Barry Crocombe

REMOTE CONTROL · AUDIO · COMPUTERS · ENTERTAINMENT

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ELECTRONICS

The Maplin Magazine

Britain's Best Selling Electronics Magazine

Special Festive Issue...

* Realistic Electronic Christmas Lantern
* Win Revell's New CD-ROM for Your PC
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* Quiz Game Buzzer
* Mysteries of DCC Revealed
* All About PIC Chips
* Control Your Video/Satellite from Another Room!
* Six Projects for You to Build

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DECEMBER 1993
VOL. 13 No. 72

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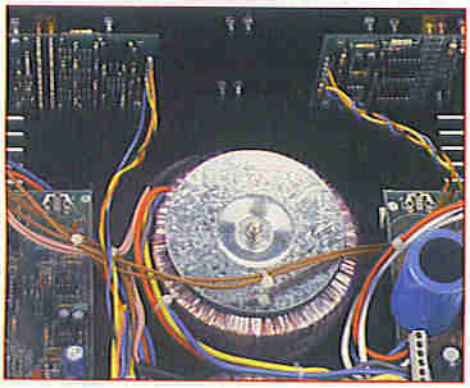

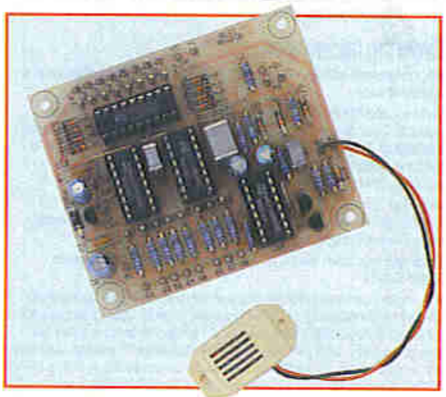

ABOUT THIS ISSUE . . .

Hello and welcome to this special festive Christmas issue of *Electronics!*

This month there's a superb collection of seasonal and novelty projects, as well as others that will be useful all year round. Plus there are some really fascinating features and series to read as well! Here's just a taster of what's in store.

The Medusa Infra-Red Remote Control Extender project is a really great innovation. If you've got a second TV in another room, with a feed from a VCR or satellite receiver, you'll really appreciate how useful this project is. It allows a standard IR remote control to be used in the room where the second TV is located and the Medusa relays the signal to the room where the VCR or satellite receiver is. So you can fast-forward through the adverts or flick through the channels without having to go for a walk! Of course it can also be used with other equipment that has an IR remote control, such as a Hi-Fi.

Philips new Digital Compact Cassette system is under the microscope this issue, Ian Poole takes a close look at just how the system works and the advantages that it offers. With the release of Sony's MiniDisc format, the battle is going to be on between these two former digital allies as to which format achieves consumer support – V2000/VHS/Betamax here we go again! However, it could be that both will be a success – and that's down to *You.* Next month we'll be looking at the MiniDisc system in similar detail, so you will be well prepared to make the choice that's best suited for your needs.

An integral part of traditional carol singing is a candle-lit lantern, however, these have an annoying habit of dripping wax and getting blown out! But not to fear, your favourite electronics magazine comes to the rescue with an electronic alternative – a realistic Flickering Christmas Candle and Lantern. Using novel digital techniques, this electronic candle won't drip wax, blow out or catch anything alight!

Many of today's top radio presenters and DJs, started their careers in hospital radio, but have long since severed the connections with their roots. However, left behind where the 'greats' cut their teeth are many other, equally talented and dedicated, unsung heroes. These people spend a great deal of time and effort working at hospital radio stations around the country. Their story is an interesting one; Iain Elliott, from one of Britain's pioneering hospital radio stations, recalls the historical developments and current activities. So whilst enjoying the festive season this year, spare a thought for those that are stuck in Hospital and those who help to make their stay a happier one – perhaps even consider lending a technical helping hand.

To help avoid arguments at quiz nights, the back-room boys have come up with an expandable priority quiz buzzer. The basic system caters for up to eight contestants and can be easily expanded (in groups of eight) to cater for as many contestants as you need.

Revell, the model kits people, have just launched a new CD-ROM based system that brings a totally new dimension to building plastic models. Frank Booty takes a look at what it's all about and there's even a chance to win Revell CD-ROMs and model kits in a super competition.

So until next month's New Year's issue, have a great Christmas, and I hope that you enjoy reading this issue as much as the 'team' and I have enjoyed putting it together for you!

CORRIGENDA FOR ISSUE 71 (November)

Due to late alterations to the Infra-red Switch project, we have to apologise for a few mistakes affecting this project.

Page 22. The circuit in Figure 2 should be altered to reflect these changes, namely D1, 2, 1N4148; D4 to D7, 1N4001; R15, 1k (R8 is correct).

Page 24. The first paragraph after sub-heading 'Testing' should end 'Note, diodes D4 and D6 are *not* fitted in this configuration.' The caption for Figure 8 in the third column should be extended with the words: 'Note, *do not* fit D4 and D6.'

Page 26. Parts List, Resistors: R8 should be 470k (as R2, 5). R15 should be 1k (as R10, 12).
Semiconductors: Only D1 and D2 remain as 1N4148, while D3-7 are changed to 1N4001 (QL73Q).
Miscellaneous: Infra-red Photodiode is YY65V (not YH71N); infra-red emitter is YY66W (not YH70M); Red LED is WL32K (not WL27E). YH70M and YH71N are optional and are therefore in the Optional list, with Mains Opto-switch LP55K.

ABC CONSUMER PRESS

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A family Christmas.

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Project Ratings

Projects presented in this issue are rated on a 1 to 5 for ease or difficulty of construction to help you decide whether it is within your construction capabilities before you undertake the project. The ratings are as follows:

1. Simple to build and understand and suitable for absolute beginners. Basic of tools required (e.g., soldering iron, side cutters, pliers, wire strippers and screwdriver). Test gear not required and no setting-up needed.
2. Easy to build, but not suitable for absolute beginners. Some test gear (e.g., multimeter) may be required, and may also need setting-up or testing.
3. Average. Some skill in construction or more extensive setting-up required.
4. Advanced. Fairly high level of skill in construction, specialised test gear or setting-up may be required.
5. Complex. High level of skill in construction, specialised test gear may be required. Construction may involve complex wiring. Recommended for skilled constructors only.

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Write your order on the form printed in this issue and send it to Maplin Electronics, P.O. Box 3, Rayleigh, Essex, SS6 8LR. Payment can be made using Cheque, Postal Order, or Credit Card.

Telephone your order, call the Maplin Electronics Credit Card Hotline on (0702) 554161.

If you have a personal computer equipped with a MODEM, dial up Maplin's 24-hour on-line database and ordering service, CashTel. CashTel supports 300-, 1200- and 2400-baud MODEMs using CCITT tones. The format is 8 data bits, 1 stop bit, no parity, full duplex with Xon/Xoff handshaking. All existing customers with a Maplin customer number can access the system by simply dialling (0702) 552941. If you do not have a customer number Tel: (0702) 552911 and we will happily issue you with one. Payment can be made by credit card.

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If you get completely stuck with your project and you are unable to get it working, take advantage of the Maplin 'Get You Working' Service. This service is available for all Maplin kits and projects with the exception of: 'Data Files'; projects not built on Maplin ready etched PCBs; projects built with the majority of components not supplied by Maplin; Circuit Maker ideas; Mini Circuits or other similar 'building block' and 'application' circuits. To take advantage of the service, return the complete kit to: Returns Department, Maplin Electronics PLC., P.O. Box 3, Rayleigh, Essex, SS6 8LR. Enclose a cheque or Postal Order based on the price of the kit as shown in the table below (minimum £17). If the fault is due to any error on our part, the project will be repaired free of charge. If the fault is due any error on your part, you will be charged the standard servicing cost plus parts.

Kit Retail Price	Standard Servicing Cost
up to £24.99	£17
£25 to £39.99	£24
£40 to £59.99	£30
£60 to £79.99	£40
£80 to £99.99	£50
£100 to £149.99	£60
Over £150	£60 minimum

Readers Letters

We very much regret that the editorial team are unable to answer technical queries of any kind, however, we are very pleased to receive your comments about *Electronics* and suggestions for projects, features, series, etc. Due to the sheer volume of letters received, we are unfortunately unable to reply to every letter, however, every letter is read — your time and opinion is greatly appreciated. Letters of particular interest and significance may be published at the Editors discretion. Any correspondence not intended for publication must be clearly marked as such.

TECHNOLOGY WATCH!

with Keith Brindley

September 16th saw the end of what was the greatest alliance in the history of computers. On that date the world's largest computer hardware manufacturer – IBM – and the world's largest computer software manufacturer – Microsoft – parted company; never to hold each others' mixed-metaphorical hands again. For some 13 years the two had co-developed complementary products and support in a marriage seemingly made in heaven.

Way back in 1980 IBM knew it could make and sell personal computers. All it needed was an operating system. So IBM the big blue knight courted, wooed and wed Microsoft the fairytale princess, who delivered the baby – PCDOS – in 1981.

Thereafter IBM sold computers – millions of them – and, of course Microsoft sold PCDOS operating systems in every one of them. IBM's personal computer became so popular that other manufacturers made clones and Microsoft sold the fledgling – renamed MSDOS – in them too. The marriage looked solid, both DOS babies looked strong, and all parties were happy.

In 1987, though, things took a turn. A new baby – OS/2 – developed as a windows-based operating system to replace PCDOS wasn't as popular as both had hoped. Microsoft had a hermaphroditic extra-marital affair and developed its own windows-based system – Windows – which isn't an operating system as such, but simply sits on top of MSDOS translating user-requirements into MSDOS commands.

Probably because Windows doesn't have to compete with already popular DOS applications it has more-or-less become the norm on IBM (or at least IBM-compatible) personal computers. This put strains on the marriage which saw an informal separation in 1990. From then on IBM concentrated on just OS/2 development, while Microsoft concentrated on just Windows. At this time any information regarding the two systems was given freely under the terms of the separation. But on September 16 the divorce was decreed absolute. Information no longer flows between the two companies. No alimony, just acrimony.

Put into perspective this has been a tremendous and traumatic break-up. These two companies effectively led the way for personal computers for over a decade. The DOS solution is simply the most popular one. Other solutions, undeniably better, never got a real foot in the door simply because people tended to buy what was seen as the industry standard.

Where this leaves the future of personal computers remains to be seen. There is no industry-standard future system in sight yet. Both prior partners are as yet in a potentially dicey situation. IBM might not be able to continue to sell its computers if it can't develop a new and acceptable hardware platform and complementary operating system. Microsoft might not be able to sell operating systems if the computer hardware business follows new IBM trends.

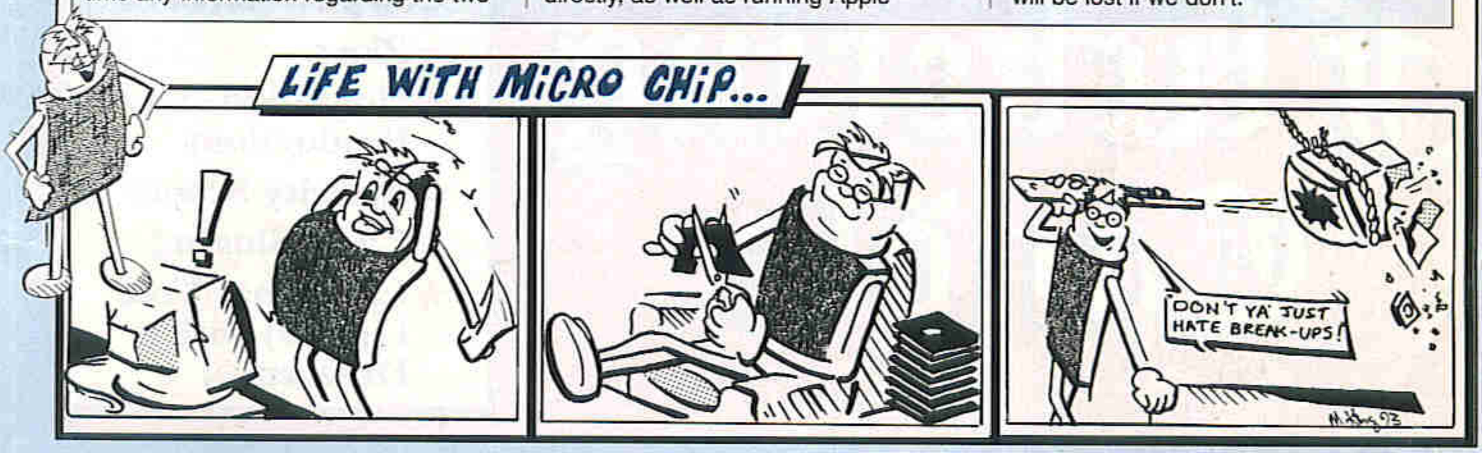
So what about the future? IBM is developing its PowerPC computer, based upon brand-new integrated circuit families from Motorola, in conjunction with Apple – the world's second-largest computer manufacturer (who undoubtedly can provide a better operating system than any Windows-based one). Microsoft is in close cahoots with Intel (who developed the x86 integrated circuit families used in IBM personal computers to date, and is currently developing Pentium integrated circuits for this pact) and Compaq – the world's third biggest computer manufacturer.

In truth, things aren't as polarised as these developments might suggest. For a start, PowerPC is intended to be able to run Windows and DOS applications. In fact, it's planned to be able to emulate x86 integrated circuit families directly, as well as running Apple Macintosh applications, those of OS/2 and UNIX operating systems as well as any others thrown at it. Pentium computers (while no solid plans have yet been announced) are simply bound to be able to do vice versa – it's a case of sink, or swim.

The combination of IBM and Microsoft 13 years ago literally gave the PC business a kick-start – albeit down the single track of DOS-based applications. The IBM/Microsoft divorce and its resultant new developments should, on the other hand, lead to a welcome opening up of computers and software. Hardware platforms of any manufacturer should be able to run or emulate any software or operating system. Cross-platform compatibility will, in fact, be the key issue for the next 13 years. Standing at the dawning of this new age of personal computing and watching the antics of these strange new bedfellows, I'm reminded of a Brian Rix farce. The overture's just begun; by the final scene computers are going to be significantly different to what they are now.

The Lowdown

A reader, PGB of Dorset, wrote to contradict my excursion in last month's Technology Watch regarding low-voltage electricity in portable industrial applications. While proposing that it's surely wrong to eliminate the use of our safe 110V portable industrial circuits I happened to give the impression that we should maintain our 240V home circuits. As PGB writes, correctly, from 1st January 1995 the nominal voltage in the UK distribution system will decrease to 230V at home circuit level. On the same date, other European countries will increase theirs to 230V. This wasn't the point, of course, but it was nevertheless a welcome reminder as it allows me to reinforce what was my original premise – we should be able to continue to use the 110V circuit in portable industrial applications. Lives will be lost if we don't.



THE use of modern technology provides several advantages over the traditional wax candle. Firstly, it doesn't melt away (although the batteries will need replacing at some point!). Secondly, you won't burn yourself or set anything alight, because the flame has been replaced with a tiny LES (Lilliput Edison Screw) 0·96W filament lamp. And thirdly, the flame won't be extinguished by the slightest breeze! Details are given for building a housing for the project – a lantern – from stiff card. Such material can safely be used, since there is no risk of fire from *this* particular candle! The circuit could be used to drive more powerful light bulbs for greater effect – handy for Christmas tree lights, or the large nativity scenes that adorn your local church at this seasonal time. If you've got one of those fake coal fires with an electric heating element, this circuit could be used to drive a low-wattage lamp bulb (30W or so). The result will be a more realistic 'coal

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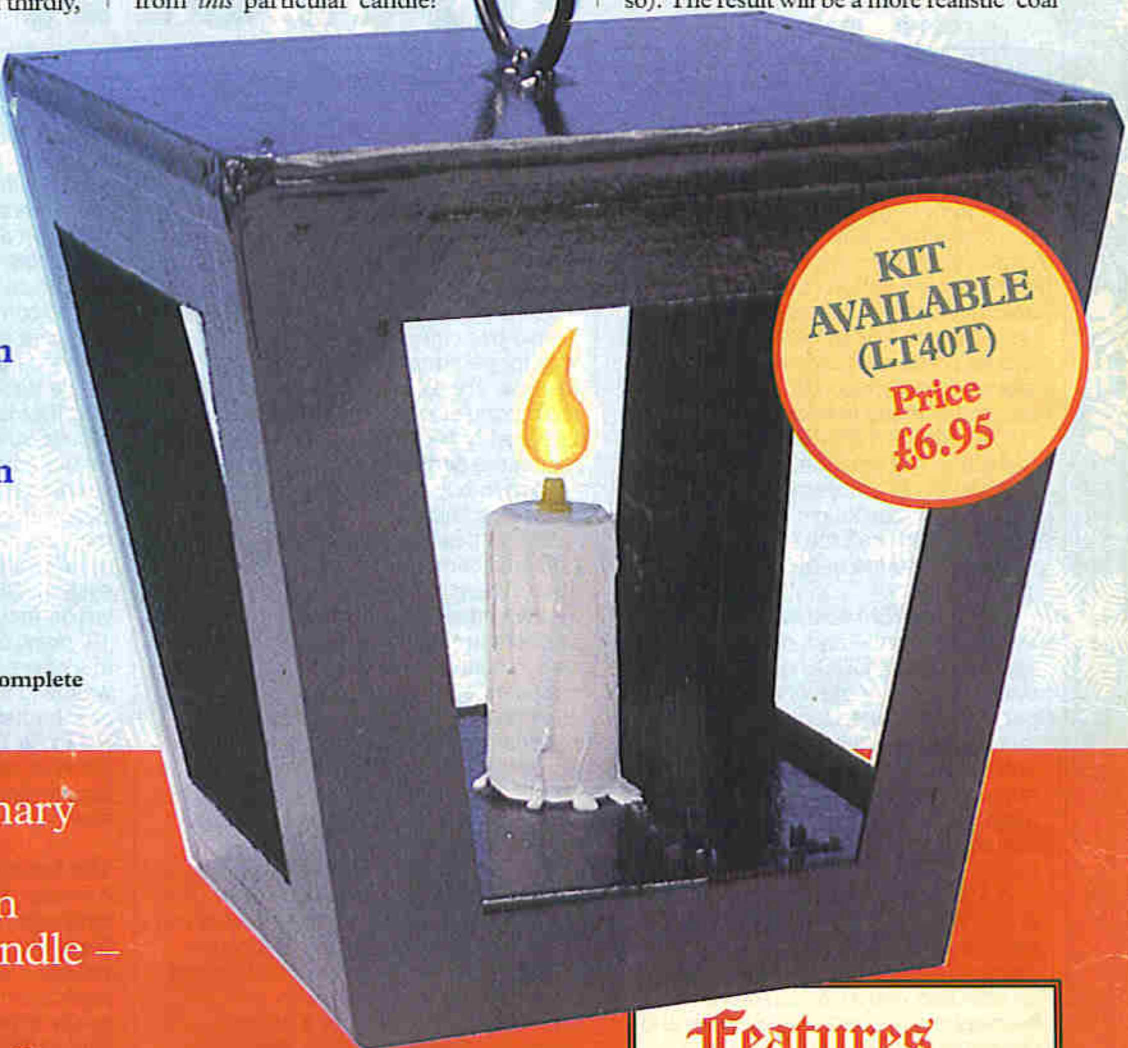
PROJECT RATING

by Dennis Butcher and Alan Williamson

Text by Martin Pipe and Alan Williamson



The finished Flickering Candle, complete with lantern.

This year's customary festive project is a Christmas Lantern and Flickering Candle – with a difference!

Christmas Lantern & Flickering Candle

Features

- ★ Realistic Pseudo Random Flicker
- ★ Simple to Build
- ★ Small Easily Concealed PCB
- ★ Low Cost

Applications

- ★ Plays
- ★ Home Video Productions
- ★ Nativity Scenes
- ★ Carol Singing
- ★ Christmas Tree Light(s) with a Difference!

burning' effect than the fan-driven devices normally fitted. Where large loads are to be switched, an external switching device (for example, a LP55K Mains Opto Switch) would, of course, be required.

Circuit Description

The basic design of the Flickering Candle is shown in Figure 1; while the specifics are given in Figure 2, the circuit diagram. IC1 (4011UBE) is a quad 2 input NAND gate. Each pair of gates (IC1a & b and IC1c & d) form an oscillator; the frequency of each oscillator is determined by the time constant of a resistor and capacitor. In the case of IC1a & b, the components are R1 & C1, whilst for IC1c & d, they are R2 & C2. The first oscillator (i.e., that built around IC1a & b) generates a square-wave pulse train of approximately 50Hz, which is fed into the clock input of IC2, a 4006BE 18-bit shift register. IC2 has a number of external nested loops to generate a binary pattern, which are based around three of the gates of IC3, a 4070BE quad 2-input EXclusive-OR gate. The function of the three gates used is to alter the bit pattern, to provide a pseudo-random sequence. The components R3, C3 & IC3c, which form a time delay, 'kick start' the circuit by providing the correct logic state, preventing IC2 from locking up. Experimenting with the values of R1 and C1 allow the flicker rate to be altered to your taste.

The output duty cycle of the second oscillator (IC1c & d), which runs at around 380Hz, is approximately 50% – this is required to provide *minimum* brightness for the lamp. The oscillator output and the final output from IC2 (pin 10) are combined via diodes D1 and D2.

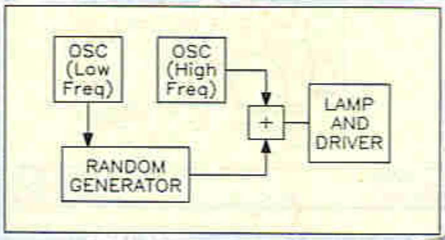
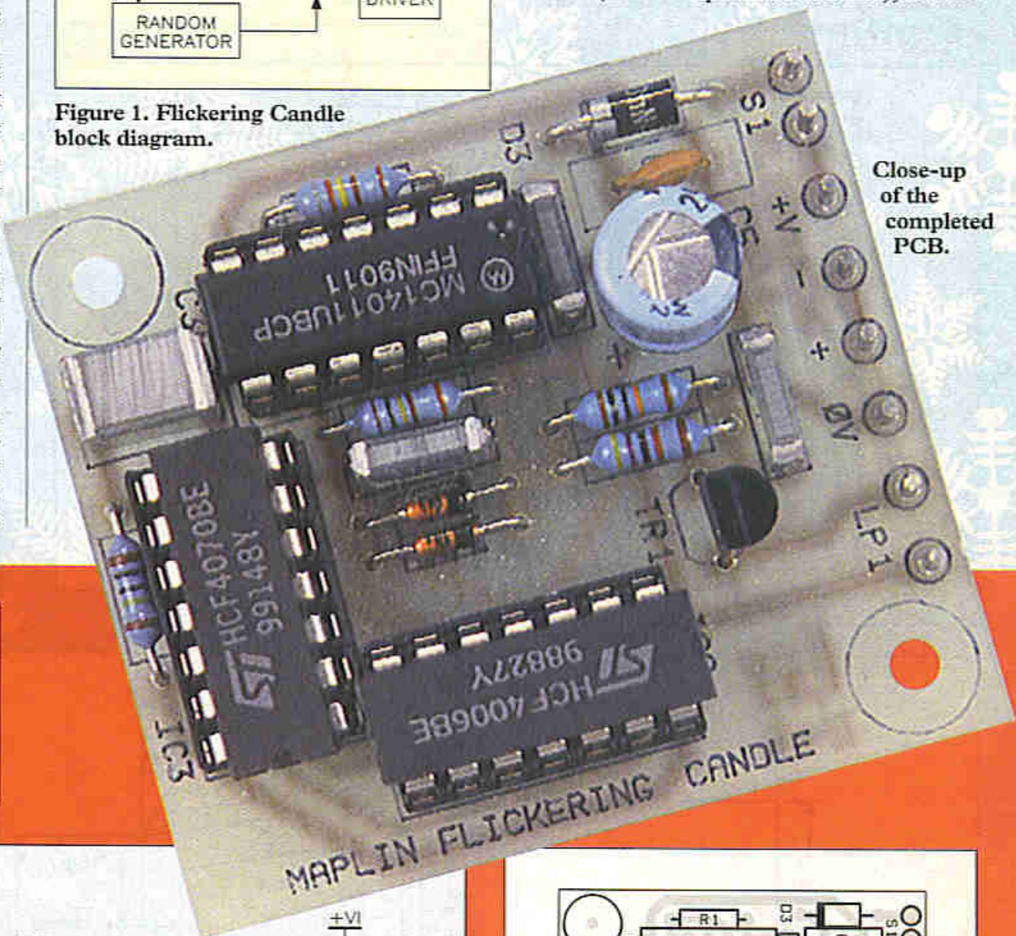


Figure 1. Flickering Candle block diagram.

The resulting signal output is partially smoothed by R5 and C4 before driving TR1, the Darlington transistor that controls LP1.

Power Supply

Power requirements are flexible. A reasonably smooth DC supply from any source can be used, but please bear in mind that nearly 170mA can be drawn on occasions – so a single PP3 battery will not last too long, a few carols at the most! We recommend using two sets of three AA cells (refer to Optional Parts List), but the



Close-up of the completed PCB.

Specification

Supply voltage:	9V DC.
Peak operating current:	166mA.
Logic supply current:	1·6mA.
PCB size:	49 x 43mm.

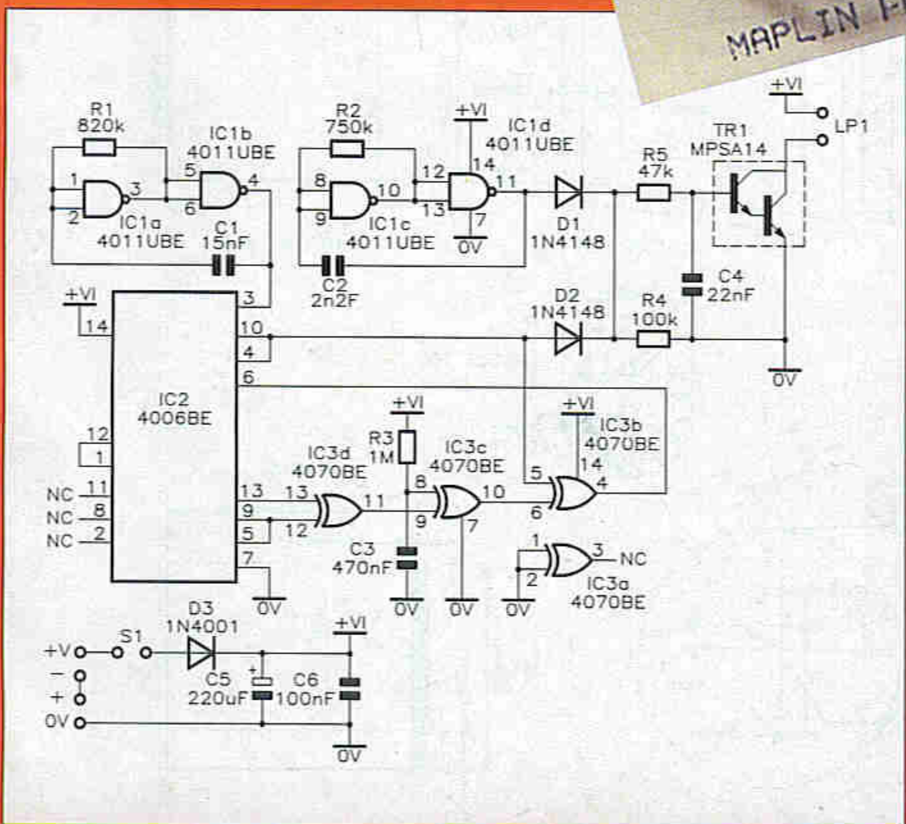


Figure 2. Circuit diagram.

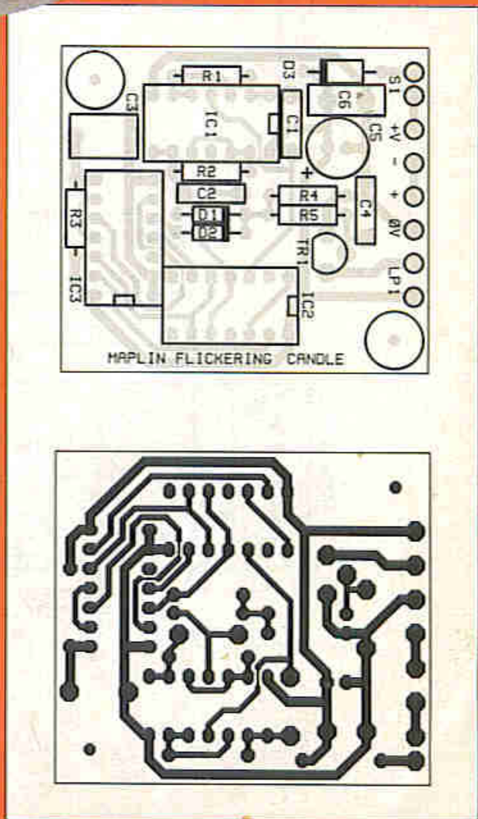


Figure 3. PCB legend and track.

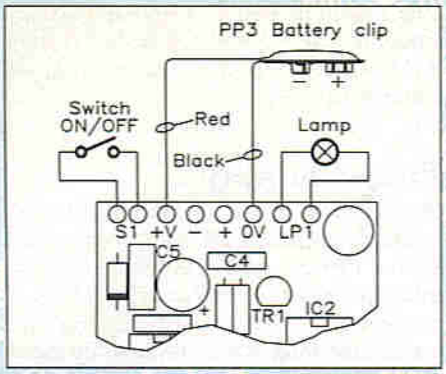
best solution, apart from carrying a higher-capacity battery such as a PP9 in your pocket, is to use Ni-Cd cells that can be recharged! The alternative is to use a DC power supply, such as XX09K. This is the best choice if the Flickering Candle is for internal use only, or you are using the module to switch a Mains Opto Switch.

PCB Construction

Construction of the simple PCB, shown in Figure 3, is straightforward, but if you're a novice to electronic assembly, most practical points are adequately dealt with in the Constructors' Guide included with the kit. Generally, though, it is advisable to start with the smallest components first, working up in size to the largest. Be careful to orientate the diodes and electrolytic capacitor correctly as they are polarised devices – TR1 should be aligned with its outline. In addition, note that the ICs are fitted in sockets – do not install the ICs until all soldering is completed. It is wise to observe the usual Electrostatic Discharge handling precautions since all the ICs are of the CMOS type.

Wiring and Testing

Red and black wires are soldered to the tags of the lampholder; the bulb can now be fitted. Refering to Figure 4a (PP3 Supply) or Figure 4b (2 off 3 x AA Supply), the board can now be wired up to the battery clip(s), switch and bulb.



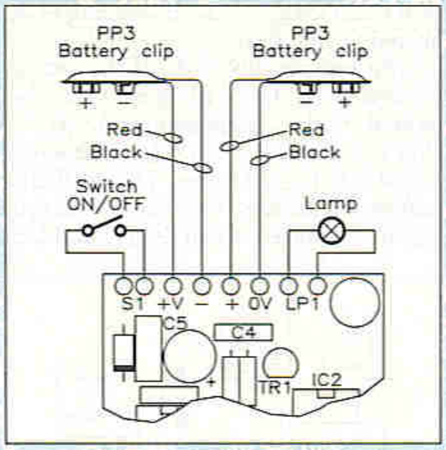


Figure 4. Wiring diagram: (a) above, 9V PP3 Battery power source; (b) right, 2 off 3 x AA cell power source.

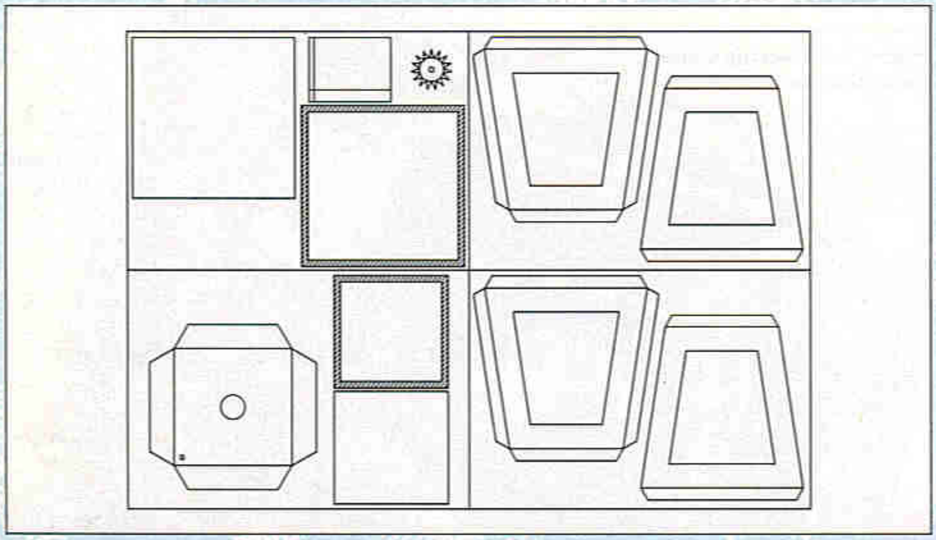


Figure 5. Layout of lantern and candle pieces when using 4 sheets of A3 card.

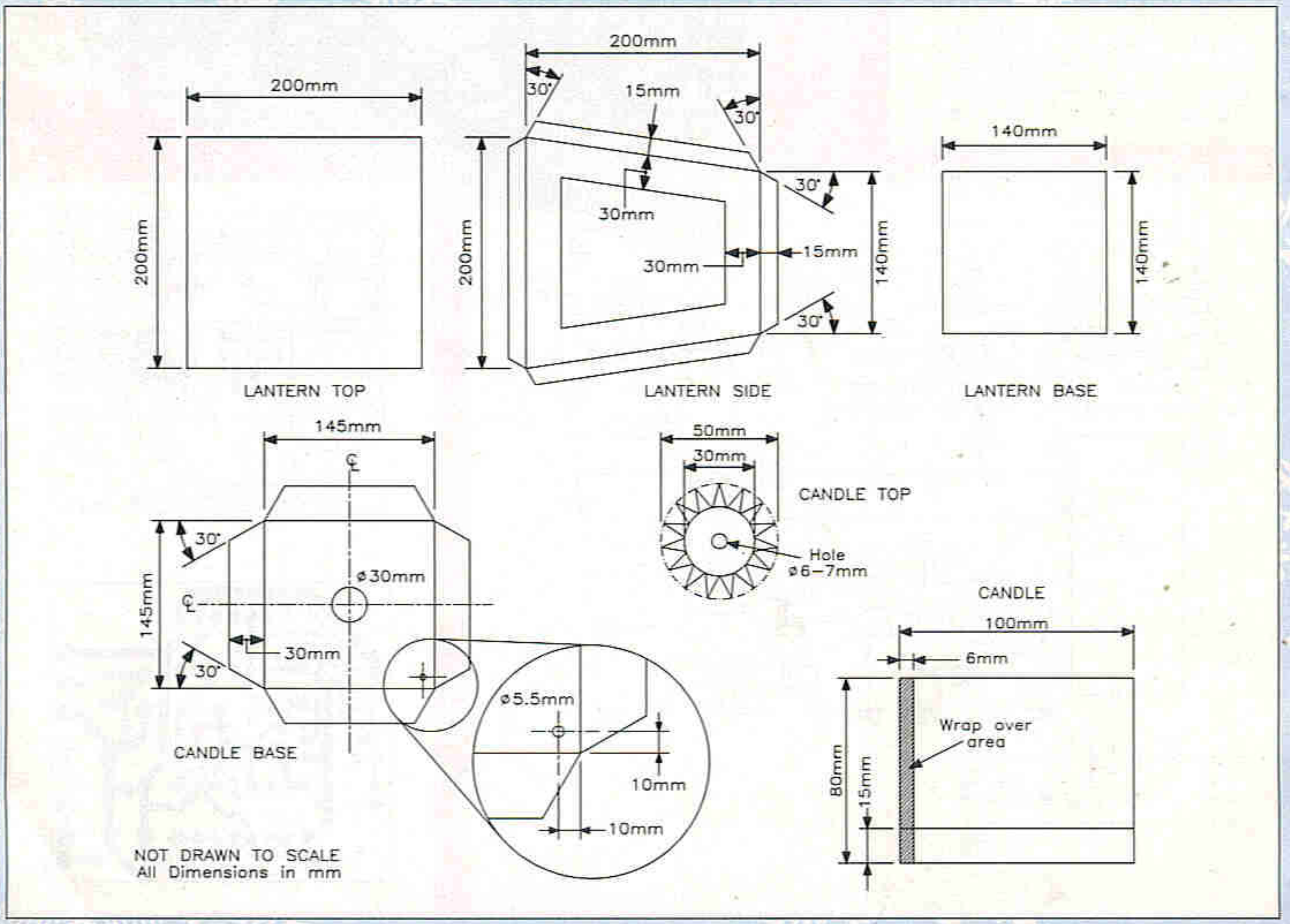
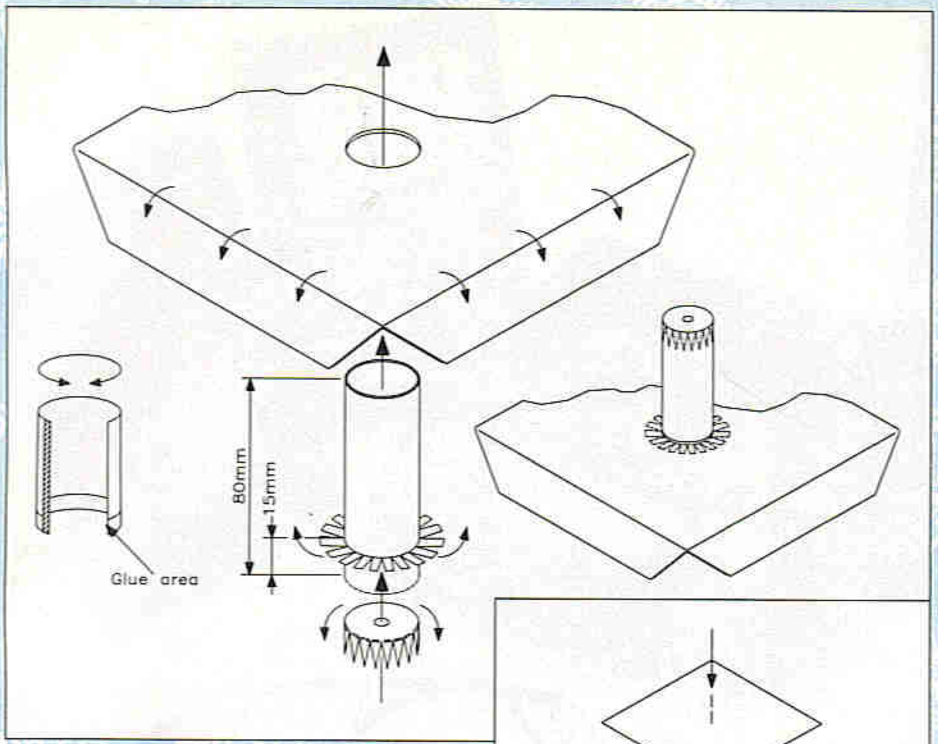


Figure 6. Dimensions of the component parts for the lantern and candle.



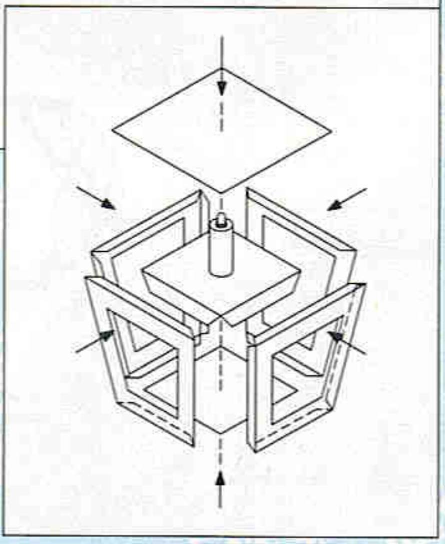


Figure 7. Assembly: (a) above, making the candle and candle holder; (b) right, making the lantern.

Finally, insert the ICs. Connect the battery pack and switch-on; the bulb should flicker like a flame of a candle.

Making the Lantern

With the Flickering Candle built and tested, we can now set about building its enclosure. If the circuit is to drive a Mains Opto Switch, the two items could be built into a suitably-sized case – switching mains loads will be covered later. The most likely use of a Flickering Candle, however, is likely to be in a lantern, for nativity plays and carol singers. An old lantern, for example one of those mock-Victorian porch lights that were so fashionable five years ago, could be pressed into service. A less expensive alternative, however, would be to build your own.

Figures 5 to 7 show the layout, cutting and assembly details for the lantern and candle – the whole shooting match can be made from four sheets of stout A3 art board (available from your local artist's supplies shop). Draw the required shapes onto the card with a pencil, and cut them out. Using a hobby knife, score the art board along all the hinge joints of the lantern (i.e., the flaps); this will help when folding it into shape. Glue the tabs to the inside of the lantern, using paper clips to hold the surfaces together as the glue sets. The candle is formed from a 100 x 80mm sheet of thin card. Roll the card into a tube and insert into the lantern's internal base. Holding the seam at the top end of the candle together with a paper clip, fold out the tabs created in the bottom of the candle, and glue them to the underside of the base, checking first that the candle is perpendicular to the base.

The bulb is held in place by a disc, which fits into the candle. The yellow lamp cover, which helps to give the candle flame that authentic 'yellowy glow', also holds the bulb and holder in position. The lamp cover is mounted on the candle top in much the same way as a grommet – in other words, the mounting surface is sandwiched between two rubber lips. The bulb assembly can be mated with the cover. The candle top, complete with lamp and cover, can be inserted towards the top of the candle, but so that the bulb is visible. Glue can now be applied to the candle top; you can gain access to the top of the candle by carefully removing the paper clip. The seam area of the candle previously held together by the paper clip can now be glued itself. At this stage, it is advisable to fit the toggle switch, PCB and battery pack into position. The switch is held to the lantern base using the nut supplied, while the PCB and batteries should be secured to the underside of the base using quickstick pads.

The candle and base can now be decorated, if required. The prototype was sprayed with black Hammerite paint to give the lantern a solid metal appearance. For added realism, drips of wax could be simulated by allowing epoxy resin adhesive to run down the sides of the candle. When dry the candle itself can be coloured.

A More Powerful Candle?

As we have mentioned earlier, you are not limited to a 0·96W LES lamp bulb for use with the Flickering Candle. If you want something more powerful to flicker – for example, a 60W mains filament lamp in that nativity scene – a Mains Opto Switch (refer to *Electronics* Issue 41, December 1990 to January 1991) can be put to good use. In fact, any combination of filament lamps totalling a maximum of 250W can be used. Remember, however, that mains filament lamps can get very hot, and should be kept away from flammable materials such as wood, paper and cloth. Figure 8 shows how the Mains Opto Switch is wired up to the Flickering Candle's bulb outputs.

It is important to observe basic safety precautions if mains electricity is being used – remember that **MAINS CAN KILL!** Ensure the mains is disconnect before making connections or changes. All connections must be insulated, and the Mains Opto Switch should be built into a solid enclosure, fitted with a suitably rated double pole switch and a fuse. If required, the Flickering Candle PCB – and possibly a power supply circuit as well – could also be built into the same box as the Mains Opto Switch. If the box is metal, the box must be properly earthed.

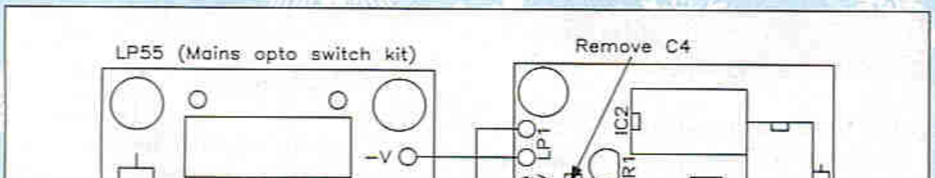


Figure 8. Mains Opto Switch wiring.

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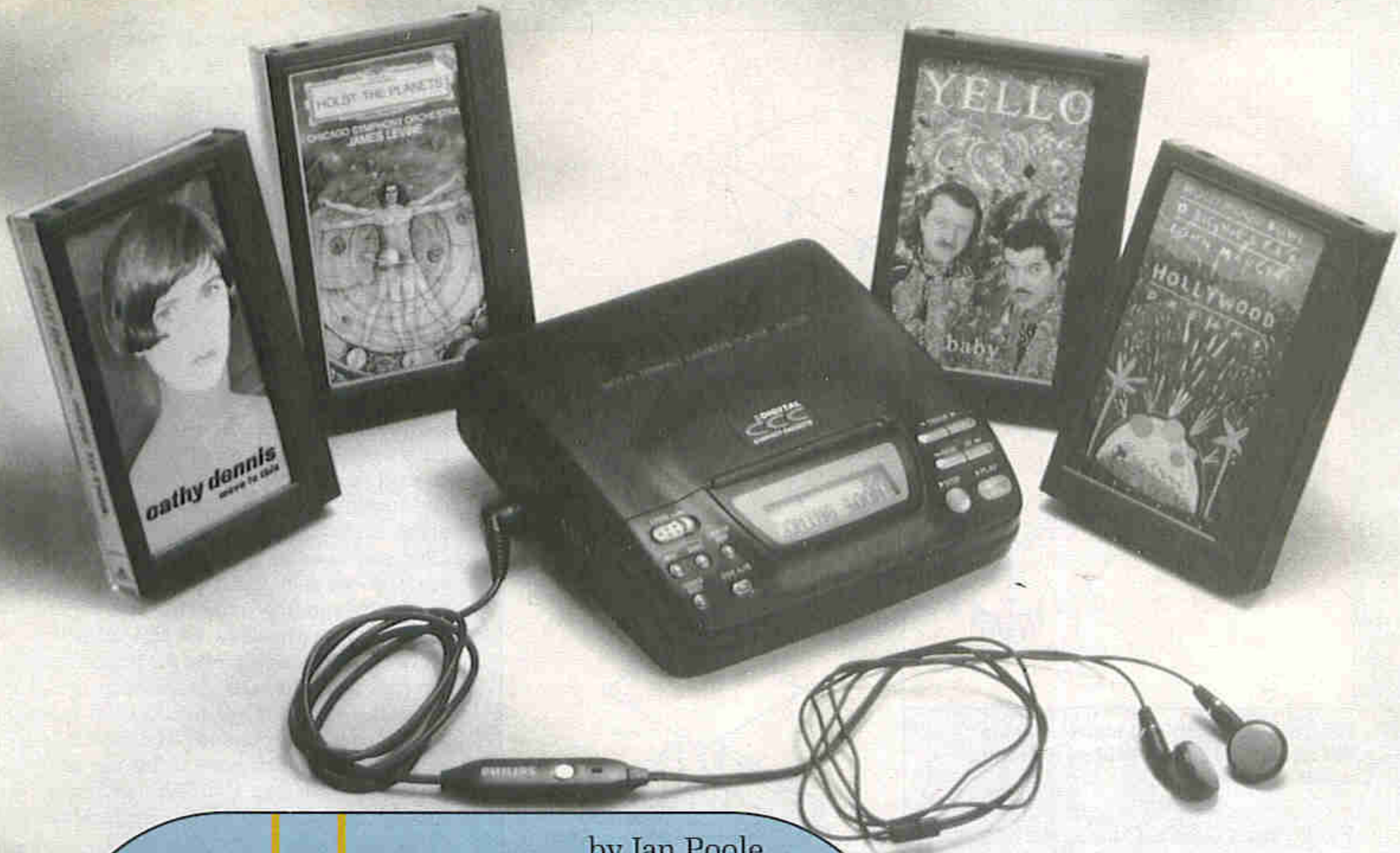


by Ian Poole

dcc Have Philips Got it Taped?

It is now thirty years since Philips invented the Compact Cassette. Since then, it has become the most popular medium for recorded music. In 1991, a phenomenal 2,600 million cassettes were sold, over a third of which were pre-recorded. This compares very favourably with around 800 million CDs, and less than 250 million vinyl discs.

The sales of cassette players have been no less successful. In 1991 over 180 million players and recorders were sold world-wide. In fact, virtually every household in the western world owns one, with an average of three per household.

This success story has come about because of the versatility of the cassette system. The cassettes themselves are very convenient and easy to use. They stand up to careless treatment, unlike vinyl discs which are very easily scratched, and often show signs of increased surface noise after only a few playings.

During its life, the performance available from a cassette has been improved quite substantially. The manufacture of better recording and playback heads, as well as the availability of better tape materials, has enabled the frequency response to be improved. Meanwhile, the introduction of noise reduction systems like Dolby B have greatly lessened the effect of background hiss.

Despite these developments, the introduction of the CD has shown what can be achieved with new digital technology. Noise levels can be reduced, distortion can be reduced and the frequency response can be made much flatter. In short, the CD was a quantum leap in terms of quality for the average audio enthusiast. Accordingly sales of CDs rose rapidly, and although they are less than those of the Compact Cassette, the CD has been highly successful in a relatively short period of time (albeit with the aid of well-publicised tricky marketing techniques! – Ed).

A New System

Although CDs offer higher quality potential than any other audio medium so far adopted by the consumer market, they have not been very successful in the car or portable markets. For after all, the discs are awkward to store in the average car, the players are expensive and tend to jump tracks when jolted (by pot-holes or when jogging), and the size of the disc makes for a bulky portable machine, when compared to a personal cassette player. Hence the proven idea of a tape for these applications is far superior. To

Above: Philips DCC130 personal DCC player. Note the styling, which is reminiscent of a portable CD player, and the LCD alphanumeric display.

Left: This mains-powered Philips DCC900 machine is intended for use in a conventional Hi-Fi system.

combine the sound quality of CD with the convenience of the Compact Cassette, Philips set about developing a new digital tape system in 1989.

Although the Digital Audio Tape (DAT) system had already been introduced onto the market and offered excellent quality, it had not been accepted in the way that was hoped. Using a helical-scan rotating head system similar to that used in 8mm home video equipment, the mechanisms were very expensive. Seeing this, the record companies were not interested and virtually no pre-recorded tapes were issued. As a result DAT machine sales have been comparatively limited, tending to be confined to those wanting to make very high quality 'master' recordings – mainly, musicians.

In view of this, it was obvious that if any new digital tape system was to become a standard in the same way as the Compact Cassette, it would have to be capable of being made quite cheaply. In addition to this, it should be rugged, and ideally the public should not see it as yet another new standard for which a completely new collection of music would have to be started.

In developing the new DCC system, Philips have endeavoured to overcome all these problems. To do this, the new system was capable of playing the old Compact Cassettes, as well as those of the new digital format. In doing this, they had to give a sufficient improvement in quality whilst not being so far advanced that the technology was too expensive for the consumer. The resulting system, 'Digital Compact Cassette', was first demonstrated in early 1991. It then took just over another year before it was launched in the UK.

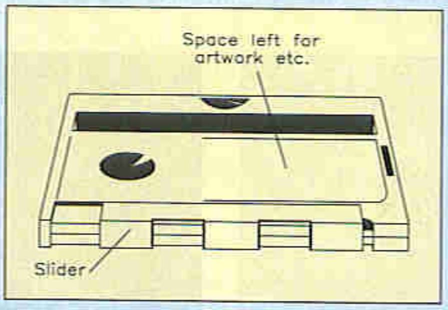


Figure 1. Physical appearance of the new Digital Compact Cassette.

The launch of DCC included glossy advertisements on television and in the press. Costing £2 million, the campaign was timed to coincide with the launch of over 350 different pre-recorded tapes in 164 stores nationwide on 9th November. By Christmas, there were around 1,000 titles available in the shops.

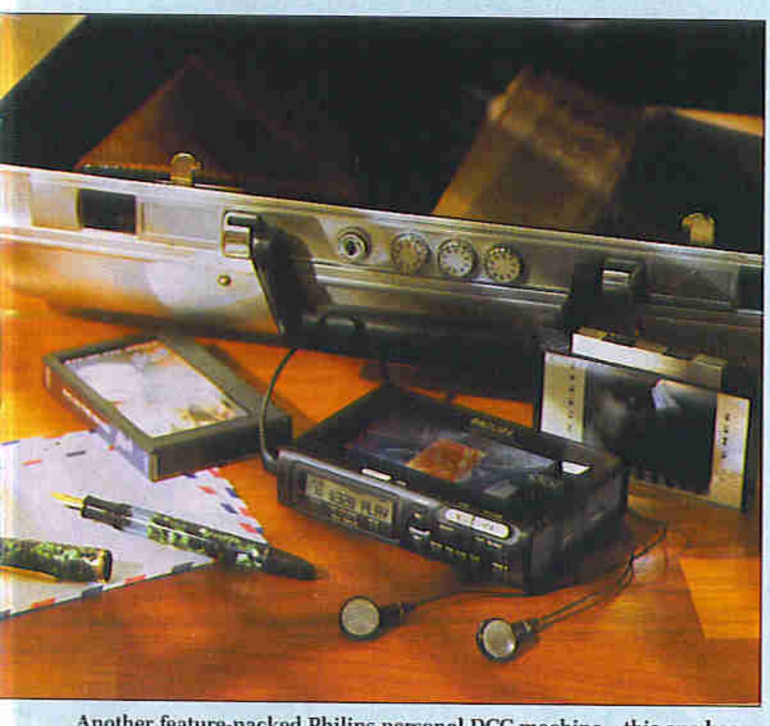
To achieve this, a tremendous amount of development work was needed. The whole tape system was evaluated, and new ideas were implemented in virtually every area – from the electronics to the mechanics, not forgetting the tape itself.

Tape Technology

The new Digital Compact Cassette, shown in Figure 1, bears many physical similarities to the more familiar analogue tapes. As DCC machines are able to cope with both types of cassette, the new digital cassettes have the same basic dimensions as their predecessors. In just the same way that there are forward and reverse tracks on the analogue Compact Cassettes, so there are on the new digital cassettes – refer to Figure 2.

Despite the fact that the basic design of the new cassette bears many resemblances to the old one, there are a large number of improvements and new ideas, which have been introduced to ensure that the new medium builds on the success of the old one.

Even at first glance there are a number of changes which will be seen. The styling of the new cassette and its holder have been improved. The holder is in the



Another feature-packed Philips personal DCC machine – this one has recording capability.

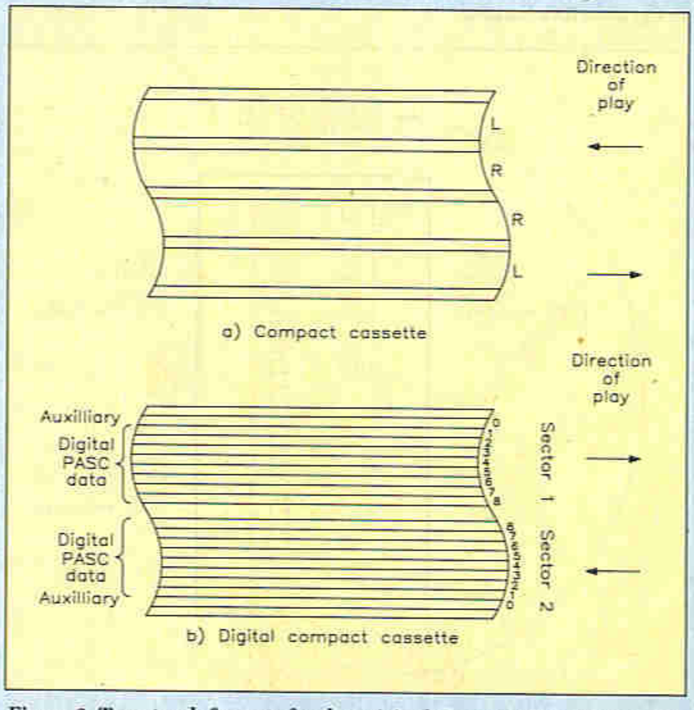


Figure 2. Tape track formats for the original Compact Cassette (upper) and the new DCC format (lower).

form of a sleeve, from which the cassette can be slid out. It is also much stiffer and has more rounded edges than its predecessor. Room has been allocated for an information booklet and display information.

The next major difference is that the tape and drive wheels on the cassette are covered by a slider. This is very similar to the ones used on the familiar 3½in. computer disks. Apart from protecting the tape and drive wheels, the slider also locks the wheels in position so that there is little chance of the tape becoming unwound. In view of all this protection, there is even less risk of damage to the tape.

The thicker section, present on the front of the old cassettes, is no longer present. This has been removed, because the record and playback heads can be made more compact with today's technology.

Finally, it will be seen that the holes for the drive hubs are only present on one side of the cassette. This has been done because the new system incorporates auto-reverse as standard. As a result of this, the other side can be left flat and free for artwork.

Other Improvements

Apart from the differences that can be seen from the outside, a number of new features have been added to the mechanics of the cassette.

At the back of a blank cassette, there are positions for three holes, as shown in Figure 3. These are used to tell the player how much time is available on the tape. Knowing the length of the tape and the amount of tape which has been used, the cassette deck can work out how much time is left. Owners of VCRs that have a 'time remain' function will know how useful it is!

In line with the improvements to the ruggedness of the cassette, the materials have been upgraded from those used on the original Compact Cassettes. The original tapes could take a large amount of punishment. Many people have left tapes in a car on a hot summer's day, to find that they have survived perfectly well. The specification of the new cassettes includes upgrading the materials used so that an even wider temperature range can be tolerated.

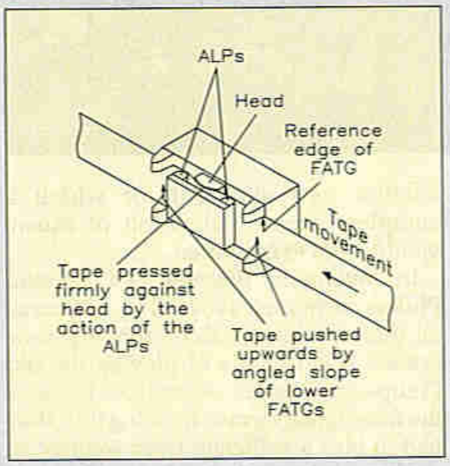


Figure 4. Correct tape-to-head alignment is ensured by the presence of Azimuth Locking Pins (ALPs) and Fixed Azimuth Tape Guides (FATGs).

The tape itself is different to that found in existing cassettes. To achieve the data rate required for the DCC, video-quality chromium-dioxide tape has to be used as standard. This is well-proven, and has given excellent results in VCRs and other applications. Since a standard formulation, rather than a state-of-the art magnetic coating like those used in S-VHS video tapes, is used, the manufacturing cost is kept down.

