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No. 55

ELECTRONICS

The Maplin Magazine

JULY 1992·£1.60

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EDITORIAL

Hello and welcome to another issue of 'Electronics'! As always there is a varied collection of projects and features. The cover feature of this issue is the Space Shuttle; in the final part of 'Electronics in Aviation', Chris Yates takes an informed look at the development of the project and the missions flown to-date. The shuttle has succeeded in blurring the previously sharp divide between space and atmospheric flight. In the near future, Chris will return to the pages of 'Electronics' with a series that deals with the history and development of satellite communication. In recent years, the Space Shuttle has played an important part in the deployment and maintenance of many of the satellites orbiting the earth.

With the warm summer weather just around the corner (hopefully!), it is the right time of year for getting out and about. In this issue, Alan Simpson has done just that, he's paid a visit to the Alton Towers theme park. Behind the scenes of such an operation, computers and electronic sensors play an important role in keeping track of the number of people in the grounds and ensuring the safe operation of hi-tech rides and attractions. In true 'Electronics' tradition, there are FREE Family Tickets for a day at Alton Towers to be won – just enter the competition on page 35!

Finally, all that remains for me to say is I hope that you enjoy reading this issue as much as the 'team' and I have enjoyed putting it together for you!

R D Ball

ABC 31,125 Jan-Dec '91

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- **Published by** Maplin Electronics Plc.
- **Colour Separations** Stirling Graphics Ltd., 16-22 West Street, Southend, Essex SS2 6HJ.
- **Printed by** Severn Valley Press, Caerphilly, Mid Glam. CF8 3SU.
- **Distributed by** United Magazine Distribution Ltd., 1-11 Benwell Rd, London N7 7AX.
- **Mail Order** P.O. Box 3, Rayleigh, Essex SS6 8LR
- **Retail Sales:** (0702) 554161, **Retail Enquiries:** (0702) 552911. **Trade Sales:** (0702) 554171.
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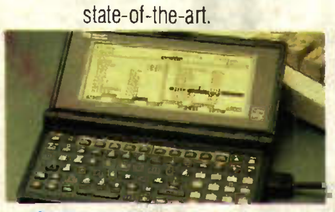
PROJECTS

FEATURES



REGULARS

CORRIGENDA

- October 1991 Vol.10 No.46

  Data File: L200

Page 50. circuit diagram (Figure 4) incorrectly shows the value of C1 as 100μF; the correct value is 100nF.

- April 1992 Vol.11 No.52

  Valve Amplifier

Page 57. the colour code for resistors R58L and R58R is incorrectly given as violet, red, red; the correct colour code is grey, red, red.

  Sequential Logic

Page 69. Figure 13c incorrectly shows the minimisation as F = D; the correct minimisation is $F = \overline{D}$.

  Data File: 78xxx/79xxx

Page 78. the pinouts shown in Figure 9 have been transposed: TO92r should be P1d. TO92n should be P1n. P1d should be TO92r and P1n should be TO92n.

- May 1992 Vol.11 No.53

  Morse Decoder

Page 73. Table 1 incorrectly shows the morse code for 'W' as '·–––'; the correct code is '·––'.

Prices shown in this issue include VAT at 17·5% (except items marked *NV* which are rated at 0%) and are valid between 5th June 1992 and 31st August 1992

NEWS Report

Maplin at NEPCON '92

It was all action on the Maplin Professional Supplies stand at NEPCON '92. But MPS, the trade arm of the Maplin group, had a lot to live up to having scooped one of the show prizes the previous year for PR/Promotion. This year, reflecting the award of the highly coveted BSI 'Quality' Certificate, the MPS stand was decked out in the guise of a hot-air balloon designed and built by Maplin at Rayleigh. Trevor Nash, director of operations, BSI Quality Assurance opened the stand, and informed Maplin managing director Roger Allen that he recognised the enormous effort that the company had put in to achieve the BSI recognition. At the close of the event, the exhibition director Stephen Farrer drew the prize for a champagne flight for two in a hot air balloon over the Cotswolds. With a bevy of glamorous girls busily handing out a puzzle challenge to each visitor, our replica balloon festooned stand was the central focus of the show.

Hot-air balloons apart, MPS was displaying the very wide range of their various components and products, highlighting that quality in Maplin terms does not mean higher prices. On show for the first time was the new Sub-Miniature Monochrome CCD Video Camera (see page 280 in the 1992 Maplin Catalogue) and the new digital multimeter priced under £10 (see catalogue page 519).

Virus Exits a Living Cell

IBM scientists believe they have witnessed a biological process never seen before – the escape of a virus from a living cell. The observation was made by a scanning force microscope, an instrument that can image biological materials and resolve details in them as small as 10 nanometres, or 10 millionths of a millimetre. Such resolution is unobtainable with even the best optical microscopes, but it is possible with an electron microscope, except that the latter requires that the specimen be in a totally airless vacuum, which has a habit of killing biological subjects.

A Virtual Universe

IBM researchers have also been involved in building a prototype general-purpose artificial world – a generic system for generating virtual reality. These are realistic models of the real world, containing three-dimensional, stereoscopic representations of physical objects with which many persons at once can interact, perhaps from remote locations, as if the synthetic environment actually existed. The prototype is multi-sensorial, involving sight and sound, gesture and speech recognition. The computer-generated model actually speaks for itself, reciting events that appear on the screen and producing sounds associated with them. It also recognises human speech and responds when spoken to. The researchers eventually want to incorporate the human faculties of touch and feel into their system, maybe even taste and smell.

What distinguishes the new IBM virtual world from most others is that, while the others may be visually interesting, not much takes place in them which was not predetermined, for example a specific action that results from a button being pressed. There is a snag however for the home enthusiast. The IBM demonstration package requires not just one, standard issue PC (with or without hard drive, mouse etc.), but *six* RISC System/6000 Power Workstations, fastened together in a way that both amasses the computing power and distributes it such that the number of users could just as easily be increased from two to five or six (given further equipment), and located not in the same room but in different places across the country or around the world. Whilst the IBM virtual-reality system is very expensive, the R&D team is looking into a future, not too distant, when such computational power and versatility can reside in a single machine.

Three Dimensional Sound

No sooner does stereo television begin to penetrate the consumer market than a group of designers predicts its demise. A three dimensional sound processor is the latest product from the laboratories of Perfect Pitch Music.

The OM 3D Sound Processor takes conventional stereo into the realms of virtual reality. An OM-encoded recording will recreate a three dimensional sound field which totally surrounds the listening position. Launched by Select Systems, no additional equipment is required by the listener and the OM format is compatible with all stereo conventions and replay systems.

Extensively field tested prior to its introduction, OM has already been used on several major projects with radio stations and record producers applying it in place of existing technology.

Where stereo loudspeakers simulate the time and intensity cues of sounds, as well as the tonal colouring that the human brain uses to perceive the *direction* of sounds in the horizontal plane, the magic behind OM consists of continually varying time-delays and filters to achieve the same effect from a *single* sound source.

The adoption of OM is left to the choice of producers. The system must be heard before evaluating the price tag however, at £3,500, a mere sixth of the cost of any similar system, OM has to bear consideration.

Tunnel Breakthrough

Back in 1981, the Scanning Tunnelling Microscope (STM) was developed which provided images of atomic steps on the surface of a calcium-iridium-tin crystal. Since then, the STM has become a widely used tool, with much development having been undertaken not least by IBM engineers. At an IBM research centre, single atoms and molecules have been picked up by the STM tip and moved across a surface and positioned where desired with great accuracy. In fact a photo of the IBM logo formed by xenon atoms and 'written' by an STM has gone around the R&D world.

Total MOSFET Protection

A new MOSFET from Philips Semiconductors appears to be totally isolated from the harsh realities of the world. Claimed to be the world's first fully protected three terminal device, the BUK101–50 is produced in a traditional TO–220 case.

So special is this semiconductor device that a new acronym has been coined – TOPFET – Temperature and Overload Protected Field Effect Transistor. Safe from short-circuit, over-temperature and over-voltage abuse, the new cockroach of the electronics industry can be driven directly from conventional logic-level FET circuitry.

The souped-up transistor is suited to switching inductive devices, boasting a peak current rating of 100A, but preferring a continuous rating of 26A. Not surprisingly, it requires no additional circuit protection.

Fault Diagnosis

An intelligent instrument, which provides fault diagnosis of unpowered circuit boards, is now available from Polar Instruments. Utilising impedance signature comparison, the T6000 is able to provide accurate component level analysis. Any type of electronic device makes a suitable patient since diagnosis is undertaken by the injection and subsequent evaluation of current limited AC stimuli.

Operational in either a routine maintenance or fault-finding mode, the machine is said to be suitable for use by experienced engineers and non-specialist service technicians alike.

Impedance signatures derived initially from circuit boards, whilst operational, are compared with those obtained from the circuit once a fault appears. Differences are produced for scrutiny, aiding the location of faulty devices.

Lower Voltage Computing

Several manufacturers have released digital logic IC families capable of running from a 3V supply – and others have announced their intentions to do so in the near future. In itself, low-voltage logic may not sound particularly dramatic – but when you consider the rapid growth in the popularity of portable electronic games and notebook PCs, not to mention an entire range of portable microprocessor-controlled products, it all begins to make sense. For example, Advanced Micro Devices (AMD) have released a 3V version of the 386 microprocessor, fully compliant with JEDEC standards on low-power computing devices. According to the advertising blurb, this device will deliver a continuous 8 hours of operation from 2 alkaline AA batteries. This fact is made even more incredible, when you consider that the 386 microprocessor is more powerful than the minicomputers (and even some mainframes!) of less than 2 decades ago – and they required a beefy power supply, not to mention a specialised environment, in which to operate. What is not mentioned, however, is that those batteries will power only the microprocessor itself for 8 hours; it does not include support circuitry (memory, display drivers, etc.) or peripherals (such as LCD panels and disk drives). Nevertheless, it is still a great achievement. AMD also supply compatible low-voltage EPROMs for the storage of firmware.

Tarzan Swings Again

The general election is now long in the past – in terms of politics anyway! Possibly one of the most interesting appointments in the new Cabinet is the return of Michael Heseltine to the DTI. In 1986 Heseltine, who founded the giant Haymarket publishing concern, stormed out of the job (amidst much publicity!) as a protest against the sale of Westland Helicopters to the US – he would have preferred a British or European buyer. In 1990 he returned to active politics, first challenging the Tory leadership before settling down in John Major's first Government as Secretary of State for the Environment.

Heseltine differs from his predecessors as he believes that "the key wealth creator is manufacturing". As has been well documented, the Conservative Government has relied upon service industry – particularly that of finance – in recent years. Where previous Conservative policy has maintained a 'hands off' approach, Heseltine would like to see improved relations between industry and Government. He would also like to see better co-operation between management and workforce – without, presumably, the direct intervention of unions – as this will lead to better productivity. Although Britain's economy is based on Thatcher's vision of American-style free-market capitalism, Heseltine takes the common-sense view that such a system simply cannot work as well here as it does over the Atlantic; the scales are too different. In his book 'Where there's a will', he states that in the US, consumer and government spending is sufficient to justify such a large level of competition. Not surprisingly, the new DTI minister does not consider his department to have enough power; the Treasury, in contrast, is very influential – witness the dominating effect that the City has upon industry. Heseltine draws from the experiences of other nations for guidance; he cites, among others, the Japanese belief in a 'global market-place' and government/industry partnership.

University and Polytechnic Entries

Potential undergraduates have faced additional worries other than A level exams this year. The University Central Council for Admissions (UCCA), which co-ordinates the allocation of university and polytechnic places, found faults in software which resulted in a number of application forms, er, shall we say, 'going adrift'.

In an attempt to cope with a growing number of applications, UCCA installed a new computer system last year. Shortly after the £1·4 million, document image scanning system was inaugurated it was noticed that student application forms were not being forwarded to respective universities and polytechnics as quickly as would normally be expected. In some cases interviews had to be cancelled because of a lack of student details.

