7402 | 25p |
| ★YF02C | 74LS02 | 25p |
| YF03D | 74LS03 | 25p |
| QX40T | 7404 | 28p |
| YF04E | 74LS04 | 25p |
| QX41U | 7405 | 28p |
| YF05F | 74LS05 | 25p |
| QX75S | 7406 | 44p |
| QX76H | 7407 | 44p |
| YF07H | 74LS09 | 25p |
| YF08J | 74LS10 | 25p |
| YF09K | 74LS11 | 25p |
| YF10L | 74LS12 | 25p |
| QX45Y | 7413 | 40p |
| YF11M | 74LS13 | 34p |
| QX46A | 7414 | 57p |
| YF13P | 74LS15 | 25p |
| YF14Q | 74LS20 | 25p |
| QX48C | 7421 | DIS |
| YF15R | 74LS21 | 25p |
| YF16S | 74LS22 | 25p |
| QX80B | 7425 | 37p |
| QX81C | 7426 | 41p |
| YF17T | 74LS26 | DIS |
| QX49D | 7427 | 34p |
| YF18U | 74LS27 | 25p |
| QX50E | 7430 | 25p |
| YF20W | 74LS30 | 25p |
| YF21X | 74LS32 | 25p |
| ★YF22Y | 74LS33 | 26p |
| YF23A | 74LS37 | 25p |
| YF25C | 74LS40 | DIS |
| QQ52G | 74LS47 | 86p |
| QQ53H | 74LS48 | 86p |
| YF27E | 74LS51 | 25p |
| YF28F | 74LS54 | 25p |
| QX56L | 7470 | 55p |
| QX57M | 7472 | 48p |
| QX58N | 7473 | 46p |
| YF30H | 74LS73 | 32p |
| YF31J | 74LS74 | 32p |
| QX60Q | 7475 | 55p |
| YF32K | 74LS75 | 43p |
| QX61R | 7476 | 48p |
| YF33L | 74LS76 | 32p |
| QX85G | 7483 | 97p |
| QX64U | 7486 | 40p |
| YF38R | 74LS90 | 48p |
| QX86T | 7491 | 74p |
| QX67X | 7492 | 63p |
| YF39N | 74LS92 | 57p |
| YF40T | 74LS93 | 51p |
| QX87U | 7496 | 82p |
| QX71N | 74107 | 46p |
| QX88V | 74109 | 69p |
| YF45Y | 74LS112 | 46p |
| QX72P | 74118 | £1.10 |
| WH00A | 74122 | 57p |
| QQ54J | 74LS122 | 62p |
| WH01B | 74123 | 82p |
| YF48C | 74LS123 | 69p |
| YF49D | 74LS125 | 42p |
| YF50E | 74LS126 | 42p |
| WH03D | 74132 | 89p |
| YF51F | 74LS132 | 60p |
| YF52G | 74LS136 | 40p |
| YF53H | 74LS138 | 55p |
| YF54J | 74LS139 | 55p |
| WH05E | 74141 | 90p |
| WH06G | 74145 | 97p |

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|---|---|---|
| YF55K | 74LS145 | £1.00 |
| QX89W | 74150 | £1.48 |
| YF56L | 74LS151 | 62p |
| YF57M | 74LS153 | 74p |
| YF59P | 74LS155 | 62p |
| YF61R | 74LS157 | 54p |
| YF62S | 74LS158 | 55p |
| WH09K | 74160 | £1.00 |
| YF63T | 74LS160 | 69p |
| YF66W | 74LS163 | 69p |
| YF67X | 74LS164 | 80p |
| YF68Y | 74LS165 | £1.08 |
| YF69A | 74LS166 | £1.00 |
| YF71N | 74LS169 | £1.00 |
| YF72P | 74LS170 | £1.35 |
| YF73Q | 74LS173 | 90p |
| WH11M | 74174 | £1.10 |
| YF74R | 74LS174 | 69p |
| YF75S | 74LS175 | 69p |
| YF78K | 74LS190 | 88p |
| YF79L | 74LS191 | 63p |
| YF80B | 74LS192 | 86p |
| YF81C | 74LS193 | 86p |
| WH13P | 74194 | 90p |
| YF82D | 74LS194 | 80p |
| YF83E | 74LS195 | 69p |
| YF84F | 74LS196 | 88p |
| YF85G | 74LS197 | 86p |
| YF86T | 74LS221 | 74p |
| YF88V | 74LS241 | 92p |
| YF90X | 74LS243 | 92p |
| ★QQ56L | 74LS244 | 80p |
| YF91Y | 74LS245 | £1.00 |
| YF92A | 74LS251 | 62p |
| YF95D | 74LS257 | 62p |
| YF96E | 74LS258 | 62p |
| YF97F | 74LS259 | £1.00 |
| YF99H | 74LS266 | 28p |
| YH00A | 74LS273 | 90p |
| YH01B | 74LS279 | 62p |
| YH02C | 74LS283 | 80p |
| YH11M | 74LS365 | 48p |
| YH12N | 74LS366 | 48p |
| YH13P | 74LS367 | 48p |
| YH14Q | 74LS368 | 48p |
| YH15R | 74LS373 | 90p |
| YH16S | 74LS374 | 90p |
| YH18U | 74LS377 | £1.10 |
| YH19V | 74LS378 | DIS |
| YH22Y | 74LS393 | 55p |
| YH23A | 74LS395 | £1.15 |
| WH02C | 74LS629=74LS124 | £1.35 |
| QQ63T | 74LS684 | £3.40 |
| UF13P | 74HC4316 | £2.75 |

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|---|---|---|
| QX37S | 7400 | 25p |
| YF00A | 74LS00 | 25p |
| QX38R | 7401 | 25p |
| YF01B | 74LS01 | 25p |
| YF03D | 74LS03 | 25p |
| QX81C | 7426 | 41p |
| YF17T | 74LS26 | DIS |
| YF23A | 74LS37 | 25p |
| YF08J | 74LS10 | 25p |
| YF10L | 74LS12 | 25p |
| YF14Q | 74LS20 | 25p |
| YF18S | 74LS22 | 25p |
| YF25C | 74LS40 | DIS |

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|---|---|---|
| QX50E | 7430 | 25p |
| YF20W | 74LS30 | 25p |
| YF07H | 74LS09 | 25p |
| YF09K | 74LS11 | 25p |
| YF13P | 74LS15 | 25p |
| QX48C | 7421 | DIS |
| YF15R | 74LS21 | 25p |

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|---|---|---|
| ★QX39N | 7402 | 25p |
| ★YF02C | 74LS02 | 25p |
| ★YF22Y | 74LS33 | 26p |
| QX80B | 7425 | 37p |
| QX49D | 7427 | 34p |
| YF18U | 74LS27 | 25p |
| YF21X | 74LS32 | 25p |

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|---|---|---|
| QX64U | 7486 | 40p |
| YF52G | 74LS136 | 40p |
| YF99H | 74LS266 | 28p |
| YF27E | 74LS51 | 25p |
| YF28F | 74LS54 | 25p |

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|---|---|---|
| WH03D | 74132 | 89p |
| YF51F | 74LS132 | 60p |
| QX45Y | 7413 | 40p |
| YF11M | 74LS13 | 34p |
| QX46A | 7414 | 57p |

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|---|---|---|
| QX40T | 7404 | 28p |
| YF04E | 74LS04 | 25p |
| QX41U | 7405 | 28p |
| YF05F | 74LS05 | 25p |
| QX75S | 7406 | 44p |
| YH12N | 74LS366 | 48p |
| YH14Q | 74LS368 | 48p |
| QX21X | 4049UBE | 40p |
| QX76H | 7407 | 44p |
| YH11M | 74LS365 | 48p |
| YH13P | 74LS367 | 48p |
| YF49D | 74LS125 | 42p |
| YF50E | 74LS126 | 42p |

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|---|---|---|
| YF90X | 74LS243 | 92p |
| YF88V | 74LS241 | 92p |
| ★QQ56L | 74LS244 | 80p |
| YF91Y | 74LS245 | £1.00 |
| QX04E | 4007UBE | 28p |

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| | | |
|---|---|---|
| YF31J | 74LS74 | 32p |
| YF75S | 74LS175 | 69p |
| WH11M | 74174 | £1.10 |
| YF74R | 74LS174 | 69p |
| YH19V | 74LS378 | DIS |
| YH00A | 74LS273 | 90p |
| YH16S | 74LS374 | 90p |
| YH18U | 74LS377 | £1.10 |

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|---|---|---|
| QX56L | 7470 | 55p |
| QX57M | 7472 | 48p |
| QX58N | 7473 | 46p |
| YF30H | 74LS73 | 32p |
| QX61R | 7476 | 48p |
| YF33L | 74LS76 | 32p |
| QX71N | 74107 | 46p |
| QX88V | 74109 | 69p |
| YF45Y | 74LS112 | 46p |
| YH01B | 74LS279 | 62p |
| QX72P | 74118 | £1.10 |

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|---|---|---|
| YF73Q | 74LS173 | 90p |
| QX60Q | 7475 | 55p |
| YF32K | 74LS75 | 43p |
| YH15R | 74LS373 | 90p |
| YF97F | 74LS259 | £1.00 |
| YF72P | 74LS170 | £1.35 |

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|---|---|---|
| WH13P | 74194 | 90p |
| YF82D | 74LS194 | 80p |
| YF83E | 74LS195 | 69p |
| YH23A | 74LS395 | £1.15 |
| QX87U | 7496 | 82p |
| QX86T | 7491 | 74p |
| YF67X | 74LS164 | 80p |
| YF68Y | 74LS165 | £1.08 |
| YF69A | 74LS166 | £1.00 |

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|---|---|---|
| YF38R | 74LS90 | 46p |
| QX67X | 7492 | 63p |
| YF39N | 74LS92 | 57p |
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| YF84F | 74LS196 | 88p |
| QW83E | 4510BE | 63p |
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| YF71N | 74LS169 | £1.00 |
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| YH22Y | 74LS393 | 55p |
| QQ44X | 4526BE | 68p |

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|---|---|---|
| QW81R | 40103BE | £2.25 |

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| YF54J | 74LS139 | 55p |
| YF59P | 74LS155 | 62p |
| YF53H | 74LS138 | 55p |
| WH05E | 74141 | 90p |
| WH06G | 74145 | 97p |
| YF55K | 74LS145 | £1.00 |

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| QQ52G | 74LS47 | 86p |
| QQ53H | 74LS48 | 86p |
| QX31J | 4511BE | 63p |

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| YF61R | 74LS157 | 54p |
| YF62S | 74LS158 | 55p |
| YF95D | 74LS257 | 62p |
| YF96E | 74LS258 | 62p |
| YF57M | 74LS153 | 74p |
| YF56L | 74LS151 | 62p |
| YF92A | 74LS251 | 62p |
| QW84F | 4512BE | 63p |
| QX89W | 74150 | £1.48 |

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|---|---|---|
| UF13P | 74HC4316 | £2.75 |

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| QQ63T | 74LS684 | £3.40 |
| QX85G | 7483 | 97p |
| YH02C | 74LS283 | 80p |

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|---|---|---|
| WH00A | 74122 | 57p |
| QQ54J | 74LS122 | 62p |
| WH01B | 74123 | 82p |
| YF48C | 74LS123 | 69p |
| YF86T | 74LS221 | 74p |

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|---|---|---|
| WH02C | 74LS629=74LS124 | £1.35 |

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| BR02C | 5W Amp PCB | £2.20 |

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| BR04E | LM381 PCB | £2.80 |

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| RA81C | SAA1099 | NYA |

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| YY73Q | LM335Z | £1.65 |

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| YY75S | ICL7660CPA | £2.85 |

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| XX04E | 15V Supply PCB | 98p |

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|---|---|---|
| YQ39N | 0.1A Reg PSU PCB | £1.60 |
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| YQ41U | 0.5/1A Reg -V PS PCB | £1.10 |
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|---|---|---|
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| UF34M | (6264-150ns) | £4.50 |
| WQ42V | MCM4027 250ns | £1.25 |

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| QQ09K | 2764 350ns | £2.30 |
| YH88V | 27128 | £3.45 |
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| YB26D | Heatsink 60DN | DIS |

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| YM43W | SC Xtd Freq Sterophn | TEMP |
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| XY79L | Ceiling Speaker | TEMP |

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| LB91Y | Flasher Unit 2-Way | DIS |

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| XB82D | Crotech 3031 | £239.95 |
| XB83E | Crotech 3132 | £374.95 |

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| YJ79L | Multi-purpose DMM | £64.95 |

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| ★FY45Y | Adjust Spanner 150 | £4.95 |

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| FY68Y | CS Kit SK5 | £8.95 |
| FY69A | XS Kit SK6 | £9.25 |

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| HY13P | Desldr Nozzle Type 2 | DIS |

## WOUND COMPONENTS

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| YK07H | Tr 32-0-32 4A | DIS |

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|---|---|---|
| ★LK78H | Stppr Mtr + Drvr Kit | £13.95 |

# NEW ITEMS PRICE LIST

The following is a list of all items introduced since our 1986 catalogue, excluding new items in this issue.

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**GB96E** ASCII Keyboard PCB. **Price £8.50**

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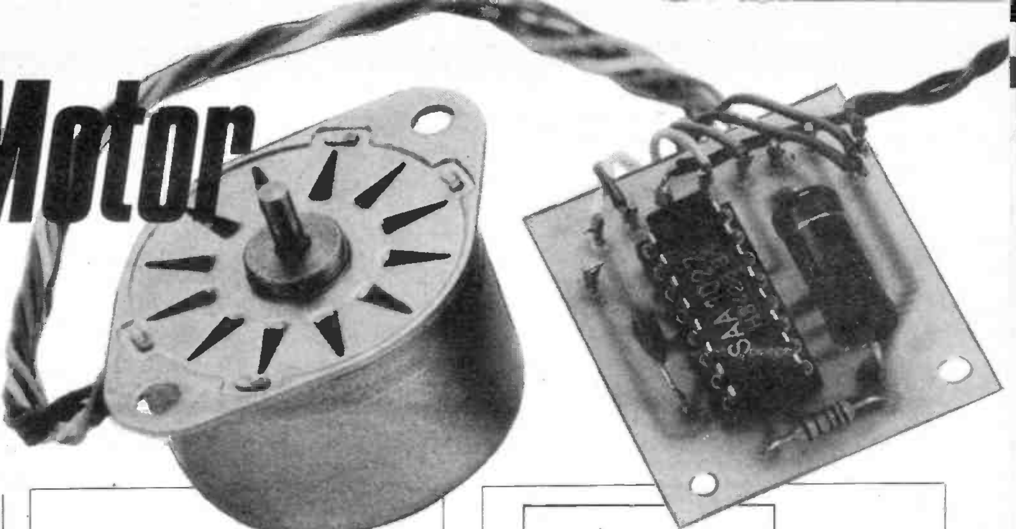
| XA21X | Issue 21 14th November 1986 | Price TBA |

# Stepper Motor Driver



by Mark Brighton

The Stepper Motor is an increasingly popular means by which positional and/or speed control may be achieved in motor driven systems, especially those controlled by digital logic or microprocessor circuits. It is, however, rather awkward to control using simple digital electronics as it requires several sequential combinations of logic states on its control lines to cause it to rotate.

★ **Simple to Use**
★ **Based on the SAA1027 IC**
★ **Easy to Construct**

In Figure 1, the SAA1027 is a Mullard IC designed to simplify the driving of 4-phase unipolar Stepping Motors, such as that shown on page 437 of the 1986 Maplin Catalogue. It requires only a 12V pulse for each step of the motor, and a 12V/0V logic state to control the direction of rotation. A reset pin is also available to internally re-initialise the stepping sequence within the chip. This chip, together with the necessary external parts and a pcb, is offered as a kit and is small enough to be mounted on or nearby the motor, where available space is limited.

## Construction

Referring to Figure 2, insert fully and solder all veropins, R1, RB, C1, and the IC socket onto the pcb, noting alignment mark on the legend. Fit the IC into its socket with the same orientation. Check for short circuits and wash off excess flux with thinners.

## Testing

Wire the pcb to the motor as shown in Figure 3. Connect the 'M' pin to 0V, and apply 12V pulses to the 'C' pin. 'R' should be connected to +12V if reset is *not* required. The motor should rotate clockwise. On connecting 'M' to +12V, it should run anticlockwise.

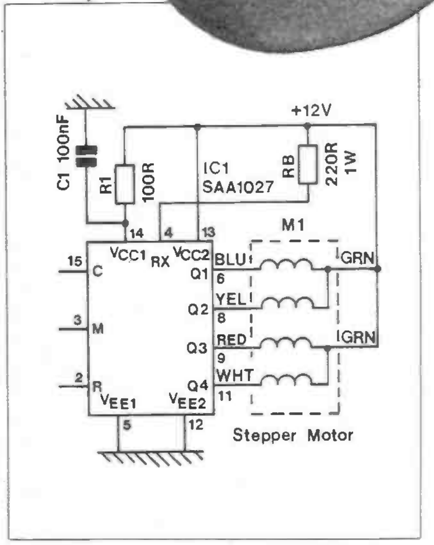



Figure 1. Circuit

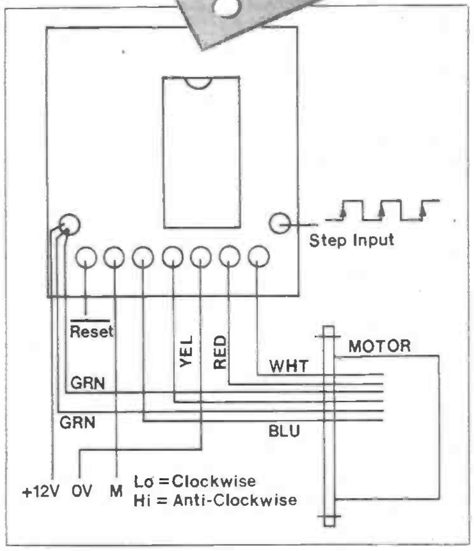



Figure 3. Wiring

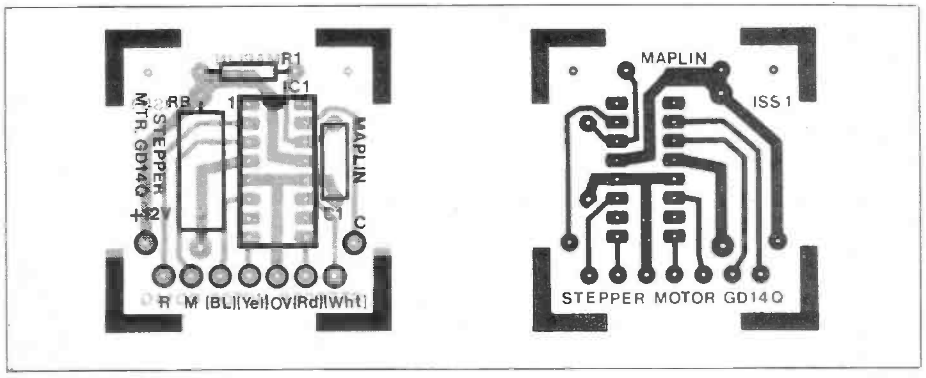



Figure 2. PCB Layout

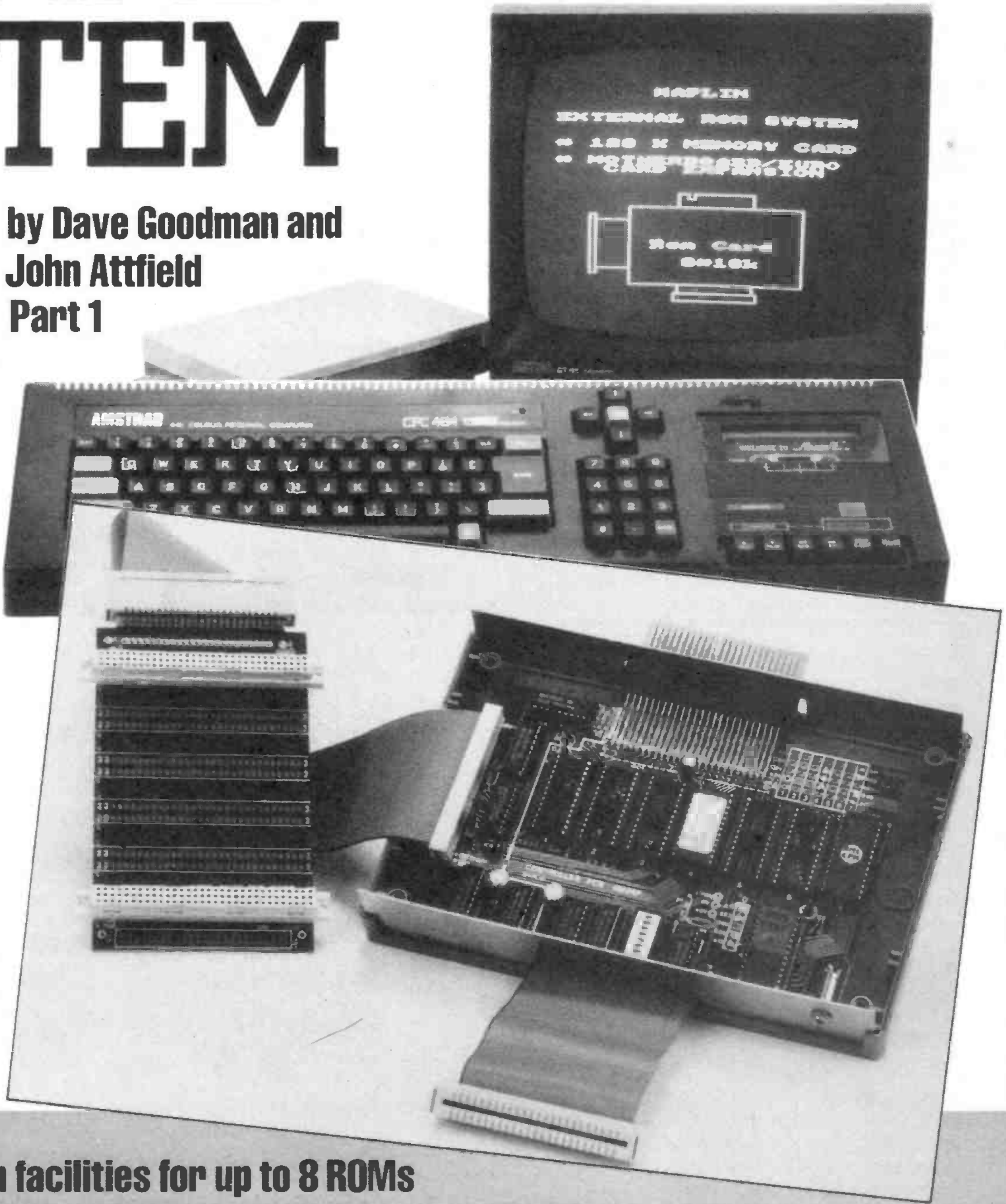
## STEPPER MOTOR DRIVER PARTS LIST

| | | | |
|---|---|---|---|
| **RESISTORS: All 0.6W 1% Metal Film unless specified** | | | |
| R1 | 100R | 1 | (M100R) |
| RB | 220R 1W Carbon Film | 1 | (C220R) |
| **CAPACITORS** | | | |
| C1 | 100nF Disc Ceramic | 1 | (BX03D) |
| **SEMICONDUCTORS** | | | |
| IC1 | SAA1027 | 1 | (QY76H) |
| **MISCELLANEOUS** | | | |
| M1 | Stepper Motor | 1 | (FT73Q) |
| | SAA1027 Data Sheet | 1 | (DS00A) |
| | Veropin 2145 | 1 Pkt | (FL24B) |
| | Stepper Motor PCB | 1 | (GD14Q) |

A complete kit of all parts is available:
**Order As LK76H (Stepper Motor Driver Kit)**
**Price £15.95**
The following item in the above list is also available separately but is not shown in our 1986 catalogue:
Stepper Motor PCB **Order As GD14Q Price £1.45**

# AMSTRAD EXPANSION SYSTEM

**by Dave Goodman and John Attfield**
**Part 1**




## External ROM Card and I/O

The Amstrad computers have proved to be very popular over the past few years, possibly due to the excellent value and facilities provided as standard. One very important feature is the Amstrad's RSX (Resident System Extension) and External or 'sideways' ROM supporting firmware, which allows BASIC command extensions, machine code routines and utilities to be added quite simply. The potential provided by this facility is well recognised by many manufacturers, and has led to a steadily increasing number of preprogrammed ROMs becoming commercially available, usually of the 8K and 16K variety.

However, before these ROMs can be used, it is necessary to fit a decoding system, designed for this purpose and the Maplin External ROM Card has been produced to this end.