The tape coating consists of a chromium dioxide (or a performance-equivalent cobalt-doped ferric oxide) layer, which is between 3 and 4μm thick. This gives the tape a total thickness of 12μm, although it is reduced to 9μm for tapes with a total playing time of more than 90 minutes. To maintain compatibility, the tape has the same width (3·78mm) as its analogue predecessor.

Tape Alignment

One of the major improvements to the mechanics involves a new method of ensuring the tape remains fully in contact with the head, and in correct alignment with it. The system for ensuring that this

Hole	Tape playing time (minutes) 45	60	75	90	105	120
3		●		●		●
4			●	●		
5					●	●

● = Hole

Figure 3. The machine determines the length of the tape using three sensors, which detect the presence of a combination of up to three holes in the cassette's housing.

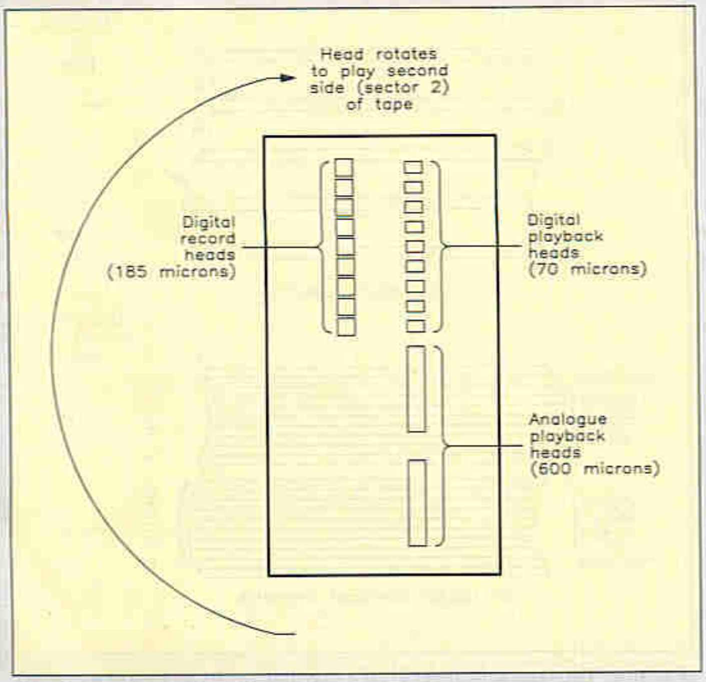


Figure 5. DCC head configuration.

A few of the DCC software titles available at the system's launch.

happens affects both the cassette, and the head mechanism as well.

The alignment is particularly important, because the new tapes carry many more tracks of information, and if the alignment is poor then the system will fail.

There are two Azimuth Locking Pins (ALPs) on the cassette itself, while the head mechanism incorporates two Fixed Azimuth Tape Guides (FATGs), as shown in Figure 4. The ALPs serve to ensure that the tape is kept in contact with the head by helping to 'wrap' the tape around the head. By doing this, the amount of tape in contact with the head is increased, and the possibility of drop-out is greatly reduced.

The FATGs are located on either side of the head. At the top is the reference surface, which is accurately positioned with respect to the head. The bottom surface, though, is slightly angled – this gently forces the tape upwards onto the top surface, thereby ensuring that the tape is accurately positioned. The ALPs also help in this process. Since they force the tape against the head, they help to prevent the tape from curling from top to bottom, making the action of the FATGs less effective.

The Head

One of the most crucial areas of the DCC system lies within the record and playback head. To achieve the necessary performance, the latest in thin film head technology has been adopted. In addition to this, the head is coated with a special anti-wear film to enable the heads to retain their performance over long periods of time.

In order to maintain compatibility with existing Compact Cassettes, the new DCC heads have to contain three different sets of heads. There are nine Integrated Recording Heads (IRHs) for digital recording, nine Magneto-Resistive Heads (MRHs) for digital playback, and finally two more MRHs for analogue playback.

From the number of digital heads required, it can be gathered that each is very small. The recording track width is only 185µm wide, and each track is separated by 5µm. For playback, the track width is an even smaller 70µm; this reduction in track width reduces the sensitivity of the system to azimuth errors.

From Figure 5 it can be seen that the digital heads occupy one half of the head surface, whilst the analogue ones occupy the other. This can be accommodated because the track pattern on the tape has be altered from that used on the analogue tapes as shown in Figure 2.

PASC

Despite all the improvements in head and tape technology, it is still not possible to record all the data needed whilst still running the tape at a speed of $1^7/_8$ inches per second. To reduce the data rate whilst enabling very high quality recordings to be made, a new data compression system has been developed. Termed PASC (Precision Adaptive Sub-Coding), it is at the very heart of the Digital Compact Cassette.

Naturally, the DCC encoding system utilises all the basic techniques that digital systems require. It uses analogue to digital conversion for the record path, and digital to analogue conversion during playback. On top of this, the various forms of error detection and correction techniques are used to ensure that each sample does not have an error. If it does, then action is taken to correct it.

To reduce the data rate, the new PASC system cleverly removes any sounds which will not be perceived. It is based upon the central principle that the ear can only hear sounds above a certain level. This threshold depends upon both the frequency of the signal, and the individual concerned. A typical threshold response is shown in Figure 6. From this, it can be seen that the ear is far more sensitive to sounds in the middle of the frequency range between about 2 and 5kHz. Above and below this, the ear's sensitivity falls off quite rapidly.

In addition to this, there is another threshold effect. It can be found that a loud sound of one frequency can mask others which are close to it but lower in amplitude, as shown in Figure 7. In this way, the ear does not perceive all the sounds which are actually present.

The PASC system computes the threshold of hearing for any given set of circumstances. Currently, it is not possible to do this on a purely theoretical basis. This may be comparatively simple for a signal which contains just a few fairly well-defined constant tones, but the situation is far more complicated for real sounds like music. To overcome this problem, engineers at Philips spent many hours performing listening tests to ensure that the system has been optimised for good sound quality.

By using PASC, the data rate is dramatically reduced when compared to that of a CD. Such compression can be implemented even when generous margins are given, so that any sound that could conceivably be made out is included. In this way, the quality of a DCC recording should match that of a CD, whilst only requiring about a quarter of the storage capacity.

A Deeper Look

In order to encode the audio onto the DCC a number of different processes are used. As one would expect, the first is to convert the audio signal into a digital format using an analogue to digital converter (ADC). Theory states that the sampling frequency must be at least twice as high as the top frequency which needs to be recorded. In the case of DCC three sampling frequencies are supported. They are 48, 44·1 and 32kHz, the same as those found on DAT recorders.

Once encoded the digital data is then presented to the PASC encoder. First, this splits the audio spectrum into 32 different sub-bands, each of which has the same bandwidth. Typically these bands will each be about 750Hz wide. This is done using digital filters contained within the PASC hardware. It then calculates the thresholds for each of the bands. This is done by looking at the strengths of the signals in that band, and the ones on either side. Having set the thresholds any signals above these levels are then encoded and the others are discarded.

Once this process has been completed

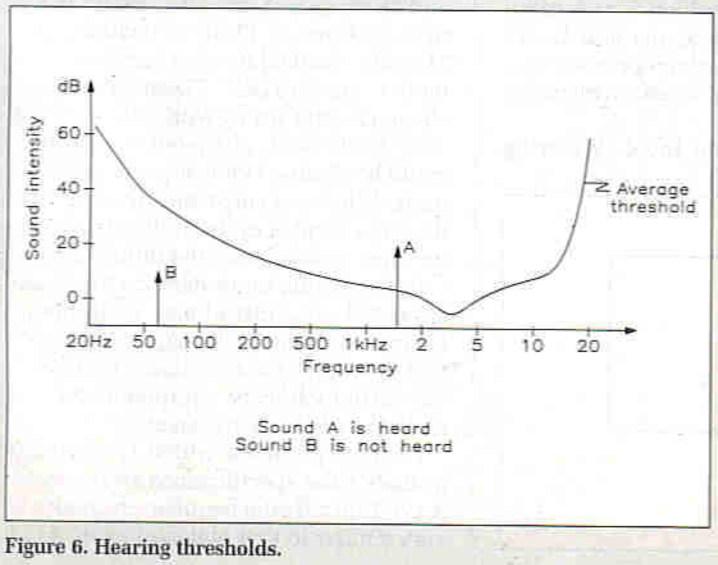


Figure 6. Hearing thresholds.

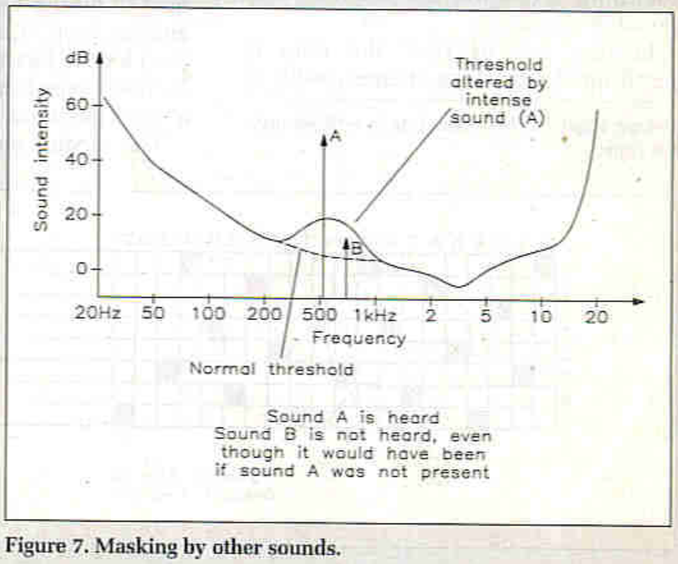


Figure 7. Masking by other sounds.

a further stage of data compression is needed; this is accomplished by choosing a clever format for the data. Essentially the data is stored in what is called a non-linear or floating point format. Using this method, shown in Figure 8, the data is split into two parts. In mathematical terms the first is the mantissa (the value of the signal), while the second is the exponent (scaling factor). For example, the value 2,656,000,000 can be expressed as $2{\cdot}656 \times 10^9$. It can be seen from this example that the second method of writing the number occupies far less space. This is even more true for the DCC system which covers the range –118 to +6dB of the full scale. The extra 6dB over the full scale is added to include a certain amount of headroom.

The actual data structure gives a total of 6 bits to the exponent. The mantissa of the sample then occupies between two and fifteen bits. The length of this depends upon the sample taken and how many bits are needed to represent it accurately.

Once the signal has been coded, it is ready to record onto the tape itself.

Exponent	Sample value
6 Bits	2 to 15 Bits

Figure 8. PASC coding structure.

On the Tape

The processed data signals are recorded onto the nine parallel digital tracks (numbered 0 to 8) on the tape. Eight of the tracks are used for PASC data, including the digital audio, error detection and correction, and finally system information. The ninth track holds track and time information, together with markers to give easier operation. This data can be used during high-speed searches, which enable particular tracks to be located.

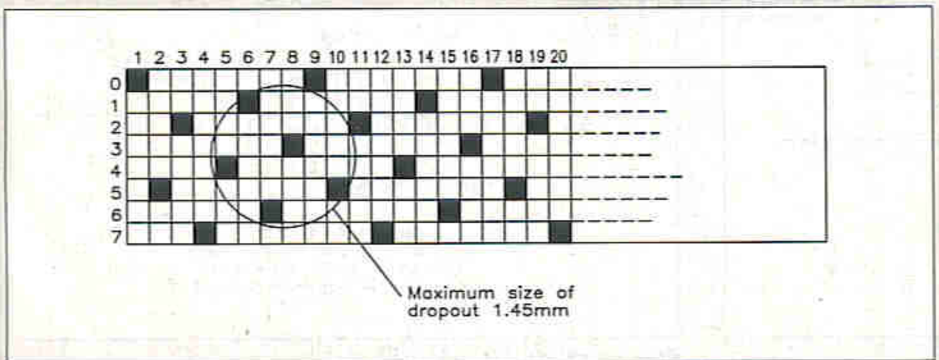
As with any form of digital storage, efficient methods must be used to format the data onto the media so that the best use is made of the available space whilst retaining the optimum resilience to possible errors.

In the case of DCC the data is partitioned into 'tape frames', each of which contains 12,288 bytes of information in addition to synchronisation data. These frames are then separated by inter-frame gaps.

The data within the frames contains 8,192 bytes of PASC encoded audio. An additional 128 bytes are used for system information, leaving 3,968 bytes for error detection and correction data.

When recorded, the data is set out in 'checker-board' fashion on the tape, as shown in Figure 9. This considerably increases the resilience to dropouts or failures on the tape. An area as large as that shown on the diagram can fail, or there can be a complete track missing without any audible reduction in sound quality.

Below: Figure 9. How the data is written onto the tape.



Text as Well

Using DCC it is possible to store quite large amounts of text in addition to the music. This is a very interesting and useful development. Not only can it be used to display the title of the album, but individual track titles with the artists names could be shown. If this was not enough, the lyrics could be made to appear in time with the music.

In fact, the text mode has a large amount of flexibility built into it. Up to seven languages can be written onto the tape, the required one being selected via the tape player. Graphics can also be stored, complete with 16 colours, various fonts and a number of visual effects.

This will undoubtedly be used to great effect in the future when more advanced machines are available. It could also be used on teaching tapes and karaoke machines, in addition to a number of other applications.

Pre-recording Tapes

When developing DCC, it was necessary to consider the duplication of tapes for sale. With over 800 million pre-recorded tapes being sold each year, it must be possible to reproduce tapes easily and cheaply if the system is to have any chance of success.

For conventional analogue cassettes, there are two processes which are currently in use. The first is a very high quality master tape which is run in an endless loop. This contains four tracks (two for the forward stereo pair and two for the reverse). All of these are recorded at the same time.

The second method involves storing all the information digitally in a solid-state memory. This is more convenient and gives an improved quality recording, particularly for large duplication runs, since there is no master tape to run out. However, the main drawback is the cost, since a very large amount of memory has to be used.

The recording of a DCC tape bears many similarities to that of its analogue counterpart. Whilst it is possible to record from a master tape (e.g., the digital output from a DAT machine), the solid-state method is much favoured. The amount of storage space is much less because the data can be stored in the compressed PASC format; therefore, only about a quarter of the capacity needed for an analogue recording is required.

During recording, the tape is passed over the recording head at 64 times the normal playback speed – naturally, very specialised heads are needed for this purpose. In addition to this, great care has to be taken to ensure that no dirt or dust particles get into the system. If a small particle came between the head and the tape, then this would reduce the amplitude of the recording pulse and cause a drop out. This is overcome by ensuring that the air in the vicinity of the head is clean.

Tolerances on the system are also very tight, in view of the very narrow track widths that are employed. This means that very precise tape guiding is necessary if positional errors are not to become too large.

One interesting point to note about the duplication of tapes is that manufacturers' tapes will contain all of the text information. Special DCC machines are required to record this, and copies made by normal consumer machines will only contain the audio information, and none of the text.

What's Available

As with any other new system being launched, the range of recorded material is currently small. CDs, though, were in much worse supply when the system was introduced, ten or so years ago.

The number of manufacturers who have equipment on the market is limited, and their ranges are also small. Three manufacturers – Philips, Technics and Marantz – had equipment on the market for the launch of DCC. These consisted of single cassette decks with a list price of over £500 each, although the Philips could be obtained for just under the £500 mark. What was surprising, though, was the large number of shops that had decks on show so soon after the initial launch.

In the future, more manufacturers are expected to introduce equipment. Kenwood is one, although reports say that they have delayed theirs until after the introduction of equipment for the rival Sony MiniDisc system.

Of the equipment which is currently available, the specifications appear to be good. Typically the frequency response is very similar to that obtained using a CD system – 20Hz to 20kHz with only fractions of a decibel variation in output. The noise level is also low. The Technics deck boasts a figure of –92dB and a dynamic range of 95dB on playback (92dB on record/playback). Finally the harmonic distortion levels are very low and comparable with CDs at around 0·003%. This is so small that even the most sensitive ears are unlikely to be able to detect it.

Whilst a number of machines are on the market, blank as well as pre-recorded tapes are also needed. For pre-recorded tapes, it is still necessary to search out the shops that stock them. By no means all the High Street W H Smith, Woolworths or Our Price shops have them, although it is likely that more shops will begin to stock them should the system be accepted by the public.

The variety of music is not a problem. There is a wide range of tapes to suit every taste – from Phil Collins and Tears for Fears to I Musici playing Vivaldi's Four Seasons, or Ashkenazy playing Rachmaninov's Piano Concertos. This range is increasing all the time, especially as Philips has its own record labels.

Pre-recorded DCC tapes cost the same as a full price CD, while DCC-90 (90 minute) blank cassettes are around £8 each. This puts them well above the cost of an ordinary cassette (you can typically buy a three-pack of good-quality chrome C90s for around £4), and it also means that making a collection of the new tapes will be more expensive than using CDs – at least for the time being – when it is considered that it is currently possible to buy many budget-priced discs for less than £5. However, if (and when!) the system becomes adopted, the price of both blank and recorded tapes should drop, as it did in the case of video tapes. Even so, they are likely to remain considerably more expensive than the analogue tapes.

Will It Succeed?

When any new system is launched onto the market there must be a large question over its future success. Many technically sound systems have failed for totally non-technical reasons. A prime example of this is the Philips V2000 video system. Technically superior to the other systems of the day, it entered the market too late to gain a foothold. Quadraphonic audio systems of the early 1970s also failed – this time it was more because of the reluctance of the public. Only a small percentage of the public wanted quadraphonics, the large additional cost gave comparatively small improvement to the average listener. As a result, the take-up was too small to warrant the large record companies continuing with it, so the idea died.

Whilst many new ideas fail, a large number are also very successful. The Compact Cassette is just one example of this. DCC has a lot of advantages which gives it a good start in the market. It cleverly combines the advantages of digital technology with the familiar cassette format – together with backwards compatibility. As a result, there will be less reluctance by the consumer, who would otherwise have to start another collection of music on yet another format. Being based around tape technology, it is inherently resilient to mechanical vibration.

However, the big question still remains. Will it succeed? This is not easy to predict, even though the system has a lot of advantages. It is probably best to follow the advice I was given in a Hi-Fi shop, where I was told it would be best to wait a year or so before buying anything. By this time the market trend would be clear and the prices would have fallen.

Acknowledgments

I would like to thank Philips and Mathieu Thomas Ltd. for their help in producing this article. The photographs have been reproduced by kind permission of Philips.

Christmas Candle continued from page 7.

FLICKERING CHRISTMAS CANDLE PARTS LIST

RESISTORS: All 0·6W 1% Metal Film			
R1	820k	1	(M820K)
R2	750k	1	(M750K)
R3	1M	1	(M1M)
R4	100k	1	(M100K)
R5	47k	1	(M47K)
CAPACITORS			
C1	15nF Polyester Layer	1	(WW31J)
C2	2n2F Polyester Layer	1	(WW24B)
C3	470nF Polyester Layer	1	(WW49D)
C4	22nF Polyester Layer	1	(WW33L)
C5	220µF 16V Radial Electrolytic	1	(FF13P)
C6	100nF 16V Miniature Disc Ceramic	1	(YR75S)
SEMICONDUCTORS			
IC1	4011UBE	1	(QL04E)
IC2	4006BE	1	(QX03D)
IC3	4070BE	1	(QX26D)
TR1	MPSA14	1	(QH60Q)
D1,2	1N4148	2	(QL80B)
D3	1N4001	1	(QL73Q)
MISCELLANEOUS			
LP1	6V LES Filament Lamp	1	(WL74R)
	1mm Veropin	1 Pkt	(FL24B)
	1A Black Wire	1 Pk	(BL00A)
	1A Red Wire	1 Pk	(BL07H)
	14-pin DIL Socket	3	(BL18U)
	LES Lampholder	1	(UJ72P)
	Yellow LES Lamp Cover	1	(YY00A)
	Double Sided Adhesive Pads	1 Strip	(HB22Y)
	PP3 Clip	1	(HF28F)
	PCB	1	(GH47B)
	Instruction Leaflet	1	(XU41U)
	Constructors' Guide	1	(XH79L)
OPTIONAL (Not in Kit)			
	2·5mm Power Socket	1	(JK10L)
	300mA Unregulated AC/DC Adapter	1	(XX09K)
	3 x AA Battery Box	2	(YR61R)
	PP3 Clip	1	(HF28F)
	Duracell PP3 Battery	1	(JY49D)
	Duracell AA Cell	6	(JY48C)
	Epoxy Resin Sachet	1	(FL45Y)

The Maplin 'Get-You-Working' Service is available for this project, see Constructors' Guide or current Maplin Catalogue for details.

The above items (excluding Optional) are available as a kit, which offers a saving over buying the parts separately.

Order As LT40T (Twinkling Candle Kit)
Price £6.95.

Please Note: Where 'package' quantities are stated in the Parts List (e.g., packet, strip, reel, etc.), the exact quantity required to build the project will be supplied in the kit.

The following new item (which is included in the kit) is also available separately.
Twinkling Candle PCB **Order As GH47B**
Price £1.98.

NEWS Report

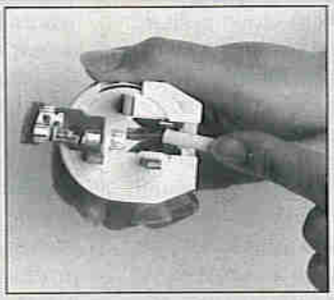
Don't Screw Up Your Wiring

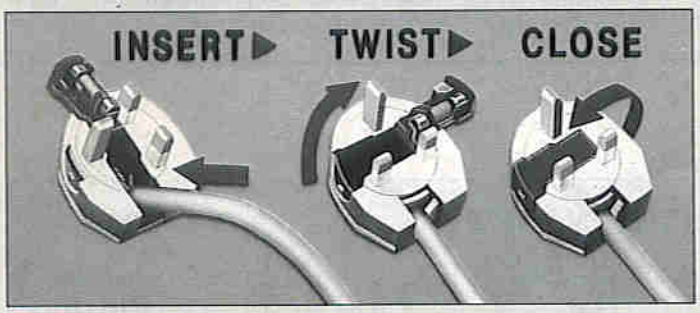
Coming to a Maplin shop near you soon, is Rotaplug an ingenious version of the standard UK 13A plug. Designed with failed DIY enthusiasts in mind, the plug is fitted to a mains flex without the use of a screwdriver.

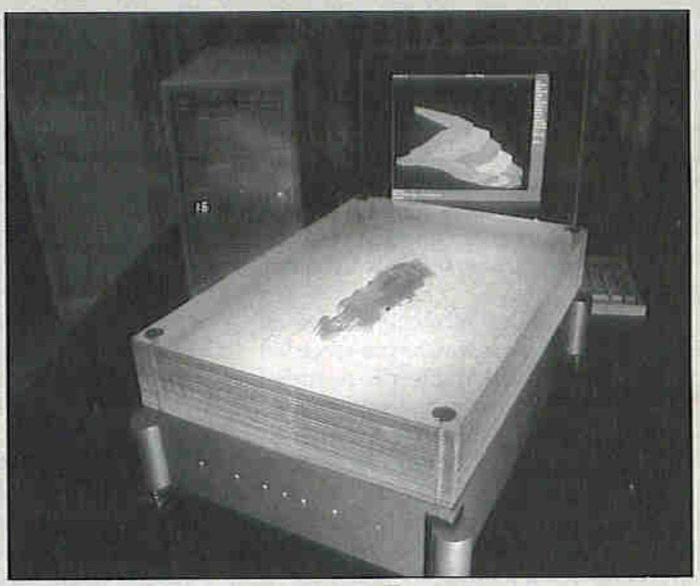
Instead the live, neutral and earth wires are separated from the outer cable sleeving and inserted into three colour coded channels. The flex is then clipped into a plastic grip and the inner section of the plug twisted to secure the cable. To complete wiring a suitable fuse is inserted inside the fuse clip, which is pressed into position locking the plug.

Mr. Hugh Gilbert the designer, claims the unique features of Rotaplug not only make it quick and easy to wire, but also ensure complete safety. With more than twenty people electrocuted in their homes in the UK last year, as a result of wrongly wired plugs, his assertions could well be justified.

Available from October 31, the plug will cost £2.95. Order As KP61R.







Model Approach

Two dimensional graphical images on a computer screen or plotter are fine as far as they go. To add realistic proportion to a blueprint, architects and graphic designers must construct a model based on two dimensional plans.

So far this has been beyond the scope of a computer unless designers opt for pioneering virtual reality technology. But now, a London based company, Vu Thru has come up with a novel way of producing three-dimensional images from a computer.

This is achieved by mounting two-dimensional computer output between Perspex layers. The computer print-outs are produced on an optically transparent film and are used as contour-slices to form a model. In all, twenty or more films are bolted together to produce a three-dimensional image.

Commenting on the modelling system, Mr. John Clancy, Senior Lecturer at Chelsea College of Art and Design said, "Art and design is developing a significant role in scientific visualisation as images become necessary to illustrate data. Vu Thru models for describing land forms and interiors have direct application to interior design, public art and sculpture."

Indeed interest has been shown from many sectors. Oil giants BP and miners RTZ are both considering the system for detailed analysis work in their respective industries, while the University of Manchester is keen to adopt the technology as a teaching aid and research tool.

Contact: Vu Thru (071) 731 7103.

Foxy Communication

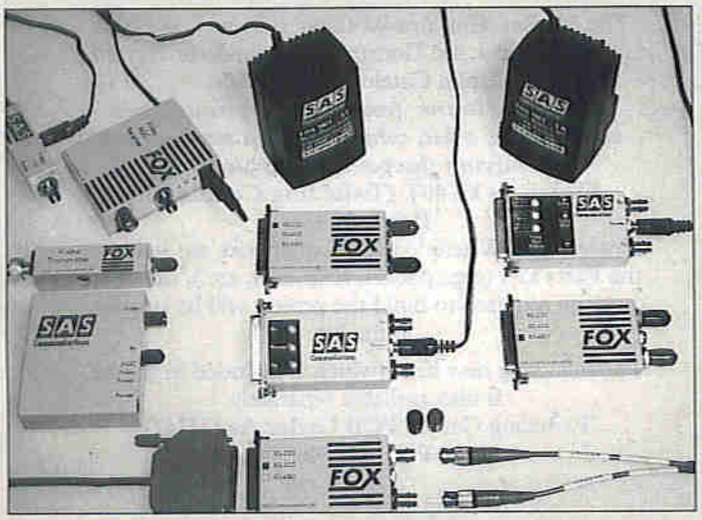
By using fibre-optic communication, data or video signals can be transmitted without being affected by cable characteristics, extraneous signals and spurious noise, even in environments with substantial electrical noise.

Additionally, data carried by fibre optic is secure against surveillance devices that rely upon electromagnetic fields and cannot disturb the function of delicate electronic equipment operating near the fibre.

SAS Communications are promoting these features in their range of miniature FOX transmitters and receivers just launched. Powered from host equipment or mains, each unit provides an interface between data or video and fibre-optic cable.

The FOX communications range simplifies data transmission, enabling signals to be sent up to four kilometres. This compares with a distance of over 200m for coaxial cable.

Contact: SAS Communications Ltd. (0732) 849 444.



Disk Diodes

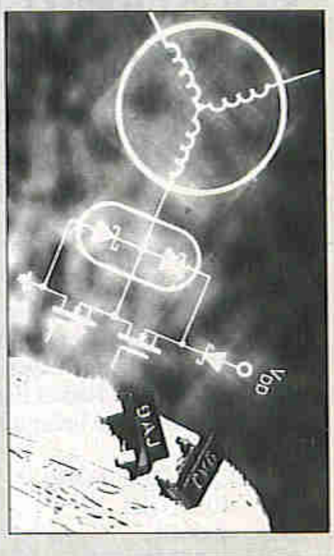
A new dual Schottky barrier diode from Allegro MicroSystems is designed specifically for use in stepper motor applications such as disk drives.

The new device combines efficient rectification with highspeed switching and low series resistance, and so is ideally suited to providing low voltage drop rectification of a disk drive spindle-motor back emf during power down or head retraction.

The forward voltage drop is typically 440mV at 150mA; maximum forward current is 500mA, and maximum reverse voltage is 20V. Reverse recovery time at 100mA is 32ns.

The A8920SL is supplied in a 3-pin SO23 transistor package for surface mounting, and has an operating temperature range from –20°C to +85°C. A multichip version, the TND8000, includes three pairs of diodes in a 16-lead SOIC package.

Contact: Allegro MicroSystems (0932) 246622.



Hoarse Restoration

J. M. Woodgate and Associates (JMWA) have undertaken some unusual jobs in their time, but a recent commission from the Horse Rangers Association of Hampton Court near London was particularly unique.

A Pye 'Transhailer' from the early seventies had been severely damaged after being hit by a horsebox. Since the loud hailer was of considerable memorial value to the Association, JMWA agreed to attempt restoration.

It was necessary to repair the horn flare, which had been crushed beyond repair, and completely repaint the unit as close to the original colours as possible. A replacement flare was retrieved by Electronic Services of Wedesfield, and a search among a comprehensive range of car colours produced acceptable matches to the original.

The 'Transhailer' was restored to full working order, and will now be preserved in memory of the association's founder, Raymond Gordon FRS, never again to be exposed to the dangers of the field.

Commenting on the completed project, John Woodgate principle of JMWA said, "We checked the amplifier and found the earlier geranium transistors gave good results. We also found that the rubber seal between the pressure unit and the horn throat had been misplaced in manufacture, so the unit now works better than ever."

Keeping Informed

WordPerfect has released its latest offering, *WordPerfect InForms*, to the computing world. This package, which runs under the *Microsoft Windows* Operating Environment is a fully featured electronic form generator. The Informs *Designer* program provides all the items required to create forms for either printing out or electronic circulation. The InForms *Filler* allows forms to be (wait for it!) filled in electronically on the computer screen. Forms both blank and filled in can be sent as E-mail on computer networks, but this raises the question, how do you sign an electronic form? Well WordPerfect have solved the problem with electronic *signatures* and to prevent information being changed without authorisation, they have also included a high security electronic *TamperSeal*. Information can also be linked to proprietary database packages as well. The package includes over one hundred ready-for-use pre-designed forms; a 115,000 word spell checker; Adobe Type Manager and TrueType fonts.

WordPerfect InForms is an ideal choice for anyone who needs to generate in-house forms, stationery, etc., or for those committed to the truly *paperless* office. The package retails at £329 RRP, but as a special introductory offer until 15th December 1993, five additional user licences for the InForms Filler (worth £299 RRP) are being bundled free – ideal for users' with a local area network. We've tried the package here at the editorial offices of *Electronics* and it's easy to install and use, so thumbs up WordPerfect, you've come up with another winner! WordPerfect UK can be contacted on: Tel: (0932) 850505, Fax: (0932) 843010.

Kinetic Watch

Twenty-five years after the launch of the first quartz wrist-watch, Japanese manufacturer Seiko has launched the first quartz watch to work off kinetic energy. Instead of traditional battery power, the watch is powered by the movement of the wearer.

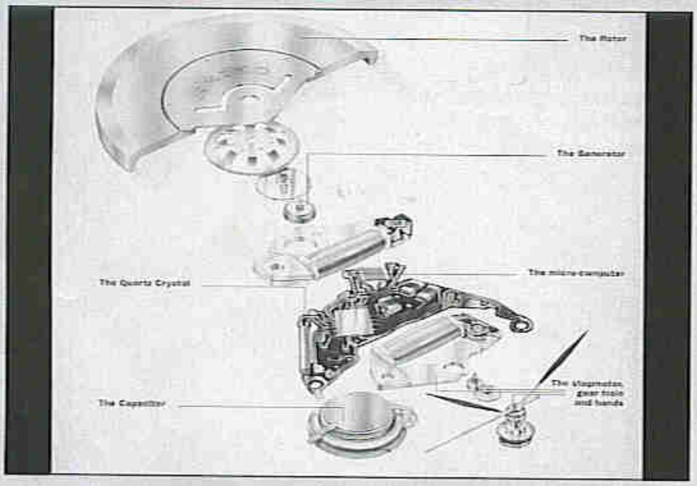
Sitting behind the watch is a semicircular rotor, about half the size of a five pence coin. Natural body movements cause this to rotate thus transferring kinetic energy into mechanical power. The rotor is attached to a small electrical generator which is designed to rotate at speed, up to 100,000 rpm, generating 2·5V during normal usage.

Due to the advanced materials used in the design of the movement, little effort is required to get the watch moving. Simply by brushing teeth for three minutes, while wearing the watch, will provide enough energy to power it for five hours – a normal days wear will keep the watch operating at optimum accuracy for at least three days.

Seiko has equipped the watch with a high-efficiency capacitor that stores enough energy to keep the watch operating accurately for an undisturbed three days. Even when power is completely drained, the slightest movement will create enough energy to start the watch mechanism again.

The Seiko Kinetic range consists of ten models, varying in price from £180 to £200.

Contact: Seiko (0628) 770001.



EARS Against Truancy

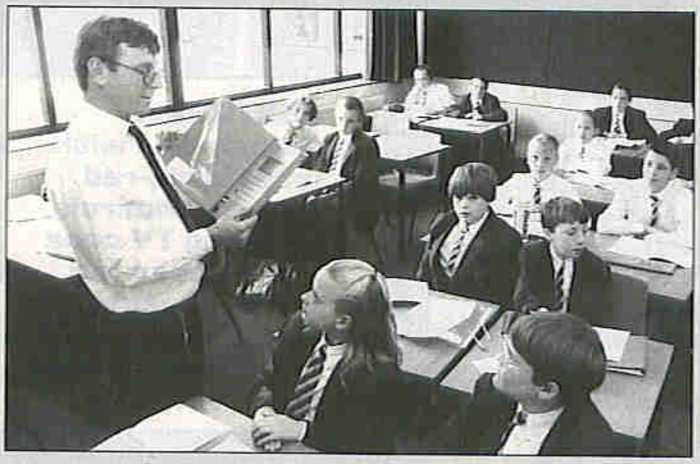
With the new academic term in full swing, schools have returned this year with a difference. For the first time, head teachers are required to publish their truancy rates.

But for more than 1,000 teachers, the new change will not be a problem. They will be fighting truancy with technology on their side.

Teachers in 30 schools, with some 30,000 pupils, will be using a paperless electronic attendance registration system (EARS) – a two-way radio-computer, purposely designed in an A4 folder, that will save teacher time and provide an efficient means of combatting truancy.

The pioneering technology, developed by Bromcom Computers Ltd., allows teachers to know who is in school, and who should be in class at anyone time. When the register is taken, the names of pupils are 'ticked' off on the hand-held EARS computer-folder screen and transmitted by radio link to a central computer in the school office. For every class from then on, the central computer will inform the teacher who should be present. The system will even write letters to the parents of missing pupils.

Contact: Bromcom Computers Ltd. (081) 461 3993.

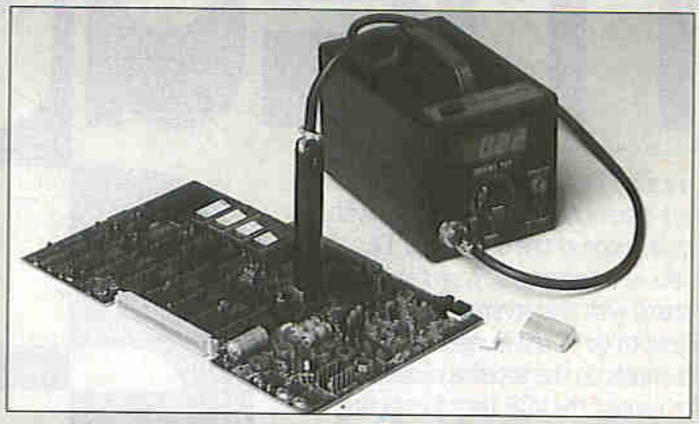


Power Checking

For engineers who may have power problems on an installation, the new PowerVisa from Cetronic Power Products, will monitor voltage lines continually and provide a printed record of all potentially damaging disturbances. This allows the operator to quickly differentiate between power-related problems and equipment failures.

The PowerVisa can monitor the mains voltage from its own cord, automatically providing daily summary graphs of RMS voltage, wave shape faults, lines impulses, frequency, high-frequency noise, temperature and RMS current. Using optional probes, the PowerVisa can be used for current measurement up to 600A.

Contact: Cetronic Power Products (0920) 871077.



Air-Traffic Control

A new low-cost air-traffic management system designed for use in commercial installations has been developed by Siemens Air Traffic Management Division. Primarily intended for tower, approach control and small traffic control centres, Watchkeeper/ap100 is based on the company's larger Controller 2000.

Contact: Siemens Plessey Systems (081) 397 5171.

Extending Terminations

Do you have problems trying to extend the leads on components when mounting them in cases or enclosures? So do the engineers at Raychem.

To cope with the problem they have launched a Soldersleeve system specifically for the termination of discrete components: transistors, neons and LEDs.

This new product offers a low-cost, low solder alternative to uncontrolled methods of terminating, such as hand soldering or crimping. It is a one-piece product, providing electrical connection, insulation and strain relief.

The Soldersleeve termination consists of a fluxed solder preform inside a transparent, heat shrinkable insulation sleeve. When the termination is heated the solder preform melts and the tubing shrinks to create a connection.

Nice idea, but unless you are making hundreds of joints a day, we suggest extending leads using the hook-up wire and heat-shrink sleeving.

Contact: Raychem (0793) 528171.

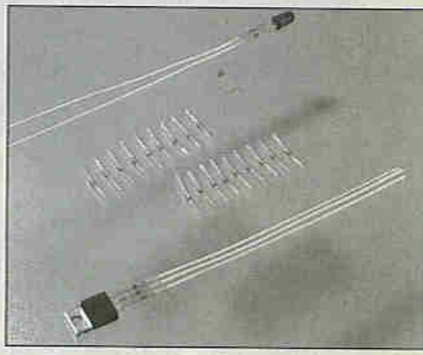
It's for Ewe

Got problems in your social life? Well get a mobile phone.

According to a new Gallup Survey commissioned by Motorola, mobile telephones improve personal relationships. This is perhaps not surprising when 61% of users have used their mobile phone to call a loved one "just to say hello" and a further one in three have called to say "I love you."

Among other questions, the survey went on to ask respondents to name the most unusual place they had used their mobile phone. The most popular was the toilet, with the bath tub coming a close second. Other more bizarre locations included inside a walk-in fridge, the bottom of an empty swimming pool, in a sewer and half-way up a Welsh mountain when lambing a ewe.

Contact: Motorola (0256) 27092.



Wider Area Networks

Intel Corporation and MCI Communications Corporation have signed an agreement to explore and develop opportunities for the integration of the PC and the telephone.

The two companies plan to utilise Intel's expertise in computer hardware, video and PC technology, and MCI's expertise as a provider of intelligent network services to enhance the capabilities that each brings to the technological market.

Local exchange carriers such as British Telecom, currently only offer digital services within designated exchange areas. The agreement opens the door for advanced PC-based data, audio and video networking between local exchange areas.

medusa

A Repeater for Infra-red Remote-Control Units

3 PROJECT RATING

Satellite TV receivers and VCRs are often located in the lounge, with distribution of the outputs to TV sets in other rooms. A problem that arises with this arrangement is the need to go to the lounge to change channels on the satellite receiver, or to control the VCR (fast forwarding through the adverts!). This problem is solved by the repeater system described here, which will allow the TV or VCR remote control-unit to be used in the remote room in the normal way

by John Dakin

The complete Medusa system including transmitter, receiver and power supply unit.

APPLICATIONS

- Control VCRs, satellite receivers or Hi-Fis from another room
- Extends the range of infra-red remote controls

FEATURES

- Compatible with most infra-red remote controls
- Existing TV coax can be used for interconnection
- Three adjustable infra-red emitters for versatility
- Compact and unobtrusive receiver and transmitter
- Receiver and transmitter interconnect using any twin-core cable

Most remote-control units for TV sets, satellite receivers and VCRs use pulses of infra-red energy to transmit the commands from the remote-control unit to the equipment; those that don't (normally the much older ultrasonic type), cannot be used with this system. Figure 1 shows how the remote-control unit's commands can be received in one room and 'repeated' in another. An infra-red receiver is placed in the bedroom from which it is desired to control the remote equipment. This is connected to a transmitter in the lounge, which repeats the remote control unit's signals so that the equipment responds to its commands exactly as it would if the control unit was in the lounge.

The receiver is housed in a small case (ABS box MB1) and is powered by the cable connecting it to the transmitter. The connecting cable is a single pair of wires. Twisted pair-telephone cable is ideal, and is suitable for connections of up to 50m. Please note that this cable must only be used for the Medusa and not shared with a telephone service. Bell wire is suitable for shorter runs. It is also possible for the Medusa and the remote TV to 'share' an existing coax cable. It is necessary, however, to use special combiner/splitter units at each end to ensure that the signals arrive at their intended destinations! The shared coax method will be described later.

The transmitter is housed in a plastic case of similar size to the receiver. The case chosen (ABS box and base type 3) has mounting flanges on the base, allowing the transmitter to be screwed to a wall, skirting board or any other suitable surface. The unit has three infra-red emitters mounted on bendable, snake-like leads emerging from the top. These 'snakes' give the unit its name, Medusa (after the infamous beast from Greek mythology), and can be set to aim the infra-red signals at the equipment being controlled to give the most reliable performance. It has been found that even with the transmitter placed where it is not in direct line of sight with the equipment, satisfactory operation can often be achieved by bouncing the signal off the ceiling or walls (presumably gloss paint is helpful here – Ed.).

The power supply is housed in a third box, of the plug-in power supply variety, with integral 13A plug pins.

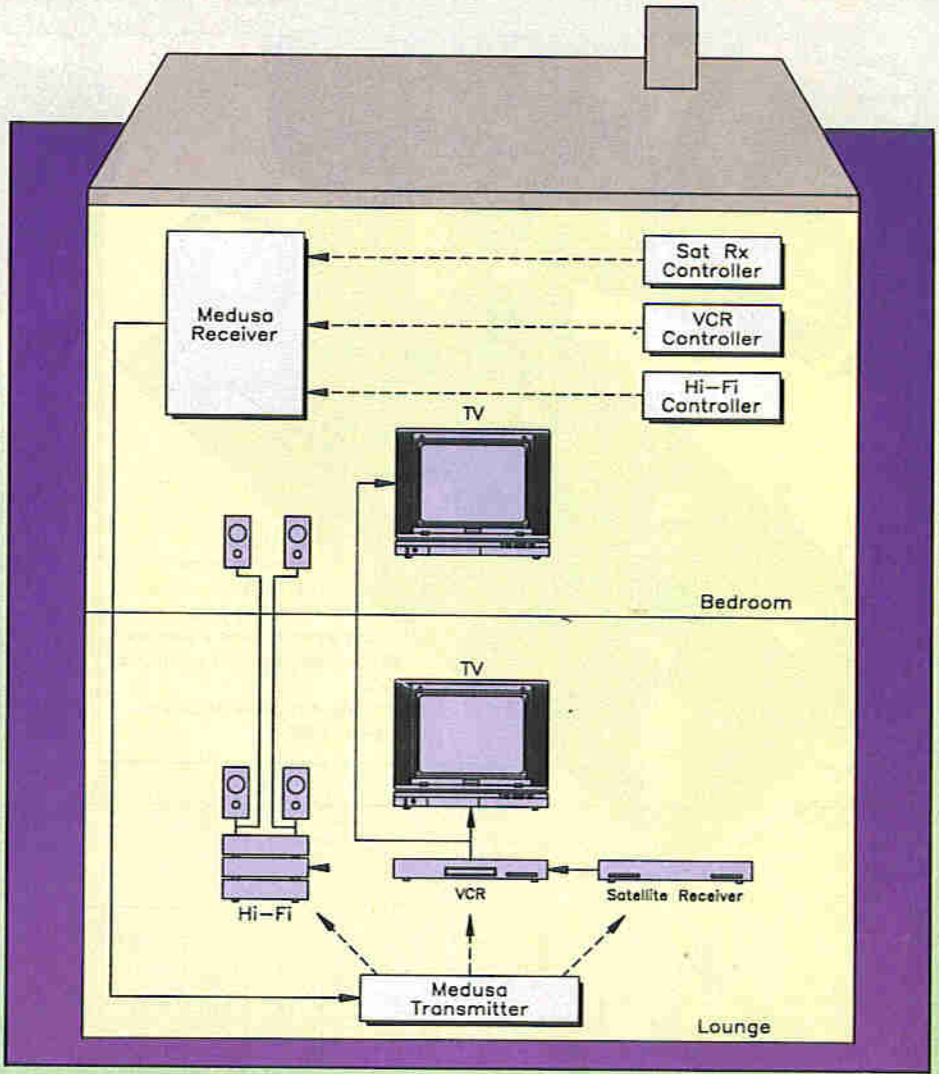
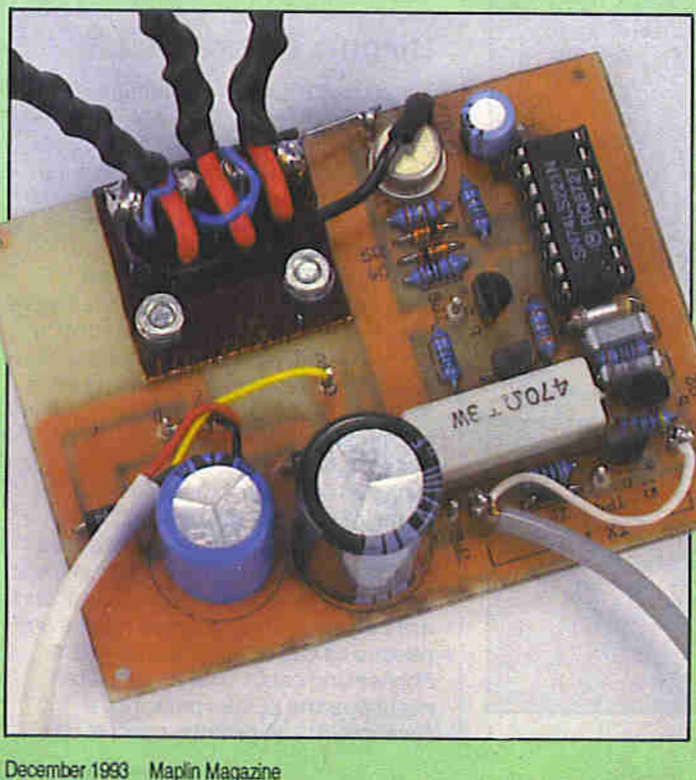
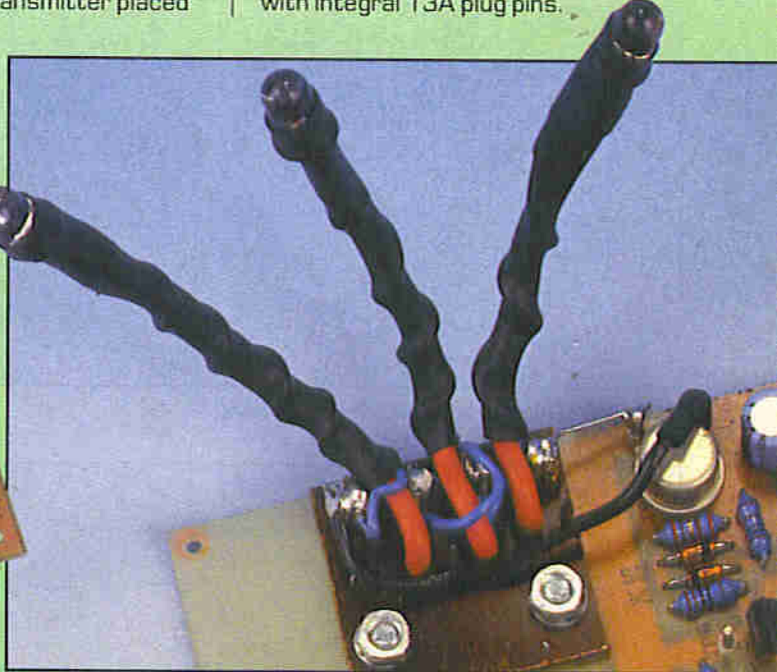
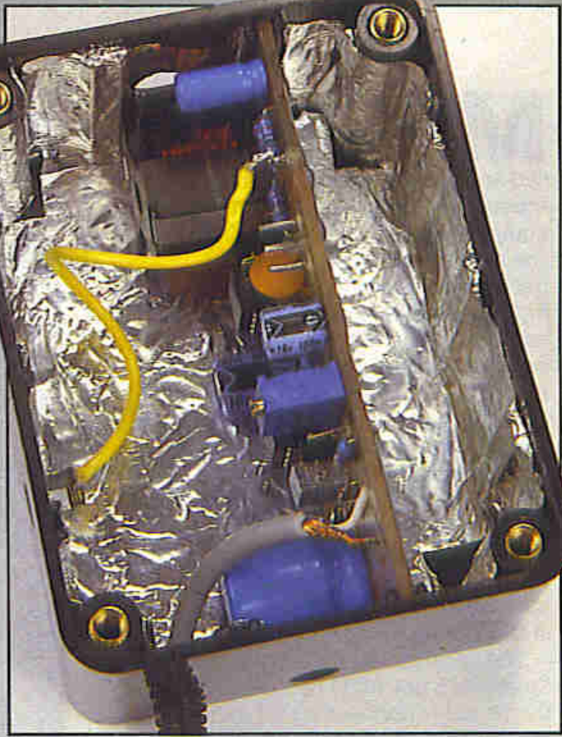


Figure 1. Typical Medusa system layout.





Left: Close-up of the complete Medusa transmitter PCB. Above: Close-up view of the Medusa's 'snakes' – the infra-red emitters are mounted on stalks so that they can be aimed towards the appropriate pieces of equipment in the room.



Right: Internal view of the receiver – the tin-foil lining provides the system with a degree of immunity against spurious noise.
Left: The complete Medusa receiver PCB.

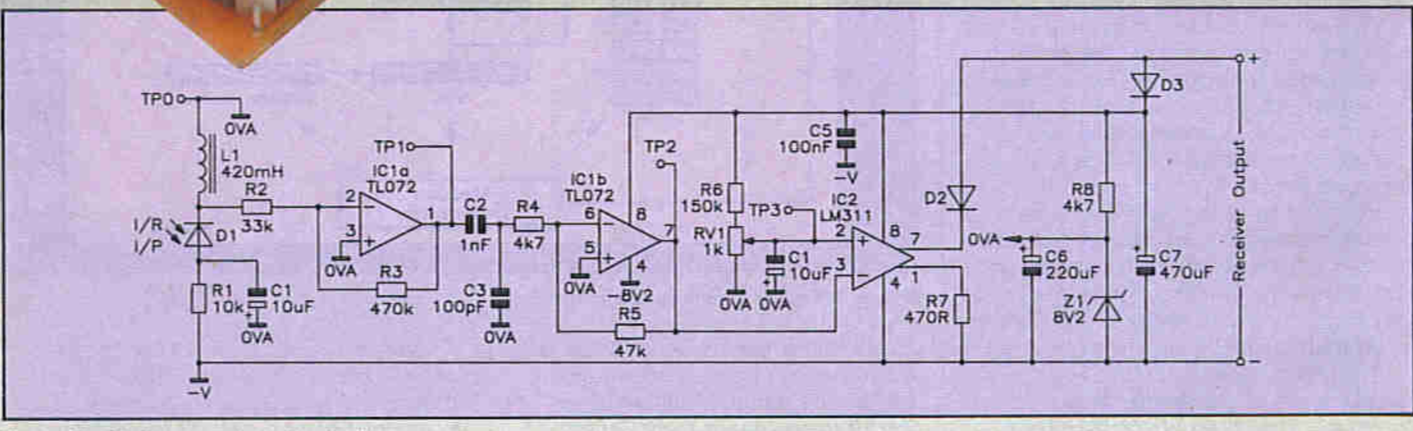


Figure 2a. Medusa receiver circuit diagram.

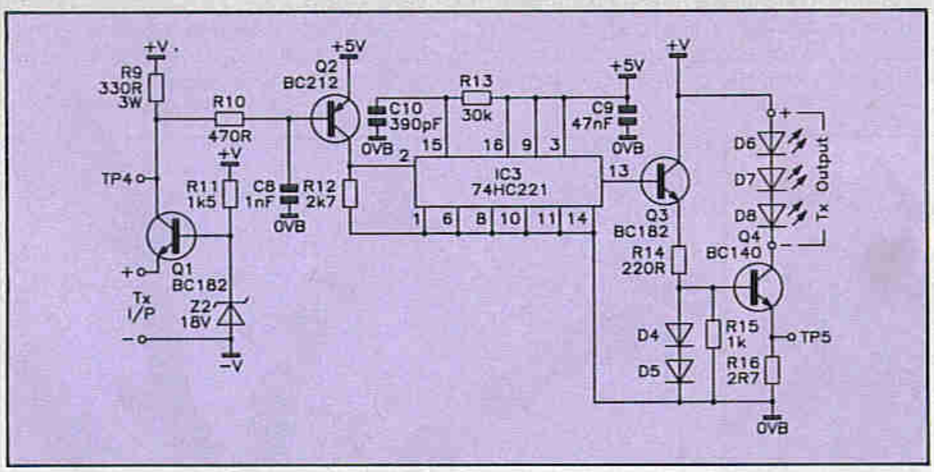


Figure 2b. Medusa transmitter circuit diagram.

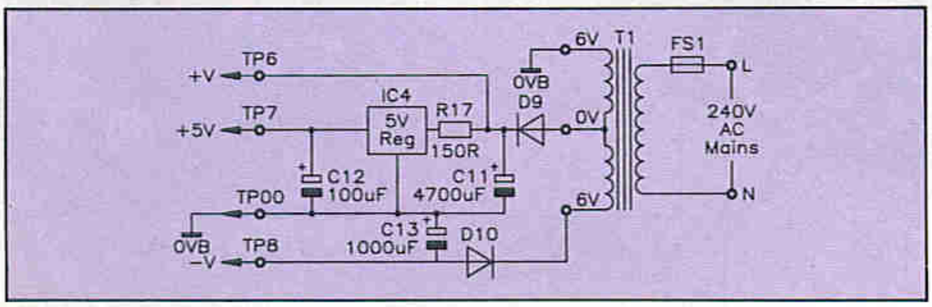


Figure 2c. Medusa power supply circuit diagram.

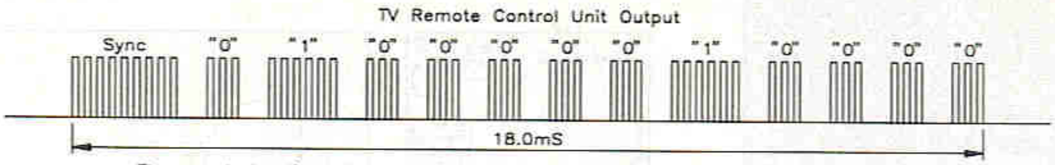
It contains a mains transformer and fuse; this connects to the transmitter using four-core cable (only three cores of which are used).

Circuit Description

The circuit diagram of Medusa is shown in Figure 2. The circuit consists of three main parts – the receiver (Figure 2a), the transmitter (Figure 2b), and the power supply (Figure 2c).

The signals from most remote-control units consist of bursts of 40kHz infra-red pulses that are transmitted as a coded stream. Figure 3 shows a typical arrangement for a Sony TV and VCR remote-control unit. However, some remote-control units (e.g., those for some items of Saisho equipment), use coded streams of single 13μs pulses. Medusa will function satisfactorily with both types of remote-control unit.

The infra-red pulses are detected by the receiver, in the room where the remote-control unit is being used, and are converted into current pulses and passed to the transmitter over the connecting cable. The transmitter reshapes the pulses back into a facsimile of the remote-control unit's



The exact duration of the code burst depends on the button which is pressed

Sync Pulse	2.4mS
"0" Pulse	0.6mS
"1" Pulse	1.2mS
Interdigit Pulse	0.6mS

All pulses are bursts of 40kHz frequency.

Some typical code bursts for the controller.

Button	12 Bit code burst			
1	000	000	010	000
2	100	000	010	000
3	010	000	010	000
4	110	000	010	000
5	001	000	010	000
9	000	100	010	000
0	100	100	010	000

If a button is kept pressed the 12 bit code burst is changed every 45mS

The circuit and information presented here must be considered as a basis for your own experimentation, no warranty is given for suitability in particular applications, reliability or circuit operation. Maplin cannot support, in any way, the information presented here. However, where possible we will endeavour to check that information presented, is correct and that circuits will function as stated.

Figure 3. Typical infra-red remote control unit pulse train, based around bursts of 40kHz pulses. The example given is that from a Sony TV remote control.

original signal, which is sent to the infra-red emitting LEDs ('emitters'). The IR signal produced operates the equipment in the room in which the transmitter is located.

Both the receiver and transmitter are powered from a single power supply unit.

(i) The Receiver

Note that in this part of the circuit description, voltages are measured with respect to the 0V rail (TP0), within the receiver circuit itself.

The infra-red pulses from the remote-control unit are detected by a PIN diode, D1, which behaves as a constant current source. Let us call the current change in D1, due to the input from the remote-control unit, the *wanted* signal. Unfortunately, the PIN diode also detects *unwanted* infra-red signals from tungsten filament lamps, and from any ambient daylight that is present. The tungsten filaments generate large 100Hz signals when operated from a 50Hz supply, as they warm up and cool down on each half-cycle. This 100Hz noise is superimposed on a DC voltage proportional to the mean level of infra-red radiation from the lamps, plus any ambient daylight. These unwanted signals are normally much larger than the wanted signal. For example, with the remote-control unit at a distance of 3 metres from the receiver, the wanted pulses will have a typical peak amplitude of 0·05μA, whereas the unwanted signal is typically 3μA Pk-to-Pk of 100Hz superimposed on a 5μA DC voltage. The receiver circuits are designed to reject the unwanted signals, while retaining the wanted signal.