These problems resulted from the system failing to produce error lists when an application form had not been scanned correctly. Faults in the scanning process, which operated well in tests, did not appear until the system 'went live'.

Happily all is now well again and the problem has been resolved. UCCA is now coping with the increased number of students applying for places in higher education, leaving exam candidates free to grapple with the prospect of forthcoming exams. The episode only goes to prove that no software is completely finished until it has been tested and debugged with real working data 'in the field'.

IT Assists Archaeology

IBM, a noted supporter of the Arts, is sponsoring a fascinating exhibition entitled 'Rediscovering Pompeii', on show in London until 21st June. Some 200 objects excavated from the ruins of Pompeii, many of which have not been exhibited before, will be offering a fascinating insight into life in the 1st century AD and illustrating how computer technology has revolutionised the analysis of archaeological evidence. If you want to take an electronic tour of Pompeii using an interactive computer system – there are hosts of touch screens and computer generated time-lapse images – then make tracks for The Accademia Italiana, Rutland Gate, London. Entry costs £5, but there are concessions. Phone: (071) 225 3474.

Recession? What Recession?

With some 500 plus exhibitors at NEPCON 1992, there was little sign of the recession taking place outside the NEC Birmingham halls.

But if Maplin had the most advanced products on show, the prize for the oldest exhibit must go to the Radio Society of Great Britain stand which had on display some radio equipment dating back to the 1920s. Other notable happenings, apart from a fleeting visit from the then campaigning Neil Kinnock, included the high profile and all-action factory automation display. A new infra-red soldering machine, which avoids the use of CFCs by operating in a nitrogen rich, inert atmosphere, was being shown on the Electrovert stand, while Hunter Equipment were demonstrating methods of measuring the thickness of materials in any 'non contact' situation, such as wet solder or wet glue.

For MPS, planning for NEPCON '93 is already in hand. With a motorbike on the stand last year promoting the Maplin courier service, and a replica hot-air balloon this year, all involved have a lot to live up to.

So You Want Your Own Satellite Service?

The ITC has now issued an invitation to any person or organisation to provide a domestic satellite service. This invitation stems from the termination of BSkyB's programme contract at the end of this year, which will release the five transponders on its MarcoPolo satellite. But be warned before you pop down to your bank. The good news is that ITC will only charge a token rental for the licence. The not so good news is that the transponders are not expected to remain operational beyond 2001. Information from: (071) 584 7011.

If you do apply for the licence, you may find yourself in competition with the BBC. In association with Thames TV, BBC Enterprises are planning the development of a new satellite TV programme service to be delivered direct- to-home and to cable services from the Astra satellite later this year. The new channel will select its schedules from existing programming, drawing heavily in peak viewing hours from the libraries of the BBC and Thames.

Mind you, you will need more than petty cash to win the Channel Five television network. Because the proposal is that it should use the same frequency as do video recorder UHF modulators, so all VCRs and anything else having such modulators need to be retuned to a free part of the band, for which work retailers and service people will charge Channel Five.

Power Points

Demonstrating the startling rate at which prices are moving, Microsoft Corporation's chairman Bill Gates notes that in January 1990, the most powerful machines the company was buying used 33MHz 80386 processors and cost about $6,000. Today, as 'Computergram' notes, the most powerful machines the company is buying use 33MHz 80486 chips, but cost only about $2,700!

STOP PRESS! STOP PRESS!

Due to popular demand, Maplin will be stocking a selection of Waters and Stanton amateur radio equipment in several stores – previously these were available by mail order only. The products available initially will include scanners, 2m and 70cm handies, and CB equipment. The stores in question are those at Glasgow, Leeds, Manchester, Birmingham, Bristol, Reading and Brighton. It is hoped that eventually, all stores will sell the range.

TESUG (The European Satellite User Group), mentioned in 'Club Corner', has announced a new data broadcasting service, to be transmitted on an Astra transponder alongside German channel Pro 7. Like the teletext (page 270) service that TESUG provides on Superchannel's 'Supertext', the 'Videodat' system used by TESUG relies upon information transmitted in the (otherwise wasted) picture vertical blanking interval. Videodat is operated by German company Wiegand Video Daten, and requires a set-top decoder unit which plugs into the satellite receiver, as well as the ubiquitous PC! TESUG will be electronically publishing its interactive newsletter using the new system which, although being used already by 25,000 Germans, is available to all those within the Astra footprint. Details: Eric. N. Wiltsher, TESUG. (0233) 610040.

High Tech on Show

This year's 'Brown Goods' (TV and audio to you and me) show in London concentrated firmly on the development of HD and wide-screen TV. In fact the trade expects TV sets to be the star retail performers over the next five years. In the forefront comes NICAM stereo, where it is estimated that this year will see over 40% of all large screen TVs and around 25% of all VCRs feature the technology. A recent survey suggests that over 15% of consumers have now connected their TV set up to a hi-fi system. Staking their claim to a large market share, Toshiba, who state that NICAM coverage is set to reach 90% of the UK over the coming months, has launched their NICAM Plus large-screen, FST range for people who require the delights of near-CD sound and a superb picture.

While many of us having been keenly waiting for HDTV to emerge, wide-screen TV appears to have already arrived. Relatively inexpensive when compared to HDTV, 16:9 wide-screen TVs were on show by several manufacturers. One pioneer, Philips, is working closely with BSkyB to help the UK-based satellite broadcaster set up a test channel. Under the Pan-European high definition project, the Winter Olympics was seen across Europe in 16:9 as will be the summer games. In total this year, there will be around 6,000 hours of the cinema-style screen programming throughout Europe, and by the turn of the century, Philips estimates that over a quarter of all TV sets sold will have the new cinema-shaped screen. However, don't all rush. Philips sets which will display both a high quality conventional 4:3 picture and widescreen programmes are priced at £1,400.

PICTURE CAPTION CHALLENGE

This month we go Up the Pole. No prizes but what is going on? What's it all about?

- ★ Engineer phoning home to see if lunch is ready;
- ★ BT engineer looking out for an AA repair van;
- ★ Engineer scaling the heights in order to listen to the test match;
- ★ BT keeping a weather-eye open for rival Mercury?

It *is* a BT engineer, but the situation is, if anything, slightly more bizarre than that. He is reporting a fallen tree and requesting the services of a large saw. Honest!

Events Listings

Till 31 October. 'Friendly Invasion', RAF Museum, Hendon. (081) 205 9191.

9/11 June. Multimedia, Olympia, London. (081) 868 4466.

20/24 July. Electro Tech '92, NEC, Birmingham. (0483) 222888.

July 1992. Pop Video Experience, MOMI. (071) 928 3232.

Also watch out for:

22/24 September. Image Processing Exhibition, Birmingham. (081) 868 4466.

6/8 October. Voice '92, Olympia, London. (081) 877 9007.

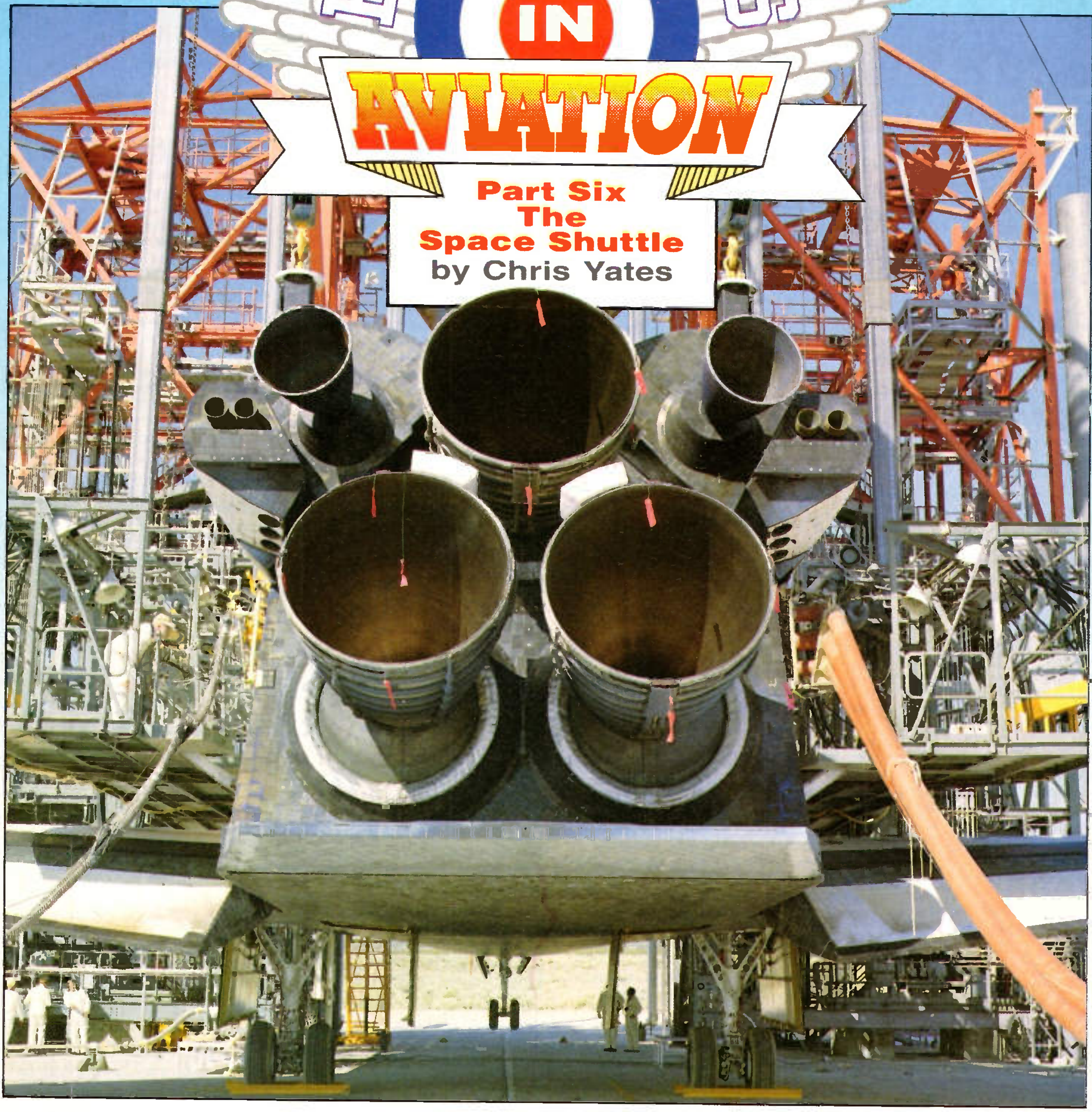
20 October/1 November. British International Motor Show, NEC, Birmingham. (081) 868 4466.

Please send details of events for the Diary Listings to The Diary Editor, 'Electronics'.