## Specification

Sockets are provided for a maximum of eight ROMs which can be 2K, 4K, 8K or 16K in size giving a total of 128K memory

- ★ **ROM Card with facilities for up to 8 ROMs**
- ★ **Accepts 2K(2716), 4K(2732), 8K(2764), and 16K(27128) EPROM types**
- ★ **Extension board and socket for DD1 Disk Drive (CPC464)**
- ★ **Buffering and mapped decoding for up to 128, 8-bit I/O addresses**
- ★ **Motherboard extension for plug in (Eurocard) modules**
- ★ **Mechanically and electrically compatible with CPC464, 664 and 6128 computers**

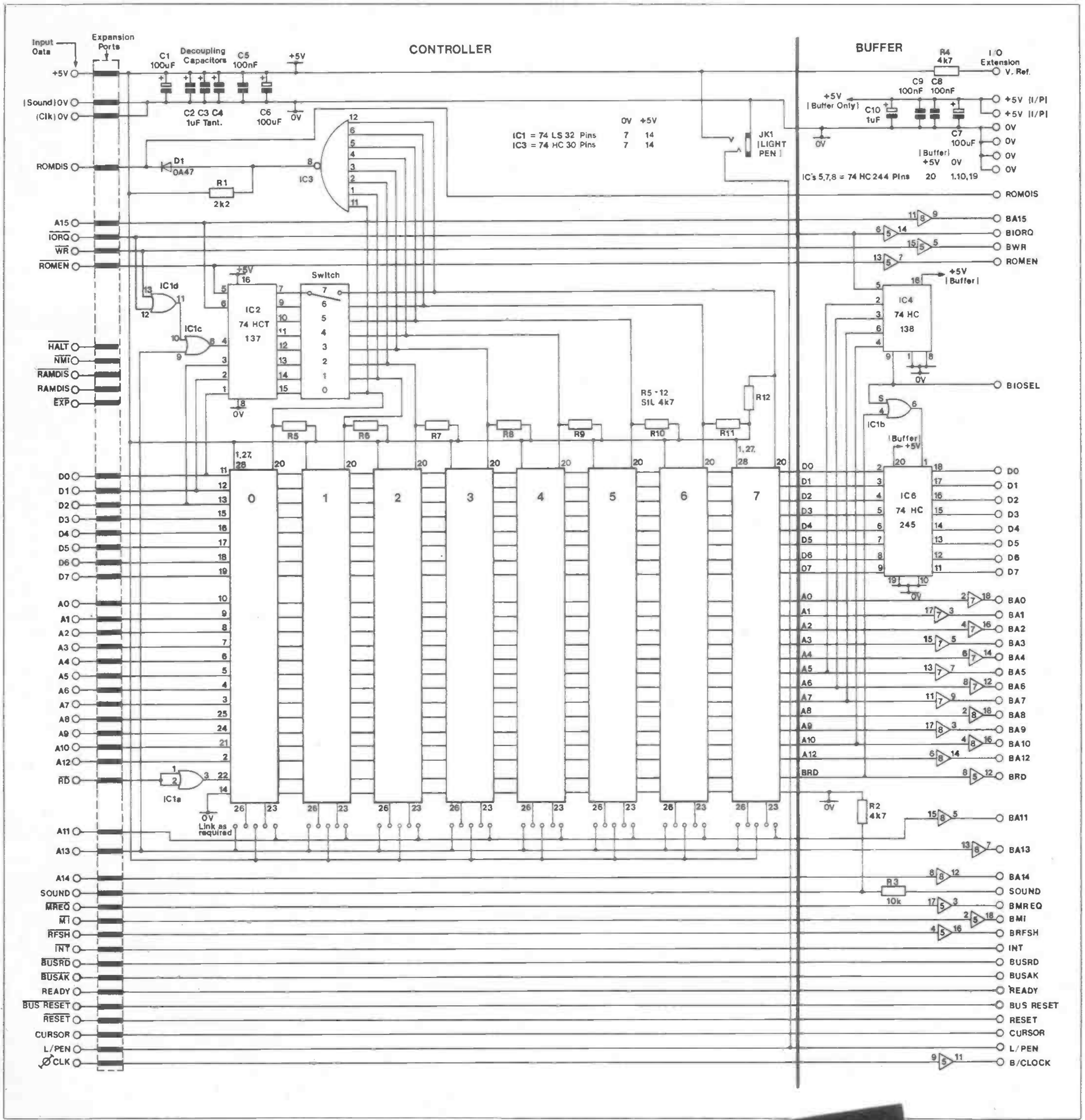
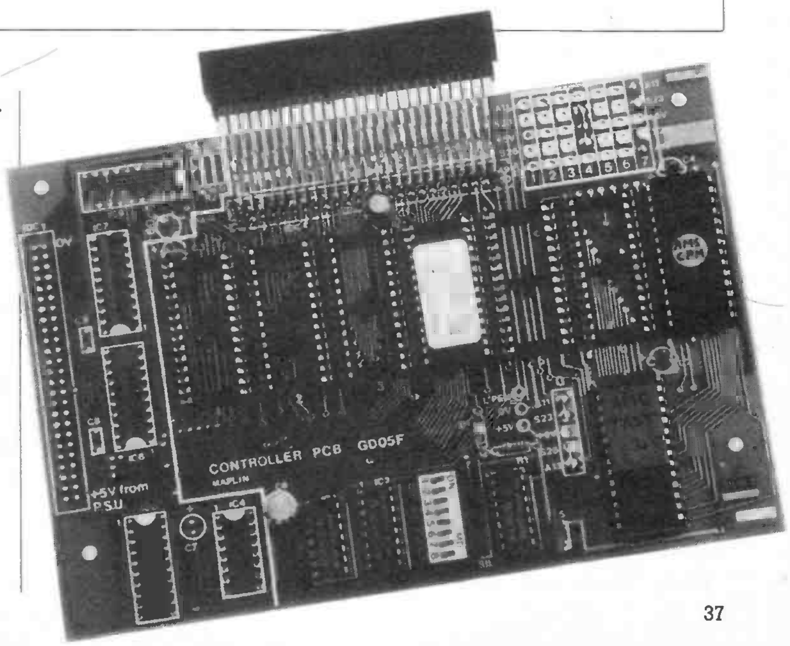



Figure 1. Circuit Diagram

expansion. Amstrad recommend fast access types of 200ns although the 250ns EPROMs available from the Maplin range have been found adequate on the prototype system. ROMs are decoded and given a positional (0 to 7) address during cold start or system reset, and any ROM found will be 'logged in' automatically. An eight position switch bank allows any ROM to be switched in or out of service as required. ROM position 7 should not be used if Amstrad's DD1 disk interface module is fitted to the 464, and this also applies to the CPC664 and 6128 versions! Therefore, only 464 machines, with no disk fitted, can use ROM 7.

A socket is provided for the connection of a Light Pen, which is wired to the Amstrad L'PEN input and 0V, +5V supply. Any Light Pen used here must have a positive pulse output at TTL levels to be compatible. A separate buffer and decoding section extends address, data and control lines out via an IDC cable to a Motherboard. IN/OUT address blocks are decoded HEX, F8, F9, FA and FB for the upper byte (A8 to A15). Lower byte decoding (A0 to A7) will be performed on individual Eurocard projects which plug into the Motherboard.



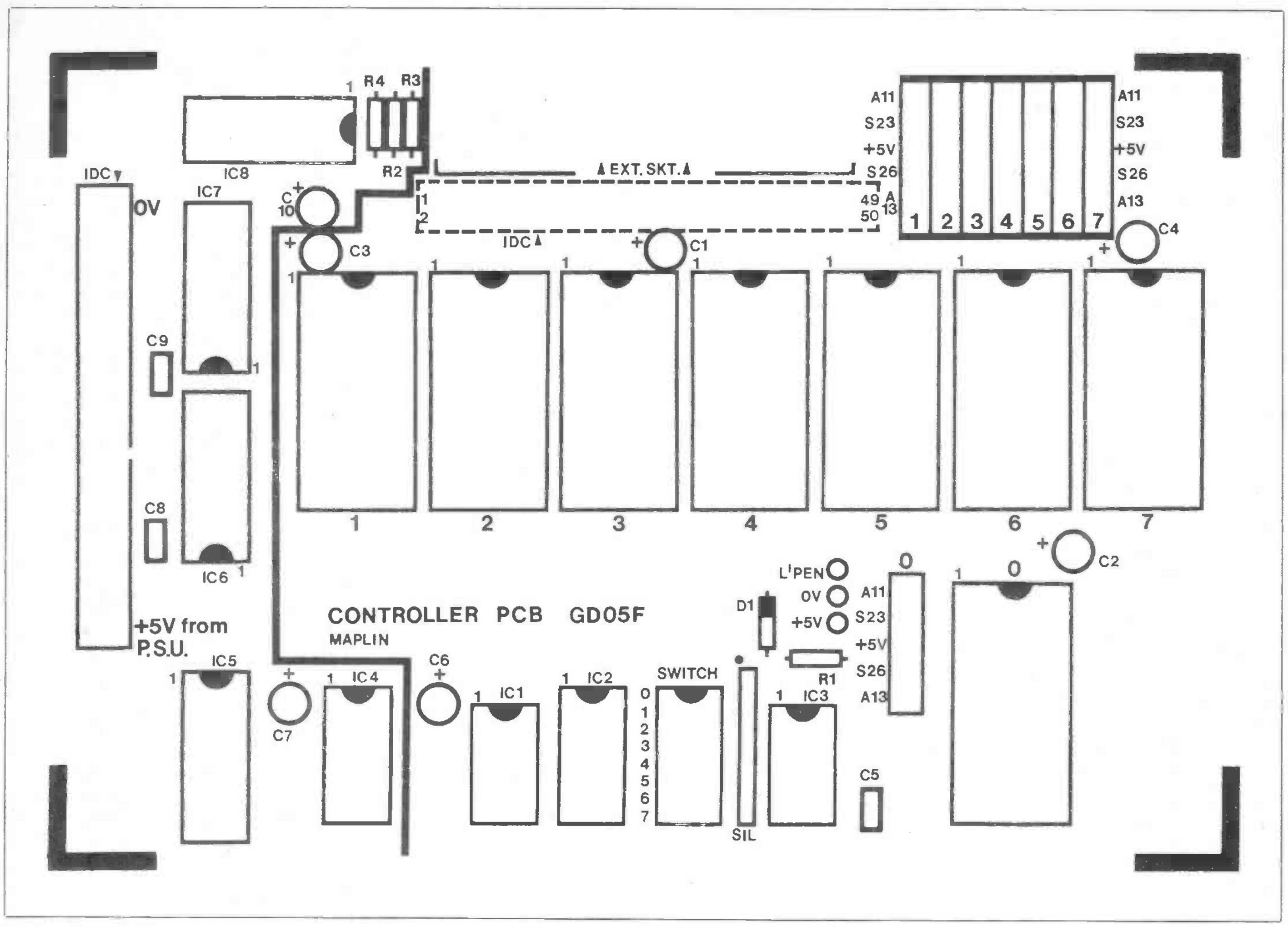


Figure 2. PCB Layout

The Amstrad expansion bus is extended out from the back of the ROM Card using a 2 x 25-way edge socket and a small plug-in extension board, thus providing facilities for disk drives, etc.

## Motherboard and Modules

This card will accept up to 6 plug-in Eurocard modules. Each position uses a DIN 41612 2 x 32-way receptacle, and the board can be extended with a 50-way IDC transition cable, if required. A separate PSU is required to power modules on the Motherboard and also to supply the buffering components used on the ROM Card. Eurocard size modules to be available in future issues are:

a) *6 x 8 I/O Port.* Decodes lower address byte for Port 1 in four blocks: E0, E8, F0 and F8 and Port 2 in four blocks: E4, EC, F4 and FC. Each lower block address is selectable as are the upper decoded address blocks, thus allowing maximum flexibility and compatibility with any other devices used on the Amstrad. Port 1 and Port 2 each have three 8-bit busses for a total of 6 x 8-bit (48-bit) input/output lines.

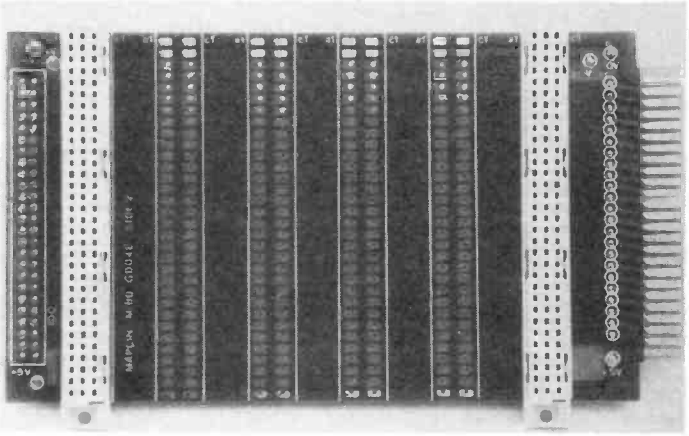
b) *EPROM Programmer.* An extension to the 6 x 8 I/O Port module will be an EPROM Programmer. This project is a must for constructors who wish to design their own external ROMs for use on the ROM card. A background ROM will be available for driving this project (via the I/O Port) which allows copying of different sized ROMs, standard and fast burn algorithms, modifying program bytes and copying from assembler buffers.

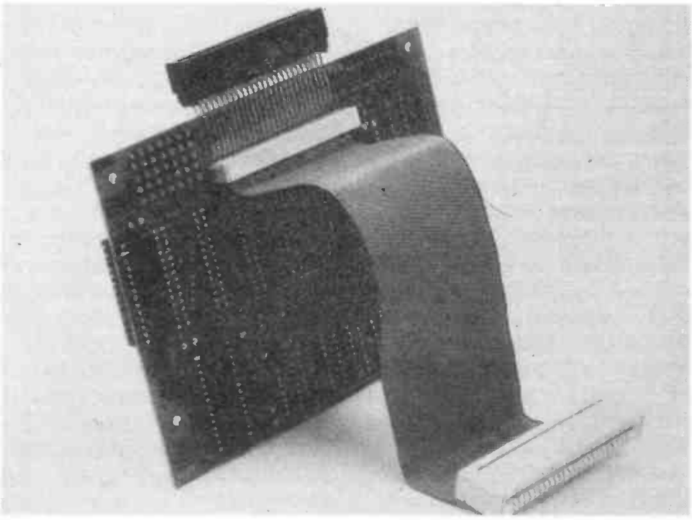
c) *Power Supply Card.* Produces a regulated +5V and unregulated supply for powering modules and buffer section.

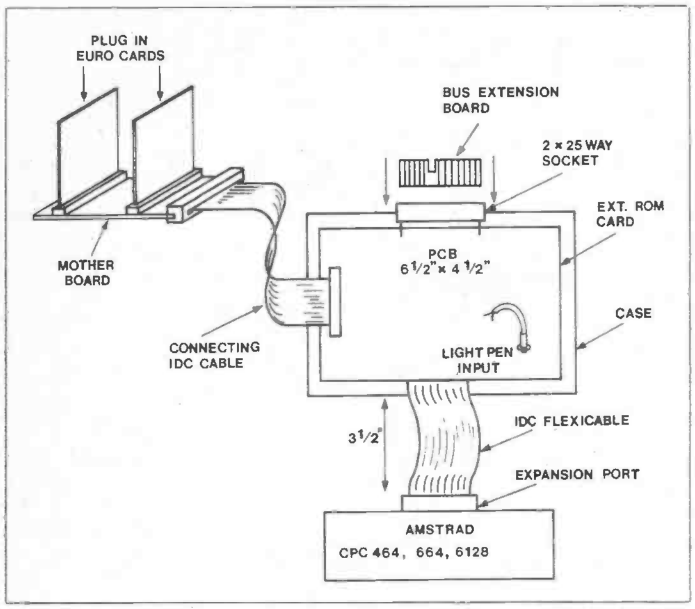
d) *Serial I/O Port.* Will have full protocol availability and selectable Baud speeds, compatible with most networks including RTTY and printers. The module will be both TTL and RS232 compatible and the system controlled by a background ROM.

## External ROM Card Details

Full construction, operational details, descriptions and







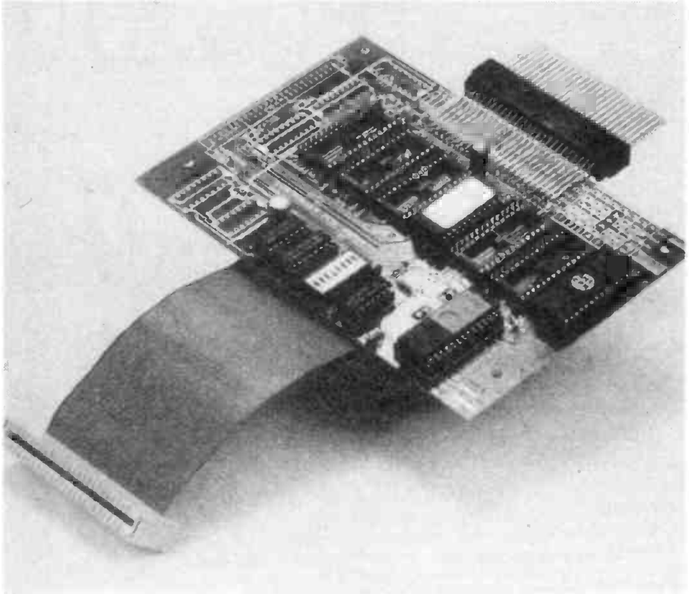



Figure 3. Overall System

ROM programming techniques are available in a separate pamphlet which is supplied with the kit version of this project. Pamphlets may also be purchased individually.

Figure 1 shows the complete ROM Card circuitry and buffer section. Figure 2 shows the ROM Card layout and Figure 3 gives an overall impression of the complete system.

The kit for the ROM Card contains the main PCB, sockets for mounting the ROMs, a cable harness for connection to the Amstrad computer, an extension connector with expansion card PCB, the case with front and rear panels, the pamphlet and ancillary components. The Motherboard Kit contains the motherboard PCB, a cableform for connection to the ROM Card, buffer components to be fitted to ROM Card and ancillary components. Note that the ROM Card kit does not contain any ROMs so that the types the constructor wishes to use can be selected by him. Also, the Motherboard Kit does not include the 64-way expansion sockets; these are rather expensive and can be purchased as required for each add-on card fitted to the unit.

## EXTERNAL ROM CARD PARTS

A kit of parts for the ROM Card is available:
**Order As LK97F (External ROM Card Kit) Price £39.95**

The following parts are also available separately but are not shown in our 1986 catalogue:
Controller PCB **Order As GD05F Price £11.95**
Amstrad Pamphlet **Order As XH65V Price £1.50 *NV***
50-way Amstrad Cable **Order As FA86T Price £7.99**
2 x 25-way Edge Connector **Order As FA87U Price £4.95**
Front Panel **Order As FA88V Price 55p**
Rear Panel **Order As FA89W Price 45p**
Expansion PCB **Order As GB99H Price £1.95**
Test ROM 2716/M11 **Order As UF73Q Price £5.95**

## MOTHERBOARD PARTS

A kit of parts for the motherboard extension is available:
**Order As LK98G (Motherboard Kit) Price £29.95**
The following item is also available separately, but is not shown in our 1986 catalogue:
Motherboard PCB **Order As GD04E Price £9.95**

## READY-BUILT CONTROLLER

The ROM card is also available ready-built into its case, together with front and rear panels, Expansion pcb and cable for connection to the Amstrad. The buffer components are also mounted onto the pcb together with the cable to connect to the motherboard. No ROMs are included however.
**Order As YM57M (Amstrad Controller Assembled) Price £59.95**

## FANTASTIC FIVE *Continued from page 30.*

frequencies of around 10 to 40kHz as these require special oscillator circuits.

TR1 acts as the basis of the oscillator, and this is a standard configuration which uses two capacitors to form a tapping on the crystal which operates as a parallel resonant tuned circuit. The crystal and capacitive tapping effectively form a single-wound resonant transformer, connected so that it provides a signal inversion. Thus, although the base and collector of common emitter transistor TR1 are out-of-phase, the inversion through the tuned circuit gives positive feedback over the circuit, and oscillation results provided the losses through the tuned circuit are not too high. Any reasonably active crystal will produce oscillation, but the values of the capacitors in the tapping circuit must have suitable values for the frequency of the test component. In this case one capacitor (C2) has a fixed value, while the other capacitor is one of three switched components (C3 to C5). Use C5 for low frequency (about 100kHz to 500kHz) types, C4 for medium frequency (500kHz to 6MHz) components, and C3 for high frequency (above 6MHz) types.

TR2 is an emitter follower output stage which can be used to drive a receiver or a frequency meter connected to SK2. TR2 is also used to drive a simple rectifier and smoothing circuit comprising D1, D2, and C8. If oscillation is produced, the strong positive bias generated across C8 is sufficient to turn on TR3 which in turn switches on LED indicator D3.

The circuit is quite easy to construct, and the only slight complication is in making the connections to the test crystals. One approach is to use several front panel mounted crystal holders wired in parallel in the SK1 position. These should be of different types so that any normal type of crystal will connect to the unit via one or other of the holders (even wire ended types can normally be connected to one of the holders well enough to facilitate testing). Of course, if you only use crystals with one type of base, a single holder will suffice. Another approach is to use two short leads terminated with small crocodile clips which fit onto the pins or leadout wires of test components.

# FIRST BASE

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

The last article in this series mentioned the Z-80 based CPU module design published in the Maplin Magazine issue 15 as the basis for some practical experimentation. We shall begin therefore with a brief explanation of this circuit (See Figure 1), since it represents a useful means of microprocessor experimentation.

## Microprocessor Based Systems

First, it is useful to look at the similarities between this design and the crude model of a system shown in Figure 2. At first sight, the two may seem completely un-related, but there are some important similarities which can be pointed out. Both have such features as a Data bus, Address bus and Control bus. For the Z-80 the data bus is 8 bits wide and the address bus 16 bits wide. The Z-80 control bus consists essentially of four lines, MEMREQ, I/OREQ, READ and WRITE, rather than just a single READ/WRITE line used in the model. There are other signals used by the processor for control purposes, such as BUSAK and M1, but we shall leave these alone for the time being. The main purpose of each of these is as follows:-

1. MEMREQ – This is an active low signal, as indeed are the others in this group, which is asserted to indicate that the address bus contains a valid address.

2. I/OREQ – A feature of the Z-80 is that it has a separate I/O space, apart from the main 64K of memory. It is the intention for this to be used to contain all the peripheral devices with which the processor needs to communicate. This line is asserted low to indicate that the bottom eight address lines contain a valid address for an I/O port.

3. READ – This is asserted low to indicate that the processor is able to accept data from a memory location or input device.

4. WRITE – Similar to read, this is used to indicate that the data bus contains valid data for sending to a selected device.

In some so-called minimum systems, the I/O line may be left unused, but since it is a feature of the Z-80 it seems worthy of further explanation.

## Memory Maps

We have seen memory maps in previous articles. These are notional maps and simply represent the total amount of memory and I/O space which the processor is capable of addressing. In any real system physical memory, or I/O ports, may only occupy a portion of the total available. The particular feature of the Z-80, not shared by other 8 bit devices such as the 6502, is the existence of this separate I/O space. This could be shown as a smaller map alongside the main memory map. The usual function of this space is to act as 256 individual 'ports'. That is, addressable locations to which peripheral devices may be connected to the buses via suitable hardware, like latches or buffers. Of course, such devices could be contained within the main memory map when they are referred to as being memory mapped I/O devices. This is unavoidable with some processors, but with the Z-80, they can all be put neatly in their own I/O space, leaving the 64K of main memory uncluttered. This produces the minor problem of how to distinguish between the first 256 bytes of memory and the I/O ports, since they both share a common address bus. This, of course, is achieved by the inclusion of the I/OREQ line in the address decoding. Thus:-

To READ from memory location 100D, then the address bus would contain 0064H (= 100D), the READ line low and MEMREQ low, but with I/OREQ high.

To READ from Port 100D, then again the address bus will contain 0064H, READ line low, but this time with I/OREQ low and MEMREQ remaining high.

## Stored Program

We can now look at the operation of the micro-based module, and explain the significance of some of the other signal lines present. Perhaps at this stage, it is worth reminding the novices there really is nothing magical about a microprocessor! A Z-80, a fairly simple device by present day standards, could be made up from discrete logic gates, along the lines that we have been looking at over the past articles in the series. It would be a rather pointless exercise, since it is the great advantage of VLSI technology that has allowed such circuitry to be 'compressed' onto a single chip.

The main function of the micro is to work through a set of instructions, the 'program', rather like someone following a recipe in a cook-book. The program consists of specific instructions which the processor understands, and it resides in memory. Without such a program, the hardware can do precisely nothing, no matter how sophisticated it may be. This leads us to something of a paradox, for with any home computer one would expect to enter the program from the keyboard or perhaps a cassette or disk unit. However, the machine must already contain an operational program in order to make any sense of such attempts at data entry.

Such a program, often referred to as the Operating System, would need to reside in a ROM as part of the whole machine, ready to spring into action as soon as the power is turned on. The module under discussion has space for both ROM and RAM, but as yet, no program to act as an Operating System.

The idea here then, would be to write some suitable controlling software on another machine, transfer this when

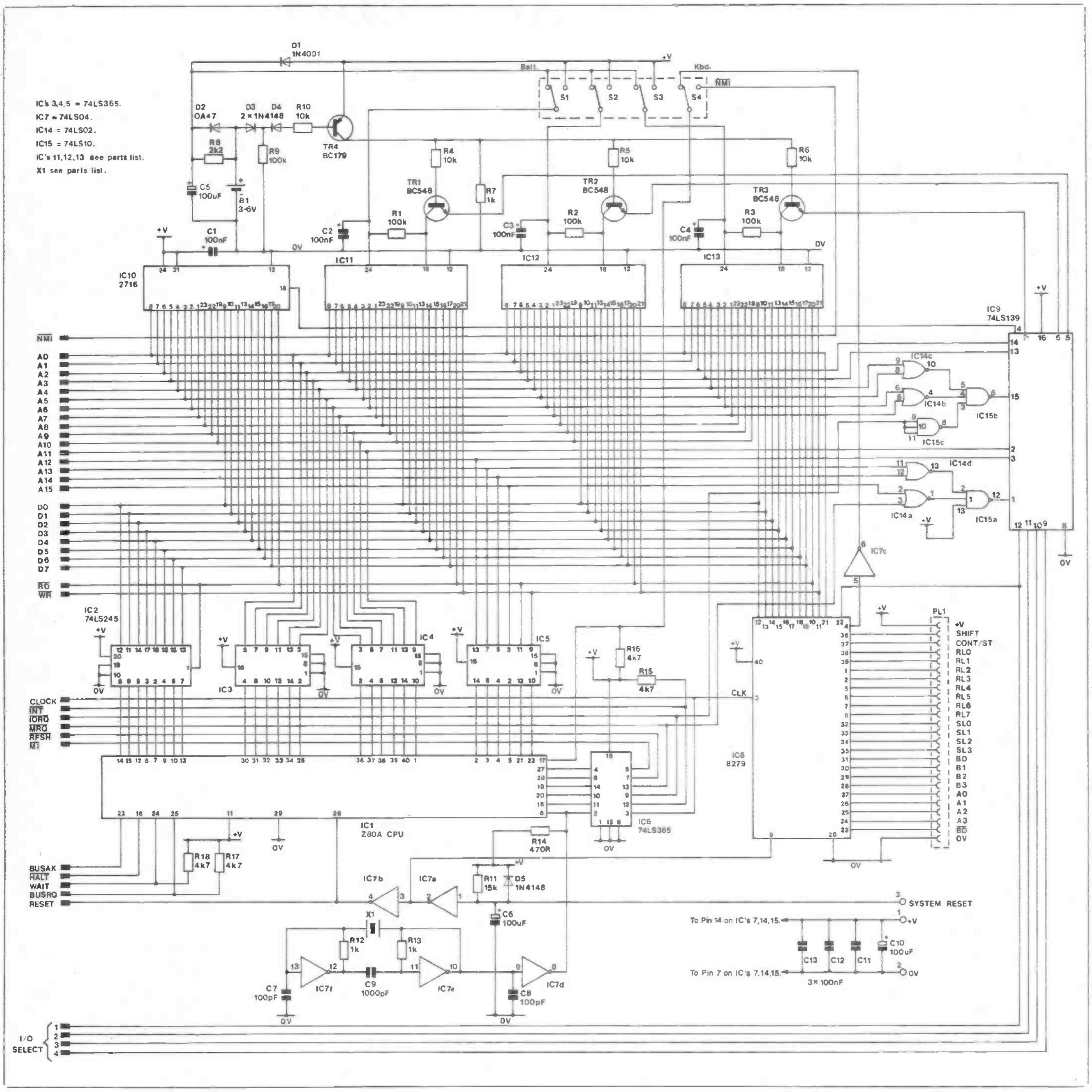



**Figure 1. Maplin Z80 CPU Circuit**

debugged into an EPROM, and plug this into the target system. Likewise, in order for the module to do anything useful, there is still a need for some means of communicating with it, and also, some way in which it can deliver the results of its working.