R1 and C1 decouple any noise on the supply rail feeding the PIN diode, and prevent it being passed to later stages of the receiver. The first stage of unwanted signal rejection is achieved by passing the input signals through L1 and R2. These components are effectively in parallel, as one end of R2 is a virtual earth point at the input

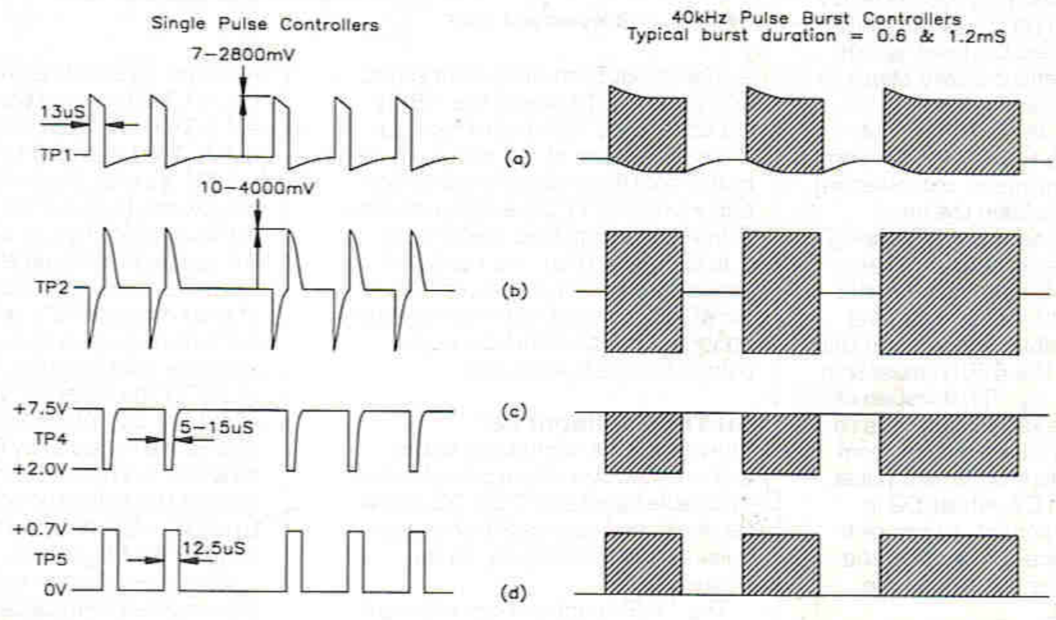


Figure 4. Circuit waveforms.

to IC1a. The value of L1 is chosen so that its impedance to 13μs pulses or 40kHz bursts is high, while its impedance to DC or 100Hz signals is low. Thus the wanted current signals are steered into R2, while the unwanted current signals are shunted to the 0V rail via L1. The value of R2 is chosen to damp out any ringing that would otherwise occur, due to the self-resonance of L1. R2 is the input arm of an amplifier formed by R2, R3 and IC1a. This amplifier has a voltage gain of about 14 times.

The output of IC1a, which is shown in Figure 4a (TP1), is a voltage that contains little of the unwanted DC and 100Hz signals, and has an amplified form of the wanted signal. At this point, this is a series of positive-going 13μs pulses or a 40kHz square wave, according to the type of remote-control unit. The rise and fall time of the pulses or square waves is typically 3μs.

The output of IC1a is coupled to the next stage via C2 and R4 which have a time constant of 4·7μs, and therefore differentiate the input pulses or square wave from IC1a. C3 decouples any high frequency noise at this point to the 0V rail. R4 is the input arm of an amplifier, formed by R4, R5 and IC1b, which has a voltage gain of 10 times. The output of IC1b, which is shown in Figure 4b (TP2), is a pair of negative-going and positive-going pulses for each input pulse or square wave cycle from IC1a. The short time constant of the coupling components C2 and R4 also reduces the unwanted 100Hz signals to a negligible level, and eliminates the unwanted DC signal.

The output of IC1b is DC-coupled to the inverting (−) input of an LM311 comparator, IC2. With no input signal to the receiver, the output of IC1b is held to within a few millivolts of the 0V rail. The non-inverting (+) input of IC2 is held at a constant DC level, which is set by VR1 to about 20mV above the level of the inverting input. In a no-signal condition, the output transistor of IC2, Q_{comp}, is turned off. When a signal is present, the inverting input of IC2 rises above the non-inverting input on each positive-going pulse and Q_{comp} is turned on. When Q_{comp} is on, 27mA is drawn from the transmitter input transistor Q1 via the connecting cable. The value of this current is set by the 470Ω resistor in the emitter of Q_{comp}. The duration of the current pulse varies from 5μs to 15μs, depending on the output from IC1b. D3 prevents the current pulse being drawn from C7, whilst D2 is a protection component, to prevent damage to the receiver circuit if the connecting cable is connected the wrong way round.

The connecting cable from the transmitter carries the supply voltage (17·3V DC) to the receiver. With no signal, about 6mA of current flows. D3, R8 and D11 derive the +8·6V, 0V and −8·2V rails from this input. D3 also isolates all the receiver power rails from the small variation which occurs on the 17·3V supply when the 27mA current pulses are flowing.

In summary then, the receiver converts the infra-red input pulses (or 40kHz bursts) from the remote-control unit into 27mA current pulses for the transmitter.

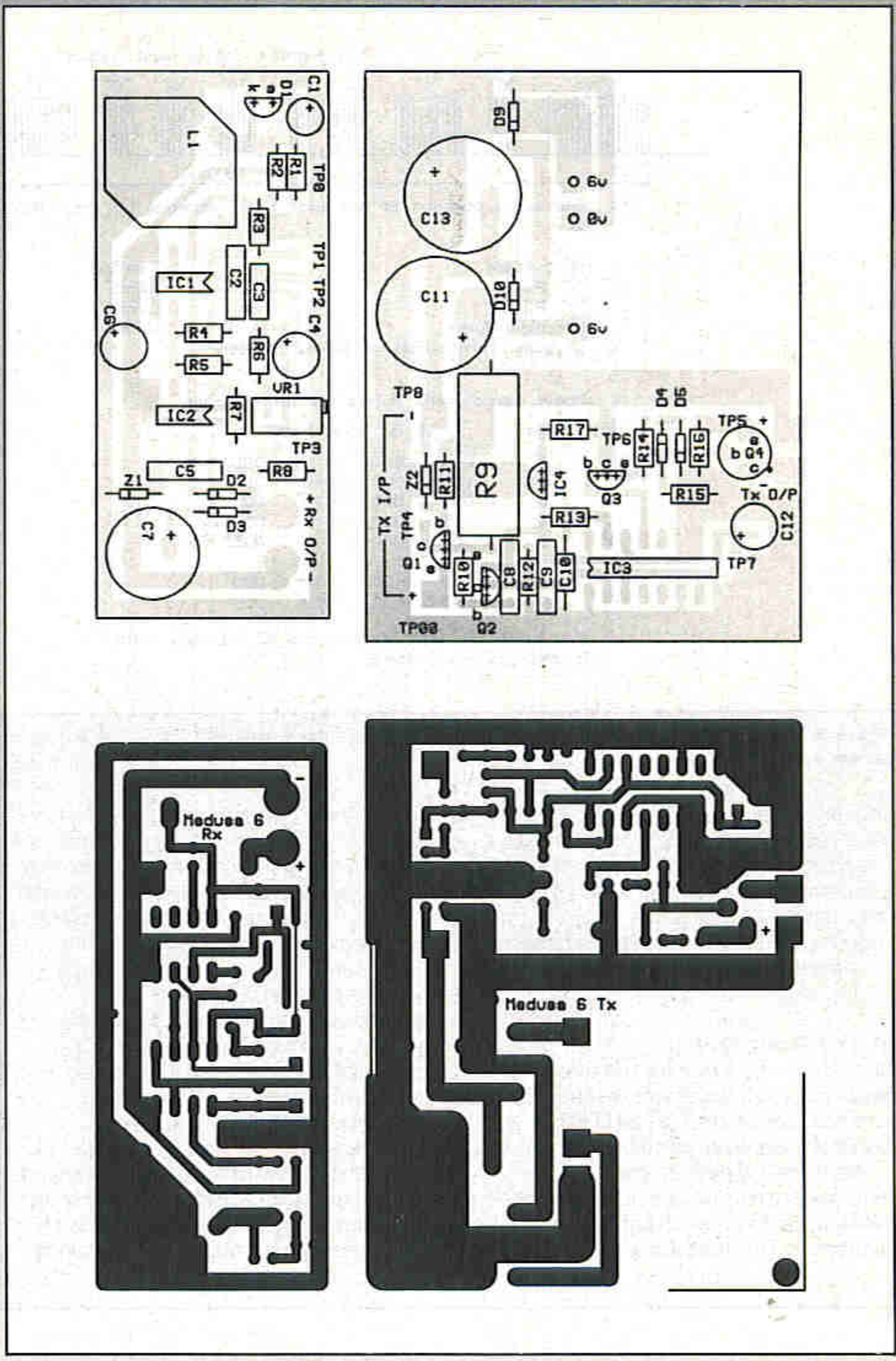


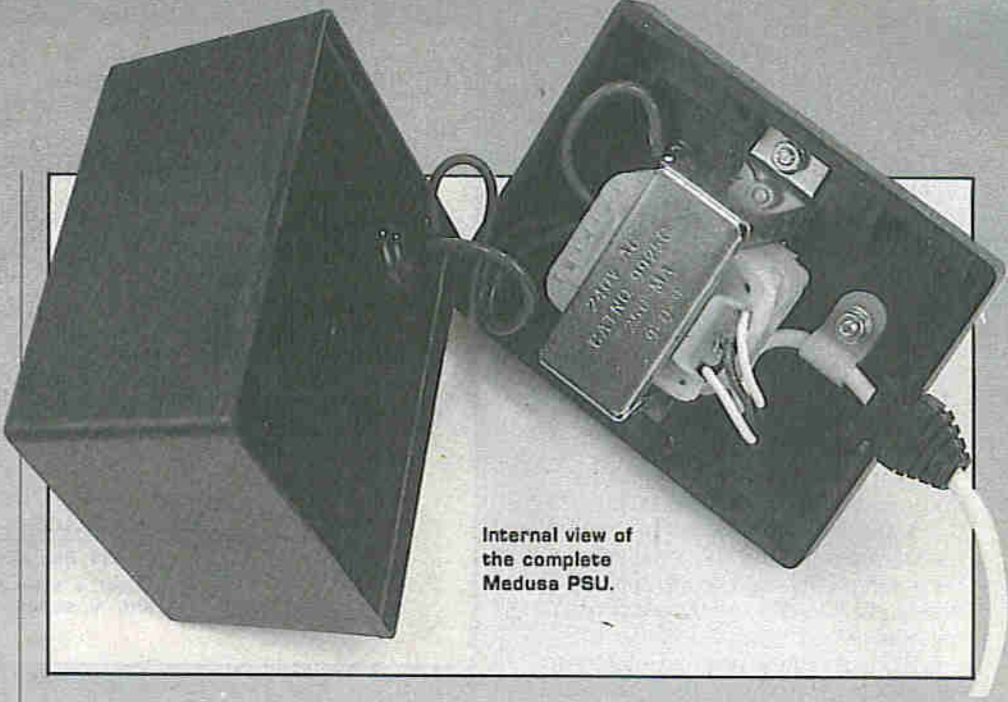
Figure 5. PCB legend and track.

(ii) The Transmitter

The receiver is connected to the transmitter by a single pair of wires. The cable supplies 17·3V DC to the receiver, and carries 27mA signal pulses from the receiver to the transmitter.

The 17·3V supply is derived from the transmitter's −19·6V and +9·5V rails using an 18V Zener diode, D12, R11 and Q1. Q1 acts as an emitter-follower, so that the output between the −19·6V rail and the emitter of Q1 is 17·3V (18V, less Q1's V_{be} of about 0·7V). The base of Q1 is at about −1·6V, so that the collector of Q1 can switch from +7·5V to −1·6V, without affecting the 17·3V supply to the receiver. With no signal pulses from the receiver, about 6mA flows out of the emitter of Q1, and so a similar current flows into the collector. As the collector load resistor, R9, has a value of 330Ω the collector voltage will be about +7·5V. When 27mA signal pulses are received by Q1, the collector current rises to 33mA so that the collector voltage falls to about +2V; refer to the TP4 waveform of Figure 4c.

With the collector of Q1 at +2V, Q2 is turned on by base current flowing through R10. C8 removes any high-frequency noise that may be picked up on the cable. When Q2 turns on, the



Internal view of the complete Medusa PSU.

collector rises to +5V and triggers the monostable, IC3. The duration of the monostable output pulse is 12·5μs, and is set by C10 and R13. A 5V positive going output is taken from pin 13 to drive Q3 which functions as an emitter follower. Part of the 20mA emitter current from Q3 turns on Q4 while the rest of the emitter current flows through D4 and D5, which set the base voltage of Q4 at about +1·5V during each pulse. The emitter of Q4 rises to about +0·7V, see Figure 4d (TP5), and an emitter current of around 250mA flows. A similar value of collector current flows and drives the infra-red emitters D6, D7 and D8. These LEDs have a voltage drop of about 2V each so that Q4 does not saturate and the current through the diodes remains constant, even with a long duration pulse burst that causes the +9·5V rail to fall by up to 0·5V. R15 ensures that Q4 turns off cleanly at the end of each pulse.

Whilst the peak current that flows through the infra-red emitters is about 250mA, the average LED current during a typical remote-control unit pulse train is only one quarter of this value, or 60mA. This is well within the rating for these diodes.

There is one unused monostable circuit in IC3; the inputs of this circuit are clamped to 0V or +5V, as appropriate, to prevent any uncontrolled behaviour.

Note that R9 is rated at 3W. This is to cater for the input to the transmitter being accidentally short-circuited, when the power dissipated by R9 can rise to about 2W. No damage should occur to either the transmitter or the receiver if this happens. Under normal operating conditions, the dissipation of R9 is only about 20mW.

(iii) The Power Supply

The voltages required by the receiver and transmitter are provided by a purpose-designed power supply circuit. The −19·6V supply is derived from a half-wave rectifier, D10, and a reservoir capacitor, C13. The +9·5V supply is obtained from a half-wave rectifier, D9, and a reservoir capacitor, C11. Finally, the +5V rail is determined from the +9·5V supply via a regulator, RG1.

T1 is a double-insulated transformer with a 240V primary winding and two 6V 250mA secondary windings. Because the average current drawn from the secondaries is much less than 0·5A the secondary voltages are typically 7·2V RMS. Thus the peak voltages are typically 10·2V; this explains why the unregulated DC outputs are +9·5V and −19·6V.

PCB Construction

Two PCBs are used – one for the receiver, and the other for the transmitter/power supply. Figure 5 shows the component legend and track for both PCBs.

The inductor, L1, is wound with 1020 turns of 0·15mm (38 SWG)

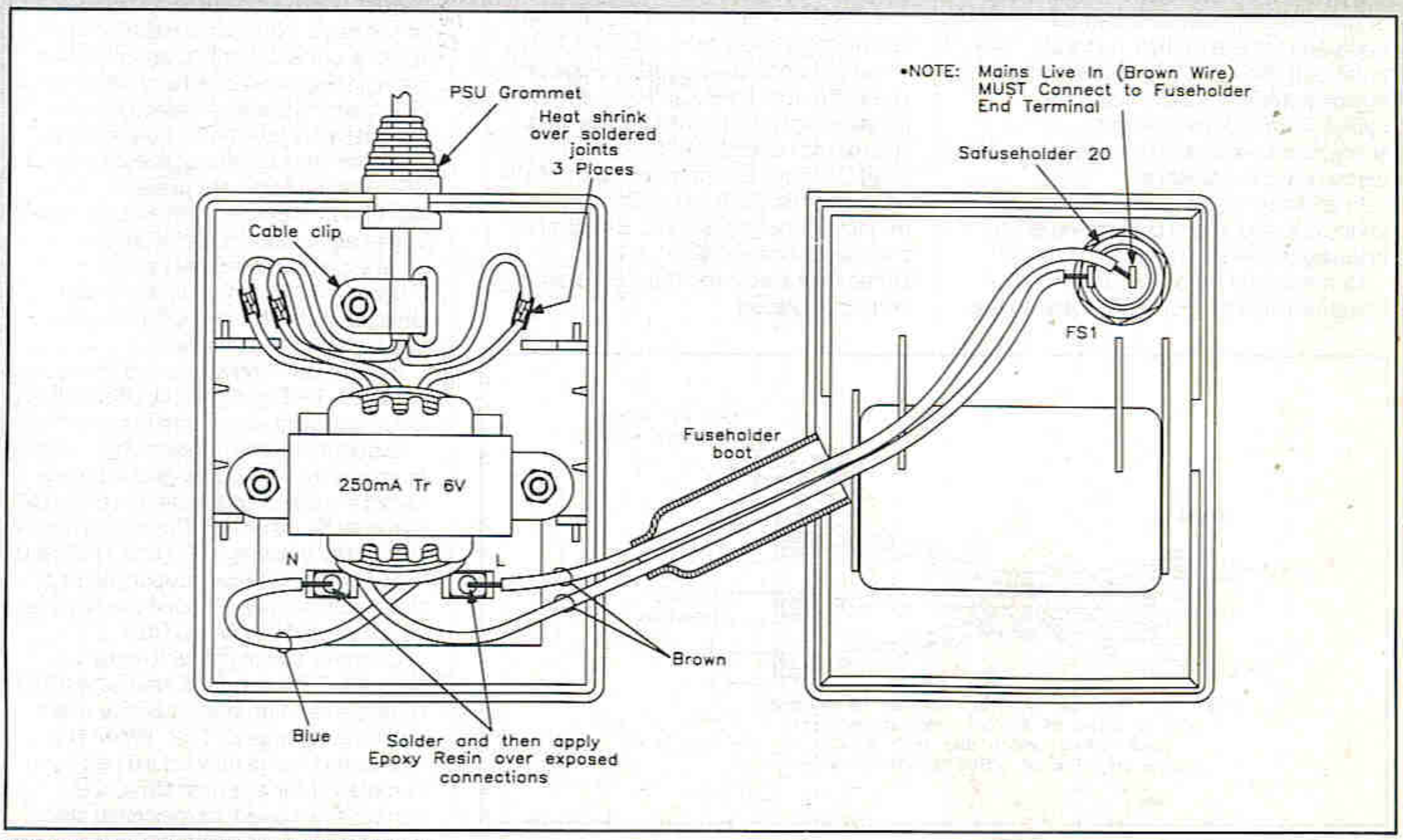


Figure 6. Assembly of the power supply unit.

enamelled copper wire. Some care is required in winding the wire onto the bobbin, as this number of turns fills the available winding space. Use of thinner wire should be avoided, if possible, as it lowers the resonant frequency of the inductor and reduces the gain of the receiver.

Assembly should follow normal construction practice with smaller components being fitted first, such as resistors, diodes, the IC socket and small capacitors, followed by the active components, such as the transistors and the +5V regulator. Larger components should now be added, such as reservoir capacitors and the mains transformer. ICs 1, 2 and 3 should not be plugged into their sockets yet, nor should the infra-red emitters be connected to the output of the transmitter.

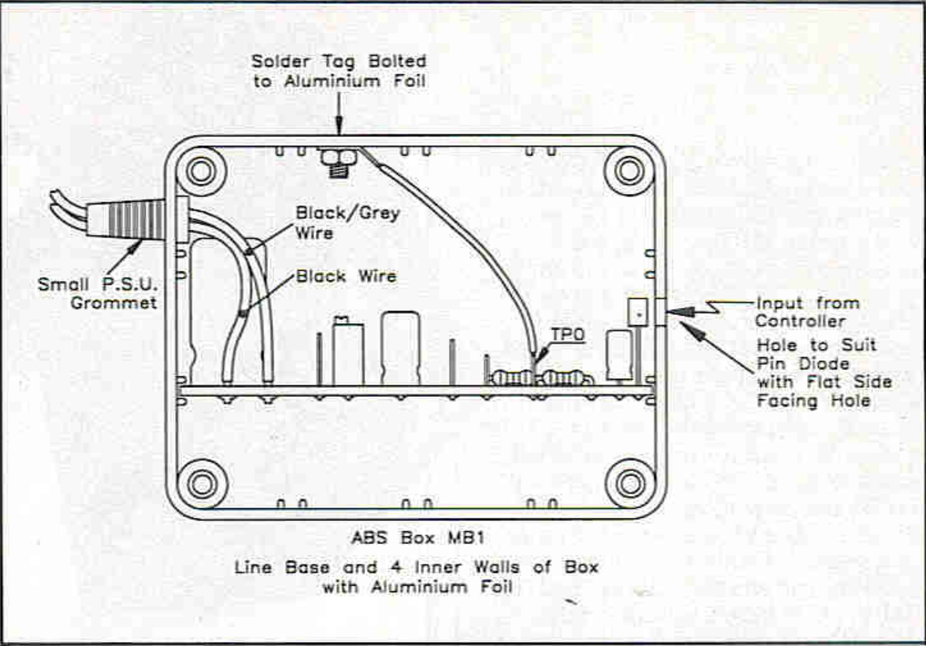


Figure 8. Assembly of the receiver unit.

Power Supply Construction

The power supply unit can now be constructed, refer to Figure 6 for details of how the unit is assembled. It is imperative that *all* connections are properly insulated as described, otherwise the safety of the system as a whole may be impaired. For test purposes only, the case should be held shut by means of adhesive tape. For safety reasons, after testing and prior to use, the two halves of the case *must* be glued together.

Testing and Setting Up

Carry out a careful visual inspection of both PCBs to ensure that all components are in their correct positions and that, where relevant, all components are the right way round. This is essential for transistors, diodes, the regulator and electrolytic capacitors.

In addition, check that all soldered joints are sound and that there is no bridging between tracks.

Connect the receiver to the transmitter with a short length of test cable. Connect the power supply unit to the transmitter. Be careful to check that you connect them the right way round. Wrong connection will not cause damage but the Medusa will not work.

DC Voltage Checks

(i) Plug the power supply unit into a 240V 50Hz mains socket. Connect a voltmeter between TP8 and ground (TP00). After switching on the mains supply, check that the meter reads: −19·6V ±1V.

(ii) Connect the voltmeter between TP6 and ground – check that the meter reads 9·5V ±0·5V. A similar check on TP7 should give a reading of 5·0V ±0·3V.

(iii) Connect the voltmeter between the 'TX I/P +' and 'TX I/P −' terminals; the meter should read 17·3V ±1·0V.

(iv) Connect the negative input of the voltmeter to 'RX O/P −', and the positive input to ground; check that the meter reads 8·2V ±0·5V.

(v) Connect the positive input of the meter to the cathode of D3, and the negative input to ground. Check that the meter reads 16·7V ±1·1V. Remove power once this test has been completed.

(vi) If any voltage is absent or outside tolerance limits, do not proceed further with these setting up instructions until the cause has been found and corrected.

Disconnect the power supply unit from the mains supply.

Operational Testing

Insert IC1 into its socket with the correct orientation. Connect an oscilloscope between TP1 and ground, and reconnect the power supply unit to the mains supply. Direct a TV, or other infra-red remote-control unit, at D1. The remote-control unit can be made to operate continuously by placing it flat on a bench close to the Medusa receiver, and standing a suitable weight (such as a battery) on one of the keys. Note that *most* remote-control units will only transmit when a single key is pressed and some units only transmit one complete burst of IR if a button is held down continuously.

Check that pulses or bursts of a 40kHz waveform are present. If no waveform is present, check that the infra-red remote-control unit is pointing at the Medusa receiver. If there is still no signal, work back through IC1a, L1 and D1 to locate the cause of the problem.

If all is well, connect the oscilloscope between TP2 and ground; check that a differentiated waveform is present.

Disconnect the power supply unit from the mains supply, and stop the remote-control unit transmitting; IC2 can now be inserted. Connect a digital voltmeter between TP0 and TP2, and reconnect the power supply unit to the mains supply. Record the reading, which should be 0V ±0·05V.

Connect the digital voltmeter between TP0 and TP3, and adjust VR1 to give a reading that is 20mV more than the voltage at TP2. When the whole setting up procedure has been completed for the first time, VR1 can be 'fine tuned' to maximise the sensitivity of the receiver by reducing

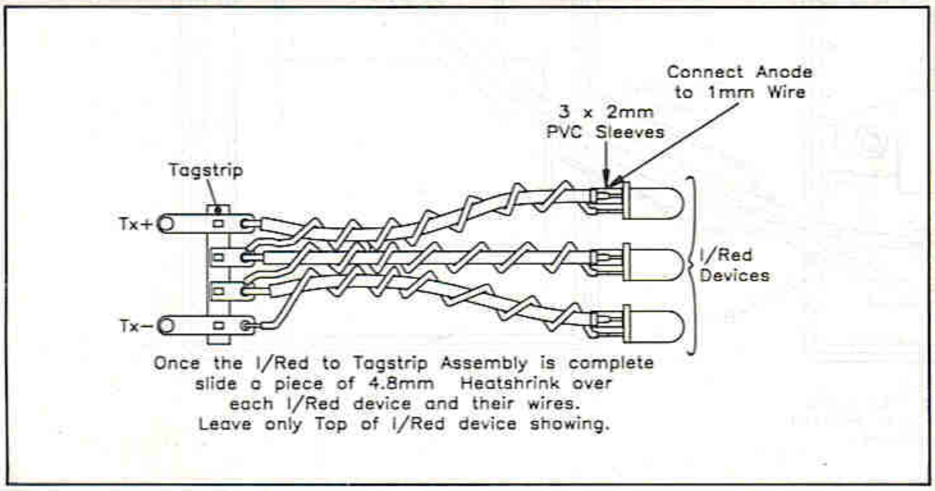


Figure 7. Preparing the transmitter LEDs.

the difference between the voltages on TP2 and TP3. Too small a difference will cause IC2 to produce a stream of false outputs; a minimum of 10mV was found to be satisfactory on the prototype.

Connect the oscilloscope to TP4, and start the remote control unit operating continuously again. Check that there are bursts of negative-going pulses, with an amplitude of about 5·5V. Connect the oscilloscope to TP5, and check that there are positive-going pulses of 12·5μs duration, with an amplitude of about 50mV.

Connect the infra-red emitters (D6, D7 and D8; note from Figure 2 that these are wired in series) to the transmitter output terminals. Move the receiver 'out of sight' from the transmitter, to avoid the risk of feedback from the emitters to D1.

After connecting the oscilloscope to TP5, check that there are positive-going pulses of 12·5μs duration, with an amplitude of about 0·7V. This completes the initial setting up procedure. Remember to 'fine tune' VR1 for maximum receiver sensitivity, if required, at this stage.

Disconnect the power supply unit from the mains supply; the assembly of the unit can now be completed. Don't forget to stop the remote-control unit transmitting, or it will flatten its battery!

Final Mechanical Assembly

Preparing the Transmitter's LEDs

Referring to Figure 7, the anode lead of each infra-red emitter is extended using a piece of 20 SWG (0·9mm dia.) wire; after soldering the two wires together, they can be covered (except the free end, of course!) with a length of 2mm PVC sleeving. A piece of 16/0·2 hook-up wire is soldered to the cathode of the LED, before being wound around the anode lead. The overall assembly can now be covered with heat shrink sleeving, but do not forget to leave the emitting end of each LED exposed! Apply heat to shrink the sleeving; this should be carried out carefully, but quickly to avoid the risk of damaging the LEDs.

The three infra-red emitters are wired onto a 4-way tag strip, which is bolted to the transmitter case (on the prototype, the assembly was fitted onto the PCB). A suitable slot should be cut to allow the case lid to be fitted. Two short leads should be connected between the tagstrip and the relevant pins on the transmitter PCB. Ensure that they are connected the right way round – the end anode (D6 in Figure 2b) is connected to the 'LED +' terminal, while the end cathode (D8 in Figure 2b) is connected to the 'LED –' terminal.

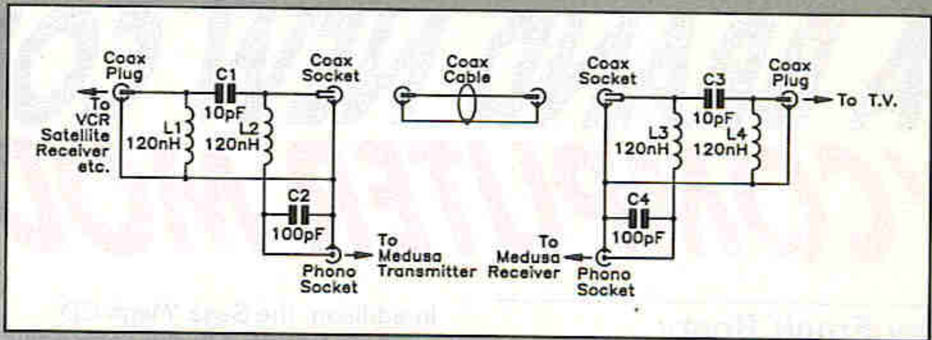
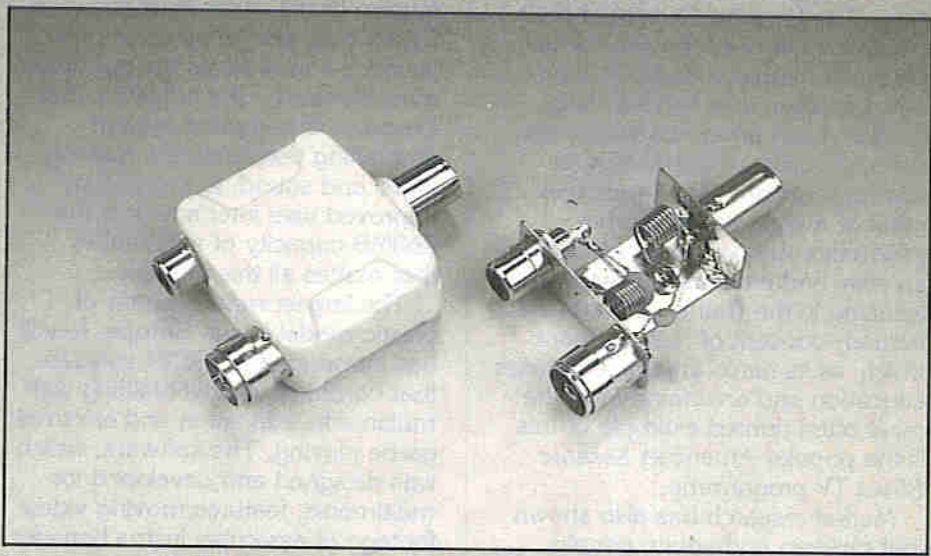


Figure 9. Circuit diagram of signal combiner/splitter units.



Signal combiner/splitter units.

Transmitter Assembly

One end of the connecting cable should now be threaded through a grommet fitted into a suitably drilled hole in the transmitter case. Use a cable tie to prevent it from pulling out. The ends should be connected to the transmitter input terminals. This replaces the short temporary cable that was used during setting up. Similarly, repeat the process for the power supply cable. As an alternative to hard-wiring the transmitter, receiver and power supply unit, suitable connectors may be used. The transmitter PCB can now be bolted in place and the lid of the transmitter fitted.

Receiver Assembly

The receiver box details are given in Figure 8. The receiver assembly has one critical requirement – the circuit is sensitive to radiated noise (e.g., from mains wiring), and therefore requires some screening to protect it from such spurious inputs. This is simply achieved by sticking aluminium cooking foil to the inside of the plastic receiver box and connecting this foil, via a solder tag bolted to the inside of the case, to the terminal on the receiver PCB. Care must be exercised to ensure that the foil does not come into contact with the solder joints on the underside of the PCB. A more elegant (but expensive!) solution would be to paint the inside of the case with conductive nickel screening paint.

The Coax Connection

Often, it is inconvenient to run extra cables, so a method of using the existing remote TV coax cable was thought to be desirable. What is required is a combiner/splitter unit, fitted at both the transmitter and receiver ends that allows both Medusa and TV signals to co-exist happily. This is achieved using simple filters, as shown in Figure 9. Each capacitor and inductor pair form either a low-pass or high-pass filter. The low-pass filter allows the Medusa signals to pass whilst blocking the UHF TV signal. Conversely, the high-pass filter allows the UHF TV signal to pass whilst blocking the Medusa signals. These may be conveniently constructed in the shells of old TV signal splitters as shown in the photograph. The inductors are made by winding seven turns 0·71mm EC wire around a ³⁄₁₆in. former.

The Medusa in Use

When the Medusa has been installed, the Medusa receiver's 'snakes' should be adjusted so that all the items of equipment, to be controlled from the remote room, respond to the transmissions from Medusa. The infra-red polar radiation pattern of each emitter is only about 10° wide, so careful adjustment will be repaid with more reliable operation. If each piece of equipment to be controlled is located in a different part of the room, the emitters should be aimed accordingly. Happy viewing!

Medusa 6 parts list on page 31.

A BRAND NEW CONCEPT IN 'COMPUTER MODELLING'

by Frank Booty

Computers are a fact of life. The Personal Computer (PC) has changed the way of life for many people. Indeed, PCs are now common in schools to help children learn about the world, and the application of technology in solving problems. The inquisitive mind of a child demands that information be presented to them in an easy and entertaining manner – resulting in the (rather unfortunately named) concept of 'edutainment' which, as its name implies, combines education and entertainment. The most often quoted example of this is the popular American *Sesame Street* TV programme.

Market research has also shown that children and young people enjoy the excitement of computer and video games, whilst at the same time possessing innate desires to be creative. The idea of putting modelling (kit cars, planes, etc.) onto a computer was exhaustively tested. The results of research indicated that children also sought 'a game to bring the kit to life'. However, to get all this onto one floppy disk was not possible. With the increasing acceptance of CD-ROM (Compact Disc Read-Only Memory), problem has been solved.

CD-ROM

CD-ROM has the *appearance* of a normal music CD; the technology is exactly the same. CD-ROM, though, is not only used for sound but words, pictures, animation and soft-compressed video as well. The sound and pictures on the disc are read by laser to give excellent quality reproduction and, just like the music CD, the sound and images cannot be changed or erased. The staggering advantage of CD-ROM is its capacity – 650MB of data, which is enough to store 330,000 pages of text, 72 minutes of continuous music, or three full length pop music videos.

In 1992, according to market research, there were some 6,000 CD-ROM drives in use. By the year 2000, there are expected to be 20 million units as new computers are sold with built-in CD-ROM drives.

In addition, the Sega 'Mega CD' product, for use with the company's game console, is bringing the system to the mass market. CD-ROM is said to be so popular because it introduces the possibility of multimedia – the adjective that describes a computer system combining text, pictures, moving video and sound, to provide an improved user interface. It is the 650MB capacity of a CD-ROM that makes all this possible.

The largest manufacturer of plastic model kits in Europe, Revell, has introduced CD-ROM software that combines model building with multimedia education and electronic game playing. The software, which was designed and developed for multimedia, features moving video footage of assembly instructions for building a model car on-screen or in reality, and combines this with a challenging road and track race.

A Flying Start

The first title *Motor Stars,* released in late summer 1993, features four exotic sports cars – the Bugatti EB110, the Porsche 911 Slant Nose, the BMW Nazca M12, and the Lamborghini LP500S.

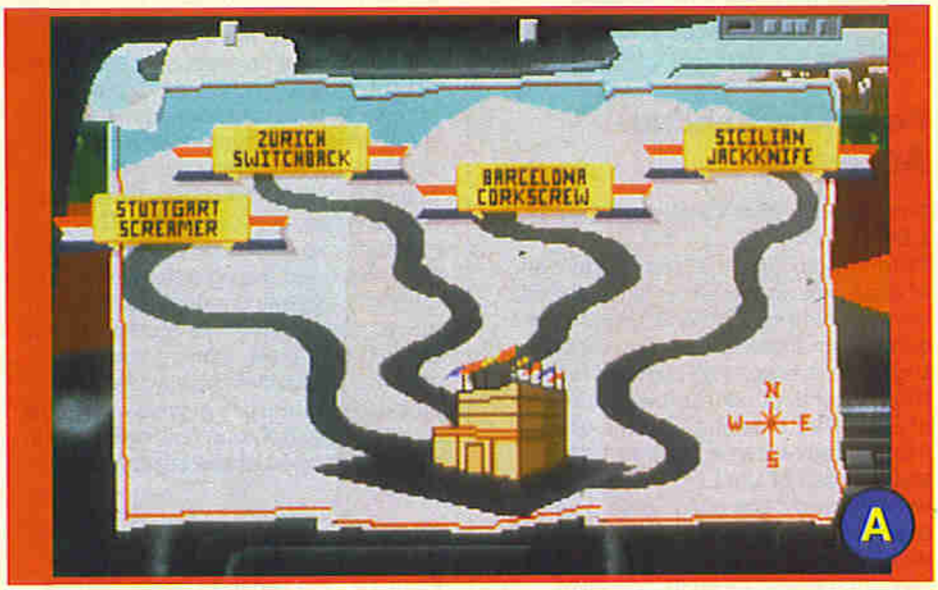
Other new titles include:

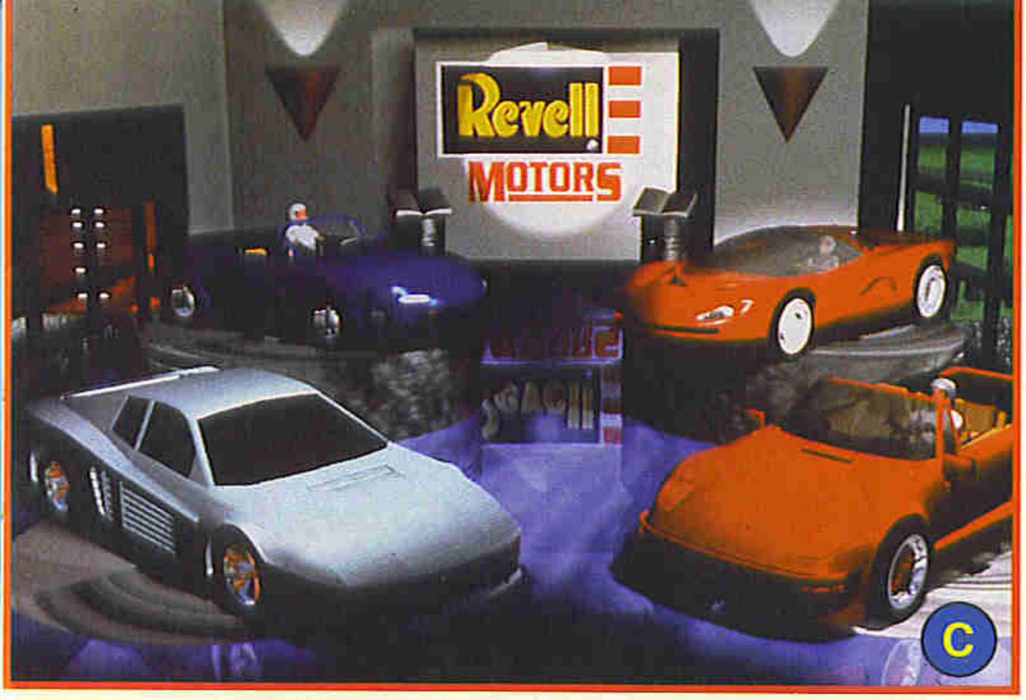
Back Road Racers, released during September 1993 (features 1970 Boss 302 Mustang, 1971 Hemi Cuba, 1967 Chevelle and 1967 Malibu SS Pro Street).

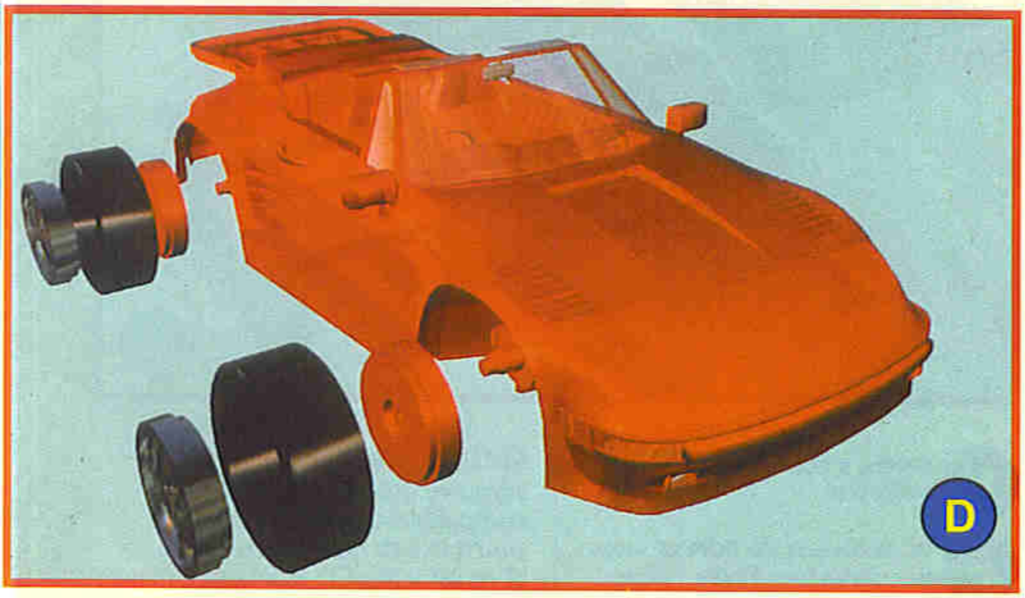
Operation Airstorm, due for release this month (features AH-64 Apache Helicopter, F-14A Tomcat, FE Strike Eagle and F-117A Stealth).

Secret of the Dinosaurs, due for release during January 1994.

Space Raiders, due for release during February 1994.







A Choose the race track.

B View from the driving seat.

C The Revell *Motor Stars* 'Showroom'.

D 3-D assembly diagrams assist model construction.

Each software title includes animated three-dimensional assembly instructions for all four featured cars or planes. The moving video assembly feature shows users how model parts fit together and provides tips on painting, gluing and detailing as well as information about the real cars or planes. Each software title also includes a driving or flight simulation game with four track or flight-path options that can be played with the featured cars or planes. The CD-ROM software features motion picture video filmed with actors and actresses, three-dimensional animation, colour graphics, and digitally-recorded sound effects and original music.

To create the multimedia software, Revell worked with Floydesign (a multimedia development company based in Atlanta, USA) and Viewpoint Animated Engineering (a creator of datasets, which are the digital coordinates used to create three-dimensional graphics).

Model Making

To enter the realm of model making or game playing, users enter the on-screen showroom, where 3-D images of the four featured cars appear. Users then drive the car of their choice into the garage to build the model using the animated assembly instructions, or drive to the race track to begin the game. The assembly instructions let the builder see how the different model parts fit together, in the proper sequence and position, at different speeds from different perspectives. Users can view the full assembly process as well as the construction of each sub-assembly.

A visual representation of the way in which the model parts fit together is easier to understand than following written instructions. The assembly section of the software also provides video model-making tips such as what glue to use on which parts, how much glue to apply and how to apply it, as well as how to add realistic details to the car or plane, such as bullet holes, mud or rust. By accessing the painting option, model builders can see how the car looks in different colours before painting their model.

For entertainment, as well as educational purposes, users can access facts about each subject, including its technical specification and how it performs. Furthermore, users can access information regarding the function of the different parts of the car or plane they are building.

Driving Simulation Game

To play the *Motor Stars* driving game, drivers' first select from one of four tracks in which to race (the Stuttgart Screamer, the Sicilian Jack-knife, the Zurich Switchback or the Barcelona Corkscrew). Then the driver must complete a road race – dodging obstacles and often out-running the police – to arrive at the track, within a set time limit. Once at the track, the driver races against five on-screen competitors, each racing the same type of car, in an action-packed five-lap race. There is a choice of a practice lap, a single five-lap race, or a championship series. Familiarising oneself with the track is possible utilising the helicopter camera facility. The computer will generate random weather conditions like snow and rain, which of course will affect the way the car handles. The winner is congratulated by full motion video of a girl wielding a trophy. Additional video scenes with policemen, petrol attendants, sportscasters and pit crew members add realism to the game.

On the version tested, the heavily-overdone Americanisms and the sexist nature of the trophy presentation were excessive. Revell says it is introducing European versions, however. Indeed, the products will be available in three European languages – German, French and English. Text and speech of the appropriate language will be substituted, and even the video actors will be re-shot to reflect language and cultural differences.

By using the latest 3-D animation technology, the driver's point of view changes throughout the game. This gives the impression of being 'behind the wheel' as the driver talks to the pit crew, spins out during a crash or navigates past an obstacle in the road.

Before and during the race, drivers can modify their car to change its performance in response to randomly-introduced weather and road conditions. Modifications include switching between automatic and manual transmission, and selecting from five spoiler settings and three tyre options. Drivers also decide how much fuel to start the race with and

whether or not to refuel during the race. To add as much realism as possible, the actual technical specifications of the real car – acceleration performance, braking characteristics and fuel economy – have been built into the game.

Hardware Requirements

The CD-ROM software can be used on any IBM-compatible PC that meets multimedia standards. Revell plans to create software that is compatible with other systems, including Sega, Apple, Commodore Amiga CDTV, CD-I, etc. The products are being distributed through Revell's network of toy stores and hobby shops as well as game stores and multiple retailers.

The basic hardware requirements are:

IBM PC/Compatible Clone: 386SX processor, 4MB of RAM (you can get by with 2MB), DOS 5 or later, 30MB of hard disk space, Super VGA graphics card and monitor, CD-ROM drive, sound card (one of Soundblaster series, Pro Audio Spectrum series or Ad Lib Gold) with speakers or headphones, and mouse. A joystick is an option.

E Getting a ticking off from a traffic cop!

F PC Multimedia CD-ROM kit which is available from Maplin

Software

The software includes assembly instructions, painting options, 'fun facts', model-making tips, an on-line catalogue (photographs and descriptions of 50 Revell and Monogram model kits), an interactive glossary (users can learn about the function of different car or plane parts), and the simulation game.

The suggested retail price for each package is £59.95. The company aims to offer the products on as many hardware systems as possible, and in a variety of languages.

For further information, contact your local Revell model dealer; in case of difficulty Revell can be contacted at the address below:

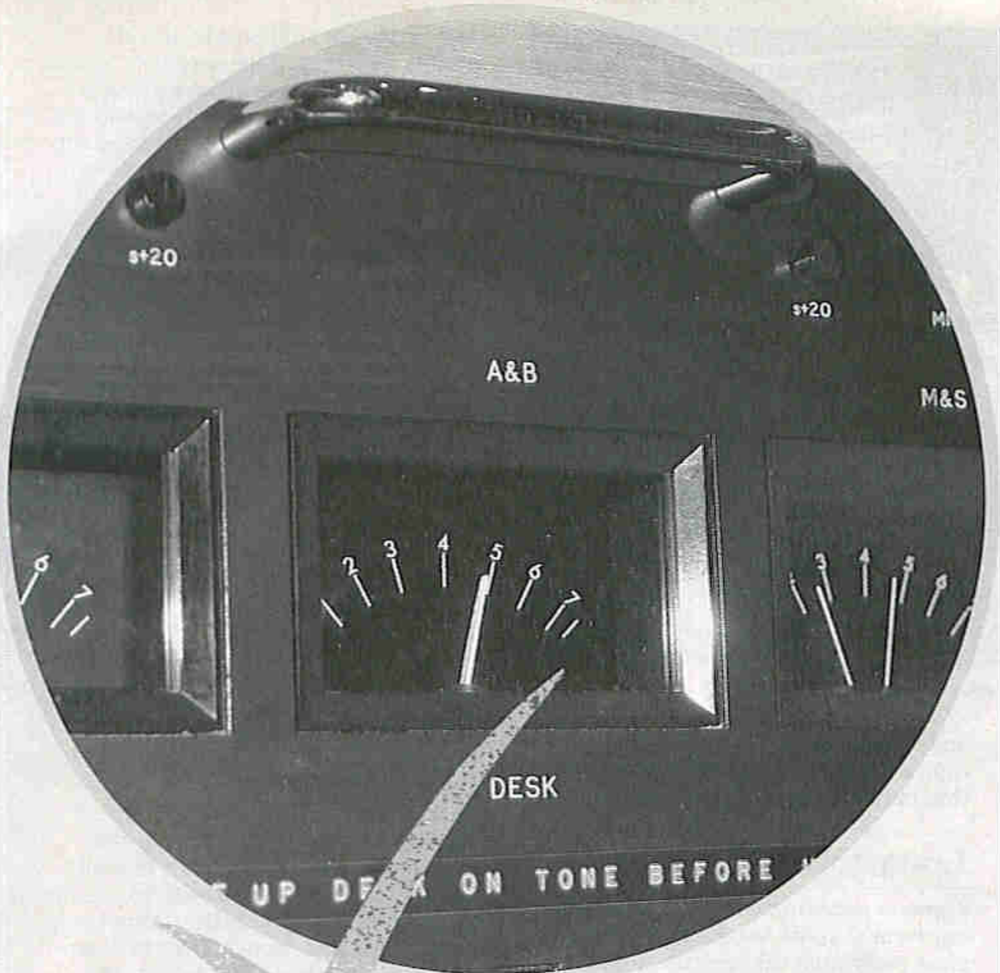
Revell (GB) Ltd.,
Foster House,
Maxwell Road,
Borehamwood,
Herts, WD6 1JB.
Tel: 081 207 1213
Fax: 081 207 1517

Getting into Multimedia

If you've got an IBM PC or compatible clone and you would like to get into the world of multimedia/CD-ROM, then Maplin can get you off to a flying start! The range of equipment available includes a CD-ROM drive (ZG84F Price £189.95 H2) and a complete multimedia/CD-ROM kit (RT37S Price £499.95 H). See the new 1994 full colour Maplin Catalogue for full details of the new expanded range of computer hardware/kits.

Revell Christmas Competition

If you'd like to have the chance of winning a Revell *Motor Stars* CD-ROM worth £59.95 or Revell Model Kits, each worth £11.50, for the Bugatti EB110, the Porsche 911 Slant Nose, the BMW Nazca M12, and the Lamborghini LP500S, then now's the time to enter our super *Revell Christmas Competition!* There's a total of six prizes up for grabs: two *Motor Stars* CD-ROMs and one each of the four car model kits. All you have to do to enter the *Revell Christmas Competition* is answer the four questions on page 30,



A GUIDE TO PROFESSIONAL AUDIO PART NINE

by T. A. Wilkinson

Last month, we examined various aspects of practical recording equipment, this month, we consider both studio and outside broadcast recording.

Multitrack Systems

Not so many years ago, multitrack tape recorders were considered as only for the serious user with plenty of money. Today things are very different and multitrack recording is possible with only very modest investment.

At the bottom end of the multitrack market are the 'Porta Studio' type cassette based machines, aimed at the home user. These units normally offer up to four recordable tracks on the cassette tape, with the ability to bounce audio from track to track for over-dubbing. Many of these machines are equipped with comprehensive mixer facilities for both line and microphone sources and some even offer MIDI facilities.

Squeezing several tracks of audio onto cassette tape is fraught with problems, and so there are obvious compromises in the quality stakes. With the addition of DBX or Dolby noise reduction systems, the use of high quality tape, and careful setting of recording levels, provides reasonably acceptable results. It must be remembered however, that these systems are intended for musicians wishing to record demo tapes and the like at home, and are therefore limited to this type of use.

Moving up-market a step, come a range of relatively low-cost open reel analogue multitrack recorders, again aimed at the semi-professional recording and home studios. Tascam and Fostex lead the way in this very lucrative area of the market-place. These machines use ½in. tape running at 15in. per second and offer line inputs and outputs on unbalanced phono or jack connectors. Like the cassette based machines, best results will be obtained only with the use of a noise reduction system.

Typical of this type of recorder is the Tascam TSR8, 8 track recorder and the Fostex B16, 16 track recorder. Having used and maintained several of these types of machine, I can say that quite good results are possible, but they do need regular line-ups and are not at all tolerant of dirty heads.

It is now possible to cram an amazing 16 tracks of audio onto ½in. tape but with obvious compromises, however, for its intended user. These types of machines offer excellent value for money and represent recording flexibility and possibilities only dreamed of ten years ago. In fact a number of CDs by very well-known artists are available, which were recorded using this type of 'budget equipment'. I – and presumably the bands involved – wonder just how many people would realise simply from listening to these on a normal Hi-Fi system, that these recordings were not made using the latest 2in. 48 track recorder?

Professional Systems

The next step up are the real professional big boys' recorders, 8, 16, 24 and more tracks being laid down onto 1in. or 2in. tape. In professional terms, 1in. tape is considered as a minimum acceptable standard for 8 tracks and 2in. for 16 and 24 tracks. Typical machines in this category come from manufacturers such as Ampex, 3M, Soundcraft and Studer. An example of a Studer machine is illustrated in Photo 1. This is expensive hardware and even second-hand machines retain their value quite well.

It is impossible within the limits and context of this article to describe in any detail the significant complexities involved in multitrack recording, thus the following offers only a basic insight into this fascinating area of recording.

When considering the concept of multitrack recording, it is easy to believe that 16 or 24 tracks will be more than sufficient, but in reality this is rarely the case and there never seems to be enough tracks to spare!

Think about this; consider a band of say six musicians recording an album or whatever, and then consider how many tracks of a multitrack recorder will be needed. Let's assume the band is a modern unit with sequencers, synthesizers, guitars, saxes, a bass and a drum kit. The track allocation might be go like this, give each of the bass, sax, guitar and synthesizer a track each, then say four tracks for the drum kit. Ah, but then there are the vocals, say two tracks, and what about a couple of spare tracks for track bouncing, and, of course, there may be need for

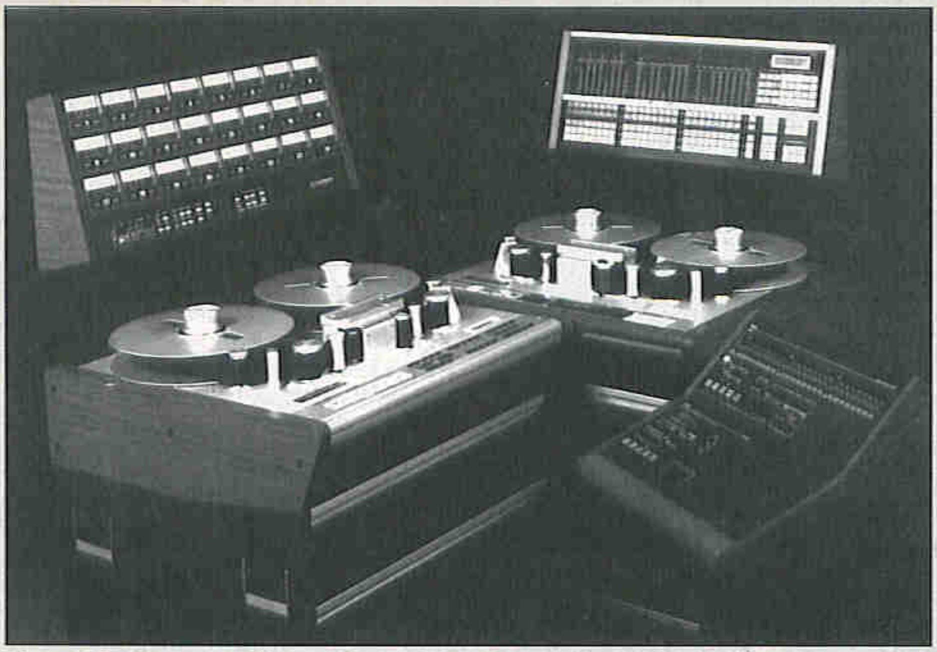


Photo 1. Big boys toys, high quality multitrack recorders by Studer.

a timecode and click track! Our valuable tape tracks are eaten up at an alarming pace. Justifiably professional recording studios go for the biggest multitrack within their reach, and invariably maximise on their use to justify the significant capital outlay.

There are ways of increasing the available track space of a multitrack machine, and one way is to use the age old technique of 'track bouncing'. For example, a recording may contain several similar recorded tracks such as vocal harmonies. On an eight or sixteen track machine, these may take up too much valuable track space for each to be allocated their own track. 'Track bouncing' allows each part to be recorded separately on its own track initially. Once all of these parts have been recorded they can be sub-mixed together and 'bounced down' to one or two tracks thus freeing several tracks for other purposes.

The big problem with track bouncing is that each time a track is bounced to another, a little more noise is added to that track and if several track bouncing operations are involved, the problem is quite noticeable. Some help is offered by the use of noise reduction systems, and it is customary to use these during track bouncing.

The other drawback with track bouncing is that once all of the tracks have been bounced to a single or pair of tracks, there is no going back. Once the original tracks have been erased, it is of course not possible to do a 're-mix'; the end result must be accepted or be completely stripped from the tape and re-recorded.

Studio track space can be expanded by synchronising together several multitrack machines, but this will necessitate the recording of a timecode track on each machine, allowing the recorders to be 'locked together' for perfect synchronisation. This can be quite an economical way of quickly increasing available track space as these additional recorders can be hired in as and when required, thus saving the capital outlay of purchasing machines that may only be used now and then.

Location Recording

Location recording is best described as any form of audio recording which takes place away from the security of a fixed base. Simple mono radio interviews in the street to highly complex recordings of orchestral concerts at large venues, all count as location recording.

The most basic set-up is the common-place radio journalist street interview or 'vox pop'. In these situations several important equipment factors must be considered.

Recording on the Move

Firstly radio (and other) journalists and reporters are essentially non-technical people, this is not a criticism but merely an observation. A reporter will naturally be less concerned with the equipment he or she may be using and rather more interested in their own creative ability to produce an informed and entertaining piece of listening material.

As such the equipment they use must be simple to operate and reliable. Equally it must be robust enough to take repeated everyday knocks and produce essentially broadcast quality results. The less equipment worries they have, the more relaxed they will feel thus giving the best circumstances for a good result.

By far the most common of portable tape recorders for journalist/reporter use, is the range of Uher machines available, currently the most popular of these is the single track Uher Report Monitor 4000 as shown in Photo 2. Although the basic mechanical design dates back many years, the electronics have recently been updated.

The machine records onto 5in. spools of ¼in. tape and offers three heads to allow for off-tape 'confidence' monitoring via the separate replay head. Facilities are simple but sufficient to provide quality recording. Tape transport control is by piano type keys allowing forward and reverse spooling and a simple pause button which takes the pinch wheel out of contact with the capstan – no fancy logic control here!

A simple peak reading VU meter, together with a rotary record level knob, sets input levels, and there is also an in-built limiter with two user selectable limiting ranges.

Monitoring of source (input) or tape (via replay head) is possible using the internal loudspeaker or via the headphone jack. The range of machines is also well blessed with a range of line in and out sockets together with various AV interface sockets.

The Uher series offers reliable service and easy maintenance but with one major criticism – the choice of microphone input socket. Fitted as standard is a locking DIN type connector, this is mounted directly onto a thin and rather flimsy printed circuit board. Pressure exerted on the normally permanently attached microphone plug flexes the PCB, causing great stress on the board tracks resulting in eventual damage to the PCB and intermittent microphone signal continuity. The only permanent solution is to retro-fit a more substantial microphone input connector, and there is just enough room to fit an XLR connector below the record level control.

Uher portable tape recorders once dominated the portable recorder section of the market as there was no real alternative, and will no doubt continue to be the industry standard for some time yet. If nothing else, these machines are ultimately maintainable I regularly come into contact with Uhers of 15 to 20 years old! However, with the cost of a new single track machine in excess of £1,200, their value for money rating is questionable when compared with modern digital competitors.

Other portable recorders in frequent use by radio journalists include a range of very compact cassette machines. The use of cassette format is considered very much of a compromise in professional terms and particularly so within the broadcasting industry. This is not without justification as cassette still does not match the quality of the ¼in. format. However, situations exist where it is desirable to use a small discrete recording system. A radio reporter may need to blend into the surroundings of a picket line, demonstration or animal rights protest and not be obviously identified as such, in order to protect their own safety, but still be expected to produce a report from the front line. Or it may be that material must be collected whilst on the move, parachuting, canoeing or whatever!