ELECTRONICS IN AVIATION

Part Six The Space Shuttle

by Chris Yates

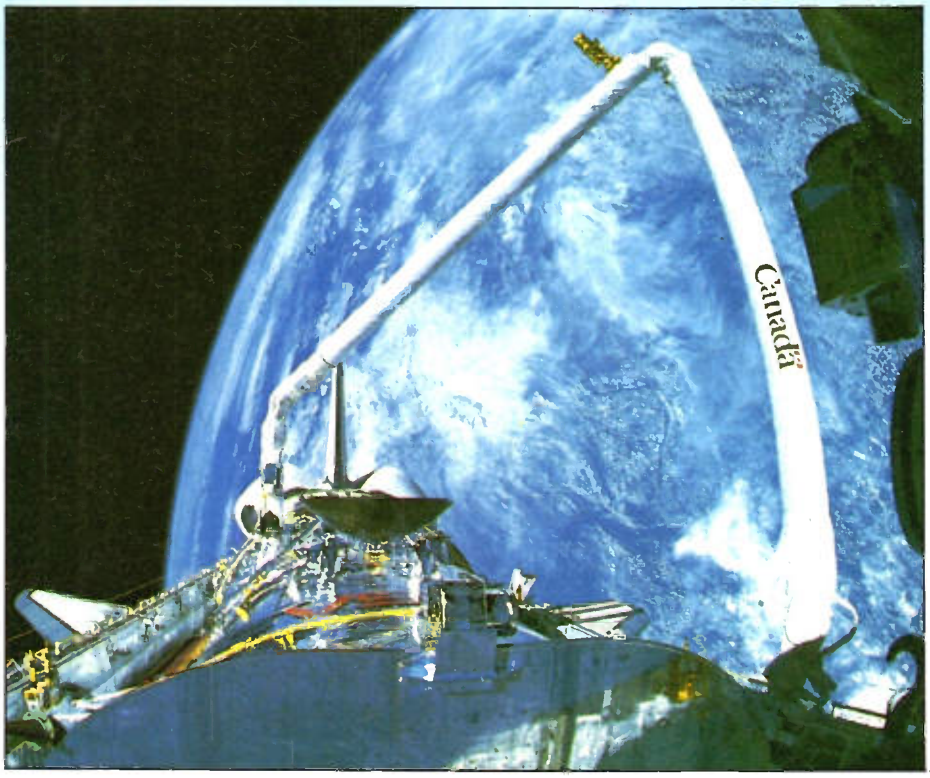


Whilst it is not strictly a part of this aviation story, the NASA Space Shuttle programme offers a unique insight into the future of manned powered flight. The five orbiters built for the programme represent the first generation of true aerospace vehicles – taking off like a rocket, manoeuvring around the Earth like a spaceship, but returning to the ground like an aeroplane. One of the five, Enterprise, was built for the purpose of in-atmosphere flight trials and is now a museum exhibit. Another, Challenger, was lost in a tragic accident on the 28th January 1986, while the remaining three maintain a hectic schedule of work for both the U.S. Department of Defense and civil contractors.

Whilst much of this work is inevitably cloaked in secrecy, space watchers are often treated to such spectacles as the deployment of the Hubble Telescope, the launch of the Magellan craft on its mission to map the surface of Venus, and the repair and refurbishment of satellites already in orbit. To date there have been around forty shuttle missions, and many of the experiments conducted aboard them have had one goal in mind – the launch and assembly of component parts for America's first permanently manned space station. In fact, it is widely recognised that the reusable orbiters were built with this very purpose in mind, and that launches will become commonplace in future years as they transfer crews to and from their place of work in space!

Left: Rear view of Columbia, showing her engines, just before being mated to a modified Boeing 747 for transport to the Johnson Space Center. This flight was necessary because the spacecraft landed in the West Coast, after its first successful mission in April 1981.
Right: John W. Young and Robert L. Crippen, Columbia's first crew, undergoing a Shuttle mission simulation at the Johnson Space Center, Florida.

Above: Columbia, seen here making its first landing after the successful STS–1 mission. This historic voyage took place between April 12th and April 14th 1981.



On the STS–2 mission in November 1981, the Canadian-built Robot Manipulator System (RMS) was used for the first time.

A Brief History

It was in May 1961 that President John F. Kennedy proudly announced that the United States of America would send a man to the moon and back by the of the decade. Those prophetic words set in motion an immense research and development programme that included the Mercury and Gemini orbital flights, and the construction of the giant Saturn V rockets – still the largest space vehicles flown to date.

This period of intense activity culminated eight years later with the immortal words; "This one small step for man, one giant leap for mankind" as Neil Armstrong and Edwin (Buzz) Aldrin became the first human beings to set foot on another heavenly body. That historic Apollo 11 mission was followed by six others that brought back a wealth of scientific data and physical artifacts from the Moon before the programme officially ended in 1972.

From 1973 to 1975 there were five further launches from the Kennedy Space Center – including the deployment of Skylab, and the Apollo/Soyuz mission – but it became increasingly evident that a more economical launch vehicle was needed if man was to continue in his exploration of space. Thus the Space Shuttle was developed, and on April 12th 1981 Columbia made history by completing a two day, 36-orbit 933,757 mile test flight before landing at Edwards Air Force Base in California.

The Shuttle

Of the three craft still flying, Columbia is the oldest. She measures 37m long, stands 17m high, has a wingspan of 24m – about that of a DC9 commercial jet – and can carry a crew of eight in addition to around 29,500kg of payload. Given those statistics, it is obvious that she cannot achieve orbit with her main engines alone. For that reason, Columbia is mated with twin booster rockets and an enormous external tank for lift-off. The orbiter's main engines start up first and build to full power before the solid rocket boosters ignite and lift-off occurs. At this point some seven million pounds of thrust is hurling the craft upward on its ascent to the heavens.

Around 160 miles later, after a burn of two minutes, the boosters are released to fall into the ocean, and Columbia continues to the edge of space with her main engines draining the attached fuel tank – before this too is discarded. At this point (around eight minutes after lift-off) the Orbital Manoeuvring engines take over, producing just enough thrust to place the craft into a low

Right: McDonnell Douglas engineer Charles D. Walker, shown here conducting one of many scientific missions designed to take advantage of the near-absence of gravitational fields. This experiment, known as CFES (Continuous Flow Electrophoresis Systems), took place on board the Shuttle in September 1984.

earth orbit. It is during this lift-off stage that Columbia's crew experience the greatest gravity load (around 3g, which is one third of the levels common on earlier manned flights).

Crew accommodation is in a split-level cabin at the forward end of the orbiter. Mid-deck is the living, eating and sleeping area for off-duty members; this contains bunks, a toilet, cooking facilities and other amenities. The upper deck is the hub of all on-board activities, with flight controls for Commander and Pilot, mission operations facilities and a control station overlooking the payload bay. From here, specialists operate the so-called Remote Manipulator System (RMS) – a 50-foot long arm that can be used to launch shuttle-borne satellites into orbit. The RMS was used to great effect during the STS–32 mission, which retrieved the Long Duration Exposure satellite. The arm successfully loaded this substantial piece of hardware (it weighed 21,400 pounds) into Columbia's payload bay for a return to Earth.

Spacelab

No longer do the United States of America have the monopoly in space, thanks to Spacelab – a fully-equipped facility designed for micro-gravity by the European Space Agency (ESA) which, ironically perhaps, is carried into orbit by the American shuttle. Spacelab is carried in the shuttle's payload bay, and is accessible through a hatch in the mid-deck aft bulkhead. It provides a 'shirt-sleeve' environment where scientific tests can be conducted within the high vacuum and micro-gravity of orbital space. Most of the experiments of any given mission encompass a single broad field, and include medicine, astronomy, space physics and pharmaceuticals.

Above left: The European Space Agency's Spacelab 1 science module in Columbia's cargo bay. The astronauts pictured are Owen Garriott (left) and German scientist Ulf Merbold.

Above right: Sally K. Ride, the first American woman in space, on board Challenger during the STS–7 mission, which took place in June 1983.

Payloads

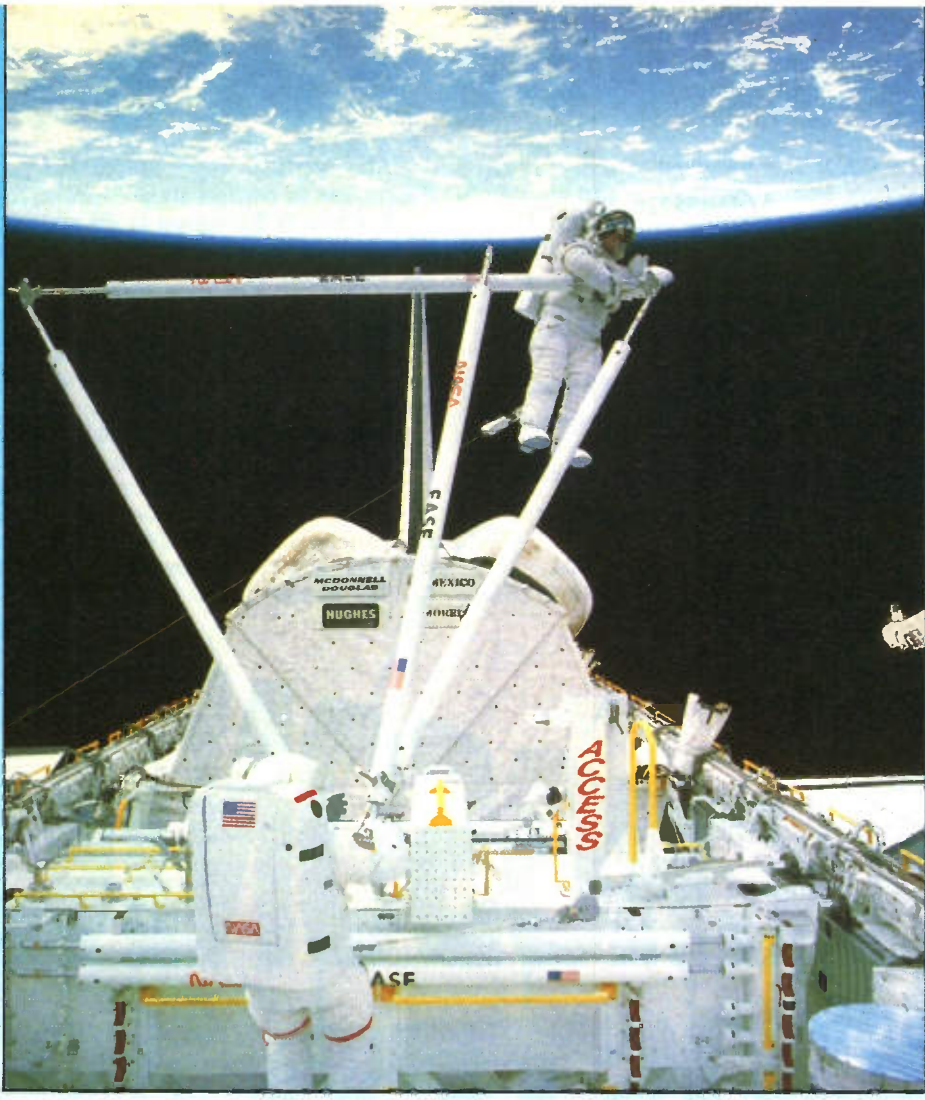
In these harsh economic times, it is a fact of life that shuttle launches must be financially viable. Although some missions have been given over to the U.S. Department of Defense, a much greater number are of a commercial nature. Many of these involve the deployment of telecommunications and DBS satellites. These satellites (or 'birds' as they are fondly referred to) are placed into a low elliptical orbit before attached rocket boosters inject them into a much higher geostationary flight path.

In much the same way, the shuttle makes an ideal platform for the launch of deep-space missions such as Galileo. This craft will be the first to fly-by Jupiter, and at the time of writing is half-way through its six-year journey to the planet. Shuttle missions have also launched a series of satellites known as TDRS. Three of these birds maintain a constant watch over low earth-orbiting satellites, and provide communications facilities for Columbia and her sister ships.

Space Station

Before their intended 100-launch lifespan is over, the three remaining shuttles will perform their most important task – the launch of component parts for America's first permanently manned Space Station. These will be assembled in orbit to create a living and working area of roughly the same size of a football field. In this environment, crews can stay for three to six months at a time.

This project, known as Freedom, is perhaps the most exciting development since the Apollo moon landings, and will give scientists of many disciplines the opportunity to conduct research in the extended weightlessness of space. Amongst other things, it could become a farm for that lifeblood of the electronic revolution – silicon crystal growth – with processing in space permitting a tion is not possible on a continuous



Left: Here, astronauts Jerry L. Ross and Sherwood C. Spring conduct an investigation into possible constructional techniques for the proposed Freedom space station. This experiment, taking place in December 1985, was known as the Experimental Assembly of Structures in Extra Vehicular Activity (EASE).

purity and uniformity far beyond that possible on Earth.

Once inhabited, the Space Station will be serviced by around six shuttle flights per year. It is expected that the ESA shuttle-type vehicle 'Hermes' will also transport crews to the facility. In addition, the possibility of visits by Russia's look-alike shuttle, 'Buran', are not ruled out.