The Maplin module can be fitted with a special type of peripheral device, namely the Intel 8279. This has the ability to be interfaced with a simple keyboard for data entry and a 7-segment LED display for data output. This would require a controlling routine as part of the operating system to allow suitable data to be entered into RAM, or to modify the contents of RAM in order for further programs to be written and executed. This would then make it possible for the module to act as, say, a micro-based controller for such applications as regulating the central heating, stage

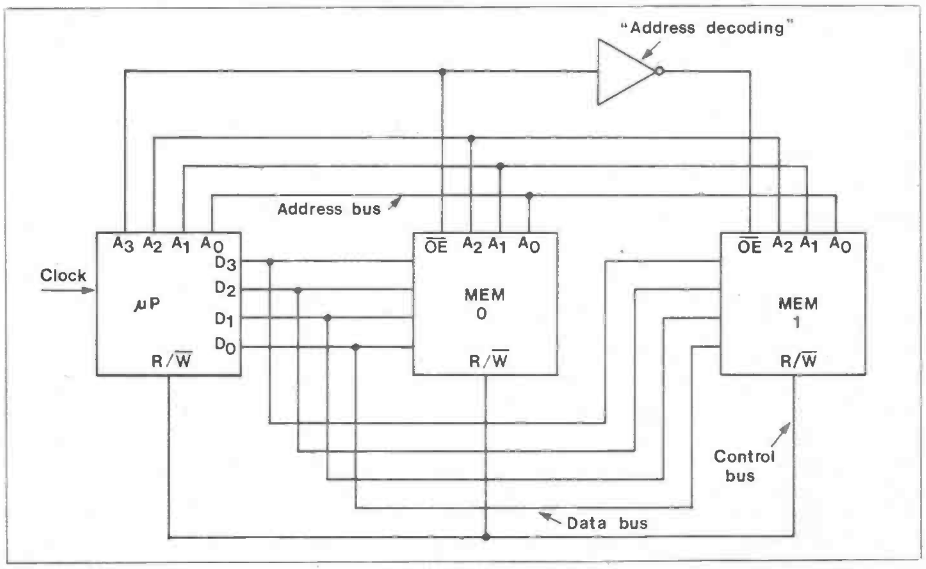



**Figure 2. Simplified Microprocessor**

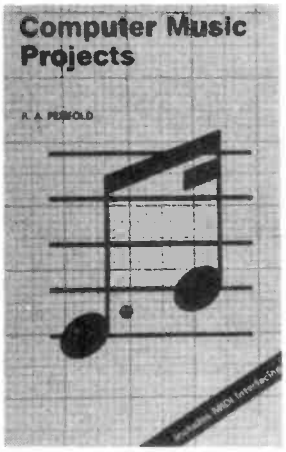
Continued on page 47.

# New Books

## Computer Music Projects

*by R.A. Penfold*

Computers have been the major contributory factor to the information revolution and increasingly fantastic arcade games, but outside of the realms of business and games they have had limited impact as yet. However, one exception is in the area of electronic music instruments and effects machines, which have transformed out of all recognition in recent years with the introduction of ever more specialised digital circuitry. Apart from gaining digital accuracy, such instruments now lend themselves to direct computer control, especially now that the MIDI (Musical Instrument Digital Interface) system is now fast becoming an established standard, with increasing availability.

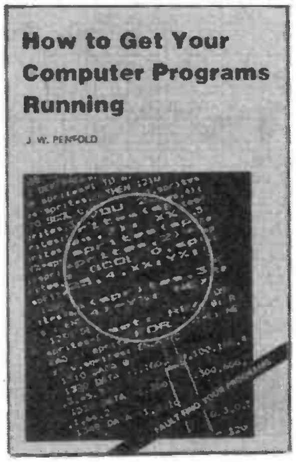



This book will show some of the ways in which a home computer can be used to good effect in electronic music generation and control, and includes sequencing and control via analogue channels, use of computers as digital delay lines and sound generators for computer control. Everything has been kept as simple and jargon free as possible, but it is assumed that the reader has some knowledge and experience of computer software, and able to construct some simple electronic projects.
1985. 178 x 110mm.
96 pages, illustrated.
***Order As WP38R (Computer Music Projects)*** ***Price £2.95NV***

## How to Get Your Computer Programs Running

*by J.W. Penfold*

For those inexperienced in programming in BASIC, finding the exact cause of an error or a bug in the program can be a problem even when help is given by the computer with error messages, the exact meaning of which are explained to a point by the manual. This is especially true where BASIC programs are copied from listings published in books and magazines, and have to be adapted because they

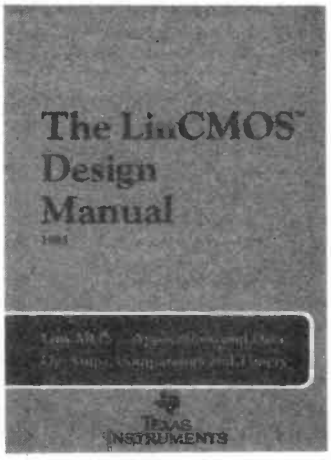



were written for a different machine. If the BASIC is a fundamental version (not an advanced version with features peculiar to one machine), this is not too difficult, but some translation is necessary, and along with the inevitable typing error there are nearly always a few errors which need locating and correcting before the program will RUN without stopping. The purpose of this book is to teach you firstly how to identify errors in programs and to understand error messages, and secondly how to correct those errors. Some advice is also given on how to write programs in a way which will make error tracing simpler and correction easier. The book only deals with programs written in BASIC, but most of the major dialects of the language, as used by popular home computers, are covered.
1985. 179 x 112mm.
84 pages, illustrated.
***Order As WP37S (How to Get Progs Running)*** ***Price £2.50NV***

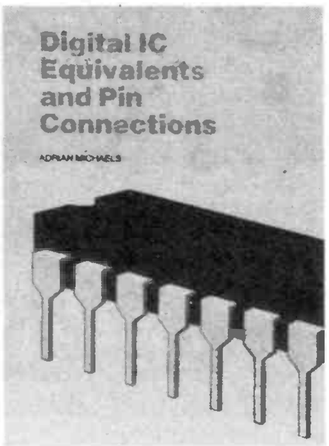
## The LinCMOS Design Manual

*by David P.E. Dale*

LinCMOS is the latest in device integration technology following on from CMOS logic. In a similar manner, LinCMOS offers much reduced power dissipation and supply current consumption, and is therefore ideal for remote, battery and solar powered applications. The TLC series devices




described in this manual have selectable bias adjustment so as to obtain the best compromise between supply consumption and throughput frequency.
The manual lists the TLC single, dual and quad op-amps, comparators and timers. Also included are copious notes and application examples with diagrams, which include oscillators, active filter designs, sampling and signal rectifier circuits, amplifiers and voltage regulators. Fully documented data sheets are also included.
1985. 210 x 148mm.
212 pages, illustrated.
***Order As WP35Q (LinCMOS Design Manual)*** ***Price £5.60NV***




## Digital IC Equivalents and Pin Connections

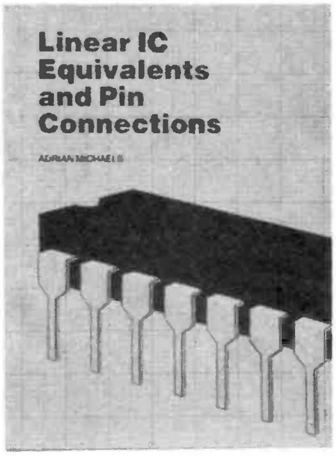
*by Adrian Michaels*

Shows the equivalents and pin connections for the most popular digital and logic integrated circuits. The book is divided into two parts; the first part consisting of the equivalents tables with the European, American and Japanese type numbers listed for any logic device, including details of packaging, the families, functions, manufacturer and country of origin. The listings incorporate a cross reference for the second section, which shows all the pin-outs diagrams for the different case styles and includes internal schematic diagrams.
1985. 265 x 194mm.
312 pages, illustrated.
***Order As WP39N (Digital IC Equivalents)*** ***Price £4.95NV***

## Linear IC Equivalents and Pin Connections

*by Adrian Michaels*

Shows the equivalents and pin connections for a popular user-oriented selection of linear integrated circuits. The first section of the book contains the equivalents tables showing the European, American and Japanese type numbers for any one device, along with the country of origin and a manufacturers guide. The

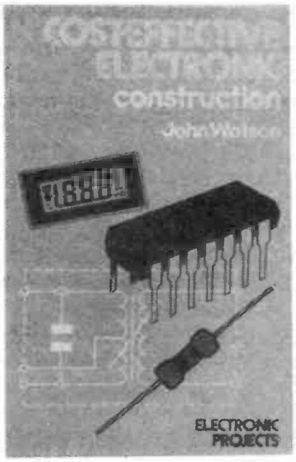



listings incorporate a cross reference for the second section, showing all the pin-outs diagrams for the different case styles and includes internal schematic diagrams. This latter provision makes for a very useful source of data should you wish to choose an IC for a particular application.
1985. 265 x 194mm.
246 pages, illustrated.
***Order As WP40T (Linear IC Equivalents)*** ***Price £4.95NV***

## Cost-Effective Electronic Construction

*by John Watson*

Originally printed under the title *'Cost-Effective Projects around the Home,'* this revised edition contains 26 detailed projects with full circuit description including infra-red burglar alarm, automatic porch-light switch, feedback drill speed controller, freezer/boiler alarm, computer I/O port, light dimmer, automatic TV switch-off, xenon strobe, and many more in addition to many simple but useful building block type circuits. One major project is for a complete multi-channel radio control system, using linear and CMOS ICs wherever possible for compactness.
1985. 215 x 137mm.
142 pages, illustrated.
***Order As XW30H (Cost Effective Elec)*** ***Price £5.95NV***

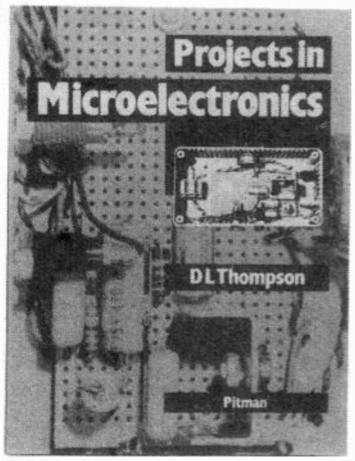


# New Books

### *Projects in Microelectronics*

***by D.L. Thompson***

Twenty-six projects originally intended to provide practical hands-on experience of electronics hardware, for both GCE electronics and physics courses and technology courses in colleges, but they could also be invaluable as exercises for anyone about to undertake electronics as a hobby. Various 'diciplines' of the subject are explained, together with a guide for good soldering, and descriptions of most of the components regularly used in the projects. The projects are divided into two main levels of aptitude; the reader can proceed onto the 'harder' projects once he/she has become practiced at construction and trouble-shooting.



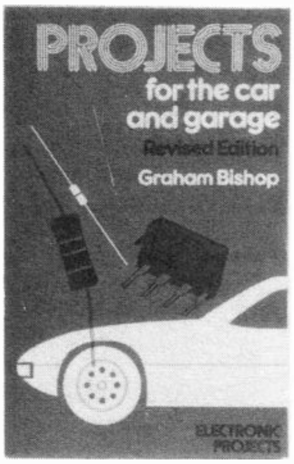

Many of the projects will form useful modules for the furtherance of the hobby, such as test oscillators, a digital counter, a voltmeter input buffer, supply voltage dividers for 0V tap for op-amp circuits and other power supplies. Other projects include light meters, single transistor and single IC radios, audio power amplifier, temperature controller, LCD thermometer, electronic combination lock.
1985. 247 x 188mm.
72 pages, illustrated.

***Order As WP41U (Proj in Micro Electronics)*** ***Price £4.95NV***

### *Projects for the Car and Garage*

***by Graham Bishop***

This is the 1985 revised edition of this popular book, containing more than 30 projects for the car owner, fully documented with constructional details, circuit diagrams, circuit board layout and installation recommendations. The projects are divided into the five main areas of ignition, anti-theft and security, lighting, accessories and test gear for the garage/workshop. For those who do not have it fitted as standard already, the first section describes a complete Capacitive-Discharge Ignition (CDI) system which requires no irreversible 'conversions' of your standard contact breaker system, yet it offers higher energy sparking for less supply current from the battery and is invaluable for winter starting. Various useful extras are



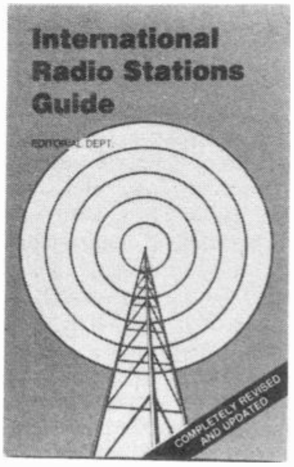

included such as an ignition timing light and a dwell meter.
Other useful add-on projects included are lights-on reminders, lamp failure indicators, rev-counter, wiper delay, digital car clock, emergency beacon, car radio add-ons and many more.
1985. 215 x 137mm.
115 pages, illustrated.

***Order As XW31J (Projects for the Car and Garage)*** ***Price £4.95NV***

### *International Radio Stations Guide*

A fully revised and updated edition of an earlier publication, *"Radio Stations Guide"*, which includes as much up-to-date information as possible, eliminating that which is no longer current or accurate. It is presented in a most readable way, and includes in many of the tables the town and country in which the radio station's transmitter is sited. The transmission frequency in kHz/MHz and/or wavelength in metres, plus the ERP in kW is listed.
The book is divided into nine sections; European Long Wave stations; European, Near East and North Africa Medium Wave; World Wide Short Wave; Broadcast Band USA; Broadcast Band Canada; Broadcast Band stations in Latin America and the Caribbean; programmes in English with transmission times; and UK local radio. Also includes wavelength/frequency conversion formulæ.
1985. 178 x 112mm, 126 pages.

***Order As WP36P (Int Radio Stations Guide)*** ***Price £2.95NV***




# TOP TWENTY BOOKS

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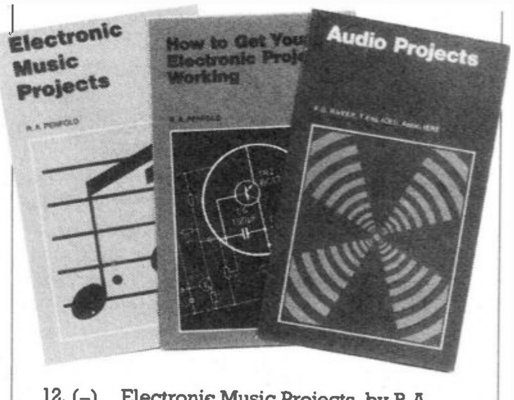


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20. (–) Electronic Household Projects, by R.A. Penfold. (XW44X) Cat. P49.

These are our top twenty best selling books based on mail order and shop sales during October, November and December 1985. Our own magazines and publications are not included. The Maplin order code of each book is shown together with page numbers for our 1986 catalogue. We stock over 500 different titles, covering a wide range of electronics and computing topics.

# MACHINE CODE PROGRAMMING WITH THE Z80

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

## Assembler Format and Machine Code

These two formats are known as 'low level' languages, as compared with a 'high level' language such as BASIC. This is because they work right down at machine level, or very nearly. The Z80 works solely in binary numbers, as does any other processor, but for a human being to be constantly handling long strings of 1s and 0s is asking rather too much. Consequently, what is needed is some form of 'interface' (using the term in its broadest sense), which is essentially what a computer language is. BASIC, to quote the best known example, makes life very easy because of its relation to everyday English; furthermore, it allows a user to communicate with the computer without actually knowing anything about the way in which the machine works. But, because of its interpretive nature, it is slow. A knowledge of machine basics plus the ability to program at low level gives one a much greater degree of control, leading to increased speed and efficiency. It is also very rewarding intellectually. Now consider the following line.

BEGIN LD A, (HL) Get value &003A 7E

For new programmers this introduces some very important ideas. In this line an instruction has first been written in assembler, and then in the corresponding machine code. What are the constituent parts of this line?

**BEGIN...**

From left to right, we first have the word BEGIN: this is known as a 'label', because it labels the program line with a specific function, a rather obvious one in this case – the start of the program. Not all lines need labels as will be seen, but for those that do it performs a valuable function. A label is also often called a 'symbolic address'.

**...LD A, (HL)...**

Next is found LD A, (HL). This is known as a 'mnemonic' instruction, which in this case means 'load the A register with the data found in a memory location pointed to by the contents of the HL register pair'. If this conveys nothing much else, then it should illustrate how succinct mnemonics are at getting the message across, once you know what they mean! In an instruction of this type, A is said to be the 'destination' and (HL) the 'source', an order that must be adhered to.

**...Get Value...**

The words 'Get value' form a 'comment', which states what the line is intended to achieve; they should be used liberally as they help everyone to understand later how the program worked, and if it didn't, they are then useful when it comes to debugging.

This completes the assembler version of the line. What follows is its machine code equivalent.

**...&003A 7E**

The two-byte HEX number &003A is a memory address and defines the location where the associated load instruction is stored. The ampersand (&) is a convention that reminds us that 003A is in HEX. It could hardly be anything else, but I think you'll agree that the number 5100 could be denary (or even octal!), whereas if we put &5100, there's no doubt that it's HEX. Leave the ampersand out if you wish, but beware of the chance of ambiguities. Where it will invariably have to be included is when using assembler software, since it is a means of instructing the assembler that a HEX number is being used. In a machine code program listing it's not really necessary to include it since machine code is always in HEX anyway, whether generated by an assembler or produced the hard way, by hand encoding from tables.

The single-byte HEX number 7E following the address is called an 'op-code', and is the machine code version of LD A, (HL). It is the means by which the Z80 knows exactly what is expected of it. Obviously, the right op-code must be taken from the tables; there is no room for error, none whatever. Why not check now from the table of 8-bit loads in Part One that 7E is the correct op-code? If you can't see why at the moment, don't worry as all the tables will be explained and used as the series develops.

## Algorithms and Flowcharts

An algorithm is a step-by-step procedure, defining the solution of a problem. Algorithms may be quite trivial or very elaborate. To take an example, suppose we have ten keys, only one of which will open a certain door, but we don't know which one. The procedure is so obvious that we don't consciously think of the individual steps. But, to solve computer problems, we have to be able to develop the ability to see the solution as a series of steps. And, because a computer is a complete idiot, each step must be explicit and none can be left out.

So the algorithm for finding the right key is:

Try first key; does it fit?
No! Try second key; does it fit?
No! Try third key; does it fit?
And so on for ten keys.

This is not a very elegant form for the algorithm. Writing it in the form of an IF THEN procedure would be much better, as follows.

Try a key
IF: this key doesn't fit,
THEN: try the next one.

This is actually a looping procedure though the algorithm hasn't expressly highlighted the fact. What will make this obvious is a 'flowchart'; see Figure 1.

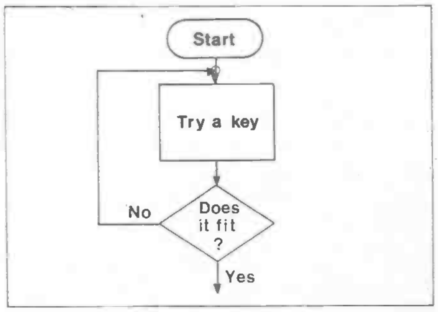



**Figure 1. Flowchart for simple looping program**

A picture conveys a thousand words, or so they say. That may be an exaggeration, but the flowchart does quite clearly show the repeated operation of trying a key until one that fits is found. The loop is formed automatically by the NO output of the 'decision diamond'; the rectangle contains a statement of an operation to be executed.

Figure 2 shows another flowchart, which has more to do with computing than the previous example. The keys Z and X on the computer keyboard are used to control the lateral position of some on-screen object, such that Z = left and X = right. Though this flowchart doesn't show all the program details, it is as complete as it needs to be to illustrate the way in which a series of questions determines the ultimate action. The first diamond describes a common procedure for scanning a keyboard. The program loops endlessly until it finds that a key has been pressed. It then asks whether the key is Z. If it is, the object is driven left; if not it asks if it is X, in which case a positive answer drives the object right. If it is neither Z nor X (we all make mistakes!) it doesn't need to ask what it is; it just goes back to the beginning and waits for you to get it right.

## Layout of Program

It is important that the program is written down in a logical manner. Most programs of any size need some debugging or modification, and it is much easier to do it if the program isn't just a collection of scribbled, random jottings. Whether you design a custom program sheet or just use plain paper doesn't matter at all. What is important is that the development of the program is clearly seen. Some programmers lay out their programs with the machine code on the left side of the sheet and the assembler version on the right. Not being an inscrutable oriental, I prefer to work from left to right, putting down the source program first (i.e, the assembler code) and then the object program (the machine code). In fact, the logical procedure must involve writing down the program in mnemonic form and then encoding it into machine code when fairly confident that it ought to work. You can rule up actual columns or just visualise them mentally. You will need to allow for the following:

Assembler:
LABEL MNEMONIC OPERAND COMMENTS
Machine Code:
PC OP-CODE BYTES 2; 3; 4

In the machine code part, PC represents the program counter, that is, the addresses in turn at which the program is stored. The op-code plus bytes 2, 3 and 4 will be filled depending upon the addressing mode used. Sometimes only the op-code column is used, sometimes all four. Two examples illustrate this.

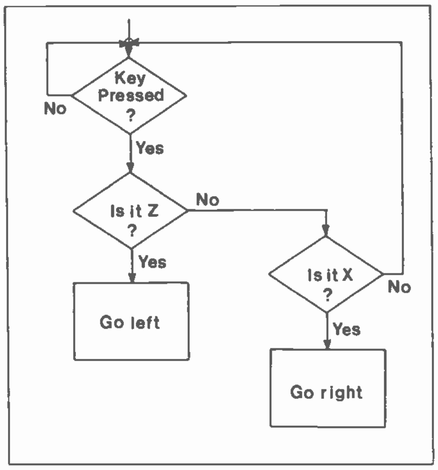



**Figure 2. Flowchart for key-press routine**

FRED EX ★ Exchange AF-AF' contents
001F 08

(★ no operand required since this is 'implied addressing mode'; hence only the op-code byte in the machine code version if filled)

FRED is a label to identify the line (for example if we need to jump to it from somewhere else in the program). You can use what names you like for labels but it is generally better to choose a name that has some relevance to what the program is doing at that point, e.g. LOOP1, START, etc.

GET LD B, (IY + d) Load B register with data
&031E FD 46 0A

This program line looks more complex but is, in fact, just an 8-bit load, i.e. the B register is being loaded with a single byte; that is the LD B part of the mnemonic. Where the byte is coming from is indicated by (IY + d) which means that the byte is found at a memory location whose address is equal to the contents of index register IY, plus a number 'd' (known as a signed displacement since it can be positive or negative). For example, if IY held &0140 and 'd' was &0A, then the address for the data would be &0140 + &0A = &014A. Because the addressing mode is that bit more complex it needs more bytes in machine code to express it, hence FD 46 0A. These will be found in the table of 8-bit loads at the intersection of SOURCE = (IY + d) and DESTINATION = B register.

Comments in the assembler program are invaluable. They play the same part as REM statements in BASIC, with the exception that they are not actually entered into memory. They just remind you why you wrote a certain line. They should, therefore, be explicit but not too wordy.

The points just discussed are concerned with an approach to programming, preparation being half the battle. The full instruction set has been given in Part One, together with a brief description of the Z80 addressing modes. In each subsequent part of this series, some time will be spent on discussing some of the Z80 instructions, and the rest of the time on programming and applications. When, eventually, all instructions have been discussed all the space will be devoted to using the Z80 by discussing both software and hardware design for a variety of uses. It will be useful to spend some time now on looking at the Z80 'load' instructions before going on to some real programming.

## The 8-bit and 16-bit Loads

The Z80 can handle data 8 bits or 16 bits at a time with the use of the appropriate instructions. This doesn't make it a 16-bit processor of course, because the data bus is only 8 bits wide. So the data is still sent a single byte at a time. It just makes programming that bit more efficient. The load instructions are found in Tables 1 and 2 of Part One.

For 8-bit loads the form used is:

LD destination, source

where LD is an obvious mnemonic for LOAD.

Taking an example from Table 1, a program line in assembler might read:

LD A, H

which means 'load the A register with the contents of the H register'. It is obvious that this could also be called a 'transfer' instruction, since a transfer of data is taking place from one register to another. This compares with LD A, #n which means 'load the A register with the number n'. Obviously, this is a straightforward load and not a transfer of data.

In the first case register addressing is being used, and the op-code is 7C, while in the second case, immediate addressing is being used and the op-code is 3E followed by a byte specifying the value of n. Check these by referring to Table 1.

The 16-bit loads cause data transfers to take place between register pairs and adjacent pairs of memory locations. For example, the contents of the AF register pair could be loaded from the memory locations 001A and 001B, or vice-versa. There are no 'store' instructions with the Z80; these are merely loads going the opposite way, from the processor to memory. The register pairs can also be loaded with data directly e.g. LD AF, #nn loads the AF register pair with the two byte number nn in what is called the 'immediate extended addressing mode'.

As an example of a 16-bit data transfer, take the mnemonic LD BC, (nn). In this case, known as 'extended addressing', (nn) is an address where a byte of data will be found; this byte gets loaded into register C. The next address, (nn + 1) contains a byte of data that gets loaded into register B. Compare this with the 16-bit load in the previous paragraph, where the data to be loaded into the register pair (AF in the example) is specified immediately. As an example of LD BC, (nn), consider the machine code ED 4B 50 0D. The ED 4B part is taken from Table 2 and means 'load the BC register pair in extended addressing mode', and the part 50 0D is the (nn) part and means 'the data will be found in memory locations 005D and 005E (since 005D + 1 = 005E)'.

Push and pop are just special types of load associated with 'stack' operations, which were explained briefly in Part One. There is no significant difference between these loads and any other 16-bit load, only in the application and in the mnemonics, of course. Examples are:

PUSH BC (Push contents of register pair BC onto stack)

POP HL (Pop contents of register pair HL from stack).

That will be enough discussion of Z80 instructions for now. Let's do a bit of programming and learn some more instructions that way.

## Bubble Sort Program

It is often necessary to be able to rearrange the elements of a table into a numerical sequence that gives increasing values from the top to the bottom of the table, or vice-versa. In a 'bubble-sort' program, the smallest elements 'bubble up' (or down!) from one end of the table to the other. To do this, each value of the table is examined relative to the one just above (or below) it, and an exchange made, or not made, depending upon their relative values. Successive pairs of values are compared in this way and, when all adjacent values have been compared with their neighbours, a single 'pass' is said to have been made. In a large table a fair number of passes will have to be made in order to complete the sort.

## Design of the Program

Think it out as fully as possible at this stage. Don't be tempted into trying to write a program from a mental outline. Sketch a flowchart to illustrate the steps, then use it with a 'dry run' to prove its validity. This establishes the basic ideas and highlights some of the specific problems that will have to be solved. The flowchart is shown in Figure 3.

For example, it is obvious that the numbers in the table are stored in memory, in consecutive locations. When the contents of two locations have to be exchanged, how can this be done? Are there special instructions to do it? There are some exchange instructions in the Z80 set but, unfortunately, they cannot be used on memory locations, only on certain registers and the stack. Figure 4 shows what can and cannot be done.