Using a compact cassette based recorder may be the solution to all of these situations, they are discrete enough to be concealed in a pocket and light enough to be carried for miles, neither of which a Uher type machine is. The big problem with using cassette format is editing. There is still not – and never will be – any successful method of 'cut editing' cassette tape. Therefore, material recorded in the field must be first transferred onto $^1/_4$in. format before any editing or processing can take place. Obviously tape to tape transfers in this way reduce the quality on each successive transfer, and considering cassette as less than perfect to start with, this situation is less than ideal, and one with which many people feel unhappy.

Probably the most popular of journalists cassette recorders is the Sony WM D6C Professional Recording Walkman – illustrated in Photo 2. It has now been around for a number of years and was probably the first of this type of machine to be considered as producing acceptable results for radio reporting and has thus become something of a benchmark.

It is capable of good clean recordings (considering the format) and has a good reliability record, it weighs less than a pound and is comparable in size with any other domestic personal stereo unit. Facilities are reasonable with a choice of Dolby B and C noise reduction (one of which should always be used) and caters for all tape types. Monitoring facilities are rather limited with no internal loudspeaker, and only two tape heads means off tape monitoring is not possible. Its one major failing has to be, again, the microphone input connector, this being a 3·5mm minijack – this is the least reliable area of the machine with frequent replacement being necessary.

However, enterprising professional audio specialists ASC Ltd., of Aldermaston, manufacture and market a solution to this in the form of a unique carrying case package. This includes monitoring loudspeaker, decent XLR connectors and storage space for accessories. Obviously the addition of this increases the overall size, but this is acceptable to some in view of the enhanced facilities.

Larger Machines

Moving on from the reporter type machines are the more elaborate quarter inch open reel format portable recorders for use where no compromise quality is required. The Nagra range of machines are typical, superbly engineered with all the functions and facilities for high quality recording. Many versions are available from full track to stereo, all with precision and resilient components for high reliability. Most of the Nagras incorporate spare parts and circuit diagrams for true 'field repairs'!

These machines are very expensive and are intended for more complex portable use, perhaps with the addition of a small mixer, and thus are not standard issue reporter-ware, but mainly used by TV/film crews and location recording engineers, to be treated with the respect they deserve.

There are situations which require more than a simple tape recorder and microphone package but do not warrant the turn out of a mobile recording vehicle. Typical examples of this type of situation include a question and answer session in a local village hall, perhaps a small church choir or a political debate. All of these will need a small number of microphones, compact portable mixer and some kind of recorder. A schematic for a small scale recording system is illustrated in Figure 1, whilst Photo 3 shows a complete package suitable for use on this sort of job.

All the equipment can be battery powered where there is no mains supply, and the whole lot, except any necessary cable drums, packs into two small transit cases. The mixer has six inputs with stereo and auxiliary outputs, all of which are balanced. The recorder is the very good TEAC DA P20 DAT machine,

Photo 2. **Professional portable recorders. Left to right (rear) Nagra E, Uher 4000, (front) Sony WM D6C cassette recorder, Teac DA-P20 DAT recorder.**

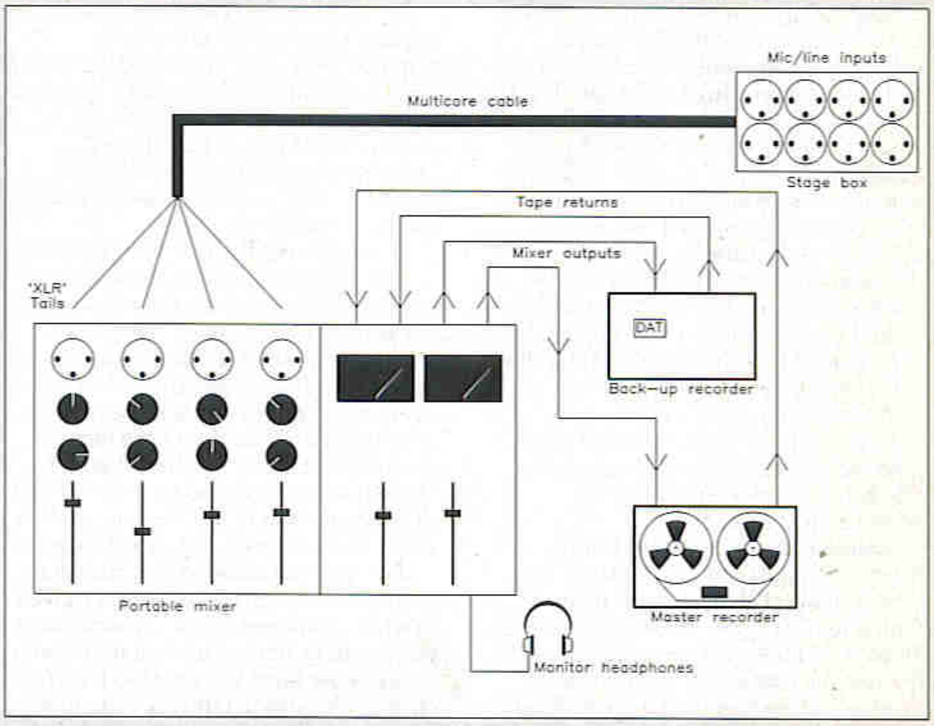


Figure 1. Small Scale Location Recording System.

Photo 3. Compact 'budget' location recording equipment system using battery powered mixer and DAT recorder.

the package is capable of good quality stereo recordings with the minimum of fuss.

Highly complex, large scale location recordings will require more than is possible with moderate portable gear, and thus will demand the use of a mobile recording vehicle used as a control room.

The use of such a facility means that setting-up (rigging) time can be kept to a minimum, a mobile simply needs to turn up and reel the cables and microphones required for the concert. On the other hand a fully portable set-up requires much unpacking of equipment with subsequent connecting together of mixers, processors and tape recorders and the construction of an on-site 'control room' biting into many valuable hours.

Typically a mobile recording vehicle will contain the necessary equipment, permanently connected together to allow full control room facilities.

Mobile Recording Studio

The following study – outlined in Table 1 – is based around a BBC type 'C' vehicle used for medium scale recording and Outside Broadcast (OB) use. The C type is constructed on a Ford Transit long wheelbase van with a height extension to the roof and the addition of ambulance type side doors. Rear doors open in the conventional way giving access to cable drum storage area, termination panel and the rear of the mixing desk. The left-hand door has a small hinged cable flap allowing cables to be passed into the vehicle whilst the doors remain locked shut.

Although the basic equipment is quite good, other units such as digital tape recorders, processing gear, special microphones are available as the situation demands.

Location recording of any kind is littered with anxieties and pitfalls. Whilst many of these may be no more than a minor niggle, unless an organised and logical method of operation is used, the real big problem is likely to be lurking just around the corner waiting to get you!

24.8.2 Mixing Desk.
2 x Studer B67 Stereo Master Recorders.
Lexicon Digital Delay Unit.
Rogers LS 5/9 Monitor Loudspeakers.
Stereo Cassette Machine for Back-up Copies.
Full Jackfield.
Comprehensive Talkback Facilities.
Glensound Output Monitor Unit.
Mains Supply Monitor Panel with earth Leakage Detection System.
50 Metre 26 Pair Multicore Cable.
100 Metre Mains Supply Cable.
Several Hundred Microphone Cables
Multicore Termination Panels (Stage Boxes).
Colour Video Monitor.
2kW Fan Heater.
Fire Extinguisher/First Aid Kit.

Other equipment carried includes:
3 Dozen Microphone Stands.
Full Range of Studio Quality Microphones.
DI Boxes/Microphone Splitters.
Tool Kit.
Full Set of Technical Drawings.
Several Hours of Tape.

Table 1. Equipment typically required for Outside Broadcast.

Firstly, get organised! Establish at an early stage before any firm arrangements have been made whether the venue is suitable for the purpose. It's no good trying to record anything acoustic in a non sound-proofed venue located directly under the flightpath of a busy airport, unless of course you really want to capture the accompanying aircraft noises!

Is a mains supply necessary? Can the whole session be done with battery power? If a mains supply is needed, how far away is the recording gear likely to be, and what sort of connector is required. Is it safe? Where is the fusebox or breakers and is there a coin operated electricity meter (honestly)! Many churches and village halls have surprisingly ancient mains supplies and these may need to be tested before any connections are made.

If you are not familiar with a venue or you are unhappy with the answer to your probing questions, then the safest bet is to do a site visit or 'recce'. This soon gives a feel of the place and a picture of what equipment will be needed and routes for running cables soon begin to form. It's a good idea on such occasions to make notes about the venue accompanied by a sketch and directional notes of the location, and hints on the nearest pub or eating place.

Having been satisfied that the venue is suitable, thought should now be given to what equipment to use. In some cases choice will be limited to what is available, on the other hand you may be spoilt for choice or be able to hire any extra bits and pieces. Often the way to decide is to sketch out a plan, this should include rough positions of artists and a basic microphone layout, a comprehensive list of all equipment likely to be used and the required interconnecting cables. As far as is practical, allowances must be made for possible equipment failure, whilst it may be impractical to lug along another mixing desk, at the very least take extra cables, connectors and microphones. Don't rely on a single tape recorder either, take a back-up machine even if it's only a basic unit and use it simultaneously alongside the main recorder for recording safety copies. When the session is over, it's a good practice to pack the master tapes and back-ups separately or even send them back to base with different people, this way if one set gets wiped or lost the other set is at least likely to survive.

When the big day arrives and your packing the gear for transport, refer to your previous notes and sketches and tick equipment off the list as it goes into the flight cases, the venue may be a long way from base and there probably will not be time to return to collect forgotten bits and pieces. Make sure you have enough of the right sort of tape – the master and back-up recorders might be using different formats!

Finally, make sure that you are well briefed on what results are expected, and be sure that all concerned know exactly where they are going and the timescale of events.

Next month we conclude the recording section of the series delving into the devious world of digital – and tapeless! – recording.

Continued from page 26

write your answers, your name and address on a post card (or sealed down envelope), affix a stamp and post to: *Revell Christmas Competition,* The Editor, *Electronics – The Maplin Magazine,* P.O. Box 3, Rayleigh, Essex, SS6 8LR. Please indicate whether or not you have a CD-ROM equipped PC. Your entry must reach us by 31st December 1993. Prize winners will be the first six correctly answered entries drawn after the closing date. No cash alternatives will be offered. Winners will be advised in writing; a full list of winners will be published as soon as possible afterwards.

Revell Christmas Competition

1. What plastic are most model kits made from?:
a) Poly vinyl chloride
b) Poly tetra fluro ethane
c) Polythene
d) Polystyrene

2. When was CD first introduced in the UK?:
a) 1983
b) 1973
c) 1993
d) 1977

3. How big is a CD?:
a) 8in.
b) 4¾in.
c) 3½in.
d) 5¼in.

4. Which of the following companies collaborated with Sony to developed CD?:
a) Amstrad
b) Ferguson
c) Philips
d) JVC

Medusa 6 continued from page 23.

MEDUSA PARTS LIST

RESISTORS: All 1% Metal Film (Unless specified)

R1	10k	1	(M10K)
R2	33k	1	(M33K)
R3	470k	1	(M470K)
R4,8	4k7	2	(M4K7)
R5	47k	1	(M47K)
R6	150k	1	(M150K)
R7,10	470Ω	2	(M470R)
R9	330Ω 3W Wirewound	1	(W330R)
R11	1k5	1	(M1K5)
R12	2k7	1	(M2K7)
R13	30k	1	(M30K)
R14	220Ω	1	(M220R)
R15	1k	1	(M1K)
R16	2Ω7	1	(M2R7)
R17	150Ω	1	(M150R)
RV1	1k 22-Turn Cermet Preset	1	(UH23A)

CAPACITORS

C1	10µF 50V Radial Electrolytic	1	(FF04E)
C2	1nF Polyester Layer	1	(WW22Y)
C3	100pF Ceramic	1	(WX56L)
C4,12	100µF 10V Radial Electrolytic	2	(FF10L)
C5	100nF Polyester Layer	1	(WW41U)
C6	220µF 16V Radial Electrolytic	1	(FF13P)
C7	470µF 35V Radial Electrolytic	1	(FF16S)
C8	1nF Polyester Layer	1	(WW22Y)
C9	47nF Polyester Layer	1	(WW37S)
C10	390pF 1% Polystyrene	1	(BX52G)
C11	4,700µF 16V Radial Electrolytic	1	(FM83E)
C13	1,000µF 35V Radial Electrolytic	1	(FF18U)

INDUCTOR

L1	420µH comprises:		
	LA4345 Inductor Core	1	(HX06G)
	DT2470 Bobbin	1	(HX07H)
	DT2396 Clips	2	(HX08J)
	0·15mm 38 SWG EC Wire	1 Reel	(BL44X)

SEMICONDUCTORS

IC1	TL072CN	1	(RA68Y)
IC2	LM311N	1	(QY09K)
IC3	74HC221	1	(UB52G)
IC4	µA78L05AWC	1	(QL26D)
Q1,3	BC182L	2	(QB55K)
Q2	BC212L	1	(QB60Q)
Q4	BC140	1	(QB37S)
D1	Infra-red Photodiode	1	(YH71N)
D2-5	1N4148	4	(QL80B)
D6-8	Infra-red Emitter	3	(YH70M)
D9,10	1N4002	2	(QL74R)
D11	BZY88C8V2	1	(QH12N)
D12	BZY88C18V	1	(QH20W)

MISCELLANEOUS

DIL Socket 8-pin	2	(BL17T)
DIL Socket 14-pin	1	(BL18U)
Small PSU Grommet	2	(JP42V)
6V-0V-6V 250mA Miniature Transformer	1	(YN14Q)
Large PSU Box	1	(YU31J)
Cable Grommet	1	(JM16S)
⅛in. P-Clip	1	(JH21X)
ABS Box Type MB1	1	(LH20W)
Box with Base Type 3	1	(YN37S)
Systoflex 2mm Red	1m	(BH09K)
Systoflex 4mm Black	1m	(BH12N)
TC Wire 0·9mm 20 SWG	1 Reel	(BL13P)
Interconnection cable e.g.,		
Zip Wire	As Req.	(XR39N)
4-wire Phone Cable	As Req.	(XR66W)
Heat Shrink CP48	1m	(BF89W)
13-Way Tagstrip	1	(FL29G)
Nuts, Bolts, Washers, Spacers, etc.	As Req.	

The Maplin 'Get-You-Working' Service is not available for this project.

The above items are not available as a kit.

CLASSIFIED

Placing an advertisement in this section of 'Electronics' is your chance to tell the readers of Britain's Best Selling Electronics Magazine 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, and thereafter the charge is 10p per word.

Placing an advertisement is easy! Simply write your advertisement clearly, in capital letters, on a post-card or sealed-down envelope. Then send it, with any necessary payment, to: Classifieds, 'Electronics – The Maplin Magazine', P.O. Box 3, Rayleigh, Essex SS6 8LR. Advertisements will be published as soon as possible, space allowing. No responsibility is accepted for delayed publication or non-inclusion of advertisements.

Private individuals only are permitted to advertise in this section; commercial or trade advertising of any kind is strictly prohibited by law. Advertisements are only accepted by the Publisher on this proviso. Readers who have reasonable grounds to believe that they have been misled as to the nature of an advertisement are advised to contact the Publisher and their local Trading Standards Office.

VARIOUS

DC TO DC CONVERTERS encapsulated, many types and currents. Prices between £3 and £15. Tel: Ian (0204) 811443.

934MHz EQUIPMENT for sale, the perfect half-way stop between CB and ham radio. Tel: Ian (081) 482 0366.

FOR SALE HN462732 (4K) EPROMS used once £1.50 each. 5V relays DPDT, fit 16-pin DIL socket, £1 each. 25-pin R/A 'D' plugs 3 for £1. V21/23 modem, auto answer/dial, Hayes compatible, offers! Tel: Mel (0533) 419742.

DYNAMCO D7100 30MHz 'scope, dual trace and delay T.B., £220 o.n.o. Solartron 7066 6½ digit datastore DVM, IEE 488, IETC66 and RS232C interface, £550 o.n.o. Racal 9915 UHF counter timer, mains/battery, £150 o.n.o. Tel: (0272) 401070 (Bristol).

MARCONI TF995A/1 FM/AM signal generator 2 – 220MHz g.w.o. with manual (photocopy). Gertsch model FM3 frequency meter 20 – 1,000Mc, ·001%, works but no info. £75 the pair. Racal Dana 4003 digital multimeter with manual, faulty, spares or repair, any reasonable offer secures. For info Tel: Pete (0508) 70432 (Norfolk).

CROTECH 20MHz dual-trace oscilloscope (incorporating several special functions) in good working condition. Selling reluctantly for a very low £120 o.n.o. Buyer must collect. Tel: Gary (0427) 668317 evenings.

LARGE STOCK of NEW ¼W resistors: 2k7 5%, 100 for 40p! 3k7 1%, 100 for 60p! R/A PCB sockets, 0·1in. pitch (like YW30H but 10-way), 10 for 50p. Add 50p p&p. Paul, 1 Sandringham Road, Chichester, PO19 2XJ.

MAPLIN 50W amplifier and PSU, 12in. 80W speaker, horn tweeter, £35 the lot. 2 × 49 note keyboards, £30 the pair. Tel: Chelmsford (0245) 450050 (home).

VALVES mixed, used, ex TV, den clearout, a bulk sale of approx. 800, £250 the lot. Buyer must collect, cash only please. Tel: Bill (0922) 648310 after 6pm.

DATABASE FILES with specs. (name, function, etc.) of over 1,300 common TTL and CMOS ICs in DBF format. For details Tel: Yiannos (061) 224 6089 after 5pm.

TELEQUIPMENT D67 oscilloscope, dual-beam, reliable, good working order, £70 offers. Tel: Simon (0734) 454840 after 7pm.

MARCONI TF2002B/TF2170B MF/HF AM/FM 10kHz/88MHz laboratory signal generator, £275 or swap for colour monitor for Amiga 1200 AGA graphics. For disabled pensioner. Buyer collects. Tel: (0706) 622430 (Rochdale).

WANTED

URGENTLY IEEE-488 interface for CBM64. Surely there is one spare somewhere in the UK? Name your (reasonable) price and Tel: Jack (G3DPS) (0420) 86235.

SPECTRUM I/O CONTROLLER for use with ZX80 Spectrum computer, as featured in 'Best of Maplin Projects Fourteen'. Order Code LK65V in 1985 catalogue. Tel: (0263) 633375.

CAN ANYONE HELP with a copy (or photocopy) of the user instructions for the Mita DC 213 DE photocopier? All expenses paid. Tel: J. Parish (0325) 720937.

A COPY OF 'Electronic Music' and 'Musique Concrete' by F. C. Judd, circa 1960s. Tel: Mike Coady (0553) 765387.

MUSICAL

FENDER GUITARS Strat, 60s re-issue, USA white, rosewood fingerboard, £350. Tele, USA standard, clear ash body, rosewood fingerboard, £395. Jazz bass, black, rosewood fingerboard, £255. Tel: Danny (0702) 549593.

DISCO CONSOLE Alpha 120M Mk2, built-in light controller, three lighting banks, red fuzzlight, ultra-violet lamp, 12in. speakers, all leads, excellent condition, £495. Tel: (0702) 201700 (Essex).

COMPUTERS

COMMODORE PET 6502 chip, screen, data-cassette, manuals. Some attention required. Keyboard and case v.g.c. £25 plus carriage. Tel: (0454) 413350.

AMSTRAD CPC 464 computer and colour monitor with 45 games, £100. Buyer collects. W. Snow, 29 Dankworth Road, Basingstoke, Hants, RG22 4LJ.

IBM/SONY 5081 colour SXVGA CAD monitor. 62·5kHz non-interlaced scan. RGB and O/P, £650 o.n.o. Tel: (0272) 401070 (Bristol).

SEIKOSHA GP100A dot matrix computer printer, compatible with most makes and models of computers. With power, parallel and other connector cables, good condition, £30. Tel: Bob (0235) 765127.

TO ALL 6502 PROGRAMMERS. Write fast, efficient and compact M/C programs easily using my Assembly Generating Compiler. Its own expandable language implements loop structures, conditional tests, string handling, I/O, integer maths, etc. in 65XX machine code. Original package runs on C64; IBM PC version also available to help program 6502 microcontroller cards, etc. or other machines. Compiler and assembler source listings can be made available if required. Expandable routine library. C64 disk has lots of demos, PC disk has lots of extra utilities. Send largish, e.g., C5 S.A.E. for more details to: Level 3, Aurora, Church Road, Laindon, Basildon, Essex, SS15 5SL.

CLUB CORNER

WIRRAL AND DISTRICT AMATEUR RADIO SOCIETY meets at the Irby Cricket Club, Irby, Wirral. Organises visits, DF hunts, demonstrations and junk sales. For further details, please contact: Paul Robinson (G0JZP) on (051) 648 5892.

WIRRAL AMATEUR RADIO SOCIETY meets at the Ivy Farm, Arrowe Park Road, Birkenhead every Tuesday evening, and formally on the 1st and 3rd Wednesdays of every month. Details: A. Seed (G3FOO), 31 Withert Avenue, Bebington, Wirral, L63 5NE.

ELECTRONIC ORGAN CONSTRUCTORS SOCIETY. For details of meetings. Tel: (081) 902 3390 or write 87 Oakington Manor Drive, Wembley, Middlesex, HA9 6LX.

TESUG (The European Satellite User Group) for all satellite TV enthusiasts! Totally independent, TESUG provides the most up-to-date news available (through its monthly 'Footprint' newsletter, and a teletext service on the pan-European 'Super Channel'). It also provides a wide variety of help and information for its members. For further information, contact: Eric W. Wiltsher, TESUG, Rio House, Stafford Close, Ashford, Kent, TN23 2TT, England.

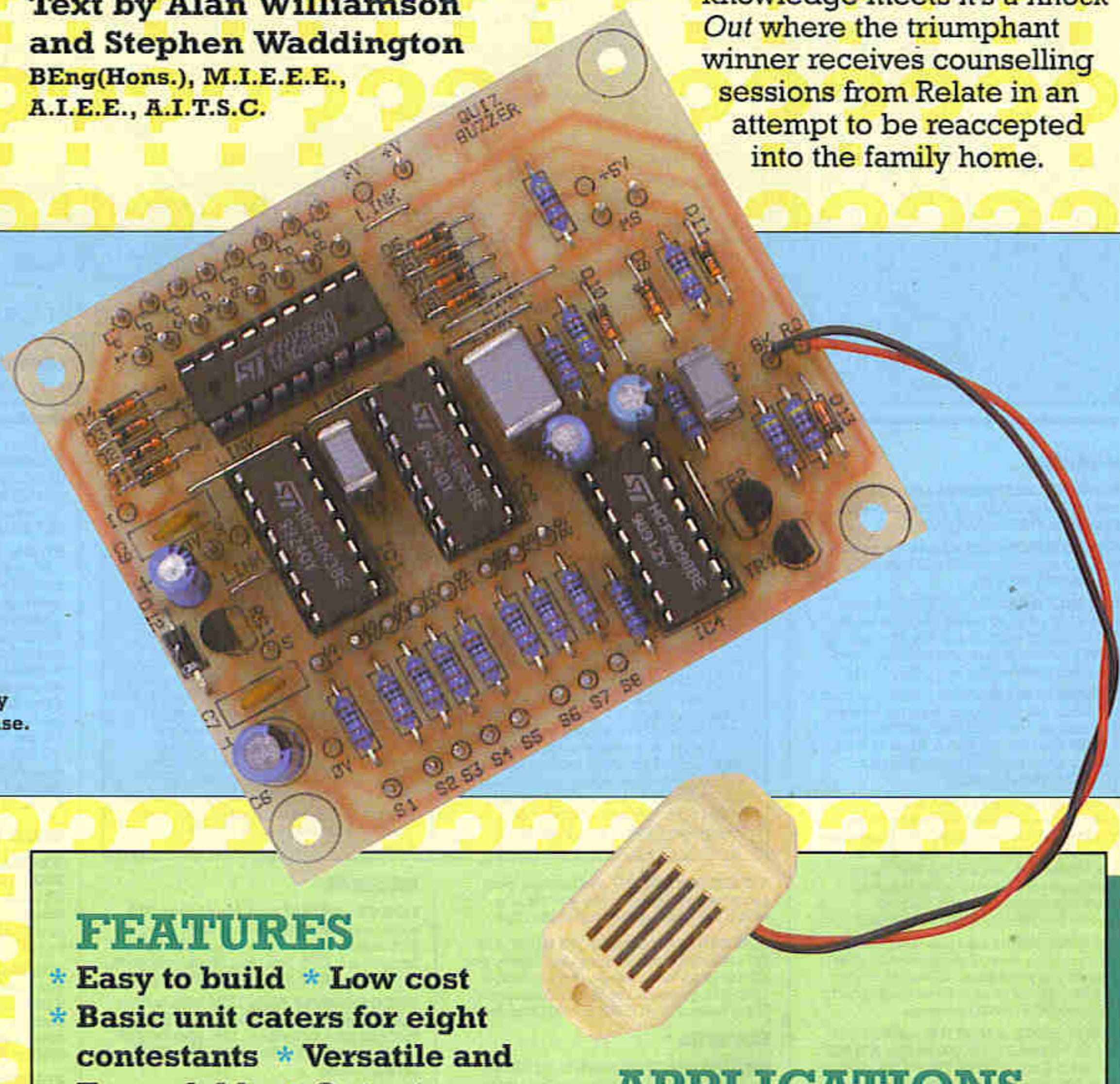
The Quizzer

PRIORITY QUIZ BUZZER

Design by Alan Williamson
Text by Alan Williamson and Stephen Waddington
BEng(Hons.), M.I.E.E.E., A.I.E.E., A.I.T.S.C.

The Christmas dinner is over. Shreds of wrapping paper, discarded about the living room floor, bear witness to the festival almost over. Attention now turns to the yearly inter-family carpet Olympics. Inevitably, the box of games is extracted from the loft and thoughts of a swift trip to the pub quickly evaporate as teams are selected for the annual game of what is far from *Trivial Pursuit*. And if the trip round the *Monopoly* board doesn't prove more deadly than a hike around the tenements of our fine Capital, the next event is bound to. General knowledge meets *It's a Knock Out* where the triumphant winner receives counselling sessions from Relate in an attempt to be reaccepted into the family home.

KIT AVAILABLE (LT41U) PRICE £9.95



The Quizzer PCB complete and ready to be wired up for use.

2 PROJECT RATING

FEATURES

* **Easy to build** * **Low cost**
* **Basic unit caters for eight contestants** * **Versatile and Expandable** * **Outputs can drive relays, buzzer, lamps or opto-isolated triacs**
* **End arguments over who answered first!**

APPLICATIONS

* **Family Fun Nights** * **Pub Quiz Nights** * **Team Games**
* **Reaction Testing** * **Charity Trivia Competitions**

Excitement

Why is it that general knowledge quizzes get people so excited? It isn't only family events either. Even the pub round the corner from our editorial offices has started holding quiz nights. Now forgive me if I'm wrong, but I thought the whole purpose of a trip to the pub was for a quite little drink with one's friends or colleagues. Instead, it seems, on a Tuesday and Thursday evening, we must now endure a night of argumentative debate. No longer is enough to sit in the corner of the Snug where the only competition is a genteel game of dominoes. Now one has to listen to clapped out tape recordings and answer questions relating to sport of Tom Finney's era. I can't think Jeffrey Bernard would be too impressed. Plenty of people are, though! You can forget your chances of a quiet evening.

Fed-up with the incessant argument over who was the first to answer a question at their local charity, domestic or pub quiz nights, readers asked us to design an electronic priority quiz indicator. This little project is ideal to prevent all altercation over 'who put their hand up first'! Up to eight individuals – or more if a second or third expansion PCB is connected – can use The Quizzer. Each is equipped with a button and a lamp that will glow triumphantly should the contestant be the first to the button when a question is posed. Facility is also provided for a buzzer, able to direct the attention of the quiz-master to the eager participant.

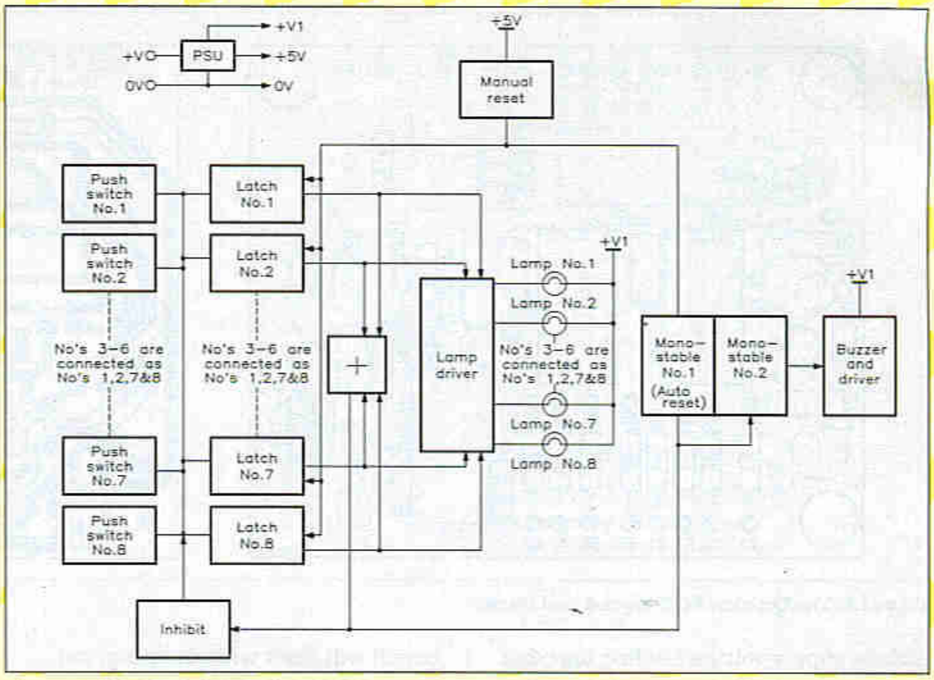
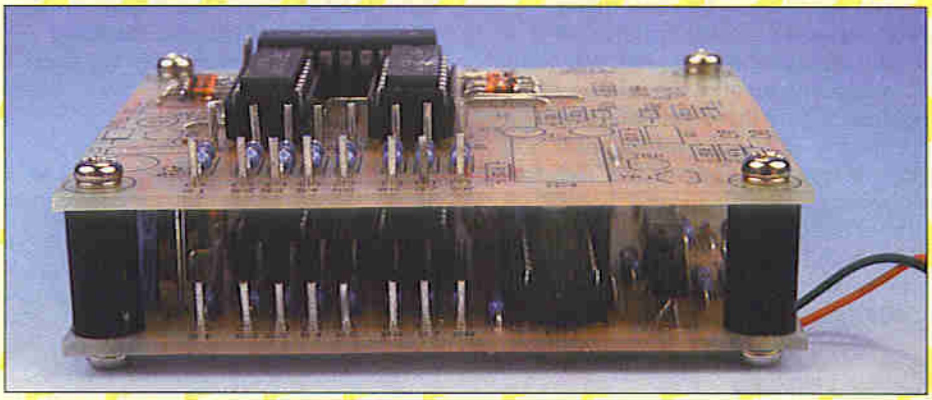


Figure 1. Block Diagram of The Quizzer.



Two Quizzer PCBs stacked to cater for sixteen contestants (Kit contains parts to build one PCB).

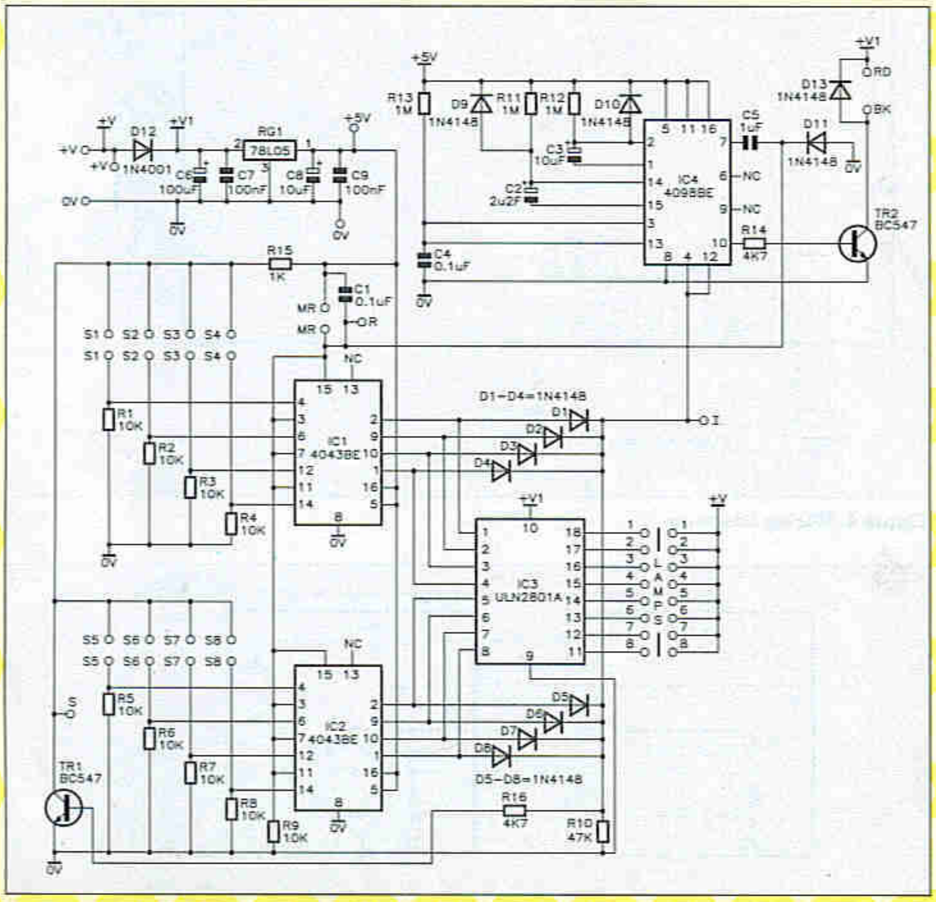


Figure 2. Circuit diagram of The Quizzer.

Circuit Description

A block diagram of The Quizzer is illustrated in Figure 1. The circuit is relatively simple and is based around a series of SR latches. The truth table for an SR latch is shown in Table 1; when any one of the set inputs is taken momentarily high, the output will latch high. The output will then remain high until a reset signal is applied.

S	R	Q
0	0	No Change
0	1	0
1	0	1
1	1	1 Dominated by S=1

Table 1. Truth table for an SR Latch.

In The Quizzer circuit, which is shown in Figure 2, eight latches are used, in the form of IC1 and IC2. When any one of the competitor's switches is pressed, the output of the appropriate latch will remain high. The outputs of each of the latches is connected on a common line via the diodes D1 to D8. Thus if the output of any one of the latches is high, transistor TR1 will be turned on, and thus

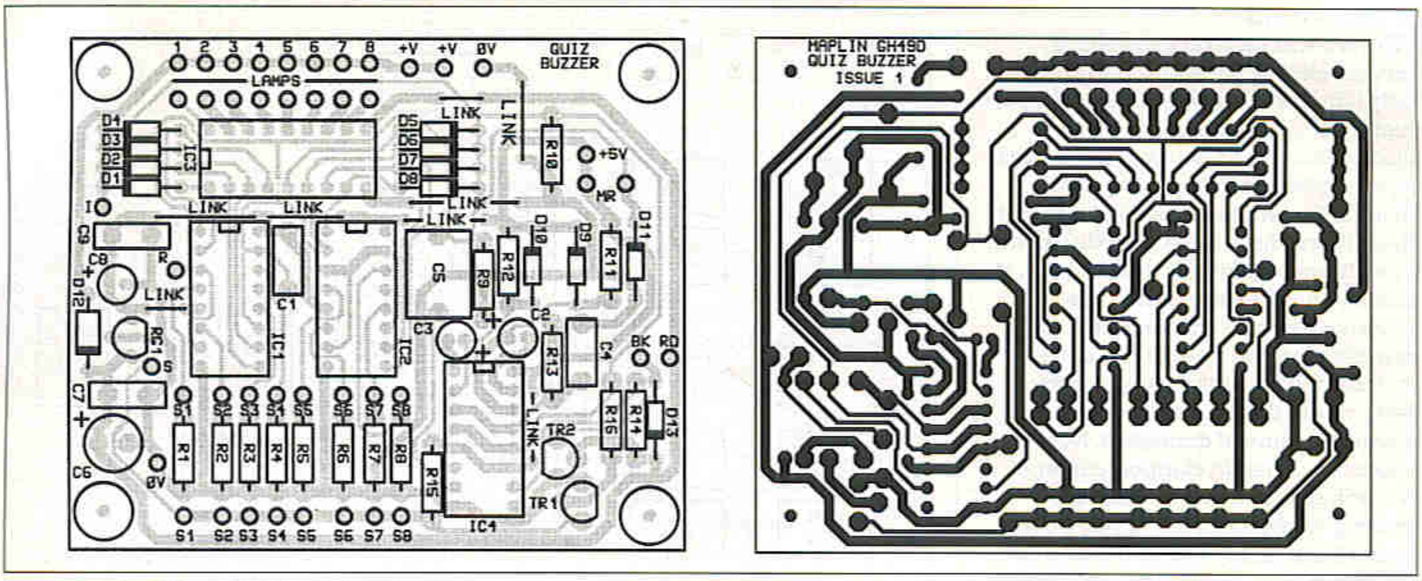


Figure 3. The Quizzer PCB legend and track.

pull the supply voltage feeding the other user switches to 0V, preventing any other contestant from triggering their latch.

The latches can be reset using the master reset (MR) switch. IC4 is a dual monostable: One half provides an automatic reset of the latches approximately three seconds after triggering. While the other half is used to operate a buzzer, via TR2, for approximately one second that will attract the Quiz-Masters attention in the event. IC3 is an octal Darlington driver, which is required to switch the contestants' lamps on and off.

Construction

Referring to the PCB legend in Figure 3, insert and solder the resistors, diodes, PCB pins and capacitors. Ensure that the electrolytic capacitors and diodes are all fitted with the correct polarity. Insert and solder the three plastic semiconductor devices into their correct positions. Using the component lead offcuts make all appropriate wire links. Fit PCB pins, but not in the following positions; I, R, S, 0V (next to C6), +V (next to LP8) and +5V. This will allow for connection to other Quizzer boards, should a larger system be required. Finally, connect the buzzer to the BK and RD buzzer terminals, following the colour coding convention.

Now check your work very carefully, making sure that all the wires and solder joints are sound.

Testing

Referring to Figure 4, connect a 12V lamp to the LP1 pins, a buzzer to BK and RD pins and a 12V DC supply to the +V and 0V pins – we suggest that you use an unregulated supply from a mains adapter. Momentarily short out the S1 switch pins; the buzzer should operate for one second and the lamp should illuminate for three seconds. Repeat the test, but this time short out the master reset (MR) pins immediately after shorting out the S1 pins – the circuit will reset without timing out. Repeat the procedure for the other seven switch (S2-8) positions (there is no need to repeat the master reset test); don't forget to move the lamp to the next position after testing each switch input.

Expansion

The circuit can be easily expanded to accommodate more players if required – in such cases, two or more PCBs must be constructed. First build the circuit as before but with the following components only; IC1, IC2, IC3 (and appropriate sockets), R1 to R9, D1 to D8, PCB pins for LP1 to LP8, and S1 to S8. Other components relate to the power supply and the time-out signals, and consequently should not be repeated on each circuit board.

Once constructed, the PCBs

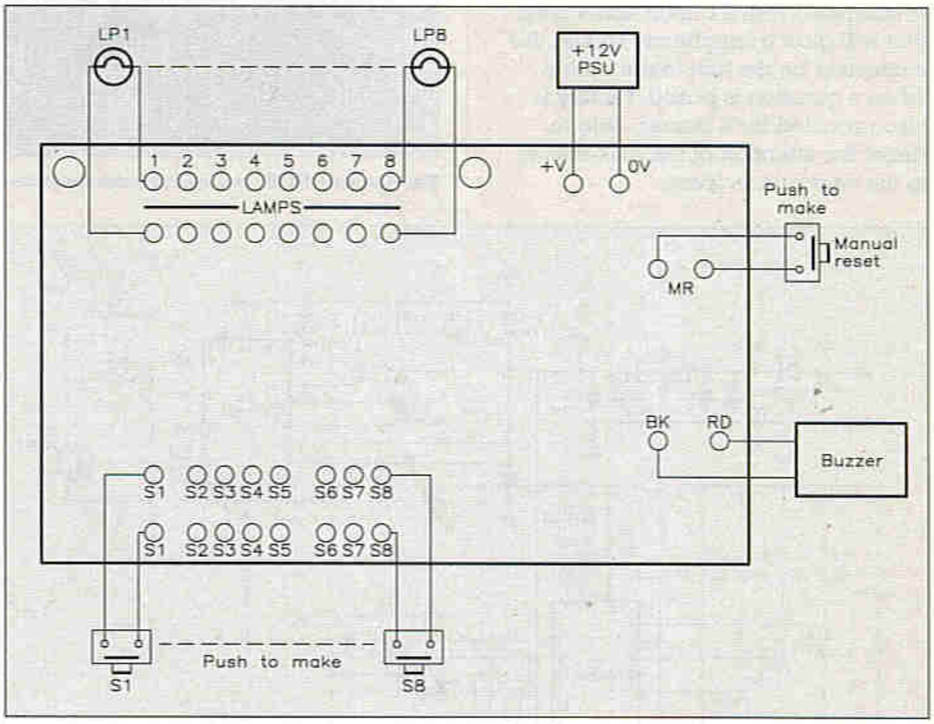


Figure 4. Wiring Diagram.

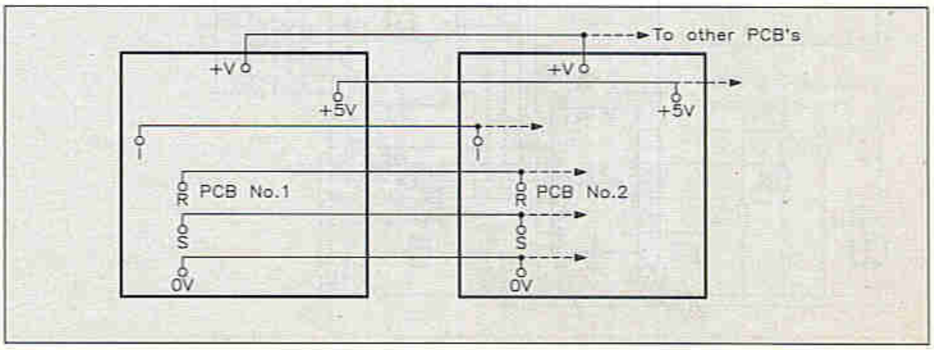


Figure 5. Expanding The Quizzer for more than eight competitors.

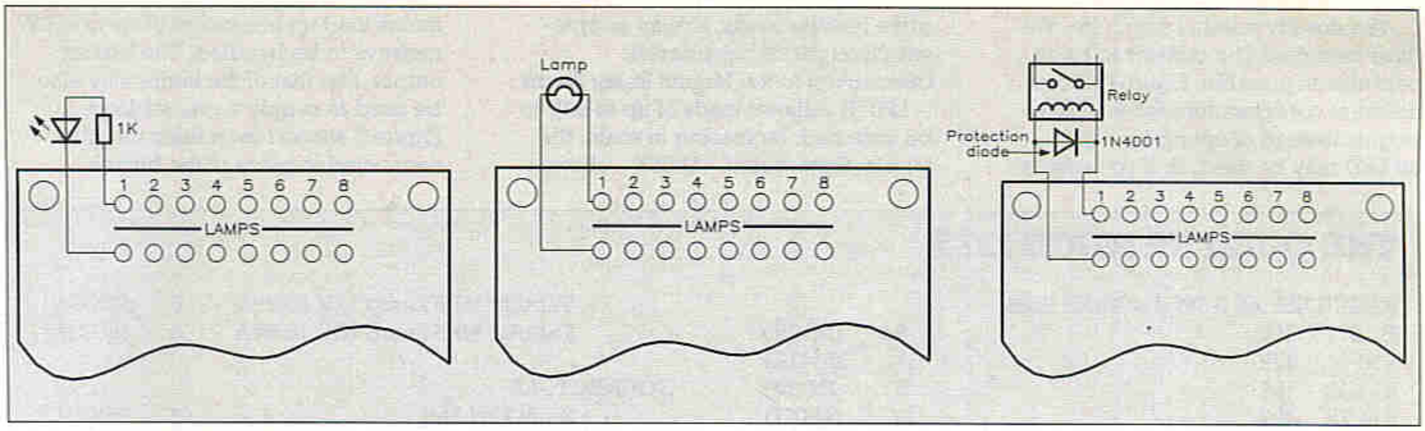


Figure 6. Output configurations: (a), LED; (b), filament lamp; (c), relay.

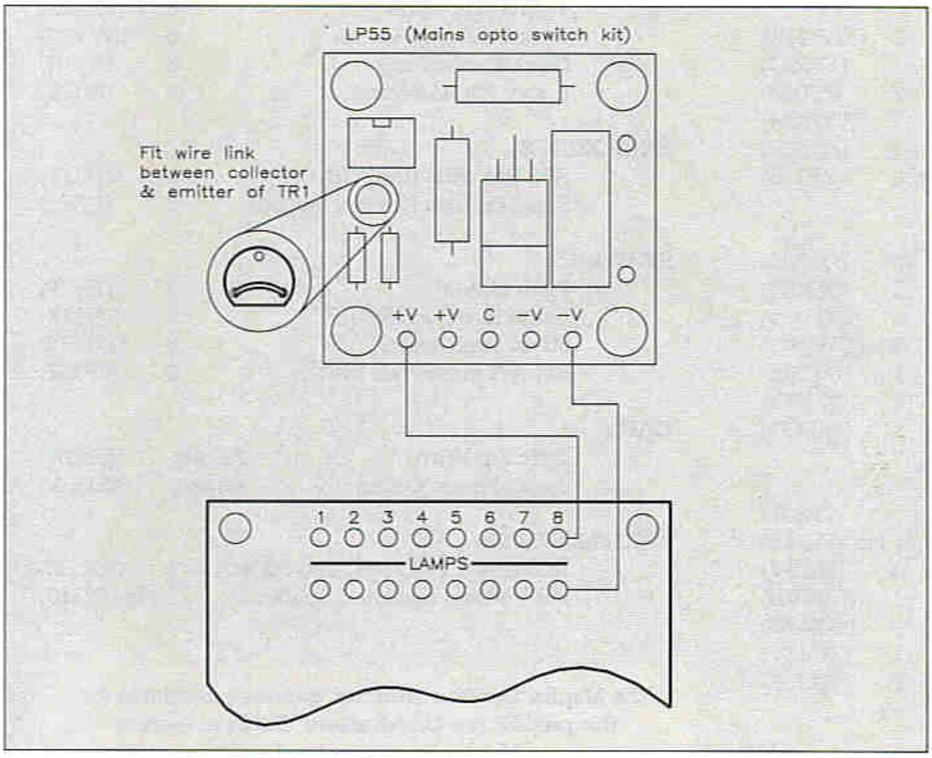


Figure 6(d). Mains Opto Switch.

should then be mounted above each other using 10mm spacers, as shown in the photographs. Wire connections can now be made between the PCBs, passing through the boards at each of the following points: S, R, I, +V, +5V and 0V, see Figure 5. The Quizzer can now be tested as described earlier, ensuring that each of the latches function correctly.

In Use

The final design of the system is left totally to the ingenuity of the constructor. To help you along, refer to the wiring diagram – Figure 4 – which shows how to interconnect the competitor's switches and lamps with The Quizzer PCB. You may decide to mount the PCB in a centralised case with the indicator lamps fixed within sight of the Quiz-Master. Competitor's switches would then be connected into the main case, and the Quiz-Master would be made aware of a response by the buzzer sounding and the appropriate lamp lighting. Competitor's switches could then be mounted in a smart hand-held case. This scheme would require twin cable between switches and the main unit. These could be terminated at either end by a two-pin DIN plug and socket, lending an air of professionalism to the project.

An alternative scheme would feature lamps by each of the competitor switches. A parallel-connected switch or LED could then mounted on the main Quiz-Master console. This would require a four core-cable between each of the competitors and the main Quiz-Master console, with competitor switches and lamps mounted in a suitable case. Again wire links could be formed using an appropriate 4-pin DIN plug. We have detailed a number of optional part which constructors might consider when finishing off The Quizzer project.

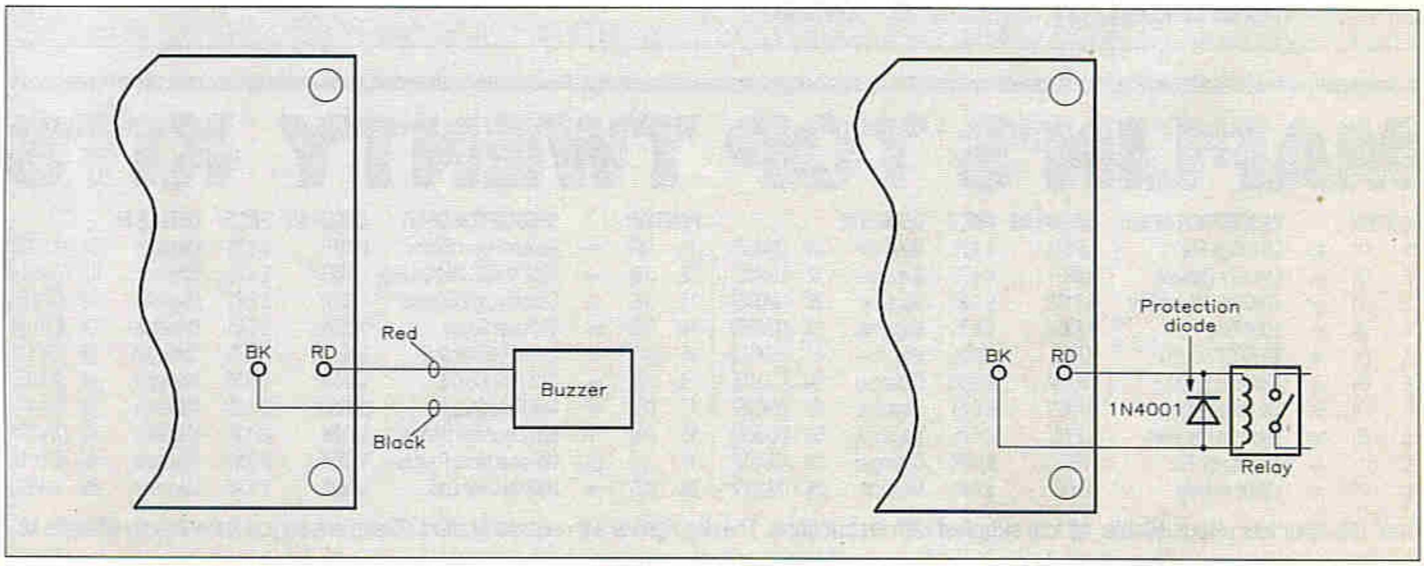


Figure 7. Buzzer Options: (a), buzzer; (b), relay.

The novelty needn't stop here. We have designed The Quizzer to be as versatile as possible. Figure 6 shows different configurations for the lamp output. Instead of opting for a lamp, an LED may be used, or if you wish to drive heavier loads, a relay or opto-switch might be considered. Connection to the Maplin Relay Board – LP07H – allows loads of up to 50V to be switched. Increasing in scale, the Maplin Opto-Board – LP55K – allows a mains load up to a rating of up to 250W resistive to be handled. The buzzer output, like that of the lamp, may also be used to supply a greater load; Figure 7 shows how a relay might be connected in place of the buzzer.

THE QUIZZER PARTS LIST

RESISTORS: All 0·6W 1% Metal Film

R1-9	10k	9	(M10K)
R10	47k	1	(M47K)
R11-13	1M	3	(M1M)
R14,16	4k7	2	(M4K7)
R15	1k	1	(M1K)

CAPACITORS

C1,4	100nF Polyester Layer	2	(WW41U)
C2	2µ2F 100V Radial Electrolytic	1	(FF02C)
C3,8	10µF 50V Radial Electrolytic	2	(FF04E)
C5	1µF Polyester Layer	1	(WW53H)
C6	100µF 25V Radial Electrolytic	1	(FF11M)
C7,9	100nF 16V Miniature Disc Ceramic	2	(YR75S)

SEMICONDUCTORS

D1-11,13	1N4148	12	(QL80B)
D12	1N4001	1	(QL73Q)
TR1,2	BC547	2	(QQ14Q)
IC1,2	4043BE	2	(QW29G)
IC3	ULN2801A	1	(QY78K)
IC4	4098BE	1	(QX29G)
RG1	µA78L05AWC	1	(QL26D)

MISCELLANEOUS

12V Buzzer	1	(FL40T)
1mm Veropins	1 Pkt	(FL24B)
16-pin DIL Socket	3	(BL19V)
18-pin DIL Socket	1	(HQ76H)
PCB	1	(GH49D)
Instruction Leaflet	1	(XU42V)
Constructors' Guide	1	(HX79L)

OPTIONAL (Not in Kit)

LAMPS

MES Batten Holder	8	(RX86T)
MES Lampholder	8	(JX87U)
LES Lampholder	8	(UJ72P)
Domed LES Lampholder Blue	8	(RX76H)
Domed LES Lampholder Yellow	8	(RX80B)
Fluted LES Lampholder Red	8	(RX69A)
LES Lamp Cover Amber	8	(YY00A)
LES Lamp Cover Yellow	8	(YY06G)
Lilliput LES Lamp 12V	8	(BU14Q)
Tubular LES Lamp 12V	8	(WL75S)
Tubular MES Lamp 12V 100mA	8	(BU20W)
Tubular MES Lamp 12V 183mA	8	(BU21X)

CONNECTORS

2-pin DIN Plug	8	(HH24B)
2-pin DIN Socket	8	(HH31J)
4-pin DIN Plug	8	(HH26D)
4-pin DIN Socket	8	(HH33L)
Chassis Phono Socket	8	(YW06G)
Black Phono Plug	8	(HQ54J)
8-way Phono Socket	8	(JK17T)

ENCLOSURES

ABS Box MB3 (for PCB)	1	(LH22Y)
Small Narrow Box (for switch)	8	(FT31J)

SWITCHES

Push switch	9	(FH59P)
Large Red Push Switch	9	(FH91Y)
Silver Push Switch	9	(FG45Y)
Black Square Push Switch	9	(FF96E)

CABLE

Twin Zip Wire	As req.	(XR39N)
4-way Phone Cable	As req.	(XR66W)

MISCELLANEOUS

AC Adaptor Unregulated 300mA	1	(XX09K)
M3 x 10mm Insulated Spacer	1 Pkt	(FS36P)

The Maplin 'Get-You-Working' Service is available for this project, see Constructors' Guide or current Maplin Catalogue for details.

The above items (excluding Optional) are available as a kit, which offers a saving over buying the parts separately.

Order As LT41U (Priority Quiz Buzzer Kit) Price £9.95.

Please Note: Where 'package' quantities are stated in the Parts List (e.g., packet strip, reel, etc.) the exact quantity required to build the project will be supplied in the kit.

The following new item (which is included in the kit) is also available separately.

Priority Quiz Buzzer PCB **Order As GH49D Price £3.75.**

MAPLIN'S TOP TWENTY KITS

POSITION			DESCRIPTION OF KIT	ORDER AS	PRICE	DETAILS IN		
1.	(1)	↔	L200 Data File	LP69A	£ 4.75	Magazine	46	(XA46A)
2.	(3)	↑	Live Wire Detector	LK63T	£ 4.75	Magazine	48	(XA48C)
3.	(2)	↓	TDA7052 1W Amplifier	LP16S	£ 4.95	Magazine	37	(XA37S)
4.	(6)	↑	1/300 Timer	LP30H	£ 4.95	Magazine	38	(XA38R)
5.	(4)	↓	MOSFET Amplifier	LP56L	£20.95	Magazine	41	(XA41U)
6.	(9)	↑	Electronic Ignition	VE00A	£12.95	Catalogue	'94	(CA11M)
7.	(10)	↑	Car Battery Monitor	LK42V	£ 9.25	Magazine	37	(XA37S)
8.	(8)	↔	Lights On Reminder	LP77J	£ 4.75	Magazine	50	(XA50E)
9.	(11)	↑	Stroboscope Kit	VE52G	£14.95	Catalogue	'94	(CA11M)
10.	(7)	↓	LM386 Amplifier	LM76H	£ 4.60	Magazine	29	(XA29G)
11.	(5)	↓	Remote Power Switch	LP07H	£ 5.25	Magazine	34	(XA34M)
12.	(13)	↑	SL6270 AGC Mic Amplifier	LP98G	£ 8.75	Magazine	51	(XA51F)
13.	(16)	↑	Courtesy Light Extender	LP66W	£ 2.95	Magazine	44	(XA44X)
14.	(19)	↑	1A Power Supply	VE58N	£ 8.95	Catalogue	'94	(CA11M)
15.	(12)	↓	LM383 8W Amplifier	LW36P	£ 7.95	Catalogue	'94	(CA11M)
16.	(18)	↑	8-bit I/O + RS232	LP85G	£19.95	Magazine	49	(XA49D)
17.	(15)	↓	Mini Metal Detector	LM35Q	£ 7.25	Magazine	48	(XA48C)
18.	(14)	↓	IBM Expansion System	LP12N	£21.95	Magazine	43	(XA43W)
19.	(–)	RE-ENTRY	Universal Mono Preamp	VE21X	£ 5.95	Catalogue	'94	(CA11M)
20.	(17)	↓	UA3730 Code Lock	LP92A	£11.45	Magazine	56	(XA56L)

Over 150 other kits also available. All kits supplied with instructions. *The descriptions are necessarily short. Please ensure you know exactly what the kit is and what it comprises before ordering, by checking the appropriate project book, magazine or catalogue mentioned in the list above.*

These descriptions are necessarily short. Please ensure that you know exactly what the kit is and what it comprises before ordering, by checking the appropriate issue of *Electronics* referred to in the list.

The referenced back-numbers of *Electronics* can be obtained, subject to availability, at £1.95 per copy.

Carriage Codes – Add: A: £1.45, B: £2.10, C: £2.65, D: £3.15, E: £3.70, F: £4.25, G: £5.10, H: £5.70.

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Order as: LM37S (Relay Interface Card Kit), **Price £12.45**; LM36P (Serial/Parallel Converter Kit), **Price £14.95**; LP12N (24-line PC I/O Card), **Price £21.95**. Details in *Electronics* No. 71 (XA71N).