The Future

Columbia, along with her sister ships Discovery and Atlantis, represent the future for space exploration. In ten years they have proved that launches need not be the preserve of expensive 'once only' vehicles like Saturn V, and have opened the access door to nations which would not normally have the financial reserve to explore space. The orbiters will reach the end of their life around the turn of the century, and are expected to be replaced by larger versions of the same basic design. Also on the cards is the NASA 'spaceplane', which will utilise advanced air-breathing engines (shades of the British HOTOL design?), and be capable of take-off and landings on conventional runways.

In the future, NASA have many exciting developments planned – including the first manned Martian landing, a vision of the current U.S. President, George Bush. However, it is clear that none of this would have been possible without Sir George Caley's research into powered flight, and the incredible advances attributed to such people as Edison, Marconi, Watt and others.

Shuttle Propellants

Whilst petroleum is still used as a rocket propellant, advances in cryogenic, hypergolic and solid-fuel technology will eventually lead to a withdrawal of this outmoded energy source.

Cryogenic propellants are liquid oxygen (LOX), which is used as an oxidising agent, and liquid hydrogen (LH2) – the fuel. Together, they create a more efficient burn than petroleum and are used to power the space shuttle's main engines. Through a process best described as 'electrolysis in reverse', they also produce the electrical power required on board the craft, and the water vapour by-product formed is used for washing/drinking, and so on.

Hypergolic propellants are fuels and oxidisers that ignite on contact with each other. However, the reaction is readily controllable, making such propellants attractive for use in both manned and unmanned spacecraft manoeuvring systems. Aboard the shuttle, the Orbital Manoeuvring System (OMS) fuel is monomethyl hydrazine (MMH), while the oxidising agent is nitrogen tetroxide (N204). This gives the craft considerable cross-range capability.

Lift-assist boosters burn a solid fuel which consists of aluminium powder, ammonium perchlorate, iron oxidiser powder and polybutadiene acrylic acid acrylonitrile. Those used on shuttle launches are the largest solid rocket motors ever built; each contains 1·1 million pounds of propellant – which is burned up in just two minutes!

Communication

Whilst space shuttle launches are a fascinating spectacle in themselves, the fascination is enhanced further with the ability to monitor mission communications from lift-off to landing. This can be accomplished without the need to resort to a vast array of expensive receiving equipment – in fact all that is needed is a single sideband (SSB) HF (shortwave) radio, and a long-wire antenna. With such an arrangement it would be possible to 'tune in' to the NASA relay station based at Ascension Island, which re-broadcasts two-way shuttle communications traffic, and various briefings throughout non-military missions.

In addition, the Goddard Space Center's amateur radio station WA3NAN provides a similar service on spot frequencies within the HF 'ham' bands, and are easily received in the United Kingdom. However, the greatest satisfaction (by far) for hardened space-watchers is derived from receiving the orbiter direct – a possibility that has been brought to the general public through the wide availability of scanners. Whilst vital radio traffic is normally handled by the three TDRS satellites, UHF communications are maintained throughout and can be heard should the orbiter be passing over your part of the world.

The minimum requirement for direct reception is an AM receiver that can be tuned to the VHF/UHF military allocation, and a crossed dipole aerial cut to the shuttle's operating frequencies. Having said this, however, the author did receive conversations from a recent mission with a vertical dipole cut to an airband wavelength, showing that anything is possible! An ideal receiver for direct shuttle radio communications is the Yupiteru MVT6000 (available from Waters & Stanton through Maplin). This rig offers excellent sensitivity throughout the VHF/UHF allocations and represents the best that money can buy. It should be stressed that direct recep-

Continued on page 15.

THE MICROSONIC AUDIO BOOSTER

by Chris Barlow

There are several commercially made hearing boosters currently available, trading under some impressive sounding names. The majority use circuit designs that are not so impressive, being only simple headphone amplifiers.

Because of this the volume control has to be constantly adjusted to suit the audio environment. A quiet sound will require a high volume setting, while a loud noise could produce a potentially dangerous sound level from the headphones.

The design presented here has a distinct advantage in that it incorporates a Voice Operated Gain Adjusting Device (VOGAD). It is designed to accept small signals from a microphone and provide an essentially constant output signal from an input covering a range of 50dB. In real terms this means that, once set to a comfortable listening level, the volume control seldom requires re-adjusting.

Circuit Description

A circuit diagram detailing the complete unit is shown in Figure 1, which can be broken down into three smaller circuits:

1. VOGAD microphone preamplifier TR1 and IC1.
2. Headphone power amplifier IC2.
3. Battery low indicator TR2, TR3 and TR4.

The VOGAD input stage, IC1, a SL6270, has its positive supply applied to pin 3, which is decoupled to 0V ground by C7 and C8 removing any supply noise. Pin 6 is used as the common ground return for all the elements within the device.

The SL6270 is provided with a low impedance differential input, best suited for the connection of a dynamic microphone insert between pins 4 and 5. A low noise transistor, TR1, is used to provide a suitable input for an electret microphone insert, MC1, which is connected to the PCB terminals P1 and P2. The DC bias for both MC1 and TR1 is provided by R1 and R2. TR1 is used as an emitter follower,

FEATURES

- ★ Audio AGC system (VOGAD)
- ★ Fast attack
- ★ Battery state indicator
- ★ Minimal wiring

supplying, via R4 and C2, the low impedance signal source required by the single-ended input (pin 4) of IC1.

Signals of less than a few hundred microvolts are amplified normally, but, as the input level increases, the VOGAD begins to take effect and holds the output signal on pin 8 constant at approximately 90mV rms over a range of 50dB. In order to ensure that internal DC offsets within IC1 are of such polarity as to inhibit oscillation at the onset of limiting, a 22k resistor, R5, is connected from pin 5 to ground. The attack and decay characteristics of the VOGAD are set by the RC timing components R6 and C3 on pin 1 of IC1.

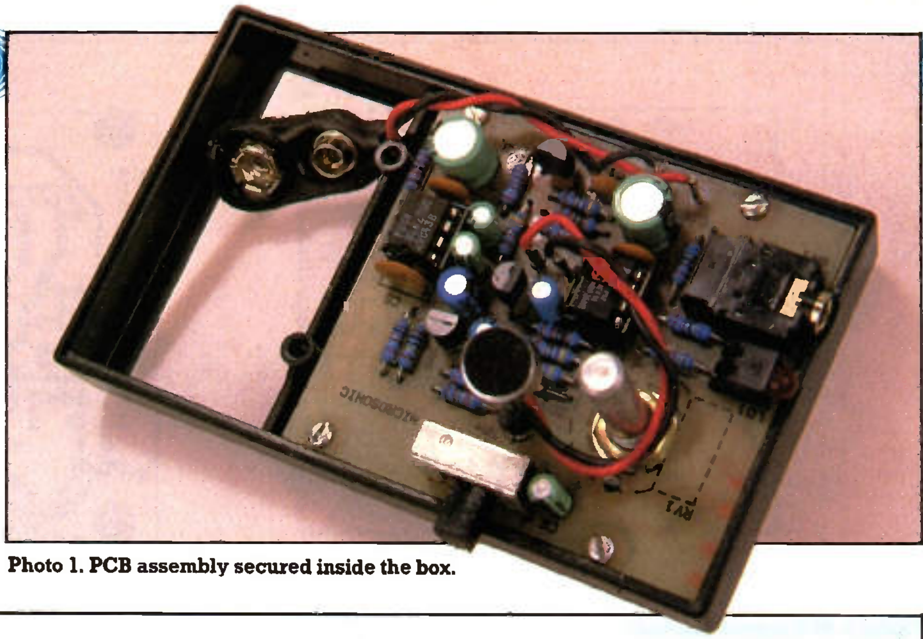


Photo 1. PCB assembly secured inside the box.

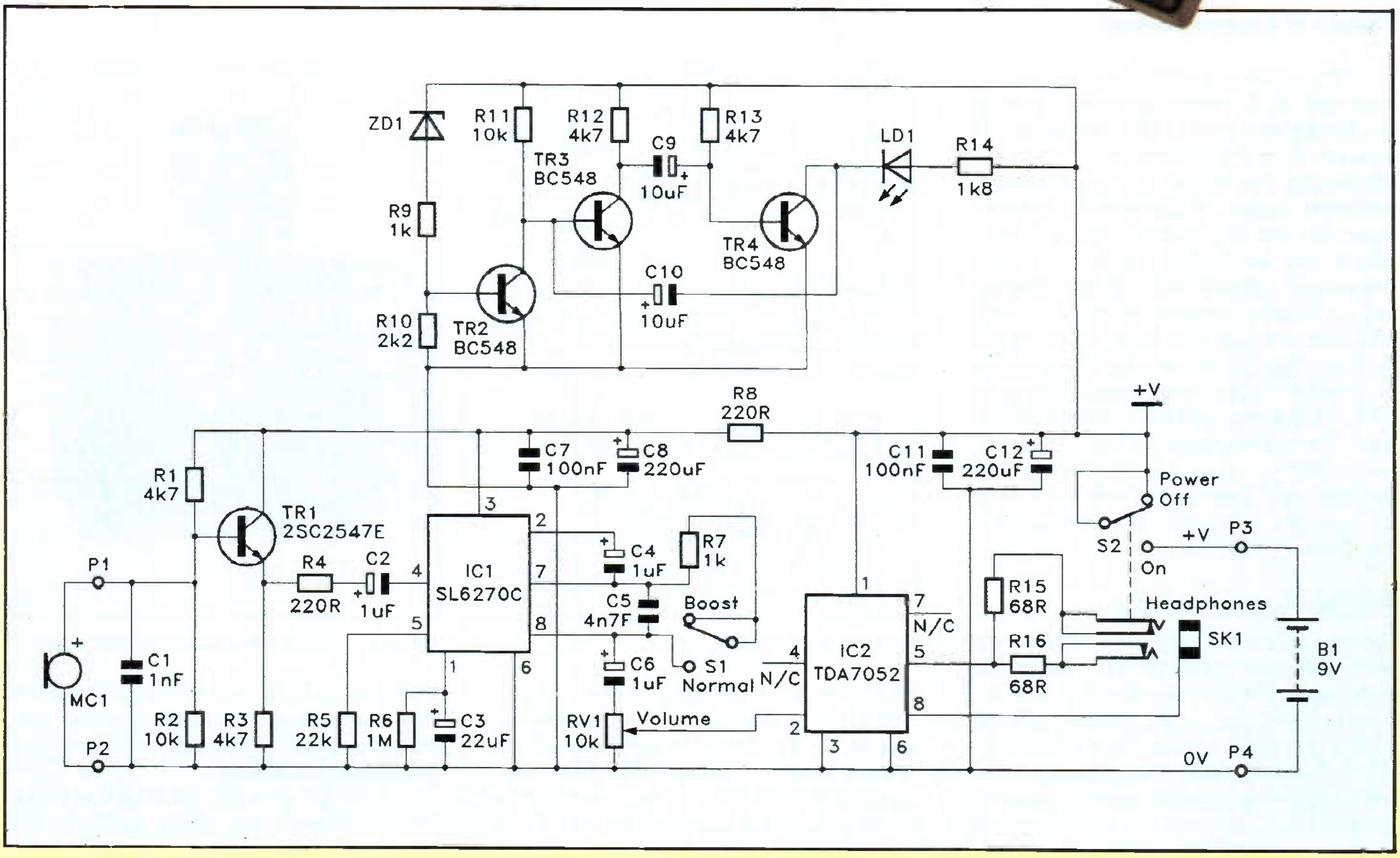


Figure 1. Circuit diagram.

The output from the VOGAD preamp stage (IC1 pin 2) is coupled via capacitor C4 to the input of the main VOGAD amplifier (pin 7). The low frequency (LF) response of the system is determined by the value of this capacitor and the internal 680Ω resistor on pin 2. High frequency (HF) response is restricted by C5 placed between the input and output connections (pin 7 and pin 8) of the main VOGAD amplifier. The combined LF and HF response has been tailored to favour the human speech frequencies from 300Hz to 3kHz. An internal 10kΩ resistor sets the overall voltage gain, but this can be further reduced by approximately 20dB if R7 is switched in by S1. The final processed audio signal from pin 8 is fed via C6 to the top end of the volume control RV1.

