JUNE TO AUGUST 1988

PRICE 85p IR £1.25

Electronics

THE MAPLIN MAGAZINE

LEARN MORSE CODE the practical way with our super practice oscillator!

TUNE IN WITH THIS SUPERB FM RADIO!

Full construction details inside!

By building this useful piece of test equipment you can generate as much noise as you want!

Also in this issue:

3-way Speaker system; Watt watcher; Telephony; Video add-ons and much more.

MAPLIN'S 6 REGIONAL SHOPS

NEW SHOP IN BRISTOL

HELP SERVE YOU BETTER!

Birmingham:
Sutton New Road, Erdington. Tel: 021 384 8411.
Bristol:
302 Gloucester Road. Tel: 0272 232014.
London:
159-161 King Street, Hammersmith W6.
Tel: 01 748 0926.
Manchester:
8 Oxford Road. Tel: 061 236 0281.
Southampton:
46-48 Bevois Valley Road. Tel: 0703 225831.
Southend-on-Sea:
282-284 London Road, Westcliff-on-Sea, Essex.
Tel: Southend-on-Sea (0702) 554000.

For mail order enquiries, please *do not* call our shops as they will be unable to help you.

Before you send your next order to us by post, take a look and see if there's a Maplin shop near you. In our shops you'll find that personal service that even the best mail-order operations cannot match. And you can look at the products before you buy. If you're coming for a particular item, a quick phone call will enable you to be certain the shop has everything you want in stock.

Our shops are pleased to accept Access, Barclaycard, Connect, American Express, Mapcard and cheques up to £50 with a cheque guarantee card. We'll even accept ordinary money as well!

All our shops are close to excellent parking facilities, meters in London and Manchester, and free elsewhere.

The South
In the South our Southampton store is conveniently placed for easy access from all parts of Hampshire and surrounding counties, and is 15 minutes from Portsmouth.

London
Our London store now open 6 full days a week is situated just to the west of the pedestrian shopping centre in Hammersmith, and is just five minutes from the end of the M4 and only a short walk from the District, Piccadilly and Metropolitan lines' Hammersmith station.

The Midlands
In the Midlands, our self service Birmingham store now open 6 full days a week is just 3 minutes from the M6. Turn north at Spaghetti Junction (junction 6), onto the A5127 following the signs to Erdington. As you approach the Erdington roundabout, you'll see the store's 50 space car park directly in front of you.

South-East
Essex and Kent are served by our self-service Southend shop now open 6 full days a week which is right on the A13, just 2 minutes before you reach the centre of Southend. And we're only 30 minutes from the M25 (junction 29) as well.

West
Our West country store in Bristol is open a full 6 days per week. The self-service store can be found on the A38 Gloucester Road, midway between Bristol city centre and the Filton airport.

The North
Our self-service store in Manchester, now open 7 days a week, serves the North and is just off the Mancunian Way, opposite the BBC, about 5 minutes from the end of the M602 or junction 10 on the M63.

All our shops are open from 9a.m. to 5.30p.m. Monday to Saturday (9.30a.m. Wednesday) except Southampton which is closed Mondays. In addition Manchester is open Sundays. All shops are closed on Public Holidays. Shops do *not* close for lunch.

There's a friendly welcome in store for you at any Maplin shop. Our helpful staff may often be able to help with a technical problem or a constructional difficulty.

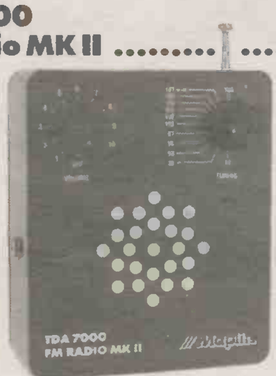
Call in at a Maplin store and get what you want today. We look forward to serving you.

June to August 1988
Volume 7 Number 27

CONTENTS

Electronics THE MAPLIN MAGAZINE

PROJECTS

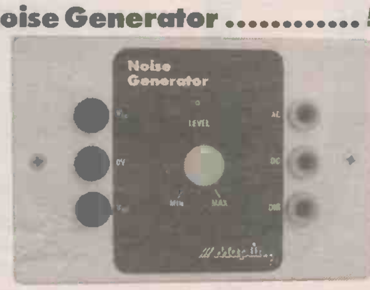


Improved version of this popular project using ready-wound RF coils. Complete kit now includes a case and aerial and at a realistic price. A superb project for any adult or child to build, as it is easy to construct and requires no alignment equipment.

Presented here is a 20 Litre passive radiator cabinet design which gives excellent sound reproduction at a very reasonable cost. Full details are shown of the cabinet construction and a kit containing the speakers, crossover, front baffle, etc. is available.

This novel project, which is simple to install, will tell you if you are overdriving your speaker system. It can be housed in the speaker cabinet or in a box of its own.

The best way to learn Morse Code is to practice until you acquire the speed and accuracy necessary to pass the Morse Test. This practice oscillator was designed to help by producing a loud clean tone, with the option of a controlled level of simulated noise. Just like the real thing!



The main use of a Noise Generator is in testing equipment on the bench which will be used in noisy environments in the field. An in-depth discussion on the types of noise to be encountered is also given.

FEATURES

Start of a new series covering the development of the telephone and ancillary equipment. This first part covers its invention, the early telephone systems and the intervention of the Post Office.

The third part of this series introduces the JK flip-flop and also covers counter chips in some depth. Example circuits are given for you to experiment and learn by using.

Another batch of very useful circuits from the prolific pen of Robert Penfold. These circuits are designed to be simple to construct but at the same time to give a useable end product and also to be fun to build for Dad and Lad!

This issue introduces the ZN414 AM tuner chip which is then used in the design of a MW radio. This little radio employs an earphone as the listening device and a PCB of the circuit is available.

Looking at the current explosion in home video equipment, John Woodgate uncovers some useful 'extras' and reading material that could help to enhance your hobby.

This article explains just what constitutes a 'diode' and includes zener diodes and LED's.

REGULARS

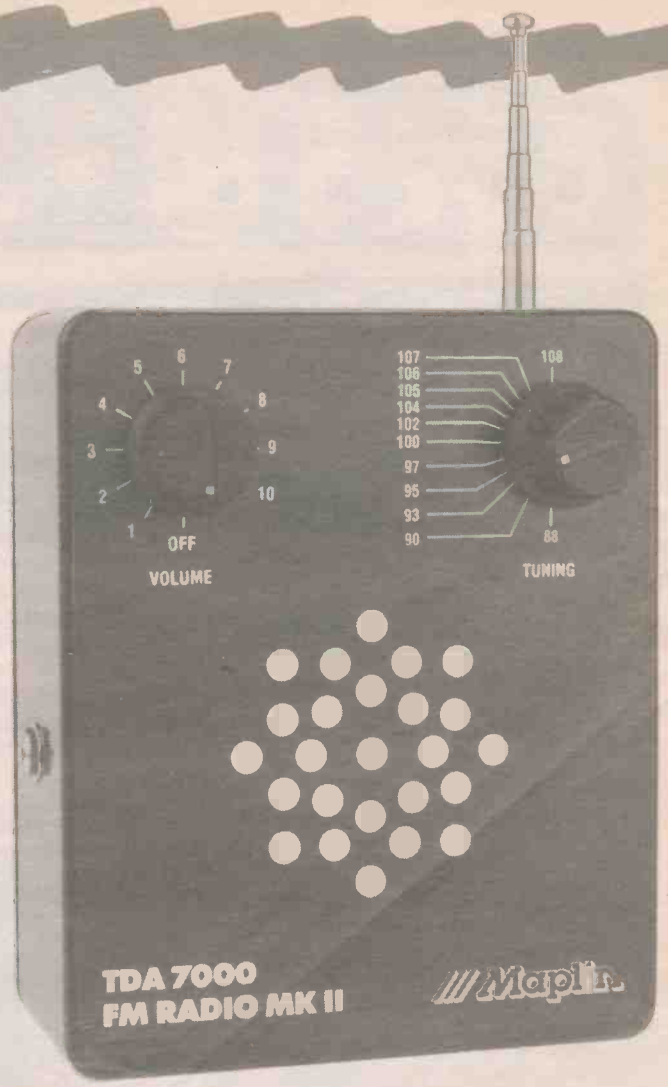
Mail Order
P.O. Box 3, Rayleigh, Essex SS6 8LR.
Telephone: Retail Sales: (0702) 554161. Enquiries: (0702) 552911.
Trade Sales: (0702) 554171. Enquiries: (0702) 552961.
General: (0702) 554155. Cashtel: (0702) 552941.

Shops: See inside front cover.

Editorial & Production
Editor Roy Smith
Production Manager Mike Holmes
Technical Editors Dave Goodman, Chris Barlow
Art Directors Peter Blackmore, Greg Buckley
Art Assistants Andy Nunn, Martin King
Technical Artists John Dudley, Lesley Foster

Published by Maplin Electronic Supplies Ltd.
Typesetting by Inline Design Systems Ltd. 258A London Road, Hadleigh, Benfleet, Essex SS7 2DE.
Printed by Mayhew McCrimmon Ltd., Star Lane, Great Wakering, Essex.
Distributed by Spotlight Magazine Distribution Ltd., 1-11 Benwell Rd, London N7.

TDA 7000



FM RADIO MK II

by Chris Barlow

★ *No alignment equipment needed*
★ *Easy to build*
★ *Ready wound RF coils*
★ *On-board power amplifier*
★ *Headphone/earpiece jack socket*

Specifications of Prototype

Radio integrated circuit	: TDA7000
Audio integrated circuit	: TBA820M
Operating voltage	: 4V to 8V
Supply current at 6V	: minimum volume 13mA
	: maximum volume 80mA
Power output 8Ω speaker	: 250mW RMS
Frequency coverage	: 88 to 108MHz
Aerial	: 6 section telescopic

Introduction

This project is an improved version of the radio originally presented in Electronics number 9 (now available as a Projects Book, see inside back cover). Conventional Band II VHF superheterodyne radios use a large number of tuned circuits as these are needed for filtering in the RF, mixer, oscillator, IF, and detector stages. Ceramic filters have become very popular in recent years, but these can only replace one or two IF transformers, and only marginally ease problems with alignment of the finished receiver. The TDA7000 is an imaginative integrated circuit which employs novel techniques that enable a good quality FM broadcast receiver to have just two tuned circuits. The reason for this device being developed is that it offers radio manufacturers the advantages of reduced costs, both in terms of components and the setting up time for the finished receiver. For the home constructor it similarly gives the advantages of low cost and ease of alignment. In fact the finished receiver only needs to have the core of one coil and a trimmer capacitor adjusted to give the correct frequency coverage. A TDA7000 FM radio is actually no more difficult to align than a simple ZN414 based AM radio!

Low IF

Strictly speaking the basic system used in the TDA7000 is not a new one, and is essentially the same as that used in the so called 'pulse counting' FM tuner designs that were popular amongst home constructors around twenty years ago (the original designs used valves!). The block diagram of Figure 1 shows the way in which these operate. The RF, mixer, and oscillator stages are fairly conventional, but usually quite simple with just a broadband (preset tuning) filter ahead of the mixer, but a more complex arrangement could be used if preferred. It is at the IF and demodulator stages where the real departures from a conventional superhet arrangement occur. The IF amplifiers are virtually ordinary high gain audio amplifiers, but filter capacitors are used to roll-off the response above about 200kHz and the coupling capacitors only need to be effective at frequencies above the audio range. This gives an IF centred at around 100kHz or so, and no tuned circuits to provide IF filtering are required. The low IF enables simple C-R filtering to give adequate results, and there is no lack of performance in this respect. A pulse counting circuit plus an RF filter provides the demodulation, and the pulse counter is merely a diode-pump frequency-to-voltage converter. Other types of circuit such as a phase locked loop or even just a monostable multivibrator can be used here to convert the frequency variations into the corresponding audio signal. While this system has obvious attractions, it is not without its drawbacks as well. The main one is the lack of any image rejection, due to the very low IF and the spacing of only a few tens of Kilohertz between what would normally be the main and image responses. Thus, when tuning a receiver of this type there are two very closely spaced points on the tuning dial where each station can be received satisfactorily, with a very narrow gap between these where the station is received, but is very severely distorted. As Band II FM broadcast stations tend to be well spread out this is unlikely to give problems with co-channel interference, but does make tuning the set a little awkward.

The TDA7000

Although pulse counting tuners were originally conceived as simple alternatives to conventional circuits, it would not be accurate to think of the TDA7000 as providing an inferior alternative to a conventional design. It uses a highly refined version of the pulse counting type of circuit, and in some respects it is superior to more conventional designs. Figure 2 shows the arrangement used in this device, plus basic details of the discrete components required. The standard TDA7000 has an 18-pin DIL plastic package, but there is also a miniature 16-pin version, the TDA7000T. The input tuned circuit is formed by La, Ce, and Cf. Internal resistors of the TDA7000 heavily damp this filter so that it has a very wide bandwidth and no RF tuning is needed. La can in fact be a zig-zag of printed circuit track, but in the design featured here it is a small moulded coil with a ferrite core. The aerial, which is a simple wire or telescopic type, is coupled to the input tuned circuit by way of a capacitive tapping. A voltage controlled oscillator feeds the other input of the mixer stage. This VCO is a straightforward L-C type which achieves voltage control using a couple of variable capacitance diodes. There are three IF filter stages, and the first of these uses a second-order low pass Sallen-Key circuit, which is the type of filter used in scratch filters and similar applications. Cq and Cr are the filter capacitors, but the filter resistors and other components are part of the TDA7000. The second filter is a simple bandpass type, and again, the only discrete components are two capacitors. The final filter stage is a straightforward passive first-order lowpass type which uses discrete capacitor Cg. The reason for using discrete rather than on-chip filter capacitors is simply that it is difficult and expensive to include even low value capacitors in an integrated circuit. The −60dB bandwidth of the filters is approximately 500kHz, which is perfectly adequate for an FM broadcast receiver.

After filtering the signal is amplified and limited in the usual way, and demodulated by a quadrature detector. Unlike a standard 10.7MHz quadrature detector, no tuned circuit is required, just

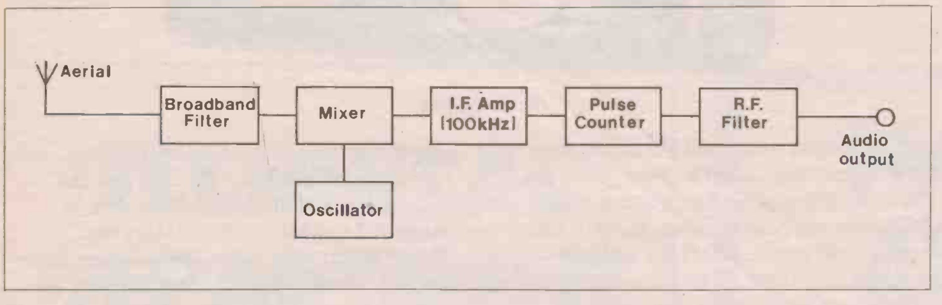


Figure 1. Block Diagram

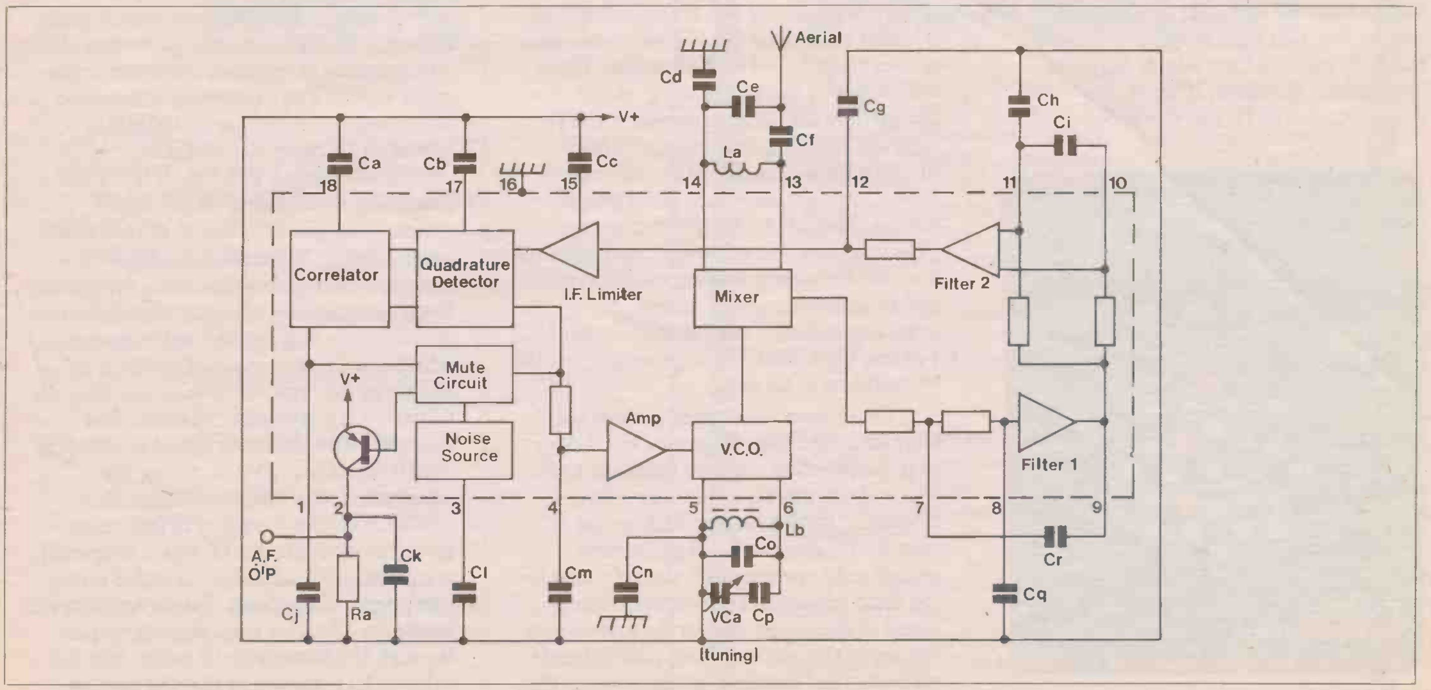
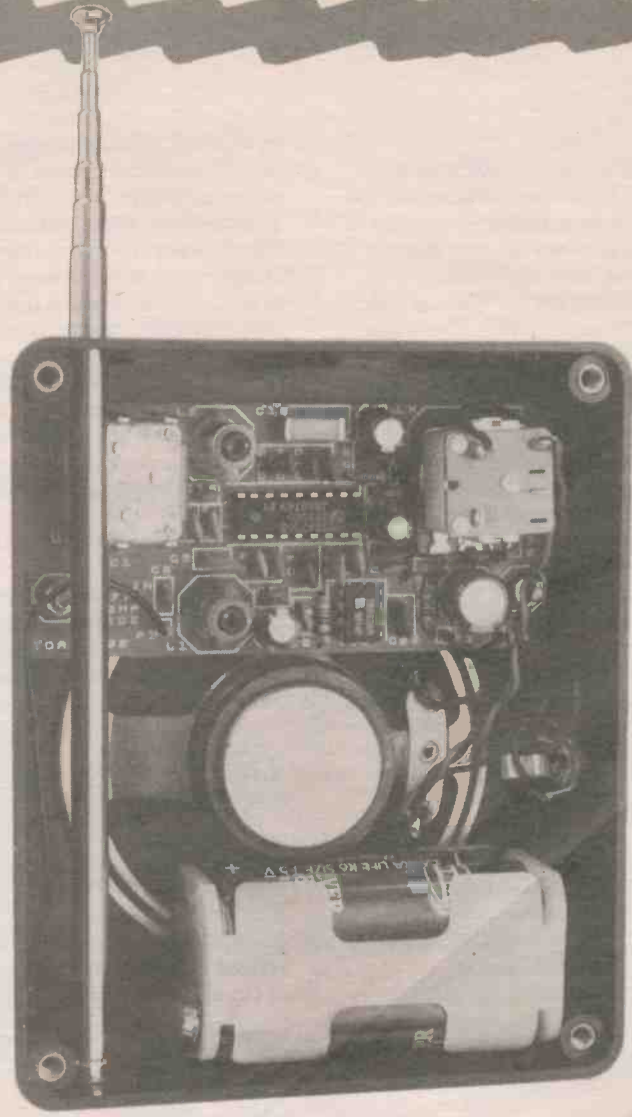


Figure 2. Connection Diagram for TDA7000

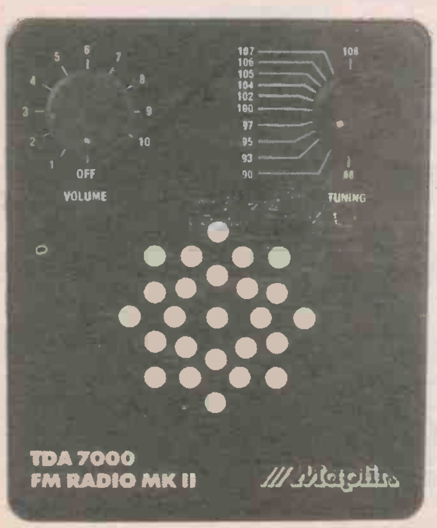
one phase shift capacitor (Cb). The intermediate frequency can be set at any reasonable figure by using the appropriate filter capacitor values, but a frequency of 70kHz would normally be used. Such a low IF eliminates any problems with the image signal of one channel interfering with reception of a transmission on the next channel. With the set tuned to one channel the image response falls roughly half-way between this channel and the next. The problem of using such a low IF is that it would result in severe distortion with signals having something approaching the full plus and minus 75kHz deviation. This problem is overcome by amplifying the audio output signal and feeding it to the VCO. This gives a form of negative feedback with the VCO following the input signal up and down in frequency. The deviation of the VCO is not quite equal to that of the input signal so that there is some variation in the frequency of the IF signal, but this is only about plus and minus 15kHz. The typical total harmonic distortion on the audio output is 2.3% at maximum deviation, which is satisfactory for portable radios and similar applications. A useful 'by-product' of the feedback to the VCO is that it gives a sort of automatic frequency control. Apart from counteracting any tuning drift, this effectively gives slow-motion tuning once the receiver has locked onto a transmission, and makes the set easy to tune even if only a small tuning knob is used.



Inside the box.

Correlator

The correlator and mute circuits of the TDA7000 are used to suppress the image response as well as giving a conventional 'squelch' action. The correlator operates by delaying the IF signal by an amount equal to the duration of one IF half cycle. This signal is then inverted and compared with the unprocessed IF signal. If the tuning is correct, the two signals will be virtually identical and will have a high degree of correlation. However, if the tuning is not very accurate the IF signal will be displaced from its normal 70kHz figure, and the delaying circuit will not give a one half cycle delay. This introduces a phase difference and poor correlation, with the mute circuit switching off the audio in consequence. If the IF signal is noise, or largely consists of noise, this also gives very little correlation between the two signals and mutes the audio output. An interesting effect of this system of muting is that it eliminates the side responses that are normally found on FM radios. These are caused by the signal being 'slope' detected by the skirt responses of the IF filtering, and they can make accurate tuning a little difficult. Many FM radios have a tuning indicator to assist proper tuning. The TDA7000 muting system eliminates the side responses, and together with the frequency locking tuning system makes tuning very easy indeed. A detuning indicator can be driven from pin 1 of the TDA7000, but in practice it would be pointless to do so.



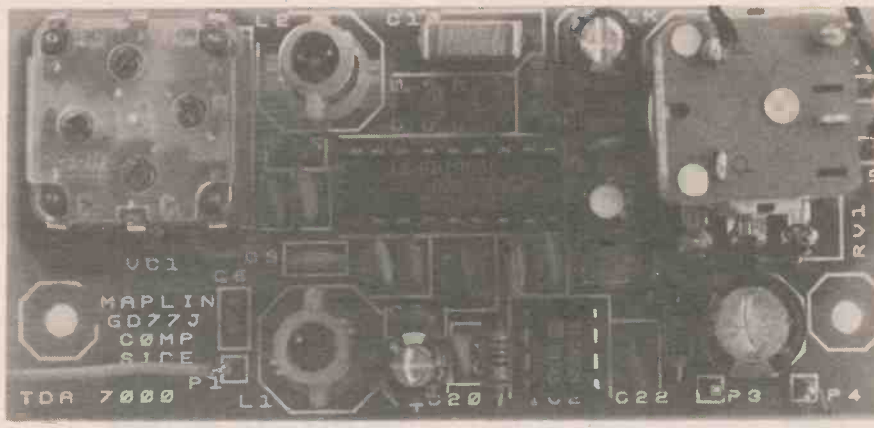
View of front panel.

On its own the correlator does not eliminate the image response, but it does so in conjunction with the feedback to the VCO which was described above (the frequency locked loop or FLL as the IC manufacturer terms it). This locking system only operates with the set tuned to the main response, and not when it is tuned to the image, due to the inversion of the signal that occurs. If we take a simple mathematical example to demonstrate this point, let us suppose that the receiver is tuned to a transmission which deviates between 100 and 101MHz, and that the oscillator is at 99MHz. This gives an IF range of 1 to 2MHz (100-99MHz and 101-99MHz). Of course, these figures have been chosen for their mathematical simplicity, and are not meant to be practical examples. As the IF signal moves up and down in frequency the audio output voltage also rises and falls, feeding a control voltage to the oscillator that shifts its frequency in the same direction as the input signal. The image response would occur with the oscillator at 102MHz, giving an IF range of 2 to 1MHz (102-100MHz and 102-101MHz). This frequency inversion of the IF signal appears as a phase inversion of the audio output signal. Where the oscillator frequency was previously taken higher and lower in sympathy with the received signal to effectively reduce the level of deviation, when tuned to the image response it is moved in the opposite direction so that the deviation is effectively increased. For example, with the input signal at 100MHz the IF signal is at 2MHz, giving the maximum audio output voltage. This sends the oscillator higher in frequency, giving an even greater IF signal frequency, greater audio voltage, and positive rather than negative feedback. When tuned to the image the IF signal does repeatedly pass through the acceptable IF range, but the value of Cj is chosen to give the muting circuit a slow response time so that it ignores these transients, and the image is suppressed. Ra is the load resistor for the audio output stage, and Ck is the de-emphasis capacitor. A slightly bizarre feature of the TDA7000 is a noise generator which gives a quiet noise signal at the audio output when the main audio signal is muted! This is included because it is otherwise very easy to tune over a station without realising it is there. The null in the noise signal as the set is tuned through a station helps to avoid this. However, if desired the noise can be eliminated by omitting C1.

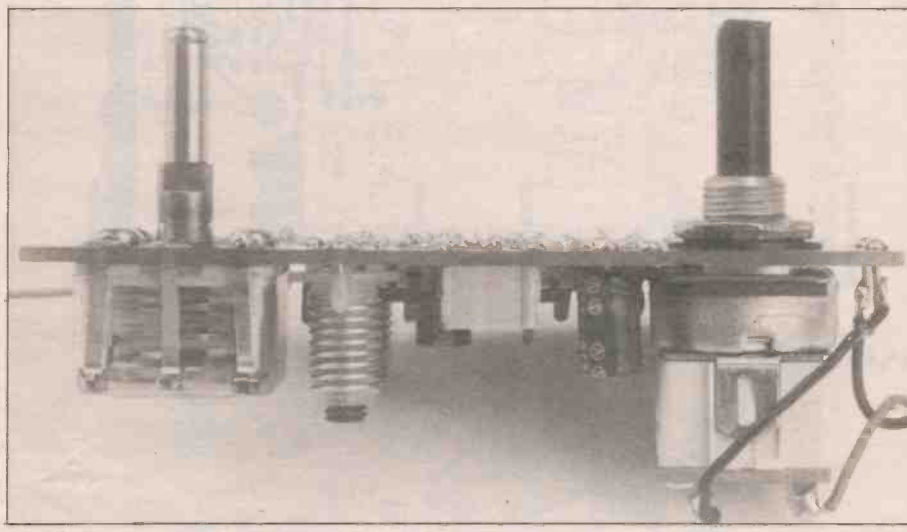
The Circuit

Figure 3 shows the circuit of a practical radio built around the TDA7000, and the circuitry associated with IC1 exactly follows the arrangement shown in Figure 2 and discussed earlier.

An audio output stage using a TBA820M (IC2) is included because of its low quiescent current, good ripple rejection and low crossover distortion. The signal from the TDA7000 (IC1) is fed via C19 to the top end of the volume control RV1. The wiper of RV1 is connected to the signal input pin of IC2, with R2 and C20 setting the gain of the amplifier. RV1 has an integral switch, S1 which is used to turn the DC power on and off to the circuit. C21 is connected to pin 1 for high frequency compensation and the zobel network R3 and C22 on pin 5 is connected to the negative rail. Pin 5 has a DC potential so a blocking capacitor C23 is used to feed the output of IC2 to a loudspeaker having an impedance in the range of 8 to 80 ohms. An output power of about 300 milliwatts RMS into an 8 ohm loudspeaker is available, and this is adequate for a portable radio. The output stage will also drive any magnetic type of earphone or headphones.



Top of PCB.



Side view of PCB.

PCB Assembly

A suitable printed circuit layout for the radio appears in Figure 4. The TDA7000 is not one of the many radio IC's that tend to be unstable at every opportunity, and the low IF eliminates problems with harmonics of the clipped IF signal being picked up at the input of the circuit. However, with frequencies in the region of 100MHz involved it is not advisable to use a different layout unless you are familiar with radio projects and know exactly what you are doing. The

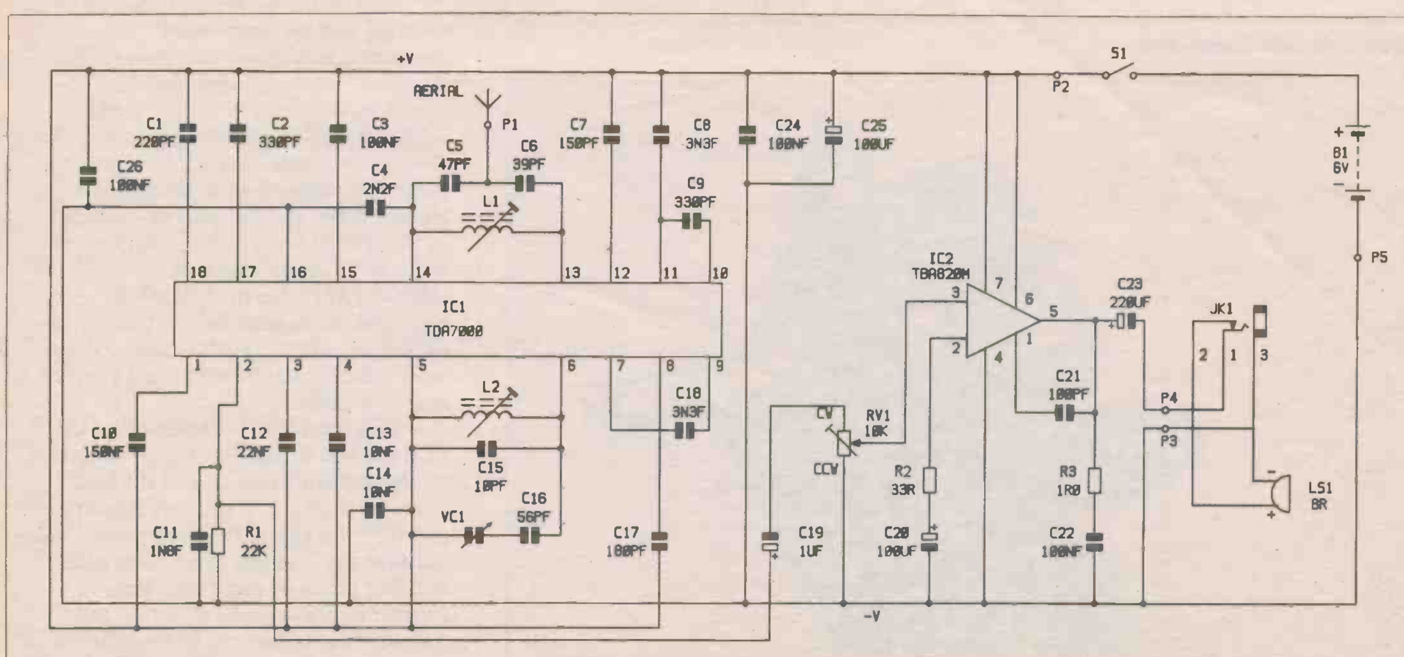


Figure 3. Circuit

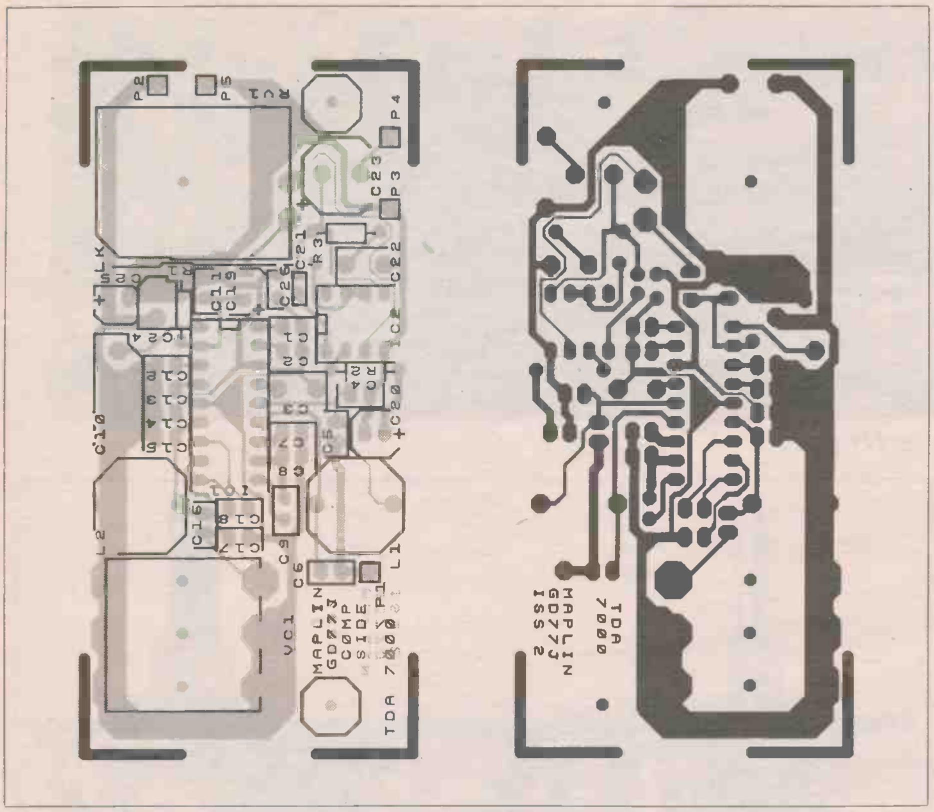


Figure 4. Track and Layout of the PCB

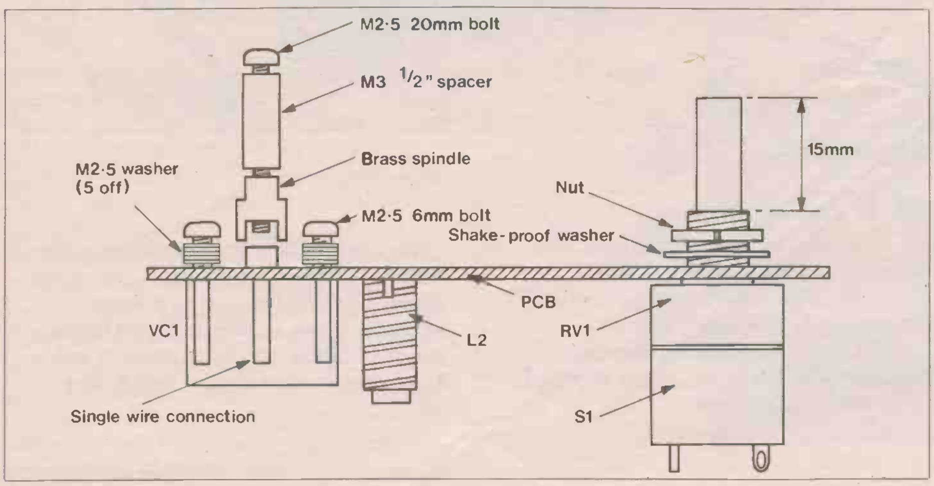
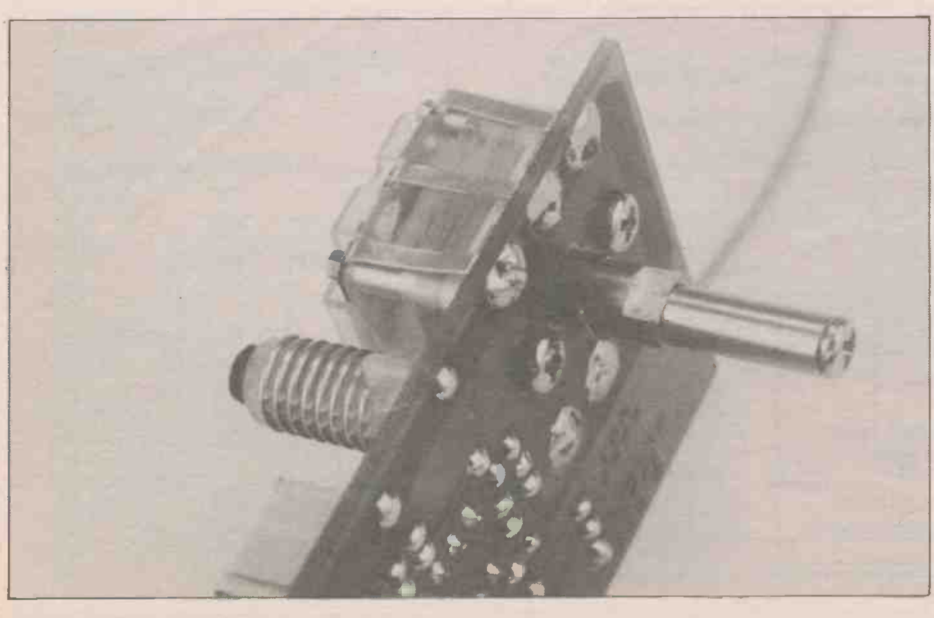


Figure 5. Spindle Preparation



Making the spindle longer.

PCB supplied in the Maplin kit is a single-sided, fibre glass type, chosen for maximum reliability and stability. However, removal of a misplaced component is quite difficult, so please double-check each component type, value and its polarity where appropriate, before soldering! The PCB has a printed legend to assist you in correctly positioning each component.

The sequence in which the components are fitted is not critical. However, the following instructions will be of use in making these tasks as straightforward as possible. It is usually easier to start with the smaller components. Begin with the pins at positions P1 to P5, then fit three more pins at RV1. Next, install the resistors, then the ceramic, polyester and electrolytic capacitors. The polarity for the electrolytic capacitors is shown by a plus sign (+) matching that on the PCB legend. However, on some capacitors the polarity is designated by a negative symbol (−) in which case the lead nearest this symbol goes away from the positive sign on the legend. IMPORTANT!! do not forget to fit the wire link (LK) on the PCB. Using a short length of insulated hook-up wire, connect one end at the hole near R3 and the other to the hole near C25, see Figure 4. Next, install the two IC's ensuring that you fit the appropriate IC in each position, matching the notch with the block on the legend. When fitting the two RF coils ensure that the correct colour coil is positioned as follows, red at L1 and white at L2. Also make certain that the two long plastic tags are facing each other.

Before mounting RV1, bend the three pot contacts back by 90°, so they lay flat on the pins as the pot is inserted. Secure RV1 by using the nut and shake-proof washer supplied with the pot, see Figure 5. Finally cut the plastic spindle of RV1 to a length of 15mm.

Next install the tuning capacitor VC1, ensuring that the centre single wire connection is as shown in Figure 5. The capacitor is secured using two M2.5 by 6mm long bolts and its spindle is then constructed in the following manner. The short brass spindle with the two flat surfaces is supplied with the capacitor. However, this spindle must be extended by using an M3 half inch spacer, secured by an M2.5 20mm long bolt. IMPORTANT!! as the bolt is fully tightened, to prevent damage occurring to the tuning vanes inside the capacitor, the brass spindle must be held using a pair of long nose pliers.

This completes the assembly of the PCB and you should check your work very carefully making sure that all the solder joints are sound. It is also very important that the track side of the circuit board does not have any trimmed component leads standing proud by more than 4mm. Further information on soldering and assembly techniques can be found in the Constructors Guide included in the Maplin kit.

Wiring

If you purchase a complete kit from Maplin it should contain a length of hook-up wire. Carefully follow the wiring shown in Figure 6. The power on/off switch S1 is connected to P2 using a 50mm length of wire. Next cut the wires on the battery clip to 110mm and connect the red to S1, black to P5. DO NOT fit the clip onto the battery until it is called for during the testing stage.

Prepare a 100mm length of wire. Connect one end to the aerial input pin P1 and attach an M3 solder tag to the free end. This tag will be bolted to the base of telescopic aerial in the final assembly stage.

Finally, using four 65mm lengths of wire, connect the headphone socket JK1 to P3 and P4 and to the two terminals on the loudspeaker. When handling the speaker, be careful not to damage the paper cone, or the terminals on the back. This completes the wiring of the PCB assembly. Now check your work very carefully making sure that all the wires and solder joints are sound.

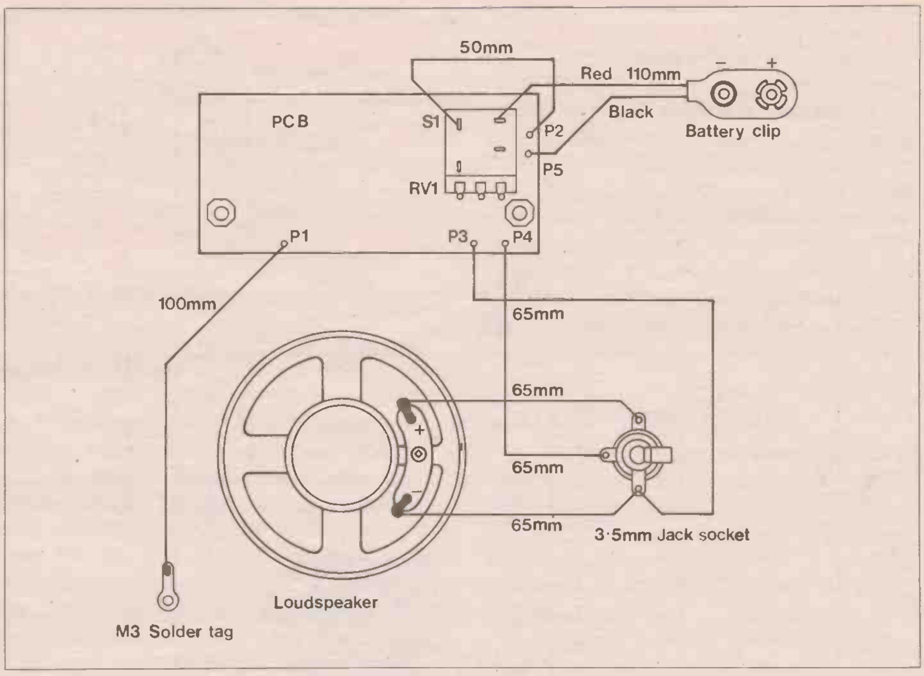


Figure 6. Wiring

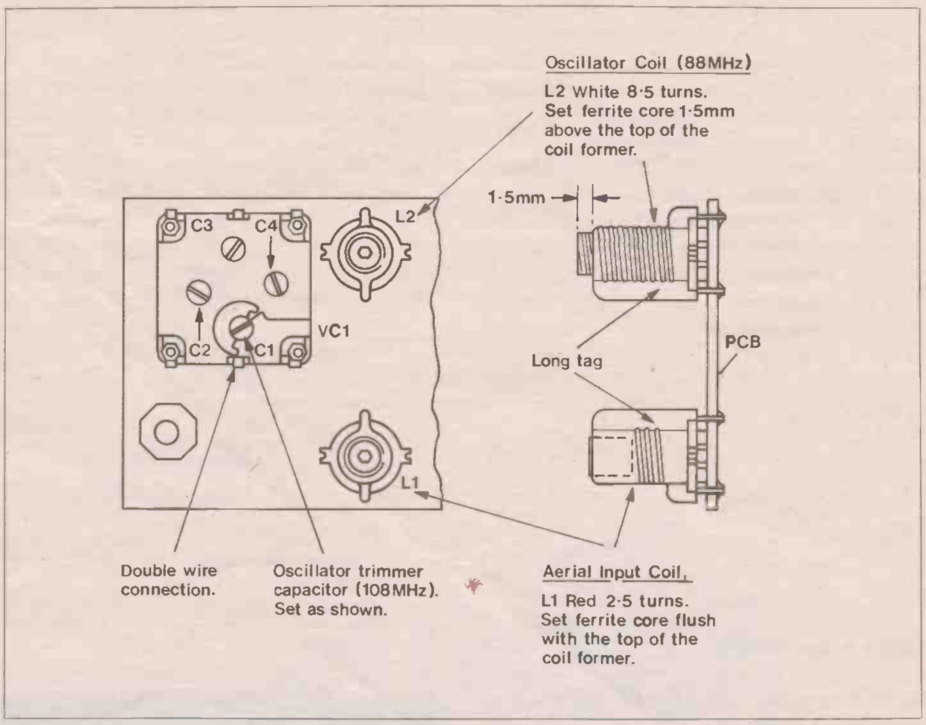


Figure 7. Receiver Adjustment

Testing and Adjustment

All the tests can be made with an electronic digital, or analogue moving coil, multimeter. The following test results were obtained from the prototype using a digital multimeter and a 6V battery pack as the power supply. Before commencing the tests, set the rotary controls as follows, VOLUME OFF, TUNING 88MHz (fully-anticlockwise). Next set the two RF coils and the trimmer capacitor as shown in Figure 7. The ferrite cores in the coils are very brittle, you must use the hexagon trimming tool supplied otherwise damage may occur. A miniature flat blade screwdriver, or preset type trimming tool can be used when adjusting the trimmer capacitor C1. The aerial input coil L1 forms part of a very wide bandwidth tuned circuit. This results in a flat tuning peak in the sensitivity of the receiver, which should occur when the core is flush with the top of L1. The setting of the oscillator coil L2 is more precise and its final position may vary from that shown in Figure 7. This also applies to the oscillator trimmer capacitor C1, however the positions shown in Figure 7 should provide a good starting point. Make a temporary aerial out of a piece of wire about 0.5 to 1 metre long and connect one end to the M3 solder tag.

The first test is to ensure that there are no short circuits before you connect the battery. Set your multimeter to read OHMS on its resistance range and connect the probes to the terminals on the battery clip. Turn on the power and with the probes either way round a reading greater than 60Ω should be obtained. Remove the probes and fasten the negative terminal of the clip to the battery box.

Next monitor the supply current, set your meter to read DC mA and place it in the positive line of the battery box. With the volume set to minimum, a current reading of approximately 13mA should be seen. As the volume control is advanced to its maximum setting, with no radio station tuned in, this reading will increase to approximately 26mA and a hissing sound should be heard. If a signal is received this reading can go as high as 80mA on sound peaks. However, when a headphone, or an earpiece is plugged into JK1 this reading will be significantly reduced. Remove your meter and fasten the clip to the battery box. Finally, check the tuning range, making any necessary adjustments to the oscillator coil L2 and the trimmer capacitor C1. You should set the low, 88MHz end of the band using L2 and C1 when adjusting the upper 108MHz limit. This completes the testing and alignment of the TDA7000 fm radio.

Box Drilling

The box that the unit is designed to fit is the black plastic MB3. Carefully follow the drilling instructions in Figure 8. The self-adhesive trim can be used as a guide for checking the positioning of the holes in the front of the box. However, DO NOT stick the trim down until the final assembly stage is completed. Having completed the drilling, at the same time clearing away any plastic swarf, clean the box using a dry cloth.

Final Assembly

Using a good quality impact adhesive, secure the loudspeaker to the inside of the box, but be careful not to get any glue on the paper cone of the speaker. Next mount

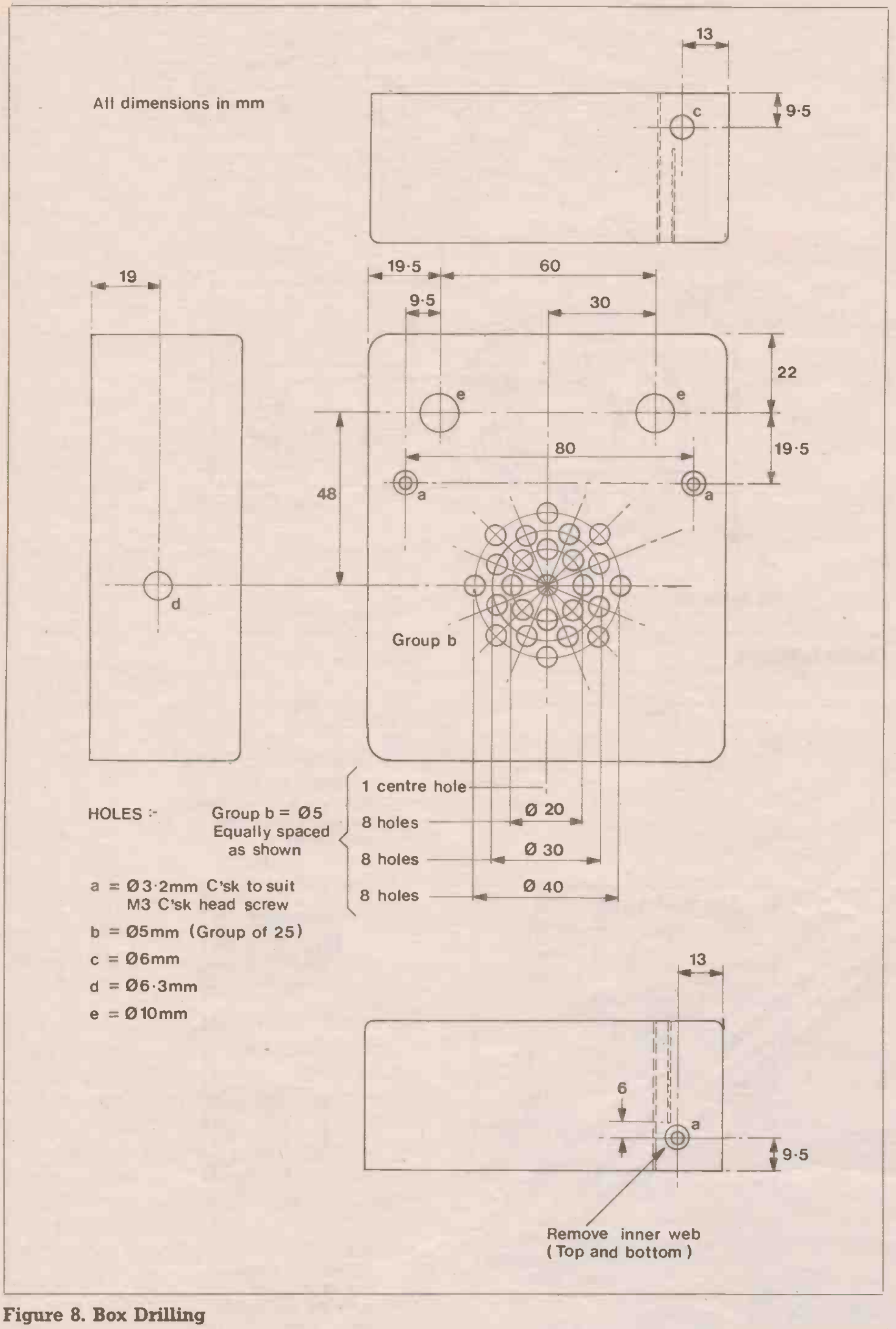


Figure 8. Box Drilling

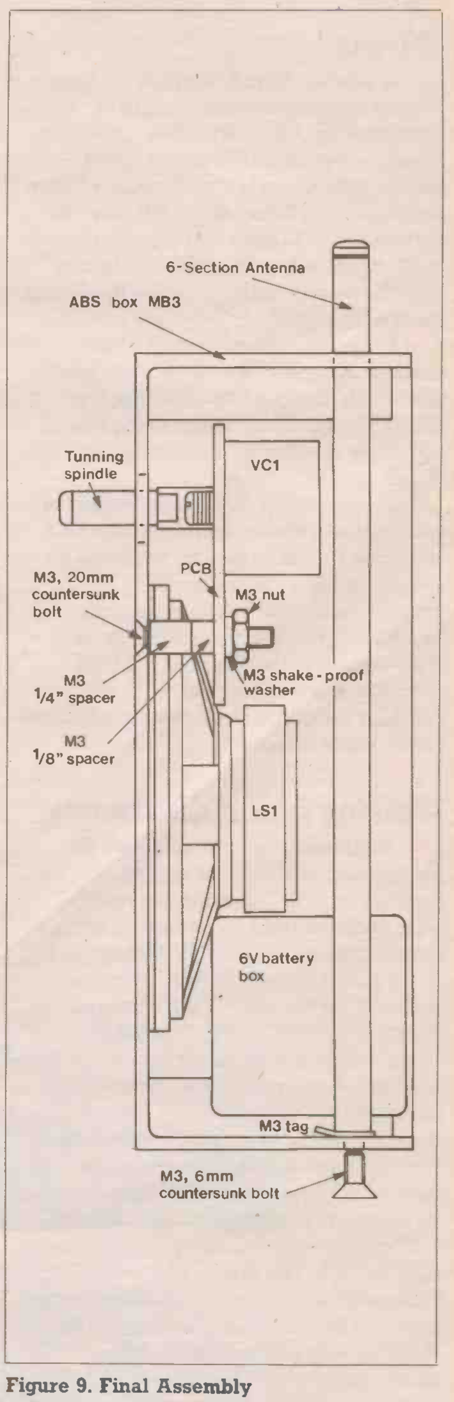
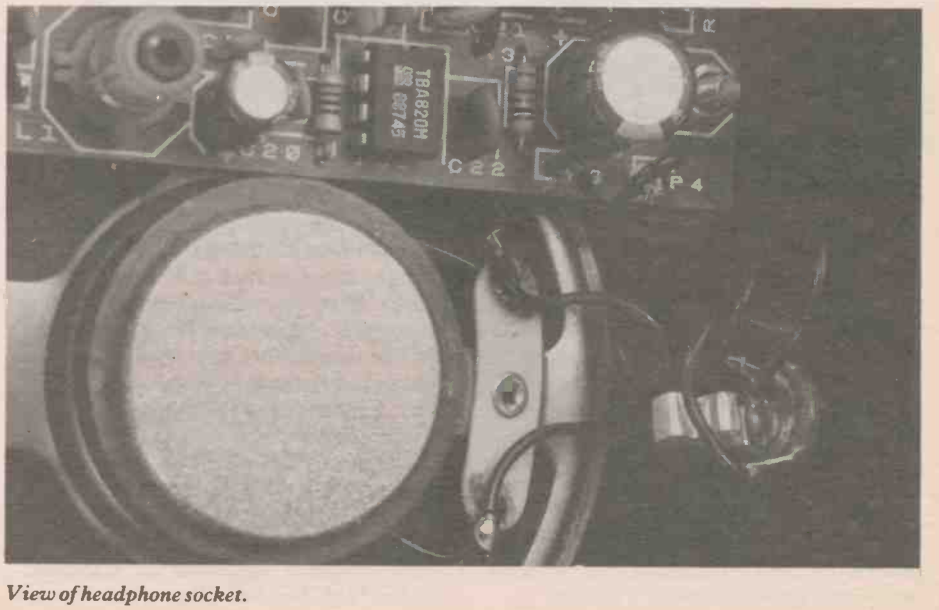


Figure 9. Final Assembly

the PCB assembly using the M3 hardware as shown in Figure 9. The 3.5mm headphone socket is then secured in the side of the box using the nut and washer provided. When fixing the telescopic aerial ensure that the M3 solder tag is tightly clamped under its base. Remove the protective backing from the trim and carefully position and firmly push it down using a dry, clean cloth until it is securely in place. Next fit the knobs so that their pointers are at the fully-anticlockwise position. Check that they travel smoothly round to the fully-clockwise position, without scraping on the front panel trim. Fit the power supply clip onto the 6V battery box and position it as shown in Figure 9. Before fitting the lid of the box, a small piece of foam rubber can be sandwiched between the battery and the inside of the lid. This will prevent the battery box from moving around inside the finished unit.