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This easy to build equaliser project has ten frequency bands that allow you to adjust audio response to your particular preference.
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This versatile project allows you to control up to fourteen locomotives on a single layout, with up to four locomotives being active at any one time. The basis of the system is a Common/PSU board, to which one controller is added for each active locomotive. All locomotives require a receiver. To complete the project, a smart, pre-drilled case is available.
Order as: LW61R (Common/PSU), **Price £39.95** C4; LW62S (Controller), **Price £9.95**; LT29G (Receiver), **Price £12.95**; XG09K (Case), **Price £24.95**. Details in *Electronics* No. 71 (XA71N).

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

Part 2

POWER ELECTRONICS IN THEORY & PRACTICE

A rectifier circuit is one which converts an alternating voltage input into a unidirectional voltage output. The requirement for such conversion will have been dictated by the nature of the load. The output from rectifier circuits is not generally pure DC but generally contains an alternating component, the amplitude and nature of which depends upon the type of rectifier circuit. The output from a rectifier circuit will have a mean value, which is the effective DC output from the circuit.

There are two broad classifications for rectifiers, namely half-wave and full-wave types. These classes may be found in both single-phase and poly-phase rectifier circuits. Rectifiers may also be classified as uncontrolled or controlled. In the latter type, the rectifying element is not simply a silicon diode but a controlled device such as an SCR or a triac. Controlled rectification will be dealt with in the next part of this series. For now we shall look at various rectifier circuits using silicon diodes.

HALF-WAVE RECTIFIER

Figure 1 shows the simplest type of half-wave circuit in which a single diode is connected in series with the secondary of a transformer to feed a resistive load. The diode conducts only on those half-cycles of the secondary voltage when the diode anode is positive with respect to its cathode. Current thus flows through the load for no more than 180° of the supply voltage cycle. The average value – the effective DC – of the output voltage of such a circuit equals V_{peak}/π, which is slightly less than a third of the peak secondary voltage. Furthermore, since there must be a forward voltage drop across the diode – nominally 0·6V – before it can conduct, this will subtract from the available output voltage.

To take an example, suppose we choose a power transformer with a secondary whose stated voltage is 12V. This is the rms value of the voltage that will be obtained across the secondary voltage when it is fully loaded with its rated current. Its peak value will then be $\sqrt{2} \times 12 = 17$V. Subtract from this the forward voltage drop of the diode, say 0·6V, and we have a peak output voltage of 16·4V. The mean value of this is obtained by dividing it by π, which gives $16{\cdot}4/\pi = 5{\cdot}22$V. This is the voltage that would be measured by a moving coil voltmeter connected across the load.

You see from this that a circuit that starts off with a peak voltage available at the secondary winding of the transformer of 17V ends up supplying effectively only just over 5V DC to the load. Not very efficient is it?

Now look at Figure 2 which shows a three-phase half-wave rectifier. Although, of course, in a domestic situation a house is only supplied with single-phase mains, in an industrial environment, as well as on aircraft, ships, etc, a three-phase supply is usually connected.

This three-phase circuit uses a special type of transformer, with three primary windings and three corresponding secondary windings, one pair of primary and secondary windings for each phase of the supply. The primary windings are connected in *delta* and the secondary windings in *star* – also known as *wye* or simply *Y*. The rectified output from each secondary winding is commoned at the load; the neutral acts as the return for the load current. Because the supply voltage is three-phase, the rectified output voltage never falls to zero, as can be seen from the output waveform of Figure 2. For one full cycle of the supply voltage, there are three positive output peaks. This means that the mean value is very much greater than for the equivalent single-phase circuit, its

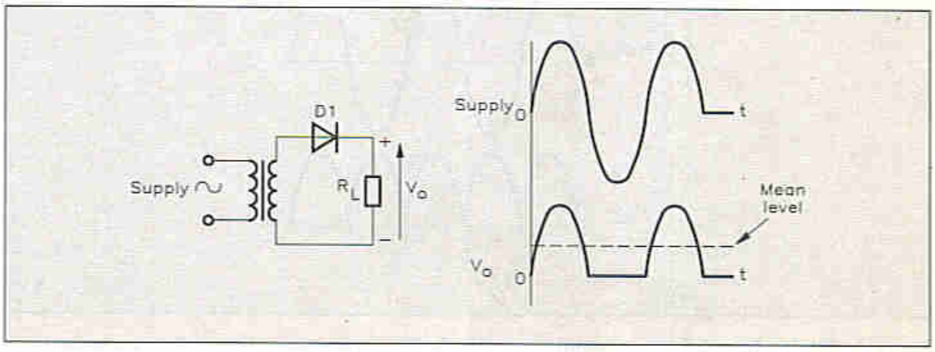


Figure 1. The simplest rectifier circuit, a single-phase half-wave type.

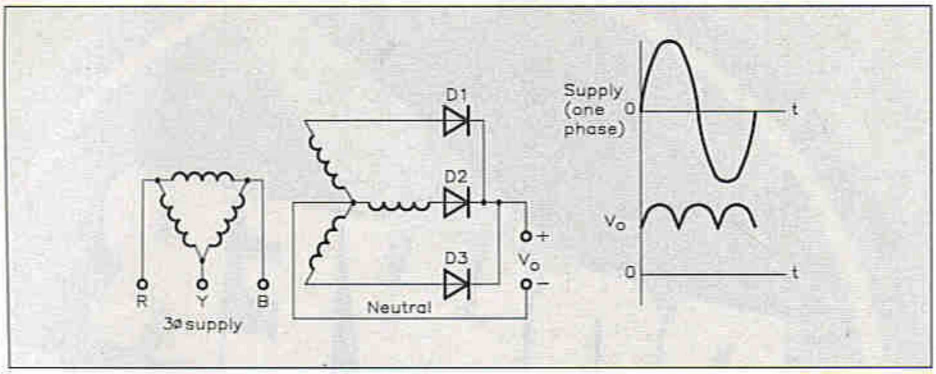


Figure 2. The three-phase equivalent of the circuit of Figure 1, with waveforms.

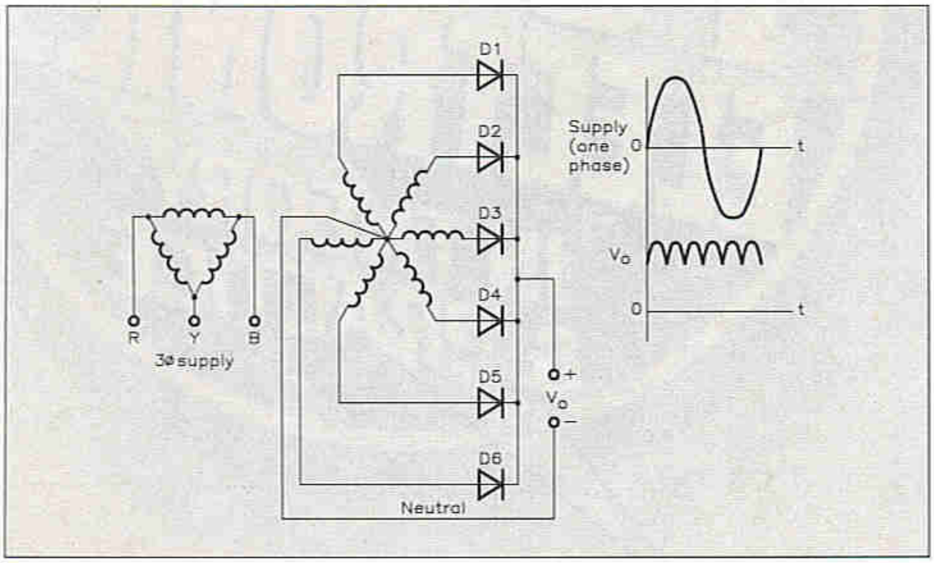


Figure 3. The six-phase half-wave rectifier with waveforms.

value being equal to $V_{peak}/1{\cdot}21$. This allows direct comparison with the previous circuit. If each secondary winding had a rating of 12V rms as before, giving a peak output from the rectifier of 16·4V, the mean output would be $16{\cdot}4/1{\cdot}21 = 13{\cdot}6V$. This is a great improvement on the single-phase circuit but does, of course, require a three-phase supply to be available.

Figure 3 takes the situation one stage further, and shows a six-phase half-wave rectifier. It is quite easy to obtain six phases from three by tapping the centre of each of the star-connected secondaries. This point then goes to the supply neutral. Each of the six phases then has a complementary phase that is exactly 180° out of phase with it. Each of the six phase connections has its own diode, all of these being commoned at the load. For each full cycle of the supply voltage, there are six positive output peaks. The mean voltage is even greater than for the three-phase circuit and is equal to $V_{peak}/1{\cdot}05$. Taking the same example as before, the mean output voltage from a 12V rms secondary winding would be $16{\cdot}4/1{\cdot}05 = 15{\cdot}62V$.

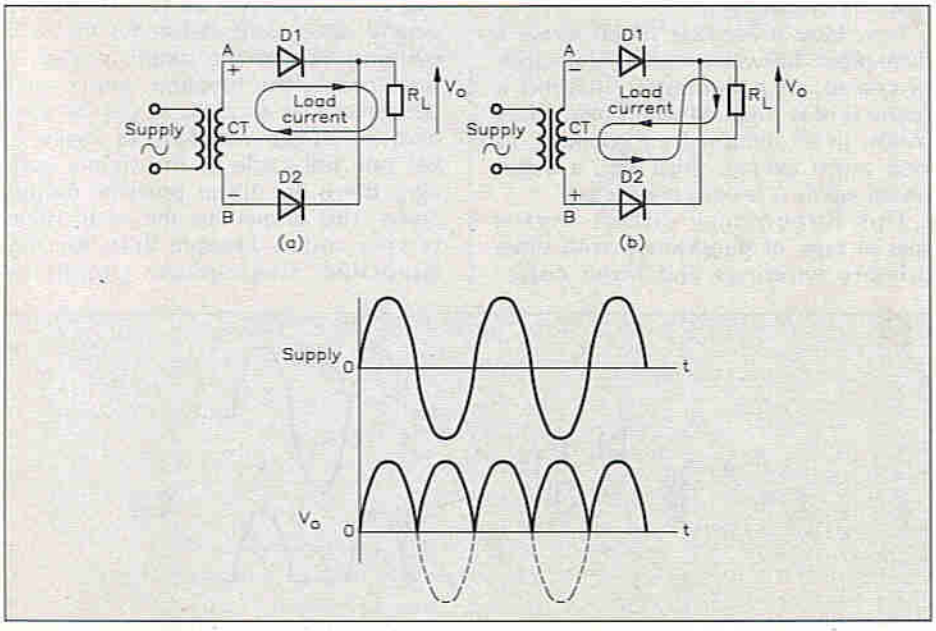


Figure 4. The bi-phase full-wave rectifier: (a), diode D1 conducting; (b), diode D2 conducting; (c), waveforms for input and output.

RIPPLE VOLTAGE

If the output of a rectifier circuit was a horizontal line, indicating a voltage that is constant with time, the output would then be pure DC, such as is obtained from batteries. The outputs seen in Figures 1, 2 and 3 certainly do not have the property of being constant with time. In the case of Figure 1, the output voltage dips down to zero after each half-cycle. The output waveforms of the other two figures also show a regular dip, though very much less. This variation in the output voltage is known as ripple. The frequency of this ripple is related to the supply frequency. In the case of Figure 1, the ripple frequency equals the supply frequency. In the case of Figure 2, it equals three times the supply frequency and, for Figure 3, it has a value that is six times the supply frequency. The higher the ripple frequency the better, since it is then easier to filter out, should we wish to do so. From this discussion and the examples of Figures 1, 2 and 3, we see that ripple in the output of a rectifier is characterised by two parameters; amplitude and frequency.

FULL-WAVE RECTIFIER CIRCUITS

Figure 4 shows one type of full-wave rectifier circuit. Full-wave means that diode conduction occurs on every half-cycle of the supply, including the negative half-cycles. This implies that at least two diodes will be needed, as can be seen from Figure 4. The transformer secondary winding is centre tapped, this point being the 0V return for the load current. The voltages across the half-secondary windings are equal anti-phase voltages. Thus, when point A is positive with respect to the centre-tap, point B will be negative with respect to this centre-tap. Under these conditions, the diode D1 will conduct and current will flow through the load, around the upper loop, as in Figure 4a. When the supply voltage reverses so will the phases of the two half-secondary voltages. Point B will now be positive with respect to the centre-tap and point A negative. Diode D2 will now be the conducting diode and load current will flow through the alternative loop, as shown in Figure 4b. Since the direction of current flow through the load is the same on both half-cycles of the supply, the output is unidirectional. Waveforms are shown in Figure 4c.

As a result of conduction taking place on every half-cycle of the supply, the output pulsates at twice the frequency of the half-wave supply. The ripple frequency is twice that of the half-wave circuit but the output still dips down to zero between half-cycles. The output has the appearance of the input waveform but with all negative half-cycles inverted so as to fill in the spaces between the positive half-cycles. The mean value of the output voltage is obviously going to be twice that of the half-wave rectifier circuit of Figure 1, that is it equals $2V_{peak}/\pi$. Making a direct comparison with the output of Figure 1, using the same data as before, the mean output voltage is $(2 \times 16{\cdot}4)/\pi = 10{\cdot}44V$. This is obviously very much better than for the half-wave case, at the expense of a more complex transformer and two diodes instead of one.

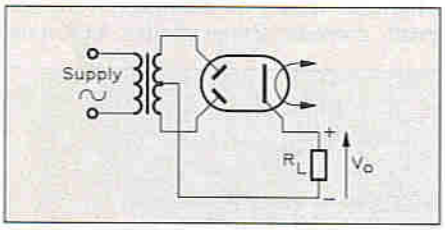


Figure 5. The circuit of Figure 4(a) as it formerly appeared using a double-diode thermionic valve rectifier.

This type of circuit was formerly fairly standard in valve practice, where a centre-tapped secondary winding was allied with a double-diode rectifier as shown in Figure 5. It is less used nowadays, the bridge arrangement of Figure 6 being more convenient and popular.

The bridge arrangement uses four diodes, these are often encapsulated in a single four-lead package, with two leads marked to indicate the AC input and the other two marked with plus and minus symbols for the rectified output. It is, of course, perfectly possible to make up one's own 'custom designed' bridge from individual diodes. In operation, two diodes always conduct together, one pair on one half-cycle, the other pair on the other half-cycle.

Referring to Figure 6; Figure 6a shows the case when the top of the secondary winding is positive with respect to the bottom of the winding. Diodes D2 and D3 conduct, with load current flowing in the path shown. When the supply reverses, as in Figure 6b, diodes D1 and D4 now conduct, current flowing through the load as shown. The load current flows in the same direction on both half-cycles of the supply, showing that the output is unidirectional.

With this type of full-wave rectifier, the transformer is of simpler construction but two diodes are always con ducting in series, so the voltage drop across the diodes is double that of the previous circuits. There will now be a voltage loss of about 1·2V during conduction so, if we start off with a peak secondary voltage of 17V as before, then the peak load voltage will be:

$$17 - 1{\cdot}2 = 15{\cdot}8V$$

The mean output voltage will be $(2 \times 15{\cdot}8)/\pi$, which equals 10·06V, slightly less than for the bi-phase rectifier.

The three-phase full-wave rectifier circuit of Figure 7 uses a delta-star transformer and six diodes, two for each phase. This delivers a higher output voltage than the circuit of Figure 2 with substantially less ripple. The actual mean output voltage obtained using the same data as previously is $16{\cdot}4/1{\cdot}05 = 15{\cdot}62V$. This is the same figure as obtained previously for the six-phase half-wave circuit, but the transformer is now less complex and costly.

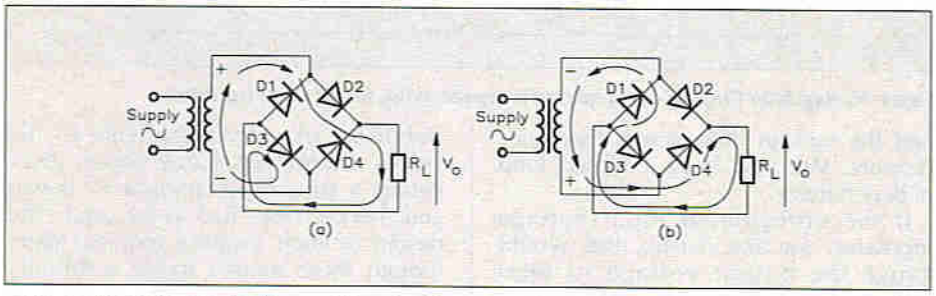


Figure 6. The full-wave bridge rectifier circuit.

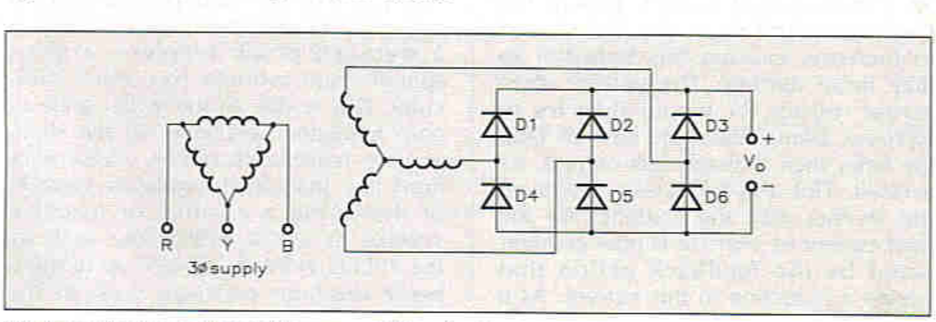


Figure 7. The three-phase full-wave rectifier circuit.

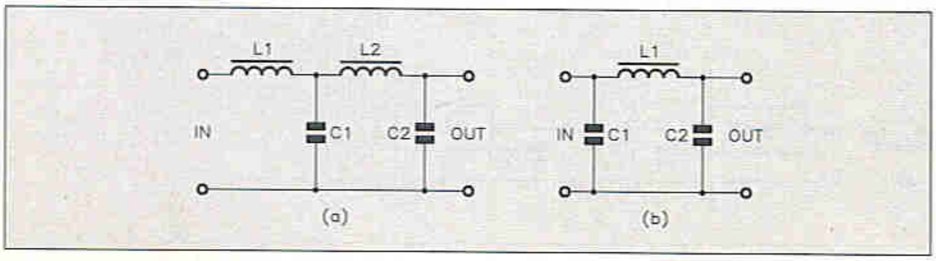


Figure 8. Filter circuits: (a), choke-input filter; (b), capacitor-input filter.

FILTER CIRCUITS

Filter circuits are used to smooth out the ripple voltage in the output of the rectifier. There are two basic types, known as 'choke input' and 'capacitor input', these being shown in Figure 8a and 8b, respectively. The latter is the simpler type and is suitable for relatively low current circuits. In this type of filter the reservoir capacitor C1 charges up to approximately the peak value of the rectified output voltage. This stored charge then supplies the load current, the reservoir being 'topped up' from the rectifier output whenever the terminal voltage of C1 tends to fall. This means that, the larger the load current, the greater the amount of charge has to be replaced in C1, in order to keep it as fully charged as possible. Thus, the ripple voltage increases from zero ripple at no load – C1 fully charged – to quite large amounts of ripple at high load currents. The choke L1 and capacitor C2 form a low-pass filter to remove a high percentage of the residual ripple voltage across C1. The larger the value of C1 the less ripple there will be for a given load current. However, there is a limit to the value of reservoir capacitor that can be used with a given rectifier because of the high charging current that flows initially when C1 is first charged up. If the reservoir capacitor is too large, this charging current can destroy the rectifier.

As an example, consider the case of the W04 bridge rectifier. This is rated at 400V PIV and 1·5A maximum forward current. the maximum rms input voltage is given as 280V but in addition to this data, a maximum value of load capacitance is also quoted, which is given as 625µF. By some standards this might be considered not unduly large and it would be easy to exceed the rectifier rating unless one was aware of this limitation.

The action of the reservoir capacitor on the output of a full-wave rectifier is shown in Figure 9. The choke input filter performs the same essential function as the capacitor input type in that it smooths the load current by storing energy during one part of the cycle and releasing it during another part of the cycle. However, the inductor acts differently by extending the time during which current is drawn from a rectifier. When used in conjunction with a full-wave rectifier, the conduction period of each rectifier may be extended so that conduction does not stop on one rectifier until the other rectifier starts conducting.

REGULATOR CIRCUITS

All of the rectifier circuits described so far are unregulated, that is, no attempt has been made to make the output voltage constant irrespective of changes in either the supply voltage or load current. A regulator performs this important function, where constancy of output voltage is important, by com paring a portion of the output voltage with a known and precise reference voltage. The difference between these two voltages represents an 'error' signal which is amplified and used to drive a control element so as to reduce the error to zero. In other words, it is a closed loop system of control whose aim is a constant output voltage. The principle of the series regulator can be explained with the simple circuit of Figure 10a. The reference voltage is the voltage across the Zener diode D1 and this is compared with the voltage across the resistor R3, this being a portion of the output voltage V_O derived from the potential divider R2 & R3. Since these two voltages are connected to the emitter and base of transistor TR1 respectively, the error voltage becomes the base-emitter voltage of this transistor. TR1 is known as the shunt element and its conduction is controlled by the error voltage. Its collector current provides the base drive for TR2, the first stage of a Darlington pair, these two transistors, TR2 & TR3, forming the series element of the regulator. The output voltage V_O from the regulator is actually the difference between the unregulated input voltage and the voltage drop across the series element. We now have a closed loop of dependence.

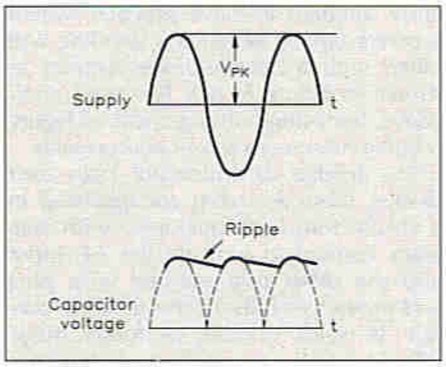


Figure 9. Action of the reservoir capacitor on the output of a full-wave rectifier.

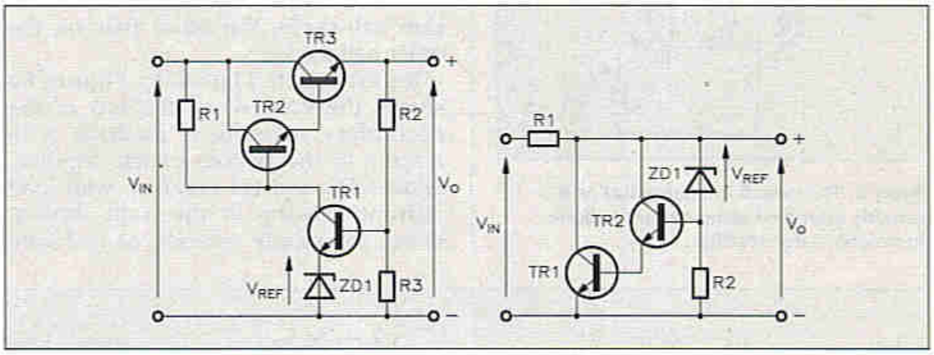


Figure 10. Regulator Circuits: (a), simple series regulator; (b), simple shunt regulator.

If the unregulated input voltage increases, for any reason, this would cause the output voltage to tend to increase also, which would result in an increased load current. In turn the base-emitter voltage of TR1 would tend to increase, causing this transistor to take more current. The voltage drop across resistor R1 would then try to increase, taking down the base of TR2, the latter then drawing less current. As a result, TR3 also takes less current or, put another way, the tendency for the load current to increase is now counteracted by the feedback action that causes a reduction in this current. As a result, the load current remains the same and so does the output voltage.

Figure 10b shows a simple shunt regulator, which works as follows. The current through the shunt element consisting of transistors TR1 & TR2 varies with changes in the load current or the input voltage. This current variation produces corresponding voltage variations across the series resistor R1 so as to maintain the output voltage constant. The shunt regulator is not as efficient as the series regulator but has the advantage of simplicity.

CHIP REGULATORS

Before the advent of integrated circuits, regulated power supplies tended to be quite complex and often rather bulky in their design. This is especially true of the days of valve technology when the reference elements were not small, compact Zener diodes, but neon stabilisers of comparable size to the valves themselves. Large valves dissipating a substantial amount of power and, hence, heat, had to be used. The design of such supplies required care, though there tended to be a formula for safe design. Nowadays, even relatively inexperienced people with a minimum of design skills can produce a regulated power supply to a given specification without too much difficulty. This is due to the wide range of chip regulators available off the shelf, at very reasonable prices. These vary from tiny three-lead regulators capable of delivering a positive or negative voltage at a few milliamps, such as the 78LO5 (+5V @ 100mA) up to quite beefy regulator packages such as the

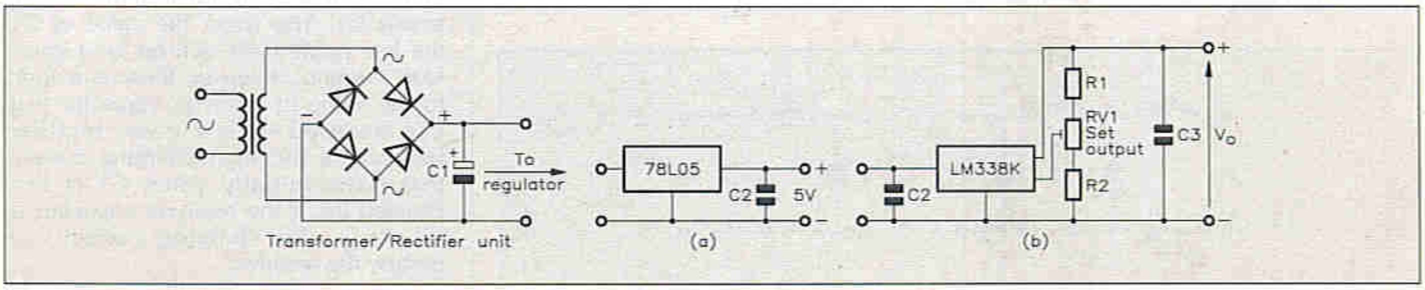


Figure 11. Regulated circuits: (a), the 78L05; (b), the LM338 voltage regulator chips.

LM338K variable regulator, which can deliver any voltage in the range +1·2V to +32V at a current of 5A. Typical circuits for complete regulated supplies using these two chips are shown in Figure 11.

CHOICE OF TRANSFORMER

The specification for a small power transformer, as it may be shown in a catalogue, might be as follows:

Primary	Secondary	Max. current	VA
0-240V	(1) 0-6V	0·5A	6VA
	(2) 0-6V	0·5A	

What the above information indicates is that; the primary winding is rated at 240V and there are obviously no taps. There are two identical secondary windings, each capable of delivering 6V at 0·5A. The total loading that the secondaries can take is 6VA. The last statement may require a little more explanation.

6VA means that the product of Volts and Amps for both secondary windings equals 6. This ties in mathematically with the secondary ratings given; two windings each rated at 6V x 0·5A = 6VA. What some may not appreciate is that the product of Volts and Amps is not necessarily measured in Watts! This product will numerically equal the load power in Watts only when the load is a pure resistance, in which case the secondary voltage is in phase with the secondary current. Otherwise, there will be a phase difference between secondary voltage and current. When this occurs the phasor diagram for a secondary winding is as in Figure12.

Two phasors, at right angles to each other, represent the resistive part of the load voltage (V_R) and the reactive part of the load voltage (V_X). The phasor sum of these two voltages is the phasor (V_Z) which is developed across the secondary impedance. The phase angle φ is the angle between the phasors for

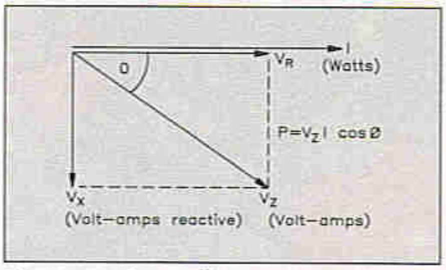


Figure 12. Phasor diagram for transformer secondary winding.

ber that, if the transformer has two identical secondaries as is often the case, it is possible to double the voltage output at the expense of current, by series connecting the windings, or double the current capability at the expense of voltage, by connecting the windings in parallel. These options are shown in Figure 13. It is important to connect the windings in the correct phase as shown, by noting the 0V end of each winding.

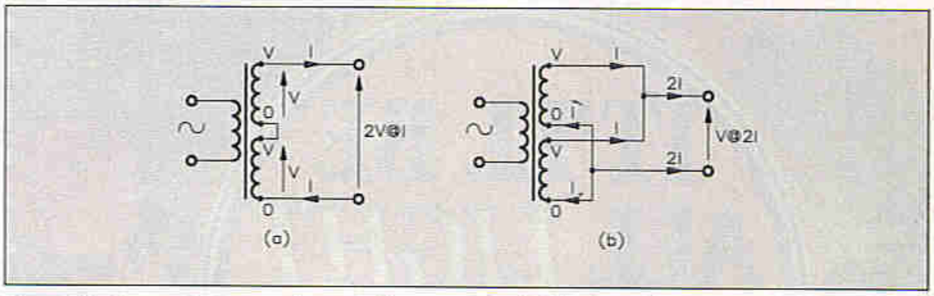


Figure 13. Connecting secondary windings to: (a), double the voltage output; (b), double the current output.

resistance and impedance. The current I flowing in the secondary is in phase with the resistive voltage V_R. From this it follows that the actual power delivered to the load is given by:

$$\text{Power in load} = V_Z.I.\cos\varphi$$

When the phase angle φ equals 0°, the power is numerically equal to the VA product, since there is clearly no reactive part. When the phase angle – equals 90°, the power is zero since the load must then be 100% reactive, such as a capacitor.

The above discussion should make it clear that if the load is reactive, the power available from the transformer will always be less than the VA rating of the transformer. Usually, the load has very little reactive component and the full VA rating of the transformer can be realised as power in the load.

As to choosing a transformer for a particular task in the general case, the choice will usually be made on the basis of secondary voltage and current. For both of these parameters, remem-

To choose the correct voltage for a given application, work back from the required unregulated voltage. For example, if this is to be in the range 12 to 16V, then choose a transformer whose peak secondary voltage lies in this range, remembering that the voltage quoted in the catalogue is an rms voltage, and that:

$$\text{Peak voltage} = \sqrt{2}.\text{rms voltage}$$

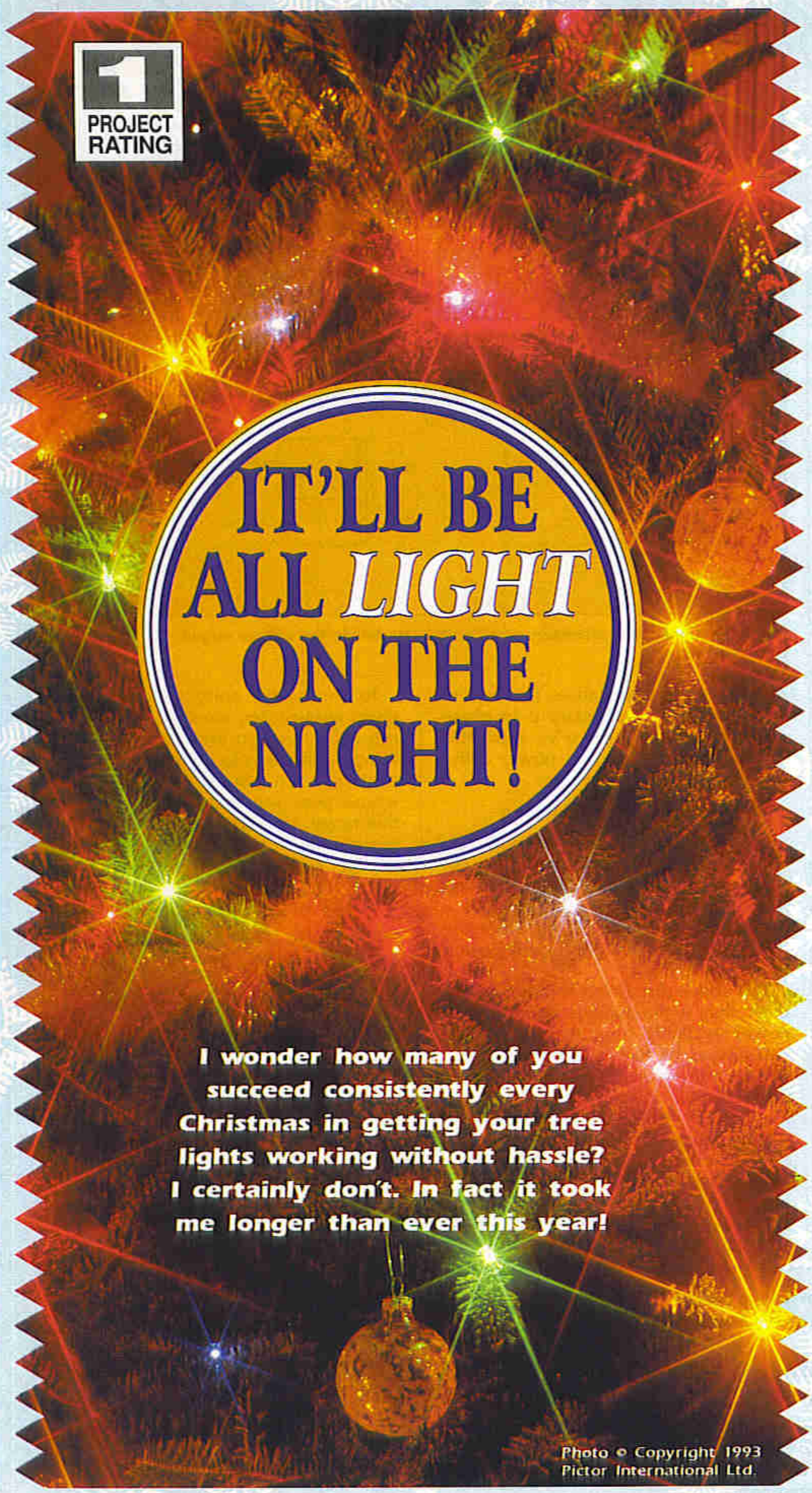
If we look at the catalogue and find two transformers, one with 9V secondaries and the other with 12V secondaries, then multiplying these two voltages by $\sqrt{2}$ in turn, gives:

$$\sqrt{2} \times 9 = 12{\cdot}73\text{V and,}$$

$$\sqrt{2} \times 12 = 16{\cdot}97\text{V}$$

The latter would probably be the better bet since it includes an allowance for the voltage drop across the rectifier diodes.

In Part Three we take a look at controlled rectification.



IT'LL BE ALL *LIGHT* ON THE NIGHT!

I wonder how many of you succeed consistently every Christmas in getting your tree lights working without hassle? I certainly don't. In fact it took me longer than ever this year!

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by Terry Pinnell

The circuit and information presented here must be considered as a basis for your own experimentation, no warranty is given for suitability in particular applications, reliability or circuit operations. Maplin cannot support, in any way, the information presented here. However, where possible, we will endeavour to check that information presented is correct and that circuits will function as stated.

At first it looked like this was to be the year they went up without a hitch, because things started promisingly enough. When I retrieved the lights from the loft, still neatly coiled in their box, and plugged them into the mains, they immediately lit up. Uncoiling them carefully resulted in some spasmodic flickering, apparently indicating one or more loose' bulbs, which should be no major problem I thought. So I switched off, confident that I'd soon have them up and working.

There were eighty bulbs altogether, in the familiar two-wire series arrangement shown in Figure 1. Yes, I know I should have invested in the more expensive and reliable three-wire type! As I wrapped them top to bottom around the 8ft. high tree, I gently tightened every one, and then plugged them in. Zilch. Not a flicker. Shouting at them didn't help, but did make me feel a bit better.

So after pouring myself a glass of wine I plunged into a methodical examination of every bulb by removing each one and testing its continuity. After half an hour or so, every single lamp had checked out okay. When I switched on again, I would have taken a heavy bet on success. But I'd have lost. Exasperatingly, the lights were still conspicuously inert.

Enough's enough, I thought. There had to be some more efficient way to go about this. I realised belatedly that the holders as well as the bulbs could be the cause of the problem, and that although I had apparently tightened every bulb at the start, there might still be one or more not making proper contact. So I decided to tackle it the way I should have done in the first place, and how I now intend to approach it in Christmases to come. It is worth mentioning that whilst my set of lights use lamps of the lilliput eddison screw (LES) variety, the same fault finding techniques can be applied to sets using miniature bi-pin lamps.

I decided to apply the technique I recalled from a book about servicing radios. I reckoned that the same principle could be applied to any circuit in which a signal flows successively from one stage to another, and certainly to my ultra-simple tree lights circuit.

Divide and Conquer

The idea is that you divide the circuit into two roughly equal parts, that is with a similar number of stages, and perform some test – which will obviously vary with the circuit – to discover which half is okay in its entirety. Then you turn your attention to the other half, the section that is *not* working, that is the signal is failing to get through it satisfactorily. You then divide that again roughly into two halves, and keep repeating this

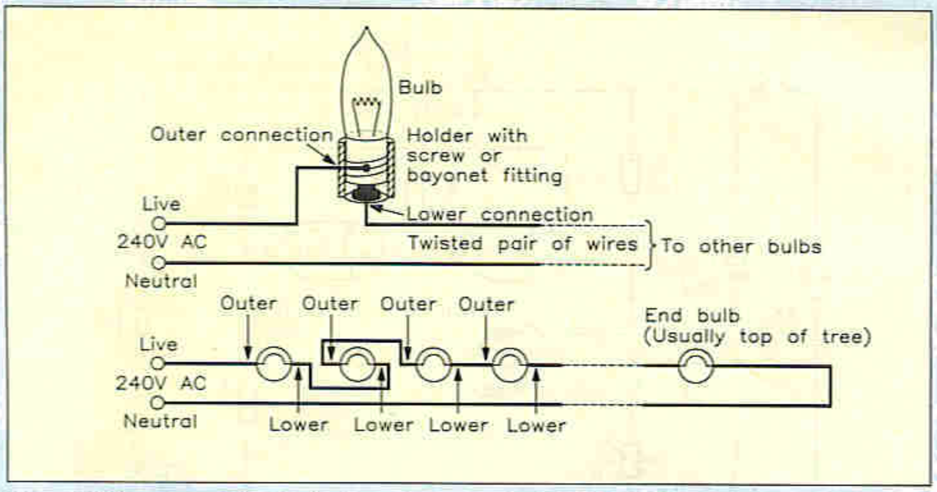


Figure 1. There are eighty bulbs in series; note that there is no consistency in the wiring of the holder's two connections; live could go to either the outer or lower contact.

procedure until the fault is isolated to a single stage. This method of fault diagnosis, not unsurprisingly, is known as the half-split method.

The power of the method is that you have arithmetic on your side. In one test you isolate the fault to about half the circuit, two tests isolates it to a quarter, the third to about one eighth, and so on. With eighty stages in your circuit, a mere seven tests are needed to isolate the problem, providing you get reasonably close to an even split each time – a vast improvement on eighty individual tests.

This is illustrated, as a hypothetical example, in Table 1, in which the splits and the faults are quite arbitrary. As soon as the number of stages in the faulty section is reduced to just one, the fault is obviously isolated. In the above fictitious example it takes only six tests. But if Test 6 showed the fault to be in Section A instead of in Section B, then, as this contains two stages a final seventh test would be needed.

Practicalities

In the case of my Christmas tree lights, the circuit was just a string of eighty identical bulbs in series, with equal current flowing through them. The obvious test for any section was therefore simply to confirm continuity, using my audible continuity tester.

If doing a similar exercise yourself, don't forget to **DISCONNECT FROM THE MAINS** first of course, especially as the lights will not be on to warn you! When I refer to the 'Live' side, I naturally just mean that side of the wiring connected to the Live pin of the plug, duly **REMOVED** from the mains supply socket.

The procedure was straightforward – in fact longer in the telling than the doing.

Having selected the first arbitrary test point, roughly midway down the tree, I unscrewed the bulb and tested the continuity between the Live terminal of the disconnected mains plug and the Live side of the holder, as shown in Figure 2.

Unfortunately I could not rely on consistency in the wiring to each holder. As you can see from Figure 1, the Live side of a holder's terminals could be either of the two wires going into the holder – the lower contact or the outer screw-thread – so in practice both contacts had to be tested each time.

While testing the Live section, the holder contact actually connected to the Neutral side would fail the continuity test, regardless of where the fault was. Therefore if one of the two holder contacts indicated continuity with a buzz from the tester then that could only mean that it was the Live side of the holder and that the entire Live side was okay. Therefore the next section needing attention would be the Neutral half.

On the other hand, if both of the holder's terminals failed to give a buzz, then there were two possibilities. Either this was the Live side of the holder and the fault was in the Live half, or it was the Neutral side of the holder and the fault was in the Neutral half.

To determine which of these was the case, the continuity tester's crocodile-clip was removed from the Live plug terminal and replaced on the Neutral plug terminal, and the continuity test repeated. If it then gave a buzz, the holder contact must be the Neutral side, and the Neutral section must be okay, so the other terminal was thus identified as the Live side and the fault was definitely in the Live section. Otherwise, if it didn't buzz, it meant the fault was in the Neutral section. Whichever section was identified as containing the faulty lamp or holder, that was then subjected to the same procedure, quickly resulting in isolation of the specific fault.

Difficult to tell what was causing my headache by this stage – the wine or the heavy logic!

Easy Access

To do the actual continuity testing I initially tried with one crocodile-clip of the tester gripping the outer terminal of the holder – the screw-thread – and the other clipped to a small screw-driver which was poked inside to touch the lower terminal. But that was clumsy so I improvised a couple of connectors from discarded bulbs.

To make each one, after breaking the glass and removing the filament I drilled a small hole in its base and soldered two short insulated wires to both terminals. Screwing this into an empty holder thus provided two accessible contacts for the continuity tests. Two of these could be used, one at either end of the section under test.

Test	Number of Stages Tested in Section A	Number of Stages Tested in Section B	Faulty Section	Action
1	42	38	A	Apply next test to A
2	22	20	B	Apply next test to B
3	9	11	B	Apply next test to B
4	6	5	A	Apply next test to A
5	3	3	B	Apply next test to B
6	2	1	B	This isolates fault

Table 1. Hypothetical example of how the half-split method can be used to locate the fault quickly.

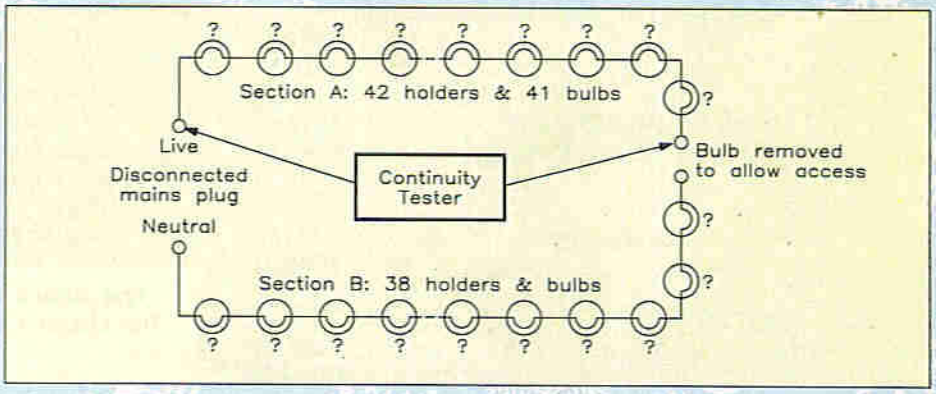


Figure 2. Using successive tests to locate the fault.

As mentioned earlier, I had checked all eighty of the bulbs laboriously, before adopting this more methodical approach, so was actually looking for one or more holder faults – ignoring the highly unlikely possibility of a dodgy wire, or a small hole in the space-time fabric of the universe. But if you apply this division technique from the outset, it will of course isolate both holder and bulb problems.

There may in practice be one or more of both types of fault, which complicates things a little. But if you keep a cool head and stay away from the Christmas booze until the job is finished then the principles described above should soon isolate each fault.

One detail to watch is that when you remove one or two bulbs to gain access to the holder's terminals, those bulbs are no longer being included in the tests. So if at some time you are apparently getting positive continuity tests throughout the entire circuit, the bulb or bulbs you have removed may be suspect.

Continuity Tester

As you have seen, this basic piece of test equipment played a key role in the exercise. In fact, over the years since it was made, my Continuity Tester has proved an indispensable tool, despite its simplicity. With the exception of my digital multimeter, few items of test gear on my bench have been used more frequently.

The circuit for the Continuity Tester is shown in Figure 3. Two of the four 2-input NOR gates of a CMOS 4001 are used in conventional fashion to make an astable, oscillating at a frequency which is roughly given by the formula $f = 0{\cdot}7 / (R \times C)$ where R is in megohms and C is in microfarads. In this case it is about 400Hz.

The astable is a gated version, and is enabled or disabled by the signal on pin 2 of IC1a. If this is at a low CMOS logic level then the astable is disabled whereas if it is high oscillation is enabled. For CMOS, the threshold is about half the voltage supply, so it is roughly 4·5V.

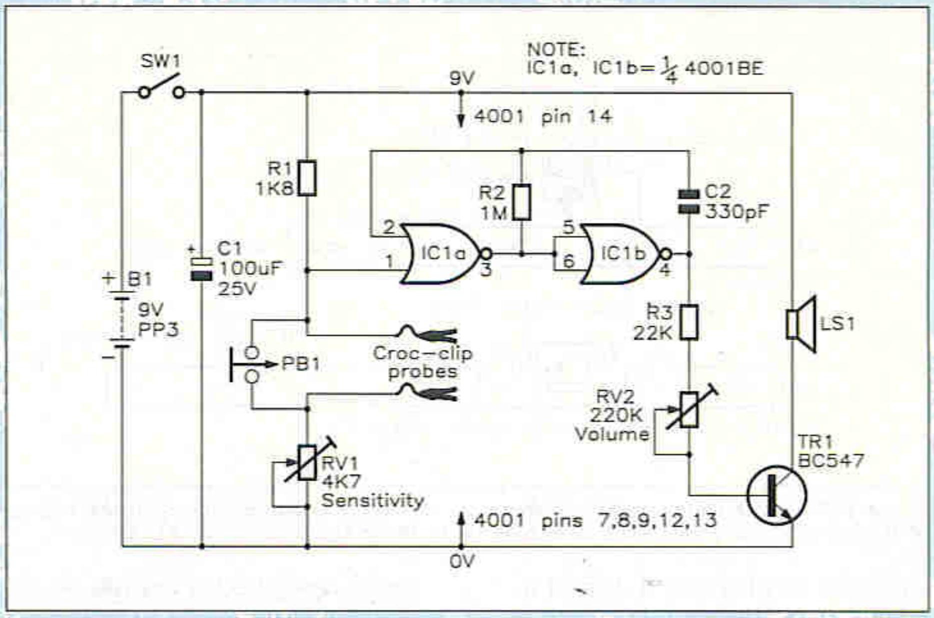


Figure 3. Continuity tester circuit diagram.

This logic level is derived from a voltage divider made up of a top section consisting of R1 and a bottom section made up of the sum of RV1 and the resistance between the probes.

Clearly, if the probe resistance is large then pin 2 will be above the threshold. In practice the preset is adjusted so that with the probes connected or the test push-button pressed, oscillation is enabled. Inserting a resistance of more than a few hundred ohms between the probes will then disable oscillation.

The output from the astable is taken via a primitive volume control made up of R3 plus RV2 to the base of transistor TR1, thus producing the required sound level from the miniature loudspeaker LS1.

I actually used a small pot for RV2, but a preset would be more suitable and is therefore specified here. In fact, with the benefit of hindsight, a variable resistor is really unnecessary. During the first few days use I set it at progressively quieter levels and have never touched it since. So, although I've left it in the circuit diagram, I would recommend you experiment with largish values of R3, choose one that suits you, and omit RV2 altogether.

The test push-button should also be regarded as an unnecessary luxury. After all, it is almost as easy to simply connect the two probes together to check that everything is working okay.

These two features illustrate the 'over-design' principle in action!

Construction can be a matter of individual preference. I used a piece of strip board, 19 holes long by 13 strips wide. A few holes were needed adjacent to the speaker, which simply rested snugly inside the case. In fact everything was so close together that a few pieces of heat-shrink sleeving were needed at certain points – such as around the push-button terminals – to avoid any risk of shorts.

Armed with this simple instrument and the technique I've described you should be more than a match for your lights next time. Happy Christmas, and may your tree shine on you!

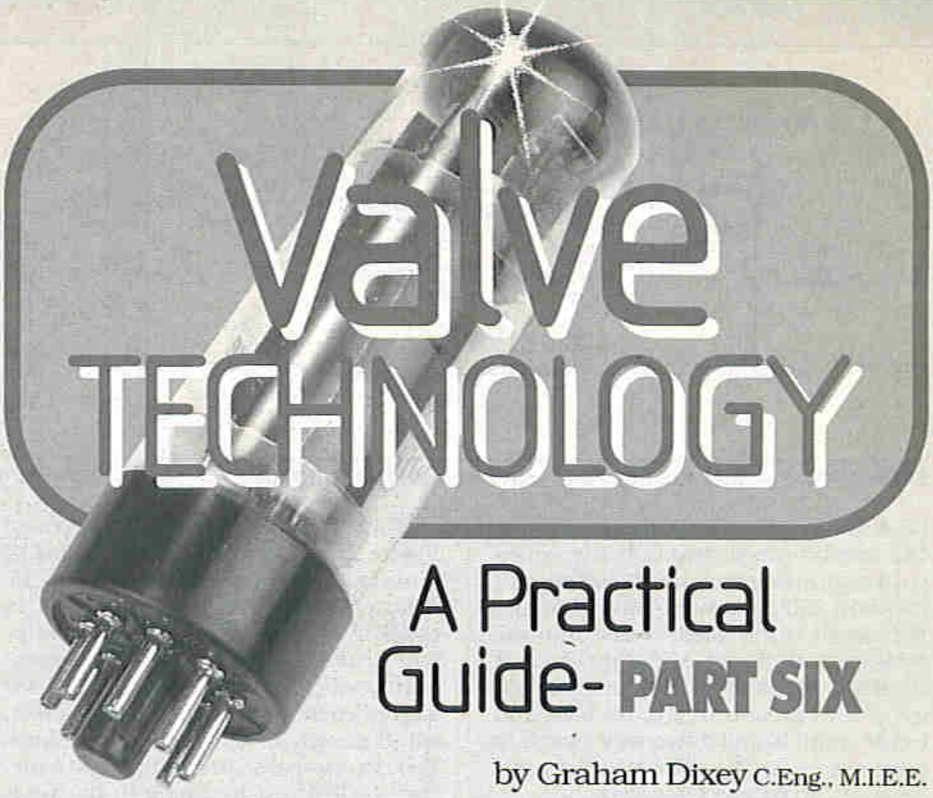
Editorial Note

The editorial staff at *Electronics* strongly advise against the consumption of alcohol whilst undertaking investigative work on your Christmas tree lights or any other electrical appliance.

CONTINUITY TESTER PARTS LIST

RESISTORS – All Metal Film 0·6W (Unless specified)		
R1	1k8	(M1K8)
R2	1M	(M1M)
R3	22K	(M22K)
RV1	4k7 Horizontal Enclosed Preset	(UH02C)
RV2	220k Horizontal Enclosed Preset	(UH07H)
CAPACITORS		
C1	100µF 25V Radial Electrolytic	(FF11M)
C2	330pF Ceramic	(WX62S)
SEMICONDUCTORS		
IC1	4001BE	(QX01B)
TR1	BC547	(QQ14Q)
MISCELLANEOUS		
LS1	64Ω miniature loudspeaker	(YT27E)
B1	9V PP3 battery	(JY60Q)
	PP3 battery clip	(HF28F)
	14-pin DIL IC socket	(BL18V)
	Small Crocodile Clip Red	(FS48C)
	Std Crocodile Clip Black	(FS49D)
	Toggle Switch, Push Switch, Wire, Strip Board, Suitable Small Case	As Req.

The above items are not available as a kit.
The Maplin 'Get-You-Working' Service is not available for this project.



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

In Part Five practical pentode amplifier stages were shown, following similar discussions for triodes and tetrodes in previous parts. Having established a few amplifier 'building blocks' using valves, we shall this month attempt to join them together to form practical, complete audio amplifier systems.

The conventional approach to audio amplifier design results in a signal chain of the type seen in Figure 1. The signal input from a transducer, such as a magnetic pick-up, tape head or radio tuner is 'conditioned' in a preamplifier. This conditioning process may involve nothing more than raising the signal level by one or two stages of wideband amplification. On the other hand, it may involve tailoring the frequency response in a particular way, such as meeting the RIAA compensation curve for magnetic pick-ups. Since the input requirements are somewhat different from other types of transducer, it is usual to provide switching for each input, so as to select the conditioning components required in each case.

Following this first preamplifier stage would be the tone controls, with at least bass and treble lift/cut controls being provided, but often a more comprehensive single 'tone' control was incorporated. (Not forgetting a volume control, of course.) Any additional facilities included special filters known as 'rumble' and 'scratch' (high-pass and low-pass) filters. One must remember that, during the period when such circuits were common, 78rpm records were still in use, the earlier ones with inherently higher surface noise – due to the fact that they were manufactured from a mixture of shellac and a filler – and especially if they had been in use for some time. Some form of top-cut reduced the effects of surface noise, though often at the expense of high frequency signal reproduction. The surface noise of the 'new' Vinylite records, both 78rpm and LP types, was much less. Motor rumble was also a problem with crystal pick-ups, since these were susceptible to the low frequency vibrations (in the range of 5 to 50Hz) emanating from the turntable motor, whereas magnetic pick-ups, which produce an output proportional to velocity (and hence signal frequency), were hardly affected.

The next stage, following the volume control, would be the driver, developing enough signal to drive the output stage to its rated output. The output stage required two anti-phase signals, since it was of the push-pull type. The driver might, therefore, have to perform this function and could be referred to as a phase splitter, of which there were many different variations.

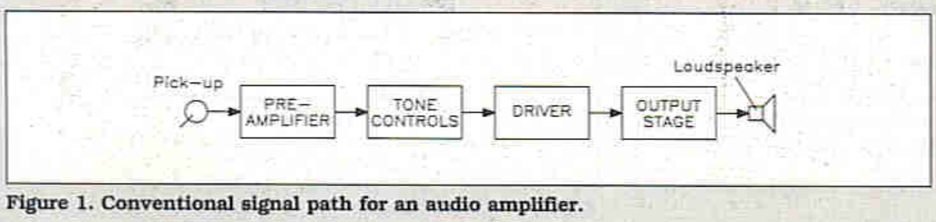


Figure 1. Conventional signal path for an audio amplifier.

We shall look, then, in turn, at these stages up to the output stage; the latter will be the subject of Part Seven (the last in this series), next month.

The Preamplifier

Here 'the preamplifier' is usually taken to mean one which performs amplification and RIAA equalisation for a record deck. An example of a two-stage preamplifier circuit is shown in Figure 2.

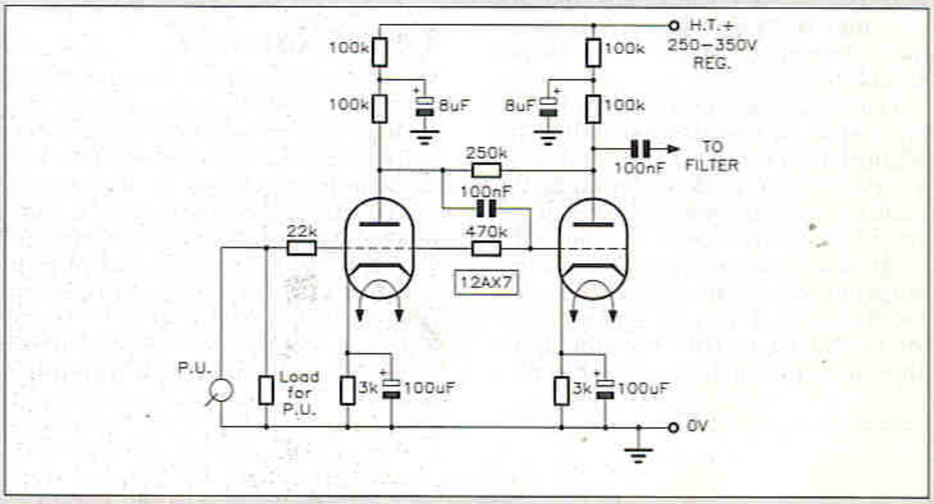


Figure 2. A two-stage preamplifier, from the early 1950s, designed for a magnetic pick-up.

This is able to use either the 6SL7 or 12AX7 (ECC83) double-triodes; the former is an earlier type of valve on the larger International Octal base. Some of the values may seem a bit odd as they don't exactly match the current preferred values, but could be rounded up or down to meet current practice. It is claimed that each stage can contribute a voltage gain of between 50 and 60, giving an overall voltage gain to the output of about 3,000 times. The intended input device is a magnetic pick-up cartridge.

RIAA equalisation could take one of two forms; either passive, where the first stage has a linear frequency response and merely drives a RC correction network feeding an output stage. The set open loop gain overcomes losses in the network. Alternatively equalisation could be achieved as an inherent part of a negative feedback loop, as is now universally done with solid state circuits. In Figure 2 the negative feedback loop is used.

Negative feedback between V1 anode and grid occurs through the series path comprising a 0·1µF (100nF) capacitor and a 470kΩ resistor. (For convenience the 470kΩ resistor is shown connected to the *right-hand* side of the valve's envelope; actually this is exactly the same point where the 22kΩ resistor connects, there is only one grid pin.) Negative feed-

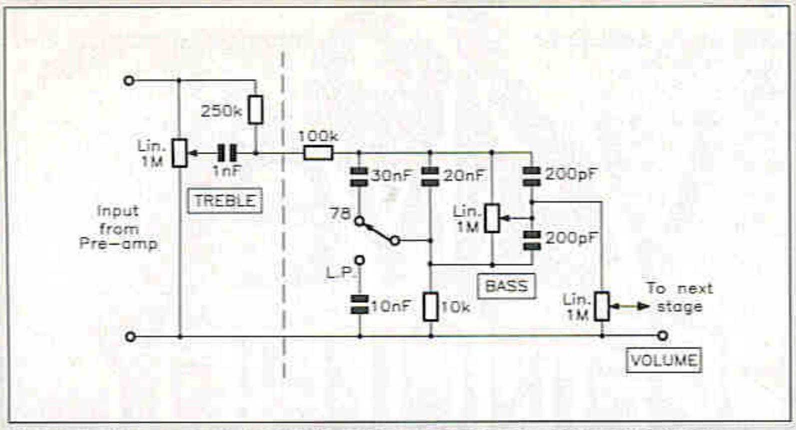


Figure 3. Tone control circuit for use with the preamplifier of Figure 2.