The headphone amplifier, IC2, a TDA7052, requires very little in the way of external components and uses the bridge tied load principle allowing a relatively high power output over a wide DC supply range, which is applied to pin 1. This is decoupled to 0V ground by C10 and C11 removing both high and low frequency noise from the supply rail. The TDA7052 has two separate ground returns, pin 3 signal and pin 6 substrate ground. Its signal input on pin 2 is connected to the wiper of the volume control RV1 and the amplified product appears between the output pins 5 and 8. Before connection is made to the headphones via SK1, two low value resistors, R15 and R16, are placed in series with the output. This restricts the maximum power output to a pair of 32Ω stereo headphones to approximately 200mW rms.

Specification of Prototype

Power Supply Voltage:	+4·5 to +9V
Power Supply Current:	100mA(+9V Supply, Max Volume)
Low Battery Indicator:	+6V Threshold
Microphone:	Electret
Preamp Gain:	52dB
Output Impedance:	16Ω (minimum)
Output Power:	200mW
Frequency Bandwidth:	300Hz to 3kHz (−3dB)

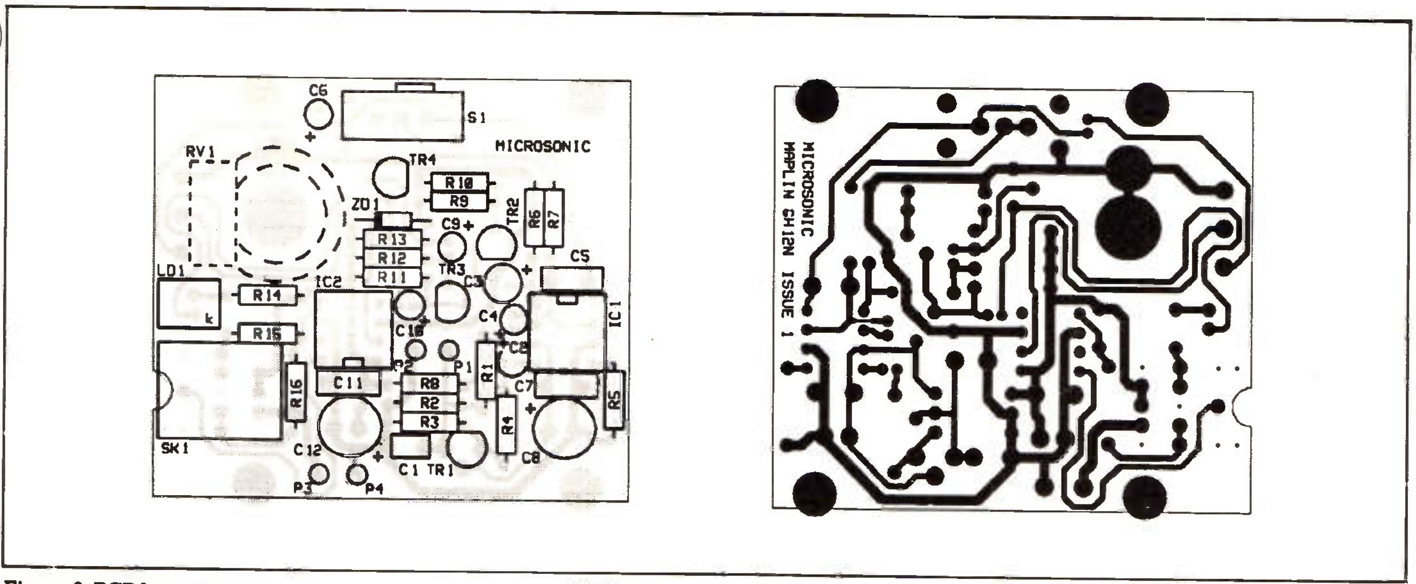


Figure 2. PCB legend and track

The battery supply for the unit is switched by S2 which is actually part of the headphone socket SK1, and is turned on each time the phones are plugged in. Monitoring this voltage is the low battery indicator circuit. It consists of a basic transistor flip-flop switch TR3 and TR4, which can be locked up by a voltage dependent switch TR2. If the battery supply voltage is greater than 6V, current will flow through the 5·6V zener diode ZD1 causing TR2 to conduct. This locks up the flip-flop and permanently turns on TR4, causing the red LED indicator LD1 to light. When the supply voltage falls to just below 6V, TR2 turns off and the flip-flop will free run. This results in LD1 flashing on and off, indicating the low battery condition.

PCB Assembly

All the information required to help you with soldering and general assembly techniques, should you need it, can be found in the Constructors' Guide included in the kit (also separately available as stock code XH79L). The printed circuit board (PCB) is a single-sided glassfibre type, chosen for maximum reliability and mechanical stability. Removal of an incorrectly-fitted component can be fairly difficult without damaging it or the PCB, so please double-check each component type, value and polarity (where appropriate), before soldering! The PCB has a legend to assist you in correctly positioning each item, see Figure 2.

It is usually easier to start with the smaller components, such as the resistors. Next, mount the ceramic and electrolytic capacitors, ensuring that the negative symbol on the electrolytics are located opposite to the positive signs on the PCB. The zener diode ZD1 has a band at one end; be sure to position it according to the legend. When installing the transistors, make certain that each case matches its outline. This also applies to the ICs and their sockets, where you must match the pin 1 notch indicator with the block outline on the legend.

When installing the volume control RV1 you should follow the mechanical assembly information provided in Figure 3. When secured, bend down the tags so

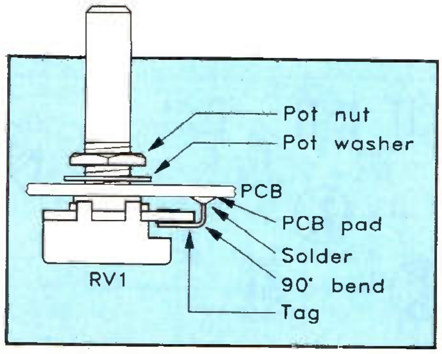


Figure 3. Mounting RV1.

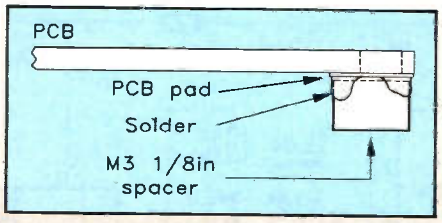


Figure 4. Fitting the spacers.

that they are touching the pads on the track side of the PCB and solder them as shown. To fix the PCB assembly at the correct height inside the box, four spacers are soldered to the board at the fixing points as shown in Figure 4. When

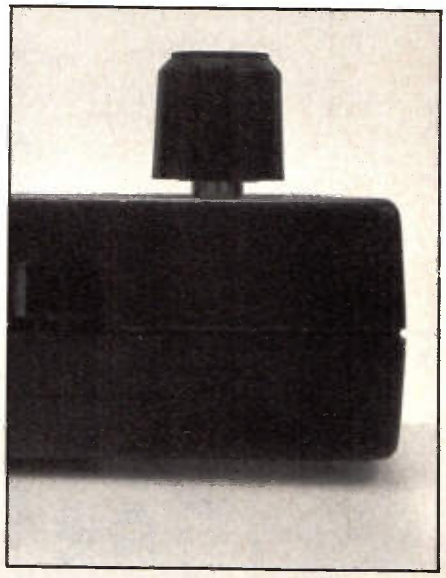


Photo 2. Correct mounting height for knob.

fitting the PCB mounted switch S1, socket SK1 and indicator LD1 make certain that they are pushed down firmly onto the surface of the board.

Finally, fit the four PCB pins at P1 to P4, then check that all the solder joints

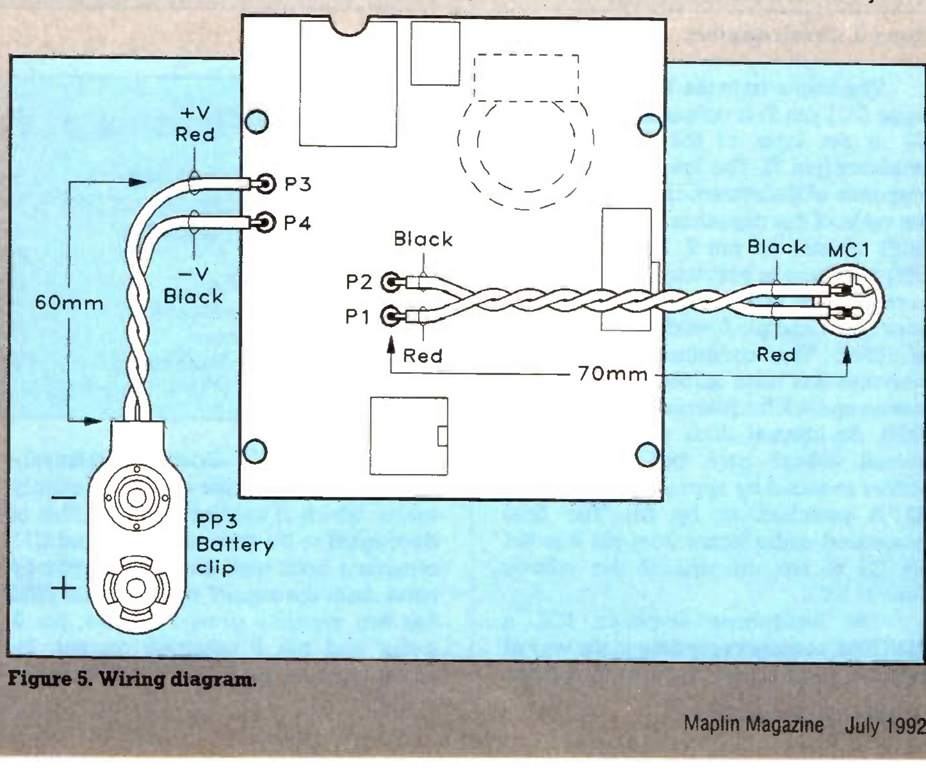


Figure 5. Wiring diagram.

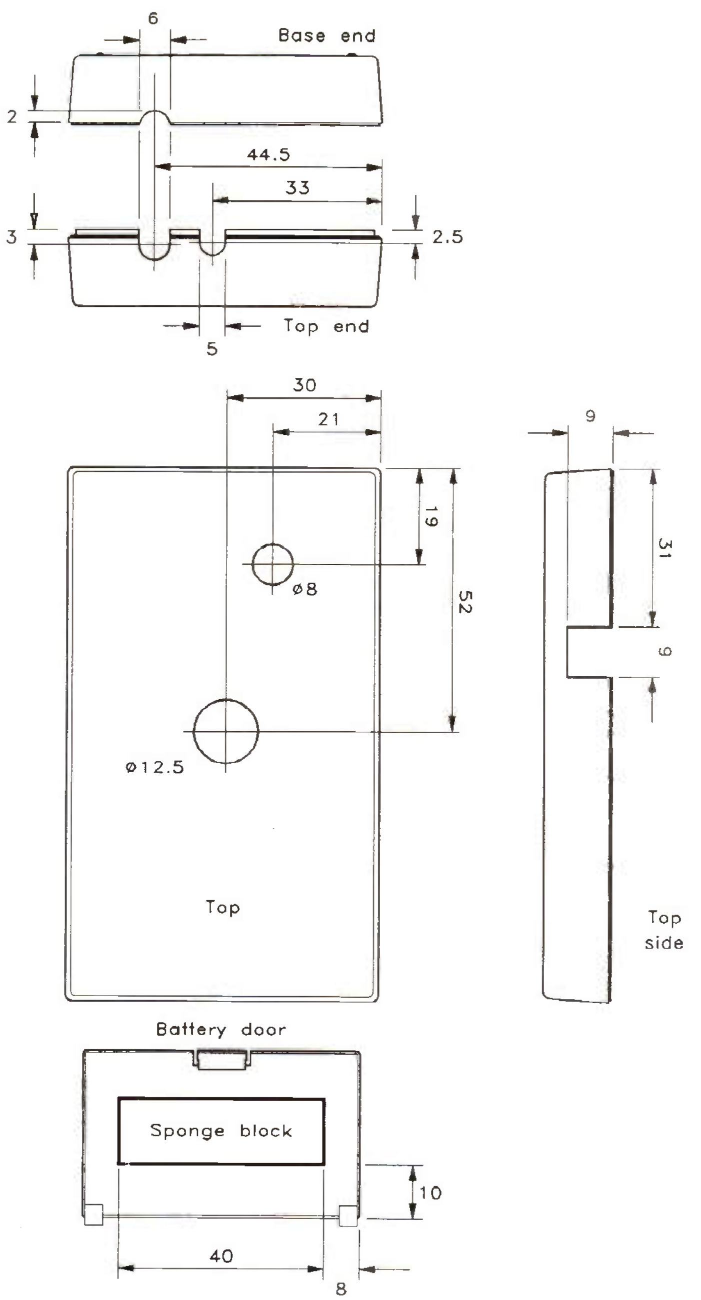


Figure 6. Box drilling.

round a reading greater than 400Ω should be obtained.