View of headphone socket.

TDA7000 FM RADIO MKII PARTS LIST

RESISTORS: All 0.6W 1% Metal Film

R1	22k	1	(M22K)
R2	33R	1	(M33R)
R3	1R	1	(M1R)
RV1/S1	10k Pot Log	1	(FW63T)

CAPACITORS

C1	220pF Ceramic	1	(WX60Q)
C2,9	330pF Ceramic	2	(WX62S)
C3,22,24,26	100nF Minidisc	4	(YR75S)
C4	2n2F Ceramic	1	(WX72P)
C5	47pF Ceramic	1	(WX52G)
C6	39pF Ceramic	1	(WX51F)
C7	150pF Ceramic	1	(WX58N)
C8,18	3n3F Ceramic	2	(WX74R)
C10	150nF Polylayer	1	(WW43W)
C11	1n8F Ceramic	1	(WX71N)
C12	22nF Ceramic	1	(WX78K)
C13,14	10nF Ceramic	2	(WX77J)
C15	10pF Ceramic	1	(WX44X)
C16	56pF Ceramic	1	(WX53H)
C17	180pF Ceramic	1	(WX59P)
C19	1µF 100V PC Electrolytic	1	(FF01B)
C20,25	100µF 10V PC Electrolytic	2	(FF10L)
C21	100pF Ceramic	1	(WX56L)
C23	220µF 16V PC Electrolytic	1	(FF13P)
VC1	AM/FM Min Tuner Cap	1	(FT79L)

SEMICONDUCTORS

IC1	TDA7000	1	(YH87U)
IC2	TBA820M	1	(WQ63T)

MISCELLANEOUS

L1	RF Coil 0.066µH	1	(UF63T)
L2	RF Coil 0.450µH	1	(UF69A)
LS1	8Ω L/S Lo-Z 768	1	(YW53H)
	PC Board	1	(GD77J)
	Control Knob K14B	2	(FK39N)
	Veropins 2145	1 Pkt	(FL24B)
	Aerial 6-section	1	(RK49D)
	Box MB3	1	(LH22Y)
	Front Panel	1	(JG28F)
	Wire 7/0.2	1 Pkt	(BL00A)
	Battery Holder 6V	1	(HF29G)
	Battery clip (PP3) Type	1	(HF28F)
	RF Coil Trim Tool	1	(UF70M)
JK1	3.5mm Chassis Socket	1	(HF82D)
	M2.5 x 6mm Isobolt	1 Pkt	(BF54J)
	M2.5 x 20mm Isobolt	1 Pkt	(JD15R)
	M2.5 Isowasher	1 Pkt	(BF63T)
	M3 x 6mm C/sk. Hd. bolt	1 Pkt	(BF36P)
	M3 x 20mm C/sk. Hd. bolt	1 Pkt	(JC71N)
	M3 Isotag	1 Pkt	(LR64U)
	M3 Isoshake	1 Pkt	(BF44X)
	M3 Nut	1 Pkt	(JD61R)
	M3 ⅛" Spacer	1 Pkt	(FG32K)
	M3 ¼" Spacer	1 Pkt	(FG33L)
	M3 ½" Spacer	1 Pkt	(FG34M)

OPTIONAL

	Battery R6S Silver Seal	4	(FK59P)
	Mag Earpiece 3.5mm	1	(LB24B)

A complete kit of all parts, excluding Optional items, is available:
Order As LM55K (TDA7000 FM Radio MKII Kit) Price £19.95
The following items are also available separately,
but are not shown in our 1988 catalogue:
TDA7000 MkII PCB **Order As GD77J Price £2.95**
TDA7000 MkII Front Panel **Order As JG28F Price £1.95**

TOP TWENTY BOOKS

1. (1) Loudspeaker Enclosure Design and Construction. (WM82D) Cat. P82.
2. (7) Mastering Electronics, by John Watson. (WM60Q) Cat. P77.
3. (2) MIDI Projects, by R.A. Penfold. (WP49D) Cat. P83.
4. (3) Power Supply Projects, by R.A. Penfold. (XW52G) Cat. P78.
5. (16) How to get Your Electronic Projects Working, by R.A. Penfold (WA53H) Cat. P77.
6. (4) IC555 Projects, by E.A. Parr. (LY04E) Cat. P80.
7. (11) Introduction to Electronics, by Pam Beasant. (WP50E) Cat. P77.
8. (8) Projects for the Car and Garage, by Graham Bishop. (XW31J) Cat. P79.
9. (–) Beginner's Guide to Building Electronic Projects, by R.A. Penfold. (RF09K) Cat. P77.
10. (9) Adventures with Micro-Electronics, by Tom Duncan. (XW63T) Cat. P77.
11. (6) International Transistor Equivalents Guide, by Adrian Michaels. (WG30H) Cat. P73.
12. (15) How to Design and Make Your Own PCB's, by R.A. Penfold. (WK63T) Cat. P76.
13. (13) Electronic Security Devices, by R.A. Penfold. (RL43W) Cat. P79.
14. (–) Modern Opto Device Projects, by R.A. Penfold (WP74R) Cat. P81.
15. (18) 50 Simple LED Circuits Book 2, by R.N. Soar. (WG43W) Cat. P80.
16. (14) Electronic Timer Projects, by F.G. Rayer. (WG72P) Cat. P79.
17. (17) How to Use Op-Amps, by E.A. Parr. (WA29G) Cat. P76.
18. (–) Servicing Radio, Hi-Fi and TV Equipment, by Gordon J. King. (WG89W) Cat. P85.
19. (–) An Introduction to 68000 Assembly Language, by R.A. & J.W. Penfold (WP54J) Cat. P87.
20. (10) Model Railway Projects, by R.A. Penfold. (WG60Q) Cat. P79.

These are our top twenty best selling books based on mail order and shop sales during January, February and March 1988. Our own magazines and publications are not included. The Maplin order code of each book is shown together with page numbers for our 1988 catalogue. We stock over 250 different titles, covering a wide range of electronics and computing topics.

'Hello Who's Calling?'

by J.K. Hearfield

How Telephones were Invented

In 1854 a paper was published by Charles Bourseul in which he described an experiment. "Suppose", he wrote, "a man speaks near a movable disc sufficiently pliable to lose none of the vibrations of the voice. If this disc alternately makes and breaks currents from a battery, you may have at a distance another disc, which will simultaneously execute the same vibrations . . . It is certain that, in the more or less distant future, speech will be transmitted by electricity". In 1876, Alexander Graham Bell's assistant, Mr. Watson, was the first man to have his work interrupted by a telephone call, and life has never been the same since.

Picture 1 shows Bell's first telephone of 1876. Bell's telephone consisted of a mobile iron diaphragm placed in the field of a polarised electromagnet, so arranged that any movement of the diaphragm produced a change in field. The same principle was used for both transmitting and receiving, so a conversation could be held between two identical instruments.

Bell was invited to demonstrate his wonderful machine to Queen Victoria at Osborne House in January 1878, and in 1879 the Telephone Company Limited was formed. The company was given a licence to use the Bell patents and opened its first telephone exchange in London the same year.

Picture 2 shows a fretwork fronted telephone, 1878 – one of the first used by the British Post Office. The user spoke into the microphone concealed behind the fretwork cover. Later in 1879, the Edison Telephone Company of London Limited opened a rival telephone exchange. Edison's design of microphone was more efficient and more practical than Bell's. It used the speech energy to compress a piece of carbon, thus varying its resistance. Two years later, the Reverend Hunnings built an even better microphone in which carbon granules replaced the single carbon block, and this design has formed the basis of most telephone microphones ever since. Picture 3 shows Edison's telephone of 1879 with its carbon transmitter and chalk receiver.

Why the Post Office Intervened

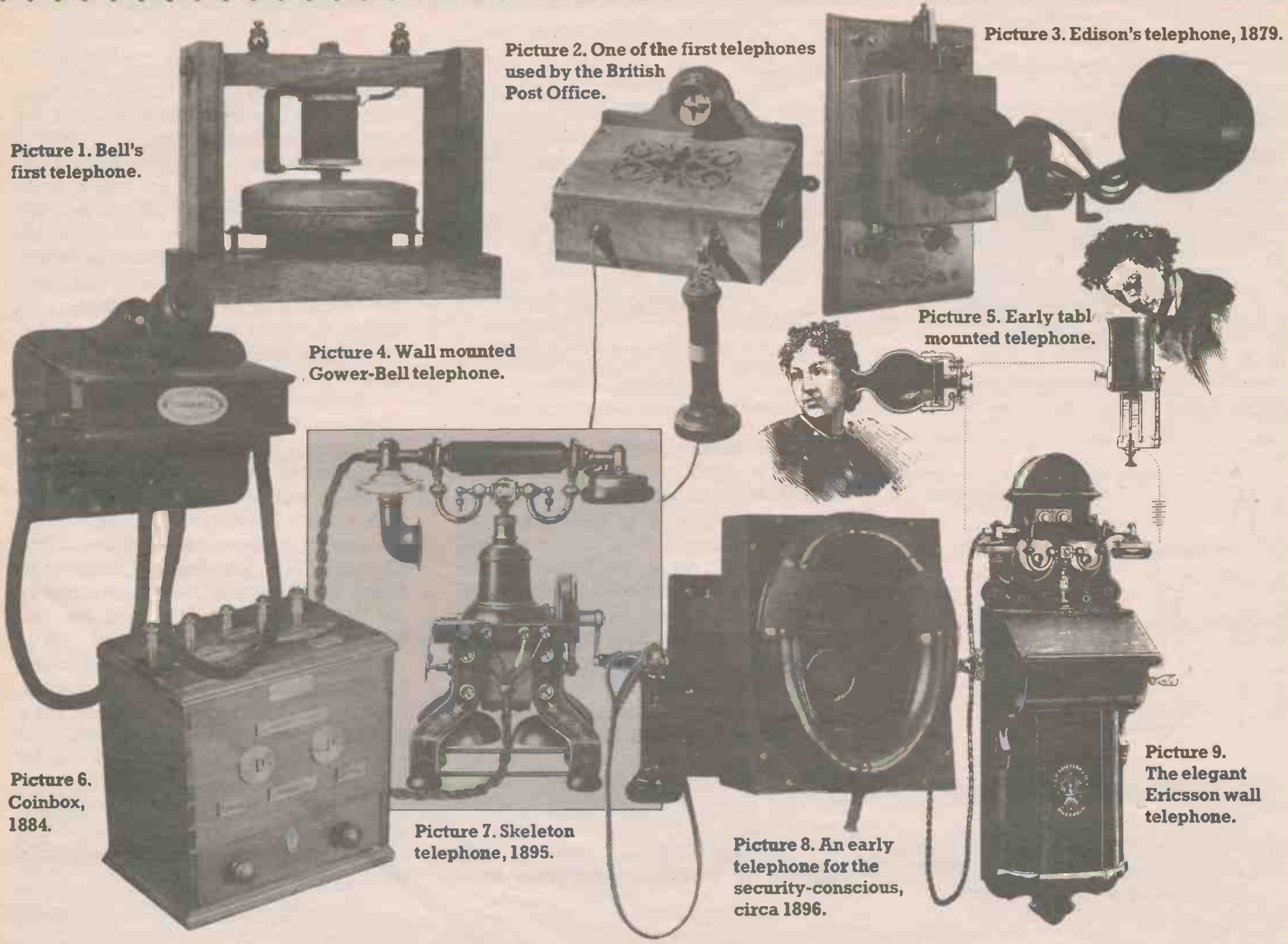
In 1880, the two telephone companies amalgamated to become the United Telephone Company, holding patents for both systems. This new telephone system threatened the then sole means of long-distance communication: the telegraph. Telegraphs were already under the control of the Post Office and, after successfully arguing that telephone calls were similar to telegrams, the Post Office was granted sole control of telephone systems by the High Court in 1880.

The Post Office then granted licences to such as the National Telephone Company to open and operate telephone exchanges. Usually the National Telephone Company operated within towns and cities, the Post Office providing the trunk lines and rural exchanges. London and Birmingham were linked in 1890, and London and Paris the following year.

The Post Office also opened a number of telephone exchanges in different cities and in 1899 an Act of Parliament enabled local authorities to operate their own exchanges. Of the few cities which took advantage of this, only the Hull system remains today as an independent telephone company.

Picture 4 is of the Gower-Bell telephone, circa 1881; the two flexible tubes were held to the ears. Elisha Gray's telephone of 1882 is shown in Picture 5 and Picture 6 shows the Smith and Sinclair coinbox.

The first public telephones were installed in shops as early as 1884. Only non-subscribers were required to use coins to pay for their calls – telephone company subscribers were issued with pass keys. The coinbox had separate



Picture 1. Bell's first telephone.

Picture 2. One of the first telephones used by the British Post Office.

Picture 3. Edison's telephone, 1879.

Picture 4. Wall mounted Gower-Bell telephone.

Picture 5. Early tabl[e] mounted telephone.

Picture 6. Coinbox, 1884.

Picture 7. Skeleton telephone, 1895.

Picture 8. An early telephone for the security-conscious, circa 1896.

Picture 9. The elegant Ericsson wall telephone.

coin slots for local calls (2d) and trunk calls (6d).

The rather elegant Ericsson skeleton telephone of 1895, also known as the Telephone No. 16 (shown in Picture 7), is an example of good industrial design, since the induction coil for the speech circuits is hidden inside the bell shape which supports the cradle for the handset (then called the 'microtelephone'), and the curved legs form the magnets for the hand generator. The local battery is accommodated in a separate box, enabling the telephone to be used as a table rather than wall-hung model.

By contrast, the horse-collar telephone shown in Picture 8 was widely disliked. The idea was simple: a caller who did not wish to be overheard could press his face against the rubber collar, emerging presumably from time to time in order to breathe. Users thought it too unhygenic, and the design didn't last long.

Basic Telephony Principles

The simplest possible two-way telephone circuit is shown in Figure 1. It consists of a microphone, sometimes called a 'transmitter', and a receiver at each end of the line, with a battery somewhere in the circuit to provide the DC needed by the microphones. A microphone translates variations in sound pressure into variations of resistance, so that the current flowing around the circuit depends partly on the instantaneous sound pressure at each microphone. A receiver works rather like a loudspeaker, translating the small current variations into varying forces on a diaphragm and hence back into variations in sound pressure.

This circuit has several major disadvantages. First, and perhaps most important, it is very inefficient. The resistance of a microphone is quite small compared to the resistance of the whole circuit, so variations in this resistance can produce only minute variations in the circulating current. In energy terms, there is a very poor impedance match between the source (the microphone) and its load.

Second, the same current flows through both receivers, so the person speaking hears himself at the same sound level as does the person listening. This local reproduction of outgoing speech is known as 'sidetone', and too much sidetone has the unfortunate psychological effect of causing the speaker to lower his voice, further degrading the effective performance of the circuit. The DC flowing through the receivers is not in itself a problem, since early receivers used it to power the electromagnets they used. Modern receivers are designed around permanent magnets however, and would not work well in this circuit.

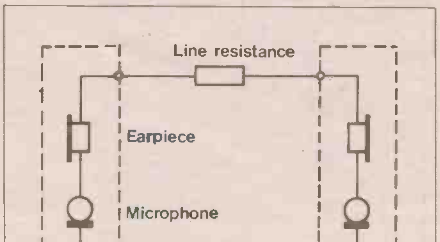


Figure 1. The simplest possible telephone connection.

Third, there is no means of signalling in either direction. The circuit consumes the same amount of power whether or not it is actually in use.

The Local Battery (LB) circuit, shown in Figure 2, was devised to overcome at least some of these shortcomings. The microphone now sees just the low (and constant) resistance of the induction coil primary, which also improves its impedance match to the line. The match will rarely be exact, of course, because each telephone will be connected to a different length of line. The induction coil is a special type of transformer in which the magnetic circuit is deliberately not closed. This avoids the problems of core saturation that would otherwise occur due to the large DC flowing through one or both windings.

The simple LB telephone still has no means of signalling either that the user wishes to make a call or that an incoming call has arrived. The first attempts to provide signalling involved the use of a trembler bell, as illustrated in Figure 3. This circuit also illustrates how the hooks-

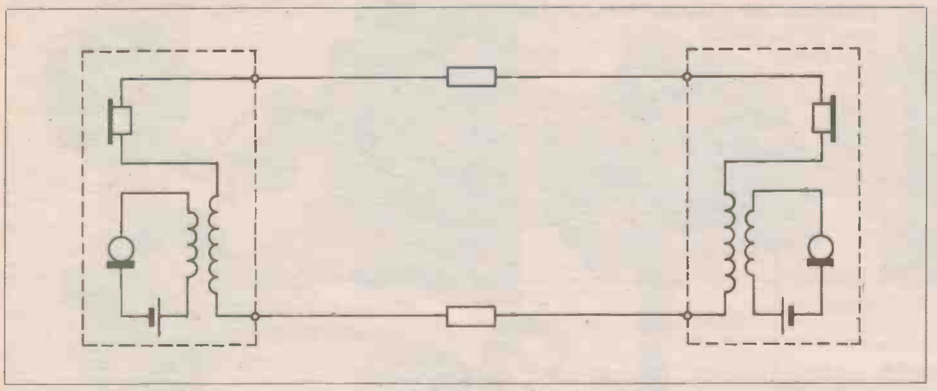


Figure 2. Local battery telephone principle.

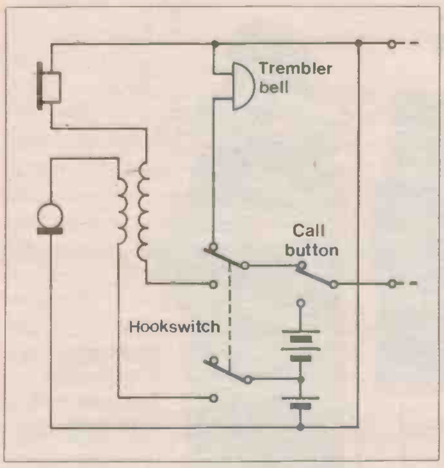


Figure 3. Local battery telephone with signalling.

witch (or 'gravity switch' as it was then called) is used to change the circuit configuration depending on whether or not the telephone is in use. In the idle state, the microphone circuit is broken, and the bell is connected across the line ready to detect an incoming ring signal (which in this case is just a battery applied across the line by the calling party). In use, the microphone is powered up and the receiver connected across the line in place of the bell. The user signals he wishes to make a call by pressing the CALL button, which connects the two batteries in series across the line in order to ring the bell at the distant end.

Trembler bells are however only suitable for signalling over quite short lines. For longer lines, a more efficient solution is to use high voltage AC, and the magneto – a hand-cranked alternator – quickly became a standard fitment on telephones. It was used not only to alert the operator that the user wished to make a call, but also to signal the end of the call by ('ringing off'). A magneto generally included some means of switching itself into circuit only when the handle was turned, as Figure 4 illustrates, to prevent its low resistance from affecting the speech performance of the telephone.

Picture 9 shows the Ericsson LB wall telephone, the ornate casing concealed the magneto generator (operated by the handle visible on the right hand side) and the large and sometimes messy battery cells mounted underneath.

One of the most popular designs was the so-called 'candlestick' telephone, which was known in its various forms as the Telephone No. 2, No. 4 and No. 150. The circuit diagram of the Type 150 is shown in Figure 5, and though it appears to differ only slightly from earlier circuits, it was in fact designed to work within a quite new system concept, known as Central Battery Signalling, which will be discussed in the next article.

Acknowledgement: All telephone illustrations are reproduced by courtesy of the archivist at The Telecom Technology Showcase.

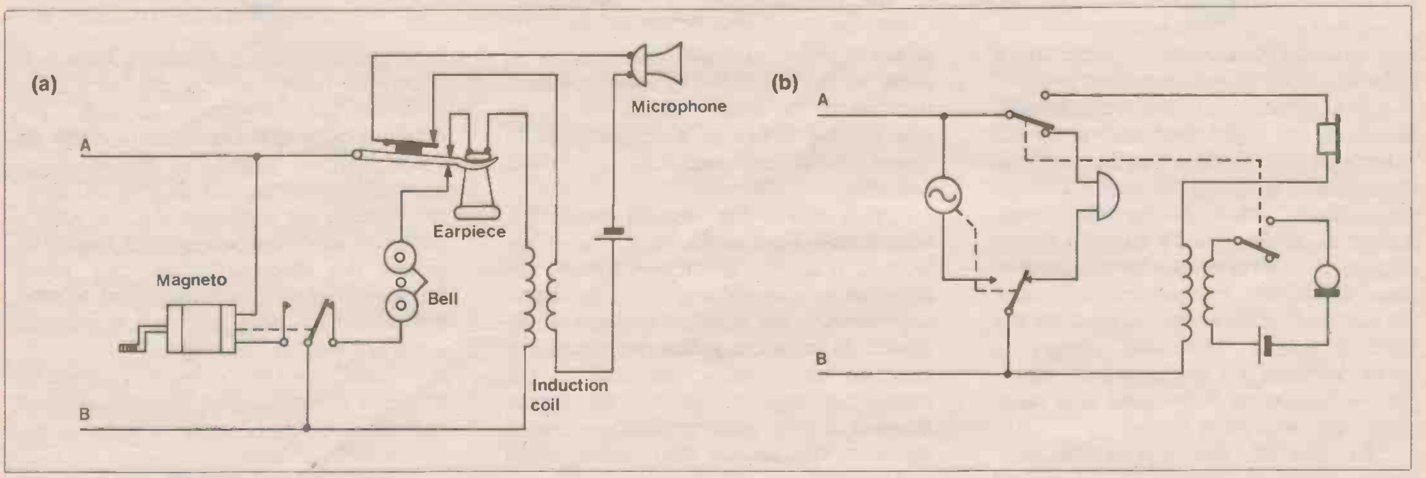


Figure 4. The Telephone No. 11 circuit (a) as it would have been drawn at the time, (b) redrawn with modern symbols.

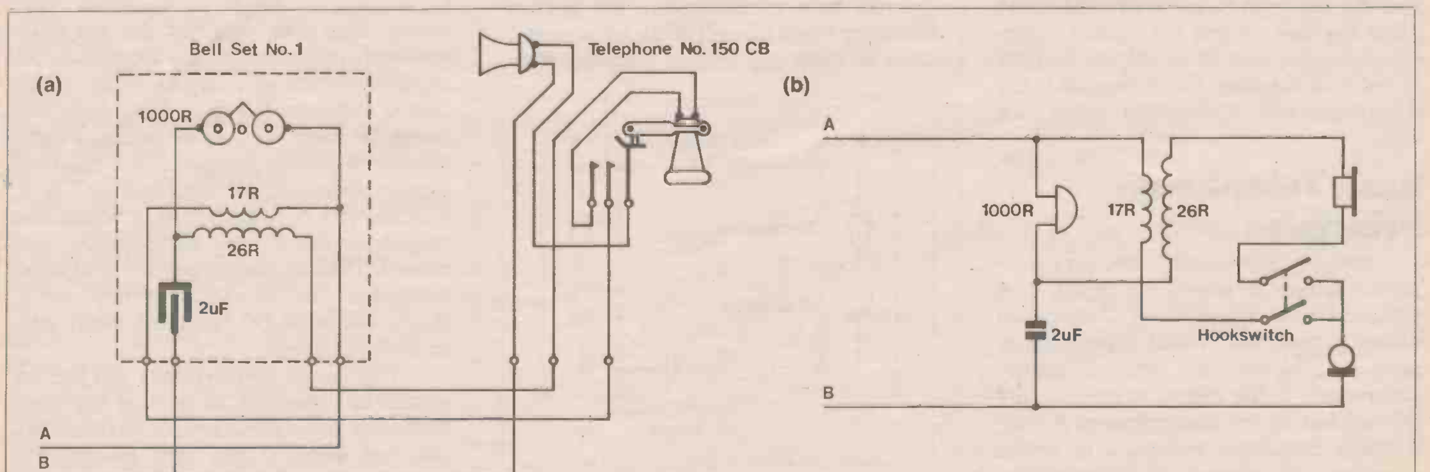
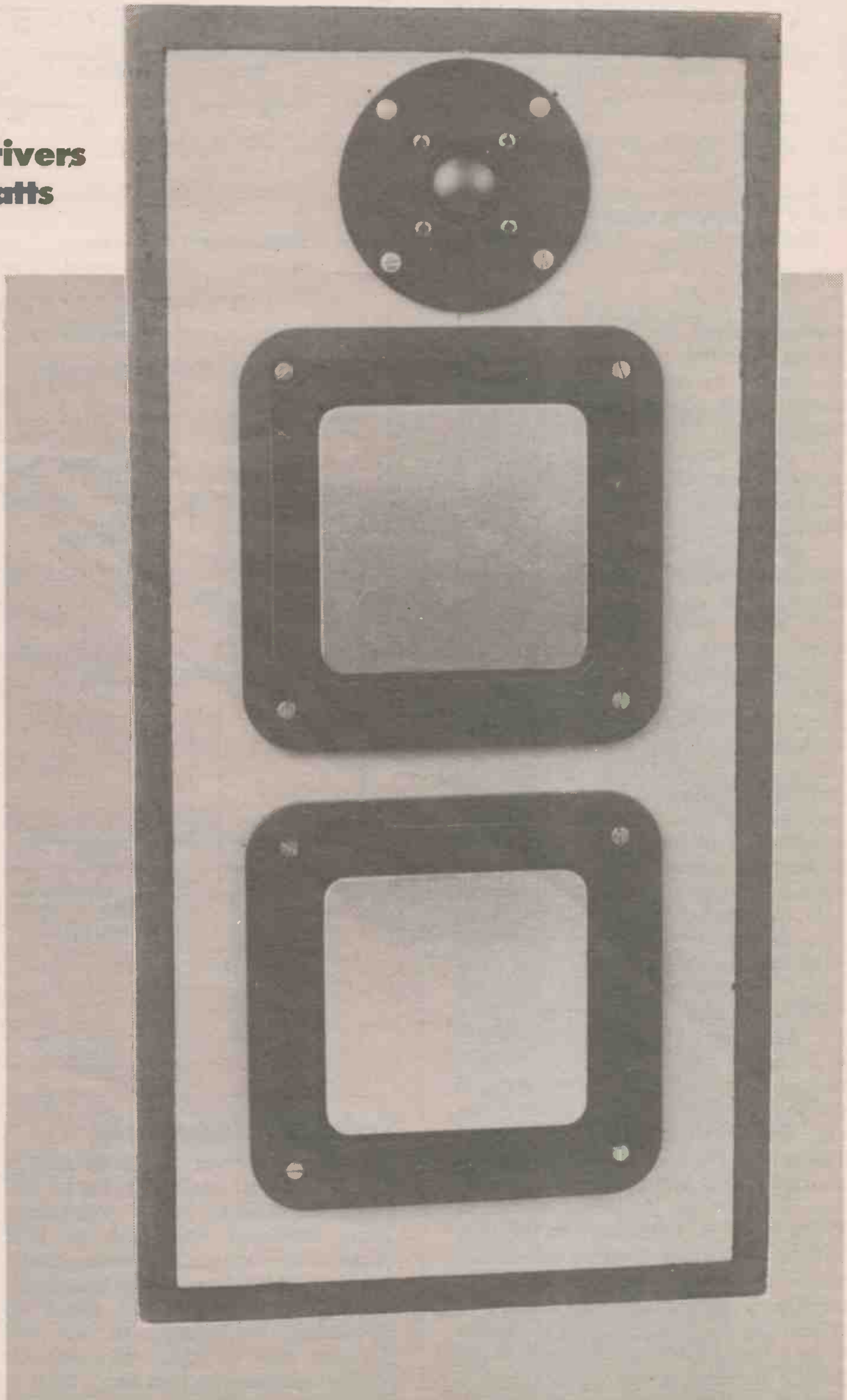


Figure 5. The 'candlestick' telephone circuit (a) in its original form, (b) redrawn with modern symbols.

3 WAY LOUDSPEAKER SYSTEM

by Dave Goodman

- ★ **20 Litre cabinet design**
- ★ **3-way speaker system, HF, Bass and passive drivers**
- ★ **40Hz to 15kHz at 25 Watts**



A loudspeaker cabinet design based on the square bass transducer and matching passive radiator, developed for use in 20 Litre cabinets. The passive radiator does not have a magnet or voice coil and is not driven electrically at all; instead, the diaphragm – piston – is driven by changes in air pressure produced from the bass speaker. The amount of movement that the piston makes is determined by the transducer and cabinet resonance, piston mass/suspension compliance, frequency and power. As the transducer diaphragm moves inward the radiator moves outward, but not exactly at the same time, otherwise – if that were so – the sound waves would be 180° out of phase and cancel out! Of course phase cancellation does occur at different areas of the frequency spectrum in this type of system and fine tuning the radiator piston and cabinet wadding can minimise this effect.

Infinite baffle (sealed cabinet) and ported reflex cabinets are, by far, the most commonly used systems in use, mainly due to their excellent performance and design/manufacture simplicity. Both types have their relative merits for example: ported cabinets are usually much larger in volume, for a given loudspeaker type; sealed cabinets have a smoother low frequency response cut off; ported designs can have a lower frequency response, but exhibit a sharp cut off slope; sealed designs are simple to develop and make.

The passive radiator design fits between the two types and exhibits the properties of both cabinets in its simple, small construction and excellent low frequency response. Due to the small cabinet volume of 20 Litres, their is an inevitable peak or hump in the response as can be seen from Figure 1, similar in effect to a ported enclosure response. Booming, often associated with this peak in ported and sealed enclosures, is not

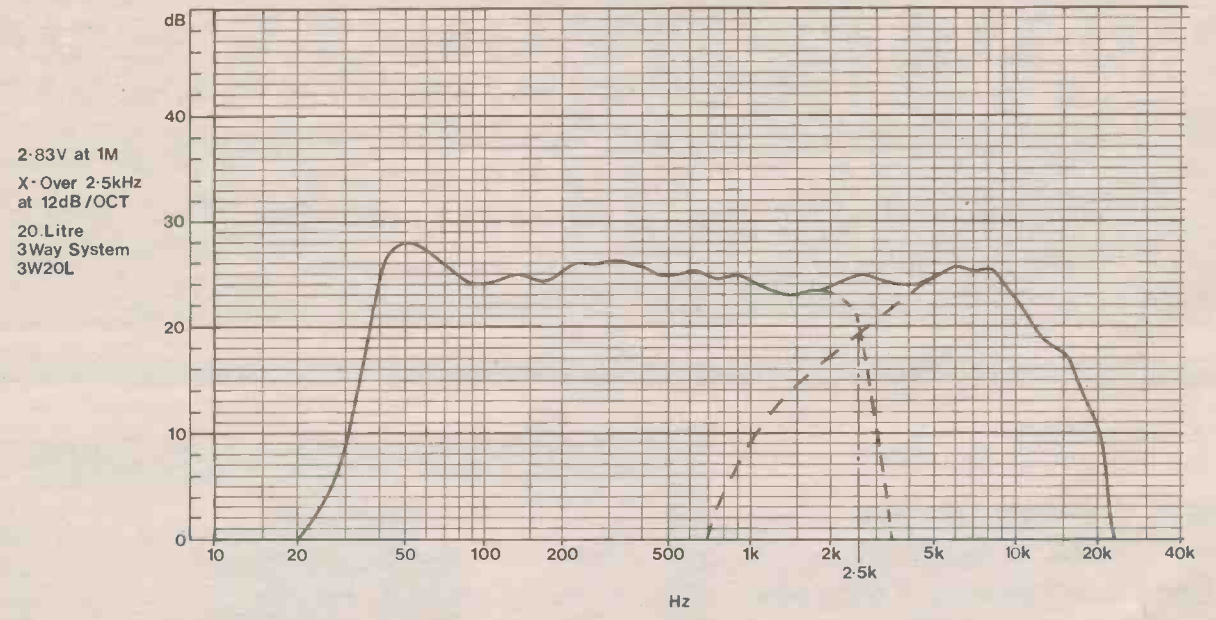
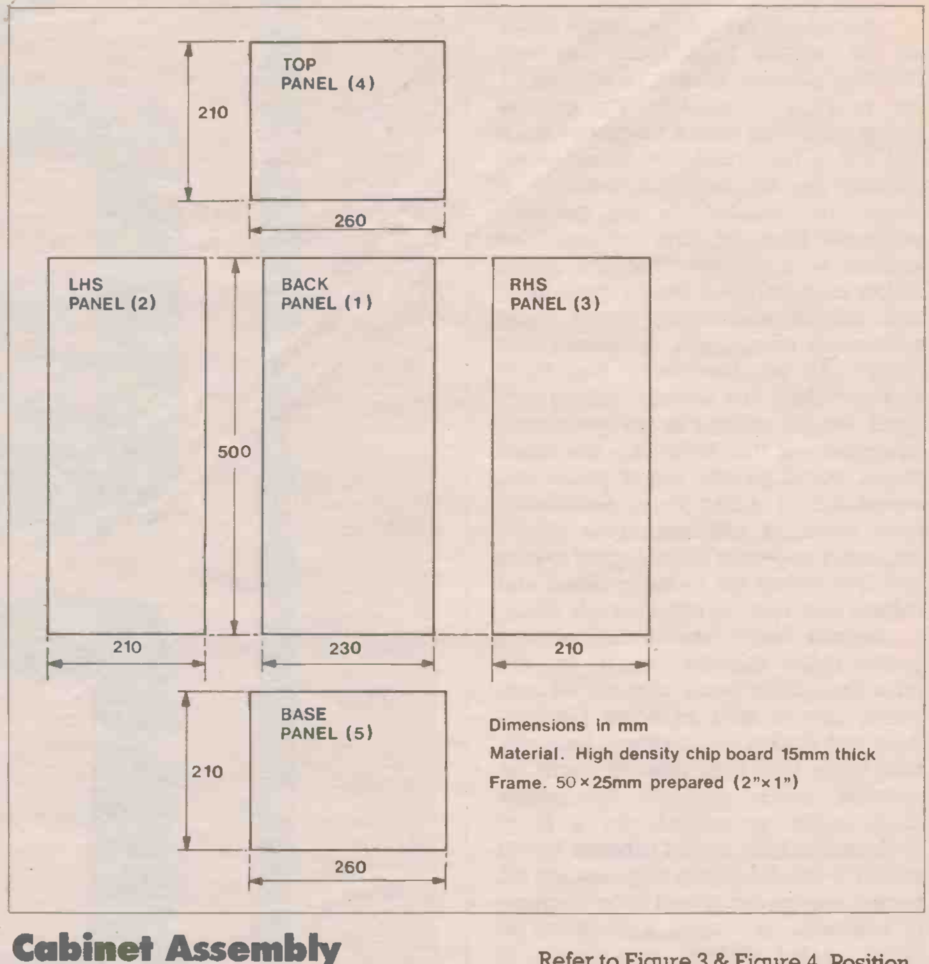


Figure 1. Frequency response.

Figure 2. Cabinet panel dimensions.



prevalent here, due to the transducer design, although its effect is mostly determined by room volume and resonance. Small volume rooms below 21 cubic metres – 2.5 x 3.5 x 2.4 for example may well resonate at 60 to 90Hz depending on wall ratios and proportions and under these circumstances the bass output will be enhanced (or reduced!).

Positioning of loudspeakers in a room is virtually a science by itself and cabinets that perform excellently in a Hi-Fi show room often sound lacking when installed in a domestic environment. High frequency sound waves are quite directional and easily deflected by hard, solid objects: walls, sideboards, windows, tables, etc., are all responsible for this and can add to the reverberative muddle experienced. Soft furnishings such as furniture, curtains and carpets will absorb high frequency sound waves, making the cabinet output more directional and, apparently, lower in intensity. Low frequency sound waves pass through solid objects quite easily and walls become transparent, as many of us have probably experienced with the neighbours choice of music perhaps!

When siting loudspeaker enclosures in a room, a general rule of thumb is to use the room corners to reflect some of the low frequency sound energy that emanates from the back of the cabinet. This sets up standing waves which travel across the floor and greatly enhance the 'feel' or 'solidness' of percussive sounds. Try to angle the enclosures so that they both face toward the listening area at 'ear' height and away from furnishings as much as possible. More often than not, this arrangement requires the enclosure to be raised a metre or more above the floor to be clear of obstructions, with a subsequent drop in bass performance – the choice is yours!

Cabinet Assembly

The five cabinet panels, detailed in Figure 2, are not supplied in the kit and should be obtained by the constructor. 15mm laminated chipboard, or high density chipboard such as flooring grade, can be used for the panels as long as the top panel (4) and bottom panel (5) dimensions are altered to suit any deviation from the 15mm thickness. Do not use materials less than 15mm thick or fibreboard, blockboard and hardboard types of material.

Refer to Figure 3 & Figure 4. Position, glue and nail vertical (9) onto side panel (2) allowing for the back panel (1) thickness of 15mm or more, and do the same to vertical (8) on side panel (3). Drill six screw clearance holes in each side panel (2) & (3), 7mm in from the front edge and countersink for the 38mm screw heads. Apply wood glue to the long edges of the baffle board, fit side panels (2) & (3) ensuring all sides and edges are exactly in line and insert 3 x 38mm screws in each panel.

Cutting list: (not supplied)		
15mm high density chipboard		
2 panels	210 x 260mm	(4 & 5)
2 panels	210 x 500mm	(2 & 3)
1 panel	230 x 500mm	(1)
1.5 metres 2 x 1 inch Prepared (44 x 21mm)		
2 verticals	500mm long	(8 & 9)
2 horizontals	188mm long	(6 & 7)
Miscellaneous parts: (not supplied)		
24 x 1.5 inch (38mm) csk chipboard screws		
6 x 1.25 inch wire nails		
Resin wood glue		
Optional parts: (not supplied in kit)		
Impact adhesive		(FL43W)
Hot melt glue gun		(YP71N)
Spare glue sticks		(FS97F)
Flexible rubber sealer		(YJ91Y)

Table 1.

Fit the back panel (1) in place and insert 3 x 38mm screws in each side panel, but DO NOT apply glue as the back panel will be removed later. Drill four screw clearance holes in each end panel (4) & (5), 7mm in from the edges and countersink as before (see Figure 5). Apply wood glue to the top edge of side panels (2) & (3) and top edge of the baffle board only, place panel (4) in position and insert the 4 X 38mm screws. Depending on panel thickness used, the top front screw may break through into the tweeter mounting hole, in the baffle. In this position only, use a shorter screw or cut/file the screw down after insertion. Apply glue to the side panel and baffle – bottom edges and fit panel (5) using 4 x 38mm screws. Remove the six back screws and back panel (1) before the glue dries. Wipe away any excess glue that may have been squeezed out from the joints and fit the two remaining horizontals (6) & (7), again using glue and nails. Drill a hole in the back panel, of a size suitable to take the cable used for connecting to an amplifier, leave the cabinet assembly for the glue to dry and proceed with the crossover module modifications.

X-Over Modifications

With reference to Figures 6 & 7, take the 10mm ferrite rod and cut a piece (A) 25mm long and another piece (B) 40mm long, using a hacksaw. Ferrite is a very brittle material which breaks easily if dropped or excessive pressure is applied whilst sawing! Orientate the x-over module, as Figure 7, and insert (A) into the former, apply adhesive or hot melt glue around the edge of the rod, to hold in place. Insert (B) into the HF filter coil on the right hand side. The 40mm long rod protrudes about 15mm above the former; again run a fillet of adhesive around the edge as shown. The driver transducer piston is covered with an

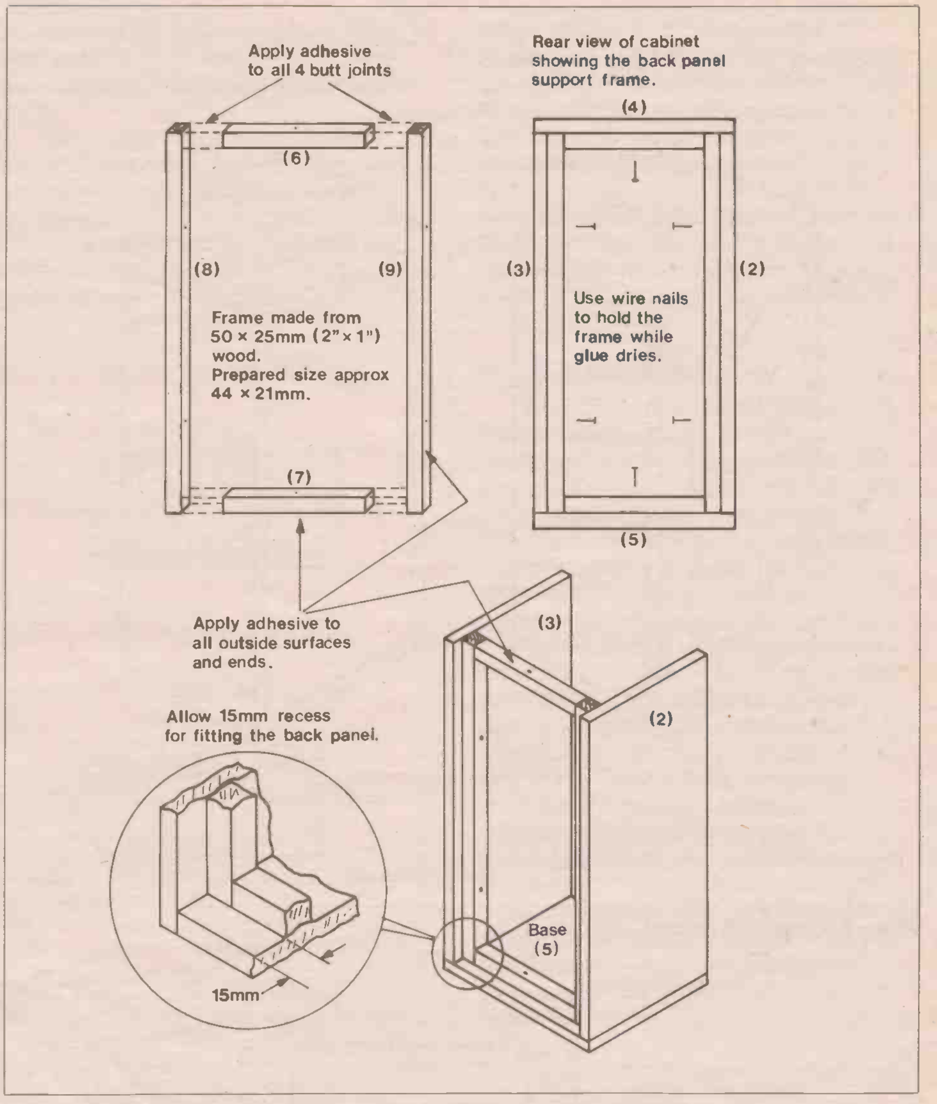


Figure 3. Back panel framework.

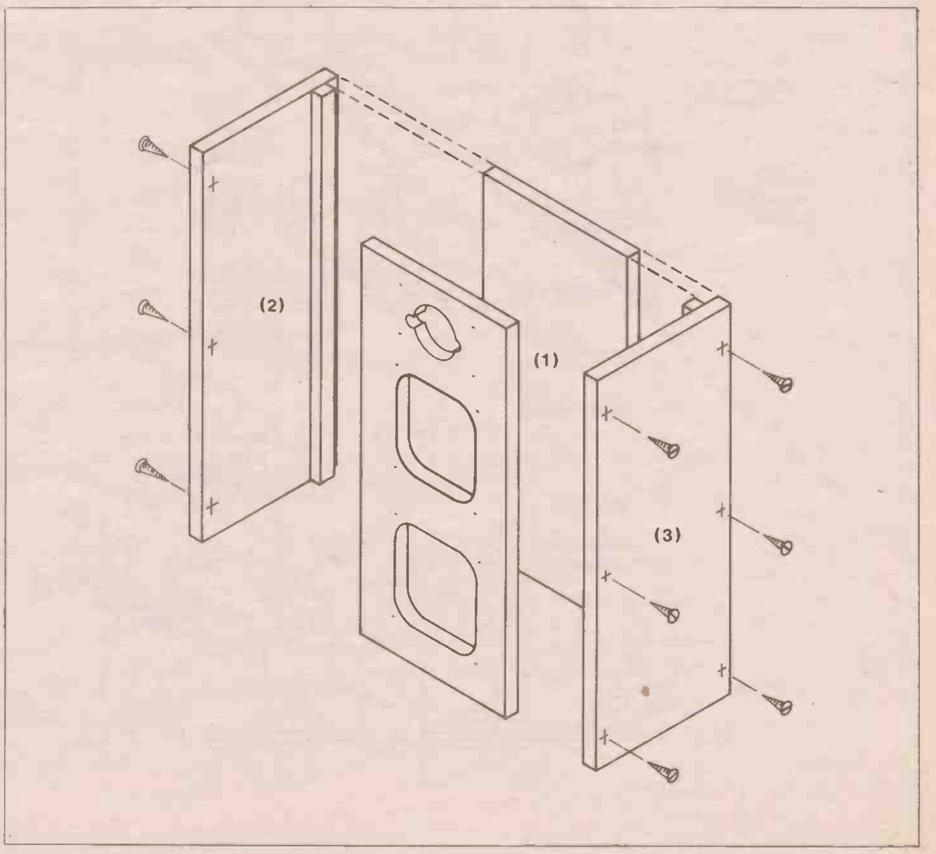


Figure 4. Panel assembly.

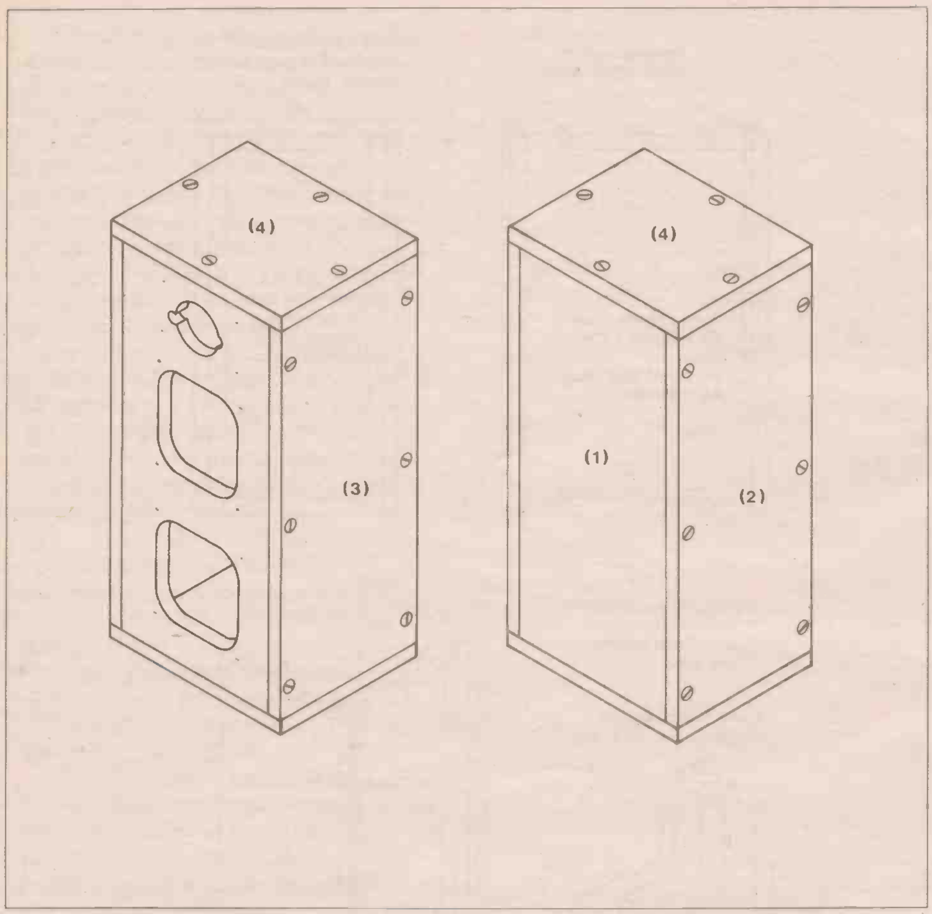


Figure 5. Completed cabinet.

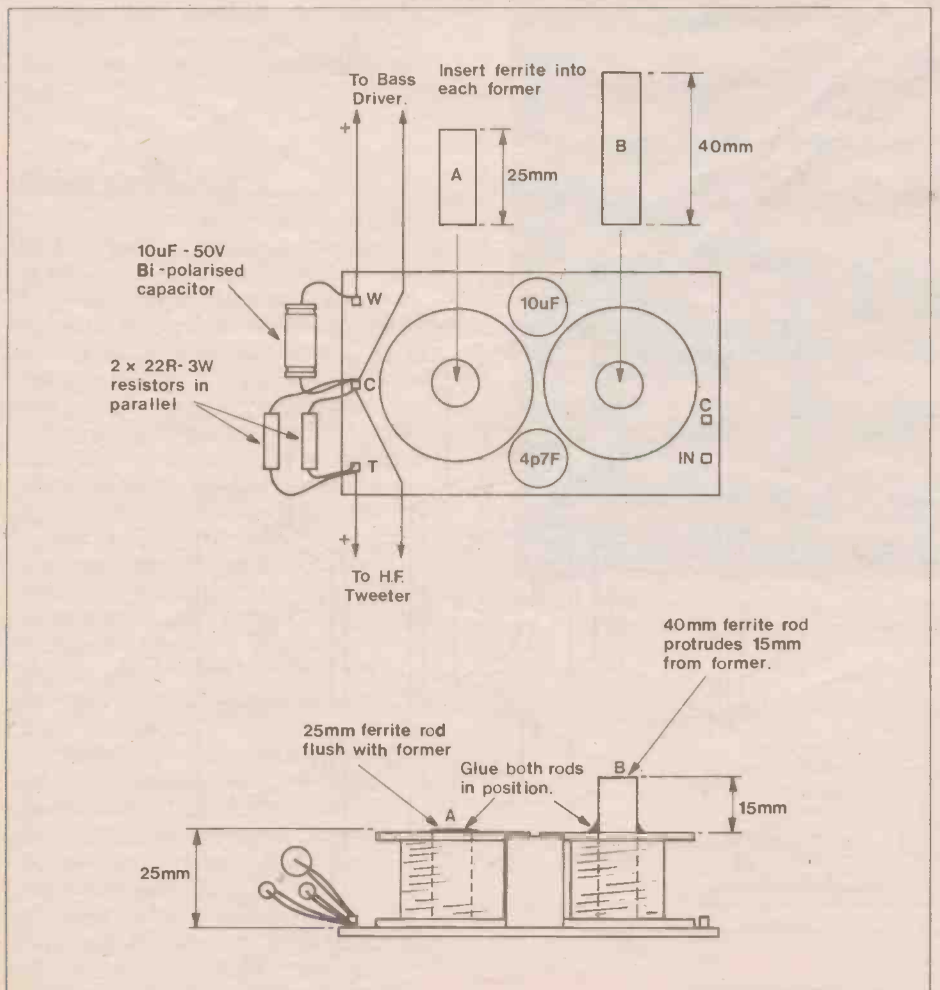


Figure 7. Modifying the crossover.

aluminous polymer layer which emits a typical bandpass – peaking – effect in the upper speech area, around 3kHz. This phenomenon does nothing to enhance reproduction quality and disappears when the modifications are made to the x-over. Fit a 10μF bipolar capacitor between common (0V – terminal C) and the bass speaker (Woofer – terminal W). The two 22R parallel resistors need only be fitted between common C, and tweeter terminal T, if the high frequency output of the tweeter sounds excessive. This being so, fitting the resistors will attenuate the tweeter output by approximately 3dB, which might be found more acceptable!

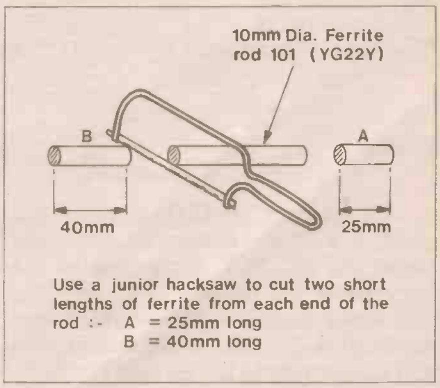


Figure 6. Cutting the ferrite rod.

Cabinet Wadding

Cut two pieces of wadding approximately 500mm x 150mm, to snugly fit each inside panel (2 & 3), behind the wood frame. Apply liberal amounts of adhesive to the panels and stick the wadding in position, as in Figure 8. Cut two smaller pieces of wadding 230mm x 150mm to fit inside on panels (4 & 5) and cut out a 100mm x 60mm section to clear the crossover, glue both in place. Cut and solder two lengths of wire to the crossover module with the black lined conductors connected to the common terminal, C (see Figure 9). Insert the module into the cut-out section of the wadding, and screw down with 4 x 0.5in self tappers. Finally, cut two 450mm x 180mm pieces of wadding for gluing one above the other, onto the back panel. Allow enough room around the edges for the wadding to clear the frame, once the panel is in position.

Loudspeaker Fixing

The three loudspeakers are mounted into the baffle from outside and held in place with 4BA x 1.5in bolts. Take care when handling the square bass driver and passive radiator, as the aluminium polymer covering on the piston can be permanently damaged from mishandling. The tweeter dome can also be damaged very easily, therefore the dome grille should be fitted by; first removing the four pozi-screws on the tweeter plate, (do not remove the magnet or voice coil!) position the grille over the soft dome and replace the four screws.

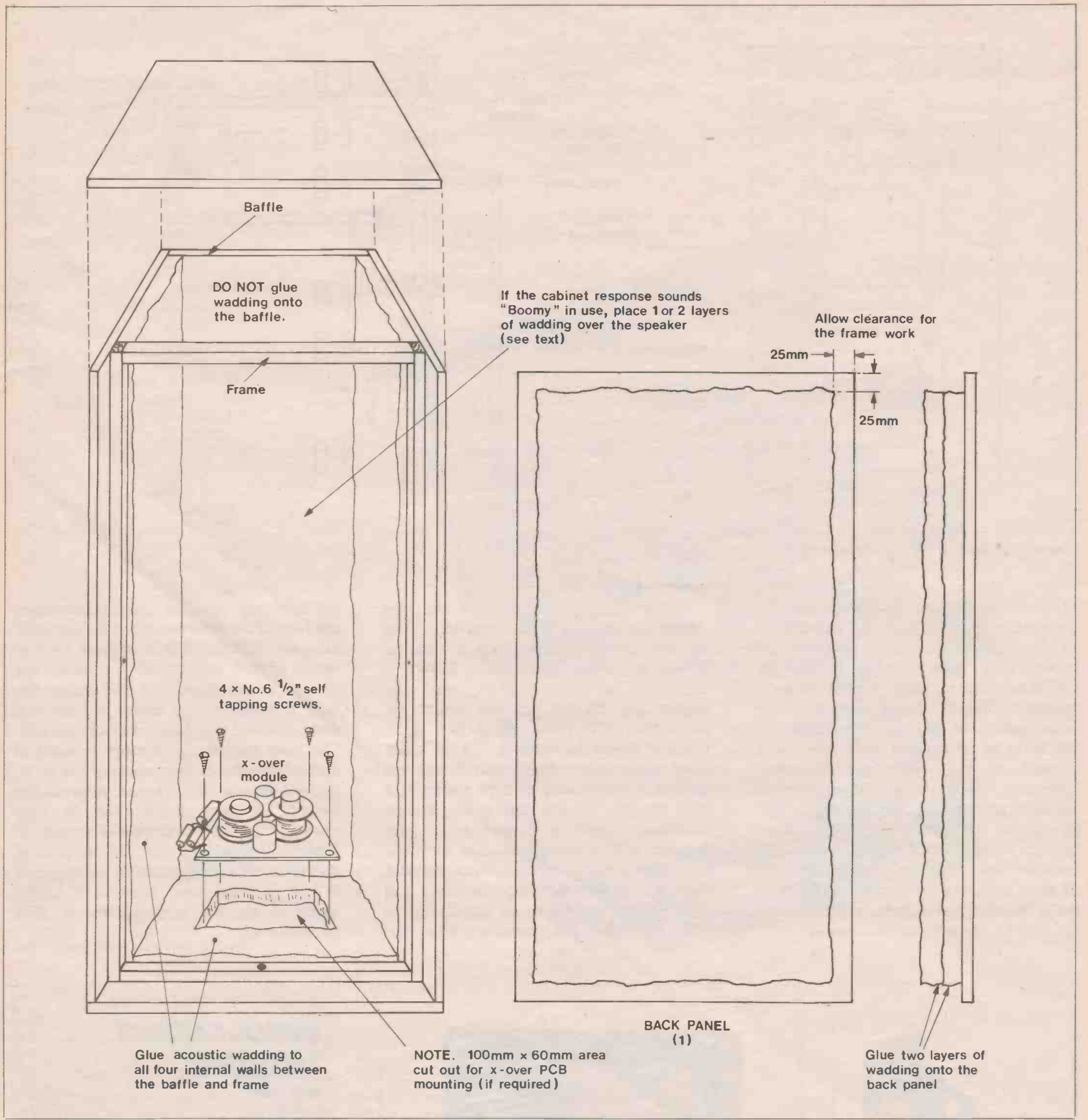


Figure 8. Fitting wadding and crossover unit.