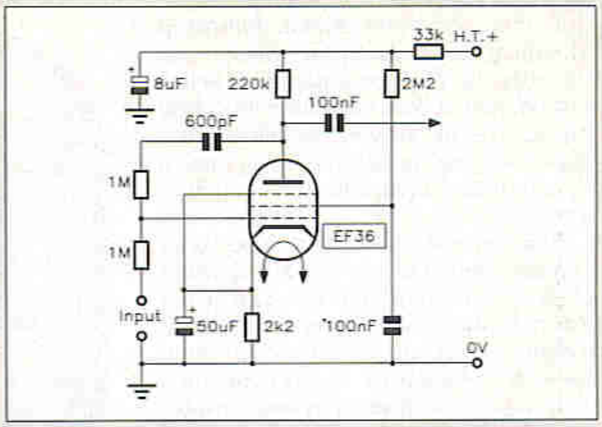


Figure 5. Tone (bass) control by negative feedback.

back is applied in a similar manner to the second stage, through the series path comprising the same 0·1μF capacitor and a 250kΩ resistor. This pre-amplifier circuit is intended to feed into the tone control circuit of Figure 3 via a 0·1μF AC coupling (DC blocking) capacitor. The tone control provides bass and treble controls and a two-way switch to compensate for the different characteristics of 78rpm and LP records.

There were many different ways of obtaining control over tonal response in the early days of Hi-Fi reproduction, with adherents of the various methods making claims that their way was the best. Strange to think that modern design has dispensed with this 'vital' facility entirely! However, Briggs and Garner, writing in 1952 in *Amplifiers, the Why and How of Good Amplification*, say *"tone control circuits are a necessary evil; they cannot improve quality, but they are necessary on account of the recording characteristics . . ."* They are referring here to the differences between the recording characteristics of 78rpm and LP records.

But we digress. The 22kΩ input resistor works in conjunction with the 0·1μF/470kΩ loop around V1 to provide a 'virtual earth' mode of input, in the same way as is done with modern operational amplifiers. It sets the gain of the stage, which varies over the frequency range due to the reactance of the capacitor. The value of the pick-up load resistor is chosen to trim the net input impedance to match the transducer.

The HT supply of both stages of Figure 2 are individually decoupled to ground, this being a vital part of the design of audio-frequency amplifiers, in order to avoid instability due to coupling between stages through the common power supply line. The true anode load of each stage is a 100kΩ resistor, wired directly in the anode lead. Above this is a low-pass filter comprising a further 100kΩ resistor going to the positive terminal of the supply, and an 8μF electrolytic capacitor to ground. As a result of this filtering, the alternating component of the anode current does not flow back to the supply, but is shunted to ground through the 8μF capacitor, after first passing through the 100kΩ anode load and developing the output voltage of the stage. (These days of course you'd be hard pressed to find an 8μF electrolytic, but a modern – and, to be honest, better – 10μF high voltage type will do just as well.)

Tone Controls

The tone control circuit of Figure 3 is of the 'passive' type and is formed by cascading a treble control with a bass control, the division between the two sections being shown by the vertical dotted line. The output level is controlled by a 1MΩ linear potentiometer.

Taking the bass section first, this is a 'Connoisseur' circuit (Connoisseur being a well-known name from the earlier days of Hi-Fi) that gives variable bass compensation for both 78rpm and LP records. The two 200pF capacitors maintain constant response at high frequencies, otherwise the following capacitance of the wiring and input of the next stage could cause HF loss.

In the treble section, the value of the capacitor can be anything between 0·0002μF and 0·002μF (200pF and 2nF), though apparently the value given of 0·001μF (1nF) offers a good compromise for both types of record.

Another Tone-controlled Preamplifier

The circuit of Figure 4 uses the once popular 6SN7 (an octal based double-triode, still available from valve suppliers as 6SN7GT, 6SN7GTY, etc.), employed as a two-stage preamplifier with the treble control in the input circuit of the first stage, and the bass control between the two stages. The claimed performance of this circuit, which goes back to 1949, is 40dB of bass control at 20Hz and 30dB of treble control at 10kHz, the crossover point being at 800Hz. The circuit is particularly useful for record reproduction because the treble cut comes in an octave higher than the top lift, so enabling surface noise to be reduced without adversely affecting the middle-to-high response and spoiling the output quality. Note again that the supplies to both stages are decoupled by their own filters comprising an 8μF capacitor in conjunction with a 50kΩ resistor.

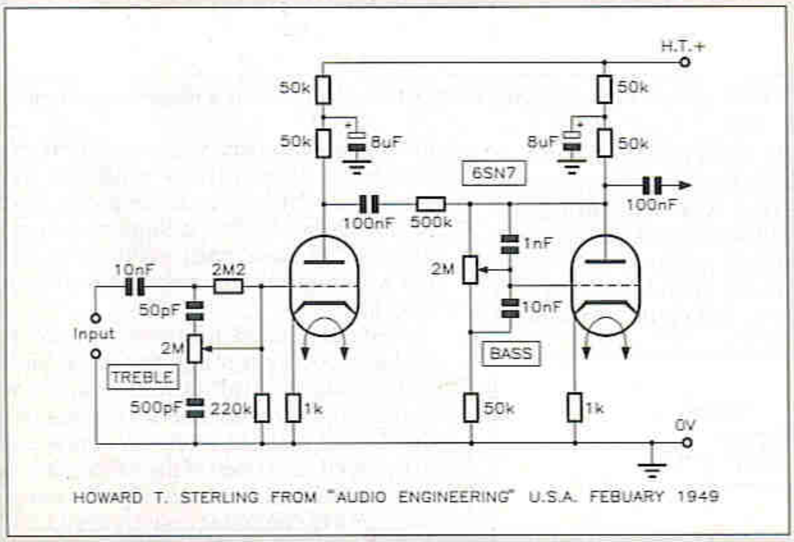


Figure 4. A tone-controlled preamplifier.

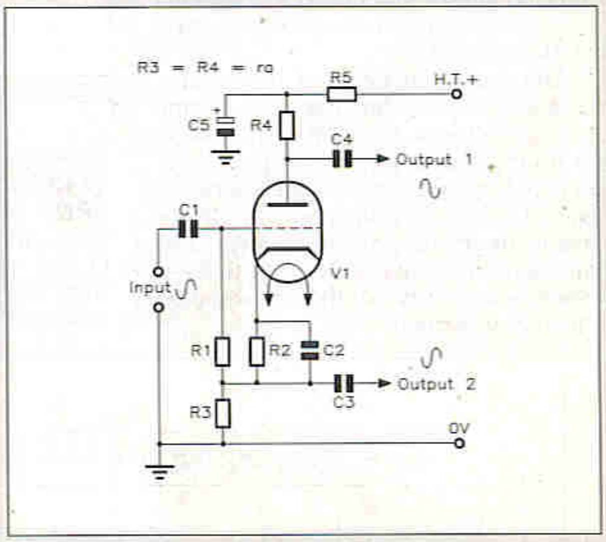


Figure 6. The concertina phase splitter.

Tone Control by Negative Feedback

It is possible to obtain tone compensation by the use of selective negative feedback. In a simple case, it is possible to make the cathode bypass capacitor smaller than the usual value, so giving incomplete bypassing at all frequencies. The effect of this is to introduce some degree of negative feedback at low frequencies (where the reactance of the bypass capacitor is high), so causing a roll off of gain in this part of the frequency spectrum. The amount of control obtained will obviously depend upon the relative values of the cathode bias resistor and its bypass capacitor.

Figure 5 shows a method whereby negative feedback is introduced between anode and control grid of an EF36 pentode valve. The feedback path comprises a series combination of 1MΩ and 600pF. Since 600pF is fairly small, the feedback will be less at low frequencies (where the total impedance of this path is high) than at high frequencies, where the impedance of the path is virtually that of the 1MΩ resistor alone.

This can be illustrated at three critical frequencies, as follows:

At the low frequency of 40Hz, the reactance of C is 6·63MΩ, giving a total path impedance of $\sqrt{45}$MΩ, which is 6·71MΩ.

At the middle frequency of 1kHz, the reactance of C (600pF) is 265kΩ, giving a total path impedance of $\sqrt{1{\cdot}265}$MΩ, which is 1·124MΩ.

At the high frequency of 10kHz, the reactance of C is 26·5kΩ, giving a total path impedance of approximately 1MΩ.

Quite clearly the feedback at middle and high frequencies is substantially greater than it is at low frequencies. For the values given in the circuit of Figure 5, the bass response rises at the rate of 6dB per octave below the corner frequency of 300Hz.

Inputs and Outputs

The output of the tone control would then go to a volume control before feeding the driver or phase splitter stage of the output amplifier. At this point unity gain output buffers of the cathode follower type could be considered, particularly following the RIAA preamplifier, for driving external equipment such as a tape recorder. Also not shown here is any form of input source selector. A rotary switch can easily precede the tone control stage(s) for inputting a choice of various programme sources, one of which would be the output of the RIAA preamp. In this case a buffered output for tape recording would immediately follow the selector switch.

Driver/Phase Splitter Circuits

The function of a phase splitter circuit is to take the, now amplified, signal – which is of course single phase in nature – and derive from it two equal amplitude, anti-phase signals, balanced about ground. These signals are used to drive the control grids of the push-pull output valves in opposition. Phase splitting, of one type or another, is always necessary with valves, since there is no equivalent of the complementary NPN/PNP devices found in semiconductors. Driving the grid of a valve in a positive direction causes an increase in anode current, whereas driving the grid in the negative direction causes a decrease in anode current. This fact dictates the need for a pair of anti-phase inputs.

One way of splitting the phases is to use an input transformer to the output stage with the secondary centre-tapped, this point being grounded. Indeed this technique has been extensively used in the past, but it carries with it all of the attendant disadvantages of such devices, not least of which is the possible poor performance at high frequencies due to shunt capacities. The trend was, therefore, to move away from the use of transformers in favour of circuits employing other techniques, some of which are described below.

The Concertina Phase Splitter

Figure 6 shows what some may consider to be the classical phase splitter circuit, the concertina phase splitter. This rather colourful title is derived from the way in which the voltages at the two output points of the circuit emulate the movements of the hands of the musician in playing a concertina. Thus, with this mental picture, it isn't too difficult to visualise the outputs rising and falling in phase opposition.

To achieve this, use is made of the fact that there is a phase shift of 0° between the control grid and the cathode, and a phase shift of 180° between the control grid and the anode. Thus these two electrodes automatically provide the two anti-phase signals required, and all that is then necessary to do is to design the circuit so that these two voltages are equal in amplitude. To achieve this, the resistors R3 and R4, which are the cathode and anode loads respectively, are made of equal value and also equal to the r_a of the valve. The voltage gain of the stage is then slightly less than unity, usually about 0·9. To balance this obvious disadvantage, the outputs can be balanced to within less than 1%, although it is necessary to use close tolerance resistors for the loads. No initial adjustment for balance is then necessary. The circuit is also simple and requires only one valve. The grid bias for the valve is derived from the resistor R2 in the cathode lead, in the usual way, the grid leak R1 being returned to the lower end of R2 rather than to ground.

The Paraphase Splitter

An alternative circuit is the paraphase splitter, shown in Figure 7. This uses a pair of triodes and, as expected, would usually employ both parts of a double-triode valve. In operation, this can be regarded as a two-stage amplifier in which each of the stages contributes one of the two complementary outputs. The input to the second stage is derived from the output of the first stage, this being tapped off using the potentiometer RV1. In this way the two outputs can be made identical, but it requires some initial setting up, observing the two outputs on a double beam or dual trace CRO (Cathode Ray Oscilloscope) while RV1 is adjusted. However, this twin valve phase splitter version has the advantage of higher gain and greater output over the concertina type, but appears to have rather poor response at high frequencies, arising because of the necessarily low value of resistor R4.

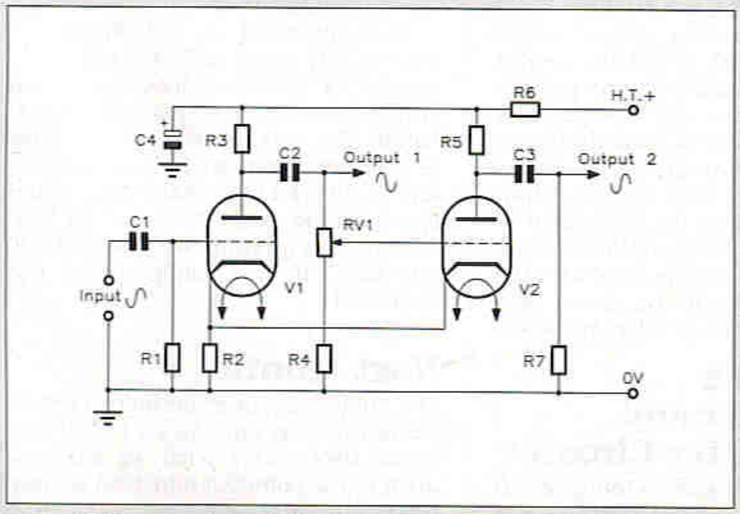


Figure 7. The paraphase splitter.

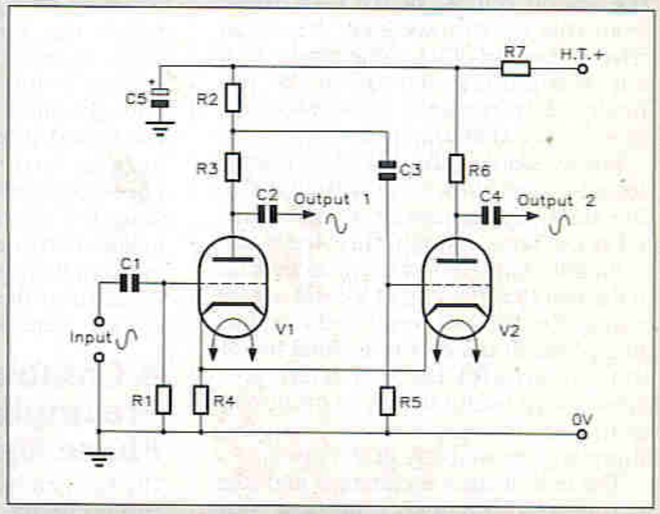


Figure 8. An improved paraphase splitter.

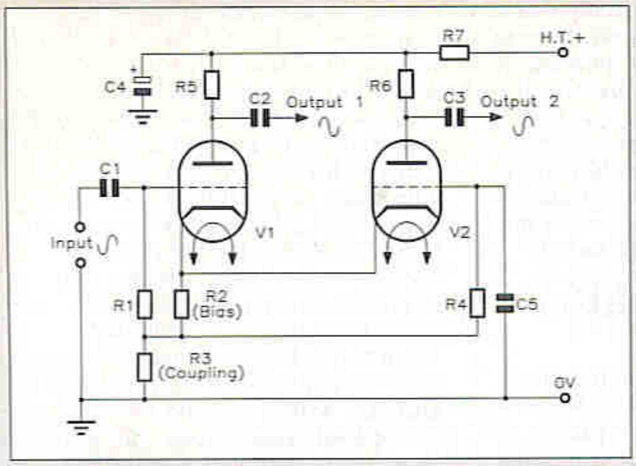


Figure 9. Cathode-coupled phase splitter.

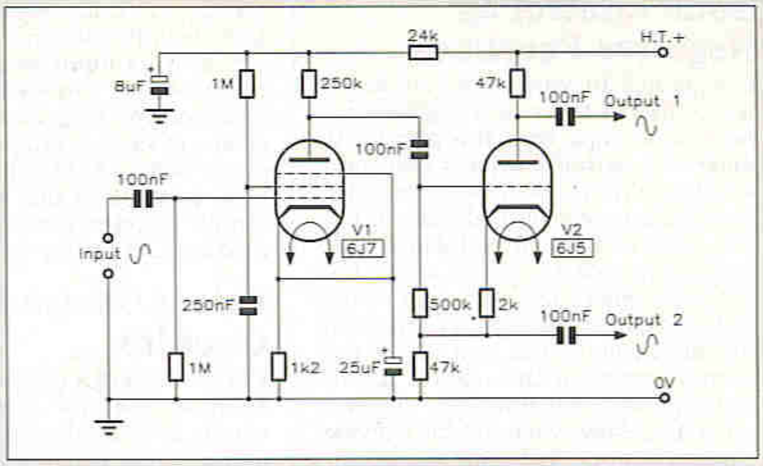


Figure 10. Combined preamplifier and phase splitter circuit.

Improved Paraphase Splitter

A version of the above described circuit, with greatly improved HF response, is shown in Figure 8. In this circuit, the principle remains essentially the same, but the potentiometer action is obtained by splitting the *anode load* of the first stage into two resistors, R2 and R3. These are proportioned so as to provide just sufficient drive to the second valve so that its output equals that of the first stage. Because the grid leak resistor of V2 (R5) can now be made larger, the HF response is better.

The Cathode-Coupled Phase Splitter

The name of this circuit (Figure 9) derives from the fact that the only signal coupling between the two stages is provided by their common cathode resistor R3. The way in which the circuit works is as follows.

If the grid of V1 is driven in a positive direction, the anode current of V1 increases, which causes an increase in the voltage across the coupling resistor R3. At the same time the anode voltage of V1 is falling. The increased voltage drop across R3 means that the cathode of V2 is now more positive *relative to its grid* than it was before (but only because C5 is AC coupling the grid of V2 to ground as a reference). It is as if the grid had been driven negatively, the result being that the anode current of V2 falls. The anode voltage of V2 then rises. From this we can see that the signal drive to the grid of V1 alone produces a pair of anti-phase voltages at the two anodes. Furthermore, these two voltages are equal in amplitude.

For AC signals, the grid of V2 is connected to ground via the capacitor C5. The size of this capacitor is important. If it is not large enough, then there will be an imbalance at low frequencies due to the fact that the grid of V2 will not be truly grounded, but connected to a tapping point on the divider formed by R4 and C5 across R3. However, it also provides a very useful degree of immunity to unwanted very low frequencies, improving the stability of the circuit.

The circuit uses a common cathode bias resistor, R2, with individual grid leaks R1 and R4. There is a slight imbalance in the outputs at all frequencies because of the current flow through the resistors R1 and R3, but this effect can be minimised if R1 is made large; values of 2MΩ often being used. Also, because of basic inefficiencies, losses can cause the non-inverted output from V2 anode to be slightly less in amplitude than the inverted output from V1 anode. A well-worn method of compensating for this is to increase the value of R6 slightly by adding another resistor in series, whose value is 5% or less than that of R6 (as a guide). In the days when only cruder, less than accurate carbon resistors were available, it could be suggested (by Mullard in one case) to test the two anode resistors with an ohmmeter. It would be quite likely that they were different. You then fit the one having the greatest resistance as tested in the R6 position!

This imbalance of outputs, and the various methods needed to compensate for it, seems to be the main aspect about the twin-valve splitter that annoys the 'concertina' fans (in that they can't understand why anybody should insist on wanting to use it if the 'concertina' is the 'best'). Another possible disadvantage has to do with valve ageing. While each of the two triodes sharing the same envelope would, arguably, be very closely matched (coming from the same batch), their characteristics may alter slightly with age, causing imbalance. However, the main advantage of the cathode-coupled paraphase splitter is inherent voltage gain, which the 'concertina' doesn't have. This, together with a greater output voltage swing capability, can provide enough signal drive for less sensitive triode and 'ultra-linear' pentode output stages, but from only two valve envelopes. For the same type of output stage the 'concertina' usually had to be followed with an additional amplifying push-pull stage, as is the case with the Williamson designs (to be shown next month), requiring three valve envelopes.

A Combined Preamplifier and Phase Splitter Circuit

The final circuit is shown in Figure 10 and comprises a typical pentode first stage voltage amplifier followed by a triode concertina phase splitter. In the original circuit, a 6J7 pentode is followed by a 6J5 triode, both of these being on the earlier International Octal bases. All of the true gain of the circuit resides in the pentode stage of course, the phase splitter, as said earlier, actually introducing a small loss. Taking the two stages into account, the overall voltage gain is reckoned to be of the order of 84 or so, the proportion of gain and loss being 94 for the pentode and 0·9 for the triode.

For the 6J7 pentode, the parameters are μ = 1,500; r_a = 1·5MΩ. It is impossible to realise the full gain of such a valve, which can only be done if the anode load is made much greater than r_a, because the HT requirement would be for an unrealistically high value of supply voltage.

The configuration of Figure 10 became very popular in the hey-day of valve power amplifiers, and can take several forms. A preceding triode might be used in place of the pentode, for instance, in which case a double-triode would fit the bill (e.g., a 6SN7 as in the 1947 'Williamson' amplifier). It is also possible for the grid of the second valve to be directly DC coupled to the anode of the first valve, making the two biasing resistors and coupling capacitor redundant and reducing component count, but it means that the DC level at V1 anode must be maintained at something like a third of the total supply voltage for the second stage to ensure correct biasing of V2.

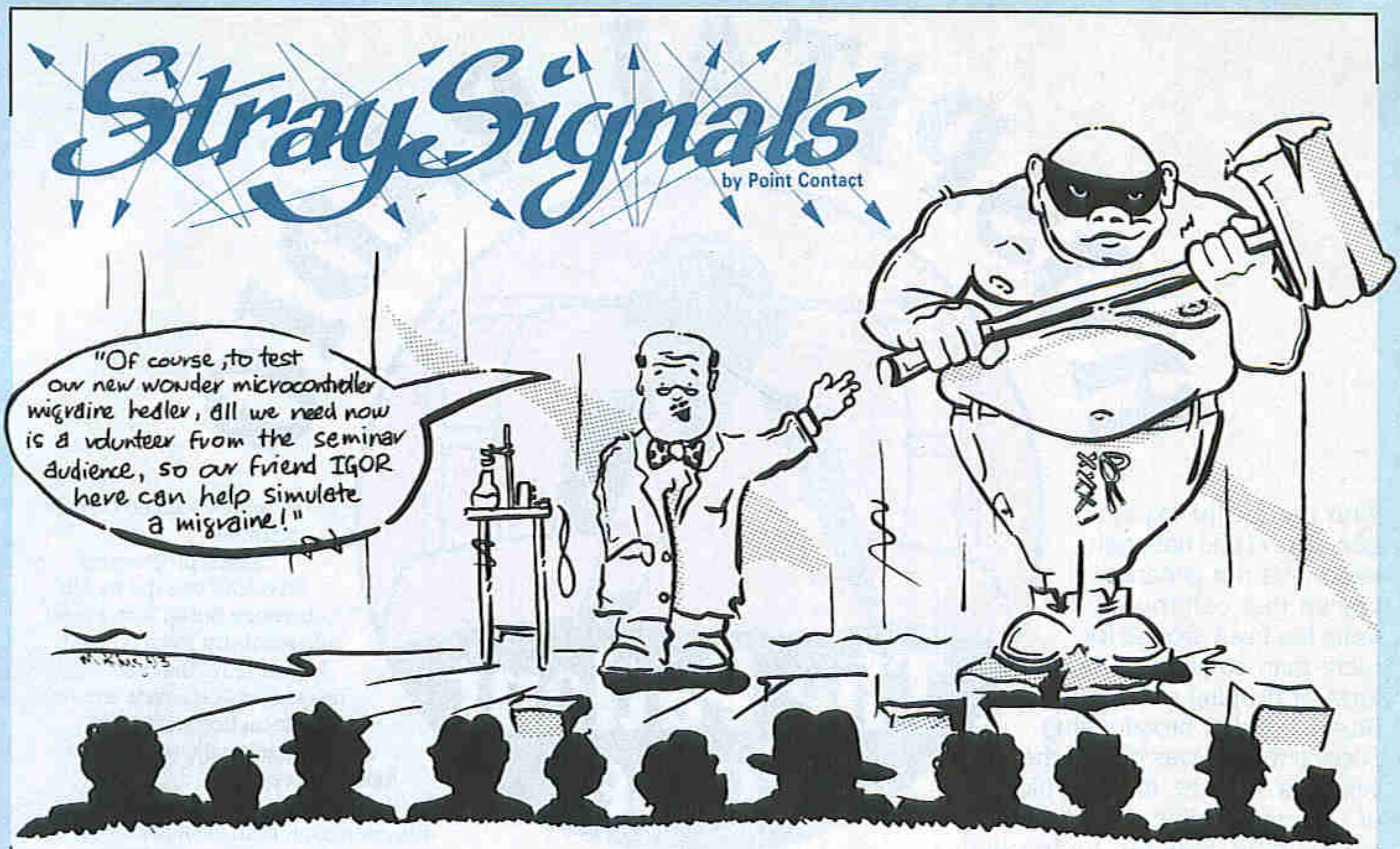
Also published was a Mullard variation of this where an EF86, taking the place of V1, directly connects to the first grid of a double-triode paraphase splitter like Figure 9, using a ECC83. There is only one common cathode resistor, and DC bias for the second triode comes also from the anode of V1, but via 1MΩ decoupled to ground with 100nF. A 6J5 and 6SN7 in this configuration also work well.

Next Month

The subject of power amplifiers will be continued next time, when I shall conclude this series with an examination of the potential minefield of valve power output stages.

Stray Signals

by Point Contact



My anecdotes about Charlie, the helpful local radio repairer of my youth, prompted a letter from a reader in Devon. He recounted how a radio repairer of yesteryear, in the village where he then lived, seemed to make up in diligence what he lacked in competence, backed up with a nice line in explanations, plausible to the non-technical, when things didn't turn out quite right. Radio and TV repairers in fact ran the whole gamut, from very competent and as honest as the day is long, like Charlie (What about those 'under-guarantee' valves, familiar to regular readers, then! – Ed), to the downright dishonest. An example of the latter actually turned out to be a lucky windfall for PC. I was a lad at the time, a few years into grammar school, and wanted to make a TV for the family to view. I already had one, converted from an ex-RAF 182A radar indicator, but the tube had a diameter of a mere $6\frac{1}{2}$in. – rather small for family viewing. Infinitely worse was that, being designed for radar use, it had a blue flash and a yellow afterglow that lasted many seconds. What was needed was a proper TV tube – 14in. rectangular tubes had just appeared, but a 12in. round one would have done very nicely were it not for the cost, which was way outside my limit.

We had just arrived back from our annual summer holiday in Cornwall, when our next-door neighbours popped in to say that their television had gone on the blink just after we went. PC was known up and down our street for fixing radios etc., but the thought of being TV-less for a fortnight was more than they could bear, so they had taken it to a local shop (not Charlie's) to be repaired. Out of interest, I enquired what the symptoms had been and was told that there were annoying bright sloping lines across the picture, which moved up and down every time the scene changed. "New frame sync separator", I thought to myself, and indeed they went on to say that they had been charged for the fitting of a new 6F14, a popular valve for this particular function. When they went to collect the set, though, and heard that it had also needed a new CRT, they told the shop that as the lad next door was interested in TV, they would take the old tube for him to experiment with, even though it was dud. I could imagine the proprietor of the shop gnashing his teeth while maintaining a polite mien, for of course there was nothing wrong with the tube whatsoever. It was a common way for an unscrupulous repair shop to get a free spare tube for the next customer whose set needed one. In the circumstances, I thought it kinder not to tell our neighbours the truth!

Some 18 months ago, the American company AT&T announced the introduction of a three chip coder/decoder set which would provide a videophone facility, allowing people to see and hear each other over their PCs. It was claimed that it would break the cost barrier, bringing video-conferencing to the lucrative mass market. Perhaps so, but I haven't heard anything more about it – have you?

A friend of mine suffers from the occasional migraine, or would do if he let it develop. At the first symptoms, which are minor visual disturbances in the corner of the eye, he takes the appropriate medication. This is, I believe, based upon an extract of ergot, a fungal growth which can affect rye, and which in former times caused many bizarre symptoms and fatalities when it got into bread undetected. Now, there is a microcontroller-based device which is said to control a migraine without drugs. It appears that compared to normal brains, the naturally occurring electromagnetic pulses at some frequencies are weaker in the brains of migraine sufferers. Via a serial port, the device accepts the output of a standard brain scan, stores the data in EEPROM, and works out which frequencies are deficient. It can then activate a coil near the skin, the electromagnetic pulses stimulating the nervous system to produce the necessary frequencies at an adequate amplitude. Though more expensive than a month's supply of a typical drug treatment for migraine, it is cheaper in the long run, being a non-recurring expense. This is yet another example of how microcontrollers are getting into everything nowadays – there seems no end to the varied uses to which they can be put.

The US Environmental Protection Agency has held its first auction of licences to pollute the atmosphere, and reaped over 20 million dollars in the process. One hopes the money will be spent in research into ways of reducing pollution in the future, rather than just disappearing into the coffers of the country's Treasury Department. Earlier, the EPA granted emissions permits to over 100 of the worst sulphur dioxide producers, mostly coal-burning electricity producers. These electricity companies may trade any excess permits they hold, above what is required to cover their own requirements. Our own government has a reputation for selling off all it can, but I don't recall being offered licences to pollute yet – have you?

Yours sincerely,

Point Contact

HOSPITAL RADIO

The Patient Voice

By Iain Elliott

With the recent expansion of local and national radio, it is not generally known that community radio has been around for more than 40 years in the form of Hospital radio. The Bristol Hospital Broadcasting Service (BHBS) was one of the very first services, and is typical of many similar organisations entertaining patients in hospital today.

In the Beginning

Prior to the start of hospital broadcasting in Bristol, in 1952, hospitals received their radio programmes on a cable system installed and maintained by Rediffusion.

The channels that could be received were the BBC Home (West of England), Light and Third programmes, and a selection of foreign programmes – in the evening, you could find Radio Luxembourg (recently sadly demised), and during the day this latter channel carried any signal that Rediffusion engineers could tune in.

All of these channels originated from MW and LW broadcast transmitters, since a VHF service did not exist at that time. This meant that, due to interference problems, the reception quality – especially in the evenings – was poor.

There was no television during the day. Certainly not on the hospital wards, where breakfast was served at 6.30 a.m.! The BBC was the only television channel available, as ITV did not start broadcasting until 1955.

Initial Benefits

When hospital broadcasts came along, they had several immediate advantages:

1. They were local, and were therefore able to bring items of local interest to their audience – notably sport, concerts and interviews with the local entertainment scene.

2. The reception quality was better than that from the BBC.

3. They had a personal touch – the names of individual patients would be mentioned.

Bristol hospital broadcasts started from the Toc H (a charitable organisation) idea of entertaining patients in hospital. The idea was further promoted by Rediffusion, who had controlled the cable distribution of radio programmes around the city. They saw the provision of hospital radio in the city's hospitals as a natural progression of their service. In 1952, Rediffusion proposed the start of a service, and agreed that the central point for the landlines should be located on their premises.

The first programme broadcast was the match between Bristol Rovers and Shrewsbury Town on 23rd August 1952. The broadcast was relayed on Post Office landlines to five local hospitals, with another joining the network the following week.

The enthusiasm for the new service was enormous. Both local papers carried many column inches describing the reaction of the patients to the football commentaries. The Chairman of the Bristol Hospital Broadcasting Service, as it became known, was interviewed by the BBC, and proudly left their studio with a recording of the interview under his arm – on a shellac 78 rpm record!

On many Saturday afternoons patients had to be content with only half a pair of headphones – whilst their visitors all huddled around the other half listening to the local football match being broadcast on the hospital radio network. It was the only way in which they could enjoy the match, as the ground capacity was always sold out, in those days!

This was not the first time that this had happened, though. At a match at Fratton

Right: The BHBS studio, circa 1968. The two Garrard turntables, which are fitted with crystal cartridges, are quick-started by applying power to the motors. The technical operator (TO) in the picture is the author.

Top left: It's not a wind up – or rather, it is! The infamous Boosey and Hawkes clockwork driven tape recorder being used for an interview on the terrace of the Avon Gorge Hotel. This picture was taken in the late 1950s.

Above: The equipment racks for the OB lines. This contains line equalisers and telephone-balancing units, jackfields and equalisers, as well as other equipment such as cassette decks (for logging purposes), talk back amplifiers and the 'Radio 2' tuner.

Below: The essential equipment located at each OB point.

Above: Bill Davis, BHBS' longest-serving member, being interviewed by Ian Hughes on the 'Saturday Supplement' programme, on the occasion of the BHBS fortieth anniversary. Bill was a member of Toc H, and a founder member of BHBS – he has also commentated on every Bristol City home match since 1952!

Park, the home of Portsmouth Town Football Club, the gates of the ground had to be closed as a capacity crowd waited for the kick-off. Outside the ground there were still hundreds of supporters trying to get in. A young Police constable, sensing impending trouble, climbed up on a wall and gave a running commentary to the crowd locked out of the ground. As soon as they realised that they wouldn't miss any of the action, the crowd settled down and were entertained by the constable's commentary. From this sprang the idea of relaying the commentary to the local hospitals.

The clock has now turned the full circle – with the need to comply with the sports ground regulations, many football clubs have approached their local hospital radio stations, and have asked if they can relay their commentaries on loudspeakers near the turnstiles, to cover the supporters still waiting to get in after the kick-off.

During the late 60s the Bristol Hospital Radio Broadcasting Service carried programmes via landline to 25 hospitals in the local area – including inmates of the prison hospital! With the health service cutbacks of recent years, this number has come down to 12 hospitals – and no prisons.

In the early days the equipment was very crude, and some services could only manage to make use of a telephone handset for relaying their commentaries from the soccer grounds.

Although the equipment at the sports grounds and studios has changed, the landline linking the two has remained virtually the same over those 40 years. Since those early days, hospital radio has always been a closed-circuit network using Post Office (now British Telecom) landlines. The lines – known as Private Wires – are equivalent to the wires connecting your telephone to the local exchange, except that they are connected between the two broadcasting points, and are permanently connected to their destination, (i.e. they are not switched).

But "ha", all of you are saying, "a

telephone line has only got a bandwidth of 3·5kHz – that must sound pretty horrible!" Well, that's true, but broadcast landlines are treated somewhat differently. When hospital radio stations use the wires they are equalised, and so a flat bandwidth, extending well up to 10kHz, can be obtained over the short distance from the local concert halls to the studio.

Hospital Radio Today

Modern hospital radio is a very sophisticated operation, when compared to the early days. Gone are the wind up clockwork tape recorders. Yes – these did exist! Made by Boosey and Hawkes, they always seemed to run down at the most critical moment. Before you wonder, though, it was only the mechanism that was clockwork driven – the valve electronics was powered by LT and HT batteries.

Today's hospital radio studio could give many of the commercial radio studios a run for their money, both in facilities and quality.

How the Programmes Get to the Hospitals

Hospital radio is a closed-circuit system. The signal, or programme, from the outside broadcast point, be it a concert hall or a sports ground, is transmitted back to the studio on a British Telecom landline. At the studio, the line is equalised to obtain a flat frequency response, and then fed through the mixer, where locally-generated items such as continuity announcements are added. As an alternative, studio-generated radio programmes can be introduced at this point. The signal passes through line-sending amplifiers before being sent out, via more BT landlines, to the hospitals. At the hospital, the amplified signal is connected to the hospital's headphone 'ring main' circuit.

On its journey from the commentator to the patient, the signal changes its amplitude and impedance several times. When it is passing along a BT line (basically a pair of wires), the signal has a level of 0dBm (0·775V), an impedance of 600Ω, and is transformer-balanced (so that common-mode noise – such as signals from adjacent cables – can be rejected). Transformer-balancing also provides isolation. When passing through the studio and the desk, the signal will still be at 0dB, and it may be unbalanced. At the hospital end, the signal is amplified, and is stepped up to 100V to match the signals in the headphone ring cable. The other signals, originally supplied by Rediffusion from their cable network, are now received from local tuners, the signals from which are brought up to the required levels.

In the larger hospitals, the signal is modulated onto a VHF carrier and distributed around the hospital via a co-axial cable, together with other radio and television services. Each hospital block has its own tuner/amplifier bank that supplies the dozen or so adjacent wards. In these hospitals, the hospital radio signal received from the landline is frequency-modulated on 103MHz, and is added to the normal services received via roof-mounted VHF and TV aerials (masthead amplifiers are used so that several such ward groups can be driven). Using this system, the individual ('local') audio amplifiers do not have to be as high-powered as the single one supplying an entire hospital, and so there is much less chance of a cable short affecting all serviced areas. This latter arrangement is shown in Figure 1.

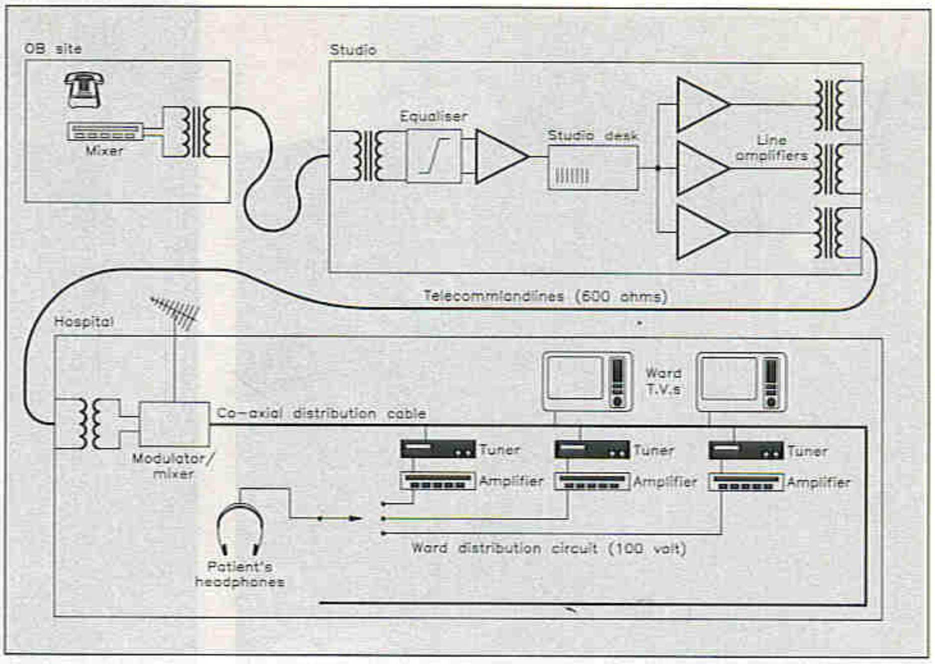


Figure 1. A typical hospital radio set-up.

The Studio

The sizes and styles of hospital radio studios vary, from nothing more than two turntables and a disco mixer in a broom cupboard, to large and lavish studios that would put quite a few commercial stations to shame. BHBS have two 'on air' studios, which are used for the record request programmes – the mainstay of all hospital radio stations. The larger of the two studios is large enough to accommodate a large discussion group around the circular table that occupies the centre of the room. The system of operation used is slightly old-fashioned since a technical operator (TO) sits in the control room with all the equipment. It is he who plays the records, CDs and tapes and balances the microphone levels, leaving the presenter to concentrate on the chat and the patients' requests – the studio and control room are linked by a large viewing window. The smaller studio is only big enough for two people, and is used mainly for record request programmes.

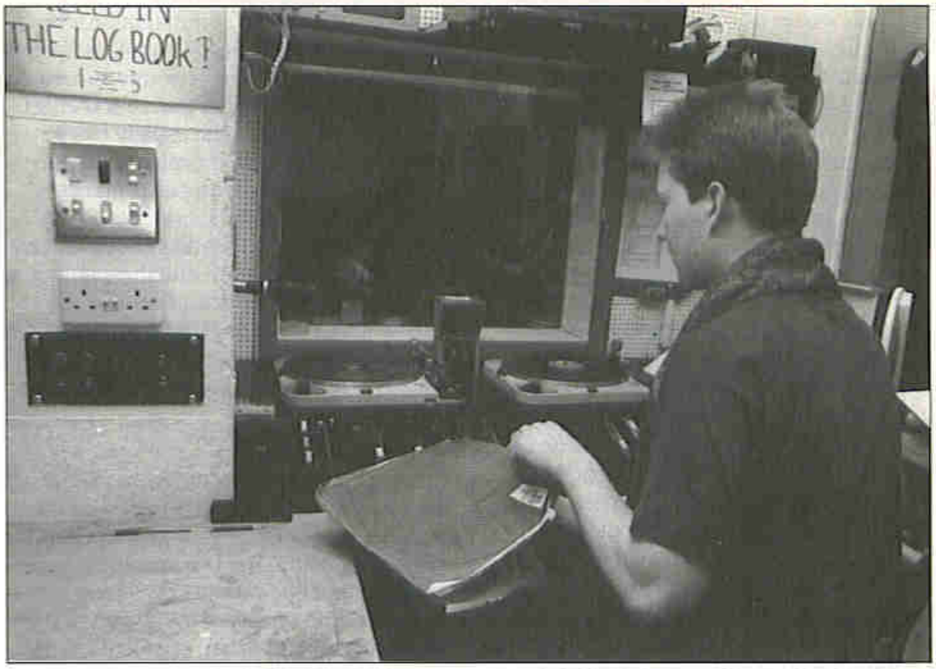
Both studios have similar facilities. The 10-channel desks, as with nearly all of the broadcast equipment, are home-made. The normal line-up is:

Channel 1. BBC Radio 2. This 'continuity service' is fed to the hospitals when BHBS is not broadcasting. Just before taking to the air, the Radio 2 fader is moved up, so that the service is continuous when the channel is switched over to BHBS. The fader is moved down at a suitable break in Radio 2's output (e.g., the end of the news), and at this point the BHBS programme can proceed. During the programme – i.e. when Radio 2 is not required – the input to this channel switched to one of the CD players.
Channel 2. CD player.
Channels 3 and 4. Microphone channels.
Channel 5. DAT (Digital AudioTape) machine 1.
Channel 6. Analogue tape machine.
Channel 7. DAT machine 2.
Channel 8. Spare, or incoming outside broadcast (OB).
Channels 9 and 10. Turntables.

Hospital radio differs from most other set ups because the station output is mono. Because of this, there are several considerations that have to be made when selecting any stereo ancillary equipment that might be required to feed mono signals to the desk. Deriving a mono signal from stereo is usually quite simple. You take the left output and sum it with the right – hey presto! You've got a mono signal. One (least expected) problem arises when your stereo signal comes from a digital source. Japanese CD players tend to use a single D-to-A converter, and a multiplexing arrangement, for economy – a sample from one channel is converted first and sent to the appropriate output amplifier, and then a sample from the other channel is treated in the same way. This means that one channel is 11·3µs out of step. This slight delay is not noticeable when listening in stereo but, because the two channels are 90° out of phase at 20kHz, some HF phase cancellation occurs when the signals are added together, and so a 'lack of treble' is apparent. Of course, the same problem will occur with off-azimuth tapes, for the same reasons – and this explains why cassette machines, which often have chronic azimuth errors and 'wandering' problems, are seldom used in broadcasting set ups of this type!

Denon CD players were selected.

Right: BHBS Studio 2. This includes a duplicate set of the equipment in Studio 1, but in a smaller space! Technical Operator Chris Horsman prepares to cue up a record on one of the Thorens TD124 turntables – these have not required servicing at any point in 25 years of constant use (How would modern turntables stand up to that kind of treatment?)



because they incorporated a sample-and-hold circuit after the D-to-A and prior to one of the output amplifiers, to compensate for this delay. European CD players, however, tend to use two D-to-A converters and no delay is incurred. So why was a Japanese type selected at all? Because the track timer of the Denon players could be switched to count down from total individual track time to zero – essential in broadcasting applications.

Landline

In Bristol, a very high proportion of programmes originate from outside sources. To interface, balance and equalise the incoming lines there is a whole rack of equipment in the workshop. All of the outside broadcast points can operate in two modes. In the first – 'auto' mode – a DC voltage is superimposed on the landline by the OB operator. This, picked off at the studio end, is used to operate a relay which removes the hospital radio output signal (known as the 'monitor programme') that is sent out over the lines whenever they are not being used. This could be the continuity service – Radio 2 for BHBS – when the studios are not in use. When it is operated, the relay switches the line back to the relevant studio input (in the case of BHBS, channel 8), rather than its monitor output. The upshot of this is that there is always a signal on the line – whether incoming or outgoing. There are two reasons for doing this. Firstly, it warns off any BT engineer who is tempted to use a silent line for other purposes – and secondly, the commentators are reassured, when they reach the OB unit, that all is well with the line. They can also use the incoming signal as a cue. This DC line switching system is shown in Figure 2.

The second method of use is to connect the landline directly to a studio desk, and use a standard telephone line to feed the monitor programme to the remote end. This two-way system is more flexible, and makes for better cueing, but needs a working telephone line as well as a programme line, and the studio has to be manned.

All incoming landlines are balanced with line transformers that have to comply to the BT standards for isolation. After equalisation, the output from the transformer is brought up to the required 0dB level. Several types of equalisation are used; on the lines used for music, passive inductive equalisers followed by a linear amplifier are the preferred method. These lines, used every week, utilise a 'phantom' configuration (refer to Figure 3) so that a third channel may be derived from a transformer placed across the two pairs of wires. As this third channel, known as a 'phantom line', appears as common mode 'noise' on the two lines, it will eventually cancel out. It is used as a telephone link between the studio and the OB unit, and the quality of the derived line is very good, no cross-talk being apparent.

For normal use, all sports ground lines are equalised using either a three-frequency (bass, middle, treble) tone control, or a graphic equaliser; the controls are set by ear to give the best perceived sound quality. All of the landlines are left terminated at the distant end with a 600Ω resistor when not in use. This enables the engineers to check them prior to use – there are plans at BHBS to use an old Apple computer to measure the resistance of the landline overnight, and to log any faults that might occur.

Outside Broadcasts

Each of the sports ground OB sites is equipped with a Shure M267E four-channel mixer. These have the advantage of being powered by either mains or batteries – handy if the mains fails. A very useful facility, as was proved when a fire at Bristol Rovers' ground at Twerton Park caused all of the broadcasting facilities to be moved to a temporary position. Unfortunately, the local hot dog stand was allocated an adjacent site and, during every match, at 3.45 p.m. the owner would turn on his grills, ready for the half-time rush. After ten minutes, the circuit

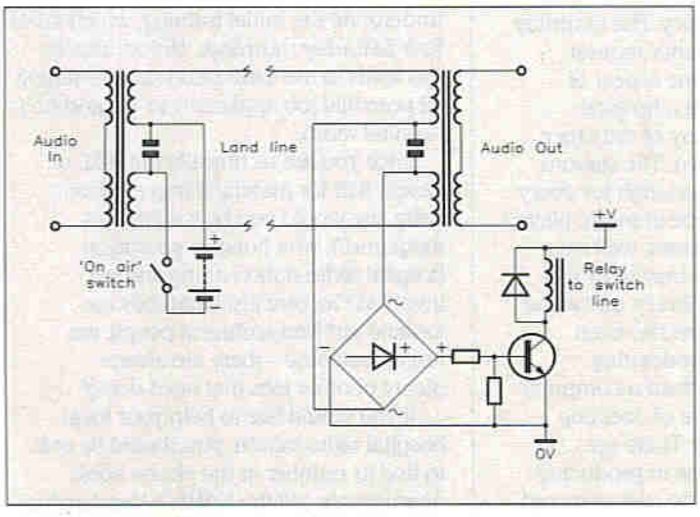


Figure 2. DC line switching arrangement. In the case of BHBS, this is used to switch the landline operating mode from 'receiving' to 'sending' – see text.

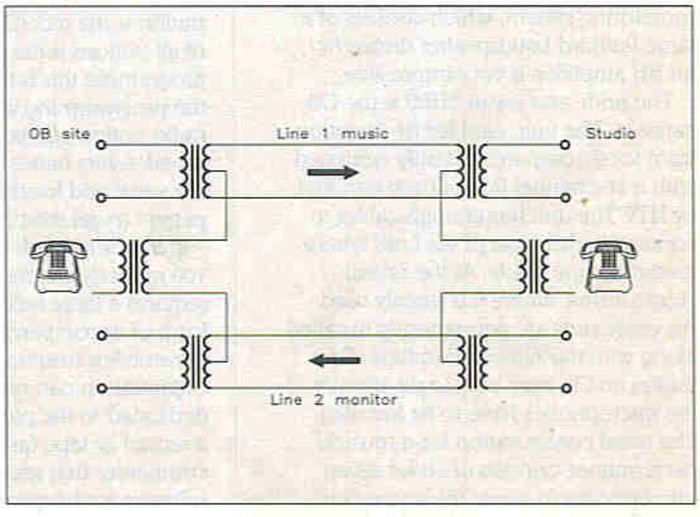


Figure 3. 'Phantom line' system. This allows a third audio channel to be derived from a pair of balanced transmission-lines e.g., two BT landlines. Cross-talk is very low.

breakers would trip, putting everyone off the air. After the first occasion, the commentators always made sure that they had the back up batteries fully charged! The headphones used are usually Sennheiser models, as they are the cheapest, that have an impedance of 400Ω. An impedance of this magnitude will avoid loading the landline if, for some reason, one of the earpieces has to be driven directly from it.

It has been found over the years that the best microphones for commentary applications are lip microphones, originally designed by the BBC. Once produced by STC, these microphones are now made by a company called Coles Electroacoustics. In the crowded positions in the press box, they exclude most of the other commentators, which is more than can be said for the 'open mic' techniques of some local radio commentators – several other commentaries can often be heard in the background under these circumstances! An assortment of effects microphones can also be called in to play at any time – including a parabolic reflector which, for example, captures well the sound of bat on ball, and the ripple of applause that is so evocative of a cricket match.

In Bristol, well over 30 concerts a year are covered from the Colston Hall, where BHBS have a studio in the basement and a commentary room overlooking the stage. The commentary room, small as it is, served as the main studio for several years until better accommodation was found. The fully-equipped studio contains a 20-channel mixing desk, and connects with tie lines to connector boxes on the stage and in the balcony. There is a closed-circuit TV link into the hall system, and full communications with the main studio and the commentary position. Nearly all of the concerts covered consist of classical music, and a single AKG C414 microphone suspended above the left side of the stage covers most eventualities, with the provision that extra microphones can be added, when needed, to cover soloists. The conductor, if he chooses to speak, is usually covered by taking a feed from the in-house public address system.

The sound quality of the control room monitoring system, which consists of a large Radford Loudspeaker driven by an HH amplifier, is very impressive.

The pride and joy at BHBS is the OB caravan. The unit, paid for by donations from local companies, is fully equipped with a 16-channel Rosser desk donated by HTV. The unit has enough cables to connect it into most of the halls where recordings are made. At the Bristol Hippodrome, where it is mainly used, the cable runs are permanently installed along with the Telecom landline. This makes an OB very easy to rig, as only the microphones have to be installed. The usual configuration for a musical performance consists of about seven microphones to cover the instruments in the orchestra pit, three microphones covering the stage, one microphone to cover audience applause and a lip microphone for the commentator, who sits in one of the boxes. A high-level feed is also taken from the stage sound system, so that radio microphones and sound effects are covered. The rigging usually takes the better part of the morning (starting at 9 a.m.), the afternoon performance acts as a rehearsal or 'soundcheck' – a chance to set the levels and check for any operational problems – and the evening performance is broadcast live. The possibility of recording, editing and broadcasting the performance at a later date is precluded by the Musicians Union.

Fibre Optics

From wind up tape recorders in the 50s, to fibre optics in the 90s! In Bristol, they have found a couple of uses for Maplin's plastic fibre-optic cable. The DAT machines have optical input and output connectors, enabling high-quality clone copies of tapes to be made. When contacted, Sony wanted an astonishing £60 each for the 'official' opto-coupling cables. A few minutes work with a Stanley knife and a piece of Maplin fibre-optic cable produced a couple of very cheap but effective fibre-optic couplers – they work very well over short distances of between 2 and 3 feet. The other problem involved the CD players. In the smaller studio, they had to go behind the technical operator due to space constraints. Using the infra-red remote control was no good as it acted on both players. The solution was easy – shine the infra-red control beam down yet more Maplin fibre optic! A cradle was made for each handset, and was attached to the fibre optic so that it pointed at the infra-red LED in the unit. The other end of the cable was glued into a small perspex block, which was itself glued onto the front of the CD player over the infra-red pick-up. The most critical part of each operation was cutting the fibre, and ensuring that a good clean flat end was produced. This method, rather than a direct electrical connection, was used so that the manufacturer's guarantee remained intact!

Record Library

Part and parcel of every hospital radio station is the record library. The mainstay of all stations is the patients' request programme this is the one aspect of the programming where a hospital radio station can beat any of the other broadcasters hands down. The stations are small and localised enough for every patient to get their choice of music played – in a typical week in Bristol, well over 100 requests are played. Inevitably this requires a large record library, and some form of accompanying index. Even the smallest hospital broadcasting organisation can now afford a computer dedicated to the purpose of locating a record or tape quickly. There are companies that specialise in producing software for hospital radio station record libraries. The software can even produce a 'top ten' list of record requests. In Bristol the original software, written in-house, ran under CP/M on a Merlin computer donated by BT. The software has now been re-written and upgraded to run on an IBM AT-compatible. The record library, at the time of writing, consists of 9,000 45 rpm singles, 1,000 albums, 300 CDs, and a rapidly growing collection of DAT tapes – that's over 27,000 titles! The whole library is indexed under track title, artist, album title, composer, band leader and record library number. Even with all this information the computer, which is not the fastest in the world, will find any track in far less than a second.

Charity

It is important to realise that every hospital radio station is run on a charitable basis, and that a great many of them are registered charities. All of their members give their time and skills entirely voluntarily, and a great amount of their time is taken up with jobs that are not in any way associated with radio. All the money needed to run the station has to be raised by the members. Collections, raffles, discos and bingo are just some of the ways in which the stations raise the money needed to keep them on air. In Bristol, the annual bill to BT for the rental of the landlines alone amounts to £11,000 a year.

NAHBO

There are over 300 hospital radio stations in Great Britain, and several hundred more throughout the world. Most of the British stations are members of the national body NAHBO – the National Association of Hospital Broadcasting Organisations. It, like all of the member stations, is manned entirely by volunteers. It co-ordinates national events, press coverage and other matters like insurance. It lobbies MPs on matters, like tape levies, that affect hospital broadcasts.

Every hospital radio station is looking for unpaid volunteers. They need helpers – with or without technical ability. Most hospital radio stations run training courses for their new helpers. In Bristol, no-one is allowed into the studio until they have undergone the initial training, which takes four Saturday mornings. Unfortunately, this leads to the local radio stations telling all potential job applicants to 'go and help hospital radio.'

Since you are technically minded, or have a flair for making things electronic (why else would you be reading this magazine?), why not give your local hospital radio station a ring and get involved? You are just what they are looking for! Non-technical people are just as welcome – there are always plenty of other jobs that need doing!

If you would like to help your local hospital radio station, you should be able to find its number in the phone book. Alternatively call the NAHBO Membership Secretary, who can put you in touch with your nearest station. The contact number is (0268) 555172.

AIR YOUR VIEWS

K4000 Quibbles

Dear Sir,
In 'Air Your Views', *Electronics* April 1992, there was a letter from Mr. John Brown regarding the Velleman K4000 Stereo Valve Amplifier in which, amongst other things, he criticised the lack of negative grid bias for the phase splitter valve. My question is two-fold. First, Mr. Brown suggested that the circuit could be improved by running the phase splitter with bias. Has this change been made to the kit design that can be purchased from Maplin?
Secondly, Mr. Brown referred to a 'Dynaco A470' 40W amplifier, a circuit of which he sent to you.
Is it possible to obtain a copy?
Mark Elder, London.

Mike Holmes replies:
No, I'm certain that the K4000 hasn't changed. There are some things about the design that I don't like either but, if I were going to do something different then, to borrow an Irish expression, 'I wouldn't start from here'. I would agree however, with Mr. Brown, and DC connect the grid of the phase splitter directly to the anode of the first valve, then bias the first valve to achieve the best voltage swing output capability from the phase splitter.
Considering that Mr. Brown's letter was published nearly 18 months ago I suspect that the A470 circuit is well and truly lost.
However, if Mr. Brown is reading this maybe he can get back to us with a new copy? Or can any of our other readers help?

Desperately Seeking Valves!

Dear Sir,
I have been following Graham Dixey's series on Valve Technology with great interest. As a fan of 'valve sound', but without the necessary technical knowledge, I would really appreciate details of currently available reference/tutorial material for further reading.
I have been trying in vain to find such material in the major London book stores. Apart from Hi-Fi applications, I'm sure you're aware of the popularity of valves for guitar and other musical instrument amplification. Is there any chance of a future project for the design of a 25/50W guitar amp with useful facilities?
Rod Hall, London.

We sympathise with your predicament. It is almost certainly true to say that the amount of valve theory and design literature still in print is zero. The only recourse is to do what the rest of us do, i.e. find and collect old books, manuals, magazines, etc. from the 1950s, 60s and early 70s. Old copies of Practical Wireless are recommended. Books include anything by Mullard, The Radio Amateur's Handbook (by ARRL), and Fundamental Electronics Principles (I think) by M. J. Scroggie (2nd edition). You can also put a advertisement in our classified for any valve information. A couple of Maplin lab members have already cited the idea of a musician's valve amp, and I think it will be perfectly feasible to adapt the forthcoming 'Millennium' project to this role with 'front-end' added. Some details may hopefully follow in due course!

S·T·A·R L·E·T·T·E·R

This month's Star Letter Award winner of a £5 Maplin Gift Token is Mr. M. Saunders of Leicester, criticising the faceless giants of electronic component manufacture.

Hobbyists Are People Too!

Dear Editor,
I would like to through *Electronics*, have a grumble at manufacturers and distributors? Often you find the need for a device or IC which is available from one source only. Upon writing to the supplier, NOTHING! is the reply. I suppose that, unless you are going to buy hundreds or thousands, they basically don't want to know. Often they don't want to know even if you give the impression that you want to buy thousands! But they should remember that we, the public, are the ones who create a need for their products. The keen hobbyist, who finds a new use for an old IC, for instance, produces a project article for a magazine, and then suddenly everyone needs an IC. So, as a final word to those concerned,

PLEASE DON'T IGNORE THE HOBBYIST.

However difficult it is for us to imagine we are still a minority as far as the manufacturers are concerned. To the manufacturer a 'consumer' is someone who buys mass-manufactured equipment from the high street stores. Hence, some 90% or more of his output goes to the equipment manufacturers, while the remaining fraction is distributed to the likes of us, and we don't have quite the same clout.
So the most likely response to your plea from a big component manufacturer, when you mention the electronics hobbyist, might be "who's he, then?" In several instances where you can't get some items for a long time, it is often down to world demand outstripping manufacturing capability. Currently, for instance, you can't get surface mount components for love nor money. Ten years ago it was the 8000 series of computer interface chips (8251, 8255, 8155, etc.). 'Silicon Valley' couldn't get them out fast enough, even working double shifts around the clock. This can apply to any component.
I heard a nasty rumour a while ago about a supplier of PCB electrolytics. An equipment manufacturer locally (far East) may want to secure a contract for all his output. The main condition of the contract is that he drops ALL his other customers!