Specifically, 4(a) shows that a direct exchange is impossible for two reasons. These are, first, that no relevant exchange instruction exists as stated already, and secondly, that moving the

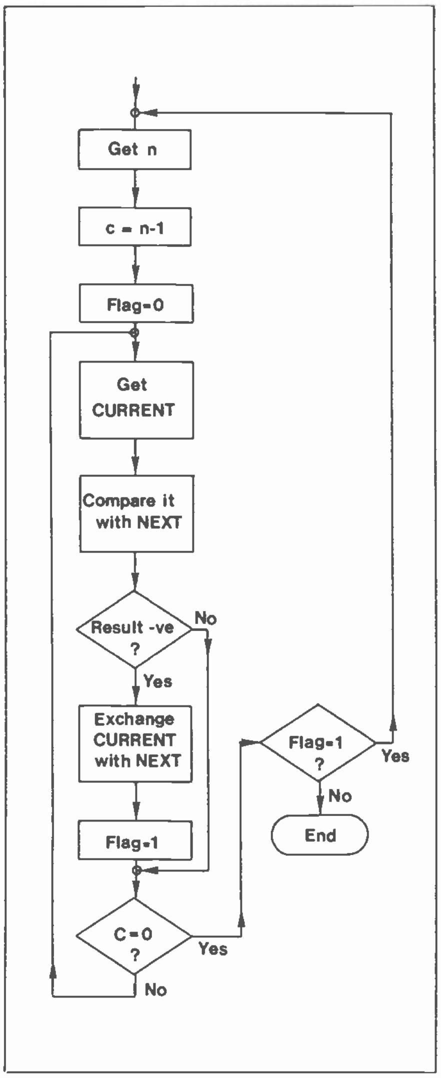



**Figure 3. Flowchart for bubble sort program**

number B into A's location will cause A to be over-written and so lost. Therefore, 4(b) shows the use of a third party, in a manner of speaking, a memory location called TEMP, whose function is to preserve one of the values while the other is being moved. Thus, the sequence for an exchange of the two numbers A and B would be: move A into TEMP; move B into A; move TEMP into B. Because of the rotation used in this technique, it is known as a 'circular permutation'.

The bubble sort idea is very easily demonstrated by taking a short list (since the length of the list has no bearing on the principle) and seeing how each pass successively sorts out the numerical order.

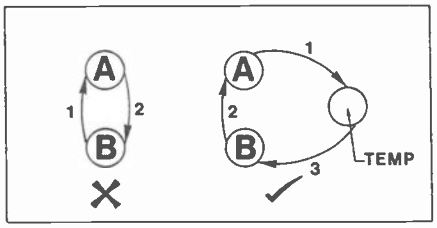



**Figure 4. The right and wrong way of exchanging data**

| Initial state | Second state | Third state | Fourth state |
|---|---|---|---|
| 16 | 16 | 16 | 16? |
| 8 | 8 | 8? | 2? |
| 20 | 20? | 2? | 8 |
| 3? | 2? | 20 | 20 |
| 2? | 3 | 3 | 3 |
| 3>2; Exchange | 20>2; Exchange | 8>2; Exchange | 16>2; Exchange |

This completes the first pass; notice how the 2 has bubbled up; at the beginning of the second pass it will be at the top, since we have just exchanged it with the 16. Now for the second pass.

| Fifth state | Sixth state | Seventh state | Eighth state |
|---|---|---|---|
| 2 | 2 | 2 | 2? |
| 16 | 16 | 16? | 3? |
| 8 | 8? | 3? | 16 |
| 20? | 3? | 8 | 8 |
| 3? | 20 | 20 | 20 |
| 20>3; Exchange | 8>3; Exchange | 16>3; Exchange | 2<3; No Change |

This completes the second pass and this should be enough to convince you that, on the third pass, the sort will be complete when the 16 and the 8 change places. However, although we can see from a diagram that the sort is complete, the program must be able, in some way, to deduce this fact also, otherwise it won't know when to stop. This can be done by using a 'flag' which is set whenever an exchange is carried out during a pass. Then if this flag is reset at the start of every pass, the completion of the sort can be determined by testing the flag to see if, after a complete pass through the table, no exchanges have taken place.

So what operations are going to be carried out in the bubble sort program? From the above discussions there are three basic types of operation.

a) transfers between registers and memory (the exchanges)

b) comparisons between numbers (to find if an exchange is required)

c) testing of a flag (to establish whether sort is complete)

It will also be necessary to set up a counter and decrement it regularly in order to find when a pass is complete. Thus, the initial value of the counter will be equal to the number of elements in the table less one and it will reach zero when all values have been compared.

## The Program in Assembler Format

The following registers will be used: A; B (TEMP); C (COUNTER); IX (accessing the elements in the table). The table will be located in RAM in successive locations, the lowest element at the lowest address. Bit 0 in the D register is the 'exchange flag.'

| LABEL | MNEMONIC | OPERAND | COMMENTS |
|---|---|---|---|
| AGAIN: | LD | C,n | Get number of elements n |
| | DEC | C | Set counter to n−1 |
| | LD | IX, BASE | Loads bottom address of list into IX |
| | RES | O,D | Exchange flag = 0 |
| GET: | LD | A,(IX + 00) | Get current element |
| | CP | (IX + 01) | Compare with next element |
| | JP | M,SWAP | If larger then exchange |
| | INC | IX | Set up address of next element |
| DECC: | DEC | C | Decrement counter |
| | JR | Z,FTEST | |
| | JP | GET | |
| SWAP: | LD | B, (IX + 01) | Load TEMP with NEXT element |
| | LD | (IX + 01),A | Load NEXT with CURRENT element |
| | LD | (IX + 00),B | Load CURRENT with NEXT element |
| | SET | O,D | Record exchange has occurred |
| | INC | IX | |
| | JP | DECC | |
| FTEST: | BIT | O,D | Is exchange flag = 1? |
| | JR | NZ,AGAIN | If yes, go round again |
| END: | | | |

This short program will need a bit of study before it is fully understood. The best way to do this is to compare it with the flow chart to see how the blocks on the latter have been implemented by the assembler program. Then, when you have a rough idea of it, do a dry run. On a sheet of paper sketch blocks that represent the registers used, including the flag. Let them all contain zero to start with; also draw a few memory locations, say five, and fill in the numbers to be sorted in them. Then go through the program line by line entering the data into the registers, swapping the data and setting and resetting the flag until you exit from the program. It doesn't take that long to do if only a small amount of data is used, but a lot can be learnt by this procedure. Anyway, it is what should be done when designing programs because it quickly shows up the bugs. You shouldn't find any in this particular program, though you may well make a few mistakes before you get a clean run through.

There are two conditional jumps, JP M,SWAP, which means 'jump to label SWAP if the result of the previous operation is Minus', and JR Z,FTEST, which means 'jump to label FTEST if the result of the previous operation is Zero'. Incidentally, JP uses the 'immediate extended' addressing mode and JR the 'relative' addressing mode. It will be as well to refer back to Part One now unless you are fully acquainted with these modes, since the op-codes are dependent upon the mode used. The machine code, line for line, equivalent will now be given. If you feel like trying your skills, why not assemble the above program into machine code by yourself first; then check it against my program. Again, it is the sort of exercise that will teach you a lot.

In the following program, the number of elements, n, is assumed to be 5 and the base address (lowest address of table) is &0500. The program has been located starting at &0000 but this choice is an arbitrary one. Remember that when addresses are used as operands in machine code, they are specified 'low byte first'. Thus, &0500 appears as 00 05 and *not* as 05 00!

| Program Counter | Op-code | Byte 2 | Byte 3 | Byte 4 |
|---|---|---|---|---|
| 0000 | 0E | 05 | | |
| 0002 | 0D | | | |
| 0003 | DD | 21 | 00 | 05 |
| 0007 | CB | 82 | | |
| 0009 | DD | 7E | 00 | |
| 000C | DD | BE | 01 | |
| 000F | FA | 1A | 00 | |
| 0012 | DD | 23 | | |
| 0014 | 0D | | | |
| 0015 | 2B | 13 | | |
| 0017 | C3 | 09 | 00 | |
| 001A | DD | 46 | 01 | |
| 001D | DD | 77 | 01 | |
| 0020 | DD | 70 | 00 | |
| 0023 | CB | C2 | | |
| 0025 | DD | 23 | | |
| 0027 | C3 | 14 | 00 | |
| 002A | CB | 42 | | |
| 002C | 20 | D2 | | |

**Machine code program for bubble sort**

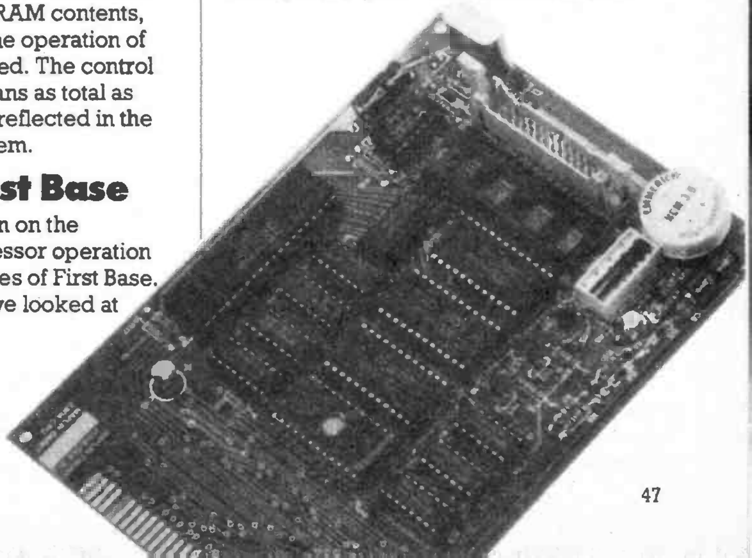
**FIRST BASE** *Continued from page 41.*

lighting, simple machinery or such-like. This 'chicken-and-egg' problem can really only be resolved by access to other programming equipment; one such piece of equipment is the so-called Microprocessor Development System, or simply MDS. These are not really within the scope of the home computer enthusiast, since they cost several thousand pounds! However, this would enable the requisite software to be written and debugged very quickly for the intended task of the module. The way this is achieved is to replace the processor in the module, or the 'target' system, with a special plug connecting to the 'host'. By this means the operation of all aspects of the target system can be controlled, or emulated, by the host machine. This would also contain sufficient memory for software to be written and debugged using sophisticated programming aids, and then allow the program to be run in the target system, but with the host keeping full control of its execution. With such a tool at ones disposal, complex programs can be produced relatively quickly, and the performance of the target monitored at all times. As a final stage, the finished program can be 'burned' into an EPROM, and then transferred to the target so it can operate as a stand-alone system.

Another slightly more simple method is to do a similar thing with the ROM resident in the target system. this then allows the program to be written and stored in RAM in a machine often called a Romulator. The target system has access to this RAM, which 'looks' like the operating system which would normally be in ROM. The romulator has the ability to modify the RAM contents, and hence its effect on the operation of the target can be observed. The control of the target is by no means as total as with the MDS, but this is reflected in the lower cost of such a system.

## First Base - Last Base

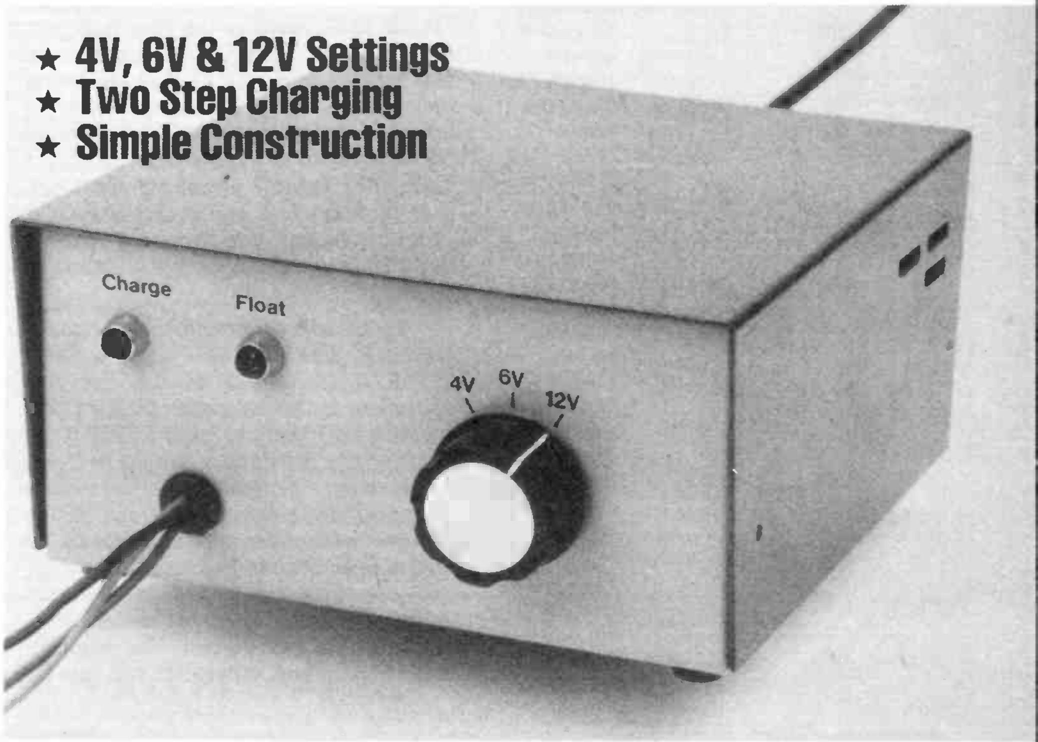
This short discussion on the principles of microprocessor operation brings to an end this series of First Base. During its course, we have looked at some of the aspects of digital electronics, and have of necessity left out a lot more. Hopefully, it may have stimulated some into enquiring further into this fascinating subject, and may have encouraged you to have a go at some construction or experimentation. If you have followed the series this far, then the whole world of the microprocessor lies stretched out before you, with all manner of delights in store! From now on, the rest is up to you with, perhaps, a little help from Maplin.



# Lead-Acid Battery Charger

by Mark Brighton

★ 4V, 6V & 12V Settings
★ Two Step Charging
★ Simple Construction




Properly charging sealed lead-acid batteries is very important for long trouble free battery service. The circuit shown in Figure 1 is capable of quickly and safely charging lead-acid batteries, and features temperature compensation in addition to two charging levels (with automatic switchover).

## Circuit Description

Temperature compensation in a charger is important to prevent over-charging, especially if the battery is subjected to wide temperature variations. A temperature coefficient of $-5mV/^{\circ}C$/cell at the output of the charger is provided by IC1, a current mode temperature sensor which is either located near the battery, or if high charging currents are involved, it could be attached directly to the battery.

The two-step charging feature provides a higher initial charging voltage

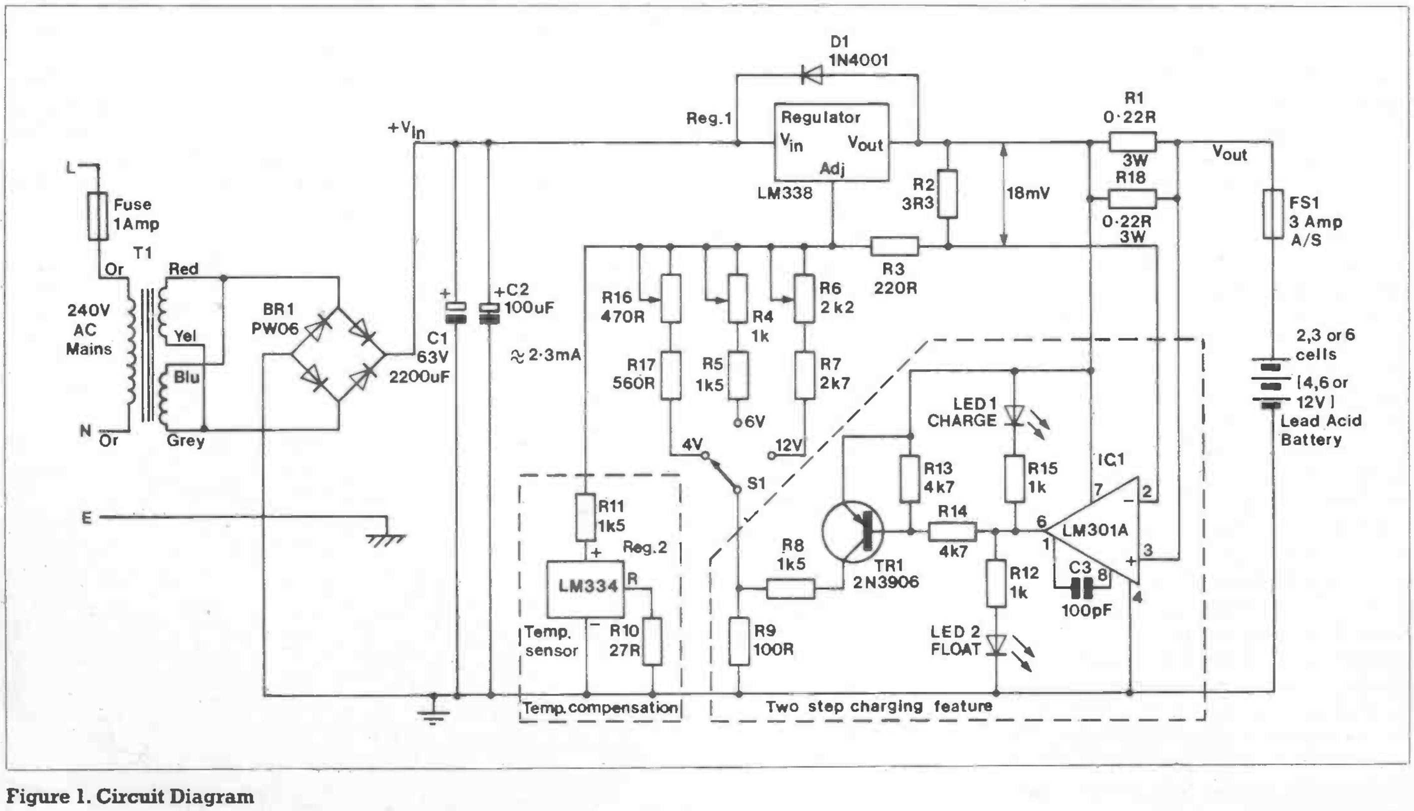



**Figure 1. Circuit Diagram**

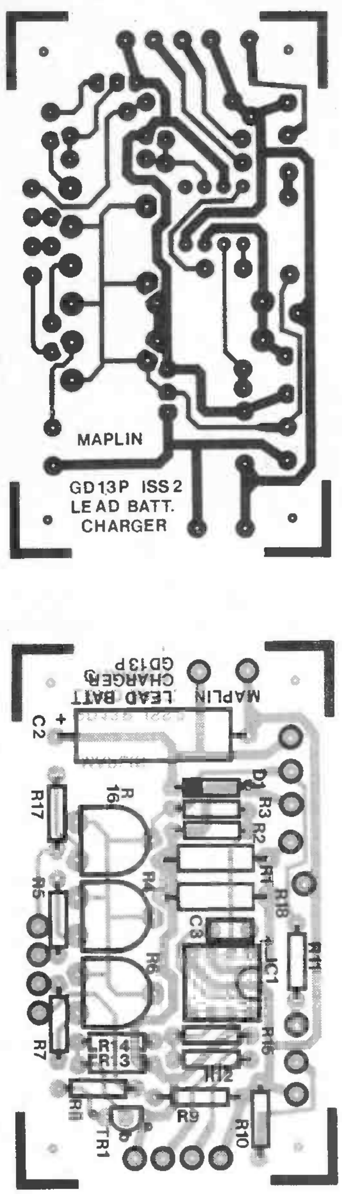



**Figure 2. PCB Layout and Legend**

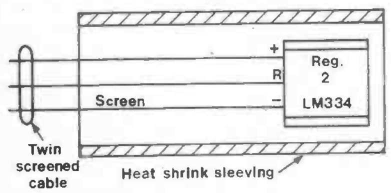



**Figure 3b. Fitting REG 2**

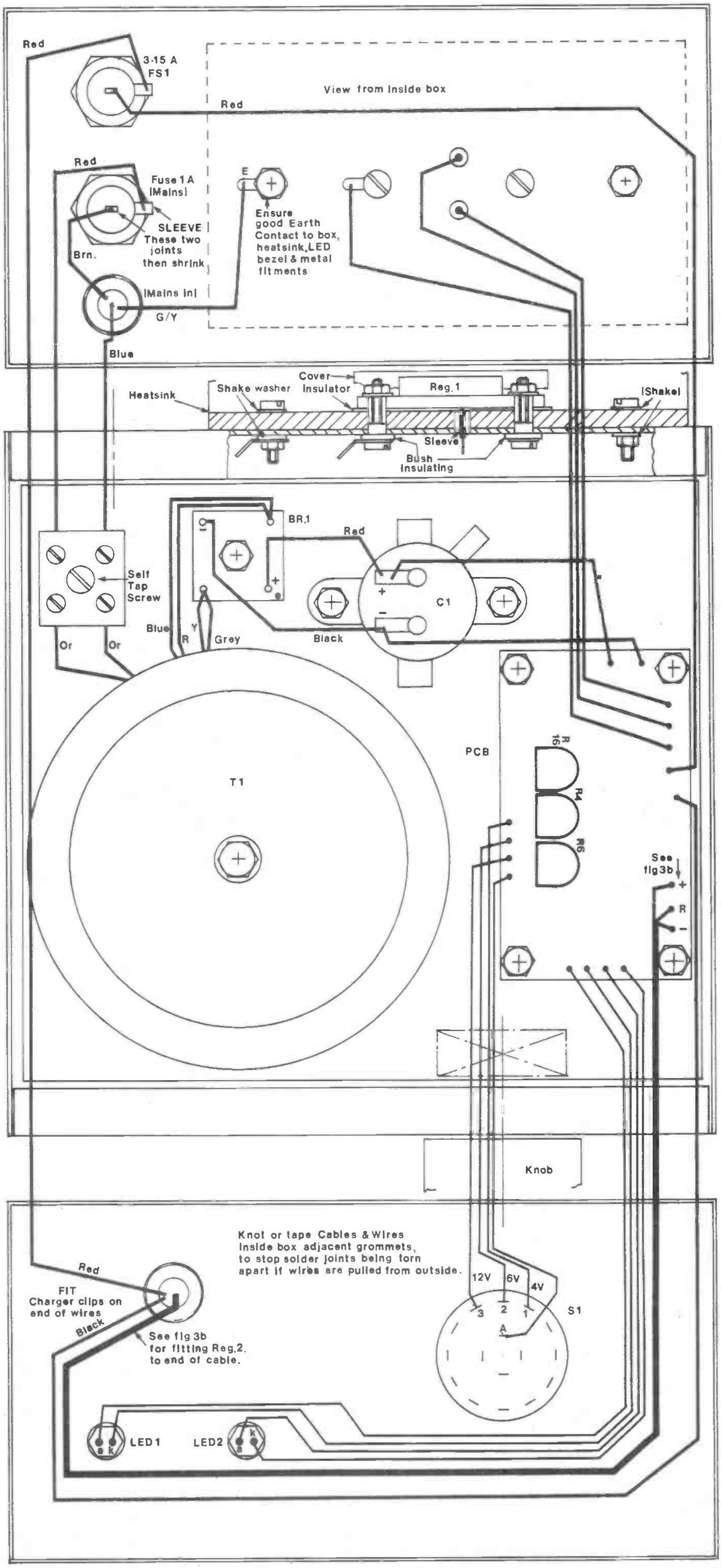



**Figure 3a. Wiring Diagram**

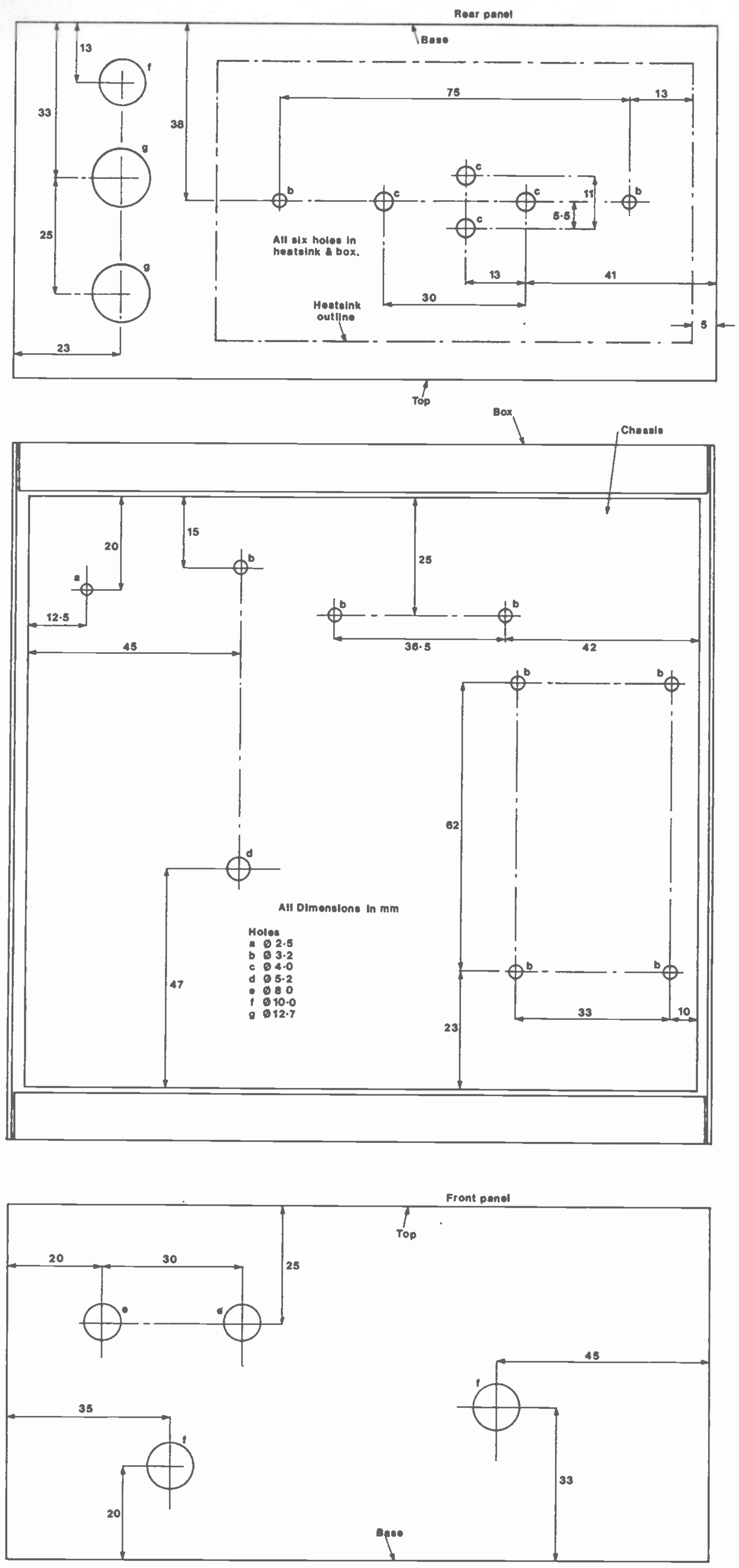
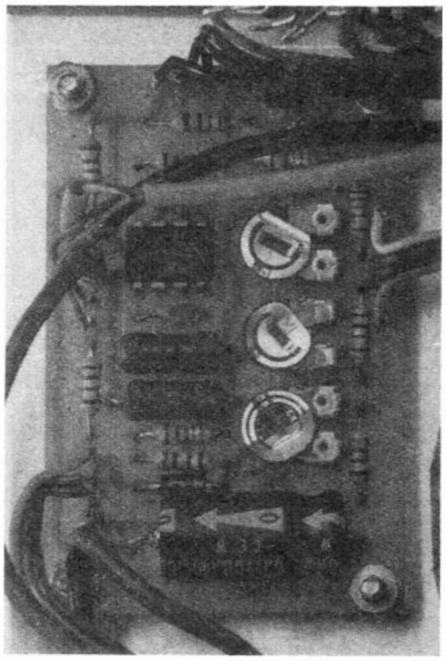



Figure 4. Box Drilling Details



(2.5 Volts/cell @ 25°C) to rapidly bring a discharged battery up to near full charge. The amount of charging current is determined by the amount of charge remaining in the battery and the current limit of the regulator, REG 1. As the battery approaches a fully charged condition, the current begins to decrease. When it drops below a predetermined level (≃180mA) the charger's output voltage drops to a float condition voltage of 2.35 Volts/cell @ 25°C, which maintains the battery in a fully charged condition. This float voltage prevents the battery from becoming overcharged, which can seriously shorten its life.