Bring the tweeter connecting wire, from the crossover module, out through the baffle tweeter cut-out and solder to the tweeter terminals. The +V terminal must be connected to T on the module. Extend the bass driver wire through the baffle cut-out as before, connect the +V or red marked terminal to W on the module. Place both speakers into their mounting positions on the baffle, fit the plastic trim onto the driver and use four screws, shake washers and nuts to hold in place. Mount the passive radiator in the same way. Tighten the nuts well and squeeze a layer of glue or rubber sealer over each nut and bolt shank, to prevent them from shaking loose in use. Rubber sealer is recommended for squeezing along all

Crossover (unmodified).

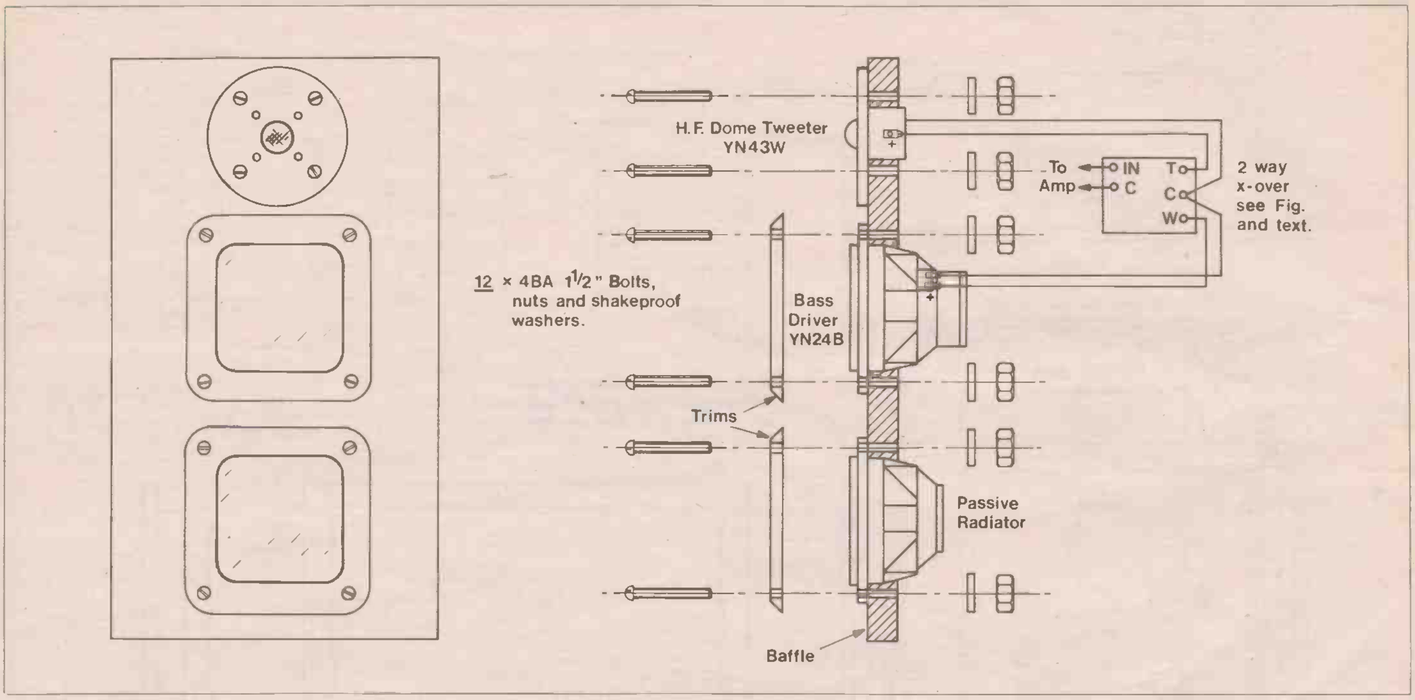
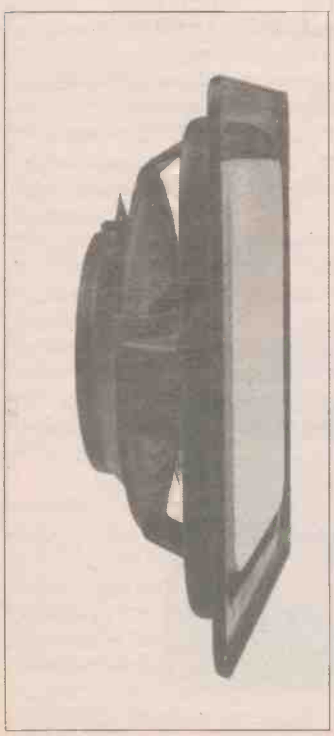


Figure 9. Installing the loudspeakers.

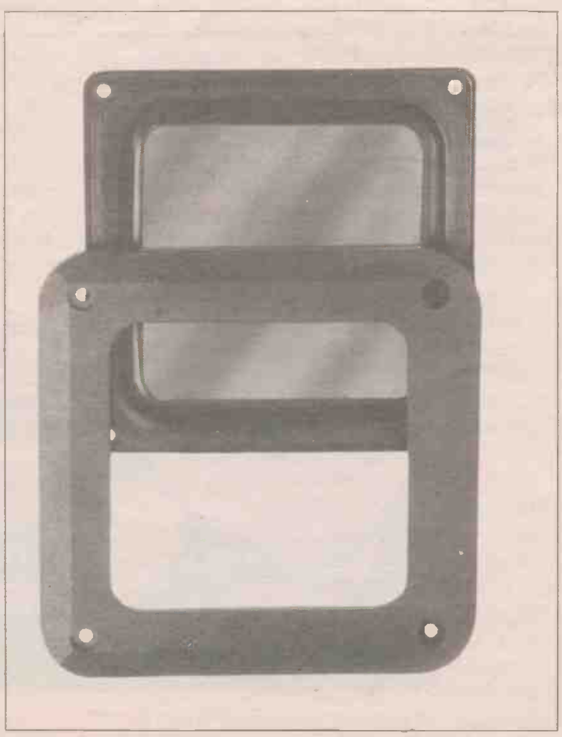
internal cabinet joints to ensure airtightness at the seams. A common source of air leakage comes from behind the loudspeaker units; spread a fillet of sealer around the outside edge of each speaker cut-out before mounting the loudspeaker, to prevent this possibility. Air leakage often manifests itself as a squeak or buzz and can be very annoying! Finally, tie both speaker wires securely so that they do not flap about, insert the amplifier connecting cable through the back panel (from the outside!) and terminate onto the crossover input terminals, +V to IN and 0V to C. Re-fit the back panel and screws and seal the four seams with rubber sealer.

Conclusion

The loudspeakers used in this design are rated at 60W to DIN 45573, this does not mean that they can be fitted to power amplifiers rated up to 60W! For maximum possible reliability and life-expectancy do not run this system at more than 25W RMS, which is a good average figure for these speakers when used continuously. Music waveforms are generally composed of high peaks and low troughs, where the peak signals produced from an amplifier can far exceed 25W, especially at low frequencies. The driver transducer voice coil and former is of high temperature rating and will happily handle peak signals up to 60W. Running a low power amplifier 'flat out' into any speaker invariably causes the reproduced waveform to be severely clipped. Allowing this to happen for any length of time dramatically increases the energy in the voice coil and hence the heat generated will cause mechanical distortion and total breakdown of the unit. The bass transducer is more tolerant of abuse than the dome tweeter, due to its larger heat dispersion areas, whereas the tweeter is very susceptible to high energy, clipped waveforms. The cabinet design is intended for use in smaller domestic type environments, as opposed to hall or stage use, where it is hardly likely to be run continuously at 25W power levels.



Passive Radiator.



Bass Driver.

3W20L CABINET PARTS LIST

Baffle board		(XJ67X)
Bass driver		(YN24B)
Dome tweeter		(YN43W)
Passive radiator		(XJ68Y)
Crossover 2-way		(WF02C)
4BA x 1.5in Bolts	2 Pkt	(LR52G)
4BA Shake washer	2 Pkt	(BF25C)
4BA Nut	2 Pkt	(BF17T)
No.6 x 0.5in Slf-Tpr	1 Pkt	(BF67X)
Ferrite rod 101		(YG22Y)
10μF Reversolytic		(FB06G)
22R 3W Resistor	2	(W22R)
Acoustic Wadding	2 Mtrs	(RY06G)
HD Loudspeaker Cable	2 Mtrs	(XR60Q)
Grille for dome tweeter		(FD93B)

A complete kit of the above parts is available:
Order As LM54J (3W20L Cabinet Kit)
Price £39.95
The following items are also available separately, but are not shown in our 1988 catalogue:
3W20L Baffle **Order As XJ67X Price £2.95**
Passive Radiator **Order As XJ68Y Price £8.95**

ELECTRONICS BY EXPERIMENT

Part 3 by Graham Dixey C. Eng., M.I.E.R.E.

Introduction

Logic circuits fall into two classes, known as 'combinational' logic and 'sequential' logic. The principles and some applications of combinational logic were the subjects of Parts One and Two. Now it is the turn of sequential logic. This, as the name implies, is to do with events taking place in some particular order. The broad divisions of circuits that come under the heading of sequential logic are 'counters' and 'registers'. There is more 'action' in a sequential circuit than in a combinational one. For this reason they tend to generate more interest. Also there is a great variety of possibilities for both counter and register circuits, so many in fact that, in this issue a selection of counter circuits only will be described, registers being covered in the next issue.

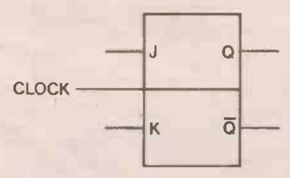
The basis of the sequential circuit is the 'flip-flop', also known as a 'bistable' (because it can take up one of two stable states) and sometimes, in particular applications, as a 'latch'. It is best, for practical purposes, to regard the flip-flop as just a 'black box' that performs some prescribed function. Textbooks for students of electronics invariably show the flip-flop function as being performed by combinations of gates, which is quite true. However, once these gates are packaged up to perform as a particular flip-flop type, there is little to be gained by considering it other than as a functional package. With this in mind look at Figure 1.

The JK Flip-flop

This figure shows the most commonly used flip-flop type, known as the 'JK flip-flop'. The symbol is shown in (a) and the truth-table in (b). The symbol is generalised to show three inputs, known as the 'steering inputs', J and K and a 'clock' input; also two complementary outputs, Q and $\overline{Q}$ (not-Q or Q-bar).

The truth-table describes the performance of the flip-flop when all possible combinations of logic levels are applied to J and K. Note the columns called Q_{NOW} and Q_{NEXT}. These are the logic levels at Q immediately before (NOW) and after (NEXT) clocking. So what is clocking?

In order to cause a counter circuit to go through its designated sequence it must be clocked. This is done by applying pulses, known generally as clock pulses to the clock input. A clock pulse is shown in Figure 2, which defines the 'edges' and 'levels' of the pulse. The JK flip-flops that we shall be using are known as 'master-slave' types. All that this means is that the flip-flop will change state at the negative or trailing edge of the pulse.



(a)

J	K	Q_{NOW}	Q_{NEXT}	COMMENTS
0	0	0	0	No Change
0	0	1	1	
0	1	0	0	Reset
0	1	1	0	
1	0	0	1	Set
1	0	1	1	
1	1	0	1	Toggle
1	1	1	0	

(b)

Figure 1. The JK Flip-flop, symbol (a) and truth table (b).

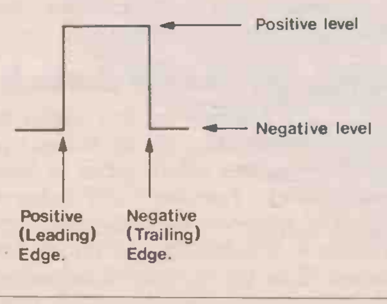


Figure 2. Clock pulse definitions.

Imagine the pulse arriving at the clock input. From logic 0 it rises abruptly to logic 1 (this is the positive or leading edge); the flip-flop does not respond at this point. Instead it waits until the logic level falls back to logic 0 when the negative or trailing edge arrives. If the J and K inputs are set up so as to demand a change of state then, at this instant of the clock pulse, the flip-flop will change state. That is, Q will either go from logic 0 to logic 1 or from logic 1 to logic 0. It is this sort of information that the truth table tells us. So back to Figure 1.

The first possible combination of J and K is that they are both logic 0. It is obviously possible for Q_{NOW} to be initially either logic 0 or logic 1. Thus the truth table has two lines for J = K = 0. Notice that for both lines Q does not change when the flip-flop is clocked. Not very exciting but, nonetheless, important. This condition is known as 'no change'.

The second possible combination is J = 0 and K = 1. Note what happens for these two lines. If Q = 0 initially, it remains at 0 after clocking; if Q = 1 initially, it becomes 0 after clocking. The flip-flop is said to be RESET when Q = 0. Thus these two lines describe the 'reset' mode.

Now reverse the logic levels of J and K so that J = 1 and K = 0. If Q = 0 initially, it becomes 1 and if Q = 1 initially, it stays at 1. The flip-flop is said to be SET when Q = 1, so that these two lines describe the 'set' mode.

Finally, there is the case when J and K both equal 1. Notice that whatever the value of Q initially, after clocking it changes to the other logic level. It is said to 'toggle' backwards and forwards between the set and reset states every time it is clocked. This is, therefore, known as the 'toggle' mode.

In order to be able to understand how any counter or register works, it is essential that the effects of the logic levels at J and K on what the flip-flop does when clocked are thoroughly grasped. This understanding, together with the realisation that the flip-flop (if it is going to change when clocked) will only do so at the negative edge of the pulse, holds the key to a proper appreciation of counter and register operation.

Level-triggered and Edge-triggered Flip-flops

There is sometimes some confusion about the meanings of 'level triggering' and 'edge triggering'. After all, both terms seem capable of describing what is happening. The triggering of the flip-flop from one state to the other may be said to occur when the 'level changes' from logic 1 to logic 0 or, in other words, at the 'negative edge' of the pulse. Let us put the matter straight. Most flip-flops that will be met are level-triggered and change state when there is a change of level, usually from logic 1 to logic 0. The clock pulse responsible for the level changes at the clock input of the flip-flop is usually fairly long. This can cause certain problems, as seen by considering what may be regarded as the normal sequence of events.

First the required inputs (to perform one of the actions described previously) at J and K are set up; next a clock pulse arrives - rising from logic 0 to logic 1 (having no effect) - then 'staying at logic 1 for a certain time period' - then falling to logic 0 (causing the action to occur). The problem is caused by the part in quotes in the centre. In effect the situation that exists during this time is that the J and K logic levels to cause the desired action to occur have been established and we are merely waiting for the end of the pulse for this action to occur. Because of the delay, it is sometimes possible for either J or K (or both) to change to some other incorrect value before the negative end of the pulse arrives, with the result that when it does so the action occurring is the wrong one.

Edge triggering is the remedy in these circumstances. The clock pulse is short and fast, giving little time for the J and K levels to change since they were established. The action is achieved by capacitive coupling that differentiates the clock pulse to give a short spike. This type of flip-flop should always be used when there is any danger of J and K changing erroneously.

The Divide-by-Two Action of the JK Flip-flop

The JK flip-flop, when in the toggle mode, acts as a basic binary or 'divide-by-two' element. This means that any train of pulses applied to its clock input at a certain frequency f will result in a train of pulses at Q of half this frequency, namely f/2. A look at the oscillograms shown in photograph 1 will make it clear why this is. Because only the negative edges of input

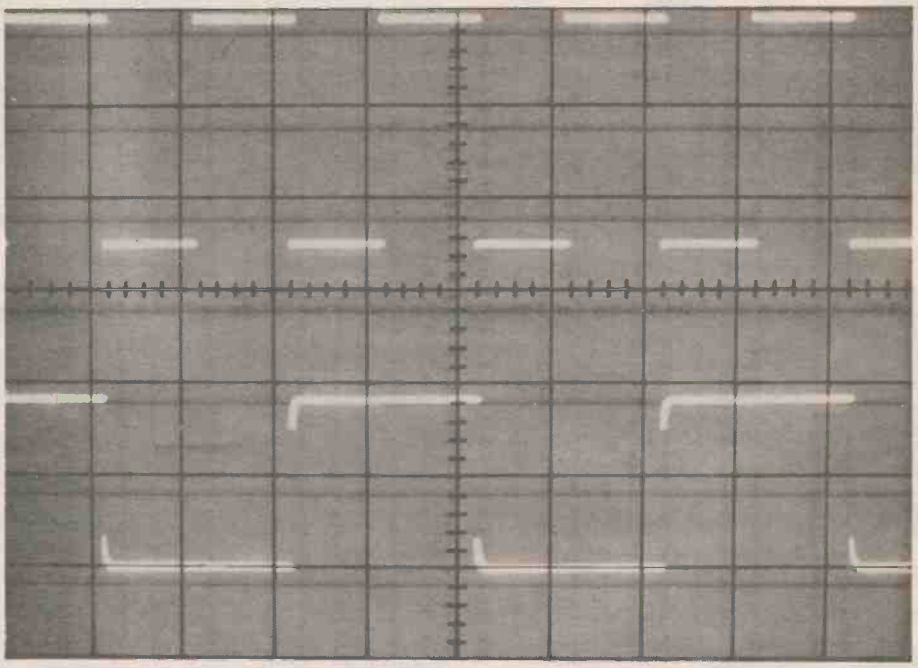


Photo 1. Oscillograms for clock input (upper waveform) and Q output (lower waveform) of a JK flip-flop wired in the 'toggle' mode. Note that the Q output changes only when the input goes 'down', hence the divide-by-two action.

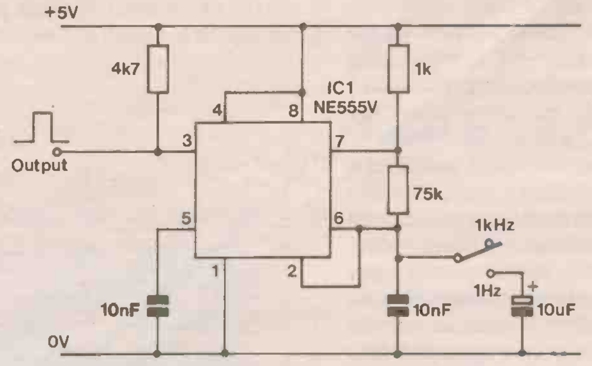


Figure 3. TTL 1Hz/1kHz oscillator.

clock pulses cause changes, all the positive edges of these input pulses are ignored. Thus, for every negative edge transition at the clock input there will be an output transition that is alternately positive and negative, hence dividing the input frequency by two. This is the basis of the counter so it is a very good idea to try this in practice. Just tie J and K together to logic 1, put in a train of pulses from the TTL oscillator (that you have now constructed!) at the clock input and look at the Q output. If you have a CRO, set the pulse frequency to 1kHz, since this will be easier to see on a 'scope. Otherwise, set the pulse frequency to 1Hz and, with LEDs on both clock and Q terminals, judge for yourself the binary dividing action.

A De-bounced Switch

Figure 4 shows another useful little circuit that you can make up. It uses a pair of cross-coupled NAND gates to form a simple latch. The feedback holds the circuit in whatever state the push-button triggers it into. Pushing the button down causes Q to go to logic 1; releasing it allows it to come back to logic 0. Thus, it generates a single pulse, very useful for

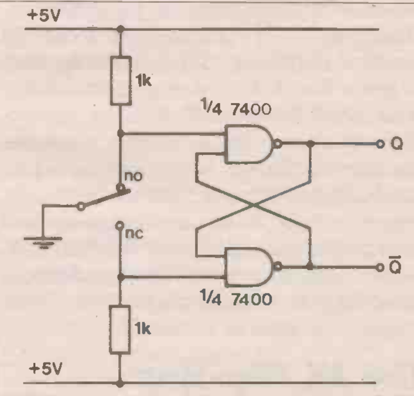


Figure 4. De-bounced switch with complementary outputs.

stepping counters (and registers) through their sequences for examination. It might be thought unnecessarily complex for such a simple task but it is not called a 'de-bounced' switch for nothing. The contacts of the average mechanical switch actually oscillate briefly between the open and closed states when the switch is operated. For many applications this effect goes unnoticed. But TTL logic devices are fast enough to follow such changes - standard TTL can respond in 10ns. Thus the circuit gets several pulses when it only needs one. The above circuit responds only to the first transition and 'masks out' those following, generating a genuine single pulse. The only awkward component is the c/o push-button switch, these mostly being push-to-make or push-to-break. If one cannot be located, a microswitch can be adapted since these usually have SPDT contacts.

Binary Asynchronous Counters

An asynchronous counter is also often known as a 'ripple through' type because the flip-flops change state one after the other, the effect appearing to 'ripple through' from first to last. Only one stage, the first, is clocked directly from the pulse train input. The others are clocked from the Q outputs of the previous stages. It is this connection that causes the ripple through action. The circuit of a three-stage counter of this type in shown in Figure 5. Since all flip-flops are connected in the toggle mode, each divides by two so the overall division ratio is 2^3. In general, for a counter using 'n' flip-flops the division ratio (also known as the scale or modulo) is equal to 2^n. Another feature of this counter, being a practical circuit, is the 'reset' line. It has nothing to do with the reset mode in line two of the JK truth-table. Instead it is a separate pin provided to reset the flip-flop; it has to be taken to logic 0 to enable this to happen. Such a connection is said to be 'active low' or, alternatively, 'negative acting'.

To investigate and learn something of the operation of this circuit, it is recommended that it is connected up, using either the TTL oscillator or de-bounced switch as input, and with LEDs on all the Q outputs. The counter should be reset to start with, so that all LEDs read 0. Pulsing the circuit through the complete sequence should take it from 000 to 111, eight states all told. From the point of view of the circuit diagram, the binary number shown by the LEDs is actually 'backwards', since the first flip-flop FFA is the Least Significant Bit (LSB) of the number. Having satisfied yourself that it does count in binary, the next step that can be tried is to connect the LEDs to the $\overline{Q}$ outputs instead. Since these are complementary to the Q outputs, the sequence will be reversed, i.e. the counter will count 'down' from an initial value of 111 to a final value of 000. Thus, the counter can be used to count up or down just by the choice of where the outputs are taken from, either Q or $\overline{Q}$.

There is a small modification that can be made to this circuit that is worth looking into - especially as it is very easy to do. Leave FFA clock input as it is but connect the clock inputs for FFB and FFC to the $\overline{Q}$ outputs of the previous flip-flops instead of the Q outputs. Record the sequences at both the Q and $\overline{Q}$ outputs, as was done before. You might like to ask yourselves whether the results are what you expected.

Binary Synchronous Counters

A disadvantage of asynchronous counters is their slowness. It should be evident that they will be slow because it is necessary to allow all flip-flops to change state before a new clock pulse can be applied. Try to clock the circuit too quickly and it becomes confused. In a synchronous counter all clock inputs are clocked from a common source, the pulse train input. This presupposes that the counter knows in advance when certain flip-flops should change state and when they shouldn't. What is not wanted is the whole lot changing whenever a clock pulse appears. It would be somewhat tedious, not to say time consuming to go through the design method of synchronous counters. Suffice it to say that some extra gating is usually needed (quite a lot sometimes) in order to sort out when any given flip-flop should change state in the sequence. From the hobbyist's point of view, it is sufficiently interesting to hook up the circuit (shown in Figure 6) and pulse it to see that it does indeed work. However, it can be taken a stage further.

While the counter is being pulsed, a logic probe can be held on the J and K inputs of FFC (that is the output of the AND gate). The output of this gate can only be either logic 0 or logic 1, putting FFC into either the 'no-change' or 'toggle' modes. Determine when it is in one mode or the other and why. Investigation of this type teaches one a lot. Try to think of other aspects of the circuit to investigate. You may well have realised that this counter is not actually a full synchronous counter. Only FFA and FFC are truly synchronous; FFB is clocked from the output of FFA. Such a circuit is a compromise between speed and simplicity.

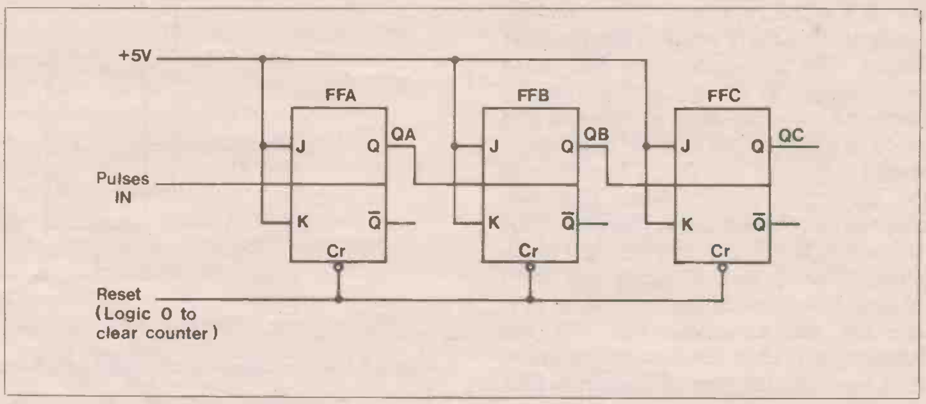


Figure 5. Scale-of-eight asynchronous (ripple-through) counter.

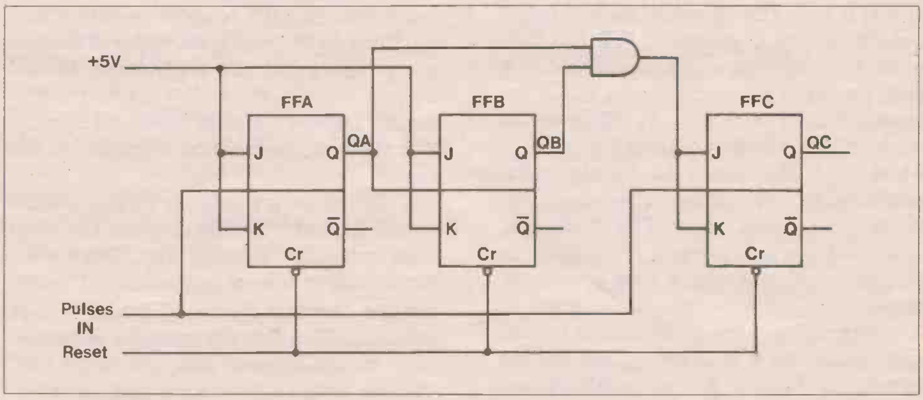


Figure 6. Scale-of-eight synchronous counter.

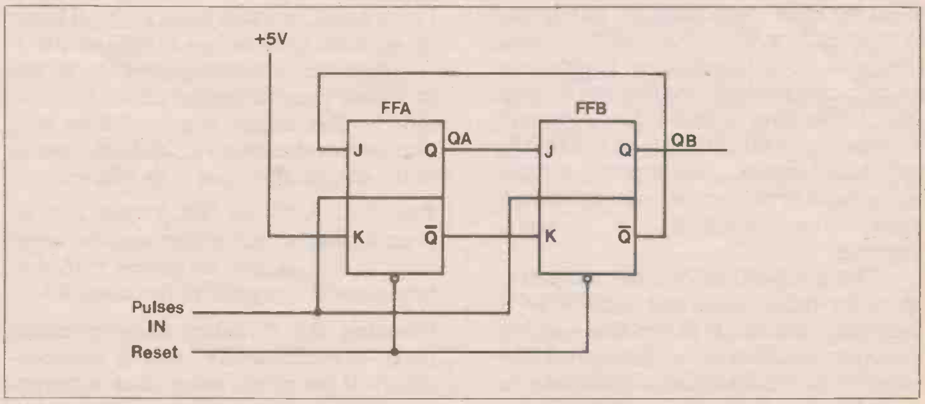


Figure 7. Scale-of-three feedback counter.

Counters to other Bases

The basic binary dividing element, the JK flip-flop, is only capable of division by two, yet there are times when division by numbers that are not a power of two is needed. As an example of this, consider the simple non-binary counter of Figure 7. This is a 'scale-of-three' counter, the three states being 00, 01 and 10; the state 11 is avoided. The circuit is forced to reset to 00 on the fourth pulse by means of the feedback between the $\overline{Q}$ output of FFB and the J input of FFA. The action of this feedback is as follows.

Assuming that the counter is initially reset, so that its first state is FFA = 0, FFB = 0, the $\overline{Q}$ output of FFB will be at logic 1 which is fed back to the J input of FFA; the K input of FFA is wired to logic 1 anyway, so FFA is in the toggle mode. The J and K inputs of FFB are fed from the complementary Q and $\overline{Q}$ outputs of FFA, so that FFB will always be in either the SET mode or the RESET mode; it has no other choice. The first clock pulse will cause FFA to toggle, its Q output going to logic 1; this same pulse will have no effect on FFB since its inputs, at the moment of clocking were J = 0 and K = 1 (RESET mode) and the flip-flop is already reset. The state after the first clock pulse is, therefore, FFA = 1 and FFB = 0. But after this first clock pulse, FFB's J and K inputs will have reversed because of the toggling of FFA and we can anticipate that FFB will become SET after the next clock pulse. Sure enough, this is what happens, FFA toggling at the same time, so that the state after the second clock pulse is FFA = 0 and FFB = 1. This is where the feedback comes in. The $\overline{Q}$ output of FFB has now gone down to logic 0; this means that FFA is no longer in the toggle mode, but in the reset mode (J = 0, K = 1). What is the mode of FFB? Look at its J and K inputs, J = 0 and K = 1. This means that it is also in the reset mode. Therefore, after the next pulse, FFA 'stays' reset, FFB 'becomes' reset and the final state of the counter is also its initial state for a new sequence, namely 00.

Taking the idea of feedback further and combining it with gating, we get the circuit of Figure 8, the 'scale-of-five' counter. If you followed the discussion about the 'scale-of-three' counter, you shouldn't have much difficulty in proving to yourself how this one works. However, there's nothing like putting theory into practice so it is suggested that you wire up this counter, reset it and follow it through its sequence (000, 001, 010, 011, 100, 000, etc). Make use of LEDs at the Q outputs and a logic probe on the gate inputs and output. You should find it a useful exercise.

The 'scale-of-five' counter converts to an even more important type if it is preceded by a single JK flip-flop wired in the toggle mode, as shown in Figure 9. The result of the two successive divisions is to produce an overall result of 'divide-by-ten', that is a decade counter. This has obvious practical applications. It is worth wiring this up, especially if you've already breadboarded the 'divide-by-five' counter. Then try reversing the order of the two component parts, that is drive the 'divide-by-two' section from the 'divide-by-five' circuit. Do you think the order will matter? You may (or may not) be surprised at the result!

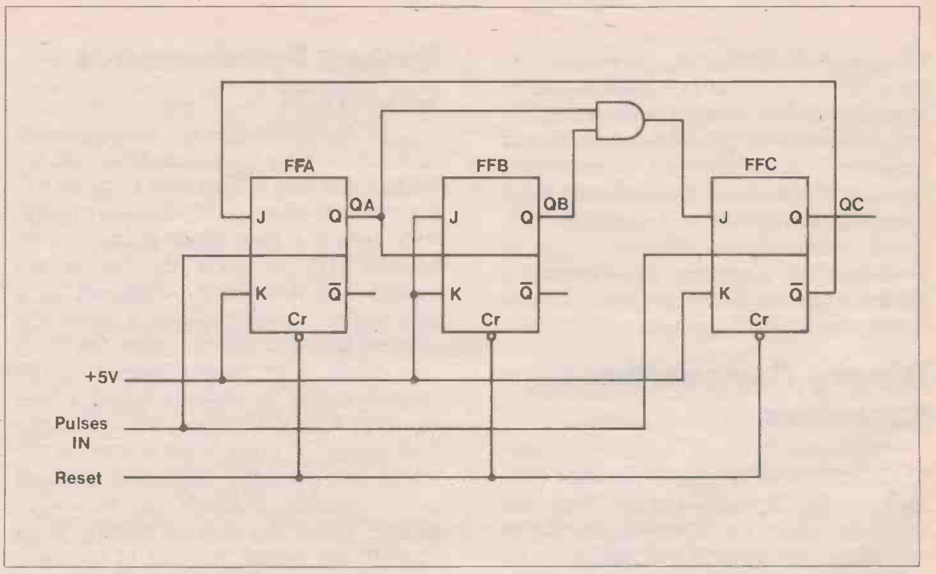


Figure 8. Scale-of-five feedback counter.

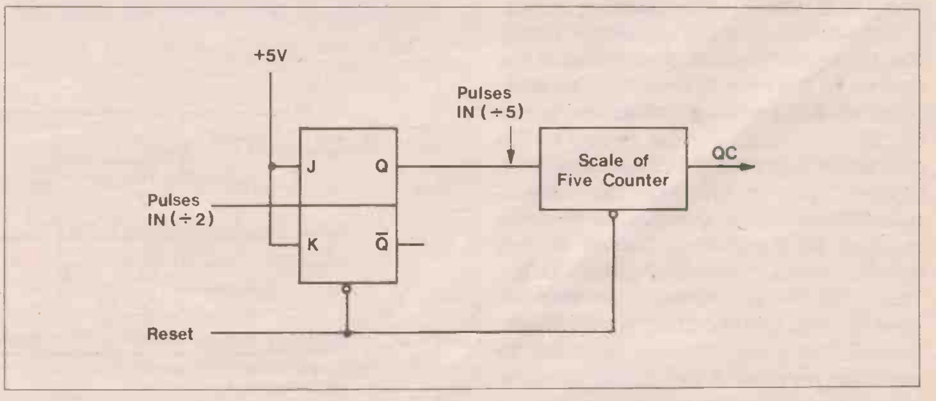


Figure 9. Decade counter constructed from basic divide-by-two stage and the circuit of Figure 8.

Of course, if you really want to build a circuit around a decade counter, you don't have to build it up in this way. There are a number of single-chip circuits, of which the one shown in Figure 10, the 7490, is an example. This actually contains the separate 'divide-by-two' and 'divide-by-five' circuits, which can be accessed separately or wired in series by connecting pin 12 (Q_1) to pin 1 (pulses in for 'divide-by-five'). Pins 2 and 3, or 6 and 7 can be used to set up an initial state of 0 or 9 (0000 or 1001).

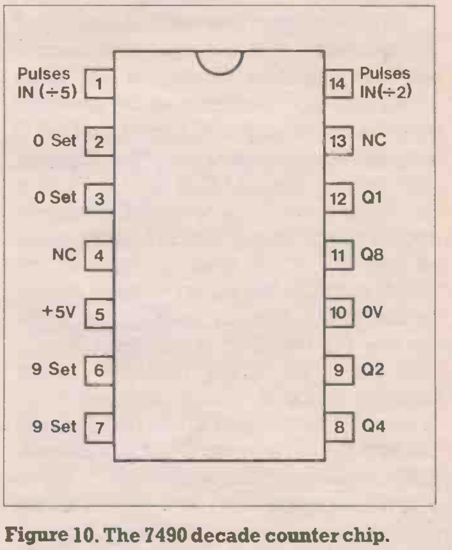


Figure 10. The 7490 decade counter chip.

Another interesting circuit is the so-called 'programmable' series of counters, 74160-3, shown in pin-out form with sample waveforms in Figure 11. A resumé of the circuit operation is as follows:

Features: A 16-pin DIL IC that can be programmed to start at any required initial state in the binary sequence 0-15 and terminate at any point in the sequence.

Clearing the Counter: Some counters clear 'asynchronously', that is independently of the clock; some clear 'synchronously', that is on the next positive clock transition.

Programming the Counter: 'Data in', corresponding to the required initial state (ABCD) is applied to pins 3-6. The 'load' line is taken low and the counter presets on the next positive clock edge.

Enabling and Disabling the Counter: Two control lines, P and T, are provided. They are both taken high to start the counter. Taking either low will disable (inhibit) the counter.

Carry 'look ahead' output: Used for successive cascading of stages without extra gating being needed. A carry pulse

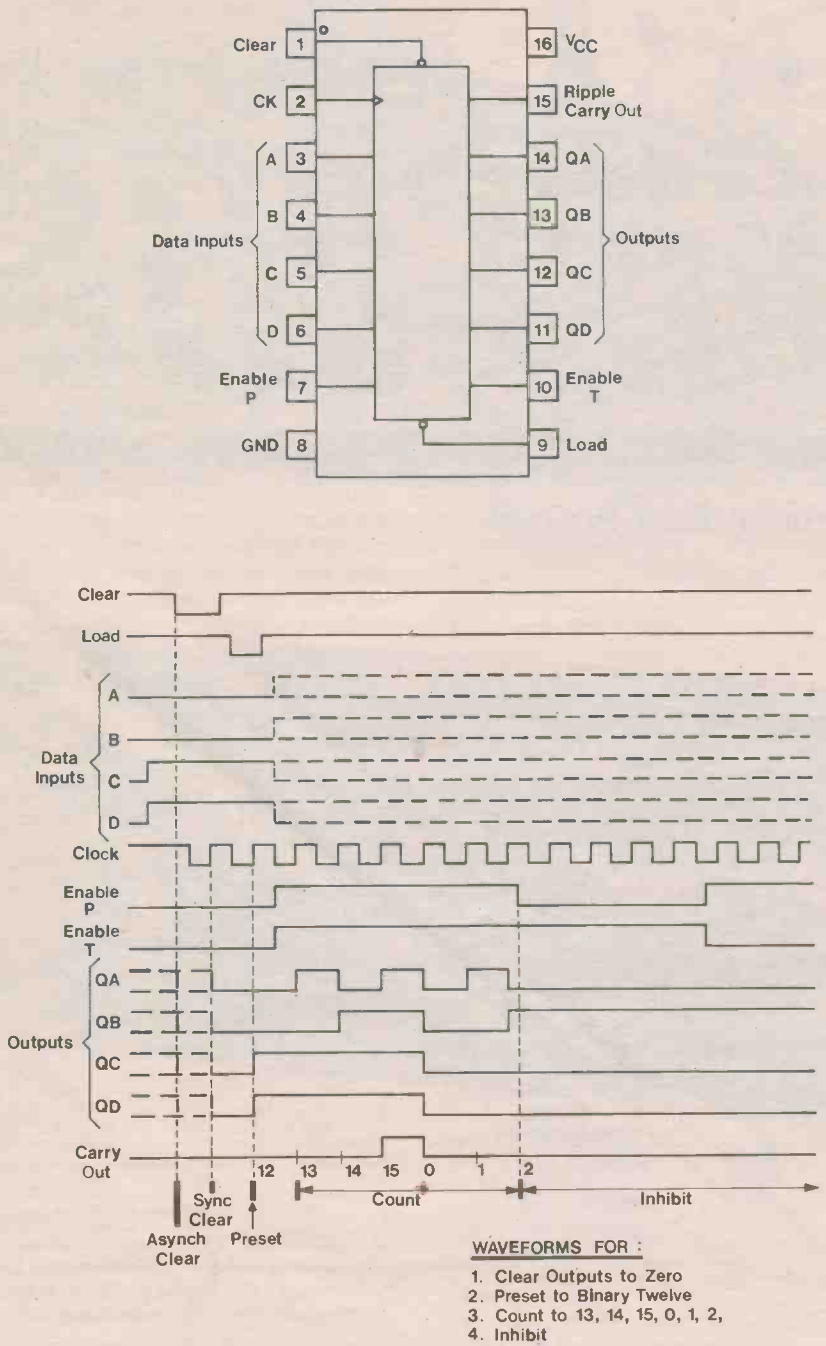


Figure 11. The SN74160-3 programmable counters.

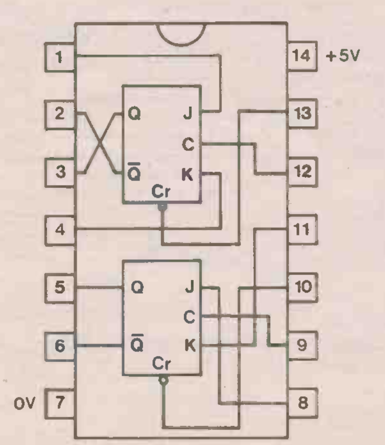


Figure 12. Pin-out for 74107 dual JK level-triggered flip-flops.

is generated and is enabled by the T enable line (must be high).

The set of waveforms of Figure 11 should help to make the operation clear.

A negative-going pulse is required to clear the counter, the asynchronous and synchronous 'clears' being shown at the bottom of the diagram. The load pulse is also negative going and, at its leading edge, the 'data in' (binary 12, i.e. 1100 in order DCBA) is preset into the counter (Q_D to Q_A) - see output waveforms lower down. The clock pulse is a regularly recurring square wave that governs the counting rate - the changes at Q_D to Q_A, 1100, 1101, 1110, 1111, etc., can be seen quite clearly to occur at the leading edges of the clock pulses. The action of the enable lines, P and T, is also seen. During the count period both are high but, at a count of 2, the P line goes low, stopping the count. If both were taken high at any subsequent instant, counting would resume from the last value. In fact, in the example shown, when P goes high again, T goes low, so the counter remains inhibited. The point that is made is that the operation of the counter is under the control of two independent lines, P and T, and how these are actually used is up to the individual.

There should be enough practical work there to while away a few evenings. Building and testing the circuits described will help in gaining a good understanding of a subject that is often imperfectly understood. As already said, a similar look at registers will be the subject of the next part of this series.

Appendix - Problems with TTL

Because TTL gates often use a type of output stage known as a 'totem pole', it is possible to generate, in normal use, short duration current spikes while conduction is changing over from one half of the totem pole to the other, a process that occurs when the output switches between logic levels. Thorough decoupling of TTL circuits is, therefore, advised. The following guidelines are suggested to cure or avoid problems of this type.

(i) Use one 10nF - 100nF short-lead disc ceramic capacitor across the supply lines for every four gate packages.

(ii) Use one similarly for every two MSI packages (e.g. counters and shift registers).

(iii) Use a separate such capacitor for every package that is further away than 3" (75mm) from the nearest bypass capacitor.

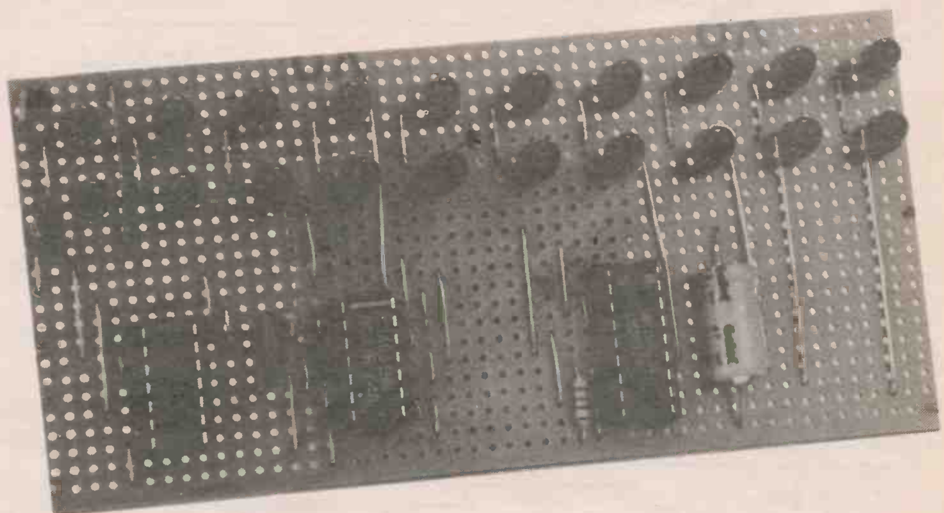
(iv) Use a 10μF 6V tantalum electrolytic capacitor where the +5V supply lines enter the board.

Bob's MINI-CIRCUITS

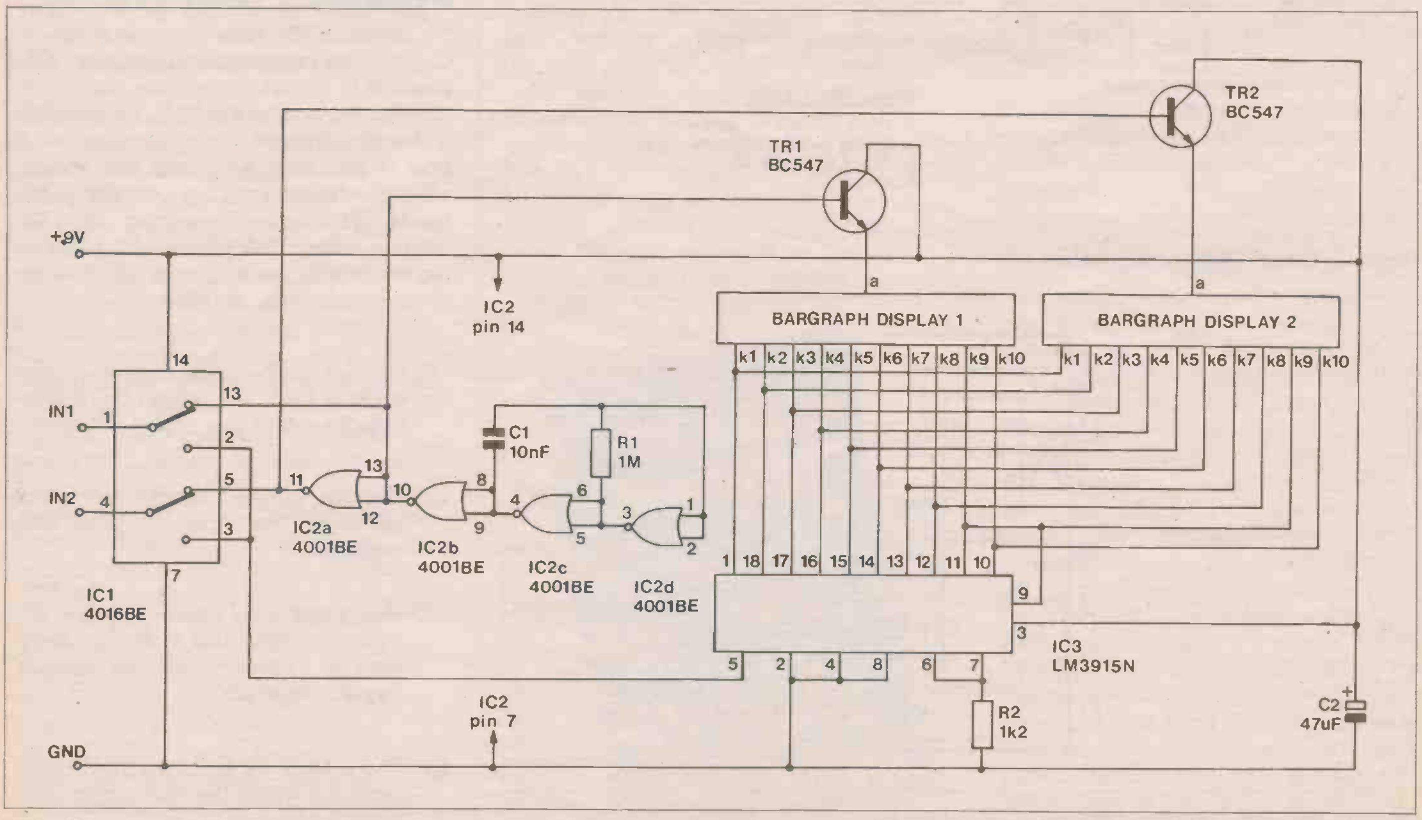
From Robert Penfold

Stereo Bargraph

Ever since they were first introduced, which was several years ago now, the LM3914/5/6 series of bargraph drivers have been popular with project designers. Unfortunately, this popularity has not been reflected in the cost of these devices, which are far from being in the 741 or 555 category in this respect. Where two or more bargraph displays are needed for a project it is possible to make a worthwhile saving in cost by using a single driver plus a system of multiplexing to enable it to drive the displays. This circuit shows how a single LM3914/5/6 device can be used to drive two bargraph displays. The obvious application for the unit is in a stereo Vu meter, using the logarithmically scaled



Stereo Bargraph



Stereo Bargraph Circuit

LM3915N, but there must be many other applications which require dual bargraph displays, and where this circuit could be used to good effect. Although the unit is based on a single driver chip, it has two separate inputs and can be used exactly as if it had two driver chips.

Multiplexing is very straightforward in principle, and it merely involves repeatedly driving first one display and then the other. The switching frequency must be high enough to avoid display flicker, which means that each display must be pulsed on at least twenty five times per second, and preferably somewhat more frequently than this. With most digital displays there is no difficulty in doing this, but with a bargraph display there is a slight problem in that the input is an analogue signal. The two input signals must be switched in unison with the switching of the displays, but analogue electronic switches are available at low cost, and this does not represent a tremendous technical problem.

In this circuit the analogue switches are two of the SPST types in a CMOS 4016BE quad analogue switch (IC1). The other two switches are not used and are simply ignored. The outputs of the two switches are connected together and coupled through to the input of the bargraph driver chip (IC3). A two phase oscillator is needed in order to drive the control inputs of the switches out-of-phase, and IC2 operates as this oscillator. It is a 4001BE quad 2 input NOR gate, but in this circuit all four gates are wired to act as simple inverters. IC2c and IC2b operate as a standard CMOS astable having an operating frequency of very roughly 100 Hertz. The other two gates act as inverter/buffers which generate the anti-phase output signals.

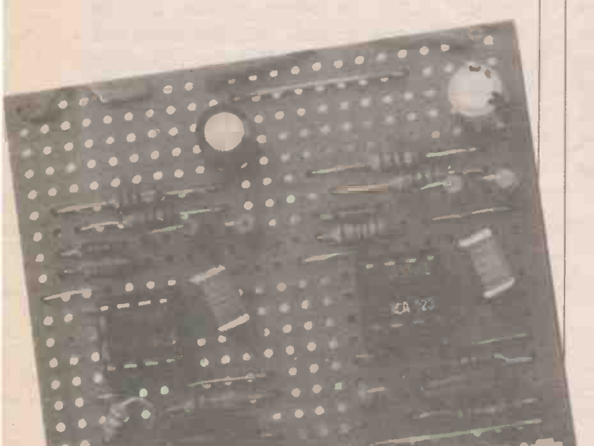
Each output of the bargraph driver drives the corresponding cathode terminal of both displays. The appropriate display for whichever input is currently connected is selected by connecting its common cathode terminal to the positive supply rail. Emitter follower switching transistors TR1 and TR2 provide this switching, and are driven by the two phase output signal of the oscillator. On the prototype the bargraphs are made up from individual 5 millimetre diameter LEDs, but proper bargraph displays can be used if preferred. These mostly have separate cathode and anode terminals for each LED, but components which do not are only suitable if they are of the common anode variety.

IC3 is used in the 'dot' mode in order to keep the current consumption down to an acceptable level. R2 sets the LED current at 10 mA, but as this is split between two displays it only represents about 5 mA per LED. The output current can be boosted somewhat if desired, and changing the value of R2 to 560 Ω will give a nominal LED current of just over 10 mA per LED. The input sensitivity is the standard 1.2 volts for this series of chips, but this can obviously be changed by the addition of an input amplifier or attenuator.

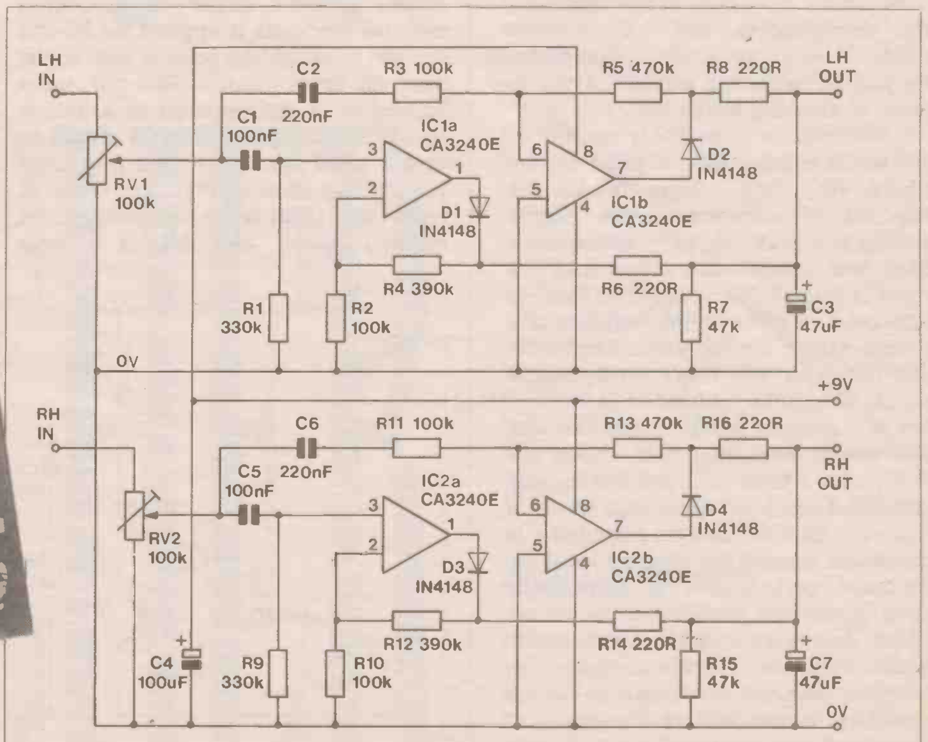
Stereo Vu Meter

This circuit was designed primarily as an add-on to the stereo bargraph unit described elsewhere in this feature. It converts the twin bargraph circuit into a stereo Vu meter of the peak reading variety. Using the LM3915N bargraph driver the unit provides indications at 3dB intervals. Just what level each LED corresponds to obviously depends on how the unit is calibrated, but typically the unit would provide indications from −21dB through to +6dB, or perhaps −24dB to +3dB. At maximum sensitivity the circuit requires only about 200 millivolts rms for full scale indication, and each channel has a separate variable attenuator to permit accurate calibration. The input impedance is in the region of 47k. If a conventional Vu meter is preferred to a LED bargraph type, the bargraph circuit can easily be replaced with two (moving coil) Vu meters.

Many Vu meters are simple average reading types, but these offer what is generally accepted as less than totally reliable results. The problem is simply that meters of this type are calibrated using a sinewave test signal, and this type of waveform has a fairly high average level relative to its peak amplitude. A signal which has a spiky waveform will then produce quite a low average reading even with the peaks of the waveform going well beyond the clipping level. Much more reliable results are obtained using a circuit which has a fast attack time and a very much longer decay time. Typically these times are around 2 milliseconds and 5 seconds respectively. The meter then reads the peak amplitude of the signal, and with the hold-on provided by the very slow decay time, any readings beyond the 0db level should be clearly indicated. In fact with most designs the odd transient exceeding the 0dB level will pass undetected, but in practice signals of this type are few and far between, and would not significantly degrade the audio quality anyway.