Less is More

In answer to the section 'Any Comments' in your Readership Survey Questionnaire, firstly, make more room for comments! I'm not a fan of kits – I think they are not in the spirit of the hobbyist – and in particular the Velleman kits are overpriced, and it is a 'soft-option' to include them under the guise of 'projects' in the magazine. Describe and review by all means, but what is the point of including them as a project when the kit comes with instructions anyway (I presume)? And who thought up the survey questions? It's all very well asking me whether I would like to see 'more' or 'less' of certain subjects, but the truth is I would actually like to see more of everything, and I suspect other readers feel the same – so long as their particular interests are covered. If we don't balance the 'mores' against the 'lesses' you could end up with everyone wanting more of everything, and proving nothing! On the subject of what factors decide whether we buy an issue or not, it surely depends on the contents. Take Issue 70 for example – a SEVENTH month

Continued on next page.

of 'Professional Audio', and an EIGHTH month of 'History of Computers', which I'm actually interested in, but we don't seem to have reached electricity yet in this series, never mind chips – I fear I won't live long enough to read about transputers, etc. And as for 'Exploring Venus' – I'm lost for words.
Keith Suddick.

Very often there is more to be said about a particular Velleman kit than is provided in its leaflet, or the leaflet's assembly instructions need clarification. It is not impossible for us to add a supplement, or replace the leaflet with our own, based on the magazine article. Personally I think kits in general are brilliant; you don't have to keep starting from scratch every time and waste hours figuring out board layouts, you can get on with producing whatever it is and get it working. From what we've seen of the survey returns so far, readers appear to have marked the 'more' and 'less' columns most, and the 'same' column least. You've practically answered your own question by saying everyone wants to see more, provided it's what they're most interested in. This will show up during compilation of the results, honest!

No Such Animal

Dear Sir,
You shock me! You make me laugh! 'Knots per hour', indeed! (page 11 Issue 70). No boat yet built has that kind of acceleration, since the knot is a unit of speed, not distance. Also, Beaufort designed his scale for seagoing captains, and no self-respecting captain would take his ship to sea in more than force 12. The figures 13 onwards are NOT the Beaufort scale; get rid of them. I have not yet read the article, the table was enough to prompt this letter!
Congratulations however on the 'Face of Venus' feature, which compares very well with the article on the subject in the 'National Geographic' magazine (no less), whose society has more facilities and resources. A cursory glance through the article confirms that it is reasonably in agreement with the 'Geographic' version.
E. J. Scudder, Cumbria.

Yes, okay, we will admit that the 'knots per hour' error was introduced quite late at night when we were trying to finish that particular article. You are right in that the Beaufort scale is specifically a sea related standard, but it was applicable to all sizes of sailing vessels, not just ships. Hence, sailors of smaller craft took note of more modest wind forces, e.g., 3 is hazardous for a dingy, 6 for a fishing smack. The extra 'levels' beyond 10 were recently added, apparently as the result of the infamous hurricane of November 1987. It used to be merely 'greater than 10'. As a matter of interest, 'metres per second' is becoming more frequently used on merchant ships as an alternative to knots. All to do with the process of standardisation with the EC and all that.

Bleeping Good Idea

Dear Sir,
The following may be of interest to experimenters. I required a pulsed 'beep', but only had a continuous sounding piezo buzzer to hand. In a flash of inspiration a very simple solution was found. Connect a flashing LED in series! From a 5V supply the LED draws approximately 10mA when ON, and less than 1mA when OFF; this can be used to pulse devices that operate at around 10mA. Small relays have also been tried successfully.
The total supply voltage needs to be chosen to operate both devices in series, but obviously care is needed to ensure that the LED is working within in maximum limits, when OFF the voltage drop across it will equal the total supply level.
Malcolm Perry, Worcestershire.

Thank you for the simple and ingenious idea. Presumably the LED could be visible if you wanted a flashing light as well, and hidden if you only want the beeping.

Where Have All the Keyboards Gone?

Dear Sir,
Although I do not normally write to a magazine, I feel I must speak out about the new 1994 catalogue. The colour pages are great, but I do not like the sectioning idea. I suspect this is merely a reluctance to change, but if it does have to be sectioned, couldn't the subsections at least be in alphabetical order?
I would also like to know whether your purchasing department actually talks to the lab about new projects. Being heavily into MIDI I was delighted about the keyboard scanner project. Mistakenly, however, I thought I'd wait until the new catalogue came out before building the MIDI bass pedals I so desperately desire – just in case there was a wider range of keyboards introduced. Instead they had all vanished! Shortly after, in this very magazine's letters pages, we are told that more MIDI projects would be popular! Surely the new scanner project warrants the continuation of keyboards for a while longer even if they're not selling well?
Mark Crutch, Buckinghamshire.

The purchasing department are harangued continually about cutting costs, namely not having too much stock on the shelves tying up money and not moving. They are sometimes at logger heads with what we want, but one good trick is to make an item part of a kit list; this makes it difficult to give it the kiss of death, the dreaded 'DIS'. However, they then start thinking how to 'DIS' the kit! On reading your letter I looked up the 61-note keyboard and noticed that we sold one a month, on average, and its price was just about £70. Buying office won. It's a harsh world, the accountants have the final word.

More TV Stuff Please

Dear Sir,
I have been reading *Electronics* for several years and have greatly enjoyed all the articles, especially those involving computers, in particular for the PC.
I have also been interested for some time in the possibility of decoding Teletext signals from the TV. I notice that you now sell a PC TV tuner, and I wonder whether an article on Teletext and perhaps even a project in conjunction with the Maplin I/O Card and NICAM Tuner would be a good idea.
Douglas Pickering, Surrey.

You will be pleased to know that a PC based Teletext decoder is already on the 'ideas list'. Not quite sure yet if or when it will appear in print, but it is being given consideration.

Report by Stephen Waddington

Christmas Computer Show

Preparations are under way by all the top computer manufacturers for the 1993 Christmas Computer Shopper Show at the Grand Hall Olympia, London. Taking place from 2nd to 5th December, the show will offer a unique opportunity to meet companies who sell direct, meaning there will be better deals to be had than available through mail-order or over the counter sales.

An independent advice centre staffed by journalists from the Computer Shopper Magazine, will be open daily to offer free and impartial advice to individual visitors, while special presentations of new software will be shown in the Software Theatre with the opportunity for visitors to have questions answered.

Also at the show will be a dedicated advice centre offering solutions for business computer users. Specialist attention will be paid to the needs of small businesses and home workers.

Not forgetting the fun side of computing, the Games and Leisure Area will offer the chance to try out all the latest games software for PCs and Apple Macs before buying, plus visitors can take part in the ingenious competitions arranged for the event.

'Electronics' readers wishing to visit the show will get £1.50 off the ticket prices (£7.00 for adults and £5.00 for under sixteens) if they use the voucher (right).

Contact: Blenheim Online, Tel: (071) 742 2828.

DIARY DATES

October 5 to January 30. Speak to Me. Exhibition exploring the role technology might have in improving communications for people with disabilities. Science Museum, Exhibition Road, London. Tel: (081) 938 8000.

October 28. Pippa Richardson of the Science Museum talks on the working women's contribution to industry. Science Museum, Exhibition Road, London. Tel: (081) 938 8000.

October 30 to 31. The Lancashire Evening Post Computer 93 Business & Leisure Exhibition. The Guild Hall, Preston, Lancashire. Tel: (0772) 254841.

November 4 to 21. 37th London Film Festival at the Museum of the Moving Image (MOMI). South Bank, Waterloo, London. Tel: (071) 815 1322.

November 10. Wirral and District Amateur Radio Club. Talk – 'Microwaves' by Mike Dixon at 8.00pm, Irby Cricket Club, Irby, Wirral. Tel: (051) 648 5892.

November 12. Children's all-night camp-in at Science Museum. Science Museum, Exhibition Road, London. Tel: (081) 938 9785.

November 16 onwards. Science in the 18th Century – The King George III Collection. Science Museum, Exhibition Road, London. Tel: (081) 938 9785.

November 16 to 18. Electronic Information Display, Sandown Exhibition Centre, Sandown Park, Esher, Surrey KT10 9AJ. Tel: (0882) 614 671.

November 20. Crystal Palace & District Radio Club, Surplus Sale, 7.30pm, Saints Parish Church Rooms, Beulah Hill, Upper Norwood, London SE19. Tel: (081) 699 5732.

November 20. All Formats Computer Fair, Sandown Exhibition Centre, Sandown Park, Esher, Surrey KT10 9AJ. Tel: (0608) 662212.

November 24. Wirral and District Amateur Radio Club, Home Construction Competitions, Social & Presentations at 8.00pm, Irby Cricket Club, Irby, Wirral. Tel: (051) 648 5892.

December 2 to 5. 1993 Christmas Computer Shopper Show, The Grand Hall Olympia, London. Tel: (081) 742 2828.

December 11. Children's all-night camp-in at Science Museum. Science Museum, Exhibition Road, London. Tel: (081) 938 9785.

December 18. Crystal Palace & District, Radio Club Christmas Social, Video/Film Show at 7.30pm, All Saints Parish Church Rooms, Beulah Hill, Upper Norwood, London SE19. Tel: (081) 699 5732.

December 22. Wirral and District Amateur Radio Club, Chairman's Night, Chairman's Surprise Talk at 8.00pm at Irby Cricket Club, Irby, Wirral. Tel: (051) 648 5892.

January 12. Wirral and District Amateur Radio Club, Annual General Meeting at 8.00pm at Irby Cricket Club, Irby, Wirral. Tel: (051) 648 5892.

January 15. Crystal Palace & District Radio Club, QRP (Low Power) Home built Radio Equipment by Wayne Dillon, 7.30pm, All Saints Parish Church Rooms, Beulah Hill, Upper Norwood, London SE19. Tel: (081) 699 5732.

January 26. Wirral and District Amateur Radio Club, Surplus Equipment and Junk Sale at 8.00pm at Irby Cricket Club, Irby, Wirral. Tel: (051) 648 5892.

February 13. Third Northern Cross Radio Rally, Rodillian School, A61 between Leeds and Wakefield. Tel: (0532) 827883.

February 19. Crystal Palace & District Radio Club, Annual General Meeting and Construction Contest, 7.30pm, All Saints Parish Church Rooms, Beulah Hill, Upper Norwood, London SE19. Tel: (081) 699 5732.

March 5. VHF Convention, Sandown Exhibition Centre, Sandown Park, Esher, Surrey KT10 9AJ. Tel: (0707) 659015.

March 24 to 27. National Computer Shopper Show, National Exhibition Centre, Birmingham. Tel: (081) 742 2828.

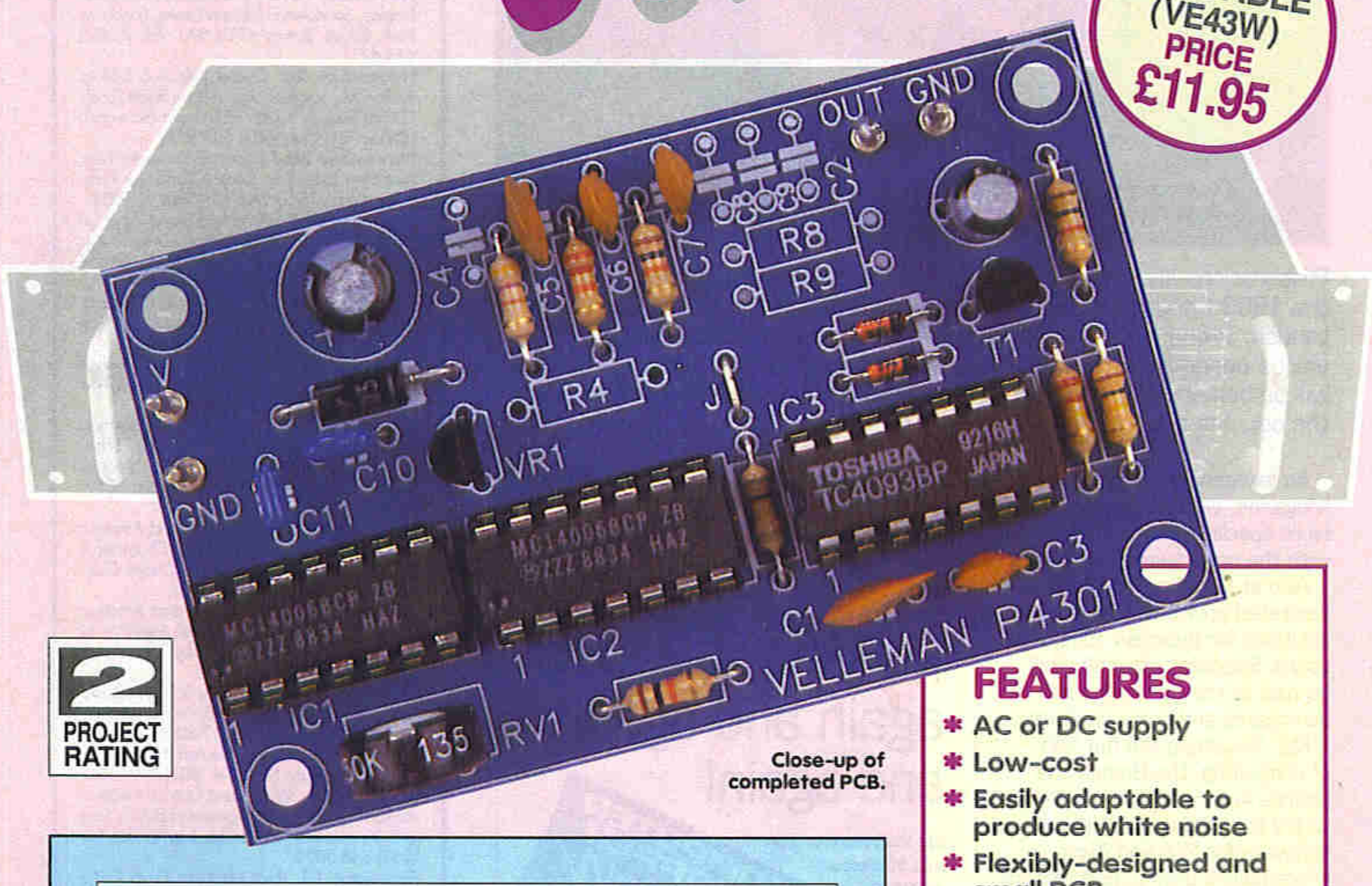
Please send details of events for inclusion in 'Diary Dates' to: The News Editor, *Electronics – The Maplin Magazine*, P.O. Box 3, Rayleigh, Essex SS6 8LR.

A pink noise generator is a device that produces noise of constant amplitude across the whole audio band. Generally, it consists of wideband random noise ('white' noise), caused by the random movement of electrons in components. Such white noise occurs over a considerable frequency spectrum, and must therefore be band-pass filtered to within the confines of the audio band, in which state it is referred to as pink noise.

Text by Martin Pipe

Pink Noise Generator

KIT AVAILABLE (VE43W) PRICE £11.95



Close-up of completed PCB.

2 PROJECT RATING

Specification

Clock frequency adjustment:	30kHz to 100kHz
Output level:	150mV RMS (Clock running at 40kHz)
Output impedance:	1kΩ
Pink noise filter:	–3dB/octave (20Hz to 20kHz)
Power supply requirement:	9 to 12V AC, or 12 to 15V DC @ 5mA.
PCB dimensions:	43 x 72mm

FEATURES

* AC or DC supply
* Low-cost
* Easily adaptable to produce white noise
* Flexibly-designed and small PCB
* Pseudo-random noise generation utilising digital techniques

APPLICATIONS

* Calibration of graphic equaliser in conjunction with spectrum analyser
* Noise generators
* Electronic music

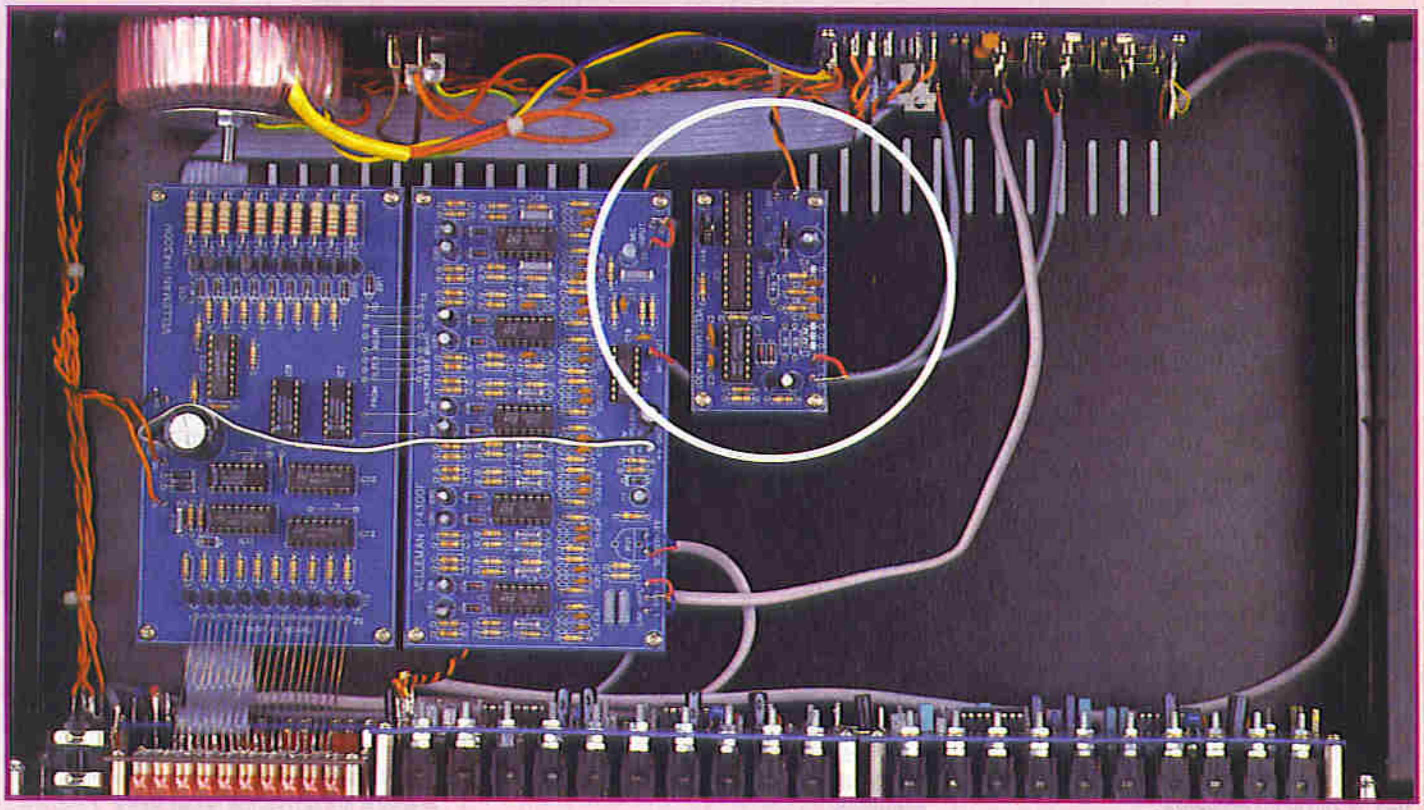
MANY pink noise generators utilise a Zener diode or reverse-biased transistor, working at a deliberately low current, as a noise source. This method, however, leads to unpredictable results as this method depends upon the behaviour of the particular device used. The circuit used here, however, uses a pseudo-random bit pattern generator, which is more reliable.

The Pink Noise Generator Module is intended for use with a graphic equaliser, in conjunction with the Spectrum Analyser covered in Issue 70 (October 1993) of *Electronics*, or any other spectrum analyser that incorporates a microphone input. In a future article, we will look at how this module, together with the Spectrum Analyser, Graphic Equaliser and Switching Module, can be combined into a high-quality self-contained system.

If you feed pink noise into both channels of your audio system via the equaliser, as shown in Figure 1, it will be picked up acoustically from the speakers by the microphone – which should be an omnidirectional type. The output from the module, by the way, should be applied to a pair of spare 'line level' inputs (aux, tuner, tape, etc.) on your amplifier – don't forget to switch out its tone controls, if it has them.

Positioning the microphone is important – it should be placed in the normal listening position. The equaliser can now be adjusted so that the spectrum analyser displays a 'flat' response. In other words, you move the equaliser's sliders until all the bargraphs are, as far as practically possible, of the same height. This system, typically used in a domestic environment, allows you to compensate for speaker frequency response, the effect of room size on frequency response, soft furnishings and hard walls, and other sources of absorption and reflection. However, you should not expect the impossible, such as deep bass out of a pair of bookshelf speakers – unless you want each woofer's cone to end up detached from its frame! Of course, it should be noted that the accuracy of this system of monitoring tonal adjustment depends on how flat the microphone's frequency response is!

In addition to its role in a spectrum analyser system, this module has many applications – for example, in experiments involving the isolation of one's senses, or a building block for other projects such as analogue music synthesisers or sound effect generators. Pink noise has particular relevance in the simulation of waves crashing or a breeze blowing past. With simple modification, the module can be used to generate white noise – this has



The Pink Noise Generator, shown installed in the complete Graphic Equaliser system.

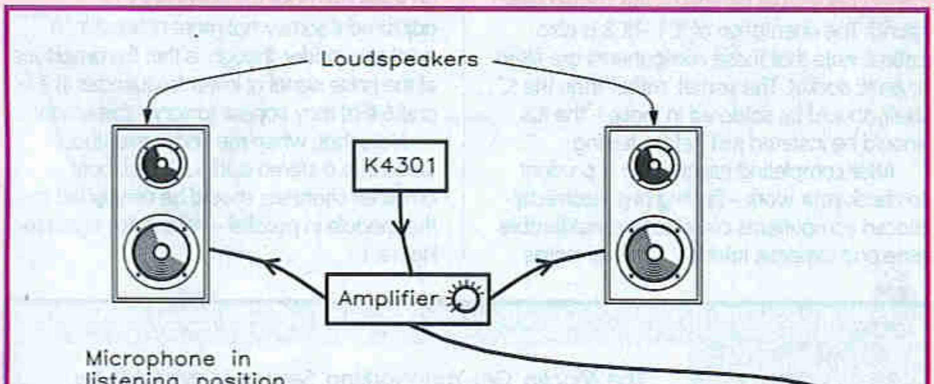


Figure 1. How a pink noise generator, spectrum analyser and graphic equaliser are set up to optimise the frequency response of your audio system.

applications in test equipment (for example, communications test sets).

Circuit Description

The circuit diagram of the Pink Noise Generator is shown in Figure 2. The first Schmitt NAND gate, N1 ($^1/_4$ 4093), is being used as an oscillator to generate a clock frequency, which is determined by the components RV1, R1 and C1. Its output is used to clock IC1 and IC2, which are both 4006 18-bit shift registers.

IC1 and IC2 are the heart of the circuit, and are combined to form a single shift register 33 bits in length. The outputs of the shift register are then manipulated by D1, D2, N2 and N3. The output of N3 will be high only when the outputs from the 20th and 33rd stages of the shift register are equal – the circuit essentially performs the function of a digital comparator. The output of N3 is then fed to the filtering components R5/C5, R6/C6

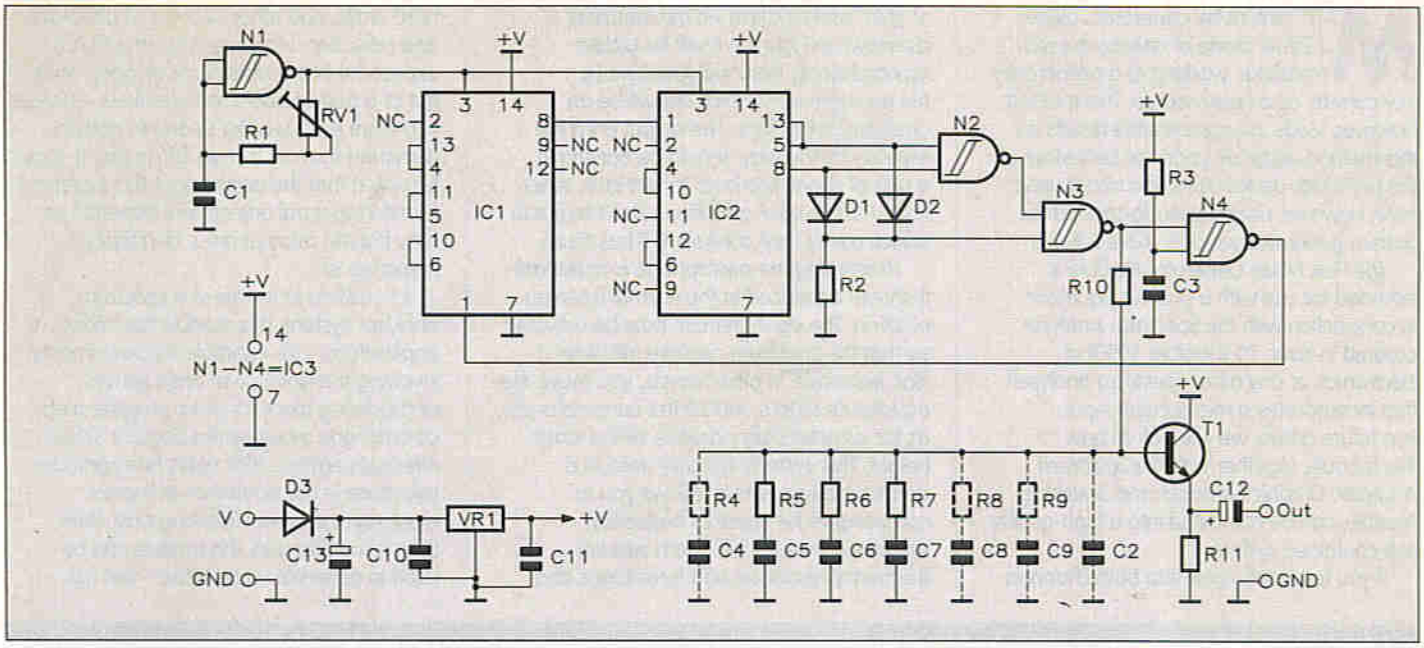


Figure 2. Circuit diagram.

and R7/C7 via R10; at this stage, the signal then closely approximates pink noise. The output is then buffered by the emitter follower and then AC-coupled to remove the DC offset. N4, R3 and C3 'kick start' the circuit by providing the correct logic state, preventing the shift register from locking up. This start-up sequence, or the output from N3, is fed back into the input of the first shift register, creating a closed-loop and allowing the circuit to run continuously.

By adding extra capacitors and resistors to the filtering section, subtle changes can be made to the noise output's audible nature – there are additional positions provided on the PCB for this reason. Of course, the most simple change that can be made is to change the clock frequency, by adjusting RV1.

A simple power supply circuit is also provided on the PCB, allowing the Pink Noise Generator to be used with both DC and AC supplies. D3 provides half-wave rectification, or provides reverse-polarity protection in the case of a DC supply. C13 is a reservoir capacitor, while C10 and C11 decouple VR1, a 78L08 8V regulator.

Construction

Construction is straightforward, and full details are given in the leaflet supplied with the kit. If you are new to project building, refer to the Constructors' Guide (order separately as XH79L) for helpful practical advice on how to solder, component identification and the like. Order of construction is not particularly important, although it is generally better to fit the

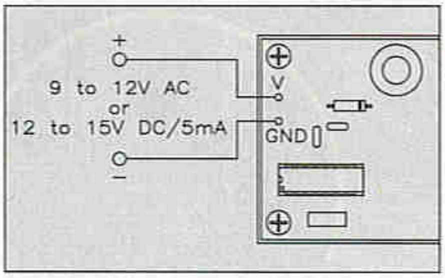


Figure 3. Wiring diagram.

smaller components first since the larger items may obstruct areas of the PCB, making assembly trickier. If the PCB pins prove to be a tight fit, push them in (they go in from the component side of the board) with a hot soldering iron.

At this stage, do not populate the positions for C2, C4, C8, C9, R4, R8 and R9. Combinations of these components are used when experimenting with the frequency response of the filter. If white, rather than pink noise, is required, the filter components (i.e. C2 and R4/C4 to R9/C9) could be left out altogether.

Whatever option is used, both electrolytic capacitors should be fitted – the correct way round. The orientation of IC1 – IC3 is also critical; note that these components are fitted in an IC socket. The socket, rather than the IC itself, should be soldered in place – the ICs should be inserted just before testing.

After completing assembly, it is prudent to check your work – finding any incorrectly-placed components could save considerable time and expense later on. Other gremlins to watch out for include solder bridges/ whiskers and poor joints. Finally, insert the ICs ready for testing.

Setting Up and Testing

With the PCB built and tested, it can now be wired up as shown in Figure 3. The power supply can range from 9 to 12V AC, or from 12 to 15V DC.

To minimise the risk of hum generation, the Pink Noise Generator's output should be connected to the spectrum analyser with screened cable. So that earth loops, which will cause false readings (a 50Hz predominance!), are avoided, the screen of the interconnecting cable should only be connected at one end, if the same power supply is used for both the noise generator and the spectrum analyser.

Now it's time for us to turn our attention to the Pink Noise Generator's only adjustment – the shift register clock frequency. RV1 should be set so that all of the columns of the spectrum analyser's display are of the same height, thus ensuring that the generator's output is flat across the audio range. If required, the input gain of the spectrum analyser may be varied to make the effect of RV1's adjustment somewhat more noticeable. A point to consider, though, is that the amplitude of the noise signal at lower frequencies (32Hz and 64Hz) may appear to vary – this is normal.

Note that, when the unit is eventually wired into a stereo audio system, both amplifier channels should be connected to the module in parallel – refer once again to Figure 1.

Optional Parts List

(Not Included in Kit)

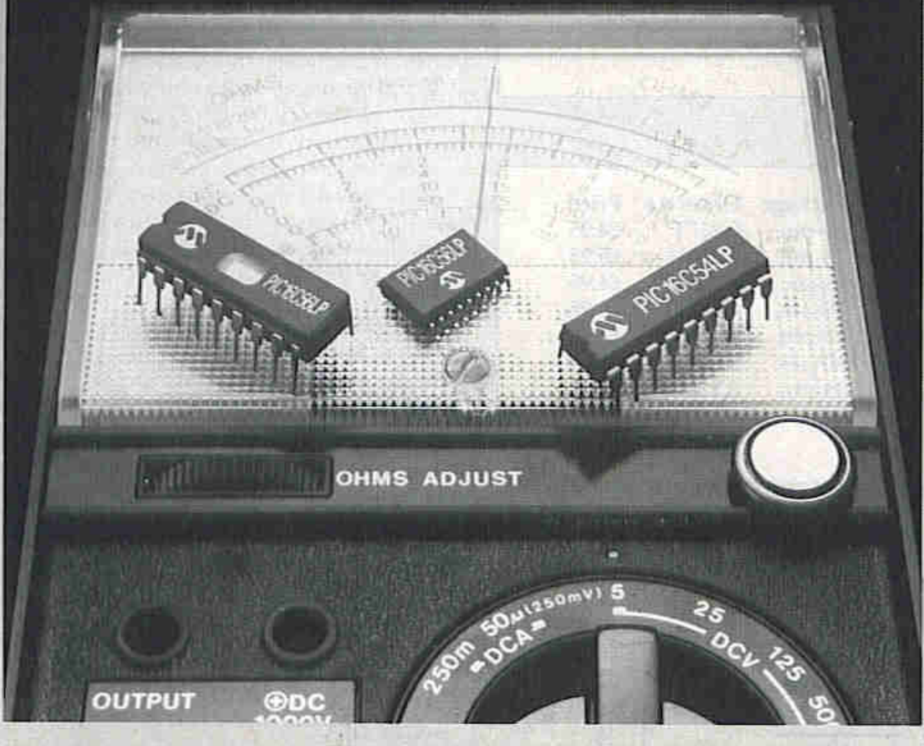
Screw-Cap Phono Plug White	2	(HQ59P)
Screened Cable	As required	(XR15R)
Constructors' Guide		(XH79L)

The Maplin 'Get-You-Working' Service is available for this project, see Constructors' Guide or current Maplin Catalogue for details.

Order As VE43W (Pink Noise Generator Module) Price £11.95.

Please Note: Some parts, which are specific to this project (e.g., PCB) are not available separately.

An Introduction to Microchip's PIC



FEATURES

- ★ Only 33 single word instructions to learn
- ★ All instructions (except program branches) take one cycle to execute (200ns)
- ★ Operating speed: DC – 20MHz clock input DC – 200ns instruction cycle
- ★ 2 level deep hardware stack
- ★ Oscillator start-up timer
- ★ Watchdog timer with its own on-chip RC oscillator for reliability
- ★ Security EPROM fuse for code-protection
- ★ Power saving SLEEP mode
- ★ RAM is retained down to V_{DD}=1·5V
- ★ Low power CMOS technology
- ★ Wide operating voltage range (3·0V to 5·5V)
- ★ Low power consumption
  <2mA typical @5V, 4MHz
  15μA typical @3V, 32kHz
  <3μA typical standby current @3V

By Tony Bricknell

The PIC (Peripheral Interface Controller) 16C5x range of microcontrollers from Microchip Technology is a family of low-cost, high performance, 8-bit, fully static, EPROM based CMOS microcontrollers. They employ a RISC (Reduced Instruction Set Computing) - like architecture with only 33 single word/single cycle instructions. All instructions are single cycle (200ns) except for program branches, which take two cycles. The PIC16C5x delivers performance an order of magnitude higher than its competitors within a similar price category. The 12-bit wide instructions are highly orthogonal (or symmetrical), resulting in 2:1 code compression over other 8-bit microcontrollers in its class. An orthogonal instruction set, by the way, allows each instruction to operate on any register, or use any addressing mode – there are no special combinations.

Microchip Technology Incorporated have been recognised as the world's leading supplier of single-chip OTP (One-Time-Programmable) microcontroller devices worldwide. Its PIC16xx family continues to grow in popularity; it is universally recognised as a powerful, easy-to-use, and cost-effective microcontroller for many low to mid-range embedded control 8-bit applications.

Over 8 million PIC16xx microcontrollers have been shipped worldwide to date, with several thousand designs in progress. The PIC16xx family has been successfully designed into applications, ranging from luxury cars to the US space programme – in fact, chances are that your home contains at least one PIC16xx microcontroller!

Applications

The PIC16C5x series fits perfectly in applications ranging from high speed automotive and appliance motor control, to low-power remote transmitters/ receivers (how many people have 418MHz car alarm transmitters – there's likely to be a PIC chip inside the key-ring), and telecom processors. The EPROM technology makes customisation of application programs (transmitter codes, motor speeds, receiver frequencies, etc.) extremely fast and convenient. Low-cost, low power, high performance, ease of use, and I/O flexibility make the PIC16C5x series very versatile even in areas where no microcontroller has been considered before (timer functions, replacement of 'glue' (support) logic, co-processor applications). Some 'day-to-day' applications are given in Table 1. Table 2, however, shows the different members of the PIC family presently available from Maplin.

Harvard Architecture

Competitor CISC (Complex Instruction Set Computing) microcontrollers with traditional von Neumann architecture use a single data and program bus, presenting an instruction/data

Computer Devices
Mouse, trackball, joystick, keyboard, parallel-to-serial conversion, application-specific secondary processing (so that main processor can get on with whatever it should be getting on with!).

Remote Control
TV/VCR remote (particularly the 'programmable' variety), garage door opener, auto security, keyless vehicle entry, light dimmer, home security.

White Goods
Washing machine control, timer circuits, refrigerator compressor control, microwave oven, coffee machine, microwave oven, rice cooker (yes, there is a manufacturer using PIC chips in a rice cooker!).

Brown Goods
Telephones and answering machines, TV sets and VCRs, satellite receivers, camcorder sub-applications (e.g., autofocus and auto white-balance), CD players, radio equipment, cassette decks, compact cameras, 'intelligent' toys.

Industrial and Commercial
Sensors, process control (PLCs), test equipment, paging systems.

Automotive
Trip computer, electronic fuel injection/engine management, ABS braking, active suspension.

Table 1. Typical PIC applications.

Device	EPROM	RAM	I/O	Package	Order As	Price
PIC16C54RC	512 × 12	32 × 8	13	18-pin	CR17T	£4.25
PIC16C55RC	512 × 12	32 × 8	21	28-pin	CR18U	£5.25
PIC16C56RC	1K × 12	32 × 8	13	18-pin	CR19V	£4.95
PIC16C57RC	2K × 12	80 × 8	21	28-pin	CR20W	£5.95
PIC16C71-04	1K × 14	36 × 8	13*	18-pin	DC19V	£7.70
PIC17C42	2K × 16	232 × 8	33	40-pin	DC20W	£16.40
PIC16C84	1K × 14+	36 × 8	13	18-pin	AY31J	£6.45

*Includes 8-bit ADC + EEPROM memory is used, rather than EPROM

Table 2. PIC Devices available from Maplin.

bottleneck. The PIC16C5x core (refer to the block diagram of Figure 1), however, uses a Harvard architecture with separate instruction and data buses. This eliminates the bottleneck, and allows faster execution throughput – refer to Figures 2 and 3.

Instruction Pipelining
The PIC16C5x core uses a pipelined architecture which overlaps the fetching of instructions, and their execution. This means that, while one instruction is executed, the following instruction is already being read from the program memory. Over 90% of the instructions will execute in one instruction cycle, resulting in faster execution throughput – refer to Figure 4. As a result, the PIC16Cx can perform a great deal faster than many of its competitors – as you can see from Figure 5.

Data Register File
The 8-bit data bus connects two basic functional elements together – the Register File composed of up to 80 addressable 8-bit registers including the I/O ports, and an 8-bit wide Arithmetic Logic Unit. The 32 bytes of RAM are directly addressable, while a 'banking' scheme (with banks of 16 bytes each) is employed to address larger data memories. This can be seen in Figure 6.

The register file is divided into two functional groups: operational registers and general-purpose register. The operational registers include the Real Time Clock Counter (RTCC), Program Counter (PC), the Status Register, the I/O registers (Ports), and the File Select Register (used for indirect addressing). The general-purpose registers are used for data and control information under command of the program instructions.

Arithmetic/Logic Unit (ALU)
The 8-bit ALU contains one temporary working register (W register). It performs arithmetic and Boolean functions between data held in the W register, and any file register. It also carries out single operand operations on either the W register, or any file register.

Program Memory
Up to 512 words of 12-bit wide on-chip program memory can be directly addressed. Larger program memories can be addressed by selecting one of up to four available pages with 512 words each, as shown in Figure 7. Sequencing of instructions is controlled by the Program Counter (PC), which automatically increments to execute in-line programs. In addition, a two-level on-chip stack is employed to provide flexible subroutine nesting.

I/O Registers (Ports)
The I/O registers can be written and read under program control like any other register of the register file. Upon a RESET condition, all I/O ports are defined as 'input' (high impedance mode).

All ports may be used for both input and output operations. For input

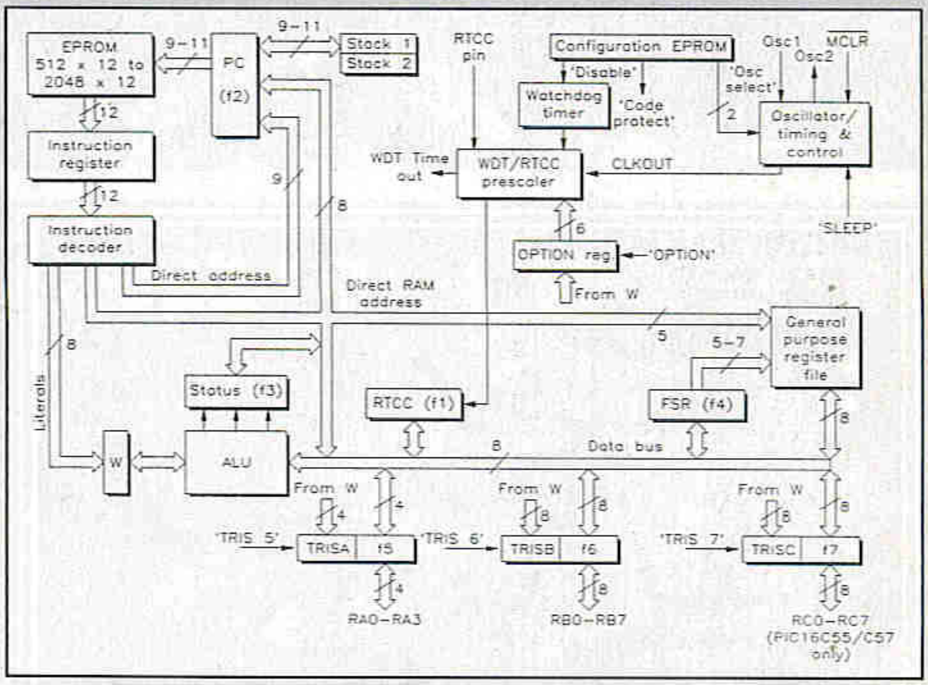


Figure 1. PIC16C5x series block diagram.

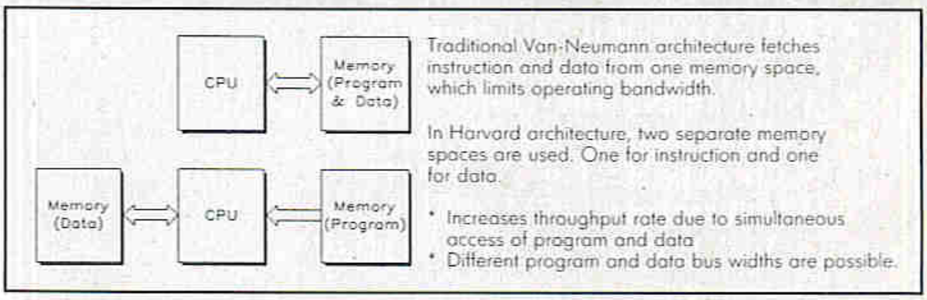


Figure 2. What is Harvard architecture?

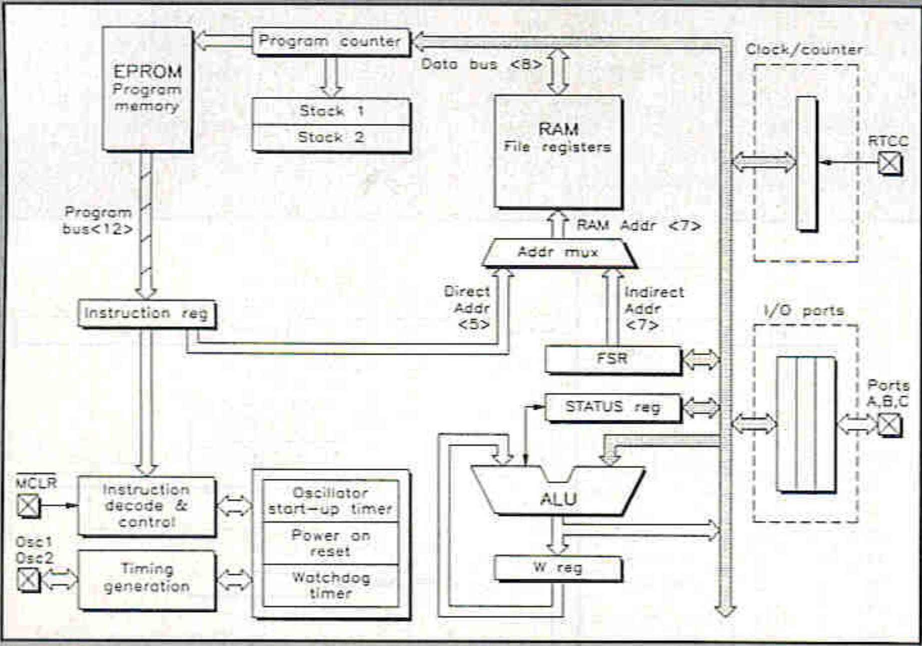


Figure 3. Harvard architecture, as implemented in the PIC16C5x series.

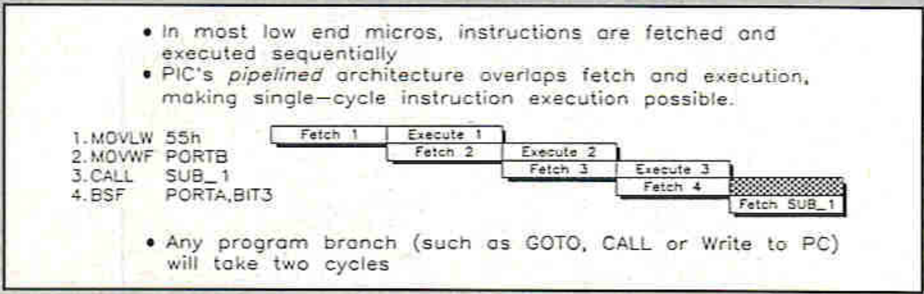


Figure 4. Pipelining.

operations these ports are non-latching. The outputs are latched, and remain unchanged until the output latch is rewritten. Any I/O pin can be programmed individually as input or output.

As you can see from the IC pin configurations of Figure 8, the PIC16C54 and PIC16C56 (18-pin DIL package) contain one 4-bit port (RA0 to RA3), and one 8-bit port (RB0 to RB7). The PIC16C55 and PIC16C57 devices (28-pin DIL package), meanwhile, feature an additional port (RC0 to RC7).

Watchdog Timer (WDT)

The watchdog timer is realised as a free-running on-chip RC oscillator which does not require and external components. This means that the WDT will run, even if the clock on the OSC1/OSC2 pins of the device have been stopped – for example, by execution of a SLEEP instruction. A WDT time-out generates a device RESET condition. The WDT can be permanently disabled by programming a special EPROM fuse, which is not part of the normal program memory.

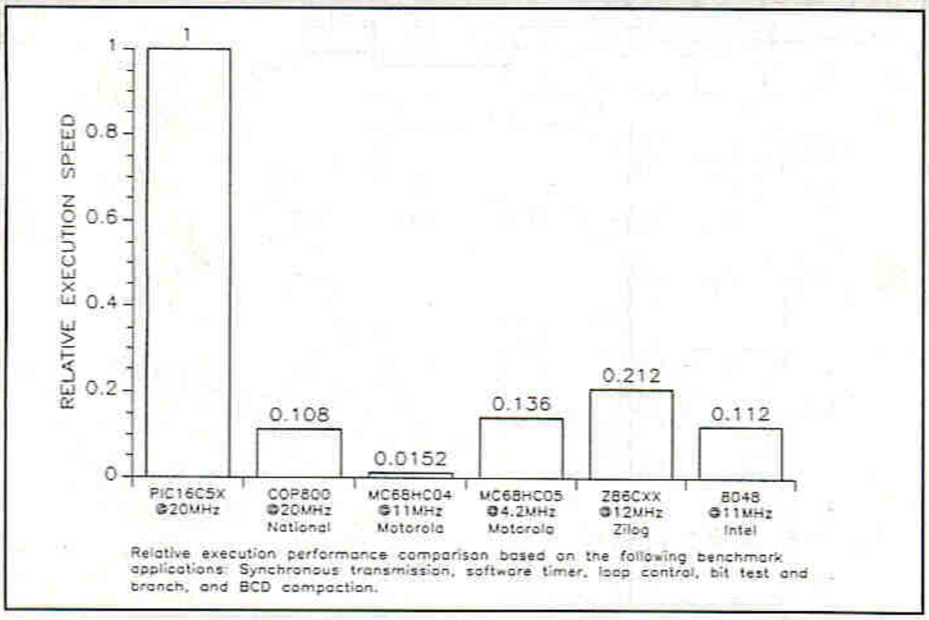


Figure 5. PIC16C5x execution speed comparison.

The WDT has a nominal time-out period of 18ms. However, if longer time-out periods are desired, a prescaler with a division ratio of up to 1:128 can be assigned to the WDT under software control. Thus, time-out periods of up to 2·5 seconds can be realised.

When returning from a watchdog time-out, a register is set to indicate the source of the RESET condition. If the WDT caused the RESET, then the software can jump to a failsafe condition, or try to recover.

Oscillator Start-Up Timer (OST)

Oscillator circuits based on crystals or ceramic resonators require a certain time after power-up to establish a stable operation. An on-chip oscillator start-up timer is provided which keeps the device in a RESET condition for approximately 18ms after the voltage on the $\overline{MCLR}$ pin has been forced high.

Power On Reset (POR)

The PIC16C5x incorporates on-chip POR circuity which provides internal chip reset for most power-up situations. To use this feature, the user merely needs to tie $\overline{MCLR}$ high (i.e. to V_{DD}). On-chip POR is guaranteed to work if the rate of rise of V_{DD} is no slower that 0·05V/ms. It is also necessary that V_{DD} starts from 0V. If using low-frequency crystals that require much longer that 18ms to start up and stabilise, then an external RC circuit should be used to give a longer power on reset.

Configuration Fuses

The configuration EPROM consists of four EPROM fuses which are not part of the normal EPROM for program storage. Two are for the selection of the oscillator type, one is the watchdog timer enable fuse, and one is the code protection fuse.

OTP devices have the oscillator configuration programmed by the factory, and the parts are tested accordingly. These packages are marked with the suffixes 'XT', 'RC', 'HS', or 'LP' following the part number to identify the oscillator type and operating range.

Customer ID Code

The PIC16C5x series has 16 special EPROM bits which are not part of the normal program memory. These bits are available to the user to store an Identifier (ID) code, checksum, or any other informative data. They cannot be accessed during normal program execution. The PICSTART 16B Development Kit's programmer, which is controlled by a host PC (suitable software is supplied in the kit), provides special commands to read or write these ID bits and configuration fuses.

Code Protection

The program code written into the EPROM can be protected by programming the code protection fuse. When code protected, the contents of the program EPROM is scrambled in such a way that the program code cannot be reconstructed. In addition, all memory locations starting at 040(H) and above are protected against programming. It is still possible to program locations 000(H) to 03F(H), the ID locations and the configuration fuses. Note that the configuration fuses and the ID bits can still be read, even if the code protection logic is active.

Instruction Set

The PIC16C5x series instruction set has a basic repertoire of 33 instruction words. These instructions fall into three general categories:

(i) General file register operations (byte-orientated)
(ii) Bit level file register operations
(iii) Literal and control operations

Each PIC instruction is a 12-bit word that is divided into an opcode, source register, destination register, or literal – refer to Table 3.

For byte-oriented instructions, 'f' represents a file register designator, and 'd' represents a destination designator. The file register designator specifies which one of the PIC file registers is to be utilised by the instruction. The destination designator specifies where the result of the operation performed by the instruction is to be placed. If d is 0, the result is placed in the W register. If d is 1, the result is returned to the file register specified in the instruction.

For bit-oriented instructions, 'b' represents a bit field designator which selects the number of the bit affected by the operation, while 'f' represents the number of the file in which the bit is located.

For literal and control operations, 'k' represents a constant value of between eight and eleven bits.

The instruction word, when expressed in binary, is also known as machine code or object code. A certain number of bits in the instruction word are allocated as an operator (opcode). An opcode specifies the type of operation to be performed. The balance of the instruction word includes one of more operands, which further specify the operation of the instruction.

It is normally very difficult for the programmer to read or write more than a few lines of this type of code. Therefore programs are usually written in a symbolic language that is easily understood by the programmer, and is also executable by the PIC Cross Assembler (this is supplied with the PICSTART-16B Development System).

Figure 9 gives a code size comparison between the PIC16C5x, and several other microprocessors.

All instructions are executed within one single instruction cycle, unless a conditional test is true, or the program counter is changed as a result of an instruction. In this case, the execution takes two instruction cycles. One instruction cycle, incidentally, consists of four oscillator periods. Thus, for an oscillator frequency of 4MHz, the normal instruction execution time is 1μs. If a conditional test is true, or the program counter is changed as a result of an instruction, the instruction execution time is 2μs.

Also supplied with the PICSTART-16B Development System is PICSIM, a PC software simulator designed to imitate operation of the PIC16C54, 16C55, 16C56 and 16C57, thereby allowing you to debug software that will use any of these microcontrollers. At any instruction boundary you may examine and/or modify any data area within the microcontroller, or provide external stimulus to any of the pins. All in all, PICSIM gives you a solid set of source-level debug tools to help you through the early design verification stages in your project.

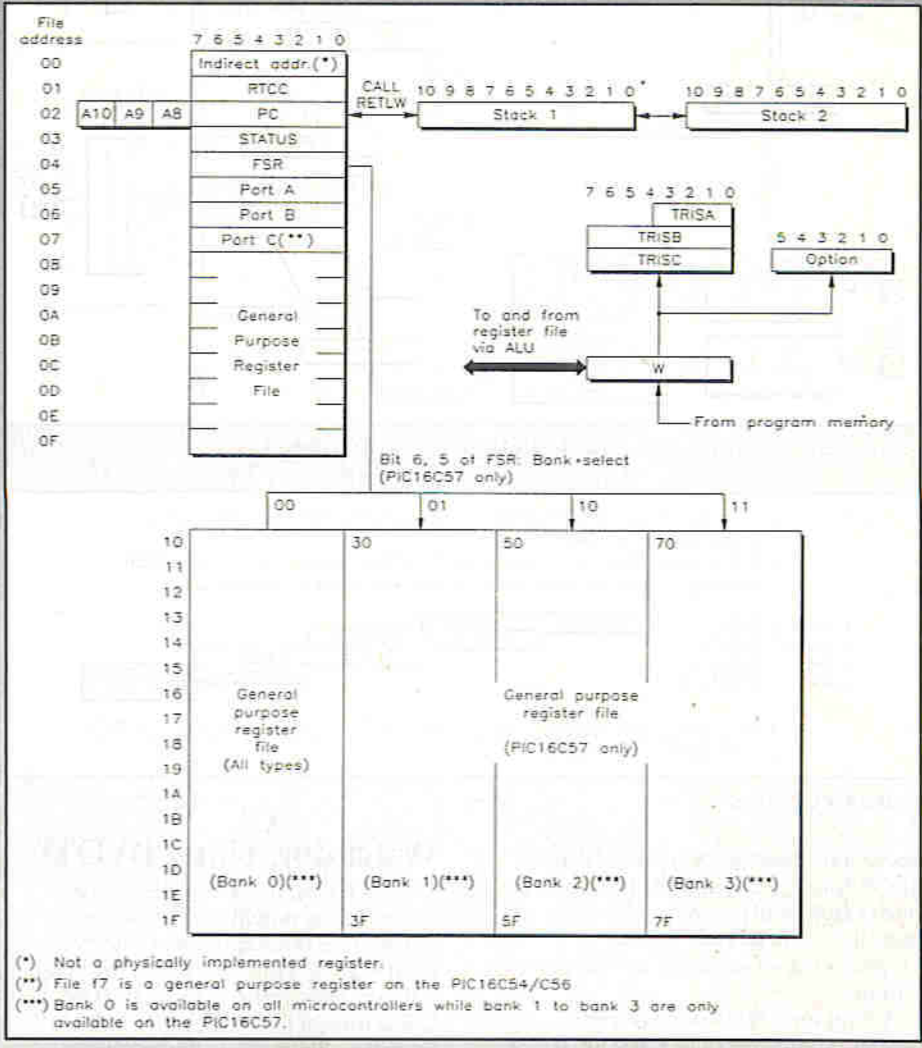


Figure 6. PIC16C5x data memory map.

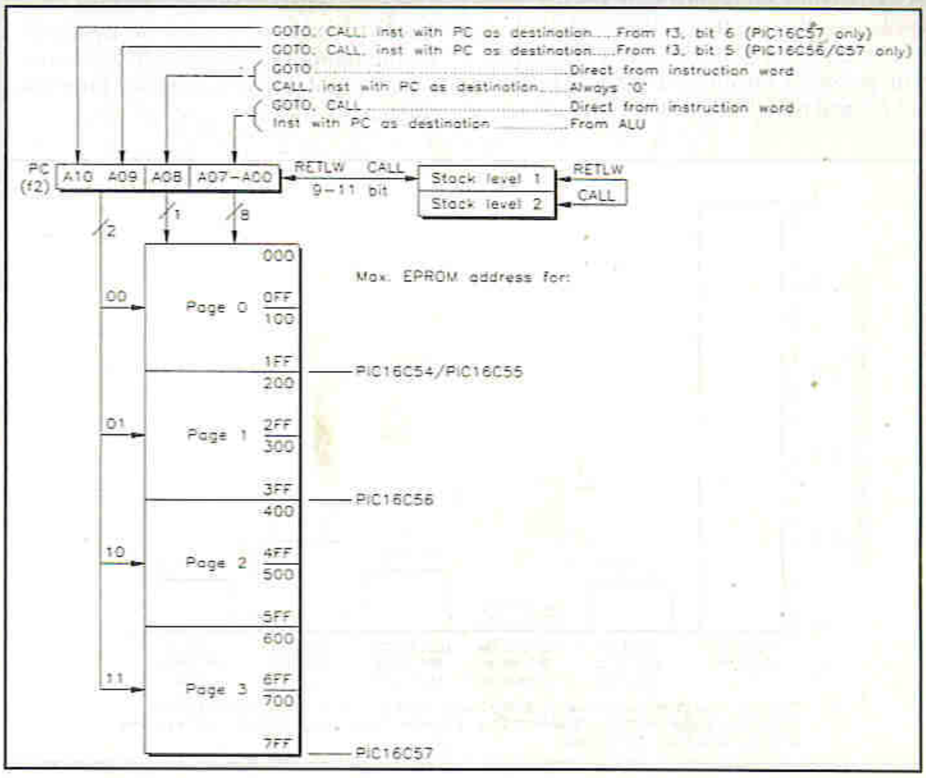


Figure 7. PIC16C5x program memory organisation.

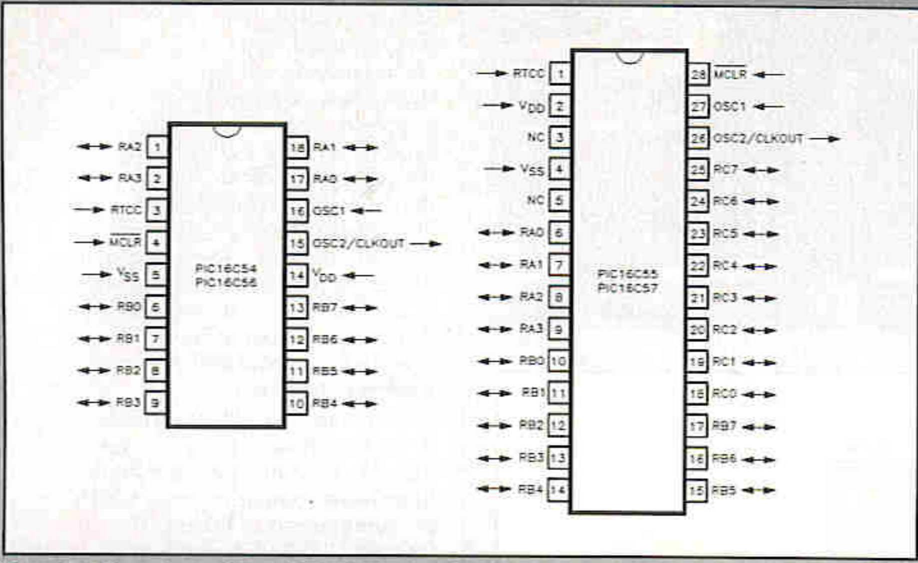


Figure 8. DIL package pin configurations.