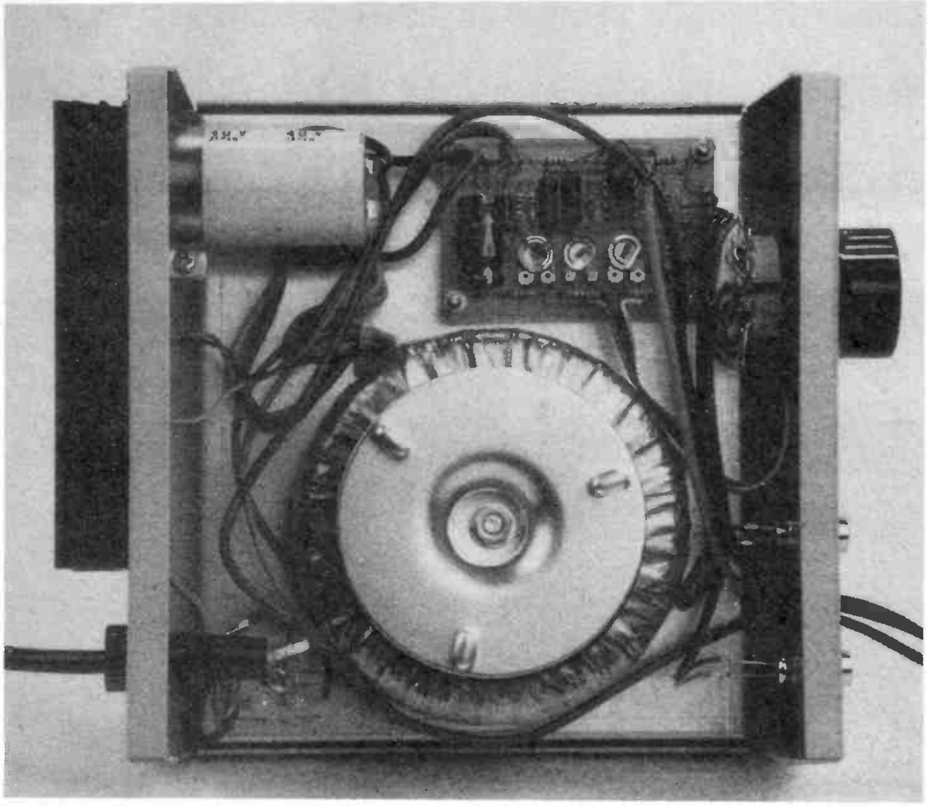
R1/R18 and R2 determine the current level when the charger switches from a charge mode to a float mode, while R8 and R9 set the amount of voltage change. The LED's indicate which mode the charger is in (charge or float). The amount of temperature compensation is controlled by the value of resistor R10.

A unique feature of this charger is that it provides the correct temperature coefficient and the correct amount of charge-mode voltage boost for each cell, regardless of the number of cells being charged.

## Construction

Insert all veropins from the track side of the board (shown in Figure 2), and push them home firmly with a soldering iron. Solder the pins into place. Now insert all resistors and capacitors, noting the polarity of C1, and solder the component leads in place. Insert and solder the IC socket, ensuring that the end notch is at the same end as the white bar on the legend; then TR1, referring to the legend for correct orientation. Plug IC2 into the DIL socket with the notch on the IC aligned with the cutout on the socket, and/or pin 1 (marked with a dot) adjacent to the '1' on the legend. Bolt REG

1 onto the heatsink, using the mounting kit provided. Referring to Figure 3, wire-up the pcb to S1, LED 1 and 2, IC1, and REG 1 respectively, and also the transformer/ rectifier etc. Figure 4 shows drilling details of a suggested case.



## Testing and Use

The accuracy of a digital voltmeter is really required here in order to carry out the following procedure. Apply power to the circuit and connect the digital volt-meter across the output leads. Set S1 to 4V, and adjust R16 for a 4.5V output. Set S1 to 6V, and adjust R4 for a 7.05V output. Set S1 to 12V, and adjust R6 for a 14.1V output. Now connect the output leads to a partially discharged lead-acid battery, first selecting the appropriate voltage setting at S1, and via a multimeter set to read current up to a minimum f.s.d. of 5A. Check the direction of current flow, (if the battery is discharging, you have a problem: re-check your wiring, etc). *Under NO circumstances should the current exceed 5A.*

The red 'charge' LED should be on and should remain on until the charge current falls below ≃180mA, at which point the green 'float' LED should light, indicating that the charge cycle has finished and the charger is in trickle charge mode.

Lastly, if the temperature sensor is held between finger and thumb, the charge current should start to drop, indicating that the temperature compensation is functioning correctly.

NOTE: When using the charger, you should ensure that correct polarity of the battery connections is always observed and that prolonged short circuit of the output leads is avoided. It is also worth bearing in mind that if the mains supply is removed from the charger whilst it is connected to a battery, the battery will commence to slowly discharge through the charger, so always disconnect the battery before switching off at the mains.

## LEAD ACID BATTERY CHARGER PARTS LIST

RESISTORS: All 0.6W 1% Metal Film unless stated

| | | | |
|---|---|---|---|
| R1,18 | 0.22Ω 3W 5% Wirewound | 2 | (W0.22) |
| R2 | 3Ω3 | 1 | (M3R3) |
| R3 | 220Ω | 1 | (M220R) |
| R4 | 1k Hor. S. Min. Preset | 1 | (WR55K) |
| R6 | 2k2 Hor. S. Min. Preset | 1 | WR56L) |
| R7 | 2k7 | 1 | (M2K7) |
| R8,5,11 | 1k5 | 3 | (M1K5) |
| R9 | 100Ω | 1 | (M100R) |
| R10 | 27Ω | 1 | (M27R) |
| R13,14 | 4k7 | 2 | (M4K7) |
| R12,15 | 1k | 2 | (M1K) |
| R16 | 470Ω Hor. S. Min. Preset | 1 | (WR54J) |
| R17 | 560Ω | 1 | (M560R) |

CAPACITORS

| | | | |
|---|---|---|---|
| C1 | 2200μF 63V Can Electrolytic | 1 | (FF22Y) |
| C2 | 100μF 63V Axial Electrolytic | 1 | (FB51F) |
| C3 | 100pF Ceramic | 1 | (WX56L) |

SEMICONDUCTORS

| | | | |
|---|---|---|---|
| TR1 | 2N3906 | 1 | (QR42V) |
| IC1 | LM301A | 1 | (QH36P) |
| REG1 | LM338K | 1 | (RA88V) |
| REG2 | LM334 | 1 | (WQ32K) |
| LED1 | Chrome LED Large Red | 1 | (YY60Q) |
| LED2 | Chrome LED Large Green | 1 | (QY47B) |
| BR1 | PW06 Bridge Rectifier | 1 | (WQ58N) |
| D1 | 1N4001 | 1 | (QL73Q) |

MISCELLANEOUS

| | | | |
|---|---|---|---|
| T1 | Transformer Toroidal 80VA 18V | 1 | (YK17T) |
| | Safuseholder 20 | 2 | (RX96E) |
| FS1 | Fuse 3.15A 20mm Anti-Surge | 1 | (RA11M) |
| FS2 | Fuse 1A 20mm | 1 | (WR03D) |
| | Heatsink 4Y | 1 | (FL41U) |
| | Insulator Kit T03 | 1 | (WR24B) |
| | Transistor Cover | 1 | (FL56L) |
| | Grommet Small | 2 | (RW59P) |
| | Terminal Block 5A | 1 | (HF01B) |
| S1 | Switch Rotary SW3B | 1 | (FF76H) |
| | Blue Case 231 | 1 | (XY44X) |
| | Knob K7C | 1 | (YX03D) |
| | P.C. Board | 1 | (GD13P) |
| | Spacer 6BA x ⅛in. | 1 pkt | (FW33L) |
| | Bolt 6BA x ½in. | 2 pkt | (BF06G) |
| | Nut 6BA | 2 pkt | (BF18U) |
| | Washer 6BA | 1 pkt | (BF22Y) |
| | Tag 6BA | 1 pkt | (BF29G) |
| | Washer Shake 6BA | 1 pkt | (BF26D) |
| | Self Tap No. 6 x ½in. | 1 pkt | (BF67X) |
| | Extra Flex Black | 2 mtrs | (XR40T) |
| | Extra Flex Red | 2 mtrs | (XR44X) |
| | Heat Shrink Sleeving CP48 | 1 mtre | (BF89W) |
| | Ribbon Cable 10-Way | 1 mtre | (XR06G) |
| | Lapped Twin Screened Cable | 2 mtrs | (XR20W) |
| | 3 Core Mains Black | 2 mtrs | (XR01B) |
| | Charger Clip | 2 | (HF26D) |

A complete kit of all parts is available for this project:
**Order As LM01B (Lead Acid Battery Charger) Price £39.95**
The following item in the above kit list is also available separately, but is not shown in the 1986 catalogue:
Lead Acid Battery Charger PCB **Order As GD13P Price £1.75**
A ready built version of this project will be available soon – check future issues for details.

# PROJECT FAULT FINDING

**by Robert Penfold Part 5**

## HOW TO USE YOUR OSCILLOSCOPE TO THE FULL

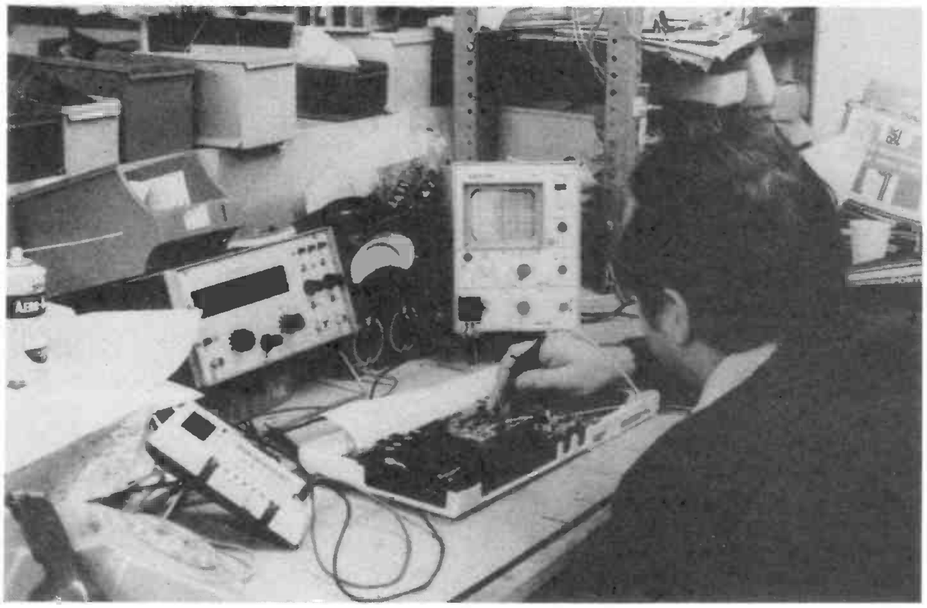
### Oscilloscope Testing

Oscilloscopes tend to be regarded by many (particularly those electronics enthusiasts who do not have access to one) as a sort of panacea for the ills of any faulty piece of electronics. This is perhaps rather a naive view, but an oscilloscope can certainly be an invaluable aid which, when used properly, will help to rapidly locate most types of fault. Apart from enabling waveforms to be displayed, it can also be used for AC voltage measurements, and with a suitably sensitive type it will also function as an AC millivoltmeter.

Measurements must be in the form of peak, or peak-to-peak, readings, rather than the usual r.m.s. value – but for a sinewave test signal simply dividing by 1.414 or 2.82 respectively gives the necessary conversion. Measurements made with a properly calibrated oscilloscope can be much more accurate than many people seem to imagine.

A DC coupled oscilloscope can also function as a high impedance DC voltmeter. Most oscilloscopes have an input impedance of 1 megohm, which is far higher than that of the ordinary multimeter switched to a low DC voltage range. The input impedance can be boosted using a so called X10 probe, and the input impedance is then about 10 megohms. The 'X10' name is not due to the boost in input impedance, but due to the sensitivity (in terms of volts per screen division), being boosted by a factor of ten. This expression is a little misleading, since an increase by a factor of ten (from say, one volt per division to ten volts per division) is obviously a reduction in sensitivity and *not* an increase. These probes are purely passive devices, and apart from giving increased input resistance they also provide reduced input capacitance.

Low input capacitance is important as this factor causes the input impedance of the instrument to fall substantially at high frequencies, giving increased loading on the circuit under investigation. The greater the input capacitance the more



pronounced the fall in high frequency input impedance. Of course, the price that is paid for the boosted input impedance is a reduction in the maximum sensitivity.

It is probably true to say that most oscilloscopes receive more use for making measurements than they do for displaying waveforms, but as we shall see later, it is not only voltage that can be measured.

### Scope Operation

We will not consider voltage testing using an oscilloscope here, since it is essentially the same as testing using a multimeter, as covered in a previous article in this series. We will mainly be concerned with waveform testing in this, the final Project Fault Finding article. Although an oscilloscope provides an easy way of testing most pieces of electronic equipment, the important point which has to be made is that *it does not represent a short cut to fault finding for the novice.* Without a certain amount of technical expertise an oscilloscope is of little or no value as the user would be unable to glean worthwhile information from the displayed waveforms. A certain amount of background information is needed in order to be able to operate an oscilloscope at all, and we will therefore start with some general background information on oscilloscope operation.

In principle an oscilloscope is a fairly simple piece of equipment, and despite the fact that most practical instruments are so packed with extra features that they become highly complex, they all have the same basic features. Figure 1 illustrates the basic make-up of an oscilloscope.

A ramp generator feeds into the X (horizontal) amplifier and sweeps the spot across the face of the CRT (cathode ray tube) at a linear rate. The input signal is coupled to the Y (vertical) input, and provided the sweep speed is suitable, one or more cycles of the input waveforms will be reproduced on the screen. At slow sweep speeds the spot will be clearly visible as such unless the oscilloscope is one of the few types which has a long persistence CRT, but mostly the sweep speed will be quite high. The human eye is then unable to follow the action properly, and the spot appears to be a line across the face of the CRT.

Normally the spot is repeatedly swept across the screen so that a continous display of the input waveform is produced, but for this to work properly the sweep generator must be synchronised to the input signal. Otherwise the trace would not be stable and in most cases would in fact just be a complete blur of lines. The most common way of synchronising the sweep generator is to have each sweep commence at a certain input voltage level. This ensures that the trace always starts at the same point in the waveform, and providing the waveform is of a repetitive and unchanging type, the rest of the trace will also be identical on each sweep.

Most scopes offer a variety of trigger options, with triggering on positive or negative edges of the input signal, and a 'level' control so that the precise trigger point can be adjusted. There are usually other options, such as automatic synchronisation, external synchronisation, and the choice of AC or DC coupling in the synchronisation circuit, but this is something that varies from one instrument to another. For most purposes a basic form of synchronisation is perfectly adequate. A free-running mode is usually provided, which as its name suggests, gives repetitive sweeping regardless of what input signal (if any) is present. Synchronisation is still possible and is needed so that trace 'crawl' can be avoided. Triggered sweep is the more popular type though, as large variations in the input frequency simply result in more or fewer cycles being displayed on the screen. With the free running mode it is unusual for a stable trace to be maintained over more than a very limited frequency range.

Sometimes the waveform to be displayed will be a non-repetitive type, and then the triggered sweep mode must be used. However, with just one sweep across the screen, especially if a very short sweep time is used, an ordinary oscilloscope will only give a fleeting glimpse of the waveform, and possibly a rather dim one at that. Special storage scopes that will hold and display waveforms are available, but are too expensive for most non-professional users to seriously contemplate.

The sweep rate should be adjustable over a very wide range of around 0.2 seconds to 1$\mu$s or less per division – oscilloscope screens are fitted with a 'graticule', a grid of squares engraved or printed onto a perspex 'window' in front of the CRT screen, to assist with accurate measurements, and the main divisions are normally in centimetres, with 1mm or 2mm markings on the X and Y axis.

Two important parameters of an oscilloscope are the sensitivity and the Y bandwidth. For most purposes a sensitivity of 10 or 20mV per division is quite adequate, but most modern oscilloscopes offer sensitivities somewhat better than this, making them that much more versatile. Most instruments of moderate cost offer a bandwidth of about 10 to 20MHz, which may seem very wide,

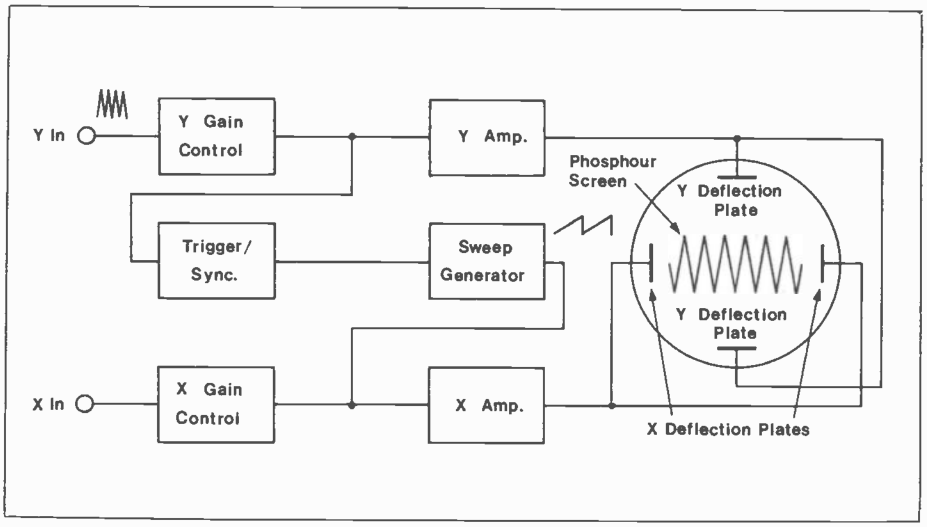



**Figure 1. Basic Oscilloscope**

but it has to be borne in mind that in order to guarantee a reasonably accurate representation of a waveform the Y bandwidth needs to be higher than the fundamental by a factor of around ten times or more. This is because the input signal (assuming it is a repetitive waveform) consists of the fundamental frequency plus harmonics (multiples) of this frequency. It is the particular harmonics present and their relative strengths that determines the waveshape, and if the harmonics are outside the bandwidth of the oscilloscope the reproduced waveform will be a sinewave type, regardless of its true waveshape.

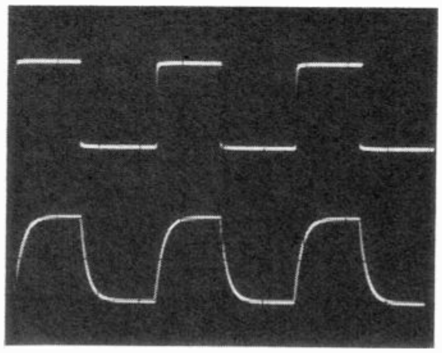


**Figure 2. Inadequate Bandwidth**

The oscilloscope of Figure 2 demonstrates the importance of adequate bandwidth. The two traces are produced from the same squarewave signal, but with one of them the bandwidth has been purposly restricted to a slightly inadequate level and it clearly shows the waveform distortion that results. Of course, for voltage measurement the bandwidth of the scope needs to be no wider than the maximum frequency you will wish to measure. A bandwidth of around 10 to 20Mhz will suffice for most applications, and the cost of wider bandwidth instruments is such that few amateur users could seriously consider using one.

Oscilloscopes almost invariably enable the user to switch out the sweep generator and couple an external signal to the input of the X amplifier. This is a useful feature, as we shall see shortly. Some instruments have a 'Z' input, which is one that enables the brightness of the spot to be modulated externally. This is undoubtedly a useful feature, but far from an essential one.

'Dual Trace' and 'Dual Beam' oscilloscopes are available, and both permit two waveforms to be displayed simultaneously for comparison purposes. A *Dual Trace* oscilloscope is one that has a CRT with only a single electron beam, but has gating circuits controlled by the timebase which alternately select either of two inputs for the Y amplifier. This either operates by very rapidly chopping the beam from one trace to the other, or drawing first one trace then the other on alternate sweeps of the screen. Some oscilloscopes give the option of either type of trace splitting.

In a *Dual Beam* oscilloscope the CRT contains a 'splitter plate' which divides the electron beam in two – the X axis and deflection amplifier are common to both, but there are separate Y amplifiers and deflection electrodes for each. With a dual beam oscilloscope no input gating is required which keeps the amplifiers simple. The dual beam variety is the superior but more expensive type. However, modern dual trace types function very well and are just as good in most applications.

The best type of oscilloscope to obtain obviously depends on the type of equipment you will be dealing with. While bandwidth may be of only secondary importance to someone who will only be dealing with audio gear, it is obviously of greater importance if logic circuits or radio equipment are the main area of interest. Oscilloscopes are quite expensive and available funds are likely to take a bigger hand in deciding which one you buy than are such things as the ideal sensitivity and bandwidth. For most purposes an instrument with a bandwidth of 15MHz or more and a sensitivity of a few millivolts per centimetre or better will suffice. Dual beam or dual trace facilities are probably more useful for circuit designers than they are for general purpose service work, and are unlikely to justify the extra cost unless you intend to design and develop your own circuits. Old secondhand oscilloscopes may not prove to be the bargains that they at first appear to be. Complex valved instruments lack good reliability, and service information and spare parts could well be impossible to obtain. It is much easier to find someone who has bought an old oscilloscope and regretted it than it is to find a satisfied user. It is almost certainly better to pay the additional cost of a new or recent secondhand instrument if at all possible.

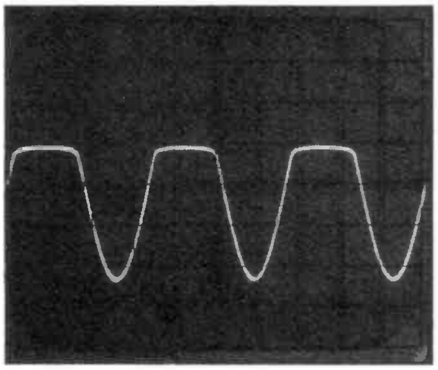


**Figure 3. Clipping**

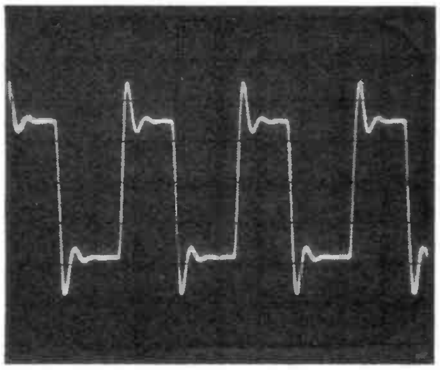


**Figure 5. Ringing Effect**

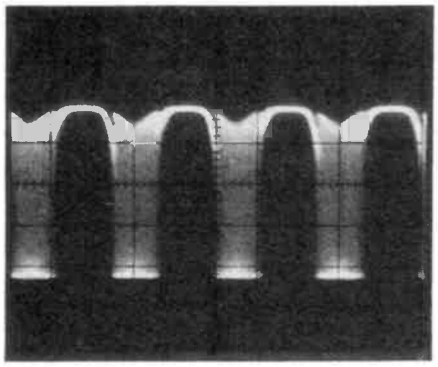


**Figure 4. Instability in an amplifier**

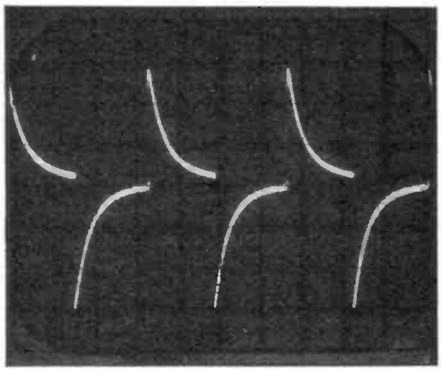


**Figure 6. Extreme Bass Boost**

## Signal Tracing

An oscilloscope is ideal for use as a signal tracer, and although it is used in much the same way as an ordinary signal tracer, it has definate advantages. Probably the most important one is that it enables signals levels to be accurately measured rather than just roughly gauged. Whereas a lack of gain somewhere in the test circuit might be missed when using an ordinary signal tracer, it should be quite apparent when using an oscilloscope. Another important advantage is that it enables waveform distortion to be readily detected. Something like clipping can be detected using a signal tracer, but it is not usually possible to tell which set of half cycles are being clipped, or if both are affected. What sounds like clipping could in fact be some other form of distortion such as high frequency instability. Using an oscilloscope obviously shows quite clearly the nature of the clipping or other distortion, as in Figure 3 where clipping of the positive half cycles is evident. Bear in mind than an excessive input signal level will cause clipping on stages that are functioning perfectly well, and that the input signal needs to be set at a realistic level.

An oscilloscope can also bring to light any imperfections on the waveform that are less obvious when simply listening to the audio output signal. For instance, instability in an amplifier can produce (inaudible) radio frequencies on the output signal, as in Figure 4. This shows the result of a very severe case of instability, and things are sometimes less apparent than this. Squarewave testing is often used with audio equipment, and this just consists of applying a squarewave input signal at a middle audio frequency (around 800Hz to 1KHz) while monitoring the output signal using an oscilloscope. Mild high frequency instability gives the ringing effect present on the waveform of Figure 5.

Irregularities in the frequency response distort the waveform, and apart from being a useful general check on a piece of audio gear, this effect can be used to permit a quick check of tone control operation. The waveforms in Figures 6 to 9 respectively show the effect of extreme bass boost, bass cut, treble boost, and treble cut.