Stereo Vu Meter



Stereo Vu Meter Circuit

This circuit is a fairly conventional type, and as the two channels are essentially the same we will only consider the operation of one of them (the left hand channel). The circuit is basically just a precision fullwave rectifier. Semiconductor diodes introduce a forward voltage drop, with a substantial drop of about 0.6 volts being produced in the case of silicon types. With the bargraph circuit having a full scale sensitivity of about 1.2 volts, this would give very poor accuracy. Not all types of diode are as bad in this respect as silicon types, but none provide quite the degree of accuracy required for this application. The diodes are therefore included in the negative feedback networks of operational amplifiers, and the feedback precisely compensates for the forward voltage drops through the diodes. In order to give fullwave rectification, two precision rectifiers connected in parallel are used. One is based on a non-inverting amplifer (IC1a), and this processes the positive half cycles. The other is built around an inverting amplifier (IC1b), and this inverts negative input half cycles to give a positive output. Note that the CA3240E is a type that can operate with a single supply rail, and that most other types (the 1458C for example) will not function properly in this circuit unless a dual supply is used. C3 is the smoothing capacitor, and a fast attack time is obtained due to the low source impedance from which it is driven. Its only significant discharge path is through the much higher resistance of R7, which gives the circuit its long decay time.

Construction of the unit should prove to be quite easy, but remember that the CA3240E is a MOS input type, and the usual anti-static handling precautions should be taken when dealing with IC1 and IC2. If moving coil Vu meters are preferred, two Maplin (RW73Q) Vu meter movements are suitable, and these should be driven from the outputs via 15k series resistors. This gives lower sensitivity and a shorter decay time than using the stereo bargraph circuit, but performance in both respects is still perfectly adequate.

In order to calibrate the unit, a steady signal at the 0dB level is applied to both inputs. RV1 and RV2 are then adjusted for the lowest sensitivities that result in their respective 0dB LEDs lighting. If meters are driven from the outputs, then the presets are adjusted for precisely 0dB indications from both meters.

Simple Fibre-Optic Link

Most fibre-optic audio link designs use a frequency modulated carrier wave, and the system described in Issue 20 of this magazine falls into this category. An f.m. system enables good range with a low signal to noise ratio to be obtained, but probably its main attraction is the low distortion level that can be attained. There is inevitably a degree of non-linearity through the transmitting LED and the receiving photocell (normally a photo-diode), but this lack of linearity does not affect the audio quality of an f.m. system. The photocells are merely handling pulse signals, and it is the frequency of the pulses rather than their precise waveform that is of importance. The linearity of the system is largely governed by the quality of the modulator and demodulators, and with modern circuits a distortion level of well under 1% can be achieved without having to resort to anything too exotic.

While there is probably no serious alternative to some form of pulse system where very high quality results are required, a somewhat more simple approach is perfectly valid where just a basic link is required. For example, if a voice link is all that is required there is little point in going to the expense of a system having the full audio bandwidth plus hi-fi noise and distortion figures. A simple amplitude modulation (a.m.) system will provide perfectly good results. The system described here shows just how simple a fibre optic link can be, and although I expected quite high levels of distortion from the design, provided it is not driven beyond the clipping level the distortion performance is surprisingly good. It certainly provides a speech link which has substantially better audio quality than an average intercom or telephone link. For someone who has yet to dabble in the field of fibre-optics it provides a very inexpensive introduction to this fascinating subject.

Transmitter

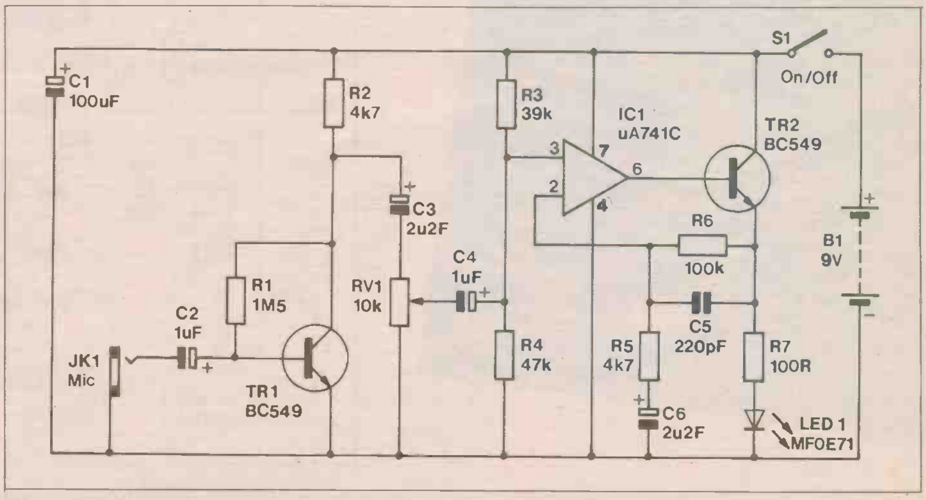
The system is designed to be fed from a microphone at the transmitter, and to drive an earpiece or headphones from the receiver. At the transmitter, TR1 is the microphone preamplifier, and this is a common emitter amplifier which provides over 40dB of voltage gain. The input characteristics of this stage are best suited to medium impedance dynamic (communications) microphones, but good results also seem to be obtained with low and high impedance dynamic microphones, or any types with similar output characteristics.

RV1 is the microphone gain control, and from here the signal is coupled to the output amplifier. This has IC1 as a non-inverting amplifier and TR2 as a discrete emitter follower output stage. Overall negative feedback is applied via R5 and R6, and these set the voltage gain at just over 20 times (26dB). The full audio bandwidth is not required in a simple system of this type, and so C5 is used to give a small amount of high frequency roll-off. This gives an improved signal to noise ratio. LED1 is the transmitting light emitting diode, and this is a type specifically designed for fibre optic applications. R7 sets the quiescent LED current at approximately 35 mA. When the unit is fully driven the output current varies between zero and about 70 mA, giving an average of 35 mA. This is comfortably within the 100 milliamp maximum current rating of the MFOE71 used in the LED1 position.

Receiver

The photocell at the receiver is a photo-diode that is designed to complement the LED at the transmitter. Both have peak response in the visible red to near infra-red part of the spectrum, and both work well with the Maplin fibre optic cable. Normally photo diodes are operated in the reverse biased mode, and generate an output signal due to the increased leakage caused by received light. In this application a stronger output seemed to be obtained using LED2 in the voltaic mode. In other words, it acts rather like a solar-cell, with the received light being converted directly into electrical signals. In this mode the polarity of LED2 is unimportant.

Only a very low output level of typically under 1 millivolt peak to peak is



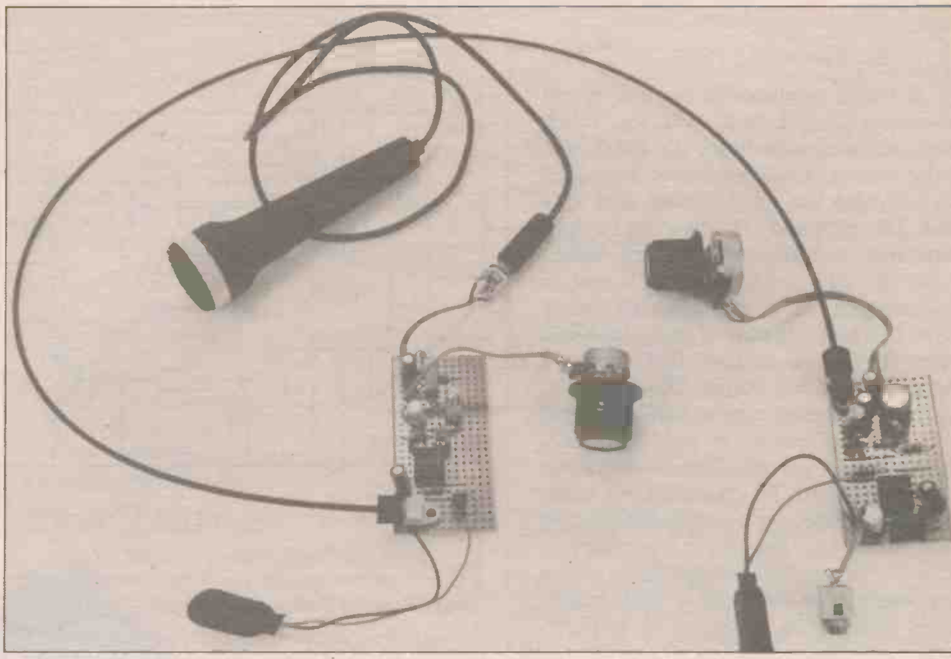
Fibre-optic Transmitter Circuit

produced by LED2, and consequently a great deal of amplification is needed in order to produce a strong enough output to give good volume from headphones. A two stage amplifier is used, and this has obvious similarities to the transmitter circuit. It differs mainly in that the emitter follower output stage has been omitted, and the feedback values for IC1 have been altered slightly in order to give increased voltage gain. IC1 provides about 40dB of gain, giving an overall gain in excess of 80dB (10000 times).

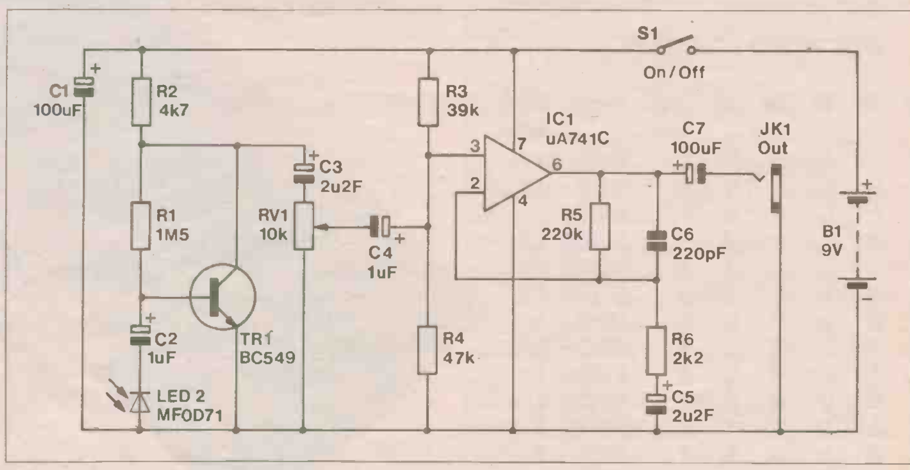
The output will drive a crystal earphone, or most types of headphone. With high impedance types it is preferable to use parallel connection of the earphones if possible, but with low and medium impedance types series connection will almost certainly give better results. Note that it is only possible to drive reasonably sensitive headphones from the unit, and types which are intended for direct connection to loudspeaker outputs are unsuitable. The current consumption of the unit is only about 3 mA, but this might increase somewhat when the unit is used at high volume levels with some types of headphone.

Construction does not present any great difficulties, and although both units contain high gain amplifiers, these do not seem to be especially fussy about the component layout. However, the leads which carry the microphone signal and the signal from LED2 at the receiver must be screened types unless they are no more than about 20 millimetres or so in length. The photocells both have a sort of screw terminal arrangement that is used to hold the cable in position, but the ends of the cable must be suitably prepared first. This is a matter of first cutting the ends of the cable cleanly at right angles with a sharp modelling knife, and then removing about 3 to 5 millimetres of the outer sleeving at both ends of the cable. Make sure that the cable is fully pushed into each photocell, and only tighten the 'terminals' just enough to firmly lock the cable in place.

When initially testing the system it is probably best to use a piece of cable about 30 millimetres or so in length. Talking into the microphone should be so strong that the volume control (RV1 at the receiver) has to be almost fully backed off. For optimum results the microphone gain control should be advanced as far as possible without the signal becoming clipped and seriously distorted. The volume control is then adjusted to give the required volume level. Although the gain of the unit might seem to be excessive when tested with a short cable (and is in fact about 40dB too high), bear in mind that losses through a fibre optic cable are generally far higher than those through an ordinary audio cable. The maximum range of the unit is therefore unlikely to be more than about 10 to 20 metres. If necessary, R6 can be made a little lower in value so as to boost the gain of the receiver.



Fibre-optic Transmitter and Receiver



Fibre-optic Receiver Circuit

Serial-Parallel Converter

When a computer is used to control electric motors, solenoids, etc., the data is generally extracted from the computer via a parallel port of some kind. For example, the user ports of the BBC model B and certain Commodore computers are often used for this sort of thing. In some applications it can be much better to use a serial output, and this mainly means applications like control of a 'turtle' or other robot. Serial communications has the advantage of requiring as little as two connecting wires, and even at high baud rates quite long ranges are readily achieved without compromising reliability. With parallel communications there can be difficulties over ranges of more than about 2 metres, and a thick ribbon type connecting cable is often less than convenient.

The obvious drawback of using a serial port for this sort of thing is that the robot (or whatever) must include a serial to parallel data converter, with the individual outputs then being interfaced to motors, etc. The serial to parallel conversion can be achieved much more easily than you might expect, and without consuming large amounts of supply current. This data converter is based on the industry standard UART (universal asynchronous receiver/transmitter) and just a handful of other components, but it can handle any standard baud rate and word format. The current consumption of the unit is only around 4 milliamps. It can be driven from any standard RS232 or RS423 output, and it gives from 5 to 8 CMOS compatible latching outputs (the number of outputs depends on the word format used).

The UART (IC2) does most of the work, with data on the serial input being clocked into a shift register where the start, stop and parity bits (if used) are stripped off leaving the data. The received byte is then transferred to an eight bit latch which provides the parallel output data. A reset pulse is needed at switch-on, and this is provided by C3 and R4. The input signal will be at approximate levels of plus and minus 12 volts, and this must be converted to an ordinary 5 volt logic signal before it is applied to the serial input of IC2. An inversion of the signal is also required. The necessary signal conditioning is provided by the simple common emitter switching stage based on TR1.

A clock oscillator is needed to set the correct baud rate, and the clock frequency is sixteen times the baud rate. In this circuit, a C-R oscillator based on IC1 provides the clock signal, and RV1 must be trimmed to give an output frequency of adequate accuracy. There is no difficulty in adjusting RV1, and in the absence of a suitable frequency meter it is just a matter of using trial and error to find a setting that gives a correctly decoded output. The specified values are for operation at 1200 baud, but by using the output at pin 13 of IC1 (instead of pin 10) operation at 2400 baud can be obtained. By changing the value of C2 it is possible to accommodate other baud rates, and the clock frequency is inversely proportional to the value of this component. For example, a 2n2F component would give operation at 600/1200 baud.

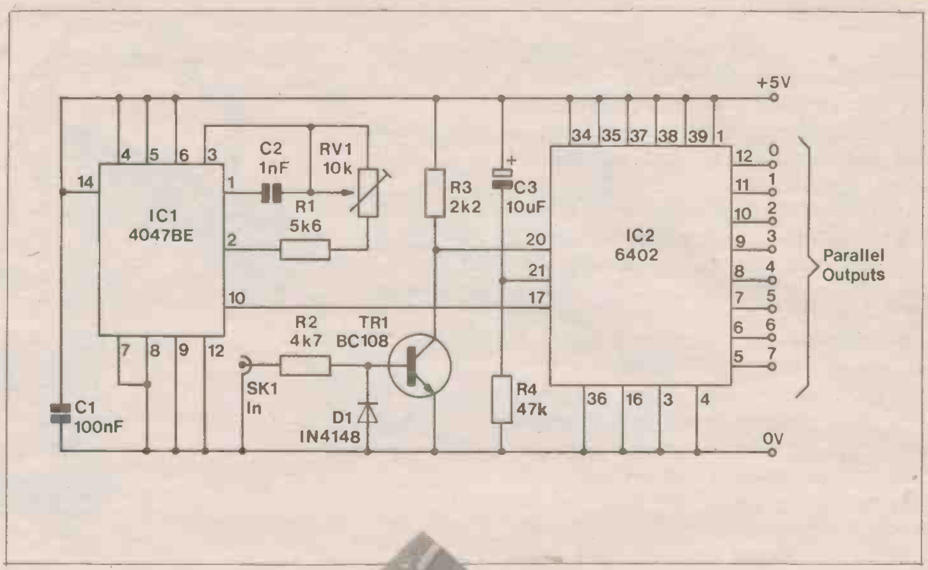
6402 WORD FORMATS

35	36	37	38	39	Data Bits	Parity	Stop Bits
L	L	L	L	L	5	ODD	1
L	H	L	L	L	5	ODD	1.5
L	L	L	L	H	5	EVEN	1
L	H	L	L	H	5	EVEN	1.5
H	L	L	L	X	5	NONE	1
H	H	L	L	X	5	NONE	1.5
L	L	L	H	L	6	ODD	1
L	H	L	H	L	6	ODD	2
L	L	L	H	H	6	EVEN	1
L	H	L	H	H	6	EVEN	2
H	L	L	H	X	6	NONE	1
H	H	L	H	X	6	NONE	2
L	L	H	L	L	7	ODD	1
L	H	H	L	L	7	ODD	2
L	L	H	L	H	7	EVEN	1
L	H	H	L	H	7	EVEN	2
H	L	H	L	X	7	NONE	1
H	H	H	L	X	7	NONE	2
L	L	H	H	L	8	ODD	1
L	H	H	H	L	8	ODD	2
L	L	H	H	H	8	EVEN	1
L	H	H	H	H	8	EVEN	2
H	L	H	H	X	8	NONE	1
H	H	H	H	X	8	NONE	2

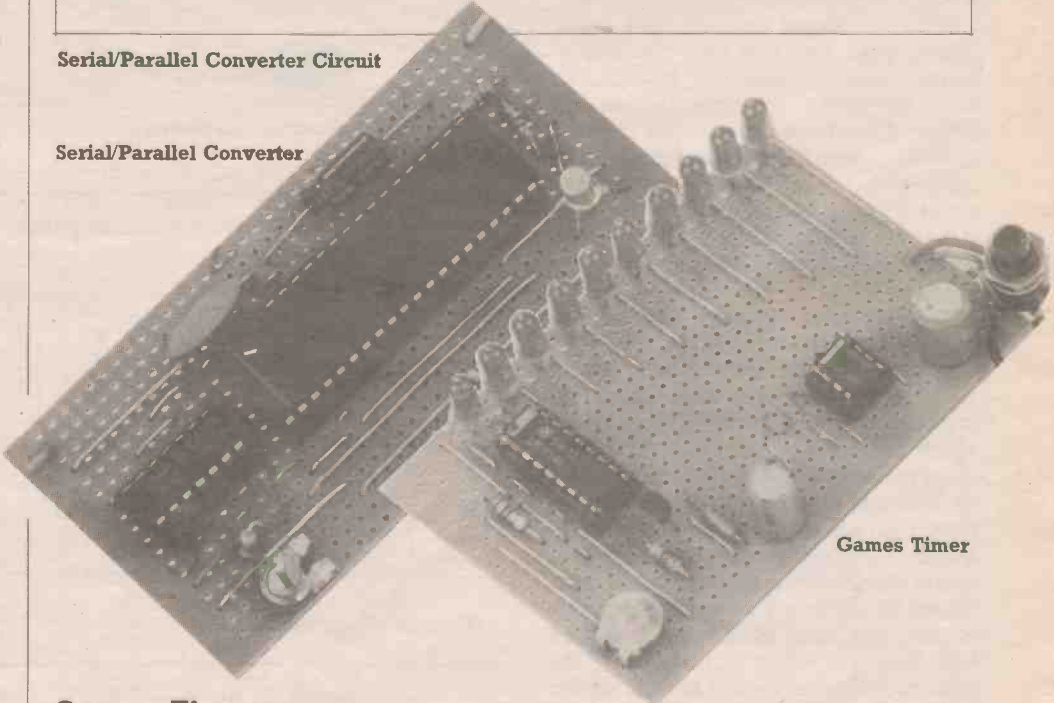
H = High, L = Low, X = either state will do.

Table 1

IC2 is programmed for the required word format by tying 5 inputs (pins 35 to 39) to the appropriate logic levels. The circuit diagram shows the connection needed for the most popular word format of eight data bits, one stop bit, and no parity. Table 1 gives the input levels for all the other available formats, and should be consulted if you wish to use a different one. Note though, that the number of outputs available is equal to the number of data bits used, and that using other than eight data bits results in a reduction in the number of outputs available. For word formats of less than eight bits it is the most significant bit or bits that are unused.



Serial/Parallel Converter Circuit



Serial/Parallel Converter

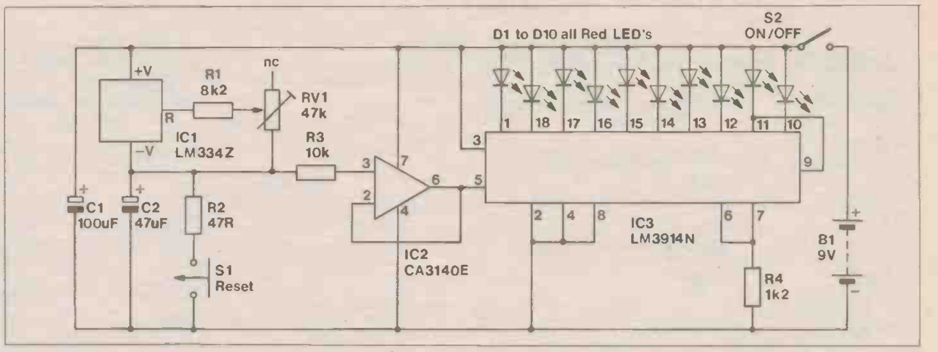
Games Timer

Games Timer

A lot of board games, including chess and draughts, can easily become very slow and drawn out with players taking ever longer to make their moves. The obvious solution to this problem is to have a time limit on moves, but some convenient method of keeping time is then needed. This is the type of application in which a simple electronic timer can be used to good effect, and the simple timer described here was designed specifically for games use. It is very easy to operate, and elapsed time is indicated on a bargraph type display. Strictly speaking it is not a true bargraph as the driver device is operated in the 'dot' mode, where only a single LED is switched on at any one time. There are ten LEDs, and the time taken for the display to increment from one LED to the next can be set at anything from around one to five seconds, giving full scale times of between about 10 and 50 seconds. The unit can easily be modified to provide times outside this range though. It is useful to be able to see how much time has elapsed (even if only a rough indication is provided), rather than simply having a unit which suddenly provides a 'time-out' signal. When a player makes a move, he or she operates a reset button which sets the display back to zero and starts the next timing run.

This type of timer could be based on digital or analogue circuits, and this particular design is of analogue variety. It consists basically of a C-R timer circuit driving a bargraph driver via a buffer stage. A drawback of a standard C-R timer circuit in this application is that the output voltage rises exponentially. In other words, it starts off rising at a relatively fast rate, but gradually slows down as the charge voltage rises. This could give (say) 2 seconds for the first LED to be activated, but around 20 seconds between LEDs nine and ten being switched on. The problem is easily overcome by charging the timing capacitor via a constant current generator instead of using a resistor to control the charge rate.

In this circuit, IC1 is the constant current generator, and the LM334Z is specifically designed for use as a current regulator. R1 and RV1 set the output current, and RV1 is adjusted to give the required full scale time. S1 is the reset switch, and this merely discharges timing capacitor C2 when it is operated. R2 provides current limiting to prevent contact sparking that could otherwise result in S1 having a very short operating life. In order to ensure proper operation of the circuit it is essential that there is minimal loading on C2, and IC2 is therefore used to buffer the output voltage. This is an ultra high input resistance device which has an input resistance of around 1.5 million meg-ohms. It is also a type which is suitable for single supply operation. Few other devices will function properly in the IC2 position of this circuit. The bargraph driver is the popular LM3914N which is operated in the 'dot' mode in order to keep the current consumption down to a satisfactory level. R4 sets the LED current at about 10 milliamps. A lower LED current can be used satisfactorily with some displays, and raising R4 to about 2.2k ohms in value will then give a useful reduction in supply current.



Games Timer Circuit

Construction of the unit is reasonably straightforward, but if the display LEDs are individual types, they must be mounted in a row and in sequence in order to give a neat and meaningful readout. If preferred, a proper ten LED bargraph display can be used for D1 to D10. IC2 is a MOS input device, and consequently requires the standard anti-static handling precautions. As IC3 is a fairly expensive device it should be fitted in a holder.

Adjusting RV1 for the required full scale time is a matter of using trial and error. Delay times outside the normal adjustment range of RV1 can be obtained by altering the value of C2, and delay times are proportional to the value of this component. Very long timing periods are not feasible though, as the value of C2 would need to be impractically large.

SERIAL-PARALLEL CONVERTER PARTS LIST

RESISTORS: All 0.6W 1% Metal Film			
R1	5k6	1	(M5K6)
R2	4k7	1	(M4K7)
R3	2k2	1	(M2K2)
R4	47k	1	(M47K)
RV1	10k Sub-min Hor Preset	1	(WR58N)
CAPACITORS			
C1	100nF Ceramic	1	(BX03D)
C2	1nF Poly layer	1	(WW22Y)
C3	10μF 50V PC Electrolytic	1	(FF04E)
SEMICONDUCTORS			
IC1	4047BE	1	(QX20W)
IC2	6402	1	(QQ04E)
TR1	BC108	1	(QB32K)
D1	1N4148	1	(QL80B)
MISCELLANEOUS			
SK1	Phono Socket	1	(YW06G)
	14 pin DIL Socket	1	(BL18U)
	40 pin DIL Socket	1	(HQ38R)

STEREO Vu METER PARTS LIST

RESISTORS: All 0.6W 1% Metal Film			
R1,9	330k	2	(M330K)
R2,3,10,11	100k	4	(M100K)
R4,12	390k	2	(M390K)
R5,13	470k	2	(M470K)
R6,8,14,16	220Ω	4	(M220R)
R7,15	47k	2	(M47K)
RV1,2	100k Sub-Min Hor Preset	2	(WR61R)
CAPACITORS			
C1,5	100nF Poly Layer	2	(WW41U)
C2,6	220nF Poly Layer	2	(WW45Y)
C3,7	47μF 25V PC Electrolytic	2	(FF08J)
C4	100μF 10V PC Electrolytic	1	(FF10L)
SEMICONDUCTORS			
IC1,2	CA3240E	2	(WQ21X)
D1,2,3,4	1N4148	4	(QL80B)
MISCELLANEOUS			
	8 pin DIL Socket	2	(BL17T)

STEREO BARGRAPH PARTS LIST

RESISTORS: All 0.6W 1% Metal Film			
R1	1M	1	(M1M)
R2	1k2	1	(M1K2)
CAPACITORS			
C1	10nF Poly Layer	1	(WW29G)
C2	47μF 16V Axial Electrolytic	1	(FB38R)
SEMICONDUCTORS			
IC1	4016BE	1	(QX08J)
IC2	4001BE	1	(QX01B)
IC3	LM3915	1	(YY96E)
TR1,2	BC547	2	(QQ14Q)
DISP1,2	5mm LED	20	(WL27E)
MISCELLANEOUS			
	14 pin IC Socket	2	(BL18U)
	18 pin IC Socket	1	(HQ76H)

GAMES TIMER PARTS LIST

RESISTORS: All 0.6W 1% Metal Film			
R1	8k2	1	(M8K2)
R2	47R	1	(M47R)
R3	10k	1	(M10K)
R4	1k2	1	(M1K2)
RV1	47k Sub-min Hor Preset	1	(WR60Q)
CAPACITORS			
C1	100μF 10V PC Electrolytic	1	(FF10L)
C2	47μF 25V PC Electrolytic	1	(FF08J)
SEMICONDUCTORS			
IC1	LM334Z	1	(WQ32K)
IC2	CA3140E	1	(QH29G)
IC3	LM3914N	1	(WQ41U)
D1 to D10	5mm Red LED	10	(WL27E)
MISCELLANEOUS			
S1	Push to Make Switch	1	(FH60Q)
S2	SPST Ultra-min Toggle	1	(FH97F)
B1	Battery 1.5V	6	(FK55K)
	Battery Holder	1	(HQ01B)
	Battery Connector	1	(HF28F)
	DIL IC Holder 8 pin	1	(BL17T)
	DIL IC Holder 18 pin	1	(HQ76H)

FIBRE OPTIC TRANSMITTER PARTS LIST

RESISTORS: All 0.6W 1% Metal Film			
R1	1M5	1	(M1M5)
R2,5	4k7	2	(M4K7)
R3	39k	1	(M39K)
R4	47k	1	(M47K)
R6	100k	1	(M100K)
R7	100Ω	1	(M100R)
RV1	10k log pot	1	(FW22Y)
CAPACITORS			
C1	100μF 10V PC Electrolytic	1	(FF10L)
C2,4	1μF 100V PC Electrolytic	2	(FF01B)
C3,6	2μ2F 100V PC Electrolytic	2	(FF02C)
C5	220pF Ceramic	1	(WX60Q)
SEMICONDUCTORS			
TR1,2	BC549	2	(QQ15R)
IC1	μA741C	1	(QL22Y)
LED1	MFOE71	1	(FD14Q)
MISCELLANEOUS			
B1	9 Volt Battery (PP9)	1	(FM05F)
S1	SPST Ultra-min Toggle	1	(FH97F)
JK1	3.5mm Jack	1	(HF82D)
	8 pin DIL Socket	1	(BL17T)
	Battery Clips	1	(HF27E)
	Microphone	1	(YB31J)
	Fibre-optic Cable	As req	(XR56L)

FIBRE OPTIC RECEIVER PARTS LIST

RESISTORS: All 0.6W 1% Metal Film			
R1	1M5	1	(M1M5)
R2	4k7	1	(M4K7)
R3	39k	1	(M39K)
R4	47k	1	(M47K)
R5	220k	1	(M220K)
R6	2k2	1	(M2K2)
RV1	10k log pot	1	(FW22Y)
CAPACITORS			
C1,7	100μF 10V PC Electrolytic	2	(FF10L)
C2,4	1μF 100V PC Electrolytic	2	(FF01B)
C3,5	2μ2F 100V PC Electrolytic	2	(FF02C)
C6	220pF Ceramic	1	(WX60Q)
SEMICONDUCTORS			
TR1	BC549	1	(QQ15R)
IC1	μA741C	1	(QL22Y)
LED2	MFOD71	1	(FD12N)
MISCELLANEOUS			
B1	9 Volt Battery (PP3)	1	(FK58N)
S1	SPST Ultra-min Toggle	1	(FH97F)
JK1	3.5mm Jack	1	(HF82D)
	8 pin DIL Socket	1	(BL17T)
	Battery Clip	1	(HF28F)
	Earphone	1	(LB25C)

Maplin's Big Heart

By J. Rose

On the 19th of June this year, on a field in south London around 20,000 people will gather to join in on one of the most popular fund raising events in the cycling calendar – the annual London to Brighton bike ride. This year the line up will include at least two members of the Maplin team. From the Birmingham branch Dave Kirk, who regularly cycles the Midlands ride, and myself being foolish enough to ride the 56 miles for the second year. All proceeds from the event will be donated to the British Heart Foundation who will use the money for invaluable research work, as well as providing much needed equipment for heart disease sufferers. If you would like to help by sponsoring the Maplin team, get in touch straight away! All sponsorship is very welcome, but I must stress that any approach must be made direct to Dave or myself at the Birmingham shop, Sutton New Road, Erdington B23 6TH. Look in the next issue to see how we get on.

1988 CATALOGUE PRICE CHANGES

The price changes shown in this list are valid from 16th May 1988 to 13th August 1988. Prices charged will be those ruling on the day of despatch.

For further details please see 'Prices' on catalogue page 20.

Price Changes
All items whose prices have changed since the publication of the 1988 catalogue are shown in the list below.

A complete Price List is also available free of charge – order as XF08J.

Key

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

1988 Catalogue Page No.		VAT Inclusive Price

AERIALS

Page 38

XQ23A	Mushkiller FM1083	£13.45
XQ25C	Mushkiller FM1085	£21.45
‡XQ27E	Mushkiller FM1087	£33.95
XQ29G	Trucolour TC10 Grp A	£12.65
XQ30H	Trucolour TC10 Grp B	£12.65
XQ31J	TrucolourTC10 GrpC/D	£12.65
XG23A	Trucolour TC10 Grp E	£12.65
XQ32K	Trucolour TC13 Grp A	£14.95
XQ33L	Trucolour TC13 Grp B	£14.95
XQ34M	TrucolourTC13 GrpC/D	£14.95
XQ35Q	Trucolour TC18 Grp A	£18.40
XQ36P	Trucolour TC18 Grp B	£18.40
XQ37S	TrucolourTC18 GrpC/D	£18.40
XG24B	Trucolour TC18 Grp E	£18.40
XQ38R	Extragain XG5	£19.95

Page 39

XQ39N	Extragain XG8 GroupA	£30.95
XQ40T	Extragain XG8 GroupB	£30.95
XQ41U	Extragain XG8 GrpC/D	£30.95
XQ42V	Extragain XG8 Wdbnd	£30.95
XQ43W	ExtragainXG14 GroupA	£59.50
XQ44X	ExtragainXG14 GroupB	£59.50
XQ45Y	ExtragainXG14 GrpC/D	£59.50
XQ46A	Extragain XG14 Wdbnd	£59.50
XQ50E	Extragain XG21 Wdbnd	£84.95
YM56L	Hi-Tech TV Aerial	£10.75
XQ51F	Super-Set Top	£10.35
XY30H	Toptenna	£5.40
XQ52G	Caratenna	£12.65
XQ53H	Mast Bracket Type 3	£9.95
XQ54J	Mast Bracket Type 8	£13.95

Page 40

BW44X	Mast Bracket Type 14	£3.95
BW45Y	Loft Bracket EM4	£2.50
XQ55K	Lashing Kit Type 4	£10.35
XQ57M	Lashing Kit Type 7	£19.50
XQ58N	Lashing Kit Type 9	£13.75
XQ60Q	Mast D	£4.35

Page 41

YX73Q	Indoor Amp XB1	£25.95
YP59P	Aerial Amp 22.5dB	£37.95
YP41U	2 Outlet TV Amp	£12.95
YQ22Y	Xtra Set Amp	£24.95

Page 42

YP42V	2 Outlet TV/FM Amp	£16.95
BK75S	Xtra Set 3 Amp	£29.50
YN42V	Xtra Set 4 Amp	£36.95
BK76H	TV Amp XB12	£16.45

Page 43

YP57M	Aerial Combiner A/E	£9.95
YP58N	Aerial Combinr AB/CD	£9.95
HX88V	Resistive Splitter	£2.50
YQ23A	Inductive Splitter	£2.95
HX87U	Surface Co-Ax Outlet	£1.50
BW55K	Flush Co-Ax Outlet	£1.99
BW56L	Flsh Dbl Co-Ax Outlt	£2.95

Page 44

LB09K	75/300 Balun	£1.40
RK47B	3dB Attenuator	£1.98
BW59P	Attenuator 6dB	£1.98
BW60Q	Attenuator 12dB	£1.98

AUDIO, VIDEO & COMPUTERS

Page 46

XG68Y	12V Disco Deck	£39.95
FQ17T	Cartridge Slide MP60	£3.80
YW58N	BSR Drive Belt	£1.98

Page 47

HR17T	Ctrdg Sono V100	£8.95
FQ38R	Ctrdg Goldring G800H	£12.95

Page 48

FV16S	ME70-B Shure Cart	£13.95
FV13P	ME75-6S Shure Cart	£14.95
FV15R	ME75-EJ 2 Shure Cart	£19.95
FV14Q	ME75-ED 2 Shure Cart	£23.95
FV18U	ME95-ED Shure Cart	£26.95
FV17T	ME97-HE Shure Cart	£39.50
HR39N	BSR TC8	£1.50
HR51F	Ronette BF40	£1.50
FV27E	BSR ST4	£2.20
HR25C	Acos GP91-1SC	£2.20
HR87U	Philips AG3306	£2.20
HR60Q	Sonotone 9TAHC	£2.20
HR42V	BSR ST10	£2.20
YX27E	Sony ND15P	£7.95
FV26D	Acos GP91-1	£2.20
HR53H	Garrard KS40A	£2.20
HR31J	Acos GP104	£2.20
HR47B	BSR ST17	£2.20
HR74R	BSR ST21	£1.50
FQ45Y	Garrard GDD1	£2.20
HR81C	Vacco Luxor	£1.50
HR45Y	BSR ST15	£2.20
FV24B	Fuji Onkyo	£8.95
FV22Y	Sanyo STG6	£2.20
HR90X	Philips GP400	£6.95
FM76H	Hitachi HN-ST6	£2.20
FV33L	Shure N95-ED	£24.95
FV20W	Tetrad T30MS	£2.20
FV34M	Shure N97-HE	£34.95
FQ51F	Tenorel 2001D	£6.95
HR89W	Philips GP205	£1.50
FM70M	Garrard GKS25	£2.20
HR97F	Sanyo 2611K	£8.95
HR76H	Goldring D110E	£7.95
FV29G	Panasonic EPS36	£2.20
HR61R	Sonotone V100	£7.95
HR95D	Sansui SN28	£7.95
HR79L	Hitachi ST103	£8.95
FV28F	Sharp STY104	£6.95
FV23A	Panasonic EPS270	£8.95

Page 52

YP45Y	CD Clean System	£4.95

Page 55

CT33L	Scotch MSIV-C90	DIS
CT02C	TDK D-60	95p
CT03D	TDK D-90	£1.20
CT08J	TDK AD-60	£1.20
CT09K	TDK AD-90	£1.45
CT23A	TDK SA-60	£1.60
CT24B	TDK SA-90	£1.98
CT26D	TDK SA-X60	£1.98
CT27E	TDK SA-X90	£2.50
CT31J	TDK HXS-90	DIS
CT39N	TDK MA-R90	£5.95

Page 57

XJ11M	Video Enhancer 406	£16.95
YP47B	Video-Cine Adaptor	£16.95

Page 58

YP84F	Surge Protectr RS232	£9.95

Page 60

FT82D	D/S Q/D Disk 5.25	£1.80
YJ72P	10 D/S Q/D Disk 5.25	£14.95

Page 61

YK97F	Minibox 10	DIS

BATTERIES & POWER SUPPLIES

Page 63

FK55K	Blue Seal R6B	21p
FK56L	Blue Seal R14B	36p
FK57M	Blue Seal R20B	40p
FK58N	Blue Seal PP3B	79p
FK59P	Silver Seal R6S	31p
FK60Q	Silver Seal R14S	54p
FK61R	Silver Seal R20S	62p
FK62S	Silver Seal PP3S	£1.07
FM13P	Gold Seal LR1	63p
FK63T	Gold Seal LR03	63p
FK64U	Gold Seal LR6	49p
FK65V	Gold Seal LR14	£1.15
FK66W	Gold Seal LR20	£1.28
FK67X	Gold Seal 6LF22	£2.39
FM02C	Trans Pwr PP1 6V	£1.99
FM03D	Trans Pwr PP6 9V	£1.69
FM04E	Trans Pwr PP7 9V	£1.69
FM05F	Trans Pwr PP9 9V	£1.69
FM07H	Photo Batt BLR121	£2.99
FM08J	Photo Batt BLR122	£3.99
FM09K	Photo Batt BLR154	£2.99
QY67X	Photo-Test PX28	£3.64
FK68Y	Gen Purpose No.8	49p
FK69A	Gen Purpose 1289	99p
YJ18U	Gen Purpose PJ996	£2.77
YJ19V	Gen Purpose 991	£7.85
YJ21X	Gen Purpose AD28	£3.20
YJ22Y	Gen Purpose HP1	£12.54
YJ23A	Gen Purpose HP992	£3.99
FK70M	Gen Purpose 126	£2.48
FK71N	Gen Purpose FLAG	£4.53

Page 64

FM14Q	Merc Batt PX1/RMIN	£1.32
FM18U	Merc Batt PX/RM625	69p
FM20W	Merc Batt PX675	58p
FM21X	Merc Batt RM13H	38p
FM23A	Merc Batt RM675H	58p
FM24B	Merc Batt BP675	48p
FM33L	Silver Batt B-SR58L	TEMP
FS76H	Silver Batt B-SR371L	DIS
FS75S	Silver Batt B-SR57L	TEMP

Page 65

YJ69A	1.2Ah L/Acid Bat 12V	£13.50

Page 66

FE09K	Ni Cad AAA	£1.80
YG00A	Ni Cad AA	£1.36

Page 68

XG88V	13.8V 7A Reg PSU	£29.95

BOOKS

Page 71

RL27E	Book NB147	£9.95 *NV*
RL31J	Book NB157	£5.95 *NV*

Page 72

WP46A	Micro Elec Dictionry	£1.95 *NV*
WA20W	Understdng Electrncs	£14.50 *NV*
XW64U	Book NB449	£5.95 *NV*
WA21X	Undrstdng Dig Elec	£14.50 *NV*
WG11M	Book JW748	£9.65 *NV*
WK61R	Electrnics for Techs	£7.50 *NV*
RF10L	Book BP228	£2.50 *NV*
WP05F	Pract Electronics	£8.25 *NV*

Page 73

WA24B	Undrstdng Communctns	£14.50 *NV*
WK45Y	Undrstn Phone Electrn	£14.50 *NV*
WP24B	Telecom Circuits	£15.50 *NV*
WP28F	Data Communications	£14.50 *NV*
WM59P	Linear Electronics	£9.50 *NV*
RL34M	Book NB189	£9.95 *NV*
RR39N	Towers Transistor Bk	TEMP

Page 74

WP67X	Elec Pocket Book	£9.95 *NV*

Page 75

WA10L	TI Linear Circuits	£11.00 *NV*
WA14Q	TI TTL Data Vol 1	£14.95 *NV*
WP31J	TI TTL Data Vol 2	£14.95 *NV*
WG58N	Book FT1199	£13.20 *NV*

Page 76

WG23A	Book JW568	DIS
WA06G	TI MDS Memory Data	£12.50 *NV*

Page 77

WG01B	Book NB447	JUL88
WP50E	Intro Electronics	£2.95 *NV*
WM60Q	Mastering Electronic	£4.25 *NV*

Page 78

RH30H	Book BP37	£2.95 *NV*
XW30H	Cost Effectv Constrc	£6.95 *NV*

Page 79

WP41U	Proj in Microelect	DIS
WG54J	Book NB535	£5.95 *NV*
RB10L	Book NB269	£7.95 *NV*

Page 80

WG53H	Book NB529	£5.95 *NV*
RQ30H	Book NB353	£8.95 *NV*
XW38R	Book NB480	£8.95 *NV*
RQ66W	Book BP59	DIS
WP00A	Fib Op Laser Handbk	£13.20 *NV*

Page 81

WP77J	Build Fibop/Lasr Prj	£12.40 *NV*
XW08J	Book BP60	DIS
WP51F	Audio Projects	£7.95 *NV*

Page 82

WG82D	Book FT1364	£8.45 *NV*
XW09K	Book NB391	£5.95 *NV*

Page 83

XW54J	Book NB439	£3.95 *NV*

Page 84

WG95D	Book FT1305	£8.70 *NV*
WP57M	DX Power	£8.00 *NV*
WG80B	Book FT1185	£8.45 *NV*

Page 85

WM99H	Satellite TV Guide	£9.25 *NV*
WG89W	Book NB132	£9.95 *NV*
XW88V	Book AG569	£3.95 *NV*
WP08J	Elect Fault Diagnos	£6.95 *NV*
WM86T	Elect Servicing	£9.50 *NV*
RL23A	Book NB137	DIS

Page 86

RQ01B	Book Sybex C201	£22.95 *NV*
XW98G	Book FT1070	£15.55 *NV*
WP12N	Micro I/F Ccts - Bk2	£2.75 *NV*

Page 87

WP62S	6502 Ref Guide	DIS
XW80B	Book C202	£15.95 *NV*
WP63T	68000 Ref Guide	DIS

Page 88

WM76H	Programming M68000	£13.95 *NV*

Page 89

WP58N	Understanding C	£18.95 *NV*
WG25C	Book JW609	£8.95 *NV*
XW79L	Book C300	£17.95 *NV*
WM77J	Working dBase II	£9.95 *NV*

Page 90

WP13P	Easy Prog Atari Micr	DIS

Page 91

†WA80B	20 ZX81 Projects	£6.45 *NV*
WG61R	Book HD192	DIS
WM37S	Und Auto Syst	£14.50 *NV*

BOXES

Page 92

FD96E	Potting Box Cube	20p
LH56L	Potting Box Min	18p
LH57M	Potting Box Small	28p
FD97F	Potting Box Medium	38p
LH59P	Potting Box Large	46p
FD98G	Potting Box Ex Large	48p

Page 93

LH90X	Smll Remote Cntrl Bx	£3.50
YK24B	Calc-Style Verobox	£4.50

Page 96

LH00A	Verobox 101	£4.65
LH01B	Verobox 102	£5.40
LL00A	Verobox 103	£7.30
LL05F	Verobox 201	£7.85
LL08J	Verobox 211	£4.75
LL09K	Verobox 212	£5.20
LL10L	Verobox 213	£6.30
LL11M	Verobox 217	£6.95
LL12N	Verobox 301	84p
LH50E	Verobox 303	£2.50
LH51F	Verobox 305	£3.30
LL14Q	Verobox 401	96p
LQ03D	Flip-Top Box 601 Blk	£3.80
LH30H	Verobox 705	£7.95

Page 98

FE38R	Sink 20	74p
FE39N	Sink 40	£1.10

Page 103

RY06G	Acoustic Wadding	80p
XS08J	Square Cloth 1.42m	£2.50
XS10L	Square Cloth 0.71m	£1.30

CABLES

Page 104

PA56L	100m Bell Wire Blk	£2.10
PA57M	100m Bell Wire Blu	£2.10
PA59P	100m Bell Wire Grn	£2.10
PA60Q	100m Bell Wire Orn	£2.10
PA61R	100m Bell Wire Red	£2.10
PA62S	100m Bell Wire Wht	£2.10
PA63T	100m Bell Wire Yel	£2.10
BL00A	7/0.2 Wire 10M Blk	30p
PA45Y	100m 7/0.2 Wire Blk	£2.50
PA28F	1000m 7/0.2 Wire Blk	£22.50
BL01B	7/0.2 Wire 10M Blu	30p
PA46A	100m 7/0.2 Wire Blu	£2.50
PA29G	1000m 7/0.2 Wire Blu	£22.50
BL02C	7/0.2 Wire 10M Brn	30p
PA47B	100m 7/0.2 Wire Brn	£2.50
PA30H	1000m 7/0.2 Wire Brn	£22.50
BL03D	7/0.2 Wire 10M Grn	30p
PA48C	100m 7/0.2 Wire Grn	£2.50
PA31J	1000m 7/0.2 Wire Grn	£22.50
BL04E	7/0.2 Wire 10M Gry	30p
PA49D	100m 7/0.2 Wire Gry	£2.50
PA32K	1000m 7/0.2 Wire Gry	£22.50
BL05F	7/0.2 Wire 10M Orn	30p
PA50E	100m 7/0.2 Wire Orn	£2.50
PA33L	1000m 7/0.2 Wire Orn	£22.50
BL06G	7/0.2 Wire 10M Pnk	30p
PA51F	100m 7/0.2 Wire Pnk	£2.50
PA34M	1000m 7/0.2 Wire Pnk	£22.50
BL07H	7/0.2 Wire 10M Red	30p
PA52G	100m 7/0.2 Wire Red	£2.50
PA35N	1000m 7/0.2 Wire Red	£22.50
BL08J	7/0.2 Wire 10M Vio	30p
PA53H	100m 7/0.2 Wire Vio	£2.50
PA36P	1000m 7/0.2 Wire Vio	£22.50
BL09K	7/0.2 Wire 10M Wht	30p
PA54J	100m 7/0.2 Wire Wht	£2.50
PA37Q	1000m 7/0.2 Wire Wht	£22.50
BL10L	7/0.2 Wire 10M Yel	30p
PA55K	100m 7/0.2 Wire Yel	£2.50
PA38R	1000m 7/0.2 Wire Yel	£22.50
FA26D	16/0.2 Wire 10M Blk	54p
PA64U	100m 16/0.2 Wire Blk	£4.45
FA27E	16/0.2 Wire 10M Blu	54p
PA65V	100m 16/0.2 Wire Blu	£4.45
FA28F	16/0.2 Wire 10M Brn	54p
PA66W	100m 16/0.2 Wire Brn	£4.45
FA29G	16/0.2 Wire 10M Grn	54p
PA67X	100m 16/0.2 Wire Grn	£4.45
FA31J	16/0.2 Wire 10M Orn	54p
PA69A	100m 16/0.2 Wire Orn	£4.45
FA33L	16/0.2 Wire 10M Red	54p
PA71N	100m 16/0.2 Wire Red	£4.45
FA35Q	16/0.2 Wire 10M Wht	54p
PA73Q	100m 16/0.2 Wire Wht	£4.45
FA36P	16/0.2 Wire 10M Yel	54p
PA74R	100m 16/0.2 Wire Yel	£4.45

Page 105

XR57M	HC Wire Black	28p
PA94C	50m HC Wire Black	£10.95
XR58N	HC Wire Green	28p
PA95D	50m HC Wire Green	£10.95
XR59P	HC Wire Red	28p
PA96E	50m HC Wire Red	£10.95
XR68Y	Min Extra Flex Black	12p
PB01B	25m Min Ext Flex Blk	£2.05
XR69A	Min Extra Flex Red	12p
PB02C	25m Min Ext Flex Red	£2.05
BL16S	EC Wire 2.0mm 14swg	57p
YN79L	250 ECW 2.0mm 14swg	£2.10
BL24B	EC Wire 1.6mm 16swg	55p
YN80B	250 ECW 1.6mm 16swg	£2.10
BL25C	EC Wire 1.25mm 18swg	55p
YN81C	250 ECW 1.25mm 18swg	£2.10
YN82D	250 ECW 0.9mm 20swg	£2.15
BL27E	EC Wire 0.71mm 22swg	64p
YN83E	250 ECW 0.71mm 22swg	£2.35
YN84F	250 ECW 0.56mm 24swg	£2.45
BL29G	EC Wire 0.45mm 26swg	66p
YN85G	250 ECW 0.45mm 26swg	£2.50
BL39N	EC Wire 0.375mm28swg	69p
YN86T	250 ECW 0.375mm28swg	£2.65
BL40T	EC Wire 0.315mm30swg	72p
YN87U	250 ECW 0.315mm30swg	£2.85
BL41U	EC Wire 0.28mm 32swg	76p
YN88V	250 ECW 0.28mm 32swg	£2.95
BL42V	EC Wire 0.236mm34swg	78p
YN89W	250 ECW 0.236mm34swg	£3.00
BL43W	EC Wire 0.19mm 36swg	82p
YN90X	250 ECW 0.19mm 36swg	£3.15
BL44X	EC Wire 0.15mm 38swg	85p
YN91Y	250 ECW 0.15mm 38swg	£3.25
YN92A	250 ECW 0.125mm40swg	£3.40
XR60Q	HD Loudspeaker Cable	42p

Page 106

XR89W	4-Wire Burglar Cable	16p
XR66W	4-Wire Phone Cable	16p
PA76H	100m 4-Wire Phone	£10.98
XS04E	6 Way Phone Cable	22p
PA87U	100m 6 Way Phone Cbl	£14.98
XR06G	Ribbon Cable 10 Way	80p
XR07H	Ribbon Cable 20 Way	£1.60
XR73Q	Flat IDC Cable 16way	30p
XR74R	Flat IDC Cable 20way	37p
XR75S	Flat IDC Cable 26way	48p
XR76H	Flat IDC Cable 34way	64p
XR77J	Flat IDC Cable 40way	74p
XR79L	Flat IDC Cable 50Way	95p
XR80B	Clr Cd IDC Cable 16W	47p
XR81C	Clr Cd IDC Cable 20W	60p
XR82D	Clr Cd IDC Cable 26W	75p
XR83E	Clr Cd IDC Cable 34W	98p
XR84F	Clr Cd IDC Cable 40W	£1.10
XR85G	Clr Cd IDC Cable 50W	£1.45

Page 107

XR47B	Twn Mains DS Black	17p
PA10L	100m Twn Mains Black	£11.65
XR00A	Twn Mains DS White	17p
PA11M	100m Twn Mains White	£11.65
XR61R	Twin 6A Mains Orange	24p
XR62S	Twin 6A Mains White	24p
XR01B	Min Mains Black	26p
PB08J	100m Min Mains Black	£17.95
XR02C	Min Mains White	26p
PB09K	100m Min Mains White	£17.95
XR03D	C6A Mains Black	37p
XR04E	C6A Mains White	37p
XR05F	C6A Mains Orange	37p
XR09K	HD Mains Black	58p
PA12N	100m HD Mains Black	£38.75
XR10L	HD Mains White	58p
PA13P	100m HD Mains White	£38.75
XR11M	HD Mains Orange	58p
PA14Q	100m HD Mains Orange	£38.75

Page 108

XR49D	1.0mm TE Cable	17p
XR51F	2.5mm TE Cable	31p
XR52G	6mm TE Cable	84p
XR53H	1mm Trpl & ECC Cbl	29p
XR15R	Min Screened	18p
PB13P	100m Min Screened	£11.95
XR12N	Cable Single Black	18p
XR13P	Cable Single Grey	18p
XR14Q	Cable Single White	18p
XR16S	Single Mic Cable	37p
PA16S	100m Singl Mic Cable	£24.95
XR18U	Low Noise Scnd	32p
PB14Q	25m Low Noise Scnd	£6.20

Page 109

XR19V	Low C Cable	38p
PB15R	100m Low C Cable	£25.95
XR63T	UR67 RF Cable	£1.10
XR20W	Lapped Pair	20p
XR23A	Cable Quad	55p
PA18U	50m Cable Quad	£19.95
XR92A	Lapped 4-Core Grey	32p
PB41U	100m Lap 4-Core Grey	£24.95
XR91Y	Lapped 4-Core Black	32p
PB40T	100m Lap 4-Core Blck	£24.95

Page 110

XR25C	Multi-Core 4-Way	70p
BH30H	Scr Stretchflex Blk	£2.50
BH34M	Scr Stretchflex Red	£2.50
HQ49D	Twin Stretchflex	£3.50
XR88V	Miniature Coax	39p
PB19V	100m Miniature Coax	£26.95
PB20W	100m Bal Feeder	£9.95

CAPACITORS

Page 118

FF58N	IS Cap 0.47uF	90p

COMMUNICATIONS

Page 127

YG16S	Mag Mount	£11.95

Page 128

YM95D	Traveler Clock Radio	DIS

Page 129

YP22Y	Clock/radio Phon Wht	£34.95

CONNECTORS

Page 138

RK60Q	D-Range 9 Way Plug	31p
BK58N	D-Range 15-Way Plug	43p
YQ48C	D-Range 25-Way Plug	51p
RK61R	D-Range 9 Way Skt	43p
BK59P	D-Range 15-Way Skt	63p
YQ49D	D-Range 25W Socket	74p

Page 140

FS92A	Finger Screw Hd 9W	DIS
FS93B	Finger Screw Hd 15W	DIS
FP30H	Finger Screw Hd 25W	DIS
†FS94C	Finger Screw Hd 37W	72p

Page 145

QY73Q	Polarising Key IDC	8p

ELECTRICAL ACCESSORIES

Page 168

HL68Y	Single Skt Unswitched	£1.85
HL69A	Dble Skt Unswitched	£3.45
HL71N	Single Sw Socket	£1.99
HL72P	Double Sw Socket	£3.99

1988 Catalogue Page No.	VAT Inclusive Price

Page 169
HL76H Cooker Switch £7.50
HL83E Switched Flex Outlet £4.25
HL86T Blanking Plate 68p
HL87U 20A Plateswitch £2.99
HL89W Light Swch ST Single £1.20
HL90X Light Swch DT Single £1.30
HL91Y Light Swch Dual £2.35