Next set your meter to read DC mA and place it in series with the positive supply terminal. When the battery is connected the red LED LD1 should light and you should observe a current reading of approximately 21mA. As the volume control RV1 is advanced the average current should increase to approximately 120mA on loud sounds, especially feedback.

If you have access to a variable voltage DC power supply you can test the voltage threshold point at which the low battery indicator LD1 begins to flash. This should be at, or just below the 6V supply level, which relates to a 9V PP3 battery rapidly approaching the end of its useful

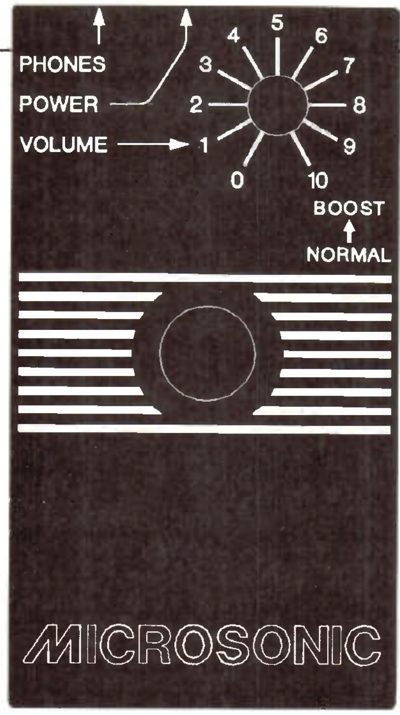


Figure 7. Front panel.

are sound. It is also very important that the solder side of the circuit board does not have any trimmed component leads standing proud by more than 3mm, as this may result in a short circuit.

Wiring

The total amount of wiring has been kept to a minimum by using PCB mounted switches and connectors wherever possible, leaving only two off-board components. Included in the kit is a PP3 type battery clip, equipped with approximately 130mm of red and black wire. These are first twisted together then cut to size in order to connect the electret microphone insert MC1 to the PCB pins P1 and P2, see Figure 5. As the two solder pads on the microphone are very similar you should double-check the wiring polarity. The black wire from P2 should connect to the pad which is bonded to the *metal body* of the insert. The battery clip, *with 60mm of cable remaining,* is then soldered to the power input pins P3 (positive Red) and P4 (negative Black).

Testing

Testing can be made with a minimum of equipment. You will require a multimeter, a 9V PP3 battery and a suitable pair of 32Ω stereo headphones. The readings were taken from the prototype using a digital multimeter, some of the readings you obtain may vary slightly depending upon the type of meter employed. Before you connect the battery and commence testing the unit, set the volume control RV1 to its fully-anticlockwise position. Next turn the unit on by plugging the headphones into SK1, then set the slide switch S1 to the 'normal' position (away from C6).

The first test is to ensure that there are no short circuits on the power rail before you install the 9V PP3 battery. Set your meter to read kΩ on its 2kΩ resistance range (or similar), and connect the test probes to the terminals on the battery clip. With the probes either way

life. This completes the testing of the Microsonic, now disconnect both the battery and multimeter from the unit.

Final Assembly

The PCB is designed to fit into a plain hand-held box type HH1, with the two halves drilled and cut as shown in Figure 6. When preparing the box, the self-adhesive front panel can be used as a guide for checking the positioning of the holes, a representation of this panel is shown in Figure 7. Having completed the drilling, at the same time clearing away any plastic swarf, apply the stick-on panel by removing its protective backing. Carefully position and firmly push it down using a dry, clean cloth until it is securely in place.

Included with the box is a small packet of self-tapping screws, four short and two long. The longer screws are used to hold together the two halves of the box. Unfortunately the short screws are not suitable for fixing the PCB assembly, so must be discarded and substituted for the four slightly longer screws included in the kit. Now carefully position and secure the PCB inside the box base, see Photo 1. The microphone insert MC1 is held in position on the top half of the box by using a rubber grommet as shown in Figure 8.

Using the two long screws, carefully fit and secure the two halves of the box. Next attach the volume control knob to the shaft of RV1, see Photo 2. Finally, cut the sponge block to approximately 40mm and glue it to the inside of the battery compartment door, see Figure 6. Allow the glue to set before installing the battery and refitting the door.

Using the Microsonic

The Microsonic is designed to operate from a nine volt battery power source. However, there is a wide range of PP3 type batteries and there quality is usually related to the initial cost. A relatively inexpensive zinc carbon battery (stock code FK58N or JY60Q) will provide sufficient power to operate the Microsonic over a reasonable time period, but this can be greatly extended if the more expensive alkaline type (stock code FK67X or JY49D) is used. Although initially more expensive than ordinary batteries, a re-chargeable PP3 and its associated charger unit (stock code HW31J and WY22Y) will eventually work out extremely cost effective as it may be recharged up to 500 times.

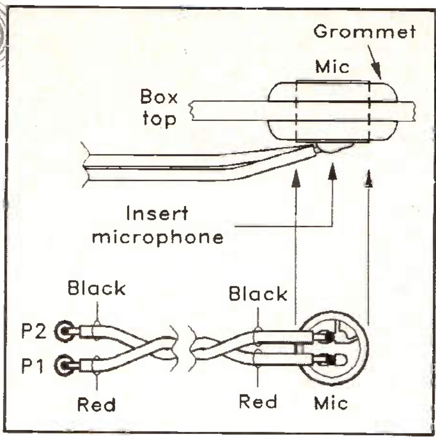


Figure 8. Mounting microphone MC1.

When powered up (headphones connected) the voltage condition of the battery is continuously monitored and displayed by a red LED indicator. If the battery charge is above six volts then the indicator will remain lit, but as this falls to just below this level the indicator should begin to flash. At this point the Microsonic will still work but at a slightly reduced performance and changing the battery is strongly recommended.

The headphones are an important part of the system as they will ultimately define the overall sound quality. Over the past few years headphone design has tended to go away from the heavy and bulky 8Ω units terminated with a standard jack plug, to light-weight and slimline 32Ω units fitted with a 3·5mm jack. This design trend is accommodated by the Microsonic, which will accept the majority of present-day stereo headphones. In any highly sensitive sound amplification system it is most important the headphone output is not excessively detected by the microphone. If this should occur a condition known as 'howl round' or 'feedback' will produce a shrill whistling sound, which will swamp out all other sounds. The exact point at which this happens will depend upon several factors, volume setting, normal/boost switch position, and distance between headphone and microphone. In an ideal world headphones would direct all their sound output into the ear and none would escape from the earpads or enclosures. However, in reality this is not the case and differing designs will result in varying amounts of sound leakage.

The gain or sensitivity of the system can be greatly increased according to the setting of the normal/boost switch. In the normal position the VOGAD chip is just ticking over, maintaining most of the dynamic range of the detected sounds. However, when in the boost mode the dynamic range is greatly compressed making everything sound loud at the same volume. CAUTION; depending upon the type of headphones used this can significantly affect the feedback point of the volume control.

MICROSONIC PREAMP PARTS LIST

RESISTORS: All 0·6W 1% Metal Film (Unless specified)			
R1,3,12	4k7	3	(M4K7)
R2,11	10k	2	(M10K)
R4,8	220Ω	2	(M220R)
R5	22k	1	(M22K)
R6	1M	1	(M1M)
R7,9	1k	2	(M1K)
R10	2k2	1	(M2K2)
R13	47k	1	(M47K)
R14	1k8	1	(M1K8)
R15,16	68k	2	(M68K)
RV1	Min Pot Log 10k	1	(JM77J)
CAPACITORS			
C1	1nF Ceramic	1	(WX68Y)
C2,4,6	1μF 63V Minelect	3	(YY31J)
C3	22μF 16V Minelect	1	(YY36P)
C5	4n7F Ceramic	1	(WX76H)
C7,11	100nF 16V Minidisc	2	(YR75S)
C8,12	220μF 10V Minelect	2	(JL06G)
C9,10	10μF 16V Minelect	2	(YY34M)
SEMICONDUCTORS			
ZD1	BZY88C5V6/BZX55C5V6	1	(QH08J)
LD1	PCB LED Red	1	(QY86T)
TR1	2SC2547E	1	(QY11M)
TR2,3,4	BC548	3	(QB73Q)
IC1	SL6270	1	(UM73Q)
IC2	TDA7052	1	(UK79L)
MISCELLANEOUS			
S1	R/A SPDT Slide	1	(FV01B)
S2	Part of SK1		
SK1	PCB 3·5mm Stereo SPCO Skt	1	(JM22Y)
MC1	Submin Omni Insert	1	(FS43W)
	DIL Socket 8-pin	2	(BL17T)
	Pin 2145	1 Pkt	(FL24B)
	PP3 Clip	1	(HF28F)
	15mm Collet ¼in. Knob	1	(JZ47B)
	15mm Cap Black	1	(JZ76H)
	Plain HH1 Box	1	(ZB17T)
	Geiger Sponge Block	1	(FS04E)
	Std Grommet 9·5mm	1	(JX63T)
	Self-Tap No.2 × ⅜in.	1 Pkt	(LR68Y)
	M3 Spacer ⅛in.	1 Pkt	(FG32K)
	PCB	1	(GH12N)
	Front Panel	1	(KP47B)
	Instruction Leaflet	1	(XT46A)
	Constructors' Guide	1	(XH79L)
OPTIONAL			
	Alkaline PP3	1	(FK67X)
	Mini Phones	1	(ZB91Y)

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 LP52G (Microsonic Preamp) Price £14.95.

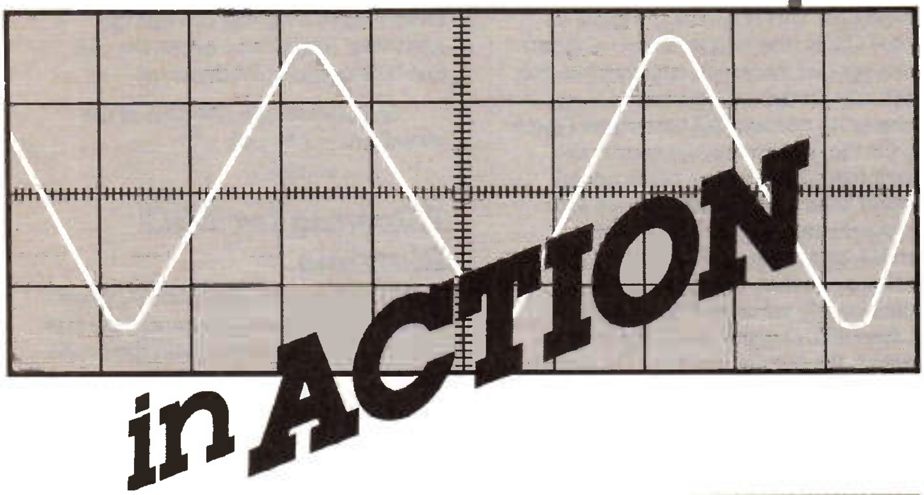
Please Note: where 'package' quantities are stated in the Parts List (e.g. packet, strip, reel etc.) the exact quantity required to build the project will be supplied in the kit.