## Phase

What sets oscilloscopes apart from other types of test gear is their extreme versatility. They can be used to measure a wide variety of parameters, including some that could not easily be checked in any other way. Phase measurement is a good example of this. While this is not somthing that needs to be checked very often, it does crop up occasionally (when testing a phase shifter circuit in a phasing effects pedal for instance). With a dual beam or dual trace oscilloscope there is no difficulty in checking the comparitive phasing of two signals, and it is just a matter of displaying them simultaneously and checking the displacement of one relative to the other. If one lags the other by (say) a quarter of a cycle, this represents a 90 degree phase lag (a full cycle passes through 360 degrees – 360/4 = 90 degrees). With a dual tracing oscilloscope it is better to use the 'chopping' mode rather than the 'alternate' one for this type of testing, as the 'chopping' mode can not introduce any slight phase shifts, whereas the 'alternate' mode might do so. Incidentally, the 'alternate' mode is better where optimum trace resolution is required.

Phase can also be measured using a single beam instrument, and quite accurately, but the oscilloscope must have full X input. The two signals are applied to the X and Y inputs, and the gain controls are set up so that the X and Y deflections are approximately equal. Figure 10 shows the trace obtained with zero phase shift. Any deflection horizontally is matched by an equal amount of vertical deflection, giving a trace that is just a line at an angle of about 45 degrees. If one of the inputs signals is inverted to give antiphase inputs the effect is much the same, but while the vertical deflection is positive (above centre) the horizontal deflection is negative (to the left of centre). The line is therefore tilted through 180 degrees (i.e. it extends from the bottom-right corner of the screen to top-left corner). One might expect a 90 degree phase shift to give a vertical line, but with intermediate phase shifts the trace opens out, and at 90 degrees the trace is actually a circle, as shown in Figure 11. This makes it slightly more difficult to judge the degree of phase shift, but it can still be judged quite accurately from the figure's angle of tilt. Incidentally, waveforms produced in this way are termed 'Lissajous Figures'.

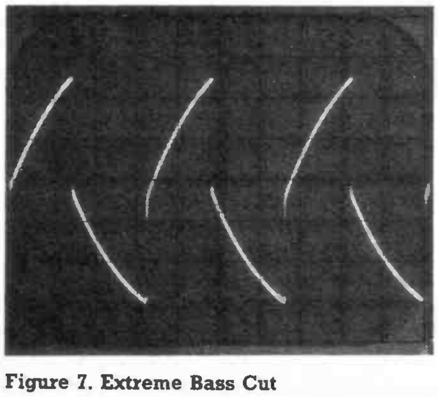


**Figure 7. Extreme Bass Cut**

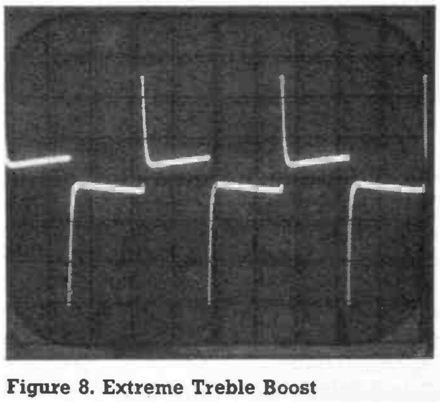


**Figure 8. Extreme Treble Boost**

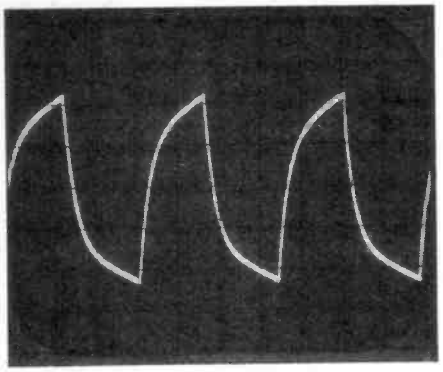


**Figure 9. Extreme Treble Cut**

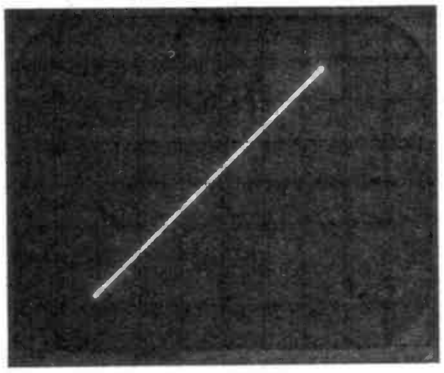


**Figure 10. Zero Phase Shift**

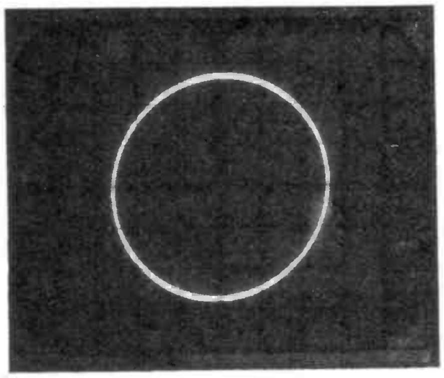


**Figure 11. 90 Degree Phase Shift**

## Frequency Measurement

Lissajous Figures can be used in conjuction with a calibrated signal generator to permit audio frequency measurement, but most oscilloscopes have accurately calibrated sweep speeds, and frequencies over a wide range can be gauged reasonably accurately by measuring the period of one cycle. Use the ordinary triggered sweep mode to avoid any slight shift away from the set sweep speed, and choose a sweep speed which gives only about one or two complete cycles on the screen. The frequency is simply equal to the reciprocal of the sweep time. For example, a cycle time of 2.5ms represents a frequency of 400Hz (1/2.5 = 0.4kHz or 400Hz). Note that measurements in seconds, milliseconds and microseconds give answers in Hertz, kilohertz and megahertz respectively.

This method will not give accuracy to rival a digital frequency meter, but it is more than adequate to check that clock oscillators are functioning properly, that divider chains are operating correctly and so on.

Delay lines can be checked using a dual beam or dual trace instrument simply by feeding an input signal into the delay line and then comparing the delayed and non-delayed signals. Start with a fairly low input frequency and a long sweep time, and then gradually switch to shorter sweep times to permit more accurate measurement of the delay. This avoids errors due to an apparent delay of (say) half a cycle actually being a one and a half cycle delay. With long delay lines it is usually necessary to use a single pulse or tone burst in order to avoid ambiguous results.

It has only been possible to cover some of the more important aspects of oscilloscopes in this acrticle, and they can be used in many other ways. An increasingly common feature these days is a built-in component tester, and this is obviously ideal for use when projects fault finding. Do not overlook the various oscilloscope add-ons that can extend the versatility of an instrument still further, such as the 16 Channel Logic IC Tester unit described in a previous issue of Electronics.

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# A·D·A Conversion Techniques

by Ray Lowe

## Why Are Converters Required?

Digital electronics, computers, etc., represent numerical values in terms of binary coded words. However, very few parameters of interest in the real world allow direct measurement of their magnitude, etc., in terms of such binary words.

The underlying physical principals by which the majority of electrical transducers, e.g. microphones, thermocouples, strain gauges, etc., operate do not lend themselves to directly outputting binary coded values. Usually, a parameter in the real world will be measured in terms of the magnitude of the e.m.f. of current that it produces at the output terminals of the transducer.

Analogue to digital converters are therefore necessary to complete the interface between the physical world and digital electronics in an input sense, and digital to analogue converters are required in an output sense.

The most obvious example of the 'state of the art' in everyday terms is the Compact Disc system which was originally developed by Phillips. Sony now market a range of domestic digital audio recorder adaptors for domestic video machines. Digital multimeters, digital frequency synthesisers etc., all require accurate conversion devices. Many video effects, video 'frame grabbers', etc., have high speed converters as an essential element so that the complex visual effects can be performed by high speed manipulation of digitised picture data.

## Methods of Digital Coding

Different coding methods have been developed, each of which have particular advantages or disadvantages, dependant upon the nature of the signal being coded and the performance/system characteristics imposed by the designer.

The most well-known coding method is Pulse Code Modulation, PCM for short. Others are differential PCM or Delta Modulation. These methods will be considered in turn, however only PCM will be considered in any detail.

## Pulse Code Modulation

In PCM the binary code produced is proportional to the signal amplitude, measured with respect to an arbitrary, but stable, reference voltage which is commonly but not necessarily chosen to be zero volts. Thus, the code directly represents the 'height' of a sample point on the signal waveform, imagining it were displayed on an oscilloscope, see Figure 1. There are many varieties of PCM data converter available. The choice of which to use depends upon design trade-offs and the overall performance that is required in terms of sampling rate or conversion accuracy.

## PCM D/A Converters

Since the majority of A/D converters actually contain an internal D/A converter as an internal circuit element, it will be useful to consider briefly the (simpler) D/A process first.

At the heart of all conventional D/A converters is a network of precision

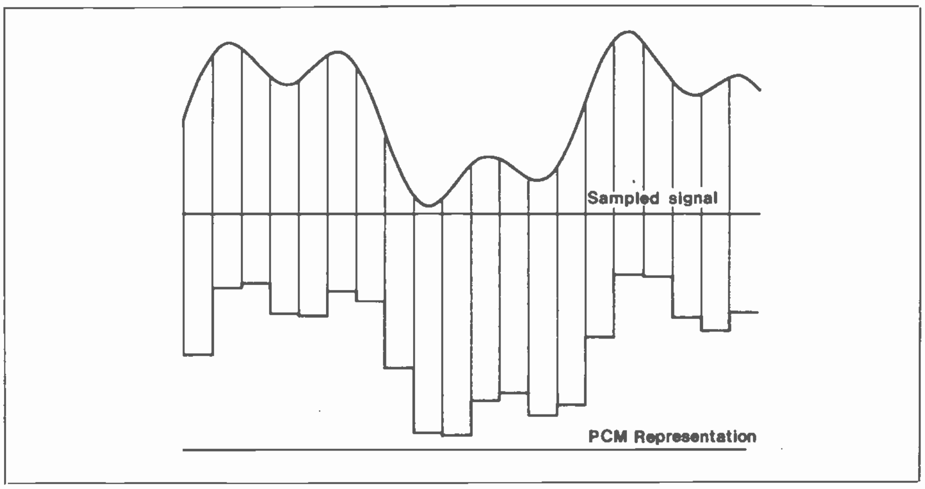



**Figure 1. PCM Representation**

current sources and a set of switches which allow current to be tapped off from the network at points dependent upon the binary input code to the converter. In addition there may be signal conditioning output circuitry such as an amplifier to scale the output signal and to adjust offset etc., in accordance with the users requirements. Precision resistors must be fabricated on chip in order to realise the set of current sources; whose currents increase along the chain by powers of two. The switches, when turned on by a binary 'one' at their respective point in the input code, connect their respective current source to a common summing node which may be an output pin. Thus the most basic converter will have a current output which is proportional to the input binary code. By resistively loading the current output and buffering the resultant voltage, a voltage output DAC (D/A converter) is produced, see Figure 2. There are a large variety of DACs available with widely varying performance in terms of accuracy, thermal stability or 'tempco', and settling time for the output etc.

## PCM A/D Converters

**Ramp Type Converters**

There are several sub-species of this type. The simplest uses a linear ramp generator i.e. a stable current source charging a low leakage capacitor, a stable oscillator driving a binary counter, and a comparator. Upon receipt of a 'Convert' command, capacitor charging and counting operations commence from zero. The comparator decides when capacitor voltage *and* the input signal voltage being sampled are equal. This decision latches the current binary count into the converters' output register.

Sub-species two is a Multiple Slope Ramp Converter. In this type the final approach to equality is slowed down, thus ensuring a more accurate conversion for the least significant bits, see Figure 3. Slight variations occur as to how the ramp is generated. Some converters use a pulsed charge in synchronisation with the counter rather than a current source to charge the capacitor. Some incorporate built-in correction for zero input integration error, i.e. the offset between what the comparator 'sees' as zero, and a true external zero voltage point; this is done by actually setting the input to external zero, and then performing a conversion. This error 'count' is subtracted from the result of any conversion digitally before the data is made available.

**Successive Approximation Type Converters**

The successive approximation method sets the output code bits in sequence, starting with the MSB and finishing with the LSB. Upon receipt of a 'Start Conversion' signal, all bits are set initially to zero. These bits, as well as being buffered internally and being made available at IC pins to represent

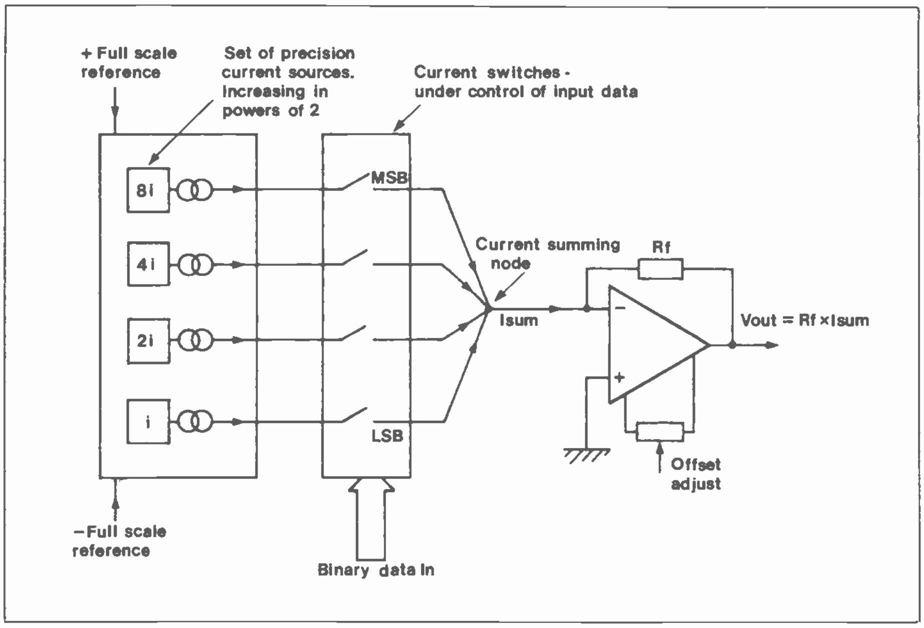



**Figure 2. Basic D/A Converter**

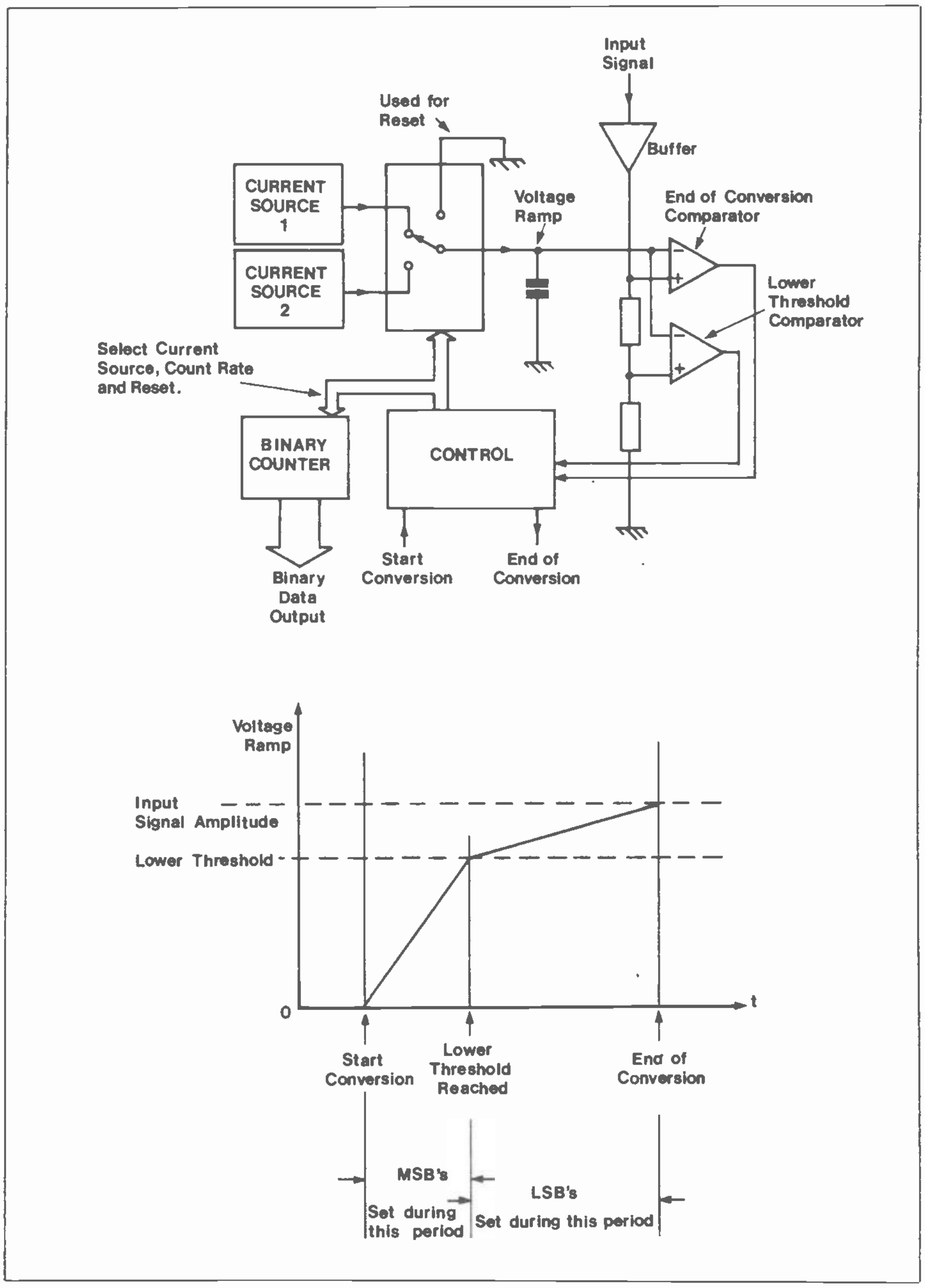



**Figure 3. Basic Dual Slope Converter**

the output code, also drive an internal D/A converter. This converter, in turn, drives one input of an internal voltage comparator; the other input being driven by the sampled signal. Obviously, this converter must have sufficient resolution to match the required A/D resolution, or number of 'bits'. Initially, all bits are reset i.e. at receipt of a 'Start Conversion' command. During the first external (or internal for some chips or hybrid converters) clock period, which we shall call the 'MSB period', the MSB is set to one (e.g. 128 in binary for an 8-bit resolution converter); the comparator output now shows whether the sampled signal is above or below this half full-scale reference, where fullscale is the voltage corresponding to all bits set to one (e.g. 255 for 8-bits).

If the comparator output is zero, then we know that the input signal lies *below* half full scale. It is the comparator output which is saved as the bit concerned (MSB in this case).

During the second, MSB−1, period, the MSB−1 bit is set (with the MSB now *remaining* in the state dictated by the comparator output during the 'MSB period'). The D/A output is once again compared with the input signal, and then the MSB−1 bit is saved to correspond with the comparator output during this, MSB−1, clock period. This comparison and bit setting procedure is repeated for all the following bits, until the LSB checking 'period' is done and then the conversion is complete, and an 'End of Conversion' pin goes active to make this known.

Some converter chips make the comparator output accessible, which is useful if the data is to be saved in serial fashion. The serial 'frame' will commence with the MSB, and finish with the LSB. Figure 4 illustrates the successive technique.

**Tracking Type Converters**

The tracking converter is, in some respects, similar to the ramp converter. However, instead of the count representing an integration time for a current source to generate a voltage ramp; here, the counter drives a D/A directly. Instead of the ramp count starting from zero for each conversion cycle, the counter involved in this 'type' is an up/down counter whose count is controlled directly by a comparator according to whether the signal being sampled has a greater or smaller instantaneous amplitude than the output of the A/D's own internal D/A. The internal D/A is driven by the counter. This type of converter can operate in a free running or 'tracking' mode, whereby the count is continuously being adjusted to keep track with the changing input signal. Obviously, there will be a maximum rate of change of the input signal above which the counter will not be able to keep track fast enough to maintain resolution down to the LSB. Therefore, a trade-off exists between resolution and input signal 'slew rate' once a critical rate has been exceeded.

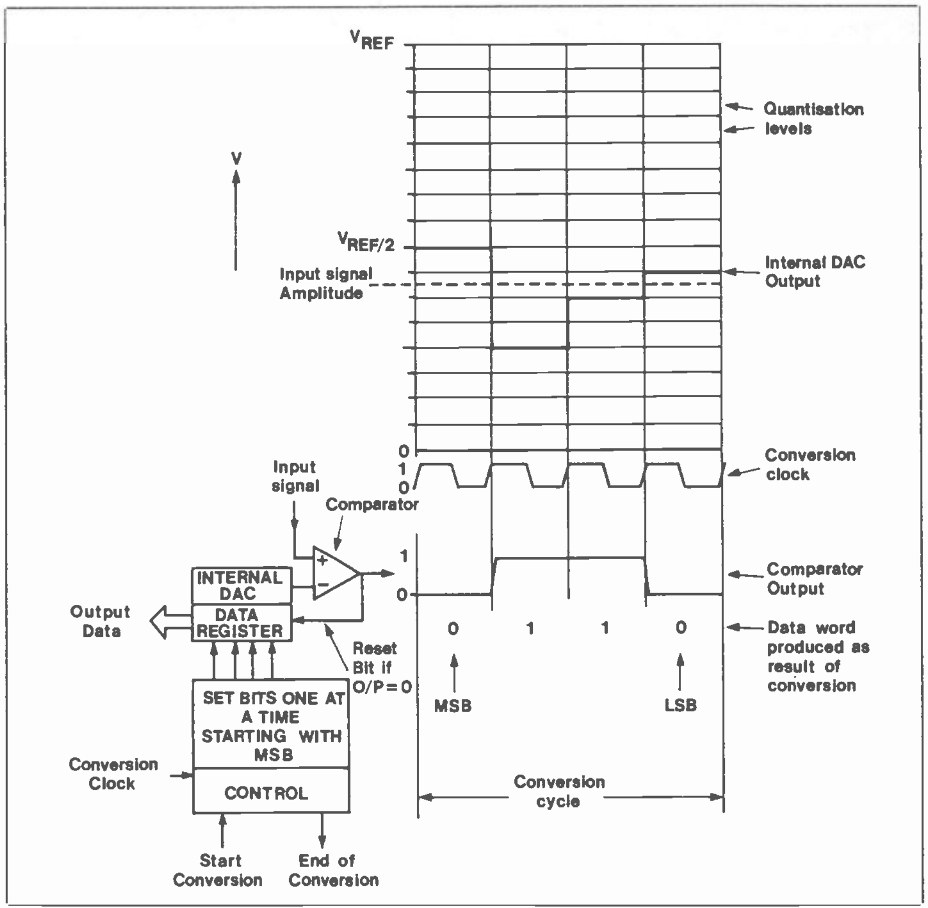



**Figure 4. Successive Approximation ADC**

**Flash Converters**

As befits its name, the conversion time for a flash converter merely depends upon propagation times through the internal circuitry, and hence conversion times are very short, of the order of a hundred nanoseconds being possible. The essentially simple concept employed is that each quantisation level (2**N for an N bit converter) has a dedicated comparator e.g. an 8 bit converter requires 256 comparators (matches in terms of drift, etc.) see Figure 5. The output from the comparators is in the form of a 'thermometer' or 'pulse height' representation if looked at in parallel. These comparator output lines then drive a priority encoder to produce a conventional binary output word.

**Half Flash Converters**

These are a compromise between

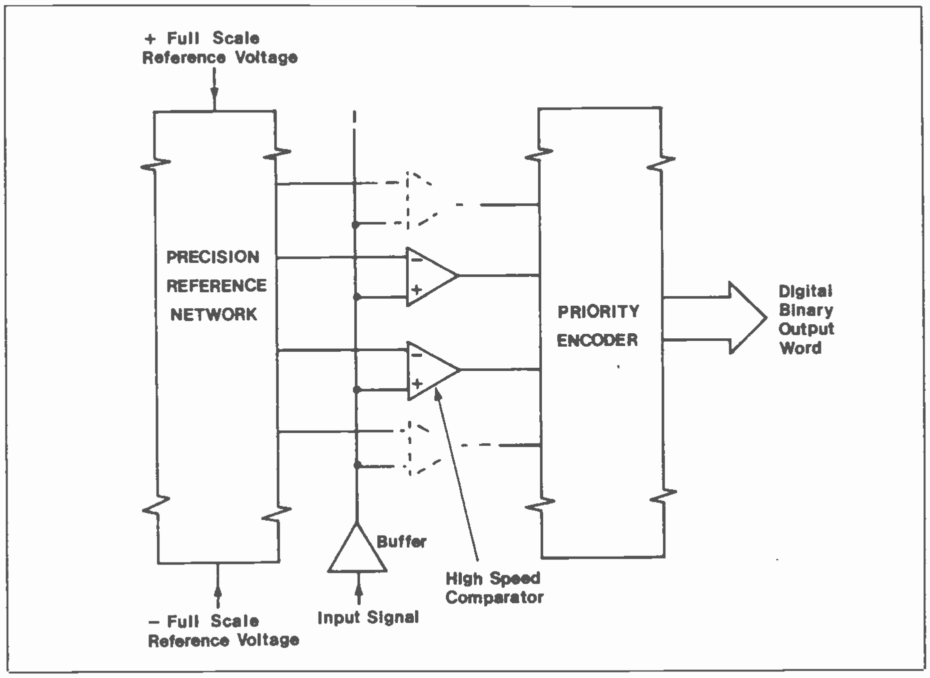



**Figure 5. Basic 'Flash' Converter**

the speed of full flash conversion, and the relative ease of fabrication of successive approximation converters in that the most significant bits are flash encoded first, then the residue error is found by subtracting the present result (i.e. feeding a D/A with the MSB's only) from the input signal. The residue error is accurately amplified to scale it correctly, and then it is flash converted with the same flash conversion circuit as used before. The result of this conversion is the LSB's which are combined with the previously coded MSB's to produce the complete binary output word.

**Serial Type Converters**

These are a compromise between the simplicity of a successive approximation type converter and the conversion speed of a flash converter. In this type, the successive technique is applied in a 'ripple through' fashion. A comparator; the 'MSB comparator', decides whether the input signal is above or below zero (full scale/$2^1$). The result sets the MSB output accordingly. If above, then (full scale/$2^1$) is subtracted from the input signal before it feeds the 'MSB-1 comparator'. The MSB-1 stage decides whether this remainder is above or below (full scale/$2^2$), and the MSB−1 bit is set accordingly. The process continues i.e. feeding the next stage with the remainder from the present stage, until the function has rippled through and set all bits.

## Coding

Upon commencing a design for a converter it must be established at an early stage what resolution is required in terms of the number of quantisation levels to be used in representing the sampled signal. This choice is based on many factors, and can greatly influence the complexity and cost of the overall design. The number of quantisation levels available with an N-bit converter will be 2**N. See Figure 6.