Page 170
YB14Q Sur Patt 20mm Sngl 65p
YB15R Sur Patt 29mm Sngl 69p
YB16S Sur Patt 29mm Dble £1.29
YB17T Sur Patt 47mm Dble £1.99
★FQ02C Lampholder 702 72p
★LB63T Bayonet L/Hldr 98p

HARDWARE

Page 172
JC80B Pozi Screw M5 20mm 23p
BF32K Pozi Screw M5 25mm 25p
JC81C Pozi Screw M5 40mm 42p
BF35Q Pozi Screw M4 25mm 18p
JC76H Pozi Screw M4 30mm 23p
JC77J Pozi Screw M4 40mm 34p
BF36P Pozi Screw M3 6mm 13p
BF37S Pozi Screw M3 12mm 13p
JC70M Pozi Screw M3 16mm 13p
JC71N Pozi Screw M3 20mm 13p
BF38R Pozi Screw M3 25mm 16p
JC72P Pozi Screw M3 30mm 18p
LR58N Pozi Screw M3 40mm 30p
JC69A Pozi Screw M2.5 20mm 15p
JC66W Pozi Screw M2 10mm 18p
JC67X Pozi Screw M2 12mm 20p
JD07H 100 Poziscrw M5 16mm £1.38
JD08J 100 Poziscrw M5 20mm £1.55
JD09K 100 Poziscrw M5 25mm £1.65
JD10L 100 Poziscrw M5 40mm £2.80
JD00A 100 Poziscrw M4 16mm 97p
JD01B 100 Poziscrw M4 20mm £1.02
JD02C 100 Poziscrw M4 25mm £1.24
JD03D 100 Poziscrw M4 30mm £1.55
JD04E 100 Poziscrw M4 40mm £2.28
JC89W 100 Poziscrw M3 6mm 88p
JC90X 100 Poziscrw M3 10mm 64p
JC91Y 100 Poziscrw M3 12mm 65p
JC92A 100 Poziscrw M3 16mm 92p
JC93B 100 Poziscrw M3 20mm 92p
JC94C 100 Poziscrw M3 25mm £1.08
JC95D 100 Poziscrw M3 30mm £1.24
JC96E 100 Poziscrw M3 40mm £1.98
JC85G 100 Poziscr M2.5 6mm 85p
JC87U 100 Pozisc M2.5 12mm 80p
JC88V 100 Pozisc M2.5 20mm £1.02
JC82D 100 Poziscrw M2 6mm £1.10
JC83E 100 Poziscrw M2 10mm £1.20
JC84F 100 Poziscrw M2 12mm £1.38
JD25C Isobolt M5 10mm 46p
BF46A Isobolt M5 12mm 51p
JD26D Isobolt M5 16mm 57p
JD27E Isobolt M5 20mm 63p
BF48C Isobolt M4 6mm 24p
JD20W Isobolt M4 10mm 27p
BF49D Isobolt M4 12mm 30p
JD21X Isobolt M4 16mm 34p
JD22Y Isobolt M4 20mm 38p
BF50E Isobolt M4 25mm 43p
JD23A Isobolt M4 30mm 48p
BF51F Isobolt M3 6mm 17p
HY30H Isobolt M3 10mm 19p
BF52G Isobolt M3 12mm 21p
JD16S Isobolt M3 16mm 23p
JD17T Isobolt M3 20mm 25p
BF53H Isobolt M3 25mm 28p
JD18U Isobolt M3 30mm 38p
JD19V Isobolt M3 40mm 48p
BF54J Isobolt M2.5 6mm 18p
JD14Q Isobolt M2.5 10mm 20p
BF55K Isobolt M2.5 12mm 21p
JD15R Isobolt M2.5 20mm 27p
JD11M Isobolt M2 6mm 18p
JD12N Isobolt M2 10mm 20p
JD13P Isobolt M2 12mm 21p
JD53H 100 Isobolt M5 10mm £3.10
JD54J 100 Isobolt M5 12mm £3.40
JD55K 100 Isobolt M5 16mm £3.85
JD56L 100 Isobolt M5 20mm £4.25
JD45Y 100 Isobolt M4 6mm £1.65
JD46A 100 Isobolt M4 10mm £1.85
JD47B 100 Isobolt M4 12mm £2.00
JD48C 100 Isobolt M4 16mm £2.30
JD49D 100 Isobolt M4 20mm £2.55
JD50E 100 Isobolt M4 25mm £2.90
JD51F 100 Isobolt M4 30mm £3.20
JD37S 100 Isobolt M3 6mm £1.15
JD38R 100 Isobolt M3 10mm £1.30
JD39N 100 Isobolt M3 12mm £1.40
JD40T 100 Isobolt M3 16mm £1.55
JD41U 100 Isobolt M3 20mm £1.70
JD42V 100 Isobolt M3 25mm £1.90
JD43W 100 Isobolt M3 30mm £2.55
JD44X 100 Isobolt M3 40mm £3.25
JD33L 100 Isobolt M2.5 6mm £1.20
JD34M 100 Isobolt M2.5 10mm £1.30
JD35Q 100 Isoblt M2.5 12mm £1.40
JD36P 100 Isobolt M2.5 20mm £1.80
JD30H 100 Isobolt M2 6mm £1.20
JD31J 100 Isobolt M2 10mm £1.35
JD32K 100 Isobolt M2 12mm £1.45
JD64U 100 Steel Nut M5 95p
JD65V 100 Steel Nut M4 78p
JD69A 100 Isonut M5 £1.10
JD70M 100 Isonut M4 85p
JD71N 100 Isonut M3 65p
JD72P 100 Isonut M2.5 62p
JD73Q 100 Isonut M2 58p

Page 173
JD94C Springwash M5 6p
JD95D Springwash M4 5p
JD96E Springwash M3 4p
JD97F Springwash M2.5 4p
JD98G Springwash M2 4p
JD99H 100 Springwash M5 43p
JE00A 100 Springwash M4 33p
JE01B 100 Springwash M3 27p
JE02C 100 Springwash M2.5 27p
JE03D 100 Springwash M2 27p

Page 174
WH19V Nylon Nut M3 5p

Page 175
FW13P Studding 2BA 40p

Page 177
LH13P Aly Sheet 16 swg £3.95

HEATHKIT

Page 178
MF27E Heathkit SB-1000 £699.95

Page 180
HK24B HN-31A Cantenna Load £24.95

Page 182
HK45Y EB-1010 Elect Dctnry £14.99 NV
HK04E EE-3140 Hobby Elect £54.95
HK32K EE-3100 Basic Eltrty £24.99 NV

Page 186
HK81C EE-1001 Passive Crs £39.95
HK82D EE-1002 Transtr Crs £44.95
HM05F EE-1003 Anlg Dsn Crs £44.95

Page 187
MD55K EE-1004 Dig Circuits £49.95
HK84F ETW-1000 Assembled £324.95

Page 189
HM15R EC-2001 Cmptr Fndmnt £44.95
MD26D EC-2002 Cmptr Prphrl £49.95

Page 190
MD31J EC-2003 Cmptr Mntnce £39.95
HK86T ET-100 16-Bit Trainr £699.95

Page 191
HK21X EE-1800 Robotics Crs £69.95 NV

Page 192
HK26D IG-5280 RF Oscilltr £79.95
HK34M IB-5281 RCL Bridge £69.95
HE98G IT-5230 CRT Tester £169.95

Page 193
†HK93B IMA-100-10 DC Probe £16.95

KNOBS

Page 195
HB34M Knob K105L DIS
†HB36P Knob K15 48p
HB40T Knob K45 DIS

Page 196
YG40T Low-Cost Collet Knob 38p

Page 197
RX94C Cord Drum Large £1.40

MICROPHONES

Page 199
FK45Y One Point Stereo Mic DIS

MUSICAL & EFFECTS

Page 211
†XG30H BBD Echo EM-006 £99.95

OPTO-ELECTRICAL

Page 224
HB09K LDR RPY58A DIS

Page 225
XR56L 1mm Light Guide 64p

ORGAN COMPONENTS

Page 227
†QL02C SAM77 £1.80

Page 228
★XB10L DM02 £14.95
★XB11M DM02T £16.95

PANEL METERS

Page 231
RW98G 2inPn Mt 100-0-100uA £5.95
FM98G 2in. Pan Meter 50uA £5.95
RW92A 2in. Pan Meter 100uA £5.95
RW94C 2in. Pan Meter 1mA £5.95
RX33L 2in. Pan Meter 100mA £5.95
RX35Q 2in. Pan Meter 1A £5.95

Page 232
RX54J 50uA Lrge Pan Meter £7.95
YJ96E 100uA Lrge Pan Meter £7.95
RX92A Meter MI 15V £11.95
RX90X Meter MI 5A £11.95
RX91Y Meter MI 15A £11.95
RX93B Meter MI 25A £12.95

PCB EQUIPMENT

Page 234
FL02C SRBP 0.1in Type 3 £1.50
FL06G Vero 14354 45p
FL08J Vero 10346 £1.80
FL09K Vero 10347 £1.95
FL10L Vero 10348 £2.40

Page 235
FL20W Pin 2140 £1.20
HY16S Wiring Pen £5.95

Page 238
RK40T Film FPF012 DIS
YJ43W Film Sheet Large DIS
RK42V PCB006 Pack DIS
YJ40T Developer FDB DIS

PROJECTS & MODULES

Page 245
LW73Q RTX3 Doppler Kit £59.95

Page 246
LM13P I/R Prox Detectr Kit £8.95

Page 249
LM01B L/Acid Bat Chrgr Kit £42.95

Page 251
LW82D Digi-Tel Main Kit £144.95

Page 253
LK42V Car Batt Monitor £6.95

Page 254
LK61R 4 Ch Servo Cntrlr Kt £25.95

Page 262
LK88V VU Meter Kit £8.95
LK89W Headphone Monitr Kit £6.95

Page 266
LM21X 23 Litre Cabinet Kit £30.95
LM20W 40 Litre Cabinet Kit £36.95

Page 272
LM17T PA Kit £20.95

Page 287
★GD67X F/Store PSU/Mod PCB £2.50
★LM34M F/Store PSU/Modulatr £9.95
FS15R Heatsink £1.50

Page 295
†XG17T ZX81 Keyboard Case £3.95

PROTECTION

Page 301
★WR96E Fuse 1.1/4 150mA 16p

Page 302
YW47B Surface BA Reed £1.20
FP10L Surface NSL Reed DIS

RADIO CONTROL

Page 308
YP25C Apache Car £39.95

Page 309
XJ19V Wild Cat Car Kit £29.95

Page 311
XJ12N Killer Kit Car £44.95

Page 312
JF57M Killer 2100 £2.50
JF58N Killer 2110 £2.95
XJ46A Beagle Car Kit £69.95

Page 313
JE78K Beagle BG-17 £2.50
JF43W Beagle BG-84 80p

Page 314
XJ47B RC Set with Meter £39.95
YP62S 2 Chn Prop RC System £39.95

RESISTORS

Page 318
W W/W Min 0.22R to 1R 28p
L 7W W/W 38p

Page 319
H 10W W/W 54p

Page 323
†XB09K Joystick Pot £5.95

SEMICONDUCTORS

Page 324
†QB01B AC126 50p
†QB02C AC127 40p
BL34M AD162 DIS
YY89W AY-3-1350 £4.00
QB39N BC142 29p
QB40T BC143 29p
QB70M BC441 39p
QB72P BC461 39p
QY53H BF173 29p
QF17T BF258 29p

Page 325
YH94C BT149B DIS
WQ20W CA3189E £1.72
WQ21X CA3240E £1.15
YH63T ICM 7555 88p
QH38R LM377 £2.85
WQ35Q LM387 £1.98

Page 326
WQ38R LM2917 £3.45
WQ40T LM3911 £2.00
WQ41U LM3914 £3.00
YY96E LM3915 £3.00
FD92A MAX232C £6.50
QH54J MJE340 45p
QH59P MPF102 40p
★WQ55K NE 544 £2.80
QH67X NE 556 52p
QH68Y NE 566 £1.60
YY68Y NE5534A £1.20
†QL02C SAM77 £1.80
WQ73Q TIP122 80p
QH55K TIP2955 60p
QH56L TIP3055 60p
RA68Y TL072CP 69p
RA71N TL082CP 58p

Page 327
YY78K TL497A £2.10
UF37S uA78S40 £2.65
★UJ45Y UM3561 95p
WQ96E VN46AF £1.05
WQ97F VN66AF £1.80
†UH92A V9938 £29.95
QL41U ZN414Z 92p
QR23A 2N3053 29p
YH98G 2N3055 55p

Page 328
QQ30H 2SA872 48p
YH88V 27128 250ns £4.95
UH95D 27C128 250ns £5.50
QW79L 40257BE £1.98
QX34M 40673 £1.20
UH93B 4464 150ns £6.95

Page 329
QX36P 5W Zener 8V2 98p
†YF00A 74LS00 25p
†QX74R 7403 28p
†UB02C 74HC03 40p
YF03D 74LS03 25p
UB08J 74HC10 35p
QX82D 7438 39p
YF27E 74LS51 18p
YF32K 74LS75 40p
QX68Y 7493 40p

QX87U 7496 58p
UB24B 74HC107 46p

Page 330
UB37S 74HC153 69p
UB70M 74HC259 £1.00
UB77J 74HC356 £1.40

Page 331
†QB01B AC126 50p
†QB02C AC127 40p
BL34M AD162 DIS

Page 332
QQ30H 2SA872 46p
QB39N BC142 29p
QB40T BC143 29p
QB70M BC441 39p
QB72P BC461 39p

Page 333
QR23A 2N3053 29p
QH54J MJE340 45p
WQ73Q TIP122 80p
QH55K TIP2955 60p
QH56L TIP3055 60p
YH98G 2N3055 55p

Page 334
QY53H BF173 29p
QF17T BF258 29p
QH59P MPF102 40p
QX34M 40673 £1.20
WQ96E VN46AF £1.05
WQ97F VN66AF £1.80

Page 336
QX36P 5W Zener 8V2 98p

Page 337
YH94C BT149B DIS

Page 340
†YF00A 74LS00 25p
†QX74R 7403 28p
YF03D 74LS03 25p
†UB02C 74HC03 40p
QX82D 7438 39p
UB08J 74HC10 35p

Page 343
YF27E 74LS51 18p

Page 348
UB24B 74HC107 46p

Page 349
YF32K 74LS75 40p
UB70M 74HC259 £1.00

Page 350
QX87U 7496 58p

Page 352
QX68Y 7493 40p

Page 356
QW79L 40257BE £1.98
UB37S 74HC153 69p
UB77J 74HC356 £1.40

Page 363
YY68Y NE5534A £1.20

Page 365
WQ21X CA3240E £1.15

Page 366
RA68Y TL072CP 69p
RA71N TL082CP 58p

Page 369
QH38R LM377 £2.85

Page 374
WQ35Q LM387 £1.98

Page 379
YY89W AY-3-1350 £4.00

Page 380
★UJ45Y UM3561 95p

Page 383
WQ20W CA3189E £1.72

Page 385
QL41U ZN414Z 92p

Page 389
★WQ55K NE 544 £2.80

Page 392
WQ40T LM3911 £2.00

Page 393
WQ41U LM3914 £3.00
YY96E LM3915 £3.00

Page 395
QH67X NE 556 52p

Page 396
YH63T ICM 7555 88p
QH68Y NE 566 £1.60

Page 398
YY78K TL497A £2.10

Page 399
UF37S uA78S40 £2.65

Page 408
†UH92A V9938 £29.95

Page 409
FD92A MAX232C £6.50

Page 412
UH93B 4464 150ns £8.95

Page 413
YH88V 27128 250ns £4.95
UH95D 27C128 250ns £5.50

Page 418
WQ38R LM2917 £3.45

Page 419
WR30H Transkt 4-Lead TO18 35p

Page 420
WR27E Kit SO55 DIS

Page 422
FG64U Coverslide 4Y DIS

Page 423
†FG65V Coverslide 6W 38p

SPEAKERS & SOUNDERS

Page 425
†LH96E Plastic Siren £6.95

Page 427
YW57M Stethoscope DIS

Page 428
YP63T I/R Stereophone £39.95

Page 430
YJ03D Crossover HPX2 £9.95
WF46A Controlled Crossover DIS

Page 432
★WF12N Hi-Fi Spkr 40W 8inch £10.95

Page 436
YP64U Personal Spkr Set £5.95
YP72P Extendispeakers DIS

SWITCHES & RELAYS

Page 441
FA97F Wafer I pole 12 way £1.80

Page 446
†YJ14Q Case For YJ13P £19.95

Page 449
†FX23A Open Relay 6V £2.98
†FX24B Open Relay 12V £3.98

Page 450
FX26D 2p Sub-Min Relay 6V DIS

TEST GEAR

Page 463
YM67X M9020 £159.95

Page 465
YM66W Audio Osc MO204 £99.95
YJ82D MF100 Freq Counter £99.95

Page 466
YM65V MF1000 1GHz Counter £149.95

Page 467
‡XB82D Crotech 3031 £249.95
‡XB83E Crotech 3132 £359.95

Page 468
XJ61R 20MHz Dual Scope DIS
XJ60Q 40MHz Dual Scope DIS

TOOLS

Page 477
FY40T Box Spanner 2BA TEMP

Page 481
FT75S 12" Stainls Stl Rule £3.95

Page 482
†FR15R Element MLX12 £3.95

Page 483
XG55K Solder Station TCSU1 £64.95
FT13P 30 Watt Iron CSTC £17.95
FT28F 40 Watt Iron XSTC £17.95

Page 485
YJ92A 18 swg Solder Reel £6.89
FY70M 22 swg Solder Reel £7.99

Page 486
JG17T Pipemastr 10mm Heads £9.95

WOUND COMPONENTS

Page 493
FD23A Mic Xfmr 600/20 £5.50

Page 494
WB06G Min Tr 6V £3.20
YJ51F Min Tr 0-6 0-6 2A £5.95
WB10L Min Tr 12V £3.20
WB25C Tr 12V 1A £5.95
WB15R Min Tr 15V £3.20
WB16S Min Tr 20V £3.20
WB20W Min Tr 24V £3.20
YJ52G PCB Tr 0-6 0-6 0.5A £4.40
YJ53H PCB Tr 0-9 0-9 0.3A £4.40
YJ54J PCB Tr 0-12 x 2 .25A £4.40
YJ55K PCB Tr 0-15 x 2 0.2A £4.40

Page 495
YM50E 100VA US Mains Trans £19.95

Page 496
YK08J Toroidal 30VA 6V £10.30
YK09K Toroidal 30VA 9V £10.30
YK10L Toroidal 30VA 12V £10.30
YK11M Toroidal 30VA 15V £10.30
YK12N Toroidal 30VA 18V £10.30
YK21X Toroidal 160VA 35V £15.95
YK22Y Toroidal 300VA 35V £19.20
YM45Y Toroidal 300VA 45V £19.20

MISCELLANEOUS

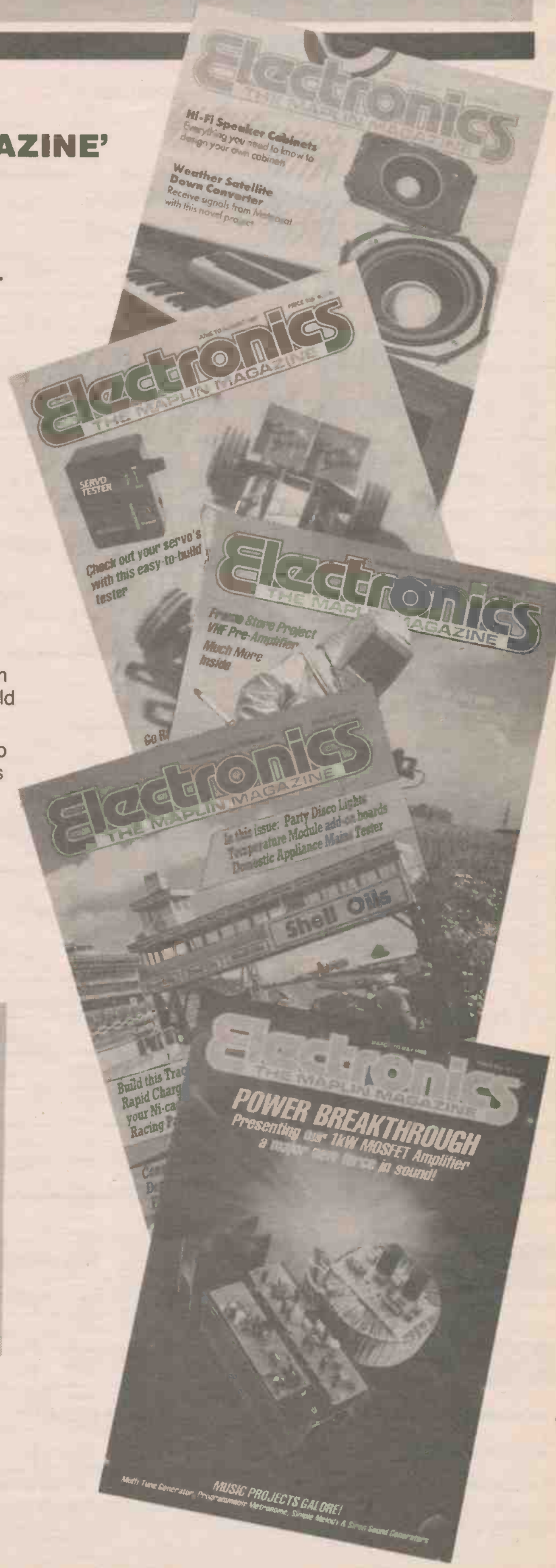
Page 499
FD26D Pocket Temp Meter £11.50

Page 500
YP16S Min/Max Thermometer £14.95

ONLY £3.40

FOR A WHOLE YEAR'S SUBSCRIPTION TO 'ELECTRONICS - THE MAPLIN MAGAZINE'

★ Every issue sent to you as soon as it's printed, post free.
★ Packed with interesting and novel projects that you can build with all components easily obtainable.
★ Many features on electronics subjects to keep you up-to-date with latest developments.
★ More pages to read than monthly magazines.
★ And much, much cheaper too. Many of the monthlies are now £1.30 or more per issue!



BUYING A SUBSCRIPTION IS THE BEST WAY TO BUY 'ELECTRONICS'

'Electronics' is different from any other electronics magazine for two reasons:

1. It's quarterly, so it's hard to remember when a new issue is due out both for you and your newsagent.

2. We don't carry any advertising, which means that having lots of copies sitting on the newstands waiting for casual sales is of no advantage to us. The newsagent will normally have plenty in stock of those magazines which advertise because in almost all cases, he can return them if they are not sold - so he doesn't pay for them.

'Electronics' has no advertisers to pay for unsold copies, nor does it need to have an impressively large circulation, so the newsagent must buy all of his delivery of 'Electronics' and cannot return those he doesn't sell. Therefore, he may not want to take stock of too many. Before you know where you are, 'Electronics' has sold out!

That's why you'll need to place a firm order with your newsagent to be sure of obtaining each new issue. Better still, place the order directly with us by sending £3.40 now and we will send you every issue for a year, post free.

Despite having very few casual sales, 'Electronics' sells more copies in the U.K. than any other electronics magazine!

BIGGEST CIRCULATION IN THE U.K.

Publication dates as follows:

XA28F Issue 28 12th August 1988 — Price 85p *NV*
XA29G Issue 29 11th November 1988 — Price 85p *NV*

ORDER COUPON

Maplin

ELECTRONIC SUPPLIES LTD.
P.O. Box 3, Rayleigh, Essex SS6 8LR.
Telephone, Credit Card Sales (0702) 554161; Enquiries (0702) 552911.
A different postal code is correctly shown on the reply paid envelopes.

In any correspondence please quote your customer number. *Date* ....

Customer No ....

Name ....

Address ....

....

.... *Post Code* ....

IT IS MOST IMPORTANT THAT YOU INCLUDE YOUR POSTCODE

Block capital letters please. ***Keep a copy of your order.***

Description (for your information only)	**Order Code**					**Quantity**	**Price Each**	**£ Total**	**p**
Current Price List (Please write 1 in quantity, if required)	X	F	0	8	J		FREE	0	00
Price Change Leaflet (Please write 1 in quantity, if required)	C	A	9	9	H		FREE	0	00

Phone before 5pm for same day despatch.

Overseas customers including Channel Isles and Eire, please deduct VAT where applicable and tick this box.

Export Order [ ]

Office Use Only			
DOR	CQ	CA	PO
CNC	Total		
CNM			

I authorise you to debit my credit card account for the cost of goods despatched.

Credit Card Number [ ][ ][ ][ ][ ][ ][ ][ ][ ][ ][ ][ ][ ][ ][ ][ ][ ]

Access/American Express/Mapcard/Visa/ .... Delete as required.
Note. Goods will be despatched only if the address above is the cardholder's address.
If ordering by Credit Card please sign:

....

Expiry date of Credit Card ....

		£	p
Total this sheet	£		
Total other sheet(s)	£		
Total for goods	**£**		
Handling Charge. If total for goods between £4.50 and £5, make total here up to £5. If less than £4.50, add 50p.			
Deduct value of Credit Note No .... Enclose the numbered Credit Note with this order.			
Please add 50p Carriage and Packing This amount must be added to each order placed.		0	50
Total	**£**		

NEW ITEMS PRICE LIST

The following is a list of all items introduced since our 1988 catalogue, excluding new items in this issue.

BOOKS

WP78K Intro Antenna Theory **Price £2.95 *NV***
WP79L Build Robot 2nd Edition **Price £10.35 *NV***
WP80B Electronics for E & E **Price £9.95 *NV***
WP81C Video Handbook **Price £30.00 *NV***
WP82D Electronics **Price £4.95 *NV***
WP83E Audio Amp Fault Chart **Price 95p *NV***
WP84F Electronic Hobbyists Handbook **Price £4.95 *NV***
WP85G A Practical Approach to Systems Electronics **Price £4.95 *NV***
WP86T Practical Digital Electronics Handbook **Price £6.95 *NV***
WP87U Radio Amateurs Examination Manual **Price £4.94 *NV***
WP88V A Guide to Amateur Radio **Price £3.62 *NV***
WP89W How to Pass the RAE **Price £3.15 *NV***

CAPACITORS

FD15R 100μF 100V P.C. Electrolytic **Price 28p**
FD16S 10,000μF 100V Can Electrolytic **Price £12.95**

PROJECTS & MODULES

GD60Q Appliance Tester PCB **Price £1.98**
GD61R Metronome PCB **Price £7.95**
GD63T Mini Metal Detector PCB **Price 20p**
GD68Y Temp Mod Relay PCB **Price £2.50**
GD69A Temp Mod Ser/Par PCB **Price £5.95**
GD70M 12V Rapid Charger PCB **Price £2.95**
GD71N Slow Charger PCB **Price 98p**
GD72P D/Party Controller PCB **Price £2.95**
GD73Q D/Party Triac PCB **Price £1.98**
GD74R TRF Receiver PCB **Price £2.95**
GD75S Simple Melody PCB **Price 50p**
GD76H Siren Sound PCB **Price £1.20**
GD79L HP Mosfet PSU PCB **Price £3.95**
GD80B HP Mosfet Driver PCB **Price £3.50**
GD81C HP Mosfet Output PCB **Price £4.50**
GD82D HP Mosfet Monitor PCB **Price £3.50**
GD83E Multi-Tune Generator PCB **Price £2.50**
JC24B Mini Metal Detector Box **Price £1.20**
JC25C 100μH Search Coil **Price 45p**
JG18U Appliance Tester Front Panel **Price £2.95**
JG19V Rapid Charger Front Trim **Price £3.50**
JG20W Threaded Spacer 10 pk **Price 60p**
JG21X Plastic Bush 20 pk **Price 45p**
JG23A Metronome Front Panel **Price £1.50**
LM35Q Mini Metal Detector Kit (PCB not included) **Price £4.95**
LM36P Converter Kit **Price £14.95**
LM37S Relay Card Kit **Price £7.50**
LM38R Appliance Tester Kit **Price £15.95**
LM39N Slow Charger Kit **Price £5.95**
LM40T 12V Rapid Charger Kit **Price £19.95**
LM41U Disco Partylite Kit **Price £17.95**
LM42V Siren Sound Generator Kit **Price £3.50**
LM43W Simple Melody Generator (V1) Kit **Price £2.50**
LM44X Simple Melody Generator (V2) Kit **Price £2.50**
LM45Y Simple Melody Generator (V3) Kit **Price £2.50**
LM46A Simple Melody Generator (V4) Kit **Price £2.50**
LM47B Multi-Tune Generator Kit **Price £8.95**
LM49D Metronome Kit **Price £29.95**
LM50E HP Mosfet Driver Kit **Price £11.95**
LM51F HP Mosfet Output Kit **Price £99.95**
LM52G HP Mosfet Monitor Kit **Price £19.95**
LM53H HP Mosfet PSU Kit **Price £89.95**
XJ65V HP Mosfet Transformer **Price £59.95**
XJ66W Heatsink Drilled **Price £27.95**

RESISTORS

L0.22 7W Wirewound 0.22Ω **Price 35p**

SWITCHES & RELAYS

JG22Y 16A 250V AC Relay 12V **Price £12.95**

AMENDMENTS TO 1988 CATALOGUE

Cordless Phone (Page 130). The range of our cordless phone, YM81C, is 100m not 200m.
Light Fittings (Page 170). Lampholder FQ02C and batten holder LB63T are approved to BS 5042, BS52 is now withdrawn.
Guitar Amp (Page 205). A strap is not provided with Guitar Amp YP49D.
Digital Master Oscillator DM02 (Page 227). In Figure 1, the plus and minus symbols on REC2 are incorrect. Pin C is the negative line.
Gold Contact Wire (Page 230). Due to a change by the supplier, this product is now supplied in 1 yard lengths, not 1 metre lengths.
Ultrasonic Intruder Detector (Page 245). The pcb's for this kit are: GB00A (Ultrasonic Xvr PCB) Price £1.95 and GB01B (Ultrasonic IF PCB) Price £1.95.
Frame Store (Page 287). In the additional parts list the transformer should be a YK09K not a YK11M.
Spectrum RS232 Interface (Page 294). The pictures for this and the VIC 20 Talkback have been transposed.
Chassis 1¼in. Fuseholder (Page 300). A new style is now being supplied. Dimensions are 53mm long x 18mm high x 12mm wide, and a solder or screw connection is available.
1¼" Quickblow Fuses (Page 301). WR96E is now a 160mA type not 150mA.
R-C Network (Page 301). Due to a change by the supplier, the contact suppressor is now made up from a 120Ω resistor (±30%) and a 0.1μF (±20%) capacitor.
Door Guard Battery (Page 307). The order code for the recommended battery for use by 'Door Guard' should be FK67X and not FK64U.
UM3561 (Page 380). The list of pin connections are transposed. Where it says Pin 1 it should be Pin 6 and vice versa.
NE544 (Page 389). In the application circuit, C1, C2 and C5 values are shown in μF, they should be in nF.
2764 EPROM (Page 412). The Vpp of this device is +12.5V not +21V.
Fan (Page 423). Standard fan WY08J's cable has no earth connection and should only be used inside equipment that is suitably insulated or earthed.
Hi-Fi Speaker (Page 432). WF12N is a 40W 8" speaker with a plasticised paper cone and soft polymer suspension. The acoustic output is 90dB.

CORRIGENDA

Vol. 7 No. 26. *1kW High Power Mosfet Amplifier.* In the description of the Monitor module on page 7 it should read: "Diodes D2 & D4 are reverse biased, IC1 pin 11 output is low, and D3 conducts;".
Simple Melody Generator. In the text it refers to C3 and C4; these should be C1 and C2 respectively. It should also be noted that both IC1 and TR1 should be laid flat on the pcb as can be seen in the photograph, and that the + leg of C1 is nearest the outside edge of the pcb.
Multi-Tune Generator. In Figure 4, the pcb track has a small link missing, there should be a connection between C10 and R12 (ends closest to TR3). If you have an issue 3 pcb, this mod will be required. Issue 4 pcb's should have this problem corrected.
Siren Sound Generator. In Figure 4, the polarity sign shown on C2 should be on the other side, i.e. connected to R2 and Pin 3.

MAPLIN'S TOP TWENTY KITS

THIS MONTH	LAST MONTH	DESCRIPTION OF KIT	ORDER CODE	KIT PRICE	DETAILS IN PROJECT BOOK
1.	(1)	Digital Watch	FS18U	£2.00	Catalogue
2.	(3)	Live Wire Detector	LK63T	£3.95	14 (XA14Q)
3.	(2)	Car Battery Monitor	LK42V	£6.95	Best of E&MM
4.	(6)	Partylite	LW93B	£9.95	Best of E&MM
5.	(4)	150W Mosfet Amplifier	LW51F	£19.95	Best of E&MM
6.	(5)	U/Sonic Car Alarm	LK75S	£17.95	15 (XA15R)
7.	(10)	Car Burglar Alarm	LW78K	£7.95	4 (XA04E)
8.	(8)	I/R Prox. Detector	LM13P	£8.95	20 (XA20W)
9.	(11)	8W Amplifier	LW36P	£5.95	Catalogue
10.	(15)	15W Amplifier	YQ43W	£5.95	Catalogue
11.	(13)	PWM Motor Driver	LK54J	£9.95	12 (XA12N)
12.	(12)	Ultrasonic Intruder Detector	LW83E	£11.95	4 (XA04E)
13.	(16)	27MHz Receiver	LK56L	£8.95	13 (XA13P)
14.	(20)	27MHz Transmitter	LK55K	£7.95	13 (XA13P)
15.	(–)	Car Digital Tacho	LK79L	£19.95	Best of E&MM
16.	(14)	VHS Video Alarm	LM27E	£11.95	24 (XA24B)
17.	(19)	50W Amplifier	LW35Q	£17.95	Catalogue
18.	(18)	Noise Gate	LK43W	£9.95	Best of E&MM
19.	(–)	TDA7000 Radio Kit	LK32K	£12.95	9 (XA09K)
20.	(17)	Stepper Motor and Driver	LK76H	£16.95	18 (XA18U)

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.

Exploring Radio

by Graham Dixey C. Eng., M.I.E.R.E. Part 3

Introduction

The Ferranti ZN414 is a single chip AM tuner developed quite a few years ago now, using a type of integrated circuit technology known as Collector Diffusion Isolation (CDI). In this integration technique a much higher packing density is possible than with conventional bipolar technology. As a result, the ZN414 is able to pack a 10 transistor RF circuit into a small 3-lead plastic encapsulation. Naturally, there are some components that cannot be integrated, especially those used for tuning, but also those needed to set the d.c. supply and AGC levels. Nonetheless, a very low component count is possible to provide the basic AM tuner, needing only an audio amplifier to develop enough power to drive an earphone or loudspeaker. There is also an enhanced version of the ZN414, known as the ZN415E, that includes an audio amplifier with just enough power to drive personal phones.

The ZN414 in Detail

Figure 1 shows the internal arrangement of the ZN414 and also the external components needed to put it into a basic configuration, using a 1.3V d.c. supply. The first stage is a very high input impedance buffer, which simplifies the tuned circuit design, followed by three stages of r.f. amplification, capacitively coupled, and a transistor detector as the final stage. The output from the latter is, of course, the demodulated signal, that is about 30mV r.m.s. of pure audio to drive a suitable amplifier.

The d.c. supply requirements are 1.2 – 1.6V @ 0.3 – 0.5mA; optimum supply voltage is 1.3V. The drive circuit that derives this voltage also sets the AGC level, and Figure 2 shows three possible drive circuits for use with this chip. If the AGC action is not correctly set up, it is possible for a strong signal to swamp the receiver with an apparent broadening of the response. When

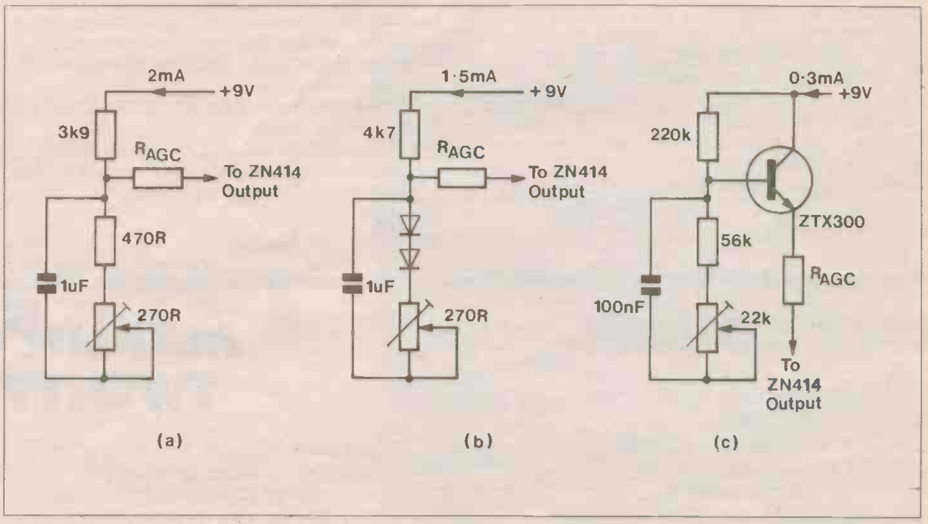


Figure 2. Drive circuits for the ZN414, (a) Resistor network, (b) Diode drive, (c) Transistor drive. In all cases the preset is a sensitivity control.

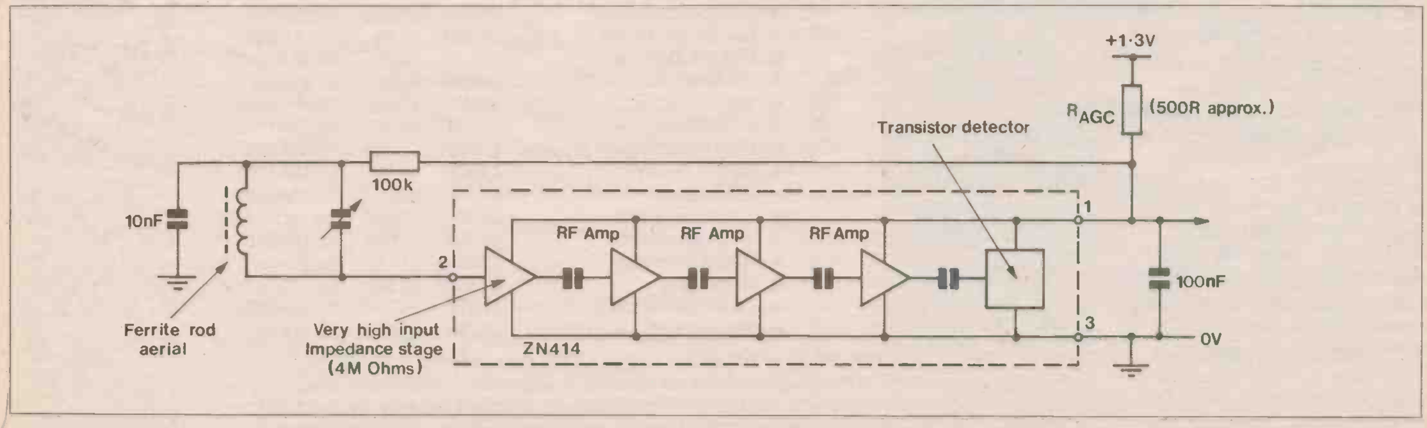


Figure 1. The ZN414 (within chain outline) in its most basic circuit configuration.

correctly set up, the selectivity approaches that of a superhet receiver. This presupposes that the tuned circuit is efficient, with a high 'Q value'. The coil-capacitor combination specified here meets those requirements.

The ferrite rod aerial size is not particularly critical. The one used with the prototype receiver was a 10cm rod cut down to 7.5cm, but it can be left at the full length and will, in fact, then be more directional. Be prepared, if necessary, to experiment with the number of turns wound onto the ferrite rod but, as a starting point, 80 turns closewound, of 30 SWG enamelled copper wire should bring in a good selection of medium wave broadcast stations. This was tuned with the aerial section of a miniature AM tuner capacitor (141.6pF). The winding of the aerial coil can be secured with electrical tape though, in this instance, a dab of superglue was used instead, to give a tidier look to the finished component.

The power gain of the ZN414 is of the order of 72dB in a typical case, though it is dependent upon the supply voltage to some extent. To give some idea of the possible selectivity, a bandwidth of about 4kHz can be achieved with correct setting up. The useful frequency range is from about 150kHz to 3MHz, making it ideal for AM reception on both medium and long waves. It can, however, be used at higher carrier frequencies by using it as the intermediate frequency (I.F.) amplifier in a superhet receiver, one application being in the radio control field (27 – 35 MHz).

All of this should give some idea of the versatility of the device. A variety of circuits are obviously possible, some of which will be presented in this series.

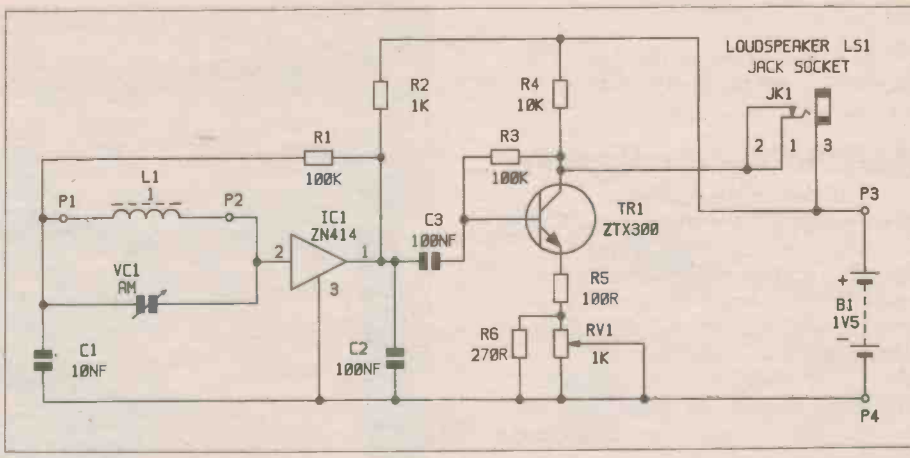


Figure 3. Earphone Radio circuit.

Circuit Layout

Any layout problems disappear if the construction is based on the PCB that has been designed to go with this project. However, for those who don't want, for whatever reason, to use the custom PCB, a few words of warning are in order.

(a) The decoupling capacitor across the output (100nF shown in Figure 1) should be wired as close to the chip pins as possible. Its value is related to that of the AGC resistor as follows.

$$C\ (\text{farads}) = \frac{1}{2\pi \times R_{AGC} \times 4 \times 10^3}$$

(b) All leads should be kept as short as possible, especially those running directly to the ZN414.

(c) The aerial and tuning capacitor should be as far as possible from the battery and earphone and their wiring.

(d) The 'earthy' side (moving vanes) of the tuning capacitor should be connected to the junction of R1 and C1.

The MW Earphone Radio

In this particular design, see Figure 3, a discrete single-stage audio amplifier is driven from the output of the ZN414. The collector load consists of the crystal earpiece in parallel with a 10k resistor, which provides the d.c. path to the collector and presents the right value of impedance to the output of the stage in order to develop the audio voltage. The ZN414 output is a.c. coupled to the input of this stage through a 100nF capacitor and the stage is biased by a 100k resistor between collector and emitter. The emitter circuit effectively consists of a fixed 100 ohm resistor in series with a variable component that gives a measure of control over the volume, should it be required. A 250 ohm potentiometer was called for, but a small carbon one of this value not being available, a 270 ohm fixed resistor wired in parallel with a 1k variable produces the same approximate value. Naturally the transistor used, a ZTX300, is not a power transistor but gives a sufficient boost to the signal level to drive the crystal earpiece in areas of adequate signal strength. The receiver operates from a 1.5V cell and the components

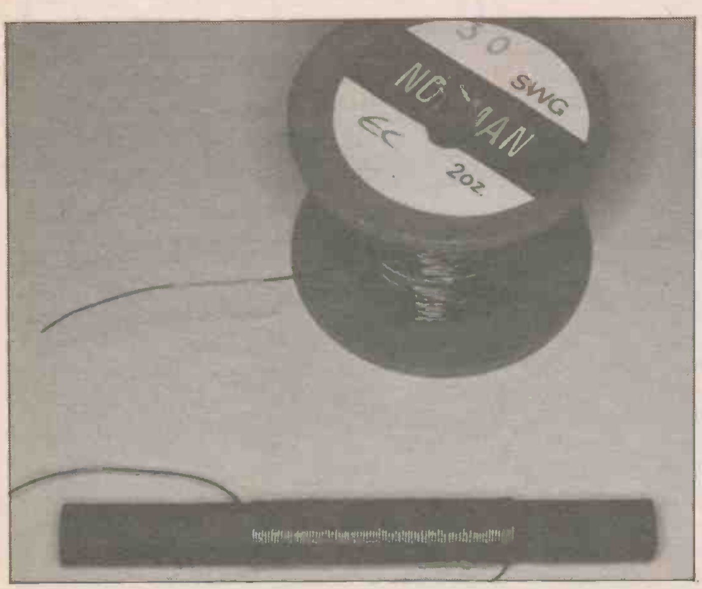


Photo 1. The tuning coil consists of 80 turns, closewound on a short length of ferrite rod, which then acts as an aerial.

Photo 2. Birds eye view of the assembled PCB. The earphone socket was an afterthought at this stage.

for AGC and drive for the ZN414 (R1, R2 and C2) are proportioned accordingly.

Assembling the Receiver

Full details, including photographs of the prototype PCB, are given even for what is quite a simple circuit so there should be no real chance of error! With resistors getting ever smaller and the colour bands on them becoming less distinct, the biggest headache is probably identifying the correct resistor. For the less than eagle-eyed a small magnifying glass can be very useful. The pin connections for the ZTX300 transistor and the ZN414 are given, viewed from the underside in each case; obviously it is important to ensure that these go in the right way round, see Figure 4.

The assembly takes a few minutes only, a lot quicker than winding the aerial coil, Figure 5 should assist you. If you've never wound a coil like this before, the procedure is to 'rotate the rod' to wind on the turns, not to wind the turns 'round and round' a stationary rod. The coil will take about five feet of wire so rather more than this can be cut off and one end secured in a vice. Remove all kinks from the wire by pulling it, with a fair amount of tension, between your thumb and a pencil. Then secure the free end of the wire to the ferrite rod by your chosen method and, keeping the wire tight, rotate the rod to wind on each turn right alongside the last, walking (and counting!) as you go. When all 80 turns are on, secure the other end. Finally, scrape off the enamel at the extreme ends and tin them ready for soldering to the wiring pins on the board.

Once the circuit is completely assembled, the battery clipped into its holder (check polarity before doing so) and the personal earphone jacked in, you can have the pleasure of listening to your favourite station. There is no alignment to do whatever.

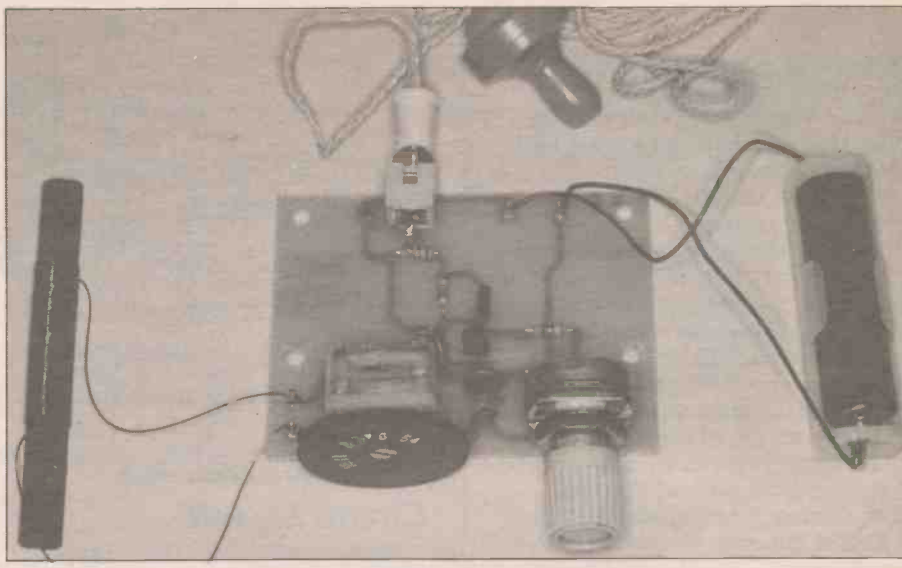


Photo 3. The fully assembled receiver, showing how simple it is!

Don't expect ear-blasting volume but there should be enough output for comfortable listening in a quiet environment. Next time we shall use the chip a little more ambitiously by giving it rather more 'voice' plus the benefits of an extra waveband.

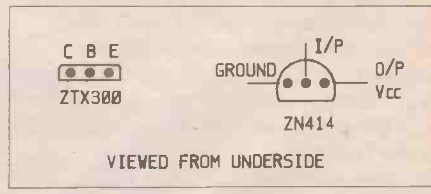


Figure 4. Pin-outs.

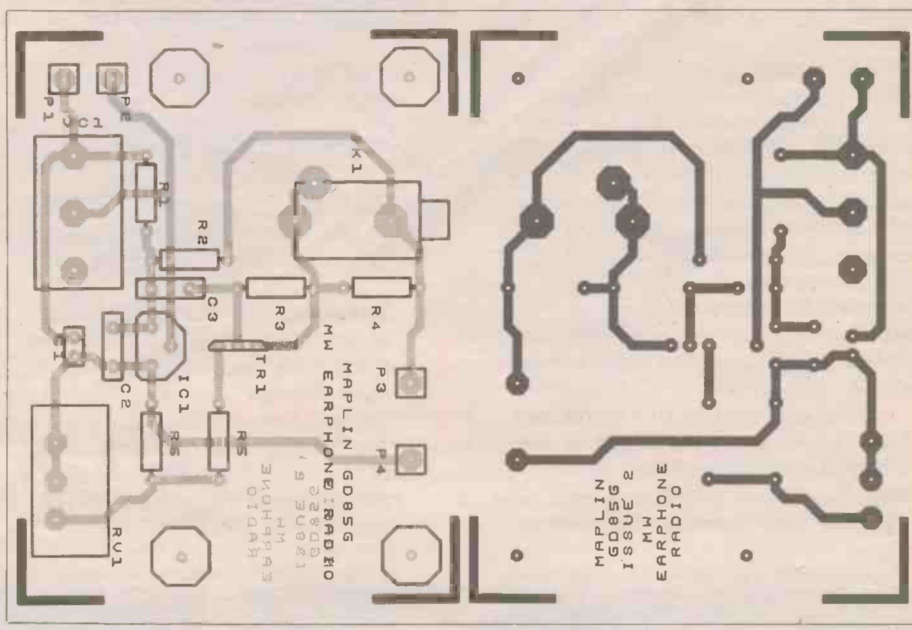


Figure 5. Track and overlay of PCB.

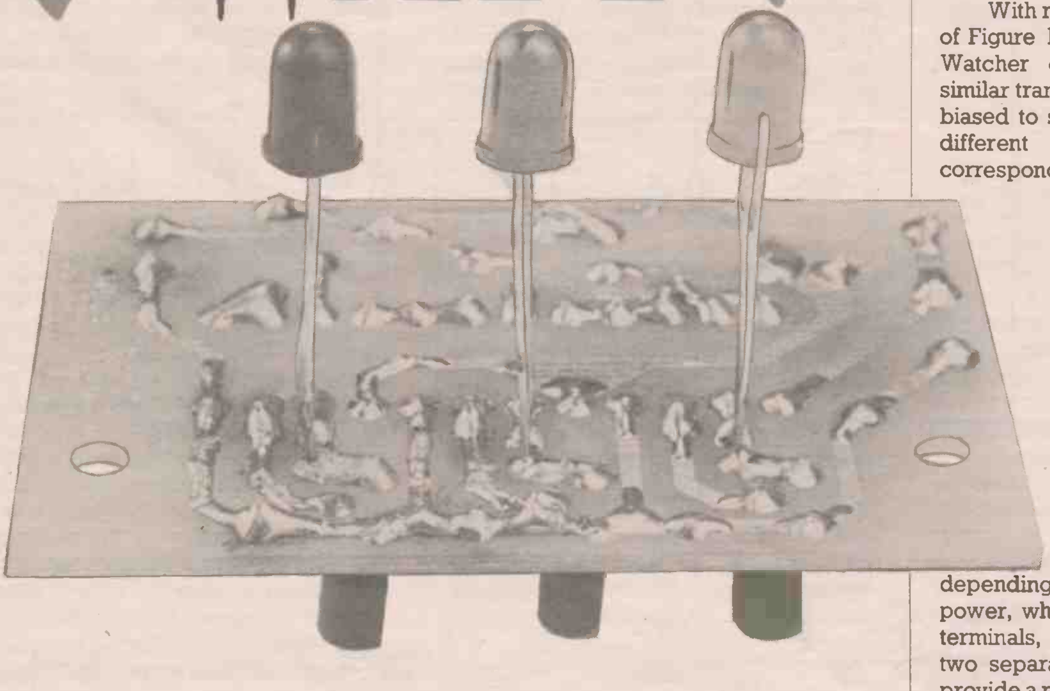
EARPHONE RADIO PARTS LIST

RESISTORS: All 0.6W 1% Metal Film			
R1,3	100k	2	(M100K)
R2	1k	1	(M1K)
R4	10k	1	(M10K)
R5	100Ω	1	(M100R)
R6	270Ω	1	(M270R)
RV1	1k LIN Pot	1	(FW00A)
CAPACITORS			
C1	10nF Minidisc	1	(YR73Q)
C2,3	100nF Minidisc	2	(YR7[illegible]S)
VC1	AM Tuner	1	(FT78K)
SEMICONDUCTORS			
IC1	ZN414	1	(QL41U)
TR1	ZTX300	1	(QL46A)
MISCELLANEOUS			
LS1	Crystal Earpiece	1	(LB25C)
L1	Ferrite Rod 810	1	(YG20W)
JK1	3.5mm Jack Socket	1	(FK02C)
	Veropin 2145	1 Pkt	(FL24B)
	Battery Box 1.5V	1	(YR59P)
	LR6 Battery	1	(FK64U)
	PCB	1	(GD85G)
	30 SWG EC wire	1	(BL40T)

The following item is available, but is not shown in our 1988 catalogue:
Earphone Radio PCB Order As GD85G Price £1.95

WATT WATCHER

by Gavin Cheeseman



When running a speaker system it is useful to have an idea of the approximate level of power being used. In particular it is important that the loud speaker manufacturer's specification is not exceeded as this could result in severe damage to the speaker. The Watt Watcher is a simple circuit that may be fitted into a speaker cabinet to provide an indication of the relative power level and uses three LED's: a green LED lights when the power is at a relatively low level indicating that the system is running; a second (orange) LED indicates an intermediate level of power and a third (red) indicates an overload condition. The level at which the orange and red LED's (LD2 and LD3) light is set by fitting resistors of selected value, depending on the required power range. The Watt Watcher derives its power from the speaker line and hence requires no external power supply.

Circuit Description

With reference to the circuit diagram of Figure 1 it may be seen that the Watt Watcher effectively consists of three similar transistor switches. Each switch is biased to switch on LEDs LD1 to LD3 at different input voltages and these correspond to different power levels depending on speaker impedance. The power, which is taken from the speaker terminals, is rectified and smoothed by two separate networks: R1, D1 and C1 provide a relatively smooth DC voltage for the supply rail, while R2, D2 and C2 provide a less smooth DC voltage for the transistor bias resistors to allow for fast changes in audio power level. Bias resistors R3, R4 and R5 determine the voltage at which the transistor will switch on and light the LED; TR1 is biased to switch on at the lowest voltage and TR3 at the highest. Zener diodes ZD1 to ZD3, serve to limit the brightness of the LEDs at higher voltage levels. Diodes D3 and D4 increase the voltage threshold at which LD2 and LD3 light, as orange and red LEDs have a lower voltage threshold than the green type. The current through the LEDs is limited to a few mA by R6, R10 and R14.