The following new items (which are included in the kit) are also available separately, but are not shown in the 1992 Maplin Catalogue.

(PCB) **Order As GH12N Price £2.45.**

(Front Panel) **Order As KP47B Price £1.20.**

The Oscilloscope in ACTION



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

Measurement of the amplitude of a signal, which was the subject of Part 2 of this series, involved the conversion of a distance measured on the Y axis of the scope screen into a voltage by reference to the selected Y amplifier gain. Measurements of time are made in essentially the same manner. However, the distances will now be taken in the X direction and the conversion performed by reference to the timebase setting. Measurement of time may be performed for various reasons. If the periodic time of, say, a sinewave is measured, the frequency can be obtained by a simple calculation. The time displacement between two waves of the same frequency can be made to yield information about their phase difference. Pulse lengths, as well as their rise and fall times, can also be measured. Measurements of this type and others will be the subject of this article.

Measurement of Time

Figure 1(a) shows a sinewave signal displayed on a CRO; the Y gain and the timebase (X) controls have been adjusted to give a display of reasonable amplitude, and of just a few cycles. The triggering has also been set so as to obtain a stable display. This may seem like stating the obvious, but it is this author's experience that students (including, presumably, quite a few amateur hobbyists) often neglect to pay enough attention to proper triggering. I am not getting at scope-using 'Electronics' readers personally when I say this, but as mentioned in Part 1 it does pay to make time to learn how to 'drive' a scope properly.

Anyway, we wish now to measure the periodic time of this waveform. This is the time between any point on the waveform and the corresponding point on the next cycle of the same wave. To measure the periodic time as accurately as possible means using the major X axis, since this has the most calibration marks. The Y shift control is used to balance the waveform around the major X axis; then the X shift control is used to make one vertical part, say a negative going slope where it crosses the major X axis, coincide with a main calibration mark. This is shown in Figure 1 (b).

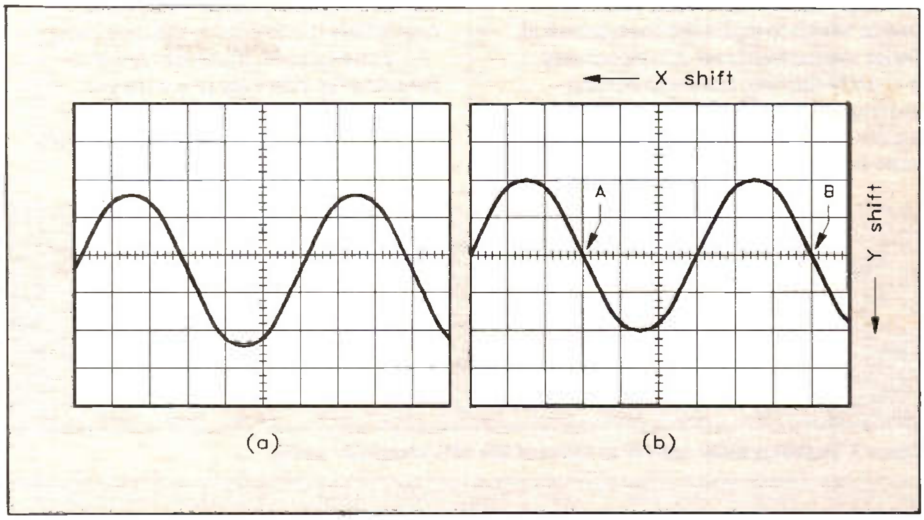


Figure 1(a), sinewave displayed on CRO screen; (b), the same waveform shifted to measure periodic time.

Using the calibrations on the X axis, the distance is now measured to the next negative going slope; these points are identified in this Figure as A and B. In this case, the distance is found to be 4·8 divisions. The setting of the timebase control is now noted and is found to be, say, 1ms/div. The periodic time of the wave is obtained by multiplying the distance measured by the timebase setting.

In this case, the result
= 4·8 divisions × 1ms/div.,
= 4·8ms.

A word of caution here: some CROs have an 'X expansion' facility, which allows the user to 'stretch' a waveform in the time axis in order to examine some portion of it more closely. If this is continuously variable, *then it will not be calibrated and any attempt to measure time in the manner described will produce errors if it is in use.* However, the control will have a CAL (for calibrated) position and, if the control is set to this position before attempting to measure time, then errors from this source will be avoided. On other CROs the X expansion may be switched: × 5 or × 10, perhaps. In this case, time can still be measured accurately by taking this known expansion factor into account. For example: Suppose we had made the same measurement as above, but the X expansion had actually been set to × 5. If we had ignored the latter fact we should have accepted the figure of 4·8ms as the right answer. But by noting the setting of the X expansion control, we realise that we must divide the value of 4·8ms by 5, giving us a figure of 0·96ms instead.

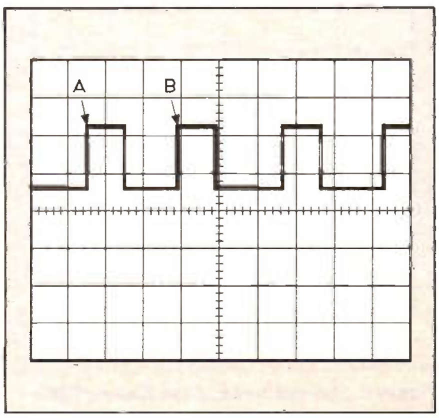


Figure 2. The PRF (Pulse Repetition Frequency) of a pulse train.

Measurement of Frequency

The CRO does not measure frequency directly; the only instrument that can do that, of course, is the frequency counter. However, by taking the effort to perform a very simple calculation (easy in these days of electronic calculators), the periodic time measurement just made can be converted to yield the frequency of the sinewave. The relation is that:

Frequency = 1 / Periodic time

In this case, periodic time = 4·8ms (assuming that the original figure was actually the correct one), so that:

Frequency = $1 / (4{\cdot}8 \times 10^{-3})$
= 208·33 Hz.

Measurements of Pulses and Square-Waves

One may measure the PRF (Pulse Repetition Frequency) of a train of pulses in the same way as for sinewaves. The PRF is simply the time taken between identical points on two consecutive pulses (Figure 2). In this Figure, points A and B are the leading edges of the two pulses and, with the nice square pulses shown, are easily defined points. However, practical pulses often do not have such well defined shapes. In fact, to be straight about it, *all* pulses have exponential leading and trailing edges; it is just a question of scale, since whether this fact is evident or not depends upon the duration of such exponentials compared with the time period of the pulse itself. In such cases, only by expanding in X considerably (choosing a very fast timebase speed) can such exponentials be studied.

What this does raise is the matter of how we can measure the length of a pulse, given such nebulous points in time at which to make the measurement. Under such conditions, it is necessary to specify the time between certain amplitudes which we can measure, usually given as a percentage of the full pulse height. One way of doing this would be to measure the time between the 50% full amplitude points on both edges. Thus, in Figure 3, the pulse length is measured between points A and B.

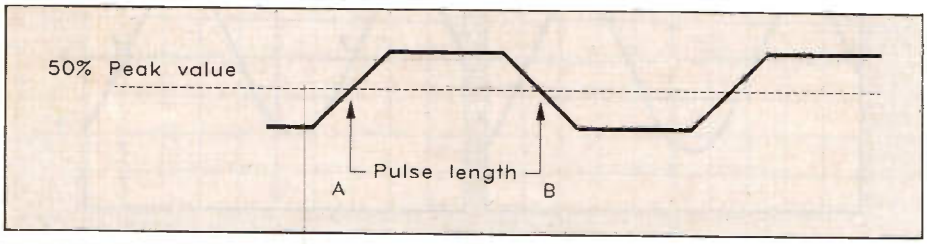


Figure 3. Defining 'pulse length' in terms of the 50% amplitude points.

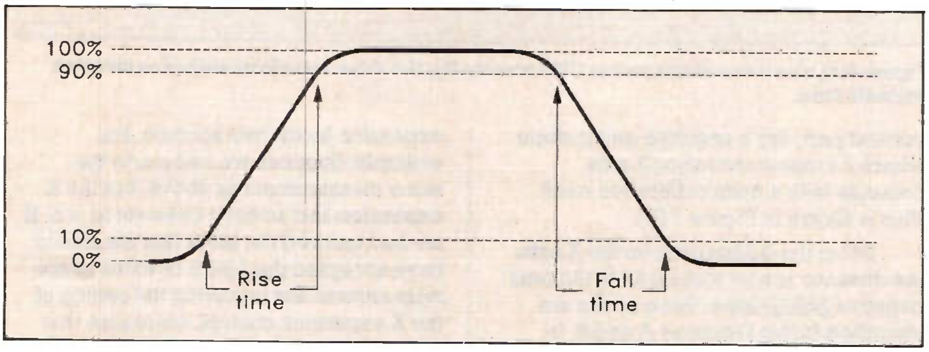


Figure 4. Defining the rise and fall times of pulses.

Measurement of Rise and Fall Times of Pulses

It was mentioned above that the exponentials may or may not occupy a significant proportion of the time duration of the pulse. In order to compare these times, it is usual to specify the 'rise' and 'fall' (or decay) times for the pulse. Often these times may be important in their own right anyway. There are applications – the clock pulse in microprocessor systems is an example – in which the rise time is critical. The way in which these times are defined is as follows.

They are both defined in essentially the same way. The time is taken between those instants at which the pulse height is equal to 10% and 90%, respectively, of full amplitude. This is shown in Figure 4. Some CROs (the Hameg is one of them) have special markings engraved on the graticule for the specific purpose of measuring rise and fall times (see Figure 5). On the instrument mentioned, the markings take the form of horizontal, dotted lines placed 2·5cm above and below the major X axis. To use this facility, an appropriate Y gain setting is chosen so that, together with the continuously variable Y-gain control of this CRO, plus the use of the Y-shift control, the full amplitude of the signal is contained exactly between the two dotted lines mentioned. The normal lines at 2cm above and below the X axis then intercept the slope of the wave (whether leading or trailing edge) at the 10% and 90% points. The rise (or fall) time is then obtained simply by projecting these points down onto the X axis, reading off the distance between them and converting it into time in the usual way.

For example, if we are trying to measure the rise time of a very fast waveform, we shall need to select a very high timebase speed. Suppose we select 0·5μs/div. and we also select an X expansion of × 10. This makes the X scaling equivalent to 0·5/10 microseconds per division, which is the same as 50 nanoseconds per division (50ns/div). From Figure 5 we can see that the horizontal distance between the 10% and 90% points is 1·6 divisions.

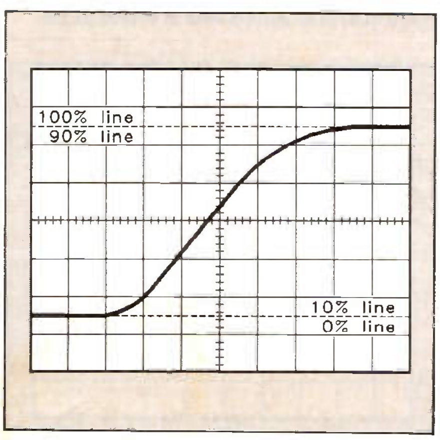


Figure 5. The graticule of the Hameg CRO showing the position of the additional engraved lines for measuring pulse rise and fall times.

In this case, the rise time of the waveform = 1·6 × 50,

= 80ns.

Allowing for CRO Risetime

In making measurements on very fast pulses we must take account of the fact that the CRO Y amplifier and the probe will have a risetime of their own, which will appear as part of the *total* rise time of the pulse being examined. This is optimistic, because it means that the rise time of the pulse is actually somewhat better than that calculated. If the rise times of the Y amplifier and probe are known, it is an easy matter to correct the result to take them into account. The formula that allows us to do this is as follows:

$$t_r = \sqrt{t_{tot}^2 - t_{osc}^2 - t_p^2}$$

With the values quoted for the Hameg of t_{osc} = 17·5ns and t_p = 2ns, the actual rise time of the waveform would be given by:

$$t_r = \sqrt{80^2 - 17{\cdot}5^2 - 2^2},$$

$$= 78{\cdot}04\text{ns}.$$

Measurement of Phase Angle

The dual trace facility allows the comparison of two waveforms that are usually related in some way. For example, they may be the input and output of a network or an amplifier. Measurement of the two amplitudes allows the voltage gain to be calculated. This is a comparison in magnitude (Y). It is also possible to make a time-based comparison, which may be of value since signals transmitted either through passive networks or through active circuits may experience a change of phase angle as well as a change of amplitude. Indeed the two invariably go hand in hand, especially at extremes of frequency.