Another decision must be made; on the coding format desired of the digital data words. Where the converter is used for positive going signals, it is normal to use straightforward binary words, where all bits=0 corresponds to minus full scale, i.e. 0V, and all bits=1 corresponds to full scale. Where the converter is used in bipolar mode, i.e. for signals that vary about 0V, there are several possibilities for the data format. Bipolar codes are codes which give *polarity* information.

Several possibilities exist: *Offset Binary* is normal binary except that all bits=0 corresponds to minus full scale, which in this case is a negative voltage, and all bits=1 corresponds to plus full scale. In *Sign Magnitude* the MSB conveys the polarity of the sample, the remaining bits giving the magnitude of 'height' of the sample. *One's complement* and *two's complement* are other codes particularly useful if arithmetic operations are to be performed on the data. In choosing a bipolar code format, it is useful to consider the conversion process itself. For example, if using *Offset Binary* to represent a small amplitude signal swinging about 0V, the data will contain many sequences where all the bits change polarity, for example 0111 1111 (127) to 1000 0000 (128) as the signal goes – to + through 0V. Basically, everytime a bit changes, a 'dynamic' error voltage or current will be produced by a D/A converter using this code. This is due to internal component tolerances, supply loading etc. Hence, it is advisable to limit the number of 'simultaneous' bit transitions that can occur to the minimum possible, preferably to that in the region of the resolution required, especially at the zero crossing point. This is particularly important for the handling of low level signals as considered above, otherwise noise problems will be the result of having 7 bits changing state at once. By using *Sign Magnitude* representation, the number of bit transitions is minimised for low level signals and hence the converters' 'transfer characteristic' will show little error (non-linearity) over this critical region (say, in the case of audio signals).

To take advantage of this, a Sign Magnitude compatible D/A converter must obviously be used where the 'sign bit' decides whether the basic D/A is to be followed by an inverting or non-inverting output stage.

| Converter Resolution (bits) | Converter Input voltage Range 20V | 10V | 5V |
|---|---|---|---|
| 8 | 39.06mV | 19.53mV | 9.77mV |
| 10 | 9.77mV | 4.88mV | 2.44mV |
| 12 | 2.44mV | 1.22mV | 610μV |
| 14 | 610μV | 305μV | 153μV |
| 16 | 153μV | 76μV | 38μV |

Voltage resolution for ½ LSB, equivalent to ½ a quantisation step.

**Figure 6. Converter Resolution**

## Some Unusual Implementations

**Companding Converters**

Up to now only linear quantising converters have been considered. The Signal/Noise ratio for a linear converter is approximately 6*N dB where N is the number of data bits per data word. Thus, a straightforward 8 bit system has a theoretical 48dB and a sixteen bit system a (very large) 96dB theoretical S/N ratio. However, due to the fact that converter costs escalate rapidly with an increase in the number of bits, it is preferable to minimise the number of bits per data word where possible. Note also that data words have to be stored or transmitted usually, which also points to reducing the number of bits where possible. The 'noise' referred to is called quantisation noise. See Figure 7. Since for a number of applications, noise is only objectional where dealing with low level signals, it would be satisfactory if the amplitude of the noise component were to be in some way proportional to the signal amplitude. That is, providing that the S/N ratio was always kept below the objectionable value, and if there were overall benefits in doing this. By making the quantisation or 'transfer characteristic' of a converter non-linear, i.e. dependant upon signal amplitude, it is possible to increase a converters' dynamic range. Note that although the dynamic range is increased the max S/N ratio is not, because (quantisation) noise is now also dependant upon signal amplitude, see Figure 8. This type of converter is known as a CODEC or A-Law converter, and is widely used in telecommunications to significantly reduce data handling requirements; because a given noise performance over a range of signal levels can be obtained with fewer data bits. Due to the subjective nature of aural noise, this system is suitable for use in musical applications e.g. delay lines etc., except in some cases: When a very

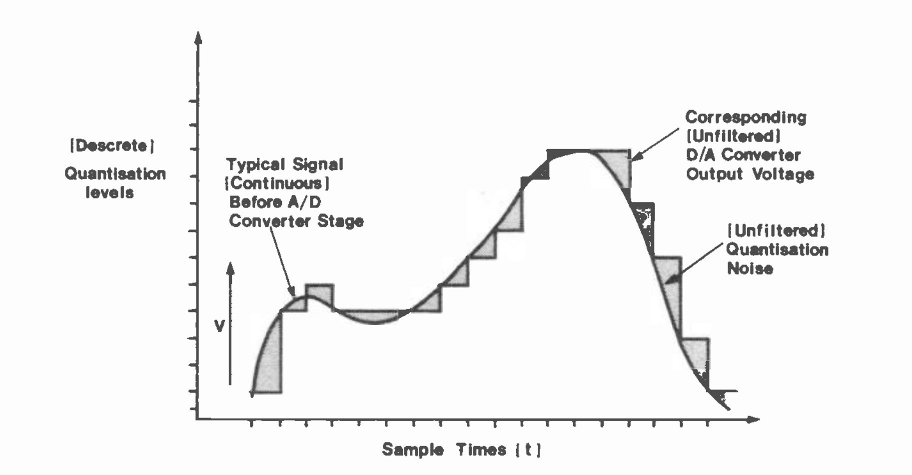



**Figure 7. Production of Quantisation Noise as a result of A/D Conversion**

low frequency signal (below 20Hz) is companded the changes in quantisation noise may become distinctly audible whereas the signal itself is not!

**Ratiometric Operation**

A/D (and D/A) converters must have references provided to determine those voltages corresponding to all output (input) data bits=0 i.e. minus full scale; and all bits=1 i.e. plus full scale. Normally the lower reference point is fixed, say at analogue ground. The higher reference point however may be variable and provided externally over some acceptable range. By using a variable reference the converter can generate 'ratiometric' data i.e. of one voltage – the input signal sample voltage – as a ratio of the reference voltage.

**Differential PCM**

In PCM absolute signal 'height' data is produced. However, there is a certain amount of redundancy in this data, depending upon the nature of the signal being sampled. Differential PCM data records only the changes in pulse height as binary words.

**Delta Modulation**

Is based upon differential PCM, however, in this case the data is simply a series of 0's and 1's which give only the direction of change of the signal i.e. increase or decrease of voltage. To obtain reasonable reproduction with this system, the sampling rate must be very high. There are modulation methods in the 'middle ground' between Differential PCM and Delta Modulation where an indication is given of the rate of change as well as the direction.

## Comparing PCM A/D Converter Types

In summary, a wide range of PCM encoding techniques exist; amongst these are Ramp, Successive Approximation, Tracking, Flash, Half-Flash, and Serial type converters. Which to choose?

The choice of which type or technique to utilise is usually based on obtaining a satisfactory level of performance in terms of sampling rate, conversion accuracy, and maybe in some cases, factors such as power consumption etc., for the minimum cost. Due to the large number of variables involved, it can be very time consuming to make the 'perfect' choice, bearing in mind that new products are appearing regularly and, in general, prices are falling. However, distinct advantages and weaknesses are apparent with certain techniques that point the designer in the right direction. That is, it is a case of swings and roundabouts, and to obtain the best of both worlds will always cost more. If conversion speed is a foremost requirement, say for a video 'frame grabber', then it is almost certain that a flash technique will be required. For sampling lower frequency signals, successive approximation and tracking converters become the ideal choice. Where absolute accuracy is important, it is multiple slope converters with built-in error correction that have the edge; at the expense of conversion speed. The cost/performance ratio can escalate quite rapidly as state of the art demands are made. A sixteen bit successive approximation A/D converter of good accuracy, intended for audio applications can cost several hundred pounds. A similar quality twelve bit converter can be obtained for tens of pounds. An eight bit device costs well under ten pounds.

When choosing a converter care must be taken to assess the accuracy and stability of the device. All converters suffer from some non-linearity. What this means is that a voltage that a converter equates with the digital code 0100, say, will not be exactly eight times the voltage (as would be expected) that the same converter equates with the code 0001. This is due to component mismatching inside the chip. The situation is further complicated by the fact that internal component values change with temperature and time at slightly differing rates. This may, for example, be due to temperature gradients in the chip as a result of the microcircuit layout. Thus the transfer characteristic at 25°C may be quite different to that at 50°C, or at 25°C two years later. The change of characteristics with temperature and time is referred to as the 'tempco' of the device.

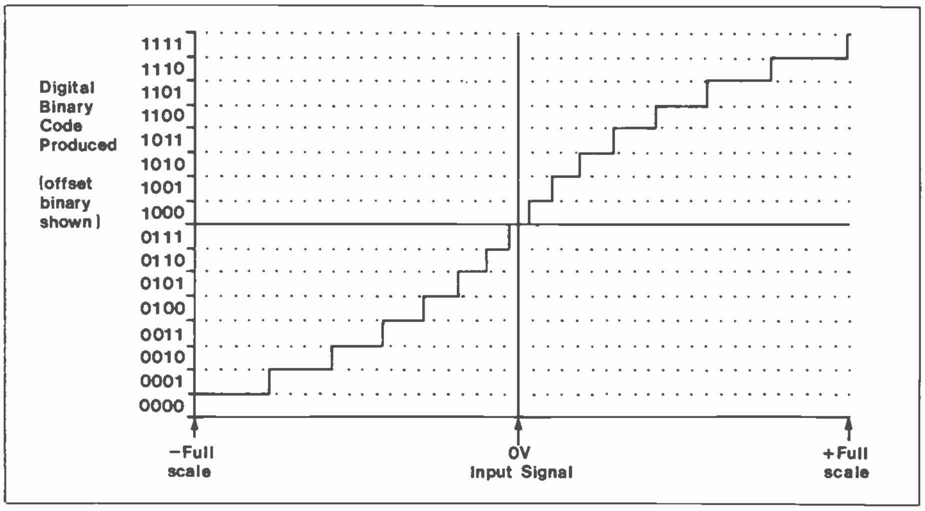



**Figure 8. Transfer Characteristic of Log Converter**

## Practical Considerations

**Sample/Hold Amplifiers**

An important subject in relation to A/D conversion, not yet considered is the use of sample/hold (amplifiers). It is obvious that whilst an A/D conversion is in progress it would be silly to change the amplitude of the input signal – unless it changes only by an amount which is much less than the resolution of the converter. This would give a corrupted data word. When digitally sampling any normal signal therefore, it is important to 'freeze' the current signal amplitude so that a stable signal level is maintained throughout the conversion cycle. See Figure 1. This technique is known as sample/hold and requires careful consideration, especially when converting to greater than, say, twelve bits resolution since any noise fluctuations or drift of the signal level during a conversion will render the (expensively obtained) A/D converters' resolution useless. It is relatively easy to implement a S/H for converters of up to 12 bits accuracy, see Figure 9. There are many S/H chips and modules available.

Beyond twelve bits, it becomes increasingly difficult and expensive and can be an exceptionally tiresome exercise to maintain sixteen bits resolution. The main performance criteria for S/Hs are 'acquisition time' and 'droop rate', which are parameters

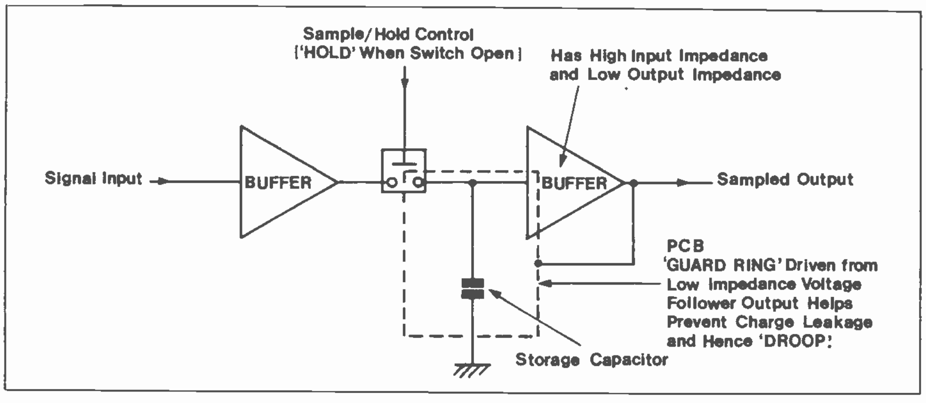



**Figure 9. Sample/Hold Scheme**

expressing behaviour before and after hold mode is initiated respectively, and are fairly self-explanatory bearing in mind that voltage is stored on a capacitor which must have a finite, however small, load attached. In audio applications however, it has been found that it makes a subjective improvement to a digital recording for example if a very slight amount of white noise is added (or not eliminated! – as the case may be). The reason for this is that for extremely low signal levels, the correlation between quantisation noise and signal becomes more subjectively annoying without the addition of this so called 'dither'; white noise is more aurally pleasing!

**Aliasing**

A well-known but very important area for consideration is aliasing and how to avoid it. There is a well known mathematical proof (Nyquists' theorem, otherwise known as the 'Sampling Theorem') which proves that: To fully reconstruct a signal from a set of sample points, the samples must be taken at a frequency which is greater than twice the frequency of any component of the original signal. Failure to comply with this criteria will result in a nasty phenomenon called aliasing – which is nothing to do with little green men from Outer Space!

See Figure 10. In audio terms, this form of distortion sounds like gurgling. The bottom line is that, assuming an upper limit on sampling frequency of S Hz; the sampled signal must be bandwidth limited to have no significant components above S/2 Hz. In practical terms, this means low pass filtering the signal before it can be sampled. The name given to a filter used for this purpose is an anti-alias filter. The roll-off of the filter to be used depends upon performance requirements and how much of the potentially available bandwidth one wishes to use. Using the example above, to maintain a useful bandwidth of S/2 Hz would require the use of a 'brick wall' or infinite cut-off filter. Of course, such filters cannot be realised in practice. If one were happy to lose some bandwidth, then a much simpler filter could be used, see Figure 11.

If the sampling frequency must be variable, then tracking filters may be considered. A particularly useful form of tracking filter for some digital applications is the Switched Capacitor Filter, since cut-off frequency is proportional to an externally applied clock signal. In many cases care must be exercised to minimise phase distortion of the signal by careful choice of filter type i.e. Butterworth or Chebychev etc. Absolute phase is not critical in subjective terms for audio signals, however, if various comb filtering effects are to be realised by mixing delayed and undelayed signal paths, then phase control becomes important.

**Equalisation**

In making the most of what you've got terms; a useful technique sometimes employed is the use of pre-emphasis before a signal is encoded, accompanied by de-emphasis after decoding (to maintain the original signal content). Pre-emphasis is simply filtering in reverse i.e. selective boosting of some frequency ranges over others. The idea is to enhance the amplitude of minor frequency components of a complex signal such that they suffer less from the degrading effects of quantisation distortion when the signal is coded. Typical musical signals are a case in point. De-emphasis is used after the D/A end of the digital chain to restore the original spectral balance.

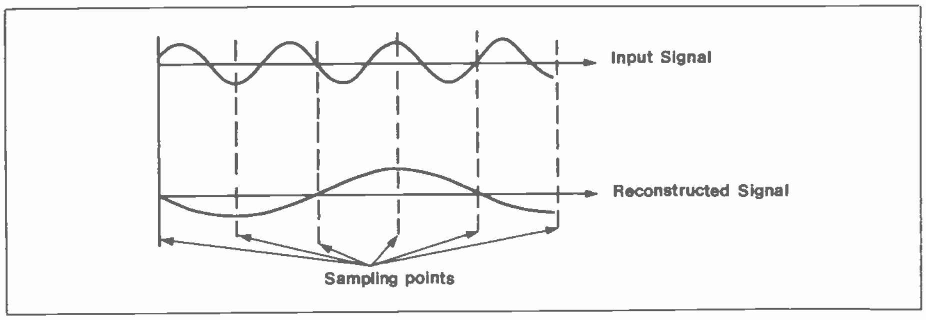



**Figure 10. Too Low a Sampling Rate leads to reconstruction of a different 'Alias' Frequency**

## Glitches

Imagine feeding the input of a DAC with a binary counter in order to generate a staircase type waveform. The number of data bits involved in each code change establishes 'major' and 'minor' transitions. The most major transition being at half full scale, where the input code changes from 0111 to 1000 (assuming four bit offset binary coding). If digital inputs are faster to switch off than on, as they can be, then for a short time the DAC will seek zero output followed by settling back at one LSB above the previous reading. Thus a large transient spike voltage can be generated which is known as a glitch. Because glitch size is not linearly related to the input code, linear filtering may in fact worsen rather than improve the faithfullness of the output signal. A solution to this problem is the use of a 'deglitcher' circuit, surprisingly enough! A deglitcher 'sample/holds' the DAC output until it has settled properly to its new value.

**D/A Filters**

The ramp-like signal from a D/A output has many frequency components outside the band of interest (defined by the anti-aliasing filtering). As they stand, the sharp corners of the samples in the output stream can be considered quite harmless in many cases, including audio – since the frequency components defining them are outside the band of interest. However, problems can arise if any following circuitry shows non-linearity over their range since in-band intermodulation products could be formed. Hence it is normal to include efficient low pass filters straight after the D/A stage to remove any higher order components; thereby rounding the edges. This will reconstruct the original waveform. Once again, attention may have to be paid to phase.

**Grounding**

When implementing a design on a PCB, special attention must be paid to grounding and layout. Some A/D converter chips provide two ground pins; one labelled analogue, the other digital. The reason for separation is to help prevent relatively heavy digital ground current spikes from upsetting the operation of the analogue circuitry on the chip. Providing that a stable and substantial Earth connection is available near the chip, possibly a ground plane, these two pins can be connected to the same PCB 'track'. Otherwise they should be separately tracked to a distant reliable Earth point. Care should be taken with shielding and Earthing arrangements for S/H devices, as these are particularly sensitive to interference. It is when dealing with resolutions in excess of 12 bits that things become a bit of a headache!

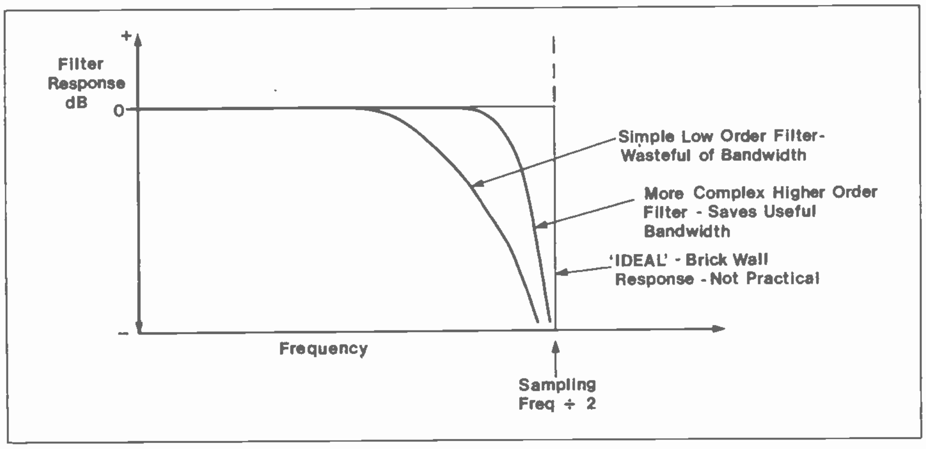
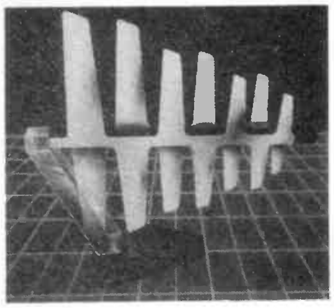



**Figure 11. Anti-Alias Filter Response Versus Useful Bandwidth**

# NEW PRODUCTS

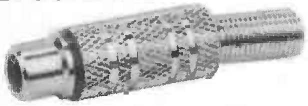


### Multi-Element Hi-Tech TV Aerial

A smart, lightweight UHF TV aerial for indoor use. The aerial features two parallel, staggered 7-element arrays of matt finished aluminium, connected to either side of a 75Ω coaxial feeder and mounted on a square section plastic support. The unusual 'log periodic' design offers up to 7dB of gain at ±760MHz, and a minimum 6dB at 470MHz. Covers all UHF broadcast TV channels from 21 to 68. The aerial comes in three parts, a triangular base for a plug-in support, and the aerial itself which is normally mounted horizontally but can be inserted vertically to help exclude unwanted strong transmitters. Safety isolated to BS5373. Fitted with 1 metre of coaxial cable terminated with a UHF plug.

*Order As*
*YM56L (Hi-Tech TV Aerial)*
*Price £10.95*

### Gold Plated Phono Line Socket



A very high quality screened phono line socket having a gold plated body in addition to gold plated contact surfaces for ultimate contact reliability. Matches our gold plated screened phono plug FK18U. Fitted with coil spring strain relief sleeve.

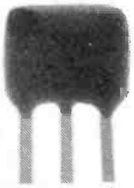
*Order As*
*FA93B (Gold Phono Line Skt)*
*Price 65p*

### Jack Socket Adaptor

An adaptor which enables a stereo 3.5mm jack plug to be used with a stereo 2.5mm jack socket.

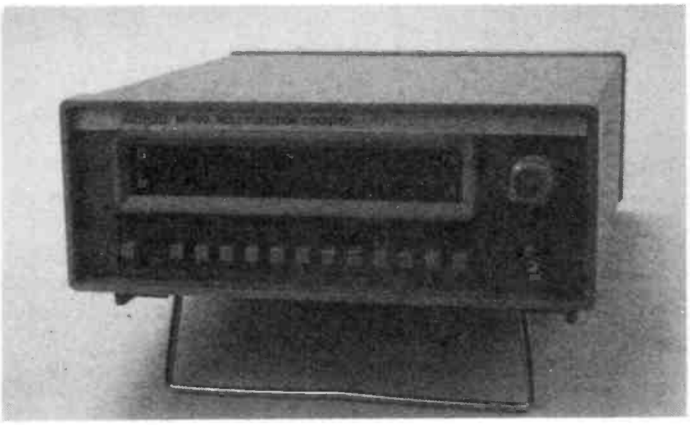
*Order As*
*FA94C (Adaptor W)* *Price 95p*

### Narrow Band 10.7MHz Ceramic Filter



A ceramic filter with a centre operating frequency of 10.7MHz, and an especially narrow bandwidth of 50kHz. Input and output impedance is 330Ω. Breakdown voltage 50V DC. Dimensions; width 8mm x height 7mm x 3mm thick. Pin spacing 2.5mm.

*Order As*
*UF71N (Cer. Fltr 10.7MHz/50kHz)*
*Price 95p*



### Precision Gold Multi-Function Frequency Counter MF100

A 10Hz to 100MHz multiple-function frequency counter with an eight digit, high brightness seven segment LED display. There are four ranges offering resolutions of 0.1Hz or 100Hz from 10Hz to 9.9999999MHz, or if the divide by ten prescaler is selected, 1Hz to 1kHz switchable resolution from 10MHz to 99.999999MHz. This is achieved by altering the gate sampling time. The accuracy is ±1 count ±time base error x the frequency, where the timebase oscillator is maintained at constant temperature in an 'oven' to produce 10MHz $\pm 1 \times 10^{-6}$ from 0°C to 40°C. Pulse period time measurements are also possible in the period mode. The input range is 10Hz to 2.5MHz, and the counter will read out the positive going pulse width time in seconds to a resolution of $100ns/F_{IN}$.

In the totaliser mode the instrument becomes an event counter and increments the display by one unit for each positive going input pulse, in the range 10Hz to 10MHz.

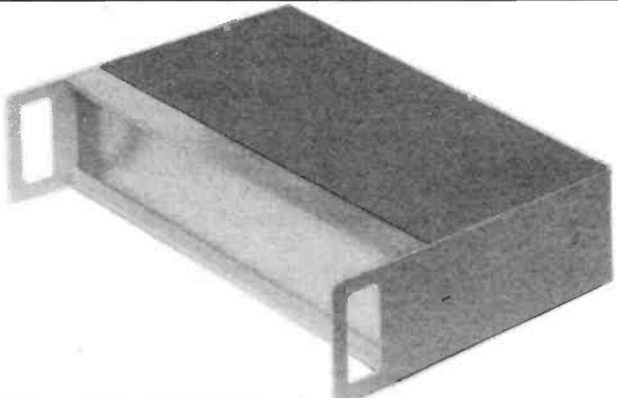
Input impedance is 1MΩ via front panel BNC socket. Input sensitivity is 25mV r.m.s. (sine) or 70mV pk–pk; a divide by 20 attenuator is included. Trigger level is continuously variable by ±350mV (x attenuator). The display includes decimal point, overflow, kHz and μs indication. Other facilities include HOLD to freeze the display, RESET, sampling gate open indicator, and check/display internal time base clock.

Supply input: 115/230V ±15% AC, 45 – 70Hz.

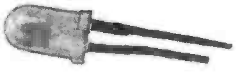
Dimensions; Width 205mm, Height 76mm, Depth 267mm.

Bench tilt stand included.

*Order As*
*YJ82D (MF100 Freq Counter)*
*Price £89.95*



### Miniature Ultra-Bright LED



An ultra-bright red LED having a 3mm diameter translucent package. All specifications as 5mm ultra-bright LED QY84F except: Light output is typically 45mcd at 20mA, with a viewing angle of 90°. Cathode is denoted by a flat on the package and the shorter of the two leads.

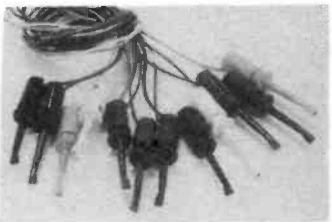
*Order As*
*UF72P (Ultr-Bright Red LED Miniature)* *Price 54p*

### NM2 Instrument Case with Handles

A multi-part instrument case to be added our NM range of cases in the boxes section of the 1986 catalogue. It is identical to type NM2 currently in that range, but has handles formed into the side plates, as have types NM6H and NM7H.

Width 300mm, Depth 150mm, Height 90mm.

*Order As*
*YM51F (Instrument Case NM2H)*
*Price £14.95*

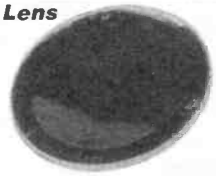


### Miniature Clip Probes Set

A pack of six test leads terminated at each end with small clip probes which can be hooked onto IC or transistor pin-outs where the use of a small crocodile clip is impossible. The test leads are 41cm long and colour coded Black, Red, Yellow, Green, Blue and White.

*Order As*
*FA96E (Min Clip Probe Set)*
*Price £2.95*

### Plastic Lens



A cost effective, simple plastic lens for opto-electronic applications. The lens proper is 30mm diameter but also has a flat rim for mounting purposes making the overall diameter 37mm. Overall thickness 3.5mm. The lens has a focal length of ≈80mm in the infra-red band.

*Order As*
*FA95D (Plastic Lens)* *Price 48p*

### Right-Angled PCB Mounting 6-Pin DIN Socket

A 240° 6-pin PCB mounting DIN socket, having a front face 21mm square, and an overall depth of 17mm.