PCB Assembly

Insert and solder the components onto the PCB refering to the legend shown in Figure 2, starting with the resistors. R9 and R13 should be selected, depending on the speaker impedance and the power with which the Watt Watcher is to be used (refer to Table 1). The levels of power shown (RMS) refer to the approximate power at which LD3 will light. Capacitors C1 and C2 are fitted observing the correct polarity; the negative lead is indicated by a negative sign (−) on the side of the capacitor which goes away from the hole marked positive (+) on the PCB legend. Diodes D1 to D4 are then inserted with the correct polarity (the cathode is marked by a band at one end of the diode). Transistors TR1 to TR3 are positioned so that their cases correspond exactly with the outline on the PCB legend. LEDs LD1 to LD3 are then installed on the track side of the board (see Figure 3). The length of the LED leads may be cut to suit individual needs, depending where the unit is to be fitted; it is important that they are inserted with the correct polarity (the short lead on the flat side of the LED is the cathode). Finally insert PCB pins P1 and P2. For more detailed information on construction techniques please refer to the Constructor's Guide included in the kit.

Testing

Before testing the unit make sure that all components are soldered and that there are no dry joints or solder short circuits. If a multimeter is available the DC resistance between P1 and P2 can be measured; this should read several thousands of ohms. Connect P1 and P2 to

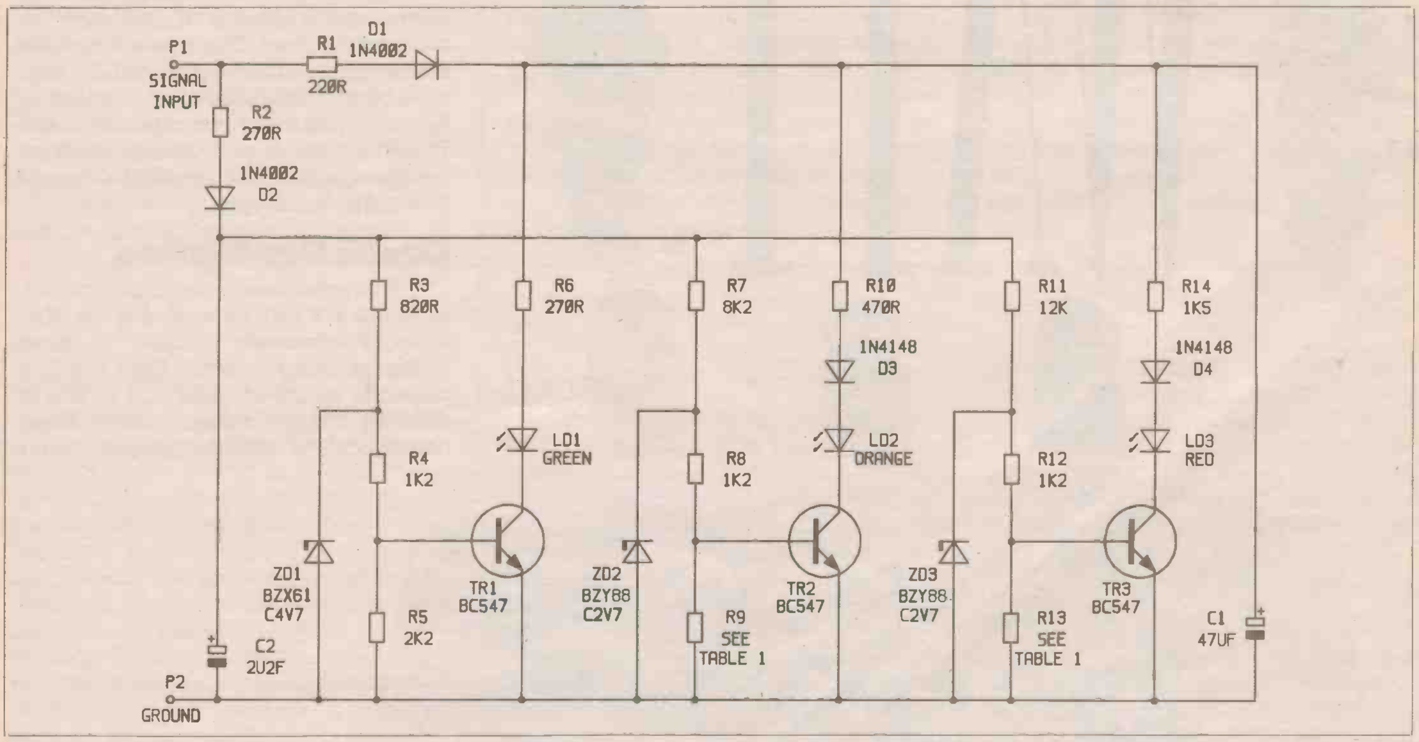


Figure 1. Circuit Diagram.

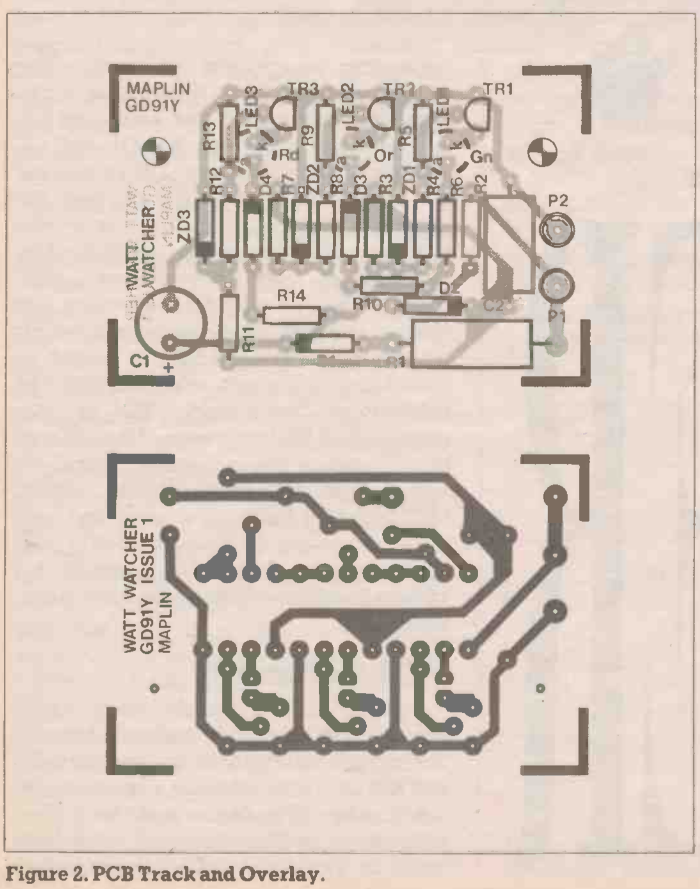


Figure 2. PCB Track and Overlay.

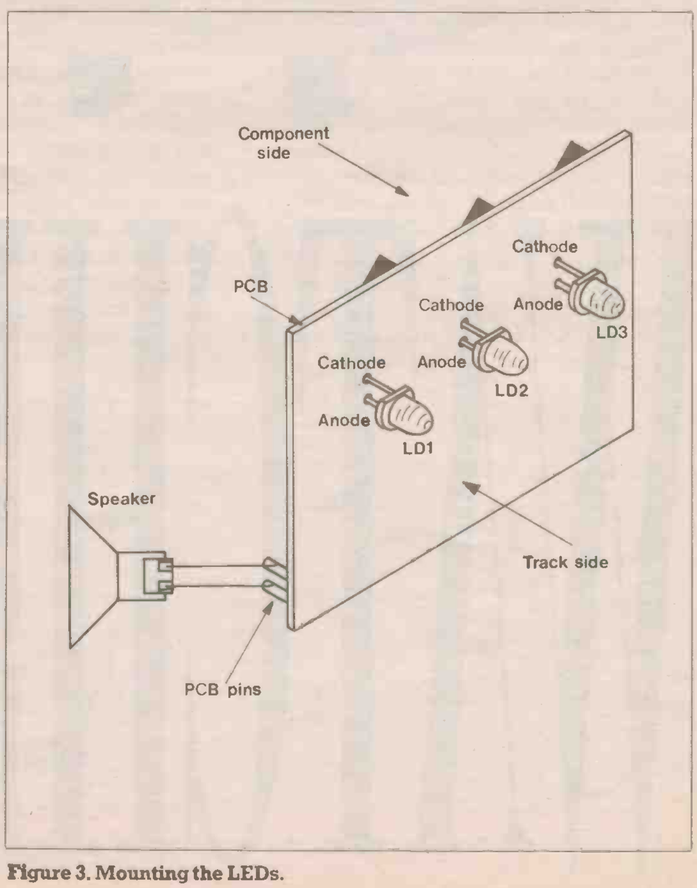


Figure 3. Mounting the LEDs.

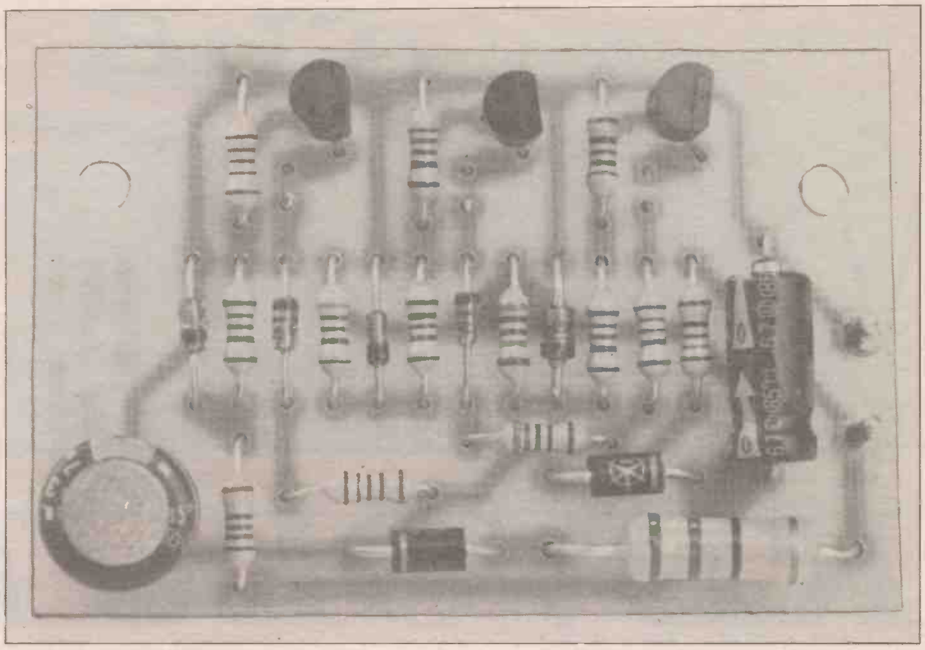
the speaker terminals using insulated wire. Switch on and slowly increase the volume. The green LED LD1 should start to light at around 3 to 5 watts depending on speaker impedance. As the volume is increased LD2 should start to light indicating an intermediate level of power. The red LED LD3 should only light when the power level chosen from Table 1 is reached; this is intended to indicate an overload condition and under normal operating conditions should not light (other than perhaps an occasional flicker). An overload condition is indicated when LD3 is lit for the majority of the time. Table 2 shows the approximate input voltage levels at which LD2 and LD3 light for each power range. If all is well the Watt Watcher may be installed into the speaker cabinet or alternatively can be housed in a separate box. It should be noted that the Watt Watcher should not be used with systems running at power levels above the chosen range or with speaker impedances other than those specified as severe damage could result.

POWER		Resistor Value	
		8R Speaker	4R Speaker
25 Watts	R9	1k5	2k2
	R13	1k0	1k5
50 Watts	R9	1k0	1k5
	R13	820R	1k0
100 Watts	R9	820R	1k0
	R13	680R	820R

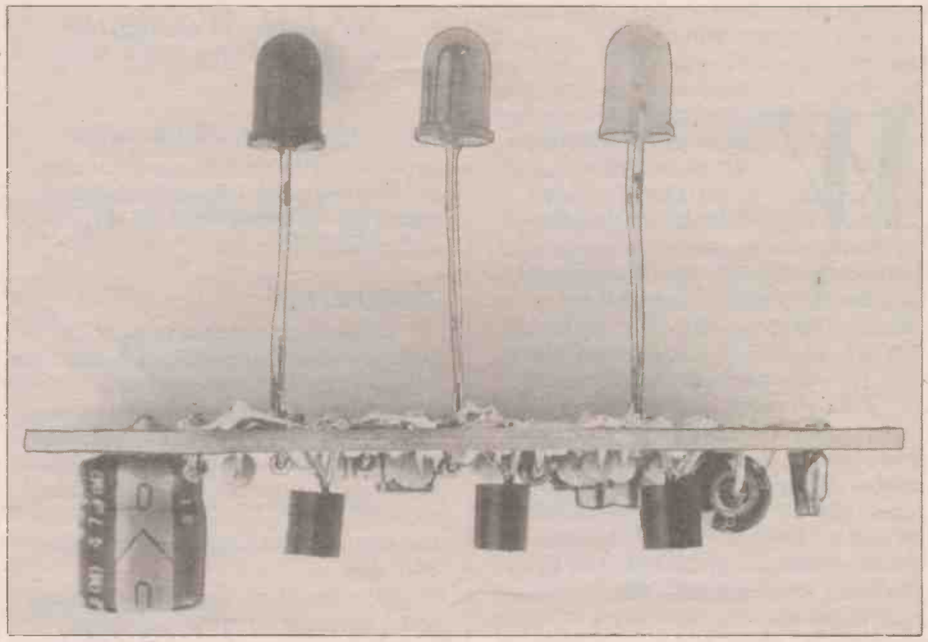
Table 1. Resistor values for various power levels and speaker impedances.

POWER RANGE (RMS)		Input Voltage (RMS)	
		8R Speaker	4R Speaker
25 Watts	LD2	9V	7V
	LD3	14V	10V
50 Watts	LD2	14V	9V
	LD3	20V	14V
100 Watts	LD2	18V	14V
	LD3	28V	20V

Table 2. Approximate input voltage levels required for LD2 and LD3 to light. Values shown for input frequency - 1kHz (sinewave).



Component side of pcb.



Side view of pcb.

WATT WATCHER PARTS LIST

RESISTORS: All 0.6W 1% Metal Film (unless specified)

R1	220Ω 1 Watt Carbon Film	1	(C220R)
R2,6	270Ω	2	(M270R)
R3	820Ω	1	(M820R)
R4,8,12	1k2	3	(M1K2)
R5	2k2	1	(M2K2)
R7	8k2	1	(M8K2)
R9,13	See Miscellaneous and Table 1		
R10	470Ω	1	(M470R)
R11	12k	1	(M12K)
R14	1k5	1	(M1K5)

CAPACITORS

C1	47μF 63V P.C. Electrolytic	1	(FF09K)
C2	2μ2F 100V Axial Electrolytic	1	(FB15R)

SEMICONDUCTORS

D1,2	1N4002	2	(QL74R)
D3,4	1N4148	2	(QL80B)
ZD1	BZX61C4V7	1	(QF45Y)
ZD2,3	BZY88C2V7	2	(QH00A)
LD1	LED Green	1	(WL28F)
LD2	LED Orange	1	(WL29G)
LD3	LED Red	1	(WL27E)
TR1,2,3	BC547	3	(QQ14Q)

MISCELLANEOUS

	Constructor's Guide	1	(XH79L)
	P.C. Board	1	(GD91Y)
	Pin 2141	1 Pkt	(FL21X)

Select R9 and R13 from the following:

	680Ω	1	(M680R)
	820Ω	1	(M820R)
	1k	1	(M1K)
	1k5	1	(M1K5)
	2k2	1	(M2K2)

A complete kit of parts is available:
Order As LM57M (Watt Watcher Kit) Price £3.98
The following item in the above kit is also available, but is not shown in our 1988 catalogue:
Watt Watcher **PCB Order As GD91Y Price £2.95**

The V·I·D·E·O REVOLUTION

by J.M. Woodgate
B.Sc(Eng.), C.ENG., M.I.E.R.E., M.A.E.S., M.Inst.S.C.E.

While audio has always been very popular with home constructors, only a few enthusiasts in the past involved themselves in video. This was because the equipment was expensive and not generally available, although these difficulties did not put off members of the British Amateur Television Club and others, many professionally involved in television.

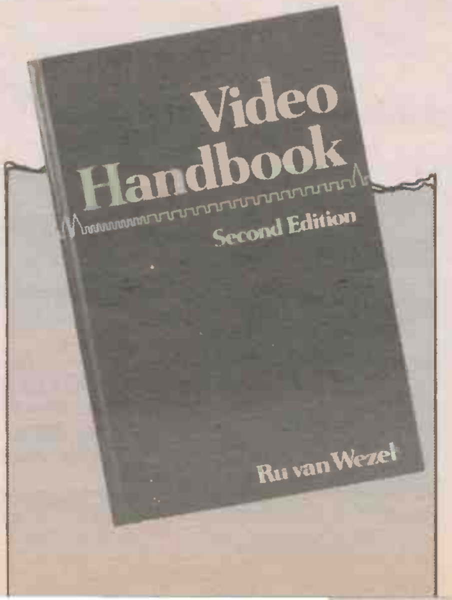
Today, however, video recorders, cameras and even video digitisers are quite freely available at sensible prices, and the number of home experiments with video is rapidly growing. Recognising this, Maplin are now stocking a hardback book, 'Video Handbook (2nd edition)' (WP81C), by Ru van Wesel, which is aimed at the experienced enthusiast and covers everything from basic optical theory and audio for television to pcb layouts for constructional projects, together with video recorders and disc players and TV production techniques. It deliberately does not cover the elementary ideas of scanning and synchronisation, and there are some new developments which will be of particular interest to readers of this magazine. It is the purpose of this article to fill in some gaps and provide an update.

Video techniques cover simple low-power linear circuits, using transistors no more exotic than BC107's, and pulse circuits which are easily designed with cheap IC's. Even digitising requires no more than 7 or 8 bits and speeds within the scope of bipolar TTL devices. For precision amplifiers, there are devices such as the LM592/LM733 which provide gains up to 400 with few external components and very wide bandwidth, but, odd as it may seem, the low-noise audio op-amps NE5532 and NE5534 can also be used for video at modest gains. Keep the feedback resistor below 10k ohm, though. Comparators are often used in video circuits: in some cases the high-speed device LM319 may be needed, but any circuits using the old 710 type devices that required two supply rails can be simplified with single-rail devices such as LM311 and LM339/MC3302.

Scanning

Converting sound into an electrical signal is in principle very simple, because the (time-varying) instantaneous sound pressure at the microphone is a single value, a one-dimensional quantity, which translates into a single, time-varying, electrical signal. Conveying directional information is rather more difficult, but Ambisonic theory shows that only four signals are necessary to do even that.

By contrast, the simplest visible thing that is worth converting to an electrical signal is (barring some techniques allied to primitive radar displays) a two-dimensional scene, either real or in the form of a projected picture. One way of doing this would be to have an array of hundreds (at least) of photodetectors connected individually through amplifiers to a corresponding array of light-emitters. Unfortunately, this is impracticable because to get reasonably sharp pictures the arrays need to contain about a quarter of a million elements, and to get reasonable moving pictures, each of the 250,000 amplifiers needs a bandwidth of about 50Hz. So, even with multiplexing techniques, a broadcast transmission bandwidth greater than 12.5MHz would be required. However, while there does not appear to be any future for this technique as a whole, the problem of making the arrays themselves is being vigorously studied in order to develop solid-state cameras and new types of display device to replace the heavy, large and fragile cathode ray tube.



The most practical method of converting a two-dimensional scene into an electrical signal is known as 'scanning', and was discovered by Paul Nipkow in 1883, long before television could be achieved in a practical form. Imagine a room in darkness, with a photodetector 'looking' at it. If we shine a narrow beam of light at a point in the room, the photodetector will respond to the amount of light reflected from the point where the beam lands. Moving the beam about will produce a varying signal from the photodetector, as the beam falls on points of different colour and brightness. Of course, moving the beam about at random isn't likely to be very helpful, but if we could make the movement systematic, we might be able to reproduce this systematic movement at the picture display device (whatever that is), and thus re-create the original picture. In principle, we could move the beam up and down, from side to side, or in a spiral, either inwards or outwards. In fact, all of these techniques have been used for various special purposes, but it turns out, because of the properties of the human eye and brain system, that for television the side-to-side scanning system is the best. It is still possible to do this in two different ways; the beam could move across, and then back at the same speed, or it could scan across and then flick back quickly. It appears that the use of the second way, which is now almost universal, is a relic of Nipkow's original ideas. Having flicked back to the starting position, the beam is moved down a little, so that it then scans across the scene just below its previous path. When the beam reaches the bottom of the scene to be televised, it flicks back to the top. Instead of moving the beam down a little when it returns to the start, ('indexed scan'), it is more usual to move it down gradually and continuously, so that the 'horizontal' movement actually takes place at a small angle downwards, see Figure 1.

The horizontal motion of the beam is called 'line scan' and the vertical motion is called 'field scan'. In the British television system (CCIR system I), the line scanning rate is 15,625Hz and the field rate 50Hz. Each field thus consists of 312.5 lines, and the odd half line means that the lines of one field fall between those of the previous and following fields; this technique is called '2:1 interlace' and is something of a mixed blessing nowadays since, while it reduces flicker on televised scenes, it increases it, in a sense, on graphics and text displays by making the display 'vibrate' vertically. A complete picture is made up of two fields, called a 'frame'. Television systems are often described by their 'scanning standards', expressed as the number of lines in a frame, followed by the field frequency. The British system is thus one of the group of 625/50 systems.

The technique of televising a dark scene with a moving beam of light is called 'flying spot scanning', and was widely used in the early days, in spite of the inconvenience of working in darkness, and was also used for televising films. In modern cameras, the scene is optically projected on a photosensitive target, which is scanned by an electron beam to produce the electrical output signal. The principle of scanning is precisely the same.

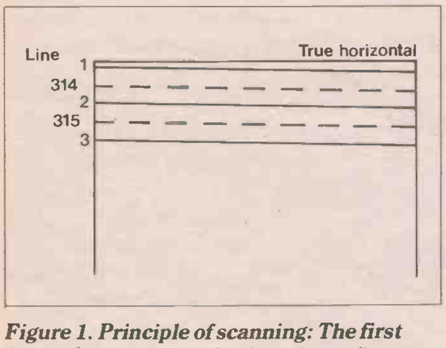


Figure 1. Principle of scanning: The first lines of two consecutive interlaced fields in a 625 line system.

Synchronisation

The process of keeping the scanning of the display device exactly in step with that of the camera is called 'synchronisation' (from Greek, syn = same, chronos = time). To achieve it we have to add timing signals to the picture signal output from the camera, in such a way that we can separate them again easily in the display equipment and use the timing signals to control the exact instant when the line and field scans of the display device start.

There are two steps to this synchronisation process. First, we have to make the display scans run at the same frequency as the camera scans, but this is insufficient by itself. We also have to make the scans start at the same instant (allowing for any delay due to the signal path from camera to display). These two steps can be described by the terms 'frequency-synchronous' and 'phase-synchronous', respectively.

Audio signals are built up from sine-waves, so they are pure alternating signals with no direct current component. Consider, however, the output from the photodetector of a flying spot scanner. A deep black object will reflect nearly no light towards the detector, as the output will be zero volts. A bright object will produce a maximum positive or negative direct voltage, depending on how the detector is connected in its circuit. Nothing will produce an output of opposite polarity, which would correspond to 'blacker-than-black'. As the beam scans across one line, a varying positive (or negative) voltage is produced, and when the beam flicks back to the start, a reversed high-speed copy of the same voltage will be produced. It won't be a very good copy, for several reasons:

1. The 'flyback' scanning speed is too fast for the photodetector to respond properly.
2. The track of the flyback beam does not follow the scan exactly, because the field scan is continuously moving the beam down slowly.
3. Even where the photodetector responds to the high-speed signals, its associated amplifier probably will not.

The video signal during the flyback period is thus not very useful and can be thrown away. This is done by switching off the photodetector (e.g. by removing its supply voltage), with a pulse signal known as a 'blanking pulse'. In the resulting 'gap' in the video signal we can put a pulse signal for synchronisation. We can make this pulse easily distinguishable from the video signal caused by a white strip by making it of opposite polarity, i.e. blacker-than-black. The 'width' (duration) of this 'sync pulse' is made slightly less than that of the blanking pulse to allow for timing errors, see Figure 2. We can do exactly the same thing at the end of each field, to produce field blanking and a field sync pulse. However, the field flyback time is 25 line periods in 625/50 systems, so that the sync pulse would be about 1.3ms long if it took up the whole of the time available for it. To reproduce this properly, all amplifiers for the combined video, sync and blanking signal (CVBS) would require an extended low-frequency response, to below 50Hz. To avoid this, the sync pulse is shortened to 160μs, and is interrupted by short 'equalising' pulses which further serve to reduce distortion of the sync pulse shape in amplifiers. For further details, and an explanation of the generation and encoding of colour signals, see the 'Video Handbook'.

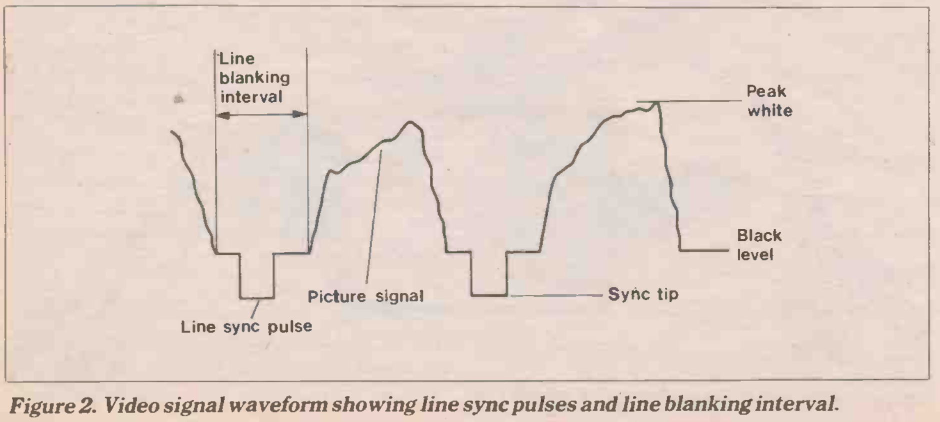


Figure 2. Video signal waveform showing line sync pulses and line blanking interval.

Video Equipment

To get started in video, you need a monitor or a TV with video input, and, probably, a VCR and a camera. You can start with a monochrome camera, which could be a second-hand one from a security system, for instance. A new one would cost about £150. Don't buy a lens with an iris: they cost about £100 more than a simple lens without one, and the camera a.g.c. will cope with a wide range of lighting levels. You may be able to buy a second-hand colour camera from someone who has graduated to a camcorder: a separate camera is preferable for serious video.

In audio, the accent is on amplification, because loudspeakers need power, but for video this is not so. In any case, it is about as usual to build your own display unit as to build your own loudspeaker drive unit. Monochrome monitors can be obtained quite cheaply these days, intended either for use with computers (these have better picture geometry) or security cameras, and more and more television sets are fitted with video input connectors, either 6-pin DIN or 21-pin peritelevision 'SCART' connectors, see Figure 3.

ON NO ACCOUNT MAKE ANY INTERNAL CONNECTIONS TO A TELEVISION SET, AS YOU ARE VERY LIKELY TO ELECTROCUTE YOURSELF OR SOMEONE ELSE IF YOU DO.

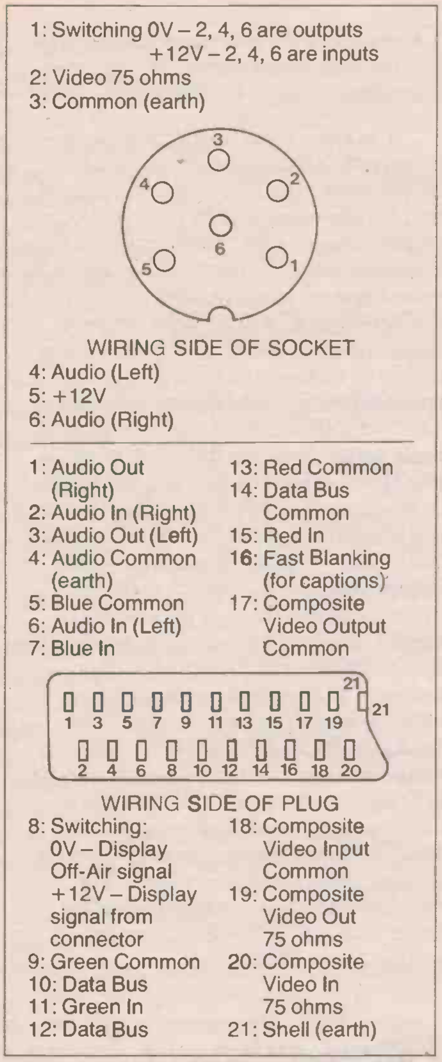


Figure 3. 6 contact DIN and 21 contact peritelevision (SCART) connectors.

If you don't have a monitor or a TV with a video input connector, you can use one of the UHF modulators stocked by Maplin to feed your signals in via the TV's antenna connector.

For colour, you need a monitor with composite video analogue input, unless you are going to work exclusively with RGB signals or make PAL encoder and decoder units. With modern IC's, such as the LM1889 encoder, neither of these is too difficult, but it is not easy at present to obtain the decoder IC's in small quantities. Monitors with 'digital' (two-state) video inputs are, of course, unsuitable because they cannot reproduce brightness variations.

Handling and Processing Video Signals

Once it is understood that a video signal consists of two parts with separate functions, the picture signal and the sync, the problems of handling and processing can be understood. The video signal requires a bandwidth ideally from zero frequency to 5.5MHz, but watchable pictures can be obtained with a bandwidth from about 250kHz to 3MHz or so, otherwise household VCR's wouldn't work!

Video processing consists of cutting, mixing or superimposing video signals from different sources, and effects processing, where the original picture is distorted in some way. The difficulty of achieving these processes varies greatly.

Cutting

This is the simplest process, and only requires that the two video signals are of more or less the same amplitude and black level. Picture signal amplitude controls the contrast of the picture, and black level controls the brightness. A standard video signal has black level at zero volts, peak white at +0.7V and sync pulse tips at −0.3V, so the peak-to-peak amplitude is 1V. Colour information can increase the peak picture signal to +0.93V. Video signals are normally carried on 75 ohm coaxial cable. To cut between two standard signals only requires a switch, provided you don't mind the occasional 'frame roll' if you happen to cut during the field sync pulse of one of the signals. The signals don't even need to be frequency-synchronous, within limits.

The Major Problem with Mixing, Fading and Superimposing

These are the most useful video processes but unfortunately they only work with phase-synchronous signals. In a television studio this is no problem because all the cameras, etc., are synchronised with a master sync generator (MSG). Special techniques have to be employed to synchronise outside-broadcast equipment with the studio. In the home, however, you may have a camera, a VCR, an off-air signal and a home computer all producing video signals. Only the camera and the VCR (if they are running together) will be synchronous. It is possible to buy a semi-professional 'genlock' unit to overcome this, but it will cost as much as a good VCR. This is the only solution where you cannot get at the sync generation processes of the two signals to be mixed (e.g. the off-air signal and the home computer), but where you can, or there is an input for external sync, it is possible to make your own Master Sync Generator: instructions are given in the Video Handbook for a device using discrete components and SSI, while it is possible to obtain complete LSI integrated circuits, such as the Ferranti ZNA134E, which provide standard sync with only a few peripheral components. There is also a new Motorola device, MC1378, which is primarily intended, with the Motorola Raster Management System (RMS) IC's to allow microcomputer video to be locked to an external video or sync signal, but could be used in principle for locking together any two signals.

Effects Processing

These can be divided into those which operate on a single video signal and those, such as wipes and dissolves, which require two or more. The latter need phase-synchronous signals and are relatively simple to arrange when these are available: full details are given in the Video Handbook of analogue methods and digital methods are also very widely used in the professional field. It should be possible to achieve some of these effects with simple video digitisers and a microcomputer.

Effects processing of single signals is a field which has considerable attraction for the home constructor, because there is no synchronisation problem to be solved. It is quite easy to produce inverted video, compress and expand contrast range and even to produce false colours. Several circuits are given in the Video Handbook: note that to invert the video to make a negative picture, you have to invert the picture signal but leave the sync the right way up! These effects can be applied to off-air signals, or video recordings or signals from your own camera. You can also produce effects by pointing your camera at the TV screen and using the camera focus, zoom and other controls, recording the result on the VCR.

Video Enhancers

Maplin offer two of these very useful units (XJ11M and XG59P), which can produce dramatic improvements in picture quality on second-generation recordings and on camera signals. They work by separating the higher video frequencies and non-linearly amplifying them. Some also improve the shape of the sync signals and stabilise the black-level. The Maplin units also include two audio channels.

Video and Audio enhancer (Maplin code XJ11M).

Video enhancer with sharpness control (Maplin code XG59P).

Video Distribution Amplifiers

These are constructable items consisting of an input buffer amplifier feeding, say, six output amplifiers designed to feed 75 ohm coaxial cable. With one of these, you can watch a picture on a monitor while feeding it also to a recorder and a digitiser, for example. You couldn't connect all this equipment in parallel to one source of signals.

Video Mixers

A mixer will allow you to do cross-fades between phase-synchronous sources, cuts, overlays (superimposing part or all of one picture on another, adding captions, etc.) and even wipes and dissolves. The Video Handbook describes two designs suitable for the experienced constructor: to some extent these could be simplified or expanded. It is, of course, necessary to make provision for mixing and processing the associated audio signals (unless you are making silent videos), and the Handbook deals with this as well.

Copying Cine Film to Video

The Maplin video-cine adaptor (YP47B) makes this very easy to do, and there are a large number of people who would like their home movies copied in this way. It is also possible to do it by projecting on a steadily supported screen the smallest picture that will fill the frame of your camera at its shortest focusing distance, but this is quite difficult compared with the use of the adaptor. You need the smallest possible picture to get enough light to work the camera properly. The projector and camera should be set at equal angles to the screen so as to cancel as far as possible the keystone distortion of the picture, see Figure 4.

Digital Video and the Digitiser

A digitiser, such as the extremely inexpensive Maplin kits (LK59D/LK60E), enables you to take video pictures from any source and process them on a suitable micro-computer; still pictures can even be stored on floppy disk. Once a picture is in digital form, there is no end to the ways in which it can be processed. This is much more fun than video games, and you can print out the results as works of art.

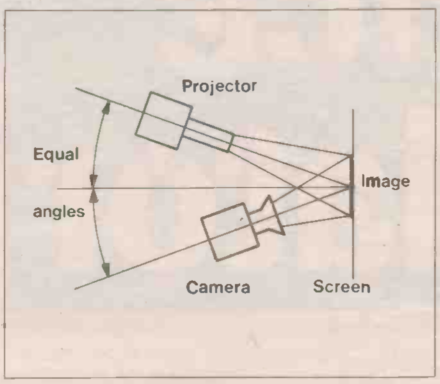


Figure 4. Cine film copying showing compensation of keystone distortion (not perfect).

Future Developments

There are plans to introduce a fifth, land-based TV channel and presumably we shall eventually actually have DBS channels available, whether they use one of the versions of the MAC system or PAL. Video recorders are offering more and more facilities all the time. (For crazy instance, a VCR offers you by far the easiest way of making long uninterrupted **audio** recordings, up to at least 4 hours!) All these developments, together with the increasing availability of IC's for complex video functions, mean that home-constructor video could become a very big thing in the next few years.

Cine to video copying adaptor (Maplin code YP47B).

Morse Code Practice Oscillator

by Chris Barlow

★ Easy construction
★ Minimum of tools and test gear required
★ No setting-up required
★ Variable volume, tone and signal to noise ratio
★ On-board power amplifier
★ Audio output for external amplifier or tape recorder

Specification of Prototype

Operating voltage :	6V to 12V
Supply current at 9V :	10mA @ min. volume
:	157mA @ max. volume
Oscillator frequency :	370Hz to 1.093kHz
Oscillator waveform :	digitally constructed analogue
Noise generator :	digital pseudo-random bit pattern
Amplifier power output :	1W when using a 12V supply
Amplifier output impedance :	8Ω loudspeaker or headphones
Tape output :	200mV peak to peak into a 47kΩ load
Morse key switching current :	800μA at 9V
Maximum contact resistance :	4.7kΩ
Printed circuit board (PCB) :	double-sided fibre glass
PCB dimensions :	130mm x 110mm

Introduction

Morse code is one of the most effective means of long distance (DX) radio communication and thousands of stations can be picked up on the short wave bands. These carrier wave (CW) transmissions can be news, weather, shipping, police, military, or amateur radio 'ham radio'. To transmit your own messages a class A radio amateur licence must be obtained from the department of trade and industry. In order to qualify for this licence you must meet the following requirements:

1. Be of British nationality.
2. You must be fourteen years or over.
3. Have passed the radio amateurs examination (RAE).
4. Have passed the Morse test.

The only way to learn Morse code is to keep up the practice until you acquire the speed and accuracy necessary to pass the Morse test. The Maplin Morse code practice oscillator was designed to produce a loud clean tone, with the option of a controllable level of simulated radio noise. This added feature will help train your ears in picking out the weaker signals, from the interference commonly found on the crowded short wave bands. Having mastered this mode of communication the whole world of CW DX radio listening is made available.

What is Morse code?

The code was first devised in 1837 by Samuel Morse, in collaboration with Alfred Vail, for the telegraphic transmission of information. The messages were sent as a series of long and short DC currents tapped out on a switch, now known as a Morse key. At the receiving station these DC currents would then be converted using an electromagnetic device into a sound, or a visual display. The short current was known as the DOT and the longer current as the DASH. The code was revised in 1844 and again in 1851 when an international conference combined four similar codes into the system we now know as the Morse code.

In radio communication a dot is represented as an audio tone of short duration and the dash, a tone of the same frequency but of longer duration. When learning the code it is easier to think in terms of dit, or di, pronounced 'dee' for a dot and dah for a dash. For example the letter R dot-dash-dot is easier to think and say in terms of di-dah-dit. The complete international Morse code giving the phonetic pronunciation of each letter and number is shown in Table 1.

Circuit description

In addition to the circuit shown in Figure 2, a block diagram of the complete system giving the signal paths are detailed in Figure 1. This should assist you when following the circuit description or fault finding in the completed unit.

The internal DC power is provided by a 9 volt PP3 type battery and when an external supply is plugged into JK4, the battery is switched out of circuit, see Figure 5. Any DC supply entering the circuit must have the correct polarity, otherwise damage may occur

Table 1.

International Morse Code

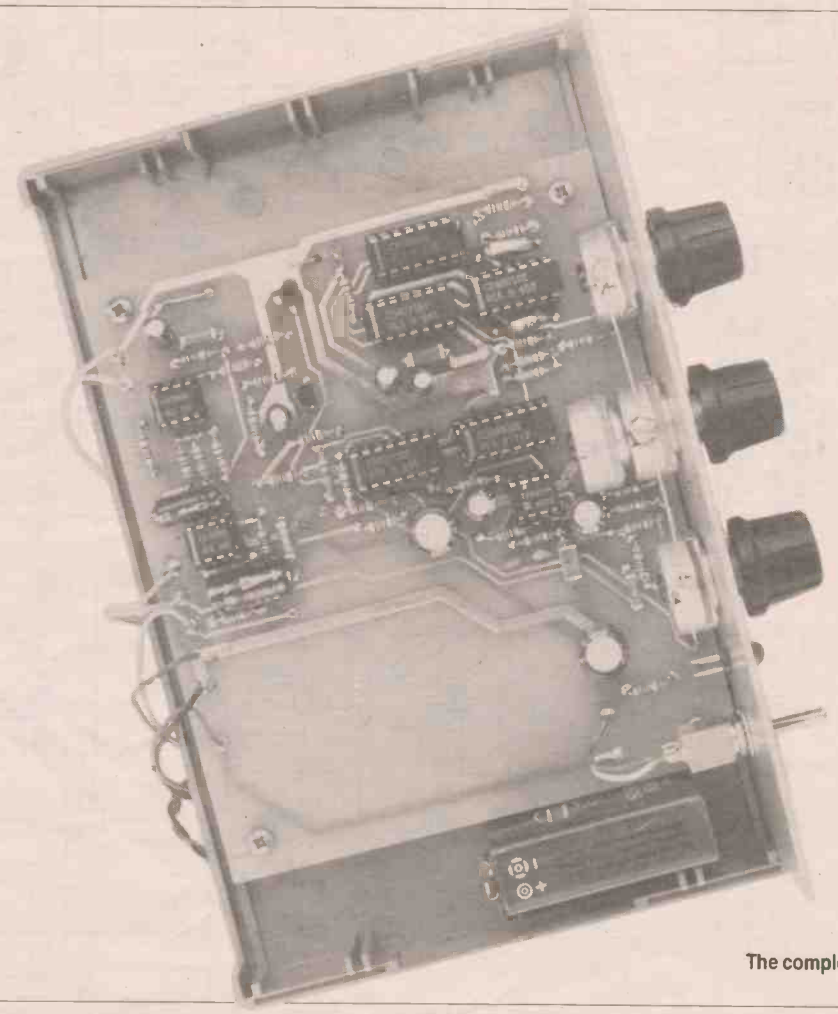
Letter	Code	Phonetic
A	.-	di-dah
B	-...	dah-di-di-dit
C	-.-.	dah-di-dah-dit
D	-..	dah-di-dit
E	.	dit
F	..-.	di-di-dah-dit
G	--.	dah-dah-dit
H	....	di-di-di-dit
I	..	di-dit
J	.---	di-dah-dah-dah
K	-.-	dah-di-dah
L	.-..	di-dah-di-dit
M	--	dah-dah
N	-.	dah-dit
O	---	dah-dah-dah
P	.--.	di-dah-dah-dit
Q	--.-	dah-dah-di-dah
R	.-.	di-dah-dit
S	...	di-di-dit
T	-	dah
U	..-	di-di-dah
V	...-	di-di-di-dah
W	.--	di-dah-dah
X	-..-	dah-di-di-dah
Y	-.--	dah-di-dah-dah
Z	--..	dah-dah-di-dit

Number	Code	Phonetic
1	.----	di-dah-dah-dah-dah
2	..---	di-di-dah-dah-dah
3	...--	di-di-di-dah-dah
4	....-	di-di-di-di-dah
5	.....	di-di-di-di-dit
6	-....	dah-di-di-di-dit
7	--...	dah-dah-di-di-dit
8	---..	dah-dah-dah-di-dit
9	----.	dah-dah-dah-dah-dit
0	-----	dah-dah-dah-dah-dah

Punctuation	Code	Phonetic
Full stop (.)	.-.-.-	di-dah-di-dah-di-dah
Comma (,)	--..--	dah-dah-di-di-dah-dah
Question mark (?)	..--..	di-di-dah-dah-di-dit

Procedure signals	Code	Phonetic
Error (eight dots)	....	di-di-di-di-di-di-di-dit
Preliminary call (CT)	-.-.-	dah-di-dah-di-dah
Wait (AS)	.-...	di-dah-di-di-dit
Break sign (=)	-...-	dah-di-di-di-dah
Fraction bar or stroke (/)	-..-.	dah-di-di-dah-dit
End of message (AR)	.-.-.	di-dah-di-dah-dit
End of work (VA)	...-.-	di-di-di-dah-di-dah
Invitation to transmit (K)	-.-	dah-di-dah

Table 1. The international morse code



The completed unit

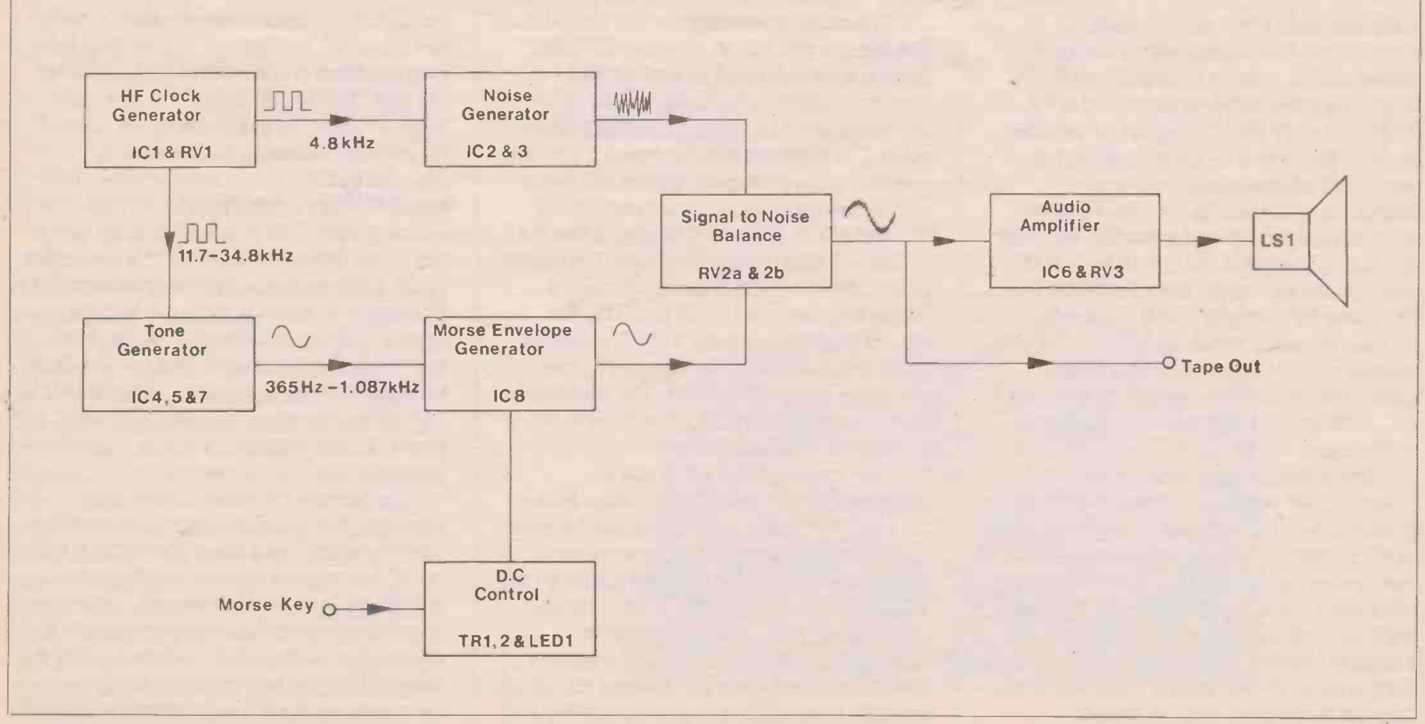


Figure 1. Block diagram

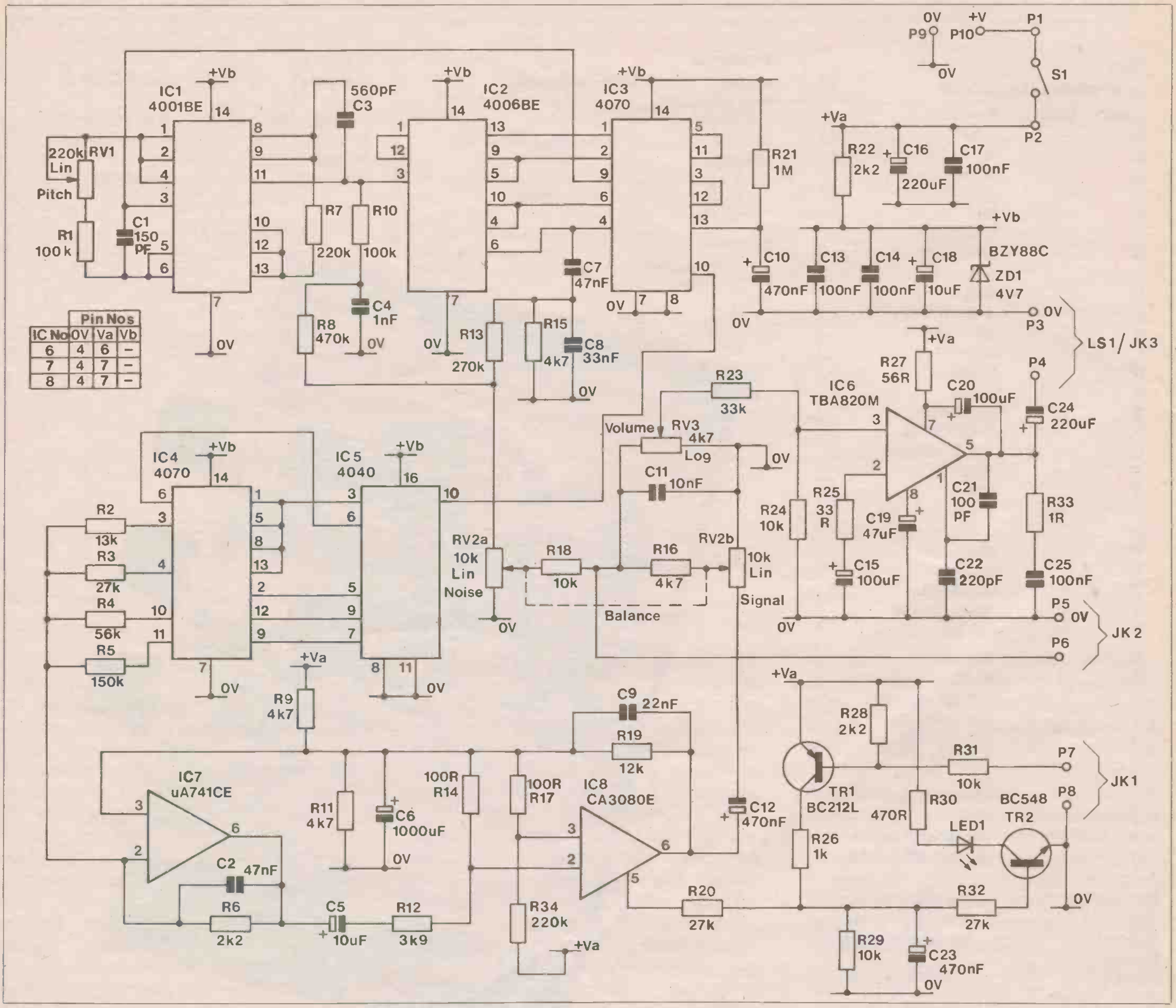


Figure 2. Circuit

to the semiconductors and polarised components. The positive supply voltage is applied to P10, passing through S1 on P1, P2 and the negative supply is connected to P9, the ground or 0V line. Capacitor C16 provides the main decoupling for the +Va analogue supply and additional high frequency decoupling is supplied by C17. NOTE when using an unregulated mains adaptor, the value of C16 must be increased to a 1000μF at 16V single-ended electrolytic capacitor (FF17T). The power for the digital IC's is derived from the main analogue supply by R22 and the zener diode ZD1. To prevent digit noise getting back to the main supply rail, capacitors C13, C14 and C18 are used to decouple the +Vb supply.

The digital tone and noise generators require a clock signal to set the correct timing of each circuit. These signals are generated by IC1, a 4001BE, used as two independent free running oscillators. The clock frequency required by the noise generator is 4.8kHz and this is set by the values of R7, C3. To provide a variable tone the frequency of the other clock is set by R1, C1 and RV1, this allows the output to be adjusted from 11.7kHz to 34.8kHz.

The noise is generated by IC2 an 18-bit shift register and IC3 an exclusive OR gate. Several feedback loops around the shift register cause it to produce a pseudo-random bit pattern which closely approximates white noise. The feedback is taken from the 5th, 9th and 18th stage in the shift register and these outputs are gated by IC3 which controls the 'D' input of IC2. R21 and C10 ensure that the system will start up from switch on. The noise output on pin 4 of IC3 is passed through a simple filter network C7, C8 and R15. The 4.8kHz clock signal on pin 3 of IC2 is filtered by C4 and R10, these two signals are then combined using R8 and R13. This simulated radio interference is then fed to RV2a in the signal to noise balance circuit.

The tone is generated by IC4 an exclusive OR gate and IC5 a 12 stage binary counter. This configuration produces 16 digital codes, which are sequentially generated at the rate of the incoming clock frequency on pin 10 of IC5. The output of IC4 is then changed into an audio tone by using a digital to analogue converter. Four bits of the counter feed the resistor ladder R2, 3, 4 and R5, either in true or inverted form to give the positive and negative half cycles. It is the state of the fifth counter dit that determines whether or not the four dits are to be inverted, by changing the logic condition of one input of each exclusive OR gate. The 741 op-amp IC7 is used as a buffer amplifier, its gain is set by the value of R6 and high frequency suppression is provided by C2. The op-amp requires a half supply DC bias applied to pin 3, its non-inverting input. This bias voltage is set by the two 4.7kΩ resistors R9, R11 and is decoupled by C6. Each analogue cycle is constructed of 32 steps, this results in the audio tone béing exactly 32 times less than that of the clock frequency. Since the clock runs from 11.7kHz to 34.8kHz the tone produced will be 365Hz to 1.087kHz. This signal then passes through C5 and R12 to the input of the Morse envelope generator.

To produce the correct Morse tone envelope, IC8 a CA3080E transconductance amplifier is used as a linear gain control. With no DC bias applied to pin 5 the gain of the amplifier is at minimum. However, as the bias voltage increases the signal output on pin 6 will reach its maximum. This level is set by the value of R19 and any undesirable high frequency signals are suppressed by C9. This has the effect of smoothing out the individual steps that make up the waveform, thus leaving the tone as clean as possible. The bias for IC8 is generated by TR1 in the DC control stage. This PNP transistor is normally biased off by R28. However, when the Morse key switch contacts join P7 to P8 the hold off bias voltage is reduced by R31 and the +Va supply will appear on its collector. If this hard on/off voltage condition was used, the shape of the envelope would be as seen in Figure 3A. This will produce a sharp clicking sound with the tone when keying the Morse characters. To prevent this, the envelope should resemble the one shown in Figure 3B. This soft on/off option has a short attack and decay slope which results in a more pleasant sound being produced. The rate of attack is set by the time constant of R26 and C23. While the decay is controlled by the combined effect of R20, R29 and R32. The resistor R20 is necessary in limiting the amount of DC current fed to pin 5 of IC8 and R32 limits the drive current to the base of TR2. This NPN transistor is used as a saturated switch to control the red light emitting diode LED1 and R30 acts as a collector current limiter. Each time the Morse key is pressed TR2 is biased on and LED1 will light until the key is released. The envelope controlled audio signal from pin 6 of IC8 is fed via C12 to RV2b in the signal to noise balance circuit.

The balance stage is a simple crossfade control and when it is rotated in a clockwise direction the wiper of RV2a moves towards the 0V line. Thus reducing the level of simulated radio noise, while the wiper of RV2b moves towards the output of the Morse envelope generator. The signals are joined by two resistors R16, R18 to a common mixing point, which feeds the volume control of the on-board power amplifier and the tape output on P6.

The amplifier circuit uses a TBA820M, IC6, which was chosen for its low quiescent current, good ripple rejection and low crossover distortion. C11 is placed across the volume control, RV3, to reduce the pick up of stray external RF interference. The wiper of RV3 is connected to the signal input pin of IC6

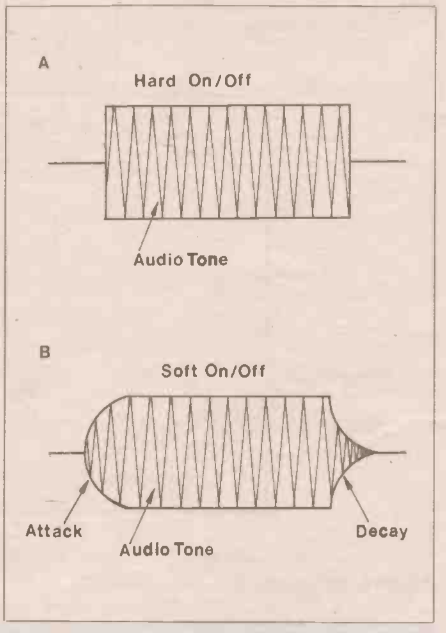


Figure 3. Morse signal envelope shaping

via the potential divider, R23 and R24. Resistor R25 on pin 2 in conjunction with C15 are used to set the gain of the amplifier. C19 is connected to pin 8 for ripple rejection and C21, C22 to pin 1 for high frequency compensation. The bootstrap components R27, C20 are attached to pins 5 and 7, with the zobel network R33, C25 connected to the 0V rail. Pin 5 has a DC potential so a blocking capacitor, C24, is used to feed the output of IC6 to the 8Ω loudspeaker or headphones on P3 and P4.