It seems, then, that PIC chips give the opportunity to design microprocessors into systems that have never used them before. They have low pin counts, are of low-cost, have the potential to reduce complexity and component count, and can provide features that only a computer-based approach can make practically possible. The speed with which these devices operate may also mean that the PIC16C5x series of devices may prove a better choice than other microcontroller or microprocessor devices, at least in certain applications. In addition, the protection built-in will provide safeguards against unauthorised copying of designs.

So why not try out PIC technology for yourself? Maplin sell a wide range of value-for-money PIC-related products – apart from the PC16C5x devices covered in this article, there is the PIC16C71,

BYTE-ORIENTED FILE REGISTER OPERATIONS

(11-6)	(5)	(4-0)
OPCODE	d	f(FILE #)

d = 0 for destination W, 1 for destination f

Name	Mnemonic	Operands	Operation	Status Affected
No Operation	NOP	–	–	None
Move W to f	MOVWF	f	W → f	None
Clear W	CLRW	–	0 → W	Z
Clear f	CLRF	f	0 → f	Z
Substract W from f	SUBWF	f, d	f - W → d [f + $\overline{W}$ + 1 → d]	C, DC, Z
Decrement f	DECF	f, d	f - 1 → d	C, DC, Z
Inclusive OR W and f	IORWF	f, d	W v f → d	Z
AND W and f	ANDWF	f, d	W & f → d	Z
Exclusive OR W and f	XORWF	f, d	W ⊕ f → d	Z
Add W and f	ADDWF	f, d	W + f → d	C, DC, Z
Move f	MOVF	f, d	f → d	Z
Complement f	COMF	f, d	$\overline{f}$ → d	Z
Increment f	INCF	f, d	f + 1 → d	Z
Decrement f, Skip if Zero	DECFSZ	f, d	f - 1 → d, skip if zero	None
Rotate right f	RRF	f, d	f(n) → d(n-1), f(0) → C, C → d(7)	C
Rotate left f	RLF	f, d	f(n) → d(n+1), f(7) → C, C → d(0)	C
Swap halves f	SWAPF	f, d	f(0-3) ↔ f(4-7) → d	None
Increment f, Skip if zero	INCFSZ	f, d	f + 1 → d, skip if zero	None

BIT-ORIENTED FILE REGISTER OPERATIONS

(11-6)	(7-5)	(4-0)
OPCODE	b(BIT #)	f(FILE #)

Name	Mnemonic	Operands	Operation	Status Affected
Bit Clear f	BCF	f, b	0 → f(b)	None
Bit Set f	BSF	f, b	1 → f(b)	None
Bit Test f, Skip if Clear	BTFSC	f, b	Test bit (b) in file (f): Skip if clear	None
Bit Test, f, Skip if Set	BTFSS	f, b	Test bit (b) in file (f): Skip if set	None

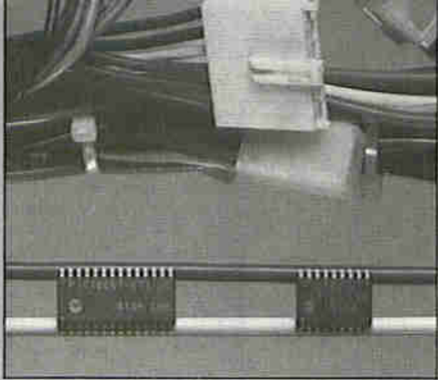
LITERAL AND CONTROL OPERATIONS

(11-8)	(7-0)
OPCODE	k (LITERAL)

Name	Mnemonic	Operands	Operation	Status Affected
Load OPTION register	OPTION	–	W → OPTION register	None
Go into standby mode	SLEEP	–	0 → WDT, stop oscillator	TO, PD
Clear Watchdog timer	CLRWDT	–	0 → WDT (and prescaler, if assigned)	TO, PD
Tristate port f	TRIS	f	W → I/O control register f	None
Return, place Literal in W	RETLW	k	k → W, Stack → PC	None
Call subroutine	CALL	k	PC + 1 → Stack, k → PC	None
Go To address (k is 9 bit)	GOTO	k	k → PC (9 bits)	None
Move Literal to W	MOVLW	k	k → W	None
Incl. OR Literal and W	IORLW	k	k v W → W	Z
AND Literal and W	ANDLW	k	k & W → W	Z
Excl. OR Literal and W	XORLW	k	k ⊕ W → W	Z

Table 3. PIC16C5x instruction set.

which features an on- chip analogue-to-digital converter (ADC), and the comprehensive 40-pin PIC17C42-161P, which features three 8-bit ports, one 16-bit port and one 3-bit port, as well as an on-chip USART and baud rate generator (for serial communications), three timer/counters – and much else besides.
A newcomer to Maplin's range of PIC devices is the PIC16C84, which offers 1k × 14 bits of EEPROM (Electrically Erasable Programmable Read-Only



Memory), rather than the one-time programmable (OTP) EPROM contained within the other devices. As a result, the device may be reprogrammed time and time again as new software is developed. That's not to say that the use of OTP devices is a handicap; software would normally be developed on the PC, which emulates the PIC, until it operates as desired; the chip is then programmed. The EEPROM version would be used in applications where unpredictable software changes are likely to be required, or a lot of PIC development work is anticipated.

It's not much use having these devices without the tools to develop them. To this end, Maplin market three development systems, which are summarised in Table 4. The first, PICSTART 16B (described earlier), consists of PC software (including an assembler and simulator), a comprehensive programmer which connects to the PC's parallel port, full documentation, EPROM and OTP (one-time programmable) versions of the PIC16C54 and PIC16C55 devices. The PICPAK-17 development kit is intended for use with the PIC17C42 device, and consists of an PC evaluation/development/programming board, software (including a macroassembler), documentation and sample devices. Finally, there is the Pro Master development kit, which is capable of handling both PIC16Cx and PIC17Cx families, and is suitable for low-to-moderate volume production, as well as development work. This kit includes very comprehensive PC software, a programmer which attaches to one of the PC's serial ports, documentation, leads and a power supply. Note that, with this system, the IC sockets depend on the device being programmed, and so no socket modules are supplied in the kit; the one(s) of your choice must be purchased separately. Each socket module is provided with sample devices.

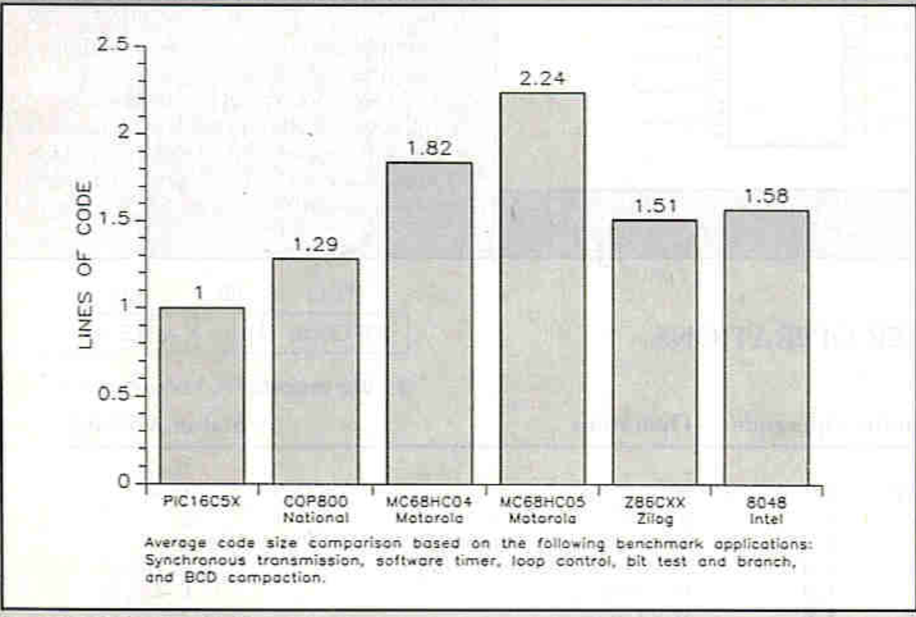


Figure 9. PIC16C5x code size comparison.

PICSTART-16B	(DM79L)	£169.95
PICPAK-17	(DC21X)	£252.04
Pro Master	(DC22X)	£581.63
PIC16C54/57 DIL socket module	(DM21X)	£123.38
PIC16C54/57 SOIC socket module	(DM22Y)	£123.38
PIC16C71 DIL socket module	(DM23A)	£111.63
PIC16C71 SOIC socket module	(DM24B)	£111.63
PIC17C42 DIL socket module	(DM25C)	£135.13

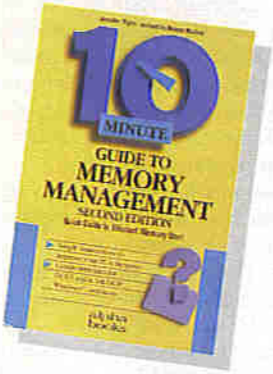
Table 4. Development Products available from Maplin.

NEW BOOKS

10 Minute Guide To Memory Management – Second Edition

by Jennifer Flynn, revised by Robert Mullen

There are many reasons why memory management is important on your PC. For instance, DOS divides the memory in your PC into two sections – the area that DOS needs for itself and the area that your programs use. Today's sophisticated software is memory intensive and finds it difficult to operate in the reduced space made available by DOS. Many benefits can be gained by optimising your memory usage. These include a faster more efficient PC, an end to 'out of memory' problems, and most importantly, utilising all of your computer's memory – not just the small part that DOS accesses. To achieve these results you need to understand memory, and how it works.



This handy guide offers a proven approach to learning for people who want results fast, the concise and accurate text shows you how to improve your PC's memory in a short period of time. The easy-to-follow lessons help you understand memory management techniques. You quickly learn to work with extended and expanded memory, RAM disks, caches and much more. A detailed glossary provides an easy access to the terms you need to fully understand. The techniques that can be acquired from this book will enable you to overcome the limitations of DOS and to manage memory efficiently.
1993. 178 pages. 214 x 141mm, illustrated. American Book.

Order as AA14Q
(Mem Management) *£9.95 NV*

Electronic Music Learning Projects

by R. Bebbington

It is a sad fact that electronic hobbyists with little or no knowledge of music often ignore projects that have the slightest hint of musical flavour. The converse is also true. Musicians are often reluctant to consider an electronic project with a musical bias. The projects in this book have been written in a style that attempts to bring together both types of enthusiasts. Whether you are interested in music or electronics, or both, then these unusual projects will provide many hours of entertainment.

When necessary, elementary music and electronic theory is covered, and although the primary object of the book is to help construct novel projects, the book should give the reader a better understanding of the related basic principles and techniques.

The circuits are tolerant of component layout and instructions are easy to follow, so the projects will be suitable for beginners and students. The projects have been designed to range from the simple to the more advanced and use discrete components and readily available ICs. All the projects in the book are powered by a 9V battery.
1993. 120 pages. 173 x 111mm, illustrated.

Order as AA13P
(Music Learning Prjct) *£4.95 NV*

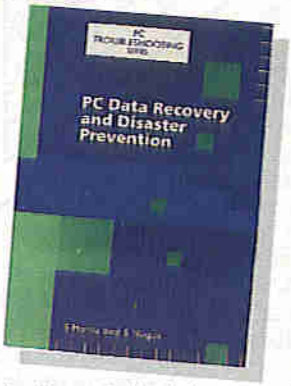
PC Data Recovery and Disaster Prevention

by S. Harris and S. Nugus

Personal computers have become an indispensable part of everyday life whether in the office, factory or at home, and are used in a variety of different tasks. When a personal computer fails it can cause a great deal of trouble and a considerable amount of time can be lost – especially when the failure involves the loss of valuable data. Yet despite all the problems and headaches that the failure of a computer can cause, few computer users make regular backups of their data. When disaster does strike, it is vital that an attempt is made to recover data from the defunct machine as quickly and efficiently as possible.

It is widely believed that data recovery is beyond the scope of all but the most skilled professionals, but fortunately recent software development has provided the tools and programs that are needed for such situations. These programs are easily usable by almost anyone who has a basic knowledge of PCs. However, data recovery is a technological minefield, in which it is very easy to cause irreparable damage to the data being recovered. It is vitally important that anyone who is likely to be involved with any form of data recovery has a good basic knowledge about data recovery. This book provides that basic knowledge, and also demonstrates through the use of examples and case studies how such data recovery problems should be approached to obtain a successful recovery. Chapters deal with using DOS to recover data as well as Norton Utilities and PC Tools. A further chapter takes an in depth look at computer viruses.

Additionally, the subject of PC security is discussed in detail, including an in-depth examination of the features that should be present in any good PC security system.



A well presented book that anyone who may be concerned with data recovery will find extremely useful.
1992. 267 pages. 243 x 170mm, illustrated.

Order as AA12N
(PC Data Recovery) *£16.99 NV*

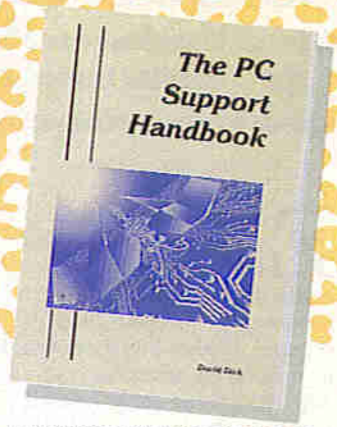
The PC Support Handbook

by David Dick

Technicians involved in the maintenance and support roles for PC installations are normally required to have skills in both hardware and software installation and maintenance. These technicians are often required to participate in a wide range of activities that may include advising on new equipment, installing new software, hardware upgrades, maintenance and repair, I.T. training, data protection and a whole range of related disciplines. However, there are very few books that cover all these topics in one volume – especially books geared to the British user.

This British book was written by a Senior Lecturer who specialises in microcomputer technical support. The A4 spiral-bound book offers a more general approach and covers a wide range of material, that includes basic DOS commands (up to DOS 6) to advanced subjects such as disk organisation and memory management techniques. This well illustrated book brings together material not normally found in one volume and covers the latest techniques such as clock-doubling, local bus systems, PCMCIA, etc.

The book is filled with numerous facts, diagrams and explanations and is divided into 15 chapters with each chapter having its own contents page. Also included is a high-density $3\frac{1}{2}$in. software disk of computer based training



material on a wide range of topics plus many diagnostic and other utilities.

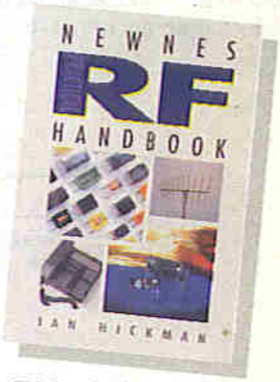
This book will form an indispensable reference text for many computing students as well as being an informative source of material for all those who carry out PC support activities, and computer users.
1993. 400 pages. 298 x 230mm, illustrated.

Order as AA11M
(PC Support Handbook) £22.50 A2 NV

Newnes Practical RF Handbook

by Ian Hickman

Since deregulation, there has been a rapid increase in the number of radio services that are now available world-wide. As a result, RF engineers are in great demand. This book is primarily intended to help both the amateur and professional increase their knowledge and expertise in the field of RF engineering. The book is not intended to be a text book, and lengthy derivation of formulae have been omitted. When required, formulae are just stated, and are used accordingly. The book covers the portion of the RF spectrum up to 1,000MHz. This is used for a wide variety of services, including sound broadcasting and television, commercial, professional, government and military communications, telemetry and telecontrol, radio telex and facsimile and amateur radio.

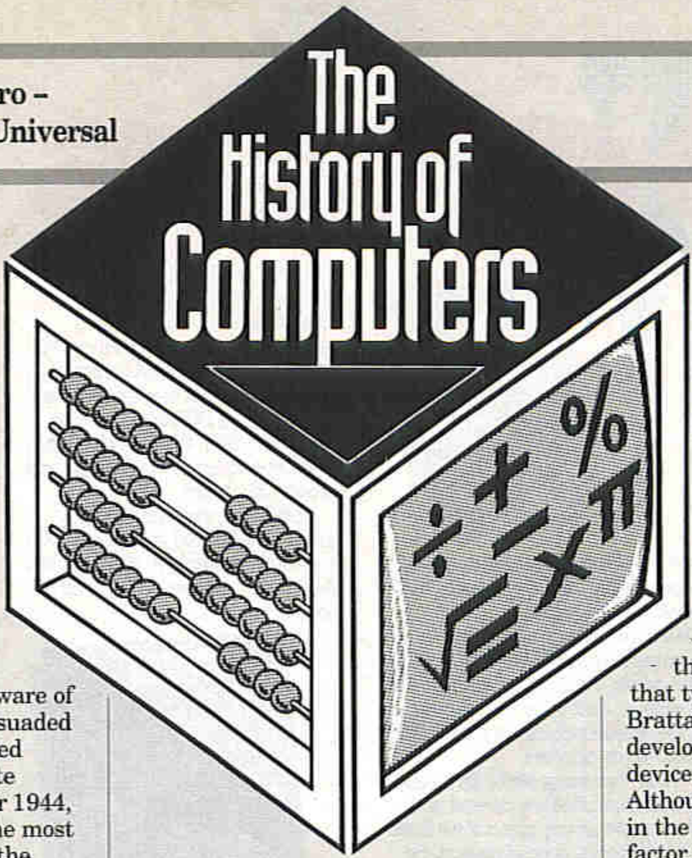


This handbook tends to concentrate on present technology with the odd mention of earlier developments when appropriate. Treatment of the subject is essentially practical rather than theoretical, with the intention of giving the reader a feel for the working of RF circuitry. The book covers a very wide range of topics from devices, circuits, equipment and systems through to radio propagation and external noise.
1993. 280 pages. 232 x 155mm. Illustrated.

Order as AA15R
(RF Handbook) *£16.95 NV*

9. From Mainframe to Micro – the Computer becomes Universal

by Gregory M. R. Grant



ENIAC, like Babbage, was a fabulous original. Difficult, occasionally cantankerous, very singular, technically capricious, but original. Without it, there could have been no advancement. After it nothing could be as it had been. It was also every bit as useful and informative in its failures as in its successes. It had shown, for example, that electronics could calculate at such stunning speeds that a stored programme was not only desirable, but *essential*.

The ENIAC team were well aware of what was required, and they persuaded the army to fund a successor called EDVAC, or the Electronic Discrete Variable Computer. In September 1944, the team were joined by one of the most brilliant mathematical brains of the present century, John von Neumann. Born in Budapest, Hungary in 1903, von Neumann was awarded a doctorate in mathematics at 22 and two years later was a lecturer at the University of Berlin. Sensing that his chances of further advancement were slim, however, he emigrated to America in 1930. By the time he joined the Moore School team as a consultant, he already held a permanent professorship at Princeton's Institute for Advanced Study.

It was von Neumann who not only put forward the idea of a stored programme, but also designed the logic circuits for it. His essay, 'First Draft of a Report on the EDVAC' of June 1945, was the earliest scientific or engineering paper to discuss what would come to be known as the von Neumann machine, a stored-programme computer.

EDVAC is, in short, the grandfather of general-purpose computers which presently govern so much of our lives. The essential components of a von Neumann machine are firstly a memory for information storage, and secondly a control unit capable of scheduling the transfers between the word stores of memory registers in accordance with the programme in memory.

Von Neumann also recommended binary notation, Boolean algebra and serial rather than parallel processing. This last was because a serial computer is easier to manufacture than a parallel one although the latter is faster. ENIAC, for example, was a parallel machine.

The first operating, completely electronic, stored-programme computer, however, was British – the Manchester University's Mark I, which went on stream in 1948, searching for the factors of particular numbers. The internal memory was a cathode ray tube called the Williams Tube, after the university's professor of electrical engineering Sir Fredrick Williams, who was also the project's chief engineer. These tubes were quite impressive for their time, storing up to 2,048 bits of information.

The year was a watershed in other ways too. In America, the Bell Laboratories announced that two of their physicists, Walter Brattain and John Bardeen, had developed a solid-state amplifying device, the point-contact transistor. Although the new device's power gain in the laboratory was of the order of a factor of 18, it was by no means easy to manufacture. Three years later, however, another member of the Bell team – William Shockley – developed a new version of the original model, called a bipolar junction transistor.

The name 'transistor', incidently, came from a casual remark by another Bell engineer, John Pierce. In conversation with the solid-state team, Pierce asked how things were coming along. They replied that a development announcement was expected shortly, but they still had no name for their invention. Pierce said that if his understanding of what they'd been up to was correct, they'd been attempting to transfer current across a resistance. Couldn't they therefore get some sort of acronym, descriptive word or anagram out of 'transfer' and 'resistance'? Transistor was the result. Seven years after the arrival of the bipolar transistor

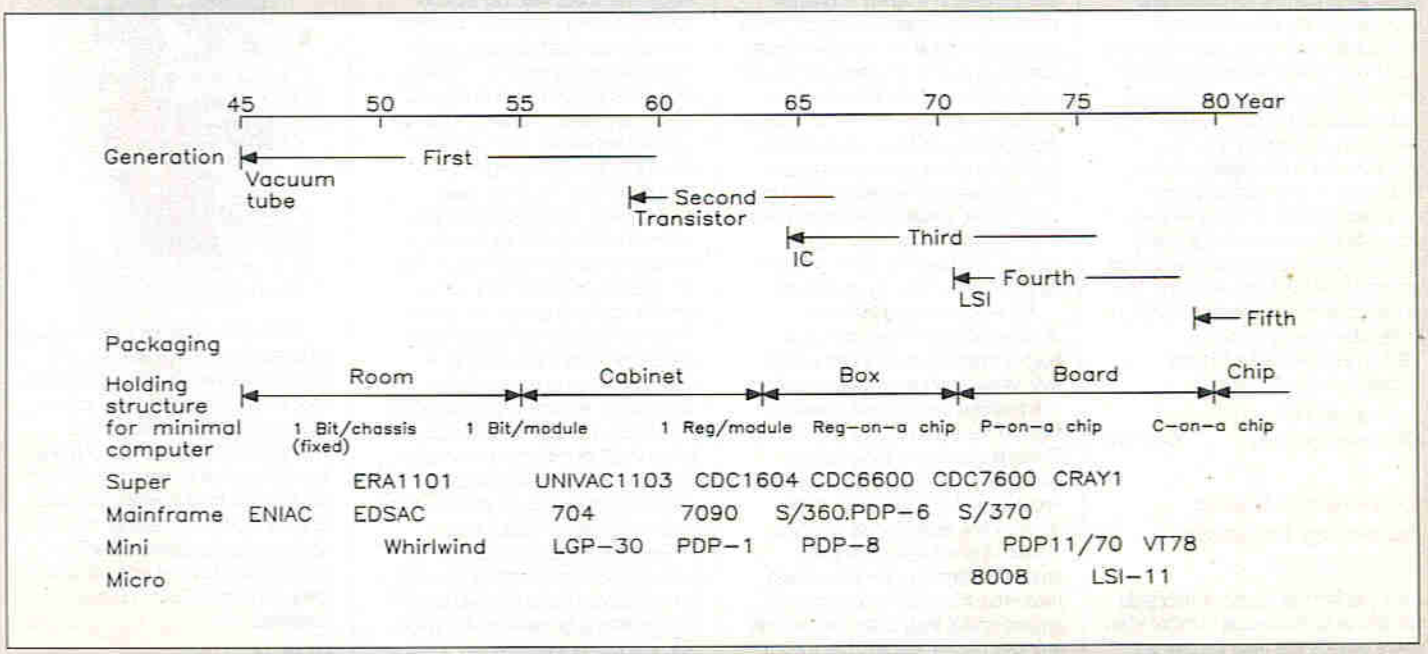


Figure 1. An illustration of how electronic packaging has revolutionised equipment size, and therefore potential performance.

the first solid-state computers appeared, manufactured by UNIVAC and Philco.

In Britain, Manchester University again led the way building the first British transistorised stored-programme computer using point-contact transistors. The first home-produced computer for the commercial market using the new devices was the Elliott 803.

In comparison to their immediate predecessors these machines were more powerful, much more economical, certainly faster and far more reliable. The transistor, in fact, became the key to unlocking what would turn out to be a fantastic future.

As early as 1952, a Royal Radar Establishment engineer, G. W. A. Dummer, proposed the creation of many active and passive components on a single block or strip of the new semiconductor material from which transistors were made. Unfortunately neither the government of the day nor industry were much interested in the idea, with the mild exception of Plessey. The Americans were, however, and six years later Jack Kilby, a Texas Instruments' research engineer, announced his development of the first integrated circuit, a phase-shift oscillator.

In 1959, Jean Hoerni, a founder-member of the Fairchild Semiconductor corporation, invented the planar process for integrated circuit manufacture. This made the solid-state circuit a practical, commercially viable device.

By the early 1960s, transistor manufacture and semiconductor processes had generally been much improved. The integrated circuit concept promised a new generation of computers with more than 100 times the number of active components contained in the valve models. Some idea of what these developments meant in terms of packaging can be seen from Figure 2.

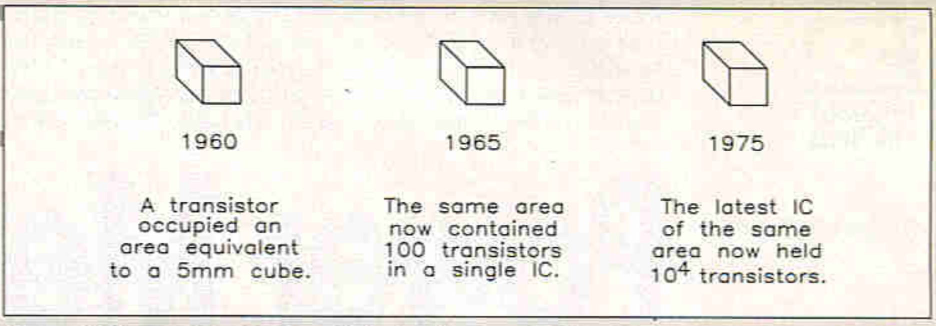


Figure 2. The miniaturisation of electronics from 1960 to 1975.

In 1964, the International Business Machines (IBM) corporation introduced their IBM/360 series of machines. They were classed as third generation machines and consisted of a 'family' of small, medium and large computers sharing common architecture and peripheral equipment. The largest processor was some 100 times more powerful than the smallest one, and a standard interface linked the peripherals.

The Series 360 machines were immensely influential, with five basic models whose calculating speeds ranged from 30,000 to 2·5 million additions per second. They quite simply re-defined the world's ideas on computers.

By 1968, the Digital Equipment Corporation (DEC) claimed that its Programmed Data Processor I or PDP-I was the first mini-computer. In fact it was a progression from earlier machines such as MIT's 'Whirlwind' model of the early 1950s. Figure 1 gives some idea of how rapidly computers have shrunk in the 35 years between 1945 and 1980. To understand what this means in short-circuiting time-consuming calculations, let's look at a rather esoteric problem – the behavioural aspects of supersonic airflow over an aircraft's wing structure.

Even today, with half a century's experience behind them, the world's aerospace manufacturers don't exactly regard the problem as cut and dried. That's why they employ computers.

If – in 1945, for instance – ENIAC had been handed such a problem it would have completed its work by 1972. In 1967, though, DEC's 7600 machine had already reduced this type of number crunching to two days. So computer, or rather packaging, development had been such that the problem-solving time had been reduced by a factor of around 5,000! A decade later, computers were performing 100 million mathematical operations per second.

What of the future? Can an industry barely half a century young – which has advanced in that period, by the same amount as took mechanical engineering two and a half centuries – continue to expand indefinitely?

Next month, in the concluding article, I'll take a look into the future and attempt that most dangerous of games: technological prediction!

NEXT *issue*

THE MAPLIN 'MILLENNIUM 4-20' 20W VALVE POWER AMPLIFIER

Another terrific issue of *Electronics – The Maplin Magazine* will be out next month with more super projects and features to tide you over till the new year, and including in particular the first instalment of our very own 20W Valve Amplifier project, beginning with the Power Supply Unit. The amplifier is guaranteed to turn any capable, domestic stereo system into something a bit special, emitting a wonderfully gutsy bass even at low volume, together with 'an extra something' in the mid and treble ranges.

Closely resembling Mullard's '520' design of the early sixties, the amplifier benefits hugely from the superior quality of modern components. Modern materials have produced transformer cores that are half the size of those of 20 years ago, yet with better specification. High-speed capacitors achieve a competent, even sparkly, HF performance, and 1% metal film resistors help push the S/N ratio to nearly 90dB, making a nonsense of the myth that valve circuits are inherently noisy. Our resident catalogue editor and valve freak was a bit worried when switching on the prototype for the first time to try it out. No switch-on thump, no hum, no hiss, nothing. Just an inky-black silence. However, inserting a screwdriver into an input socket proved that it was in fact very much up and running!

The construction concept is modular. There will be just two basic kits: a PSU module, and an amplifier module. Each will contain everything required to build the basic module, including a standardised aluminium chassis (8 x 6 x 2½in.). PCBs are included to simplify construction. Options can be a traditional 'monobloc' (single amplifier and PSU), or a full stereo assembly (1 x PSU, 2 x amplifier modules: The PSU is designed to power a stereo pair).

Project rating is 4, but no special setting up is required and initial testing only needs an ordinary multimeter.

Brief specification: Amplifier type: Class AB1 'ultra-linear'; output power: 20W rms (27W max.); frequency response, 25Hz to 30kHz flat @ 20W (–3dB @ 75kHz); speaker load: 8Ω; total distortion: 0·4% @ 20W (1% @ 27W); S/N ratio: 89dB; output noise, hum: <3mV, white noise: <2mV; input sensitivity: 220mV for 20W; input impedance: 1MΩ (500kΩ if volume control added); valves: 1 x EF86, 1 x ECC83, 2 x EL34; dimensions: monobloc, (W)12 x (D)8 x (H)6½in., stereo, (W)18 x (D)8 x (H)6½in.

By coincidence, this issue also sees the last instalment of Graham Dixey's 'Valve Technology' series, which deals with power amplifiers and audio output stages. Other fascinating features include an explanation of the Sony Mini Disc system, an absorbing look at the planet Mars and a review of an impressive software package which aims to teach electronic principles to newcomers.

Other projects include the power supply for the graphic equaliser system, a twilight switch, how to control domestic equipment by computer and how to use the excellent (and legal!) 418MHz radio link modules.

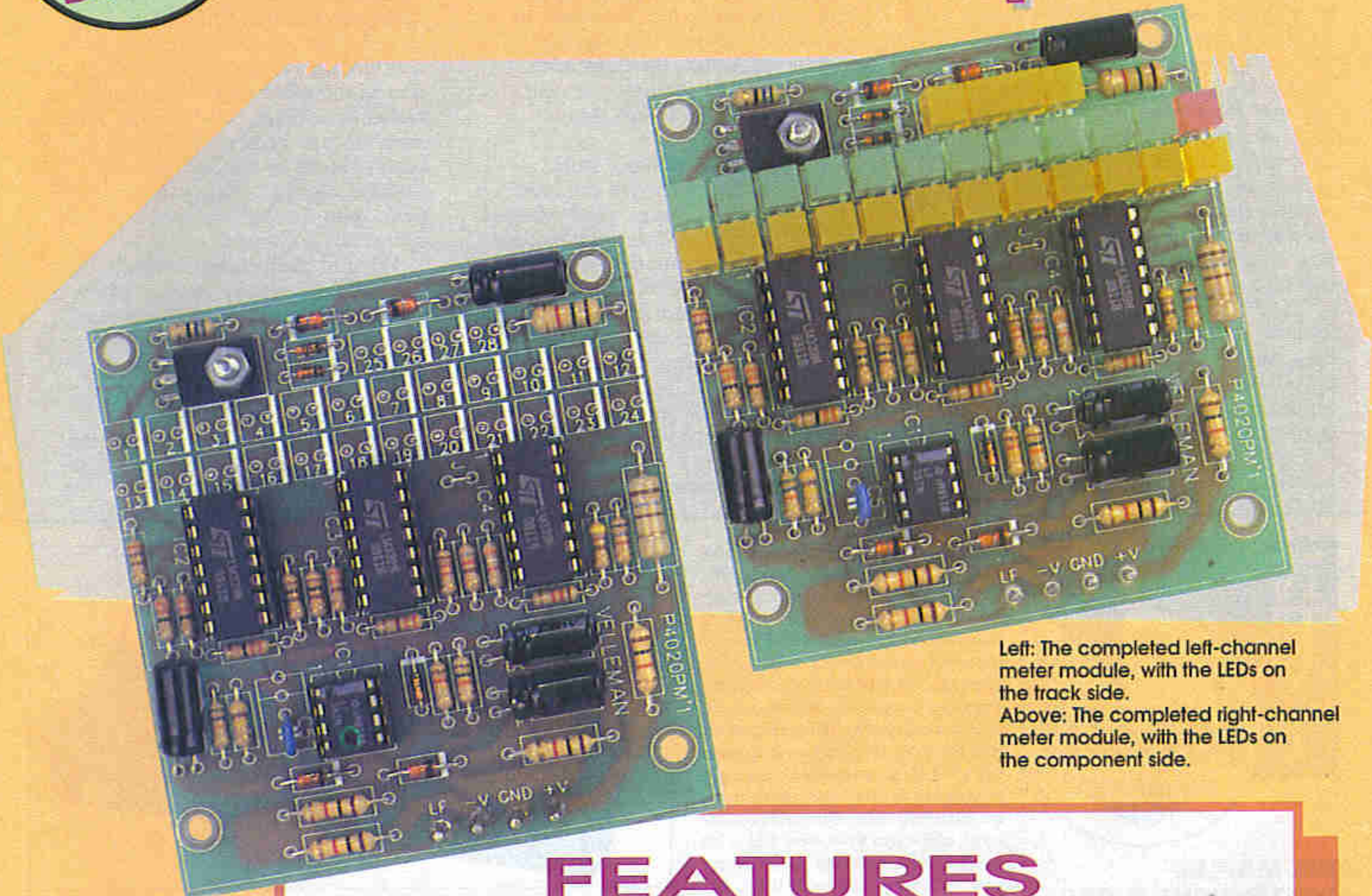
2
PROJECT RATING

These power meters are designed to give a visual representation of the output power from amplifiers built around the 300W MOSFET amplifier modules – refer to the previous two issues (October and November) of *Electronics*. Since the amplifier system can be configured in two different ways – stereo (two independent 300W mono amplifier modules) and bridged (both modules combined into a single 600W amplifier) – this meter system has been flexibly designed.

Text by Martin Pipe

Power Meter for 300W/600W MOSFET Amplifier

KIT AVAILABLE (VF18U) PRICE £34.95



Left: The completed left-channel meter module, with the LEDs on the track side.
Above: The completed right-channel meter module, with the LEDs on the component side.

FEATURES

* 12-LED display * LED scale illumination
* Wide range of power indication

APPLICATIONS

* 300W/600W MOSFET amplifier
* Power monitoring for your own amplifier
* In-car audio * Disco equipment

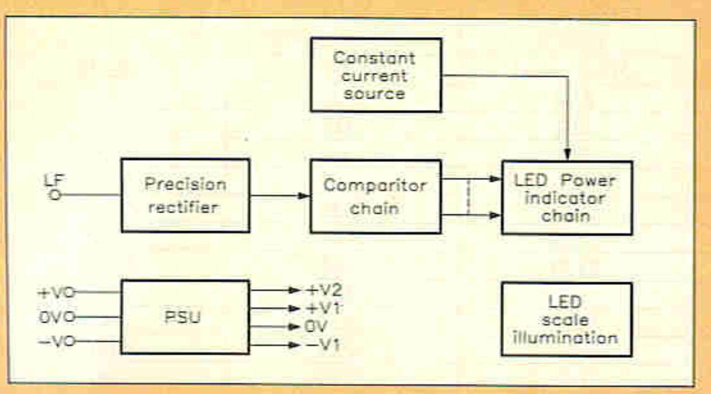
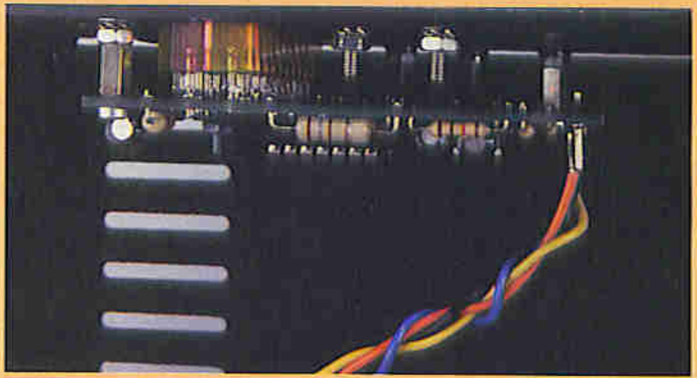


Figure 1. Block diagram.


Close-up view of LEDs, showing mounting arrangement.

WHETHER you have a stereo 300W amplifier or a mono 600W unit, two meters are required. In the latter case, the two meters work together to form a single large (24-LED) meter.

Apart from its application within the 300W/600W amplifier, these modules could be used to provide reliable power indication for any audio power amplifier – homebrew Hi-Fi amplifiers, disco systems and the like.

A visual indication of the instantaneous power output of your amplifier can be useful in that you can 'see' if you are about to endanger the lives of your speakers by exceeding their maximum input power level, or by running the amplifier into clipping, which will also damage your speakers (particularly the tweeters).

Circuit Description

From Figure 1, it can be seen that the circuit consists of three separate parts – the power supplies, the illuminations for the amplifier's front panel scales, and the main part of the circuit – the drivers for the 12-segment power meter. The output signal of the power amplifier is fed into the circuit via the board's 'LF' input pin. With reference to the circuit diagram of Figure 2, C5 and R15 form a high-pass filter at the input of IC1. This op amp is configured as a half-wave precision rectifier in which the negative peak voltage is stored on capacitor C4, and resistor R18 provides a slow discharge path for C4.

The DC voltage on C4 is fed into the bargraph driver circuit. This consists of a resistor chain and ladder of voltage comparators (op amps A1 to A12), which are referenced to the supply and ground through resistors R1 to R13, to form a voltage reference for each comparator.

The power supply for IC1 is derived from the –V and +V supply rails via R21, R22, R23 and R24. ZD1 and ZD2 are the voltage reference components, while C1 and C2 decouple and stabilise the –V1 and +V1 rails, which are used to power IC1.

The +V2 supply is derived in the same way as ±V1 – the components responsible for this are R25, C3, ZD3 and ZD4.

Transistor T1, in association with D1, D2, R14 and R20, form a constant current source. LD25 to LD28, four of the scale illumination LEDs, derive their power at this point but are not an essential part of the constant current source (if scale illumination is not required, the base of T1 can be linked to R20, and the LEDs left off). The series-connected LEDs LD13 to LD24, powered from the +V rail via R19, provide the remainder of the scale illumination, but can be left off.

Turning back to the current source, the collector of T1 is connected to the top end of the LED chain to illuminate the power level LEDs LD1 to LD12. The function of the constant current source is to set the current at a level that the comparitors are able to sink, which in turn allows the LEDs to be turned on and off.

Construction

The exact way in which you fit the components depends on how the Power Meter will be configured. There are a number of components common to all options, however, and these need to be fitted first. These include R14 to R25, the link (J), all capacitors (C1 to C5), diodes (D1 to D3, ZD1 to ZD4) and TR1. Note that the four electrolytic capacitors (C1 to C4) are mounted flush against the PCB; this of course requires that the leads must be bent through 90°. Of course, please remember to observe the correct polarity; the same applies to the diodes, and to TR1, which is also mounted flush against the PCB, in this case being secured via a M3 nut and bolt (the nut should be on the component side of the board); the tab side of the transistor faces the PCB. Note that the board legend provides information as to the correct orientation of each device. IC sockets

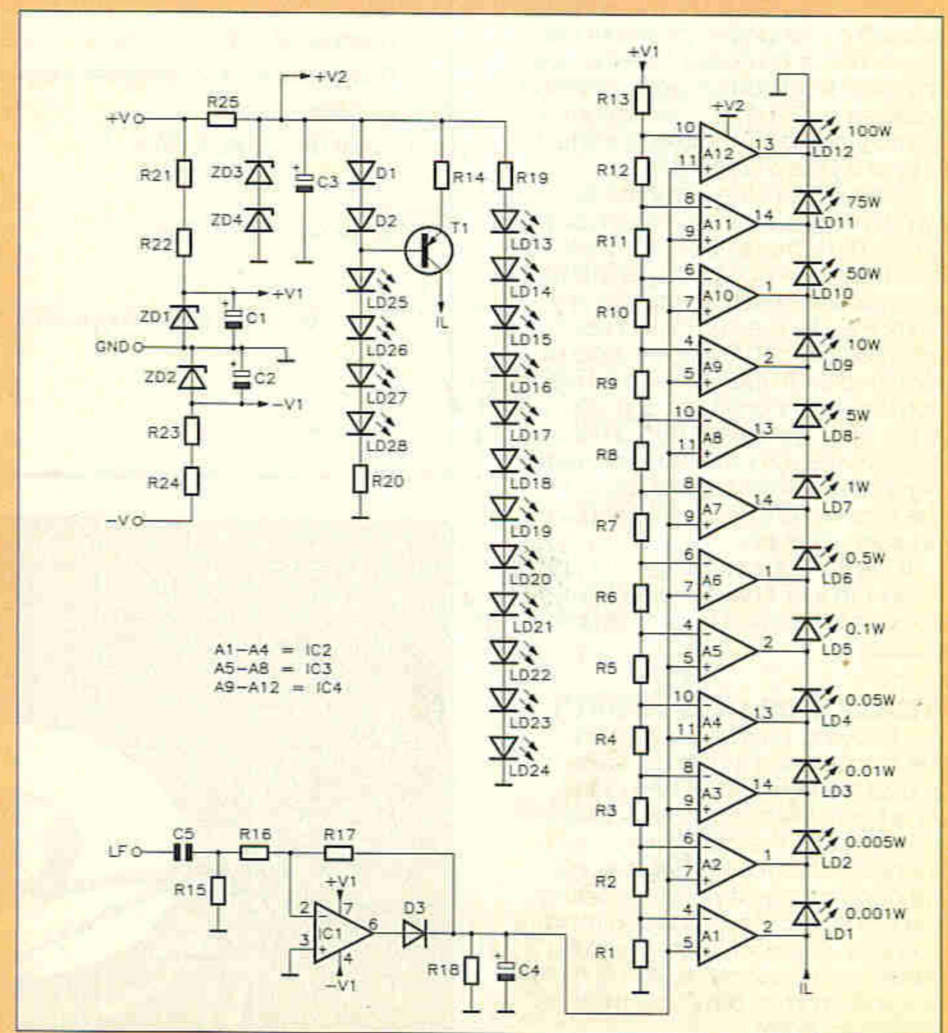


Figure 2. Circuit diagram.

should be fitted in the positions for IC1 to IC4, aligning the notch on the socket with that on the board legend.

Which components are fitted next depends upon which one of the three construction options is chosen. These are summarised in Table 1.

All components should be fitted on the component side, except for those marked with a *, which are fitted on the track side.

When fitting the LEDs, it is advisable to start with the first full row of LEDs (the scale illumination), followed by the second row (the meter itself), and finally the block of four additional scale illumination LEDs. This is so that each device can be easily accessed, for accurate positioning, as construction proceeds.

Note from Figure 3 that each LED should be mounted, so that its top is 14mm above the surface of the PCB – this comment applies regardless of the side of the PCB on which the devices are placed. The shorter lead of the component is its cathode, and it

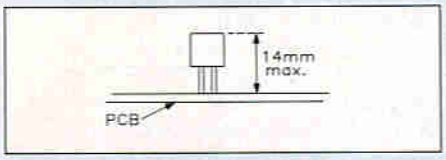


Figure 3. Mounting the LEDs.

should be orientated with the ***thicker*** line of its symbol on the PCB legend. It is advisable to solder in only one lead of each LED in the current row. By placing a ruler across the top of the row to act as an horizontal reference, the other lead can be positioned and soldered in. Once the row has been completed, the next can be started until all LEDs are in place.

In the case of the stereo meter, which makes use of a single module, LD1 to LD11 are green, LD12 is red, and the remainder (scale illumination) are yellow. Where two modules are combined for use in a 600W bridge amplifier, LD1 to LD12 of the module mounted on the left (when viewed from the front panel) are all green; in the other module, LD1 to LD10 are green, while LD11 and LD12 are red. Again, the yellow LEDs are used for the scale illuminations (LD13 to LD28 on each module).

If the PCB pins are a little reluctant to go into their holes, a hot soldering iron can be used to coax them into position.

Installation and Testing

The following information relates to the installation of the Power Meter in a 300W/600W MOSFET Amplifier. Apart from the actual mechanics of installation, the information (particularly that relating to wiring) will apply to any application making use of the module. Do bear in mind, however, that each meter module requires a split supply of –40V/0V/+40V, at a maximum of 60mA per module (120mA for both).

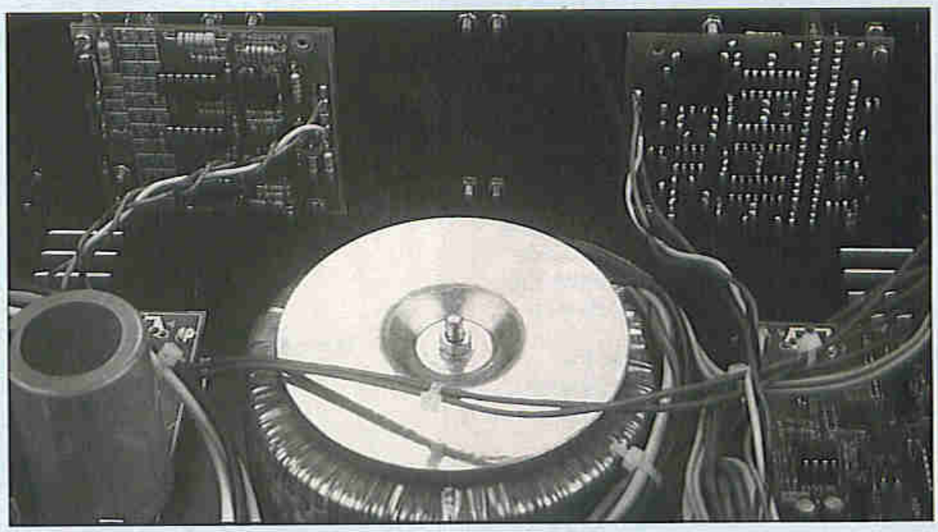
The aluminium front panel of the

COMPONENT	STEREO	BRIDGE MONO	
	LEFT & RIGHT	LEFT	RIGHT
R1	33Ω	15Ω	1k5
R2	33Ω	6Ω8	330Ω
R3	33Ω	12Ω	270Ω
R4	100Ω	12Ω	820Ω
R5	100Ω	22Ω	680Ω
R6	330Ω	39Ω	560Ω
R7	330Ω	39Ω	470Ω
R8	1k2	68Ω	1k
R9	820Ω	120Ω	1k
R10	3k9	120Ω	820Ω
R11	1k2	220Ω	680Ω
R12	470Ω	390Ω	1k2
R13	6k8	15k	5k6
LD1 to LD10	GREEN Left channel * Right channel	GREEN	GREEN
LD11	GREEN Left channel * Right channel	GREEN	RED
	LD12 Left channel * Right channel	RED GREEN	RED
LD13 to	YELLOW *	YELLOW	YELLOW
PCB Pins	Left channel Right channel *	*	*

Table 1. PCB component options.

Specification

Number of LEDs (power indication):	12
Number of LEDs (scale illumination):	16
Power supply (from amplifier module):	±40V DC at 60mA (maximum)
PCB size:	72 x 78mm.
Scale (8Ω load, 300W):	1mW, 5mW, 10mW, 50mW, 100mW, 500mW, 1W, 5W, 10W, 50W, 75W, 100W
Scale (4Ω load, 300W):	2mW, 10mW, 20mW, 100mW, 200mW, 1W, 2W, 10W, 20W, 100W,150W, 200W
Scale (8Ω load, 600W bridge mode):	1mW, 2mW, 5mW, 10mW, 20mW, 50mW, 100mW, 200mW, 500mW, 1W, 2W, 5W, 10W, 15W, 20W, 40W, 60W, 80W, 100W, 150W, 200W, 250W, 300W, 400W



The meter modules, seen here in a 300W stereo MOSFET amplifier.

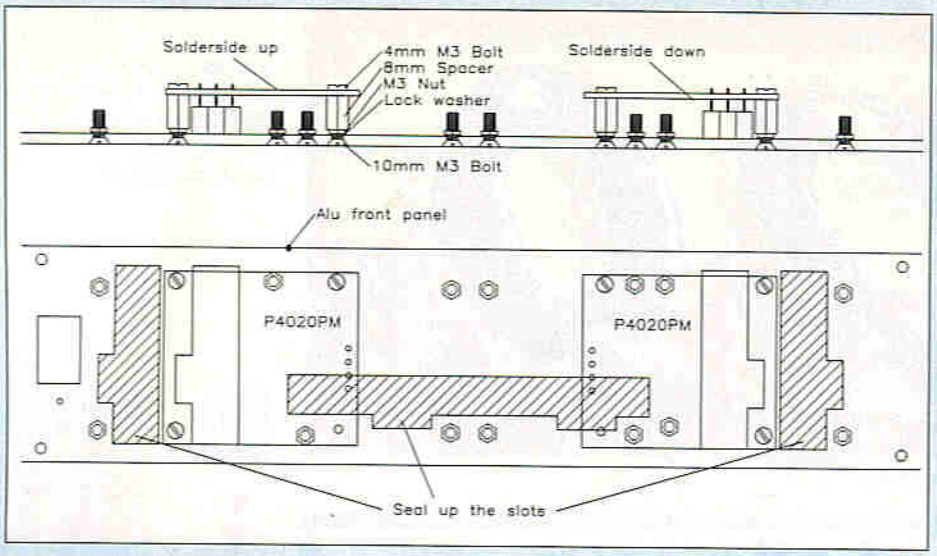


Figure 4. Fitting the meters in a stereo 300W MOSFET amplifier with an 8Ω load.

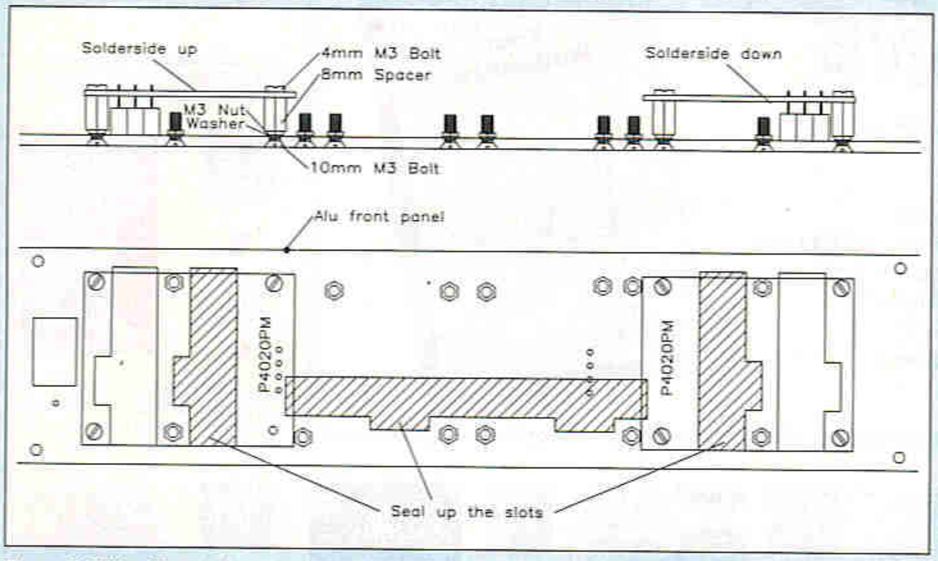


Figure 5. Fitting the meters in a stereo 300W MOSFET amplifier with an 4Ω load.

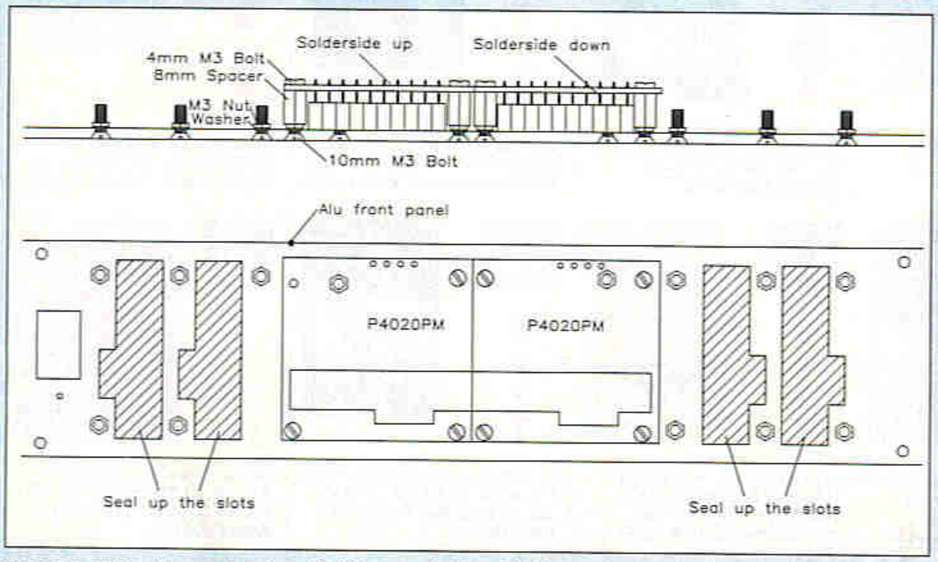


Figure 6. Fitting the meters in a 600W mono bridge MOSFET amplifier with an 8Ω load.

300W/600W amplifier contains five cut-outs, and the self-adhesive label that is applied features legends which correspond to these cut-outs. There is a centrally-located cut-out for the large 24-LED power meter used in the 600W bridge amplifier, and either side of that are 4Ω and 8Ω 12-LED versions for each stereo channel. Those who have built the amplifier already will wonder why so many threaded spacers were fitted onto the front panel. This is so that the meter modules can be lined up with the cut-outs that correspond to the correct legend. The amplifiers can be used in three ways – with a 4Ω or 8Ω load, or in mono bridge mode. The meters are mounted in the position that correlates to the chosen option, using the M3 hardware supplied with the amplifier and meter kits – refer to Figures 4, 5 and 6. It is advisable, just before fitting the modules, to cover over the unused slots with black insulating tape. Note that each meter module is held in place with four screws.

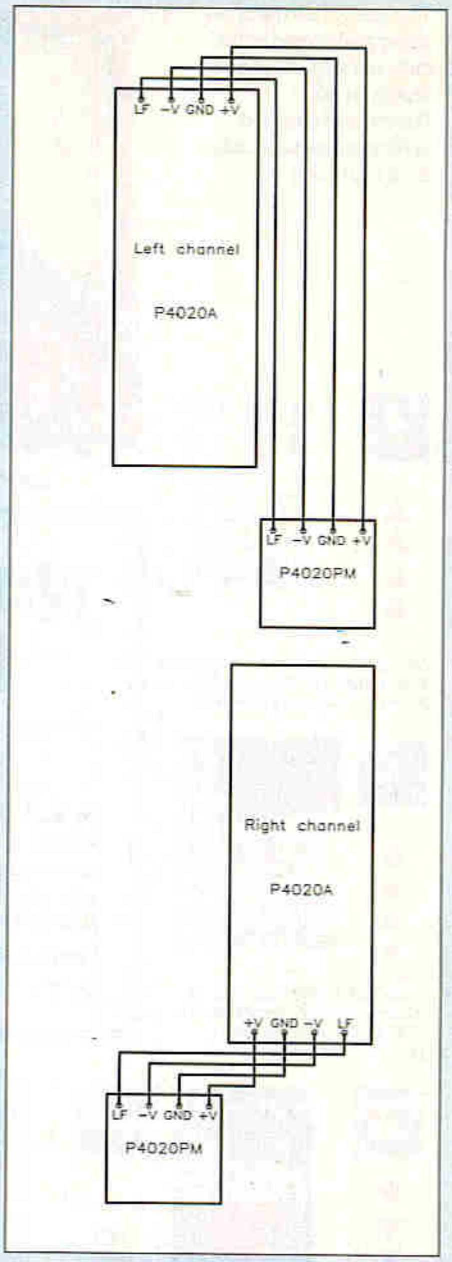


Figure 7. Wiring diagram.

If you are building the Power Meter into a front panel of your own specification, spacers of at least 12mm (depending on the panel thickness) will be required to provide sufficient clearance between the components and the mounting surface. The required slot for the LEDs can be cut using a keyhole saw, after drilling a hole as a starting point. As mentioned earlier, the scale illuminations may not be required, in which case a slot with a simpler shape will suffice.

With the modules in place, wire them up to the amplifiers as shown in Figure 7, using 0·5mm insulated wire.

The best method of testing the Meter is to use it in its intended application; the length of the column of glowing LEDs should vary in sympathy with the power demand exerted on the amplifier. Before powering up, it is advisable to carry out a final check – for the sake of the amplifier as well as the meter.

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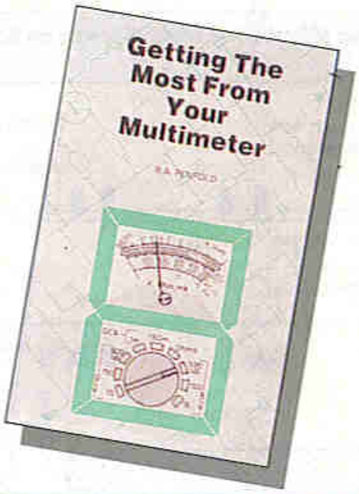

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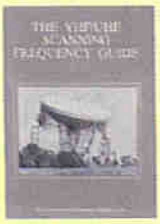

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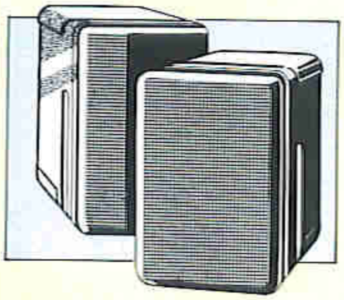

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