*Order As*
*FA90X (PC DIN Skt 6-pin)* *Price 58p*

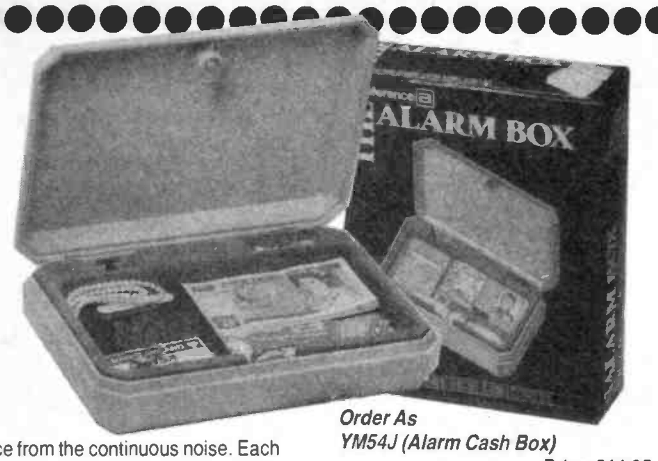
### Portable Anti-Theft Alarms

These new electronic security devices provide a second line of defence against theft either in the home or business premises. There is no substitute for good locks on windows and doors and professionally installed alarm systems, but what if a thief successfully gains entry?

### Alarm Box and Jewellery Box

A portable electronic safe that protects your most valuable personal possessions in three ways – if moved an extremely loud alarm is sounded, detering any would-be thief. In conjunction with a high security 8 tumbler lock, forcible entry is made very difficult. Portability means that the box can also be hidden from view, or used away from home. The Alarm Box is big enough to hold your precious jewellery, documents and cash.

All these devices incorporate a battery operated system which uses a dedicated logic IC for 'intelligent' operation – if moved the alarm is sounded for a short period and then is switched off, the unit resets itself in anticipation of a further trigger signal. Only if movement continues is the alarm retriggered, this prevents premature battery failure and annoy-





ance from the continuous noise. Each of the above units can only be armed or switched off with a key. The Alarm Box has a switch-on delay of 1 minute during which time you can put it away out of sight.

*Order As*
*YM54J (Alarm Cash Box)* *Price £44.95*

*Order As*
*YM55K (Alarm Jewellery Box)* *Price £54.95*

***The Spider***

The Spider can protect up to five items at once using four sensor units connected via umbilicals to the 'master' unit. Ideal for a group of valuable items, such as a stereo system, home computer set-up (computer, monitor and disk drive etc.), or articles in a shop window display. Simply attach the Spider to one item and the Spiders 'legs' to up to four other items – sets off a loud alarm if any are moved.

*Order As*
*YM53H (The Spider)* *Price £34.95*


***The Fly***

Is a battery operated, highly sensitive motion detector, which can be attached to valuable articles such as a video recorder, TV set, stereo, documents safe etc. If moved the Fly responds with a loud audible alarm, drawing attention to itself and detering would-be thieves. It may readily find applications in shop or showroom displays to help prevent handling or theft of goods.

*Order As*
*YM52G (The Fly)* *Price £24.95*


# AMENDMENTS TO 1986 CATALOGUE

**PLEASE NOTE** that the telephone number of MPS (Maplin Professional Supplies) is 0702-552961.

**KINGDOM GAME CASSETTE** (Page 104). This cassette game for the Atari has been listed as having the stock code KB97F, whereas it should be YG55K.

**PRINTER CABLES FG30H & FG31J** (Page 133). These 26-way and 20-way ribbon cables have had their lengths quoted as 30cm, they should be 1m as before.

**SPINDLE COUPLER RX29G** (Page 184). The length of this brass coupler is 15mm and not 22.5mm.

**ULTRA-BRIGHT RED LEDs QY84F, QY85G** (Page 199). It is the anode and not the cathode that is denoted by the flat of the package and the shorter of the two leads.

**5x7 LED ARRAY FT61R** (Page 201). The dimensions of the 5x7 LED array have been erroneously omitted from the catalogue. The dimensions of the array are 53 x 38 x 8.5mm deep excluding pins.

**REPLACEMENT STYLI** (Page 279). The prices for the styli shown on pages 279 and 280 of the 1986 catalogue have been omitted. For prices refer to a copy of the current price list.

**ALL ROTARY POTENTIOMETERS** (Page 290, 291). The shaft length of all types (single, single with switch and dual gang) is 50 ±0.5mm minimum. Also the thread length of the single and dual gang is 9mm and not 7mm. Note that the body length of the switched types is 22mm not 20.8mm, and that the switch rating is 4A at 250V AC and not 2A.

**4702B PROGRAMMABLE BIT RATE GENERATOR** (Page 296). The order code for this device is UF36P, *not* UF35Q.

**74HC4316 UF13P** (Page 297). In the semiconductors index on page 297, the 74HC4316 IC has been listed as being described on page 328, it is in fact to be found on page 323.

**7402, 74LS02, 74HC02 AND 4001BE, 4001UBE QX39N - QL03D** (Page 307). The captions for the pin-out diagram of the TTL devices have been accidentally transposed with those for the CMOS diagram.

**74LS244, 74HC244, 74HCT244 OCTAL BUFFERS QQ56L, UB65V, UB66W** (Page 311). In the pin-outs diagram for these octal buffers note that the control input via pin 19 should have an inverting input symbol at the control input buffer.

**4040BE, 74HC4040, 4060BE, 74HC4060 RIPPLE COUNTERS** (Page 318). The pin-outs diagrams for these ICs have the wrong captions. The 4060BE and 74HC4060 devices are actually the 14-stage ripple counter with oscillator, and the 4040BE and 74HC4040 devices are the 12-stage ripple counter.

**AUDIO POWER AMP IC's QH39N, WQ33L, WQ66W, WQ67X, YY70M,** (Pages 335 – 337). Please note that although these devices are described as having heatsink mounting tabs that do not need to be electrically insulated from a chassis, this is on the condition that the chassis is the same potential as the most negative supply pin of the IC. The mounting tab is connected to the IC substrate, and it is required that this be equal to or up to 0.6V more negative than the negative supply pin voltage. If chassis = IC 'ground' potential, then the omission of an insulating kit will satisfy this condition, but do not overlook the possibility of earth related instability problems. If you intend to use a split-rail power supply, you *must not* bolt the tab direct to chassis without an insulating kit!

**TEMPERATURE COMPENSATED TWO STEP LEAD ACID BATTERY CHARGER** (Page 364). In the circuit diagram a value is missing for R14, it should be 4k7.

**MID-RANGE SPEAKER WY15R** (Page 389). This mid-range unit is for use in systems up to 25W and not 40W.

**RIGHT-ANGLED PCB ROTARY SWITCHES FT56L, FT57M, FT58N & FT59P** (Page 395). The specifications of these switches should be amended as follows – FT56L is 1-pole 12-ways, FT57M is 4-pole 2-ways (4-pole changeover), FT58N is 2-pole 5-ways, and FT59P is 3-pole 3-ways.

**PUSH BUTTON DIGITAL MULTI-METER M6000 YJ78K** (Page 411). Note that the table of resistance ranges has been erroneously omitted from the catalogue. The resistance ranges for the M6000 are as follows, written as 'Range, Resolution, Accuracy':
200Ω, 100mΩ, ±(0.5% of rdg + 1digit); 2kΩ, 1Ω, ±(0.3% of rdg + 1d); 20kΩ, 10Ω, ±(0.3% of rdg + 1d); 200kΩ, 100Ω, ±(0.3% of rdg + 1d); 20MΩ, 10kΩ, ±(1.5% of rdg + 1d). Max open circuit voltage drop across probes, <3V. Overload protected to 250V DC or rms AC.

**ADJUSTABLE SPANNERS FY45Y, FY46A** (Page 420). The dimensions of these spanners have changed slightly. The small adjustable is now 150mm in length with a maximum jaw opening of 19mm, and the large adjustable has an overall length of 200mm with a maximum opening of 24mm.

**SATURN MAINS DRILL YW65V** (Page 423). Please note that the specifications in the catalogue are not quite correct. The mains supply voltage range is actually 220 – 250V, the off-load speed is 12,000 r.p.m. and the 3-jaw pin chuck has a maximum capacity of 2.9mm and not ⅛in.

**SOLDERING IRON HOOK FT09K** (Page 425). This clip-on hook/finger guard will fit the XS and MLXS soldering irons only, and not the CS type.

**TOROIDAL TRANSFORMER YK33L** (Page 436). In the case of the toroidal transformer with 0–24, 0–24, 0–100V secondaries, the wire colour codes for the 100V secondary have been omitted. They are: start of winding, Black. Finish of winding, White.

**TRANSFORMER KITS** (Page 436). The turns ratio quoted for the 20, 50, and 100 watt transformer kits are in the wrong order. Correct turns/volts ratios are as follows:-
20VA – 6.04 turns per volt, +1% for each multiple of 10VA loading.
50VA – 4.8 turns per volt, +1% for each multiple of 10VA loading.
100VA – 4.16 turns per volt, +1% for each multiple of 10VA loading.

**STEPPER MOTOR KIT LK76H** (Page 437). This kit now includes a pcb.

# CLASSIFIED

## VARIOUS FOR SALE

**SIX CPU's** for sale: Z80A, calculator, video-game, 'Mastermind game', synthesiser IC, Space Invaders. £2 each or £10 for the lot. Telephone Joel on (01) 699 5354.

**ANTIQUE RADIO** equipment for sale: 200 valves, valve tester, oscillator, etc. Telephone Joel on (01) 699 5354.

**TEKTRONIX 545A OSCILLOSCOPE** with 1A1 plug-in, not working £25. Taylor model 67A signal generator 100kHz to 240MHz, working £10. Buyer collects. 01-470 4977.

**FERRANTI LR25 He Ne LASER** complete with power supply, output meter and a variety of stands, mirrors, lenses, splitters, gratings, etc. £50 ono. Horrocks, 49 Wheelwright Rd, Erdington, Birmingham. 021-373 6188.

**WIRELESS WORLD FM TUNER** and hi-fi preamplifier, working. Black and white television camera, should work. Wireless World magazines 1968 – 1982. Offers? Phone 05873 246 after 6 p.m.

**PRINTER, IBM GOLFBALL** with interface, or suit Maplin project £60. Chelmsford (0245) 355505.

**BROTHER EP22 PRINTER/TYPEWRITER.** Integral RS232 interface. Only one year old. Offers in the region of £55. Steele, Keighley (0535) 600034.

**ORGAN KEYBOARD 73 NOTE F – F** £15. Organ switch banks 10p. Teletype mechanism, PSU and keyboard £5. Electrostatic CRT's £1. Chart recorder mechanism, £2. Model motors 25p. Farnborough (Kent) 55965.

**IBM GOLFBALL PRINTER** as in photograph on page 26 of December issue Maplin magazine. Offers to 0284 61870 (Bury St Edmunds).

**TYPING SERVICES** for electronic and computer enthusiasts provided privately and inexpensively by fully-experienced secretary: Sally Keyrealm, 245, Colyers Lane, Slade Green, Kent DA8 3QD.

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For the next issue your advertisement must be in our hands by 1st April 1986.

**ELECTRONICS THE MAPLIN MAGAZINE** Nos. 1 to 16, in mint condition. 50p each or £7 for the lot. Moore, 56 Archers Court Road, Whitfield, Dover, Kent, CT16 3HS.

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**MOBELEC CAR COMPUTER** new, £25. Wanted, circuit diagrams for Vox Continental II and 300 organs, TMS 3802 dividers, original metal Maplin drawbars. Gibson, 14 Leigh Gardens, Wimbourne, Dorset, BH21 2EW.

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**ORIC TALKBACK** speech synthesiser kit built and functioning, in good condition for £15. Telephone Joel on (01) 699 5354.

**10 ARCADE AND ADVENTURE GAMES** on one cassette for the Amstrad CPC 464/664/6128. Send cheque/P.O. for £3 to Alan Cooper, 4, Carol Avenue, Martlesham, Woodbridge, Suffolk.

**VIC-20 CARTRIDGE-AREA MEMORY-EXPANSION KIT** for machine code use, etc. Includes board and instructions. Just add 2K RAM or 2–4K PROM. Only £4.95 from Seddon, 63 Portland Road, Birmingham.

**48K SPECTRUM AND SOFTWARE** £70. Mutilated DKtronics keyboard £5. Kempston Pro interface and software £15. Phone 051-648 1694 after 6 p.m.

**COLOUR GENIE 32K,** printer plus paper, dual joysticks and keypad, LC24 tape recorder, £200 worth of software, 11 Genie mags, cassette case, leads etc. All in original boxes, £250 the lot o.n.o. Phone A.Fowler, Kibworth 2100.

## CLUBS

**ATARI MONITOR** magazine issue 10 is now available, filled from cover to cover with interesting Atari snippets, software reviews, tutorials and program listings. Send for a copy now for just £1.30 (inc. postage) to: The UK Atari Computer Owners Club, P.O. Box 3, Rayleigh, Essex, SS6 8LR.

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**CASIO PT-80** plus ROM cartridge with manuals, in good condition. Approximately six months old and rarely used, you can have it for £60. Telephone Daniel on (01) 699 5354.

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**HOHNER SYMPHONIC 320 ELECTRIC ORGAN** with footswell and bass pedals and Laney 40W reverb combo. Amplifier vgc, offers around £125. Buyer must collect. Phone Matthew, (021) 552 5715.

**MES 53 ORGAN** with 2 5-octave keyboards, auto-organ rhythm generator (MES 55), pedal electronics (MES 54), but no pedalboard. Built and working with minor faults in incomplete cabinet. Offers. Phone (0270) 764993.

**MAPLIN MATINEE ORGAN** complete with handbook, one year old, £250. Akai 4000DS tape deck, 3 heads, sound on sound, 15 reels of tape £99. Telephone Cardiff (0222) 628473.

**MAPLIN SERIES 53/4/5 ORGAN.** 2 x 65 note keyboards. 30 note pedals. Cheap to good home. Details from St Albans 59450.

## WANTED

**16K ZX81 OR ORIC ATMOS** 48K for £20 and £30 respectively. Also ZX printer wanted for £20, black and white or colour TV for £25. Telephone Joel on (01) 699 5354.

**HAS ANYONE** seen details of a plug-in teletext decoder project in an electronics magazine? Any answers please to Luke Walker, Department of Electrical Engineering U G, Imperial College, London SW7.

**WANTED CIRCUIT DIAGRAM,** kit or assembled unit of an FM stereo transmitter. Write to: Hallvard Tangeraas, Kvitsund Gymnas, 3850 Kviteseid, Norway.

# CORRIGENDA

**Project Book 2**
**Burglar Alarm; External Horn Kit LW58N.** In the External Horn Kit, R2 is now 10k (M10K), R5 is now 470Ω (M470R), and TR1 is a 2N4393 (RA99H).

**Project Book 6**
**MOSFET Amp Bridging Module LK03D.** There are two errors in the construction details for the 'MOSFET Amp Bridging Module' under the section 'Test and Use'. (1) The reference to 'pin 12V' should read 'pin 12'. (2) The sentence 'Remove the meter lead from pin 11 and reconnect to pin 8.' should read 'Remove the meter lead from pin 11 and reconnect to pin 7.' General notes – the 0 volt connection from the power supply should be made with heavy duty cable, and *not* thin cable which can cause 0 volt setting problems. If problems in setting 0 volts are encountered, R8 can be reduced in value, or replaced with a wire link. The 0 volt setting can be in the range 0V to +20mV.

**Project Book 11**
**Xenon Flash Tube Driver GB61R.** C6 should be Axial Electrolytic FB72P, and not PC Elect.

**Vol. 3 No. 13**
**Explosive Gas Alarm LK60Q.** If on inspection you find that both sensors are marked with spots, then that which has a blue spot is the one referred to in the text.

**Vol. 3 No. 9**
**Infra-Red Movement Detector LK33L.** Please note that the Infra-Red Movement Detector, LK33L, has been superceded by a superior model. We regret that we can no longer supply the Infra-Red Movement Detector in kit form, since due to the construction of the improved design it is too complex to assemble and test without special equipment.

# MAPLIN'S TOP TWENTY KITS

| THIS MONTH | LAST MONTH | | DESCRIPTION OF KIT | ORDER CODE | KIT PRICE | DETAILS IN PROJECT BOOK |
|---|---|---|---|---|---|---|
| 1. | (2) | ▲ | Live Wire Detector | LK63T | £3.50 | 14 (XA14Q) |
| 2. | (4) | ▲ | Partylite | LW93B | £9.95 | Best of E&MM |
| 3. | (1) | ▼ | 100W Mosfet Amplifier | LW51F | £17.95 | Best of E&MM |
| 4. | (3) | ▼ | Car Burglar Alarm | LW78K | £7.95 | 4 (XA04E) |
| 5. | (9) | ▲ | U/Sonic Car Alarm | LK75S | £17.95 | 15 (XA15R) |
| 6. | (5) | ▼ | Ultrasonic Intruder Detector | LW83E | £11.95 | 4 (XA04E) |
| 7. | (6) | ▼ | 8W Amplifier | LW36P | £5.95 | Catalogue |
| 8. | (19) | ▲ | Computadrum | LK52G | £11.95 | 12 (XA12N) |
| 9. | (7) | ▼ | PWM Motor Driver | LK54J | £9.95 | 12 (XA12N) |
| 10. | (11) | ▲ | 15W Amplifier | YQ43W | £6.50 | Catalogue |
| 11. | (8) | ▼ | Logic Probe | LK13P | £14.95 | 8 (XA08J) |
| 12. | (12) | ◆ | Light Pen | LK51F | £8.95 | 12 (XA12N) |
| 13. | (–) | ▲ | Scope Logic Tester | LK77J | £11.95 | 16 (XA16S) |
| 14. | (10) | ▼ | Syntom Drum Synthesiser | LW86T | £13.95 | Best of E&MM |
| 15. | (14) | ▼ | Burglar Alarm | LW57M | £59.95 | 2 (XA02C) |
| 16. | (15) | ▼ | Harmony Generator | LW91Y | £17.95 | Best of E&MM |
| 17. | (–) | ▲ | Musical Announcer | LK57M | £14.95 | 13 (XA13P) |
| 18. | (16) | ▼ | ZX81 I/O Port | LW76H | £10.95 | 4 (XA04E) |
| 19. | (–) | ▲ | DXer's Audio Processor | LK05F | £9.95 | 7 (XA07H) |
| 20. | (–) | ▲ | Mains Tx/Rx Driver | LK68Y | £34.95 | 16 (XA16S) |

**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.*

# DID YOU MISS THESE ISSUES?


**Project Book 1 Universal Timer**. Programmable mains controller. **Combo-Amplifier**. 120W MOSFET power amp. **Temperature Gauge**. 10°C - 100°C, LED readout. **Pass The Bomb!** Pass-The-Parcel with a difference. **Six easy-to-build Projects on Vero-board**. Car batt. monitor; Colour snap game; CMOS Logic Probe; Peak Level meter; Games timer; Multi-colour pendant.
**Order As XA01B (Maplin Project Book No. 1)**
**Price 75p *NV*.**

**Project Book 2 Digital Multi-Train Controller**. Controls up to 14 model trains. **Home Security System**. Six in-dependant channels. **Digital MPG Meter**. With large LED display, a must for more economical motoring.
**Order As XA02C (Maplin Project Book No. 2)**
**Price 75p *NV*.**

**Project Book 3 ZX81 Keyboard**. 43 keys, plugs directly into ZX81 with no soldering. **Stereo 25W MOSFET Amp**. 25W r.m.s per channel; Disc, Tape, Tuner & Aux. **Radar Intruder detector**. 20 metres range, may be used with our security system. **Remote Control for Train Controller**. Remote control by infra-red, radio or wire.
**Order As XA03D (Maplin Project Book No. 3)**
**Price 75p *NV*.**

**Project Book 4 Telephone Exchange**. Up to 32 extensions on 2-wire lines. **Remote Control for Amplifier**. Volume, balance and tone controlled via infra-red link. **Frequency Counter**. 8 digit DFM, 10Hz - 600MHz range. **Ultrasonic Intruder Detector**. Areas up to 400 square feet can be covered.
**Order As XA04E (Maplin Project Book No. 4)**
**Price 75p *NV*.**

**Project Book 5 Modem**. 300 baud transmission speed over normal telephone lines. **Inverter**. 240V AC 60W from 12V car battery. **ZX81 Sound Generator**. 3 tone generators fully controlled from BASIC. **Central Heating Controller**. Optimised performance with this advanced system. **External Horn Timer**. Exterior intruder alarm. **Panic Button**. Add on to our Home Security System. **Model Train Projects**. Add on to our Multi-Train Controller. **Interfacing Micro processors**. How to use parallel I O ports, with circuits.
**Order As XA05F (Maplin Project Book No. 5)**
**Price 75p *NV*.**

**Project Book 6 VIC20 & ZX81 Talkbacks**. Speech synthesis projects. **Scratch Filter**. Tunable active circuit 'reclaims' scratched records. **Bridging Module**. Converts two 75W MOSFET amps to one 400W full bridge amplifier. **Moisture Meter**. Finds damp in walls and floors. **ZX81 TV Sound and Normal/Inverse Video**. TV sound and inverse video direct. **Four Simple Veroboard Projects**. Portable Stereo Amp; Sine Generator; Headphone Enhancer and Stylus Organ.
**Order As XA06G (Maplin Project Book No. 6)**
**Price 75p *NV*.**

**Project Book 7 CMOS Crystal Calibrator**. For amateur radio receiver calibration. **DX'er's Audio Processor**. Improved sound from Communications Receivers. **Enlarger Timer**. An accurate timer for the darkroom. **Sweep Oscillator**. Displays AF frequency response on an oscilloscope screen. **VIC20 and ZX81 Interfaces**. RS232 compatable.
**Order As XA07H (Maplin Project Book No. 7)**
**Price 75p *NV*.**

**Project Book 8 Spectrum Modem/RS232 Interface**. 2400 baud self contained operating system. **Synchime**. Simulates bells, gongs and other chiming sounds. **Dragon 32 RS232/Modem Interface**. Plugs into ROM expansion port. **Codelock**. Programmable electronic lock. **CMOS Logic Probe**. Digital display shows logic states. **Minilab Power Supply**. Versatile unit for the test bench. **Dragon 32 I/O Ports**. Two 8-bit ports. **Doorbell for The Deaf**. Flashing lamp attracts attention.
**Order As XA08J (Maplin Project Book No. 8)**
**Price 75p *NV*.**

**Electronics Issue 9 Spectrum Keyboard**. 47 full travel keys. **VIC Extendiboard**. Three expansion ports, one switchable. **Oric Talkback**. Speech synthesiser for the Oric 1. **Infra-Red Movement Detector**. 30 metres range outdoors. **TDA7000 FM Radio**. Complete FM receiver on a chip. **ZX81 High Resolution Graphics**. 256 x 192 fine pixel display. **Ten Projects!** Personal Stereo Dynamic Noise Limiter; Logic Pulser; ZX81 1K Extendi-RAM; TTL RS232 Converter; Pseudo Stereo AM Radio; and more.
**Order As XA09K (Maplin Magazine Volume 3 Issue 9) Price 70p *NV*.**

**Project Book 10 Spectrum Easyload**. Helps cassette loading with the Spectrum. **80m Receiver**. Simple SSB direct conversion receiver. **Fluorescent Tube Driver**. 8W 12V for camping and caravanning. **Auto-Waa**. Automatic waa-waa effects unit. **Digi-Tel Expansion**. Expands Maplin Telephone Exchange to 32 extensions. **Oric 1 Modem Interface**. Adapts the Oric 1 to the Maplin Modem. **Dragon 32 Extendiport**. Makes the Dragon's cartridge socket more accessible.
**Order As XA10L (Maplin Project Book No. 10)**
**Price 75p *NV*.**

**Project Book 11 Mapmix**. Six channel audio mixer. **Xenon Tube Driver**. Xenon flash tube module with strobe. **Enlarger Exposure Meter**. Simple inexpensive tool for the darkroom. **8 Channel Fluid Detector**. Check control fluid level in up to 8 containers. **Servo & Driver Module**. Servo mechanism with driver module kit. **Mk II Noise Reduction Unit**. Improves signal noise ratio of tape recordings. **Cautious Ni-Cad Charger**. Controlled charging of ni-cad cells. **Motherboard for The BBC Micro**. Gives easy access to ports.
**Order As XA11M (Project Book No. 11)**
**Price 75p *NV*.**

**Project Book 12 RTTY Unit**. The TU1000 receives transmits Radio Teletype; connects to computer via RS232. **Computadrum**. Use your computer as a drum synthesiser. **Light Pen**. Draw onto the TV screen or select menu options. **PWM Motor Drive**. Reversible model motor driver for 6V and 12V.
**Order As XA12N (Maplin Project Book No. 12)**
**Price 70p *NV*.**

**Project Book 13 Explosive Gas Alarm**. Flammable gas detector. **Flash Meter**. Get your exposure right when using your flash gun. **Musical Announcer**. A doorbell with a difference. **Mains Controller**. An add-on for the 8-Channel Fluid detector.
**Order As XA13P (Maplin Project Book No. 13)**
**Price 75p *NV*.**

**Project Book 14 Live Wire Detector**. Invaluable aid for the handyman. **Trundle**. The line follower robot as featured on Channel 4. **Zero 2**. High quality 'turtle' robot. **4-Channel PWM Controller**. Digital control of motors and servos. **Display Driver Module**. How to use our LED bargraph display ICs. **Control-A-Train**. Full inertia control of model trains.
**Order As XA14Q (Maplin Project Book No. 14)**
**Price 75p *NV*.**

**Project Book 15 Z80 CPU Module**. Expandable CPU based controller. **Zero 2 Ins & Outs**. Connecting up to the Commodore 64, BBC-B and Spectrum. **Sharp MZ-80K Serial Interface**. Get into communications with this project. **Ultrasonic Car Alarm**. Stop car thieves. **Active Crossover**. Includes matched output power amplifiers. **Guitar Equaliser**. Specifically for six string electric guitatrs. **Fabulous Five**. A selection of interesting circuits.
**Order As XA15R (Maplin Project Book No. 15)**
**Price 75p *NV*.**

**Electronics Issue 16 Floodlight Controller.** Both power supply and mains switching unit for the Infra-red Intruder Detector Kit. **Spectrum Parallel/Serial Interface**. Provides 8-bit I P and O P parallel or serial transfer with programmable UART. **Mains Tx/Rx Data Communications System**. Sends or receives data via the mains wiring. **16-Channel Logic IC Tester**. Simultaneously displays logic states for any logic IC of up to 16 pin-outs on your oscilloscope.
**Order As XA16S (Maplin Magazine Volume 4 Issue 16) Price 75p *NV*.**

**Electronics Issue 17 Video Digitiser**. Interface a TV camera to your computer. **Mixing It**. A comprehensive range of audio amplifier modules. **Hobbyist's Temperature Controller**. General purpose electronic mains power thermostat. **ASCII Keyboard**. Professional computer keyboard with standard ASCII output. **Play Along Mixer**. Play along to your favourite records and tapes on your own instrument.
**Order As XA17T (Maplin Magazine Volume 5 Issue 17) Price 75p *NV*.**


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