PCB assembly

The PCB is a double-sided, plated-through hole type, chosen for maximum reliability and stability. However, removal of a misplaced component is quite difficult with this kind of board so please double-check each component type, value and its polarity where appropriate, before soldering! The PCB has a printed legend to assist you in correctly positioning each component, see Figure 4.

The sequence in which the components are fitted is not critical. However, the following instructions will be of use in making these tasks as straightforward as possible. It is usually easier to start with the smaller components. Begin with the resistors as usual, then the ceramic, polystyrene, polyester and electrolytic capacitors. The polarity for the electrolytic capacitors is shown by a plus sign (+) matching that on the PCB legend. However on some capacitors the polarity is designated by a negative symbol (-) in which case the lead nearest this symbol goes away from the positive sign on the legend.

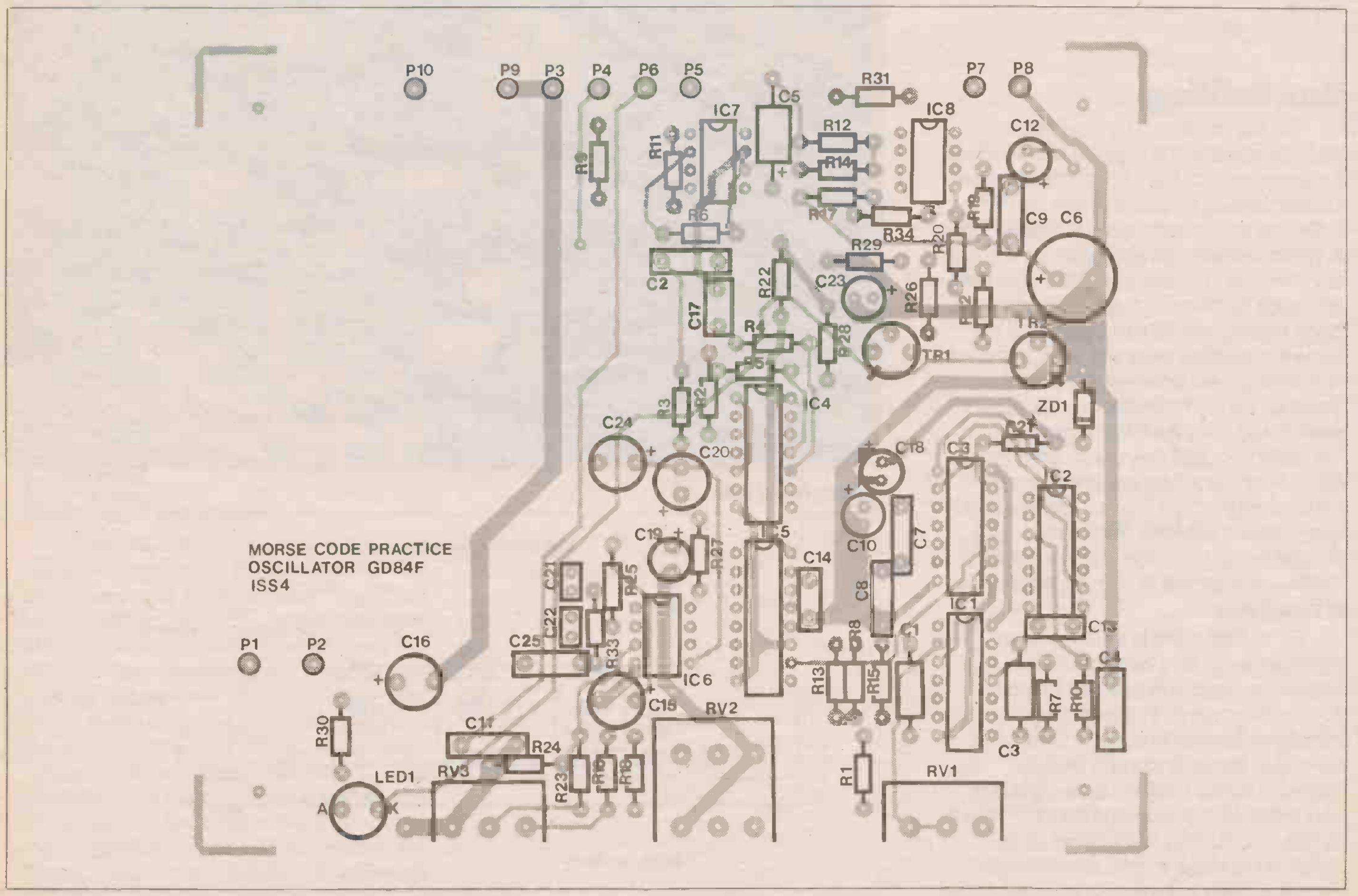


Figure 4. Track and layout of the PCB

The zener diode has a band at one end to identify the cathode connection. Be sure to position it according to the legend. There are only two transistors in the entire project, but you must carefully identify each type and match the case to the outline shown on the legend. Next, install the IC sockets ensuring that you fit the appropriate holder in each position, matching the notch with the block on the legend. Now fit the IC's in the sockets, making certain that they are the correct way round and pushed down firmly into each holder. When mounting LED1 it must be 11 millimetres above the board and bent over at 90°, see Figure 6. The LED has a short lead and a flat edge on one side of its case to identify the cathode (K) connection. When inserting it into the board make sure that it is the correct way round, otherwise it will not light.

Next prepare the three rotary potentiometers by cutting the spindles to a length of 10mm. Install them into the board making certain that they are pushed down firmly on to the surface, see Figure 6. An earthing strap is then soldered to the metal body of each pot and then to the 0V ground near to RV3, see Figure 6.

This completes the assembly of the PCB. The remaining components are connected to the circuit board by wires at a later stage. You should now check your work very carefully making sure that all the solder joints are sound. It is also very important that the track side of the circuit board does not have any trimmed component leads standing proud by more than 4mm. Further information on soldering and assembly techniques can be found in the Constructors Guide included in this kit.

Box drilling

The box that the unit is designed to fit is the Vero type 215. It is supplied with anodised aluminium panels, four self-adhesive feet and four self-tapping screws to secure the PCB. Follow the drilling instructions in Figures 7 and 8. When preparing the aluminium panels, the self-adhesive front and back trim can be used as a guide for checking the positioning of the holes. Having completed the drilling, at the same time clearing away any swarf, clean the aluminium panels and apply the trim by removing the protective backing. Carefully position and firmly push them down using a dry, clean cloth until they are securely in place. Next drill out the loudspeaker holes in the lid of the box, see Figure 8. Using a good quality impact adhesive, secure the loudspeaker to the inside of the lid, but be careful not to get any glue on the paper cone of the speaker.

Fit the front panel to the three rotary potentiometers using the shake-proof washers and nuts provided with the pots. Secure the knobs so that their pointers are at the fully-anticlockwise position. Check that they travel smoothly round to the fully-clockwise position, without scraping on the front panel. Next position the red LED through its hole, but DO NOT fit the power on/off switch at this stage. Finally, mount the four chassis sockets at the correct positions on the back panel.

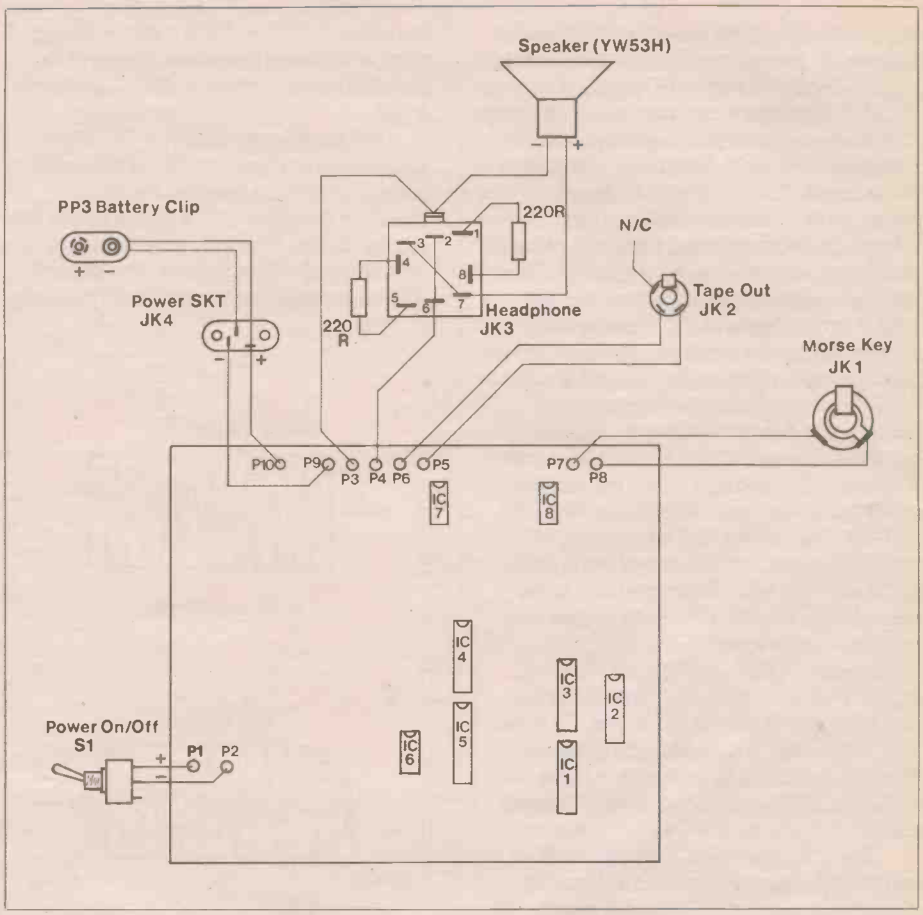
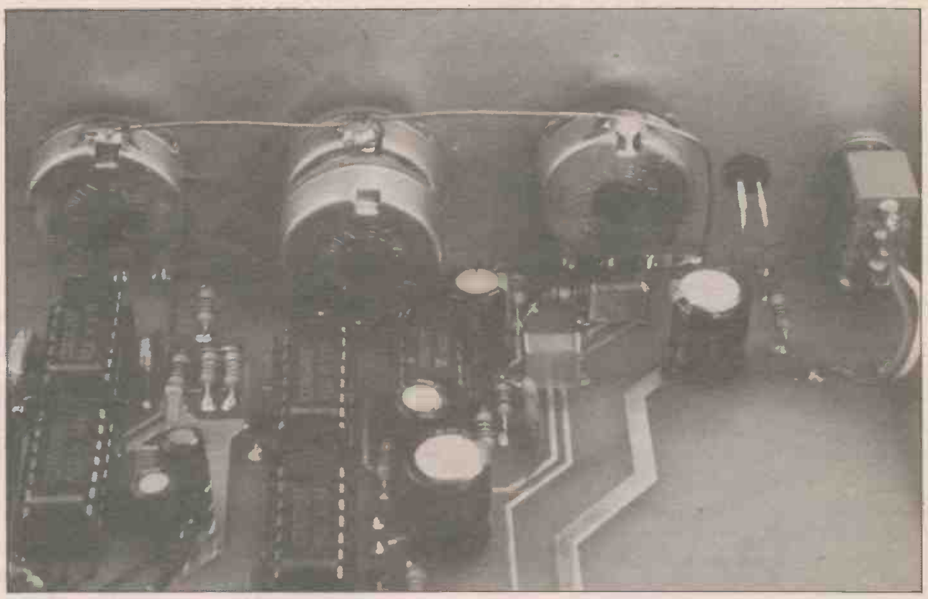


Figure 5. Wiring diagram



View on rear of pots

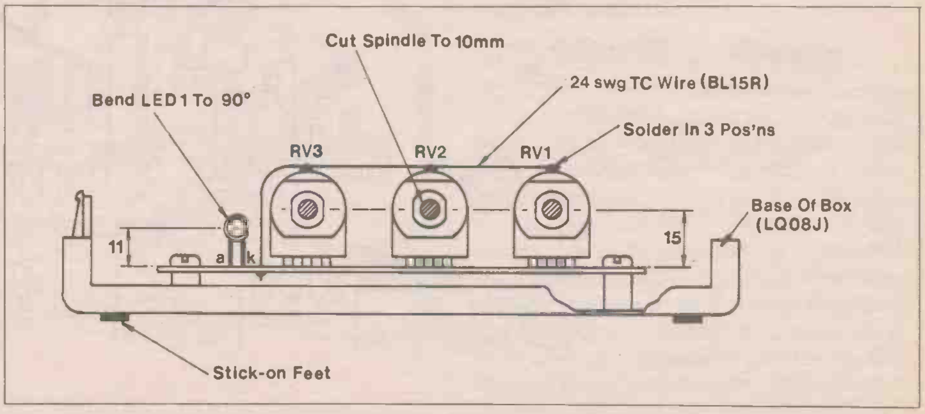


Figure 6. Assembly drawing

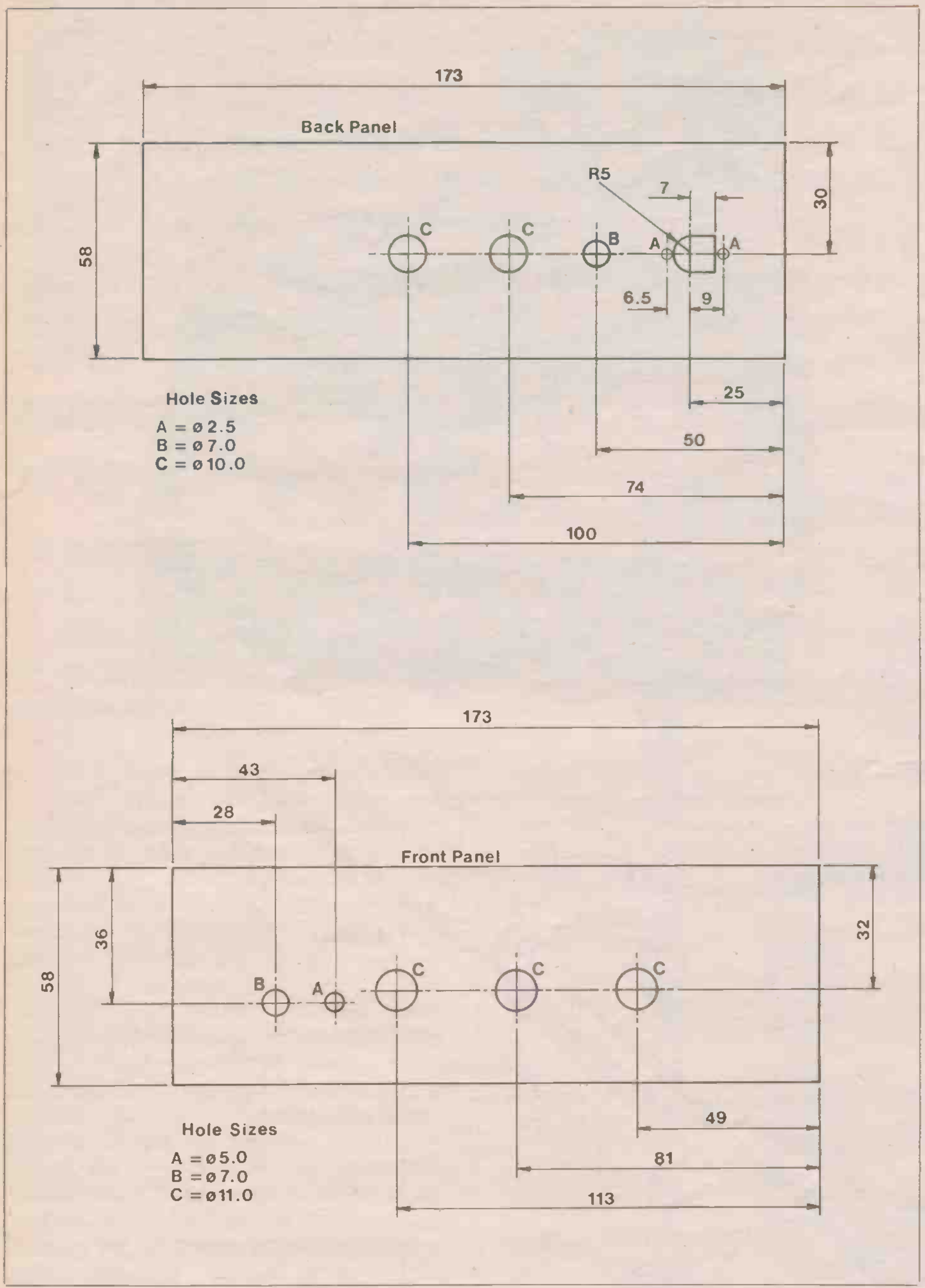


Figure 7. Front and back panel drilling

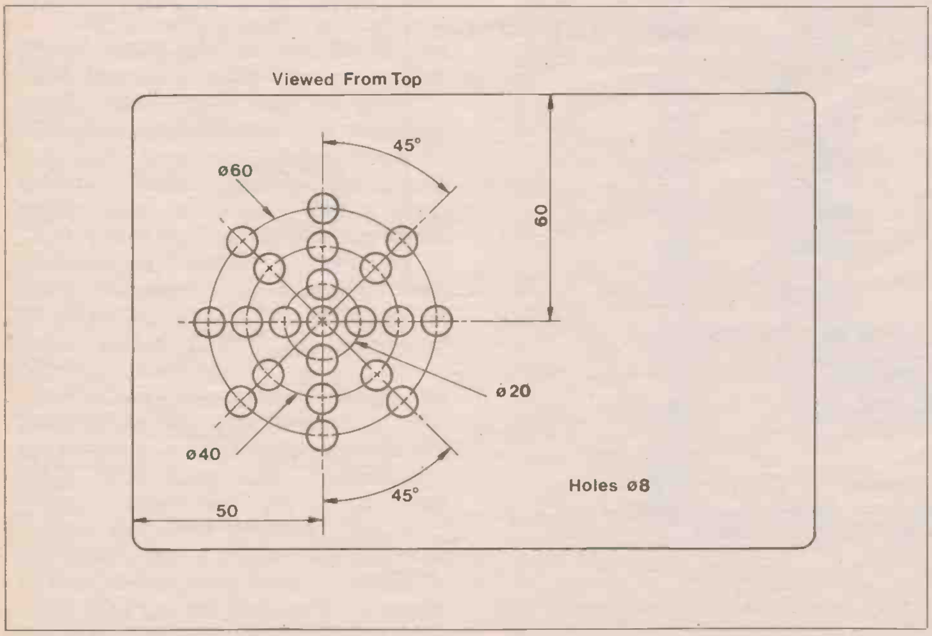


Figure 8. Box lid drilling

Wiring

If you purchase a complete kit from Maplin it should contain a length of ribbon cable. No specific colour has been designated for each wire connection, it is entirely up to you. The use of coloured ribbon cable is to simplify matters, thus making it easier to trace separate connections to off-board components, just in case there is a fault in any given part of the circuit. Strip off from the main group whichever colour you prefer for each installation.

Carefully follow the wiring shown in Figure 5. The power on/off switch S1 is connected to P1 and P2 using two 35mm lengths of wire. Cut the wires on the PP3 battery clip to 70mm, use the off cuts to connect the power socket JK4 to P9 and P10. Socket JK3 has two 220Ω resistors to reduce the output power level when using headphones. This socket is connected to P3 and P4 on the PCB using two 70mm lengths of wire. Next fit two wire links and the 140mm speaker leads, but do not connect the loudspeaker at this time. The Morse key input JK1 and the tape output JK2 are both connected to the PCB using 60mm lengths of wire. This completes the wiring of the PCB assembly. Now check your work very carefully making sure that all the wires and solder joints are sound.

Final assembly

Mount the four stick-on feet on the base of the unit and secure the board using the self-tapping screws supplied with the Vero box, see Figure 6. Install the power switch on the front panel and slot the back panel into the base. When handling the loudspeaker, be careful not to damage the paper cone or the terminals on the back. Connect the speaker to the wires from the headphone socket and lay the lid to one side of the base.

The PP3 battery is fixed to the base, near to the power switch using a Quickstick self-adhesive pad. Each time the battery is exchanged the pad is destroyed, so a strip of ten pads (HB22Y) is recommended in the optional parts list. DO NOT fit the clip onto the battery until it is called for during the testing stage.

Testing

All the tests can be made with an electronic digital, or analogue moving coil, multimeter. The following test results were obtained from the prototype using a digital multimeter and a 9V PP3 battery as the power supply. Before commencing the tests, set the three rotary controls as follows, VOLUME 0, BALANCE 'signal' 5 and TONE 5.

The first test is to ensure that there are no short circuits before you connect the battery. Set your multimeter to read OHMS on its resistance range and connect the probes to the terminals on the battery clip. Turn on the power and with the probes either way round a reading greater than 60Ω should be obtained. Remove the probes and fasten the negative terminal of the clip to the battery.

Next monitor the supply current, set your meter to read DC mA and place it in the positive line of the battery. A current reading of approximately 10mA should be seen and the red LED should not light up. Using a piece of wire, place a temporary short circuit across P7 and P8 on the PCB. The 'KEY' LED should now light and a current reading of approximately 26mA will be observed. As the volume control is advanced, an audio tone of approximately 550Hz should be heard and at maximum output the current drain will be approximately 140mA. The frequency can be varied by altering the position of the tone control, 370Hz at the '0' setting to 1.093kHz when set fully-clockwise. As the balance control is swung from SIGNAL to NOISE the strength of the tone will decrease as the level of simulated radio noise increases.

Remove your meter, fasten the PP3 clip to the battery and disconnect the wire link from P7, P8 on the PCB. This completes the testing of the Morse code practice oscillator. Before fitting the lid to the base, a small piece of acoustic wadding (RY06G) can be placed inside the box to reduce cabinet resonance.

Morse key preparation

For best results the key should be secured to a stabilising base, made from a sturdy material. The prototype used a 17mm thick wooden base, measuring 230mm by 100mm, see Figure 9. To prevent the base from slipping, four stick-on feet are mounted underneath the unit. The key is held in place by two fixing screws and the cable is fastened using a round 3.5mm plastic cable retainer.

The movement and pressure of the key is controlled by the two adjusting screws and once set are fixed by the locknuts, see Figure 9. As your Morse skills improve, you may need to reduce the amount of movement and pressure to allow for higher operating speeds. The tune up lever is used if both hands are required in setting up the Morse oscillator or any other equipment.

Using the Morse Code Practice Oscillator

The DC power for the unit is supplied by the internal alkaline PP3 9 volt battery. However, if long practice sessions are employed, external power can be fed into JK4 from a 9V regulated mains adaptor (YB23A). If you use an unregulated adaptor (XX09K), its voltage output must be set to 7.5V and the value of C16 inside Morse unit be increased to 1000μF at 16V (FF17T). This is done in an attempt to reduce the level of hum, which is caused by the high amount of ripple found on this basic type of supply. When using either adaptor, its polarity must be set to produce the positive voltage, on the centre pin of the 2.5mm power plug.

With the addition of the simple circuit shown in Figure 10, the Morse unit can be controlled by a TTL logic source, i.e. a computer. The minimum voltage required to key the unit is approximately +1V, while the maximum input should not exceed +12V or go below 0V.

For your private listening and so you won't disturb others, the unit has a headphone jack which cuts out the speaker as the plug is inserted. When you begin to learn the Morse code it is advisable to use the clean tone, i.e. balance control set fully-clockwise. However, to train your ears in picking out the weaker signals from the interference commonly found on the short wave bands, the noise level can be progressively increased. The way this is

Back panel wiring

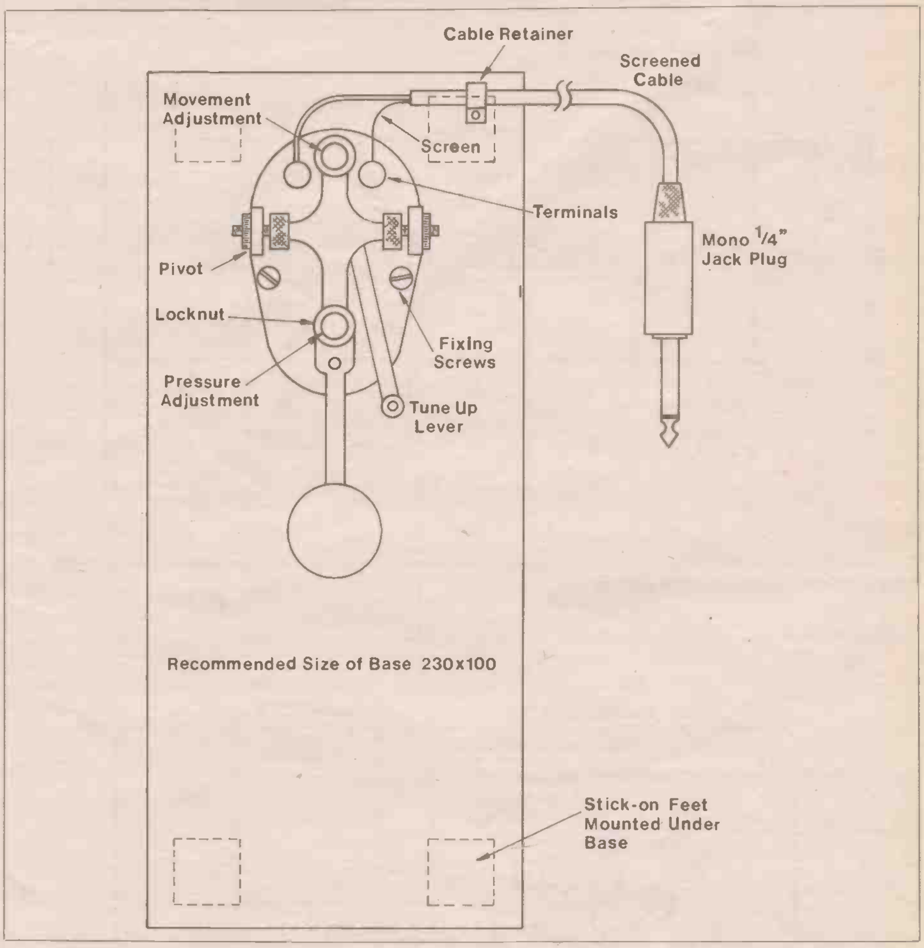


Figure 9. Morse key assembly

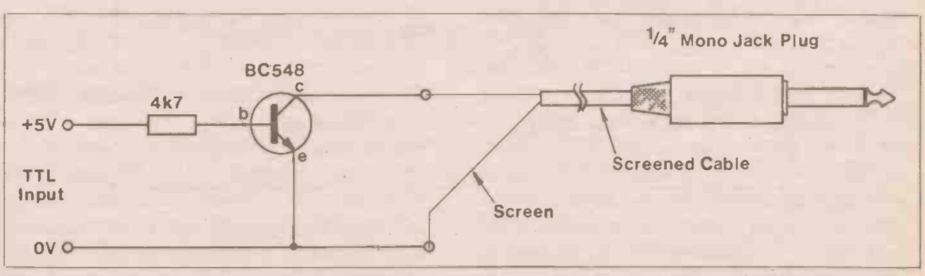


Figure 10. TTL interface

expressed is the RST code, readability, strength and tone, see Table 2.

Further information on learning Morse code can be found in the following publications:

A guide to amateur radio,
by Pat Hawker G3VA
Amateur radio questions and answers,
by F.C Judd G2BCX.
The secret of learning Morse code,
by Mark Francis.

All of these are available from the Radio Society of Great Britain (RSGB) publications, Lambda House, Cranborne Road, Potters Bar, Hertfordshire EN6 3JW.

Rear view showing the morse key and headphones

Table 2

The RST code

Readability		Strength		Tone	
R1	Unreadable	S1	Faint signals, barely perceptible	T1	Extremely rough tone
R2	Barely readable	S2	Very weak signals	T2	Very rough tone
R3	Readable with difficulty	S3	Weak signals	T3	Rough tone
R4	Readable with practically no difficulty	S4	Fair signals	T4	Rather rough but better than T3
R5	Perfectly readable	S5	Fairly good signals	T5	Reasonably clean tone
		S6	Good signals	T6	Clean tone
		S7	Moderately strong signals	T7	Nearly d.c. tone i.e. a little mains hum audible
		S8	Strong signals	T8	Good d.c. tone, slight trace of hum
		S9	Extremely strong signals	T9	Pure tone

Table 2. The RST code

MORSE CODE PRACTICE OSCILLATOR PARTS LIST

RESISTORS: All 0.6W 1% Metal Film			
R1,10	100k	2	(M100K)
R2	13k	1	(M13K)
R3,20,32	27k	3	(M27K)
R4	56k	1	(M56K)
R5	150k	1	(M150K)
R6,22,28	2k2	3	(M2K2)
R7,34	220k	2	(M220K)
R8	470k	1	(M470K)
R9,11,15,16	4k7	4	(M4K7)
R12	3k9	1	(M3K9)
R13	270k	1	(M270K)
R14,17	100Ω	2	(M100R)
R18,24,29,31	10k	4	(M10K)
R19	12k	1	(M12K)
R21	1M	1	(M1M)
R23	33k	1	(M33K)
R25	33Ω	1	(M33R)
R26	1k	1	(M1K)
R27	56Ω	1	(M56R)
R30	470Ω	1	(M470R)
R33	1Ω	1	(M1R)
RV1	220k Pot Lin	1	(FW06G)
RV2	10k Dual Pot Lin	1	(FW85G)
RV3	4k7 Pot Log	1	(FW21X)
CAPACITORS			
C1	150pF Polystyrene	1	(BX29G)
C2,7	47nF Polylayer	2	(WW37S)
C3	560pF Polystyrene	1	(BX33L)
C4	1nF Polylayer	1	(WW22Y)
C5	10μF 25V Axial Electrolytic	1	(FB22Y)
C6	1000μF 16V PC Electrolytic	1	(FF17T)
C8	33nF Polylayer	1	(WW35Q)
C9	22nF Polylayer	1	(WW33L)
C10,12,23	470nF 50V PC Electrolytic	3	(FF00A)
C11	10nF Polylayer	1	(WW29G)
C18	10μF 25V PC Electrolytic	1	(FF04E)
C13,14,17	100nF Mini Disc	3	(YR75S)
C15,20	100μF 25V PC Electrolytic	2	(FF11M)
C16,24	220μF 16V PC Electrolytic	2	(FF13P)
C19	47μF 25V PC Electrolytic	1	(FF08J)
C21	100pF Ceramic	1	(WX56L)
C22	220pF Ceramic	1	(WX60Q)
C25	100nF Polylayer	1	(WW41U)
SEMICONDUCTORS			
IC1	4001BE	1	(QX01B)
IC2	4006BE	1	(QX03D)
IC3,4	4070BE	2	(QX26D)
IC5	4040BE	1	(QW37E)
IC6	TBA820M	1	(WQ63T)
IC7	μA741C	1	(QL22Y)
IC8	CA3080E	1	(YH58N)
TR1	BC212L	1	(QB60Q)
TR2	BC548	1	(QB73Q)
ZD1	BZY88C5V1	1	(QH07H)
LED1	Red LED	1	(WL27E)
MISCELLANEOUS			
S1	Sub-Min Toggle A	1	(FH00A)
LS1	Loudspeaker Lo-Z 768	1	(YW53H)
	Morse Code Practice Oscillator PCB	1	(GD84F)
	PP3 Battery Clip	1	(HF28F)
	Ribbon Cable 10 Way	1 Mtr	(XR06G)
	8-pin DIL Socket	3	(BL17T)
	14-pin DIL Socket	4	(BL18U)
	16-pin DIL Socket	1	(BL19V)
OPTIONAL			
JK1	Jack Skt Open	1	(HF91Y)
JK2	Jack Skt 3.5mm	1	(HF82D)
JK3	DPDT Jack Socket	1	(BW80B)
JK4	2.5mm Chassis Socket	1	(FT97F)
	220Ω Headphone resistors	2	(M220R)
	Quickstick Pads	1 Strip	(HB22Y)
	Knob K14B	3	(FK39N)
	Acoustic Wadding	1	(RY06G)
	Verobox 215	1	(LQ08J)
	Front Trim	1	(JG26D)
	Back Trim	1	(JG27E)
	Morse Key	1	(LQ01B)
	Screened Cable	1 Mtr	(XR13P)
	Jack Plug Plas	1	(HF85G)
	Battery 6LF22 (PP3)	1	(FK67X)
	Regulated AC Adaptor	1	(YB23A)

A complete kit of all parts, excluding Optional items, is available:
Order As LM48C (Morse Code Oscillator Kit) Price £19.95
The following parts are also available seperately,
but are not shown in our 1988 catalogue:
Morse Code Practice Oscillator PCB **Order As GD84F Price £8.95**
Front Trim **Order As JG26D Price £1.98**
Back Trim **Order As JG27E Price £2.20**

Diodes

by R. Richards

A material such as metal is a good conductor with low resistivity and is only slightly affected by changes in temperature, materials such as plastics are good insulators with very high resistivity and are also only slightly affected by temperature changes. Semiconductor materials have a resistivity somewhere between that of a conductor and an insulator. The resistivity of this material can be accurately changed by adding small quantities of impurities and its conductivity approximately doubles for each 20 degree centigrade temperature change.

The commonest materials used in the manufacture of diodes are silicon and germanium. These are treated with impurities to alter the conductivity and this is known as doping. One half of the diode is treated with indium aluminium or gallium which forms the P region, the other half is treated with phosphorous arsenic or antimony to form the N region. The area where the P and N type materials are fused together is known as the P N junction or potential barrier. To understand how diodes behave in a circuit is simple, but one would require a sound knowledge of physics to fully understand the operation of semiconductors, so for simplicity we shall deal with basic principles only.

The P type material contains the positive carriers and the N type material the negative carriers, the potential barrier is formed between the two types and acts as a kind of insulator, see Figure 1a.

When the negative pole of a battery is connected to the P type region and the positive pole to the N type region, the carriers are drawn apart widening the depletion zone and preventing any flow of current. Under these conditions the diode is said to be reverse bias, see Figure 1c.

If, on the other hand, the positive pole of the battery is connected to the P region and the negative pole to the N region, the carriers will be drawn across the PN junction allowing current to flow. The diode is now said to be forward biased, see Figure 1b.

The P region of the diode is called the Anode (denoted as A) and the N region is called the Cathode (denoted as K), so from the previous explanation you will appreciate that the conventional current can only flow in one direction, i.e. from anode to cathode.

Diodes are used quite a lot in electronic circuits and rely on the unidirectional nature of the component and will repel the flow of current from cathode to anode until the pressure builds up to the breakdown voltage, and if heavy current is allowed to flow it will damage the diode. This breakdown voltage is known as the peak inverse voltage (P.i.v.), it is therefore essential when choosing diodes that the P.i.v. should be greater than the maximum voltage the diode is expected to carry.

It must also be noted that a diode will not conduct until a certain voltage is reached to overcome the junction barrier. These values are known as the potential barrier and are different for each type of material. Typical threshold voltages are silicon 0.5 to 0.7 volts and germanium 0.1 to 0.2 volts. Germanium diodes are used where a low forward voltage is required, but the P.i.v. is much lower than the silicon diode.

There are two kinds of diodes, namely the signal diode and the rectifier diode. Signal diodes are used for demodulation, clamping and gating. They have a very small junction which can only pass small amounts of current with low capacitance, which is a very desirable factor for use in high frequency circuits.

Rectifier diodes are used for power supplies of low frequency, normally used for rectifying AC voltages derived from mains transformers prior to smoothing and regulator circuits.

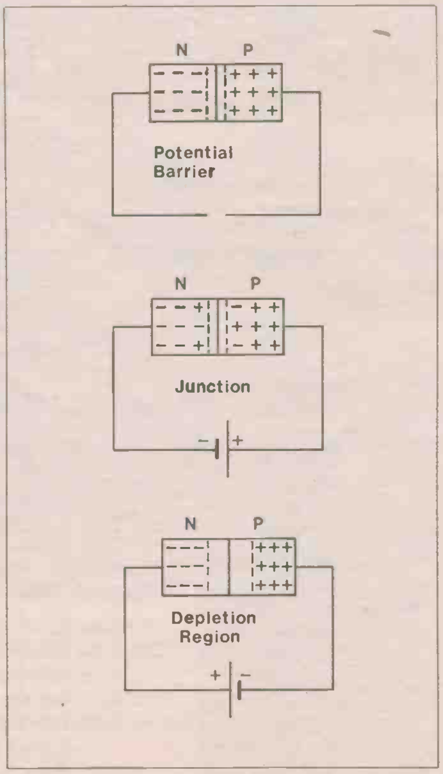


Figure 1. a) Unbiased junction, b) Forward bias, c) Reverse bias.

The modern types of diode are made from silicon and are encapsulated in plastics, but the larger types are encapsulated in a metal stud device, which has provision for mounting on a metal heatsink to dissipate the heat generated internally in the diode during operation. For example, the current flow and voltage drop across the diode causes a power loss which must be dissipated in the form of heat. Power diodes are therefore mounted on heatsinks to improve the cooling of the diode.

The circuit symbol for a diode is shown in Figure 2a. It will be noted that the arrow part of the symbol points in the direction of conventional current flow. Figure 2b illustrates the identification for plastic diodes with the ring marking the cathode end, usually this type is used for currents up to 1 ampere. Diodes from 1 to 3 amperes are also encapsulated in plastic but are generally larger, see Figure 2c. Diodes above 5 amperes are usually metal stud types and the screw end is normally the cathode and the diode symbol is often marked on the body, see Figure 2d.

There are many different diodes available, varying with peak inverse voltages from 8 to 1250 volts and capable of dealing with currents from 30mA to 20A. The most popular ones are listed in Table 1.

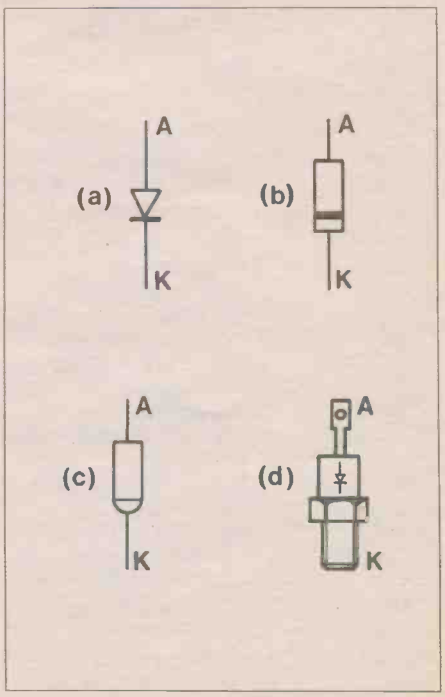


Figure 2. a) Diode symbol, b) 1 amp case, c) 3 amp case, d) Stud mounted, over 5 amp.

Low Power (signal) Germanium

Device	Volts	Amperes
OA47	25	0.11
OA90	30	0.03
OA91	115	0.05

Low Power (signal) Silicon

Device	Volts	Amperes
OA202	150	0.08
1N4148	75	0.075
1N914	75	0.075
BA154	50	0.03
BA155	100	0.1

Power Rectifier Diodes

Device	Volts	Amperes
1N4001	150	1
1N4002	100	1
1N4003	200	1
1N4004	400	1
1N4005	600	1
1N4006	800	1
1N4007	1000	1
1N5400	50	3
1N5401	100	3
1N5402	200	3
1N5403	300	3
1N5404	400	3
1N5405	500	3
1N5406	600	3
1N5407	800	3
1N5408	1000	3
BYX71-350	350	7
BYX71-600	600	7

Table 1. The commonest diodes in use.

Zener Diodes

The most common way of providing a fixed reference voltage is with a zener diode. Ordinary diodes will break down if the reverse voltage increases to the breakdown point. This occurs at a precise voltage which can be varied by adding specific amounts of dope to the semiconductor material. It is therefore possible to manufacture diodes which will break down at a fixed and predictable voltage. Zener diodes are made in such a way that the breakdown region is not damaged at the breakdown voltage providing the current is limited by a series resistor to a safe value.

The zener diode forms an excellent constant voltage source because in the breakdown region of operation the voltage drop across the diode remains constant and independent of the current flowing through it.

Zeners are specified by their breakdown voltage and their power rating, so by dividing the power rating by the breakdown voltage, the maximum current that can be safely allowed to flow can be deduced and is expressed in formula as $I = P/V$. For example, if we wish to know what is the safe current allowed to flow in a BZX61C5V6 where $P = 1.3$ and $V = 5.6$ we get $I = 1.3/5.6 = 0.232$ or 232mA.

Figure 3a illustrates the circuit symbol used for a zener diode. It should be noted that the arrow part always points towards the positive supply rail. Low powered zener diodes are encapsulated in plastic with a ring marking the cathode. The body is usually marked with the series code and the breakdown voltage, see Figure 3b. High current zeners are normally stud mounted in a similar fashion to their silicon cousins, see Figure 3c.

The most common use of zener diodes is for voltage stabilizing and so they are manufactured in a number of standard power ratings and breakdown voltages as shown in Table 2.

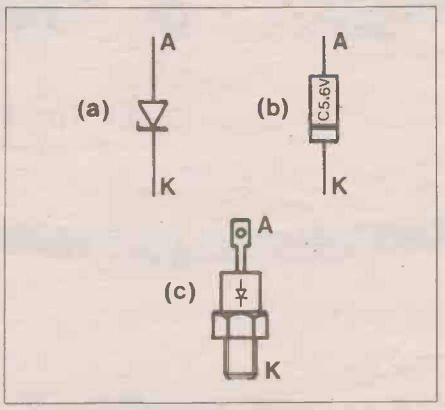


Figure 3. a) Zener diode symbol, b) Plastic case, c) Metal stud.

Series Code	Volts	Power in Watts
BZY88	2.7 to 33	0.4
BZX85	2.7 to 6.8	1.3
BZX61	7.5 to 72	1.3
1N5333	3.3 to 24	5
BZY93	9.1 to 75	20

Table 2. Zener diode ratings.

Light Emitting Diodes

These diodes (which are often abbreviated to LED) are made of transparent semiconductor material which has the property of emitting light when forward biased. When the electrons cross the potential barrier in a forward bias the energy they lose will appear in the form of light. This is achieved by making the diode with gallium arsenide phosphide which produces light in the visible region when forward biased. The voltage drop across the LED is rather higher than that of a normal diode. Forward current of 10 to 50 milliamperes can produce a voltage drop of 1.5 to 2 volts. An LED is usually a two terminal device which will only allow current to flow in one direction, i.e. anode to cathode, see Figure 4a.

The P.i.v. of the LED is very low and if the device is subject to any reverse voltage then it should be protected by fitting an ordinary diode with reversed polarity and connected in parallel with it, see Figure 4c.

The current flow through the LED must not exceed 50mA. To achieve this a resistor is inserted in series with the LED. The value of the resistor is calculated by the following formula:

$$R = \frac{E - 2}{I}$$

Where R = resistance, E = battery voltage, 2 = the voltage drop across the LED and I = the current flowing through the LED. See Figure 4d for example.

The circuit symbol for the LED is illustrated in Figure 4b. Note that the arrow part again points in the direction of conventional current flow. Apart from the single LED, arrays of LEDs can be combined to form a 7 segment LED display, as used in calculators and electronic recording devices for example. Single LEDs are manufactured in many colours although red, green and yellow are the most common, and are used for multitudious purposes. Basic LED details are shown in Table 3.

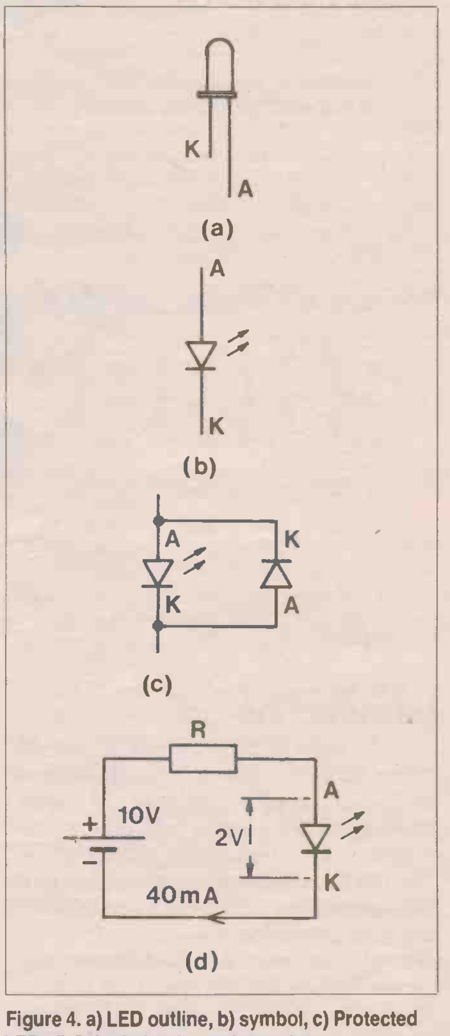


Figure 4. a) LED outline, b) symbol, c) Protected LED, d) Calculation for series resistor.

Colour	Diameter	Forward volts	Reverse volts	Max current	Max power
Red	0.2"	2V	5V	40mA	125mW
Green	0.2"	2V	5V	40mA	125mW
Yellow	0.2"	2V	5V	40mA	85mW

Table 3. LEDs.

NOISE

by Tim Watson
BSc. (Hons), AMIEE.

Introduction

The purpose of this article is twofold. Firstly, to give an introduction to types of noise and possible sources of noise. Secondly, a design, and full constructional details, for a noise generator are given. The main use of a noise generator is in testing equipment on the lab bench which will be subjected to noise in the field. For example, a modem designed to work over normal telephone lines may work fine in a noise free lab with zero line length, however as we all know, telephone lines can be very noisy, especially as they get longer. If you have ever built something which worked fine in the lab, but failed in the field, then noise may be the problem.

Virtually any signal in a system that is not desired might be classified as noise. However, the term noise is usually taken to mean an unwanted signal that has random properties. A few types will now be considered.

White Noise

The noise power of white noise is flat across the frequency spectrum. That is to say, there is the same power of noise in each hertz, and it occurs at all frequencies. What ever frequency an item of equipment operates at it cannot escape white noise. The term 'noise bandwidth' is sometimes used with respect to an item of equipment. This means the bandwidth to which the item of equipment is sensitive to noise. For example, if a particular piece of equipment is designed to observe a low level analogue signal with a frequency of DC to 100Hz, then to help bring the signal out of the noise it would be sensible to low pass filter the signal, with a filter cut-off frequency just above 100Hz. The signal would be unaffected by the filter, but the unwanted noise above 100Hz would be rejected. The noise bandwidth would be said to be 100Hz. Of course, noise below 100Hz would still be present.

Now let us consider some origins of white noise. Noise is often caused by thermal effects (including problems like thermal drift). All resistors generate white noise merely because they have a temperature, sometimes called 'Johnson' noise. The RMS noise is proportional to the square root of absolute temperature. The only way to get rid of the noise is to operate the resistor at 0°K (−273°C), not exactly an easy condition to meet!

The second most well known source of white noise is shot noise. This noise is due to the fact that current is not constant and smooth flowing, but consists of a stream of electrons. This causes current flow to fluctuate.

Both thermally generated and shot white noise are due to fundamental principles and as such can not be reduced by making better quality components, for example a carbon film resistor and a metal film resistor of the same value will cause the same amount of thermally generated white noise. We have to live with this noise.

Flicker Noise

Flicker noise is also known as 1/f noise and pink noise. It is known as 1/f noise since this describes the noise power spectrum, noise power is proportional to 1/f, where f is frequency. 1/f noise has equal power per frequency decade. 1/f noise is an extra in that it is due to manufacturing imperfections. For example, a carbon film resistor will generate more 1/f noise than a metal film resistor, simply because carbon film resistors are of lower quality than metal film resistors.

Interference

Most other types of noise are commonly put into this class. It includes things such as mains 50Hz pickup, which is not at all random, and impulsive interference such as electrical motors, car ignitions, lightning, etc. Impulsive interference is broad band in the frequency spectrum.

The Noise Generator

As mentioned at the start of this article any unit which may have to work when subjected to noise/interference will require testing on the lab bench before it can be placed in the field. To test noise performance a controllable noise source is needed. The noise generator design to be described here produces band limited white noise from virtually DC (0.0001Hz) to around 250kHz. The generator requires a supply between +5V (or ±2.5V) and +18V (or ±9V), split supply rails are not required, but can be used. The supply will typically be taken from the unit under test. A noise level control is provided to allow the noise output level to be adjusted. The absolute maximum output level is dependent on the supply voltage. Three outputs are provided, DC coupled, AC coupled and digital, the use of these outputs is described later.

Psuedo Random Bit Sequences

The noise is generated using a psuedo random bit sequence (PRBS). A psuedo random bit sequence is a sequence of logic ones and zeros that appears to have random properties, that is the sequence has the same probability properties as that produced by repeatably tossing a coin and calling logic one for heads, logic zero for tails. The bit sequence is produced using a digital shift register with exclusive OR feedback, thus the sequence is entirely predictable, however any portion of the sequence looks random. Since the sequence in this design is 8, 589, 934, 591 bits long and takes over two hours to repeat, it can be assumed to be as good as random in just about all circumstances.

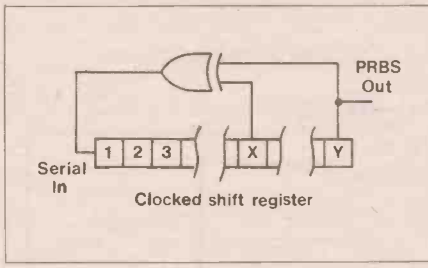


Figure 1. PRBS generator.

The basis of a PRBS generator is shown in Figure 1, a Y bit long shift register with EXOR feedback from the X and Y bits. In Figure 1, only two feedback taps are shown, in fact more than two taps may be needed, depending on the shift register length. The circuit described here uses a 33-bit shift register with feedback from bits 20 and 33. The feedback taps must be chosen correctly to give a maximum length bit sequence. The maximum number of different states for a Y bit shift register is 2^Y (i.e. all binary permutations). However, the state of all zeros causes feedback of zero and the register stays stuck at zero. The maximum sequence length possible is 2^Y-1.

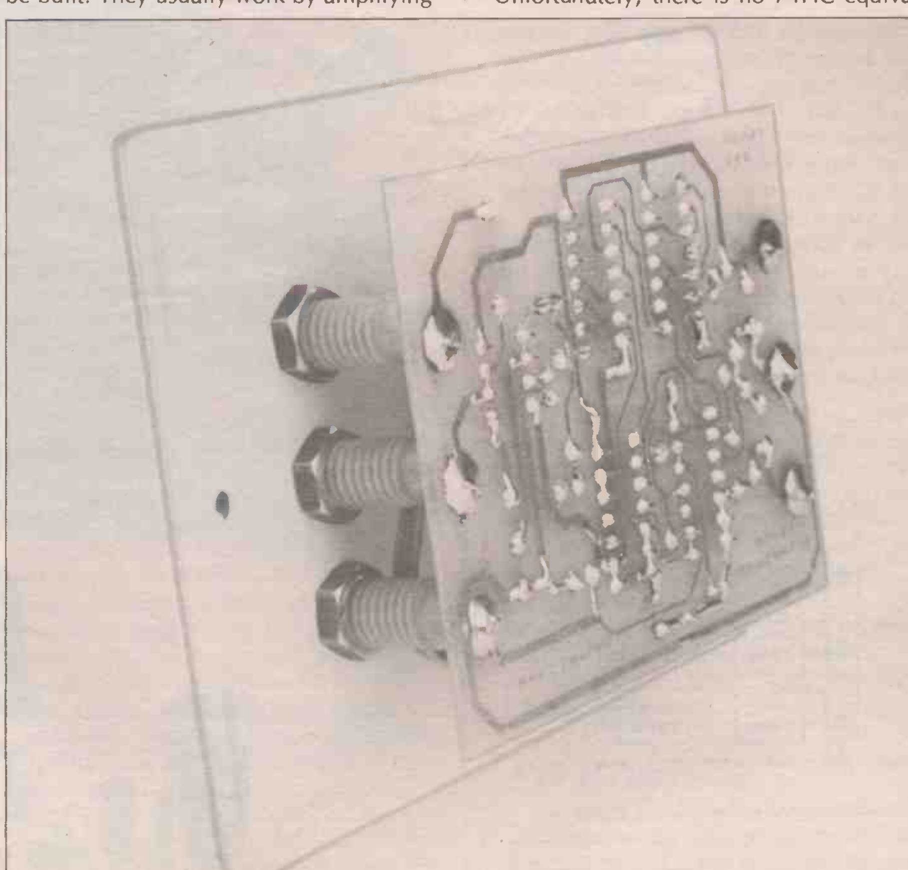
PRBS generators have other uses such as, encipherment of data, radar ranging codes, error checking (typically on disks, cyclic redundancy check characters, CRCC), digital signature analysis, etc. For the applications involving data, the data is fed into the shift register by adding it to the EXOR feedback. PRBS generators can be implemented in software, and are sometimes used as the basis of random number generators.

Analogue based noise generators can be built. They usually work by amplifying the noise produced by a diode or resistor. Since the noise generated by resistors and diodes is reasonably low level, a lot of amplification may be required, this causes sensitivity to interference pickup. The main advantages of using a digital noise source are, the ability to produce noise of known spectrum, all circuits built to the same design will behave the same, that is better repeatability of design and finally insensitivity to supply variation and other interference pickup.

Circuit Description

The noise spectrum generated by a PRBS is almost flat up to a frequency 26% of the shift register clock frequency. At this frequency the noise power is −1dB down. Band limited white noise is simply produced by low pass filtering the PRBS output.

Referring to Figure 2, the shift register clock does not need to be particularly stable or accurate and a simple RC oscillator, using IC3d, has been used. This gives a clock frequency of approximately 1MHz. Increasing the clock frequency increases the bandwidth of white noise, the higher the clock frequency the better. The maximum clock frequency is limited by the propagation delays to 1.5MHz. The 4000 series CMOS integrated circuits used are rather slow, but do have the advantage of operating from a wide supply variation, it was for this reason that they have been used. The schmitt trigger NAND gates and EXOR gates could be replaced by 74HC series equivalents, which are around ten times faster. Unfortunately, there is no 74HC equiva-



Rear view.

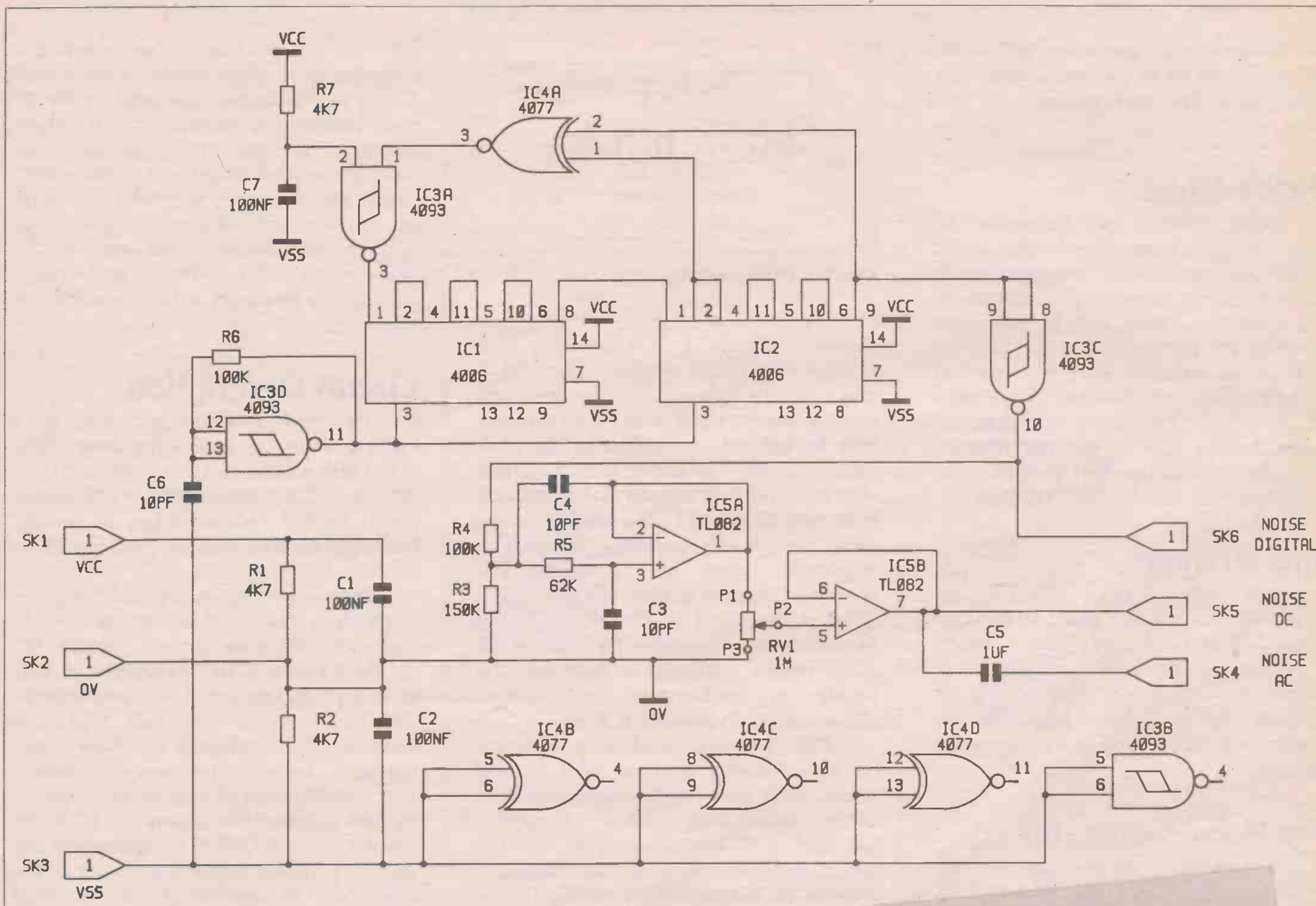


Figure 2. Noise generator circuit.

lent of the 4006 (IC1 and IC2) 18 bit static shift register. The 4006 is internally organised as shown in Figure 3, it consists of two four bit shift registers with outputs after the fourth stage available, and two five bit shift registers with outputs at the fourth and fifth stage available, all registers are operated from the same clock. IC1 is used as a 16 bit shift register and IC2 is used as a 17 bit shift register, this gives a total length of 33 bits.

As stated earlier, PRBS generators have a 'stuck at zero' state. At power up this state must be avoided. The usual trick to get round this is to use EXNOR feedback, all data is then inverted and the 'stuck at zero' state becomes 'stuck at

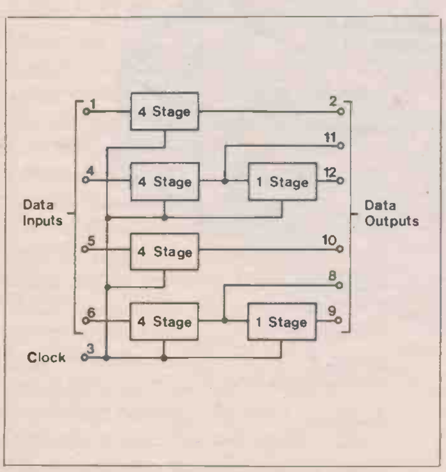
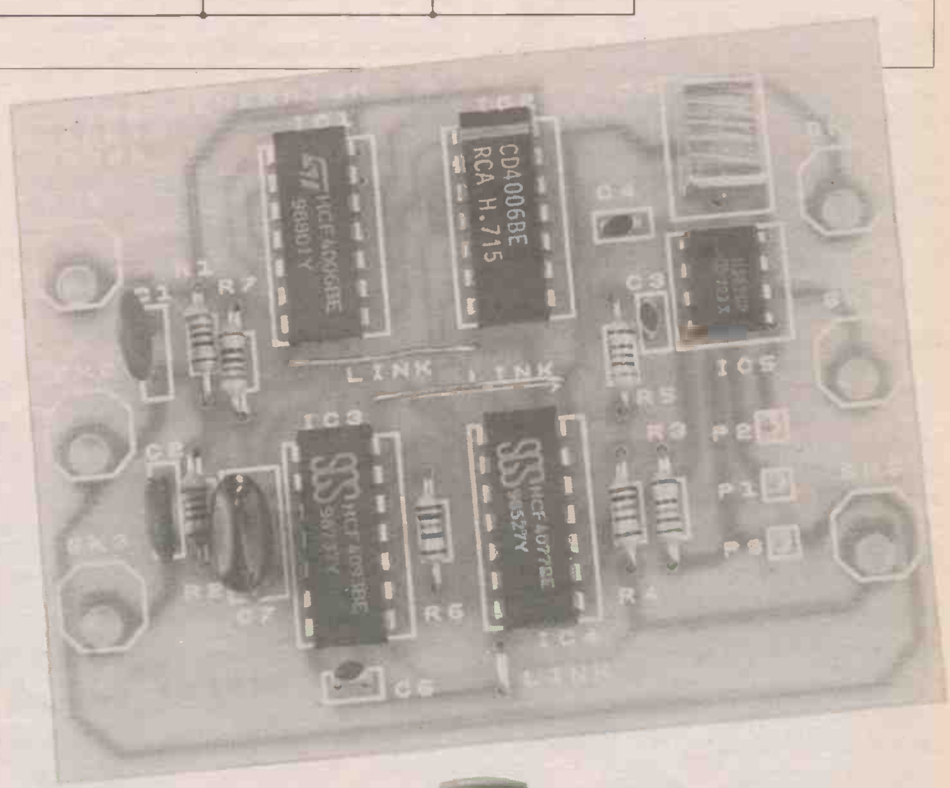
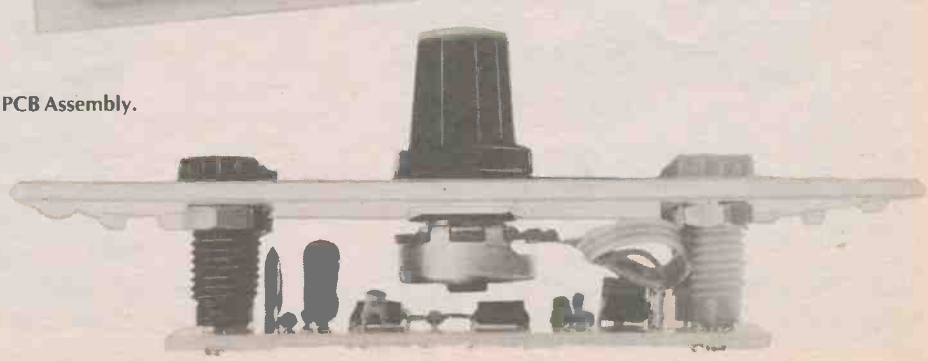


Figure 3. Pin-out of the 4006.



PCB Assembly.



one', a reset input on the register is then used at power up to ensure that it starts operation in the all zero state. The 4006 has no reset input so this trick can not be used. The problem has been solved by forcing logic ones into the 33 bit shift register at power up. This is done by IC3a, at power up C7 takes one input low, the output is high regardless of the other input. After a period given by R7 & C7 time constant, the input goes high and IC3a then inverts the output of IC4a. The shift register feedback is thus EXOR and the 'stuck at zero' state has been avoided by shifting in ones at power up. The R7 & C7 time constant is much longer than 33 clock periods, this ensures the shift register always starts in the state of all ones.

Band limited white noise is produced by low pass filtering the shift register output, in fact any shift register tap will do. IC5a and associated components form a second order low pass filter. This gives a roll off of 40dB per decade, starting at 250kHz. The circuitry around IC5 requires a mid-supply rail. This rail, called 0V, is derived by R1 and R2 from the logic supply rails, Vcc and Vss. R3 and R4 reduce the input voltage swing to IC5, to avoid clipping distortion. IC5a is followed by the noise level control, and finally IC5b, a unity gain buffer. Three outputs are provided, the unfiltered output of the shift register buffered by IC3c, a DC coupled output and an AC coupled output. The AC coupled output is DC decoupled by a 1μF polylayer capacitor. This capacitor needs to be as large as possible because when the output is connected to a load impedance it will cause high pass filtering and thus attenuate the low frequency noise. For example, with a 10k resistive load, noise below 16Hz will be filtered out. Electrolytic capacitors have not been used to DC decouple, because they have poor high frequency performance.

Construction

The PCB does not contain many components and should be easy to construct, use Figure 4 to help in building it. The 4mm sockets are mounted in the case lid, drilling details shown in Figure 5. The PCB is then mounted directly onto the rear of the sockets, component side to the case lid, see Figure 6. Connections to the noise control are made by flying leads. Since once the PCB has been soldered onto the sockets it is difficult to remove, the unit should be tested before final assembly. Testing will require temporary connections to the socket PCB pads. The best method to test the noise source is to check the noise output on a spectrum analyser. Since not many people own a spectrum analyser the next best method is to use an oscilloscope, the noise output should look reasonably the same for any timebase setting upto around 20μs/div. Since the signal is random, it is difficult to say exactly what it will be!

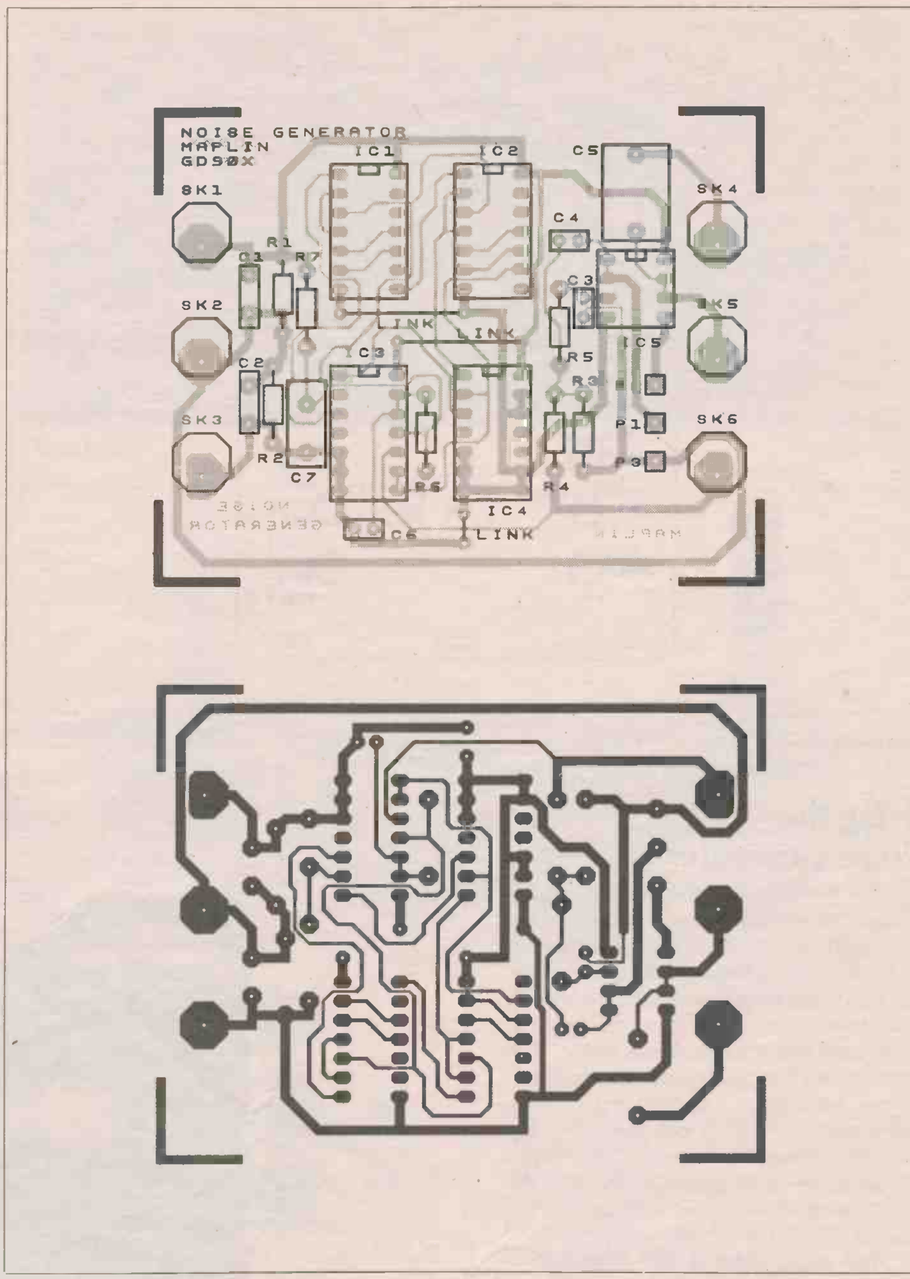


Figure 4. Track and overlay of PCB.

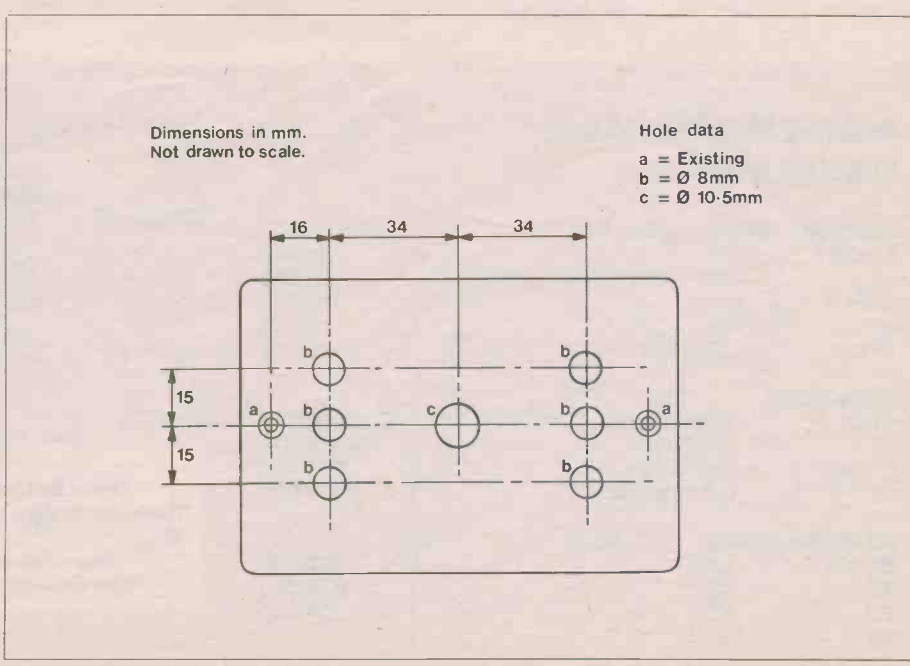


Figure 5. Case lid drilling details.

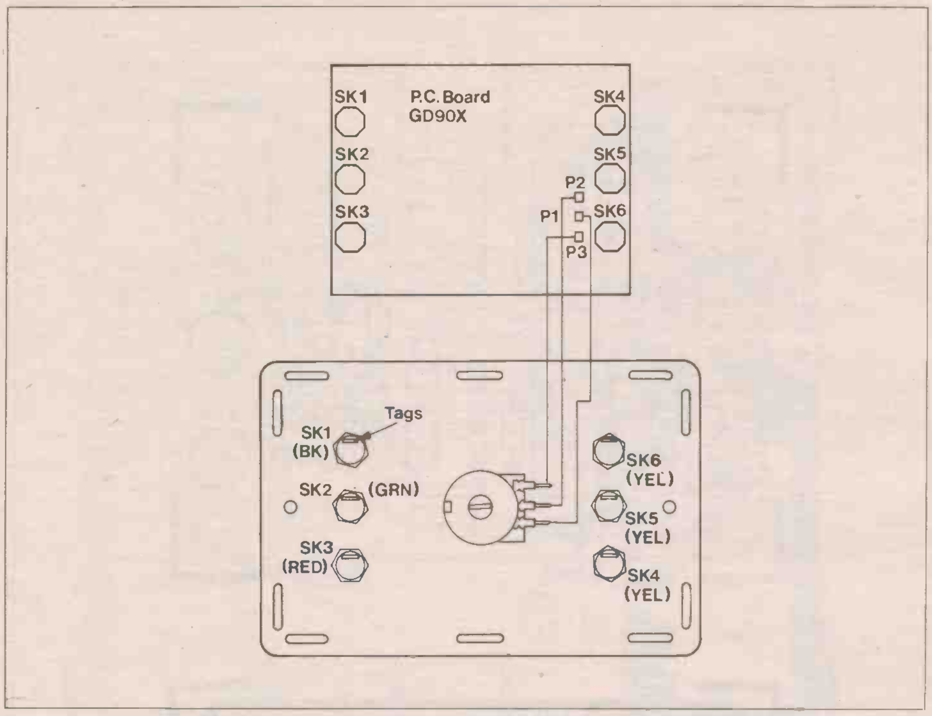
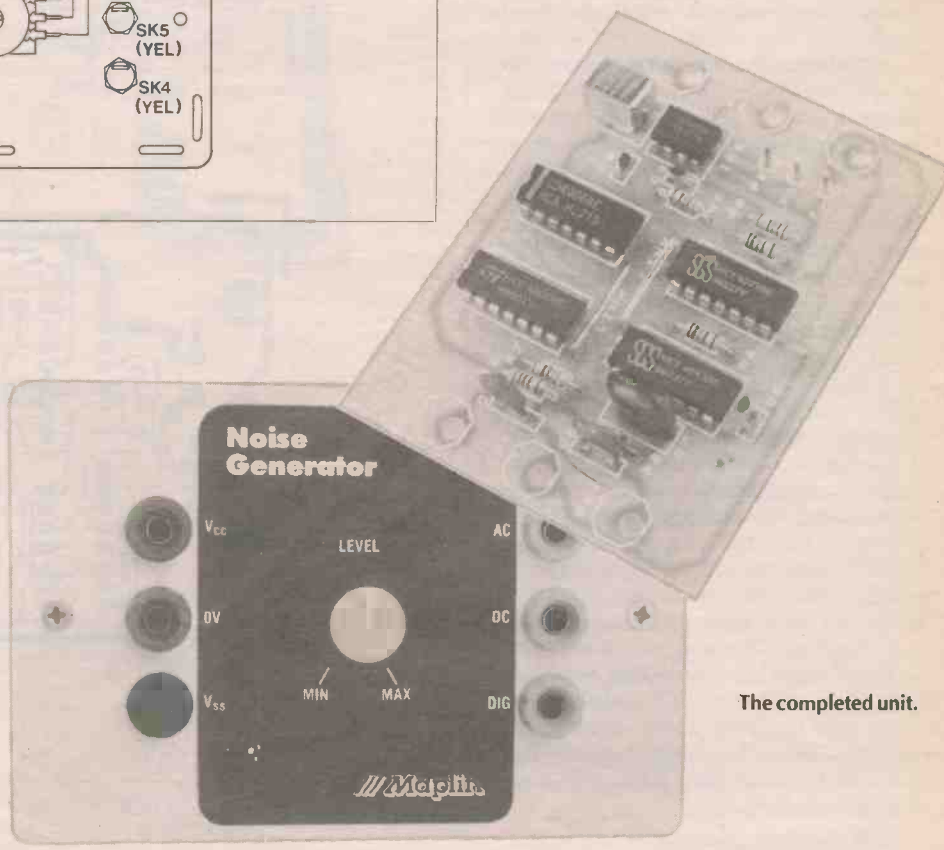


Figure 6. Assembly.

Using the Noise Generator

It is intended that the noise generator is operated from the power supply of the equipment under test, of course there is no reason why it should not have its own supply. A supply between +5V and +18V should be connected from Vss to Vcc, black and red sockets respectively. The green 0V socket can be left unconnected. If the equipment under test has a mid-supply rail then it can be connected to the 0V socket. This ensures the 0V rails will be at the same potential and thus the DC coupled noise output will have no DC offset with reference to the equipment 0V.

The exact method for coupling the noise into the equipment under test will depend on the exact nature of the equipment. Basically the noise must be added to the signal for which noise rejection is being tested. The simplest method is by means of a high value resistor, however this may be too basic in some cases. The DC coupled noise output should be used whenever possible as this output will not attenuate low frequency noise. Indeed when very low frequency noise performance is being tested this output must be used. If equipment DC bias levels must not be upset then the AC coupled output can be used, but remember the high pass filtering problem discussed above. In some cases this may not matter, for instance when testing equipment that works in the audio range (about 30Hz to 20kHz).



The completed unit.

NOISE GENERATOR PARTS LIST

RESISTORS: All 0.6W 1% Metal Film

R1,R2,R7	4k7	3	(M4K7)
R3	150k	1	(M150K)
R4,R6	100k	2	(M100K)
R5	62k	1	(M62K)
RV1	1M Lin Pot	1	(FW08J)

CAPACITORS

C1,C2	100nF Minidisc	2	(YR75S)
C7	100nF Mylar	1	(WW21X)
C3,C4,C8	10pF Ceramic	3	(WX44X)
C5	1μF Polylayer	1	(WW53H)

SEMICONDUCTORS

IC1,IC2	4006	2	(QX03D)
IC3	4093	1	(QW53H)
IC4	4077	1	(QW47B)
IC5	TL082	1	(RA71N)

MISCELLANEOUS

SK1	4mm Socket Red	1	(HF73Q)
SK2	4mm Socket Green	1	(HF72P)
SK3	4mm Socket Black	1	(HF69A)
SK4,SK5,SK6	4mm Socket Yellow	3	(HF75S)
	Collet Knob	1	(YG40T)
	Yellow Knob Cap	1	(QY06G)
	Box PB1 White	1	(LF01B)
	PCB	1	(GD90X)
	Front Panel	1	(JG29G)
	Wire	1 Pkt	(BL00A)

A complete kit is available:
Order As LM56L (Noise Generator Kit) Price £10.95
The following parts are also available separately, but are not shown in our 1988 catalogue:
Noise Generator PCB **Order As GD90X Price £3.95**
Noise Generator Front Panel **Order As JG29G Price £1.50**

Maplin ELECTRONICS

Sorry we don't need any more STARFLEET CREWMEN...BUT!! we do need several TECHNICAL SALES STAFF

These vacancies are being created continuously as a result of our perpetual expansion program. Currently we are looking for staff in the North, Central and South East of England. We are looking for enthusiastic personnel to help us open new stores throughout the country. These positions offer real prospects up to, and including, branch management.

Both junior and experienced people will be considered. A knowledge of sales, although an asset, is not essential. But, to become part of the team you do need to be self motivated and have a cheerful personality. Applicants should also be smart and have a knowledge of electronic components.

We offer excellent working conditions and job security, plus a good salary with commission and a realistic pension scheme.

Apply in writing enclosing CV to David Snoad, P.O. Box 3, Rayleigh, Essex. Or for further information, ring 0702 554155.

If you are seeking an interesting career in a Hi-Tech environment then contact us.

NOW!

TECHNICAL DEPARTMENT NEWS

Our design and development lab' is responsible for appraising new products sourced from countries all over the world and also for researching and developing projects. As the department is now expanding, we are looking for a suitable engineer to join our technical team and assist in all aspects of project design from initial concept to final production. The position demands a proven technical background in both analogue and digital disciplines, good communicative skills and the commitment required for working to deadlines.

If you feel that you could be just the right person for us, please send details about yourself to:

Mr. D. Goodman,
The Design Manager, Maplin Electronics,
P.O. Box 3, Rayleigh, Essex SS6 8LR.

TECHNICAL AUTHOR/ JOURNALIST

Here's an exciting opportunity for someone with a technical knowledge of electronics who enjoys writing. Maplin Electronics has a vacancy for a technical author/ journalist to assist in the production of this magazine. In addition the successful applicant will be required to assist in the writing up of new products for inclusion in the Maplin Catalogue as well as assisting with advertising copy and in other areas that will require creative writing.

You will work in a small friendly office suite close to Maplin's headquarters near Rayleigh, Essex. Wages are commensurate with your qualifications and experience.

We are looking for a lively, intelligent person who can become a major influence on the non-project part of the magazine with creative new ideas. The Maplin Magazine has the largest circulation in the U.K. of any electronics magazine or newspaper, so what you write will be the most widely read in the industry.

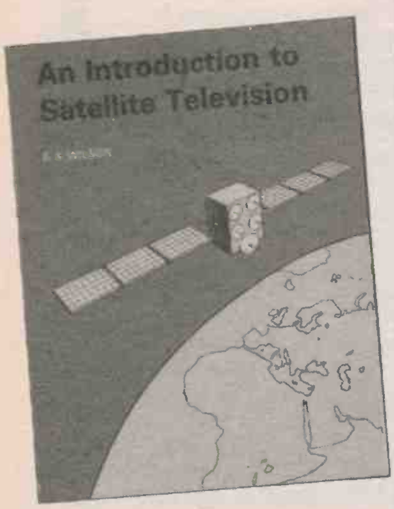
If you would like to be a part of the most successful electronics magazine in the country, write today enclosing your CV to **The Editor, Maplin Magazine, P.O. Box 3, Rayleigh, Essex SS6 8LR.**

New Books

More Advanced Power Supply Projects

by R. A. Penfold

This book is the companion volume to 'Power Supply Projects' and should be of interest to any one who has a reasonable knowledge of power supply basics and would like to learn about recent developments and more advanced designs. The practical and theoretical aspects of the circuits are covered in some detail, and the reader is not assumed to have an in-depth knowledge of electronic circuit design. However it is recommended that any one who is not familiar with the fundamentals of power supply design and operation should obtain the introductory book first.
Topics covered include switched mode power supplies, precision regulators, dual tracking regulators and computer controlled supplies. It is a fact that this book should cover the vast majority of your power supply needs that were not shown in the first book.
96 pages, 111mm x 178mm, illustrated.
Order As WP92A (More PSU Projects) Price £2.95 NV



An Introduction to Satellite Television

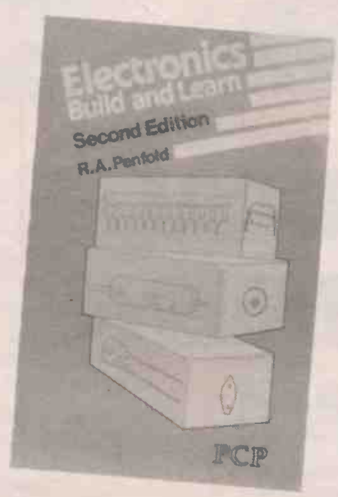
by F. A. Wilson

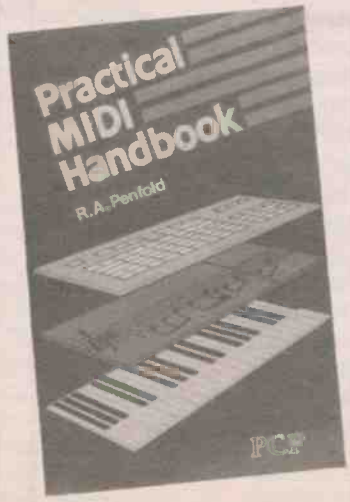
Can I pick up transmissions directly from anywhere in the world? Will I need a dish and how big must it be? Will I be able to receive many new channels? Will I have to buy a completely new TV? These are the sort of questions people are starting to ask themselves as television enters the new and exciting era of satellite reception.
As a definitive introduction to the subject this book is presented on two levels. For the absolute beginner or anyone thinking about purchasing or hiring a satellite TV system, the story is told as simply as such a complex one can be in the main text. For the professional engineer, electronics enthusiast, student or others with technical backgrounds, there are numerous appendices backing up the main text with additional technical and scientific detail, formulae, calculations, tables, etc.
There is also plenty for the DIY enthusiast with practical advice on choosing and installing the most problematic part of the system; the dish antenna. Fully illustrated throughout and packed with all the very latest information, this is the book which will help you to avoid the expensive pitfalls and make the most of this exciting new development.
112 pages, 195mm x 264mm, illustated.
Order As WP99H (Intro Satellite TV) Price £5.95 NV

Electronics - Build and Learn

2nd Edition
by R. A. Penfold

Electronics is a practical subject, but a certain amount of theoretical knowledge is necessary if you are to become proficient in it. This book combines theory and practice so that you can 'learn by doing'.
Full constructional details of a circuit demonstrator unit are given which is used in subsequent chapters to introduce common electronic components. Later chapters describe how these components are built into useful circuits, oscillators, bistables and logic circuits.
At every stage in the book there are practical tests and experiments that you can carry out to investigate the points described and to help you understand the principles involved.
This second edition has been updated to include a new circuit demonstrator board using IC holders, a new chapter on logic circuitry, and many new drawings and photographs.
An essential book for the beginner in electronics!
128 pages, 138mm x 216mm, illustrated.
Order As WP97F (Elec. Build/Learn) Price £5.95 NV

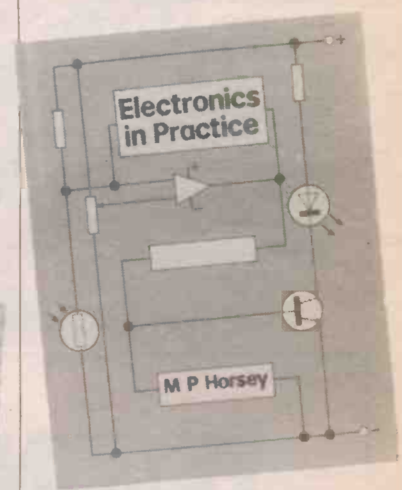




Electronics in Practice

by M. P. Horsey

A practical introduction to electronics in which the reader is encouraged to start building circuits immediately. Instructions are given for constructing circuits on both breadboard and stripboard. Simple devices, such as a steady-hand tester, are dealt with initially. More complicated projects such as building an electronic organ, are then described before the introduction of logic integrated circuits and computer interfacing.
This book contains theory appropriate to GCSE physics, but could also be used in electronics and CDT classes. The practical approach makes this a very suitable manual for TVEI and other vocational courses.
138 pages, 215mm x 275mm, illustrated.
Order As WP98G (Elec in Practice) Price £4.95 NV



Practical MIDI Handbook

by R. A. Penfold

The Musical Instrument Digital Interface (MIDI) is surrounded by a great deal of misunderstanding, and many of the user manuals that accompany MIDI equipment are quite incomprehensible to the reader.
This book is aimed at musicians, technicians and enthusiasts who want to exploit the vast capabilities of MIDI. It explains what MIDI can do and how you can exploit it to the full, with practical advice on connecting up a MIDI system and getting it to work, as well as deciphering the technical information in those equipment manuals.
It covers all the MIDI based equipment you can use; keyboards, drum machines, sequencers, effects units, mixers, drum pads and guitars. There's also a section on computer music that covers software, real and step time sequencing, notation/score writing programs, voice filers, etc. And for those of you who want to do your own MIDI programming there are details of the MIDI code numbers.
A great book for the MIDI enthusiast!
160 pages, 138mm x 216mm, illustrated.
Order As WP96E (Pract MIDI Handbook) Price £5.95 NV

New Books

Optoelectronics Circuits Manual

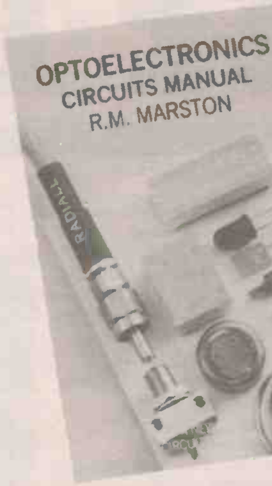
by R. M. Marston

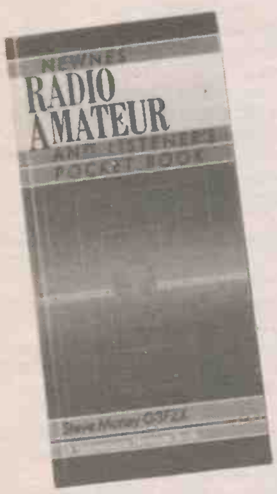
Optoelectronics is the study of any devices that produce an electrically-induced optical (visible or invisible light) output, or an optically-induced electrical output, and of the electronic techniques and circuitry used for controlling such devices. It is one of the fastest-growing branches of modern electronics and encompasses a wide variety of devices, ranging from simple light bulbs and light emitting diodes to complete infra-red light-beam alarm and remote control systems.

This manual is a useful guide to the opto-electronics device user, and is especially aimed at the practical design engineer, technician, and experimenter, as well as the electronics student and amateur. It deals with the subject in an easy to read, down to earth, and non-mathematical yet comprehensive manner, explaining the basic principles and characteristics of the best known devices, and presenting the reader with many practical applications and over 200 circuits. Most of the ICs and other devices used are inexpensive and readily available.

182 pages, 137mm x 215mm, illustrated.

Order As WP93B (Opto Circuits Manual) Price £10.95 NV





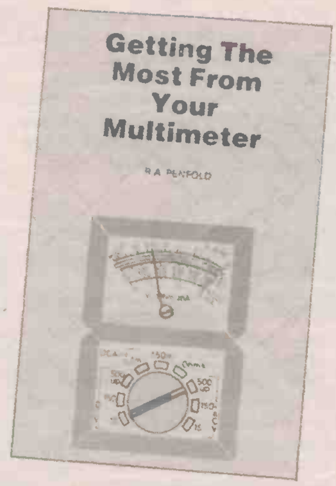
Radio Amateur and Listener's Pocket Book

by Steve Money G3FZX

A unique collection of useful and intriguing data for the traditional and modern radio amateur and the hi-tech listener. Familiar radio topics are probably covered more concisely than in any similar book (for example, abbreviations and codes, symbols, formulae and frequencies) but the most interesting sections of the book deal with the newer features of the ham's world; AMTOR, Packet Radio, Slow Scan TV, computer decoding, airband and maritime glossaries and so on. Radio amateurs, hackers and monitors will all find this book the best single-source, quick reference guide to an increasingly wide-ranging subject.

160 pages, 95mm x 196mm, illustrated.

Order As WP91Y (Ham's Pocket Book) Price £8.50 NV



Getting the Most from your Multimeter

by R. A. Penfold

The first piece of test equipment that most electronic hobbyists normally buy is a multimeter. This is probably because it is one of the least expensive items and, also if you know how to use it properly, one of the most useful. This book is primarily aimed at beginners and those of limited experience of electronics. The basics of analogue and digital multimeters are covered, discussing the relative merits and limitations of the two types. Various methods of component checking are described, including tests for transistors, thyristors, resistors, capacitors and diodes. Circuit testing is also covered with subjects such as voltage, current and continuity checks being discussed. In the main little or no previous knowledge or experience is assumed. Using these simple component and circuit testing techniques the reader should be able to confidently tackle servicing of most electronic projects.

112 pages, 111mm x 178mm, illustrated.

Order As WP94C (Get More Multimeter) Price £2.95 NV

Introducing Digital Audio CD, DAT and Sampling

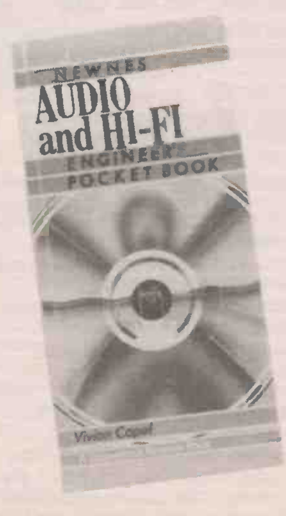
by Ian R. Sinclair

Digital recording methods have existed for many years and have recently become familiar to the professional recording engineer, but the compact disc (CD) was the first device to bring digital audio methods into the home. Compact discs are now well established, to the extent that newspaper reviews of new releases concentrate more on CD than on other media such as tape or LP, and digital audio tape (DAT) equipment has now appeared.

All this development has involved methods and circuits that are totally alien to the technician or keen amateur who has previously worked with audio circuits. The principles and practices of digital audio owe little or nothing to the traditional linear circuits of the past, and are much more comprehensible to today's computer engineer than the older generation of audio engineers. This book is intended to bridge the gap of understanding for the technician and enthusiast. The principles and methods will be explained, but the mathematical background and theory will be avoided other than to state the end product. The aim is to show what is involved in the digital part of audio signals, particularly in the newer devices such as CD, DAT and sampling, rather than go into esoteric details.

112 pages, 138mm x 216mm, illustrated.

Order As WP95D (Intro Digital Audio) Price £5.95 NV



Audio and Hi-Fi Engineer's Pocket Book

by Vivian Capel

A concise collection of practical and relevant data for anyone working on sound systems. The topics covered include microphones, gramophones, compact discs, tape recording, high quality radio, amplifiers, loudspeakers and public address.

Acoustics is not often dealt with in audio books, nor is it too well understood; so a lengthy section has been included dealing with most aspects the technician is likely to encounter, from human hearing to sound insulation. Apart from providing reference material, it should serve to give a basic grounding in the subject.

From this ancient art to the modern wizardry of digital recording and the compact disc is an enormous leap that illustrates the wide range of knowledge required of the audio engineer; one that encompasses mechanics, heat, magnetism, semiconductor technology and electronics.

190 pages, 95mm x 196mm, illustrated.

Order As WP90X (Audio Pocket Book) Price £9.95 NV

CLASSIFIED

VARIOUS FOR SALE

Stereo 2 x 24W amp/tuner (SX-636), two speakers (all by Pioneer), Aiwa AD-6300 cassette and Goldring-Lenco record decks, Shure cartridge. £115 altogether. A. R. McCrae, Port Erin, I.O.M. Tel: 0624 834141.

Valved Oscilloscope 3", scratch built from PW project. Working but needs a complete service. £45 ono. Spare CRT 3" for above, £20. Phone: 021 426 4471.

High quality copper clad circuit board for sale, 280mm x 216mm, single sided £1, double sided £1.50. Send cheques to: M. Ffitch, 56 Hall Green Lane, Hutton, Brentwood, Essex CM13 2QU.

Switch mode PSUs, monitors, fans, heatsinks, transistors, (ex mainframe), for sale. (To empty my garage!) Send SAE for list to: A. Burnham, 1 Woodside, West Horsley, Surrey KT24 6NA.

Two, Pye Bantam, transceiver, radio-phones, ready to use. Rechargeable batteries. Leather case. Very good condition. Offers around £200. Pye Pocket Phone, transmitter and receiver, boxed, (police type talking brooch), working, good condition. £46 ono. Phone: 021 426 4471.

FREE Television magazines some from 1964 till 1980's. Interesting for beginners. Contact Mr. M. Alter, 18 Twyford House, Chisley Road, London N15 6PA. Phone: 01 800 7636.

Yaesu FT-1 HF transceiver, all options fitted, £1100. Latest Kenwood portable TH-205E, plus extras, £160. ATV transceiver with built in monitor, £75. Tel: Rotherham (0709) 554665.

Phillips PM3230 dual trace scope, manual, Maplin probe kit. £125. Audio component clear-out, wondercaps, etc. SAE for list: 8 Church Row, Carharrack, Cornwall, TR16 5RP. Tel: 0209 820066.

Electronic components, resistors, capacitors, semiconductors, transformers, stripboard, etc. Too many to list, plus test gear and tools, will sell or exchange for disk drive. Cheshire area. Tel: 060684 6438.

Garrard 401 transcription deck with strobe/turntable, SME 3009 tone arm, Shure VN35HE cartridge, all fitted in solid wooden cabinet, £90. Oric 4 colour printer/plotter, £40. Gould Alpha 4 digital multimeter, LCD, bench model, £45. Contact: M. Saunders, 7 Drumcliff Road, Thurnby Lodge, Leicester LE5 2LH.

Hitachi 9" black & white video monitor, £40. Spectrum 48K with recorder and 10 games, £70. Tel: Southend (0702) 461893.

Bargain Bags, contain many useful electronic components including PCBs. Mostly new components at least £10 worth, only £3 per bag. Mr. J. Norman, 25 Milton Road, Corby, Northants NN17 2NY.

Tune Generator kit, ideal for beginners. Brand new. Includes easy to understand instructions, all parts, etc. £6 (including postage and packing). D. Gaunt, 11 Barber Street, Eastwood, Nottingham NG16 3EW.

Relays for sale, 240V 10A 8 pin 2 pole, RS stock 348-762, £1.50 each or 4 for £5. 8 pin relay bases, 50p each. P & P add 50p. Octal timer relays 240V 3A, all time ranges available, £3 each. SAE for details. P. M. Green, 6 Stilecroft, Harlow, Essex CM18 6LN.

If you would like to place an advertisement in this section, here's your chance to tell Maplin's 200,000 customers what you want to buy or sell, or tell them about your club's activities - absolutely free of charge. We will publish as many advertisements as we have space for. To give a fair share of the limited space, we will print 30 words free of charge. Thereafter the charge is 10p per word. Please note that only private individuals will be permitted to advertise. Commercial or trade advertising is strictly prohibited in the Maplin Magazine. Please print all advertisements in bold capital letters. Box numbers are available at £1.50 each. Please send replies to Box Numbers to the address below. Please send your advertisement with any payment necessary to: Classifieds, Maplin Mag., P.O. Box 3, Rayleigh, Essex SS6 8LR.

For the next issue your advertisement must be in our hands by 8th July 1988.

Have LEDs, will sell, rectangular red and green from 7p each. For list please send SAE to Box 8, Maplin Magazine, P.O. Box 3, Rayleigh, Essex SS6 8LR.

Component clear out, full spec unused Op-amps, digital, caps, etc., eclectic selection, value £80, lost interest, £40 including post. Tel: 01 299 0867.

Enamelled copper wire, various gauges on 1 to 2kg reels. PVC covered wire, assorted colours and sizes. All under half new price. Magnifying glass on stand, £5. Phone: 01 568 6014.

Realistic PRO-31 handheld FM scanner. 60 - 512 MHz, 10 memories, as new, £110. Tel: Colchester 210878.

50pF variable capacitors, panel mounting, £1.50. 100kHz crystals, B7G glass type, £1.50. Valves, new, ten mixed £6. Postage included. Mr. Greenough, 2 Bexley Close, Glossop, Derbys SK13 9BG.

Metrix 210 wobbulator £39. Tech RMS/dB audio millivoltmeter £27. Sabatronics digital multimeter £29. Intracept N7118 TV colour bar generator £39. Tel: 0502 66026.

Neos mouse and cheese. Brand new mouse for all computers, also has a joystick mode for best compatability. Cheese CAD package on disk for C64. £15. Phone: Fareham (0329) 235370.

Two Digiplan stepper motor drive cards size CD20, as new, will split. £80 each. Tel: 0772 314980.

Building a mixer console? 25 22k LOG single and 55 220k LIN dual sliders. £25 the lot. Phone D. Stephen, Banbury 810859.

COMPUTERS FOR SALE

Pet CBM 8096 c/w 8050 twin, cased drives and 'Silicon Office' £235. Commodore 8026 daisy wheel type writer/IEEE printer (Olympia ES100 type) £195 inc ribbons, lift-off tape, spare D-wheel. Tel: (0903) 200111 evenings.

Spectrum 48K computer, plus Maplin speech synth, interface, joystick and 18 programs, £75. Fidelity sensory 8 chess challenger £38. Tel: 0502 66026.

Commodore MPS-801 printer. Brand new, will suit any Commodore computer. Includes 2 ribbons, paper, books, plus superb Supercom chip giving 24 type-styles. Cost £200, bargain £85. Phone: Fareham (0329) 235370.

Atari ST/Mapsat weather satellite project software. Demo disk £3, requires computer only. Refundable against full program and manual, £19.95 inclusive. GEM based machine code, data and processed screens (Degas) to disk. Orbit forecast, construction tips, interfacing and more. Contact Les Kaye, Fieldvale, Park Lane, Snitterfield, Warwicks CV37 0LS.

BBC 'B' mathematics educational software package for young children. 4 programs covering addition, subtraction, multiplication, division. Multiple difficulty levels. Sound, colour, graphics. Disk only. £6.25. More details from Box 9, Maplin Magazine, P.O. Box 3, Rayleigh, Essex SS6 8LR.

CLUBS

19th June 1988. Denby Dale Mobile Rally will be held at Shelley High School, approx. 5 miles SE of Huddersfield, West Yorkshire. Rally opens at 1100 (disabled 1030). Usual traders, good food and sideshows for all the family. Talk in on S22, SU22 and 10FM. Details from G3SDY on 0484 602905. Also club meetings take place every Wednesday at the Pie Hall, Denby Dale at 8 pm. Further info from G. J. Bond (G4GJB), Wolvelay House, Woolley, Wakefield (or QTHR).

How would you like to make local and world-wide contacts, using Morse Code, on simple home made equipment you could build yourself for under £30? If the answer is 'Yes' then for more information on a Novice 'Ham' radio transmitting licence please send an SAE to Ian Abel G3ZHI, 52 Hollytree Ave, Maltby, Rotherham, Yorkshire.

MUSICAL FOR SALE

Casio CZ-230S digital synthesiser keyboard, 4 octaves, polyphonic, 100 voices, rhythm, programmable memory, MIDI in/out. £220. Tel: Colchester 210878.

Maplin Rhythm Generator, plus 96 note 5 footage organ generator board, plus drawbars with data, £48 inc P & P. Tested/unused. Phone: Helensburgh (0436) 71181.

Bargain audio cassettes! Blank TDK-D tapes, nine D90's, two D60's. Plus red/black lockable cassette case, gold colour fastening, etc. Worth £20, bargain at £10! Phone now! Fareham (0329) 235370.

MIDItations: cassette of easy listening synthesiser music prepared by David Howard using MIDI. Price £3.50 (inc P & P) from: MIDItations, 9 Cavendish Drive, Leytonstone, London E11 1DN.

Solid oak organ console with space for two manuals. Full size pedal board. Originally housed valve organ. £50. Phone: Richard Creak, Danbury (0245) 413725.

Electronic Organ. Technics U40, immaculate condition, big sound, even a beginner will sound good and the experts won't get bored. £499 or offers. Phone: Godfrey on 01 958 5113.

Toshiba rack system, SB-M20 amp, ST-U20L tuner, PC-G10 cassette deck, SR-B20 turntable in cabinet with glass top and front. Original packing. £200. Ring 051 677 3670 (Wirral).

MES 53, two 4 octave keyboards. All boards complete, partly built console, leslie, etc. Tel: 0463 782163.

Nivico solid state stereo tape deck, model TD344U. Two mics, many connecting leads, 12 x 7 inch (one new) and 3 x 5 inch tapes, 6 tape cases, many extras, little used equipment, £120 ono. Tel: 0726 66984.

WANTED

Copies of 'Electronics - The Maplin Magazine', issues 1 to 19 and if possible 20 to 22 and issue 24. Send replies to: 13 Westfield Road, Stonehaven, Kincardinshire, AB3 2EE or phone (0564) 64584.

Patchboard YB08J (with patch plugs if possible); Patchboard HF00A; 5600 front panel XQ01B; Sequencer interface PCB YQ59P; VC filter PCBs (2), the earlier 4600 type, *not* the 5600 type BB65V. Would consider purchase of abandoned project, etc., in order to obtain these items. Details and price to D. Parsons, 62 Mill Lane, Woodhall Spa, Lincs, LN10 6QZ.

Wanted books: 'Electronic Music Circuits', 'Servicing Electronic Organs' and 'Musical Applications of Microprocessors'; good payment (exc. if mint!). Contact G. Calderini, Via Ardeatina 222, 00042 Anzio (Rome), Italy.

Wanted: Please any information about a Heathkit MGP-1, contact Bill McGill, Rotherham 814010.

Maplin magazine, volume 4 issue 14. Will someone sell the issue to me? Or will you lend it to me for 3 weeks. Write to: R. Heland, Legdesvingen 21A, 5030 Landas, Norway.

Wanted end cheek set (XY96E) for 'Matinee'. Ring: 0234 68433 anytime, or write G. C. Rogers, 39 Goodmayes Close, Bedford MK42 0LX.

Hawaii 5-0 siren; 1983/84 catalogue number LH98G, or complete schematic diagram. Contact J. Golding, 97 Langton Road, Norton on Derwent, Malton, N. Yorks YO17 9AE or Tel: 0653 600027.

Does anyone have an M147 integrated circuit to sell please? Contact J. D. Jenkins, 3 Orchard Court, Pontllanfraith, Gwent NP2 2NG.

Information please. Where can I get two 16 swg aluminium chassis for valve amplifiers made up to requirements? F. D. Cosgrove, 59 Fenton Road, Bournemouth, Dorset BH6 5BS.

ZX81 and 16K RAM pack for GCSE technology project. Doesn't matter about condition as long as it works! Will pay for postage. Ring Tim after 6 pm on Bradford 492911.

Wanted. Synthesiser Maplin 5600S, built, part built, kit or parts of. Anything considered. Also consider sequencer or other synths. Contact Paul (0274) 734009, 9 am to 5 pm.

Mapsat Equipment Users. Please contact me. I need your help and advice. Postage refunded. Jon Larcombe, 2 Farmhouse Drive, Frome, Somerset BA11 2SS.

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 Veroboard.** 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 85p *NV*.

Project Book 2 Digital Multi-Train Controller. Controls up to 14 model trains. **Home Security System.** Six independant channels. **Digital MPG Meter.** With large LED display, a must for more economical motoring.
Order As XA02C (Maplin Project Book No. 2) Price 85p *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 85p *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 85p *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 85p *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 85p *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 85p *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 85p *NV*.

Project Book 9 Spectrum Keyboard. 47 full travel keys. **VIC Extendiboard.** Three expansion ports, one switchable. **Oric Talkback.** Speech synthesiser for the Oric 1. **TDA7000 FM Radio.** Complete FM receiver on a chip. **ZX81 High Resolution Graphics.** 256 x 192 fine pixel display. **Nine Projects!** Personal Stereo Dynamic Noise Limiter; Logic Pulser; TTL/RS232 Converter; Pseudo Stereo AM Radio; and more.
Order As XA09K (Maplin Project Book No. 9) Price 85p *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 85p *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 (Maplin Project Book No. 11) Price 85p *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 85p *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 85p *NV*.

Project Book 14 Live Wire Detector. Invaluable aid for the handyman. **Trundle.** The line follower robot as featured on Channel 4. **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. **Spectrum I/O Controller.** Buffered 2-way 8-bit data bus and 8 control lines.
Order As XA14Q (Maplin Project Book No. 14) Price 85p *NV*.

Project Book 15 Z80 CPU Module. Expandable CPU based controller. **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 85p *NV*.

Project Book 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 Project Book No. 16) Price 85p *NV*.

Project Book 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 Project Book 17) Price 85p *NV*.

Project Book 18 Weather Satellite Receiver. Display regional weather systems on your TV or monitor. **Mixing It Part 2.** Mono/stereo Hi-Z mic input, mixer and line amplifiers; VU/headphone driver. **Stepper Motor Driver.** How to build and start using the Stepper Motor Kit featured in the Catalogue. **Amstrad Expansion System.** The Maplin Amstrad External ROM Card System for the CPC 464, CPC 664 and 6128. **Sealed Lead Acid Battery Charger.** Special high stability output with automatic trickle charge mode for sealed lead acid batteries. **Fantastic Five.** Veroboard projects comprising HF tremelo unit, crystal checker, clap switch, low-Z ohmmeter, snooze timer.
Order As XA18U (Maplin Project Book 18) Price 85p *NV*.

Electronics Issue 19 Active Aerial and Aerial Tuning Unit. Get more from SW. **Amstrad Expansion System.** 6 x 8-bit parallel I/O card and PSU. **ADA Digital Echo.** RAM based low cost echo machine. **Mixing It.** Mixer Modules' PSU.
Order As XA19V (Maplin Magazine Volume 5 Issue 19) Price 75p *NV*.

Project Book 20 Weather Satellite Decoder. Displays output from Satellite Receiver on TV or monitor. **Infra Red Proximity Detector.** Short range heat or movement detector. **Fibre-Optic Link.** Sends AF signals over up to 20m of fibre-optic cable. **Low-Z Microphone Pre-amp.** For 200-600Ω mics plus gain adjustment.
Order As XA20W (Maplin Project Book 20) Price 85p *NV*.

Electronics Issue 21 6 Channel Burglar Alarm. Develop a complete security system. **Six Circuits.** Bass Fuzz, Voice-Over Unit, Noise Gate, Envelope Tremolo, RTTY Decoder and Scratch & Rumble Filter on veroboard. **Notch Filter.** AF processor for communications receivers. **12V Public Address System.** 10W per channel from car battery. **Tungsten Lamp Controller.** AC phase control for mains lamps.
Order As XA21X (Maplin Magazine Volume 6 Issue 21) Price 85p *NV*.

Electronics Issue 22 MIDI Interfacing Techniques. Connect MIDI instruments to the VIC20 or CBM64. **Hi-Fi Speakers & Enclosures.** Two high quality loudspeaker cabinet designs. **Keypad for Z80 CPU.** At last a keypad I/F & ROM for the Z80 CPU kit. **4½ Digit Counter.** Versatile basic counter module to 4½ digits. **Weather Satellite Down Converter Part 1.** Aerial & freq. converter for MAPSAT Receiver to tune into the Meteosat satellite. **Mini Circuits.** Veroboard Audio Level Tester, Sound Triggered Flash, In-Circuit Resistance Meter, I/R Audio Isolator.
Order As XA22Y (Maplin Magazine Volume 6 Issue 22) Price 85p *NV*.

Electronics Issue 23 MAPSAT Frame Store #1. Z80B CPU controller. **Servo Tester.** Proportional servo tester. **Weather Satellite Down Converter Part 2.** Channel Switching Unit. **Capacitance Tester.** 5 ranges, 3 digit display. **More Mini Circuits.** Movement alarm, Stepper Motor Driver, Pink Noise Generator, Optical Port Data Link, 'Metal Pedal'.
Order As XA23A (Maplin Magazine Volume 6 Issue 23) Price 85p *NV*.

Electronics Issue 24 Nuclear Radiation Monitor. Alpha, Beta, Gamma & X-ray gieger counter. **VHF Pre-Amp Module.** MAPSAT VHF pre-amp. **External Horn Programmable Timer Update.** Modifying the module for use with other than the Maplin Home Security System. **MAPSAT Frame Store #2.** The Video Graphics Card. **VHS Video Alarm.** Battery powered portable movement alarm built into a VHS Video Cassette.
Order As XA24B (Maplin Magazine Volume 6 Issue 24) Price 85p *NV*.

Electronics Issue 25 Track side Rapid Charger. Model radio control car ni-cad battery pack charger using 12V car battery as power source. **Slow Charger.** Mains powered trickle charger for model cars. **Temperature Module Expansion.** Relay switch board and serial to parallel converter add-ons. **Disco Partylite.** High quality, 3 channel party lights. **Mini Metal Detector.** Detects ferrous and some non-ferrous metals such as iron wall board nails or brass screws. **Tester for Electrical Domestic Appliances.** Check the safety of any new appliance before you plug it into the mains. **Bob's Mini Circuits.** A pulsed speed controller, a train controller & an electronic lock.
Order As XA25C (Maplin Magazine Volume 7 Issue 25) Price 85p *NV*.

Electronics Issue 26 1kW High Power Mosfet Amplifier. Superb amp primarily aimed at use in halls, auditoriums, etc. **Simple Melody Generator.** Versatile musical project with four tunes available. **Multi-Tune Generator.** Built around the UM3411A giving 16 tunes etc. **Siren Sound Generator.** Gives 4 different types of siren noises. **Programmable Metronome.** Useful musicians aid.
Order As XA26D (Maplin Magazine Volume 7 Issue 26) Price 85p *NV*.