Figure 6 shows (a) two waveforms of the same frequency, but with a phase shift between them. In the same Figure, diagram (b) shows the same two waveforms after shifting them vertically so as to align them on the same axes. This makes the phase displacement evident and also makes it easier to measure this angular displacement. To make this measurement we now need to shift both waveforms so as to align their slopes with an X axis, as in Figure 6 (c). We can now measure the horizontal distance between a vertical part of one waveform and that of the same part of the other. This will be expressed in divisions as usual at the moment. We must next convert it into an angle.

To make this measurement as accurate as possible the timebase setting should be selected so that the display is something like that of Figure 7. Only a

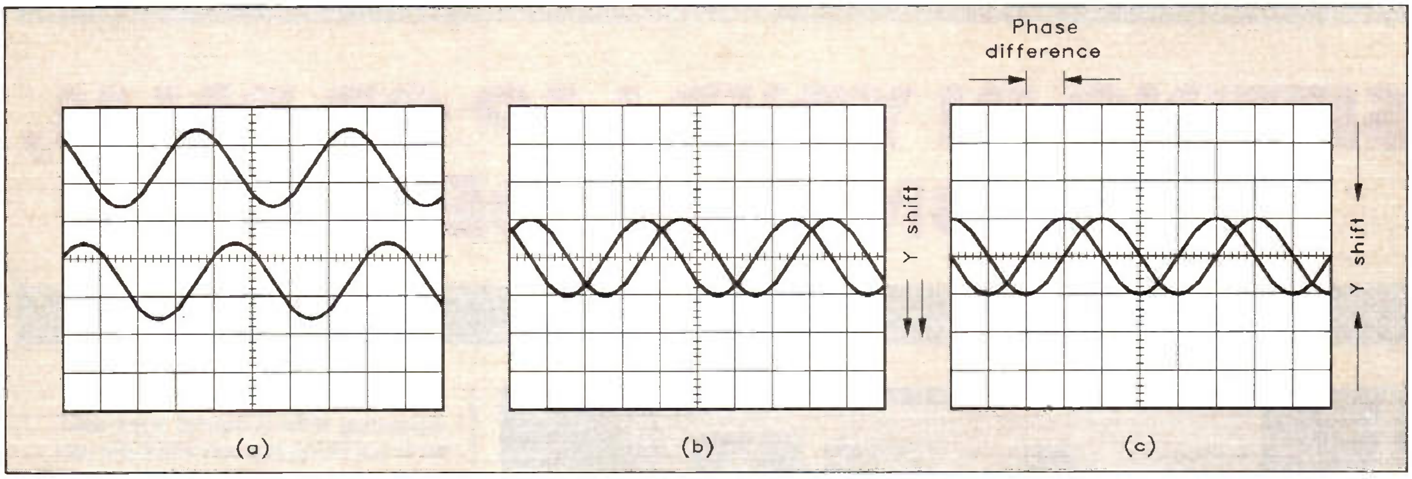


Figure 6. Two waveforms compared in phase; (a), normal display; (b), displayed overlapping and (c), aligned vertically to measure phase angle.

little over one cycle of the two waves is shown. Using the calibrated X axis, the length of a complete cycle should be measured; this will be 'so many divisions'; in Figure 7 it is exactly six divisions. It is convenient if this figure is an exact number like this. The chances are that it won't be unless the X expansion is continuously variable, in which case the cycle length can be stretched to fit the required figure. The calibrations are of no relevance in this measurement as we are about to make our own!

Since one complete cycle = 6 divisions and there are 360 degrees in one cycle, then:

1 division = 360/6,
= 60 degrees.

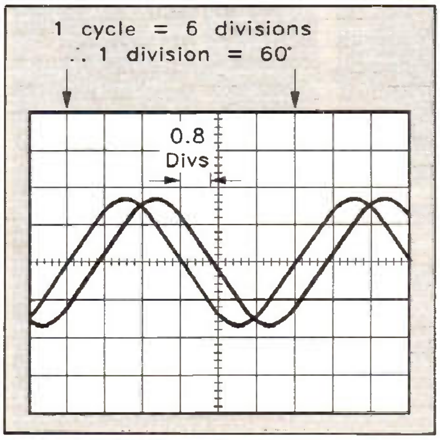


Figure 7. Measuring phase angle by calibrated X axis.

In other words, the X axis has now been calibrated on a scale of 60 degrees/division.

Returning to the matter of the horizontal distance between the two waves, from the example in Figure 7 we note this to be 0·8 divisions.

The phase angle
= displacement in divisions × degrees/division.
= 0·8 × 60,
= 48 degrees.

This is not the only way of using the CRO to measure the phase angle between two voltages (or between a voltage and a current). Another method will be described in Part 4 of this series.

Electronics in Aviation continued from page 7.

Right: Astronaut Bruce McCandless II testing the Manned Manoeuvring Unit (MMU) backpack during the February 1984 STS–41B mission. This marked the first NASA Extra Vehicular Activity (EVA) independent of tethers.

basis – it can only be heard for a few minutes at a time, when it passes above your location. The Shuttle completes one orbit approximately every ninety minutes.

Frequencies

NASA Relay	WA3NAN	Orbiter
20·198MHz	14·195MHz	259·7MHz
13·200MHz	21·295MHz	270·0MHz
	28·650MHz	296·8MHz

The frequencies listed give the best reception in the United Kingdom. VHF frequency 296·8MHz is normally reserved for Extra Vehicular Activity, better known as space walks.

Processing Facility

On their return to the Kennedy Space Center, orbiters spend some time in the Processing Facility, where they are checked out, modified and prepared for their next mission. This immense building is capable of handling two vehicles in parallel, and resembles a sophisticated aircraft hangar. From here they are transferred to the Thermal Protection System (TPS) facility, where the famous heat-resistant silicon tiles are repaired or replaced.

Once given a clean bill of health, the orbiter will then move to the Vehicle Assembly Building (VAB), the final stop before the launch pad (one of the tallest man-made structures in the world), to undergo a process known as build-up. This delicate operation involves hoisting the orbiter into a vertical position, and mating it with the external fuel tank and solid rocket boosters. Once complete, the assembly is lowered onto a giant crawler transporter for its journey to the launch pad.

From check-out to lift-off this entire process is watched over, by the Launch Processing System (LPS) computer, from one of four firing rooms in the control centre. This system is largely responsible for the reduction of shuttle countdowns to around 43 hours, as compared to more than 80 hours needed for earlier Apollo flights. However, its work ceases when the solid rocket boosters ignite, because at this point control passes to the Johnson Space Center at Houston in Texas.

Acknowledgments

Photos courtesy of National Aeronautics and Space Administration (NASA).

Editorial Footnote

Any readers who are planning a holiday to Florida/Disney World are well advised to visit the Kennedy Space Center on the east coast. Excellent visitor facilities are provided, along with coach tours around the launch pads and the chance to see the Shuttles first hand.

SITTING IN YOUR LAP OR PALM, OR ON YOUR DESK?

by Frank Booty

As computers get smaller, their market gets bigger. Indeed the portable PC market (portable is a term embracing many concepts) is growing by as much as four times faster than the desktop market. By 1994, laptop computer sales are expected to exceed 3 million units. Notebook computer sales are set to account for over 6·5 million units, a compound growth rate of 76%.

These figures, gleaned from market research company Dataquest, are awesome. The quest for the truly portable computer has intensified. However, 'portability' is a flexible concept when it comes to computers which encompass machines ranging from a pocket or notebook size device, to those matching the power and sophistication of the top of the range desktop computers.

Although the term 'notebook computer' is today one of the most popular buzzwords around, most suppliers in general believe that the end-user already knows what a notebook PC actually consists of. But many do not.

A notebook PC belongs to the latest generation of portable microcomputers. But many of the portable/laptop/notebook's limitations stem from the shape of the human body, not from technology – for example, shrunk keyboards are acceptable on calculators but not for typing, and reduced display sizes are fine for maths but not for word processing.

There is also the question of how many people actually do any computing while on the move. With changing working patterns, many people may need to move the computer between work and home, which is a different view of portable computing. If the computer is not used while travelling, but only when the user arrives at a location where there is mains power and a desk to sit the machine on, the attraction of a lightweight and ultra-slim battery powered model becomes less crucial.

Portability is something of a malleable term when applied to computers. It is interesting to look at the technology behind these machines, as the portable market vocabulary includes a host of terms alien to those people normally used to the terms ascribed to the desktop machines.

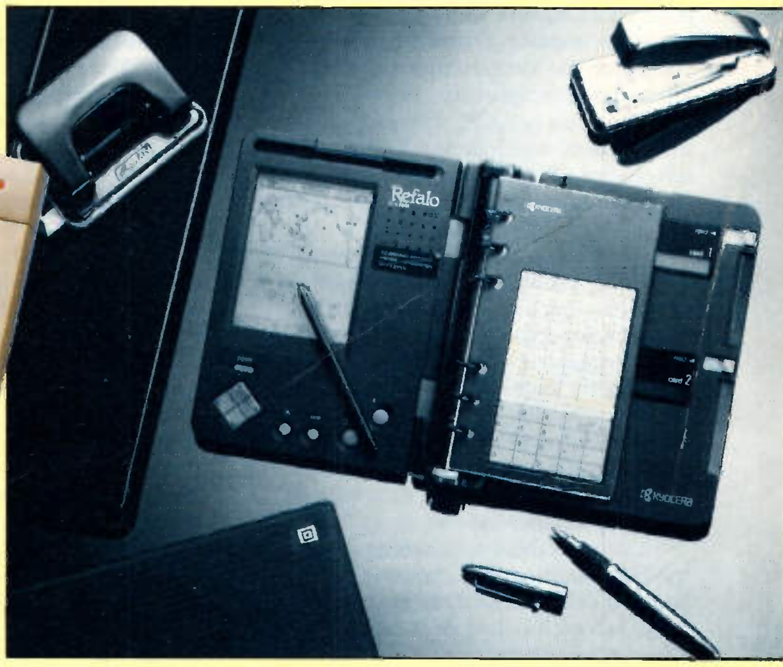
Hitherto, portables have not been standardised. Indeed, most were sufficiently different from each other in that, for example, it was impossible to replace the gas plasma screen in one machine with the liquid crystal display (LCD) screen from another. Rather than select single features and 'mix and match', as with desktop models, it is a case of choosing the machine which, overall, best suits the user's needs. It can be a matter of selecting which manufacturer's choice of compromises is found least unpalatable.

There has also been a split of the portable market into two distinct variations of portable desktops: the industry standard high performance portables, and the notebook class. There is a market for small machines, if they can run DOS and if they conform to industry standards.

The portable market is still a small chunk of the overall PC market. Estimates vary from about 10 to 15%, with the battery portable in particular forging ahead.

Portables are intended to be carried around rather than spending all their

Top and right: NCR's 'Pen Point' PCs can be used in a wide variety of situations.



life on the desktop. The original portable PCs were mains powered and very heavy (hence the term 'luggable'). Indeed these machines could go anywhere and do anything *provided* that the user was no more than three metres from a power source!

The next stage was to create a battery powered PC which could sit on a user's lap, so that it could be used on the move in a train or on an aeroplane. To be of any use such machines required a hard disk, and this, of course, adds to the weight – most units averaged out at 14lbs. Laptops are supposed to be easy to carry around. The weight limit is open to debate, but anything more than 20lbs was considered unreasonable. The shape of the beast and its weight distribution are also important – a bulky and awkward machine will make for a difficult life.

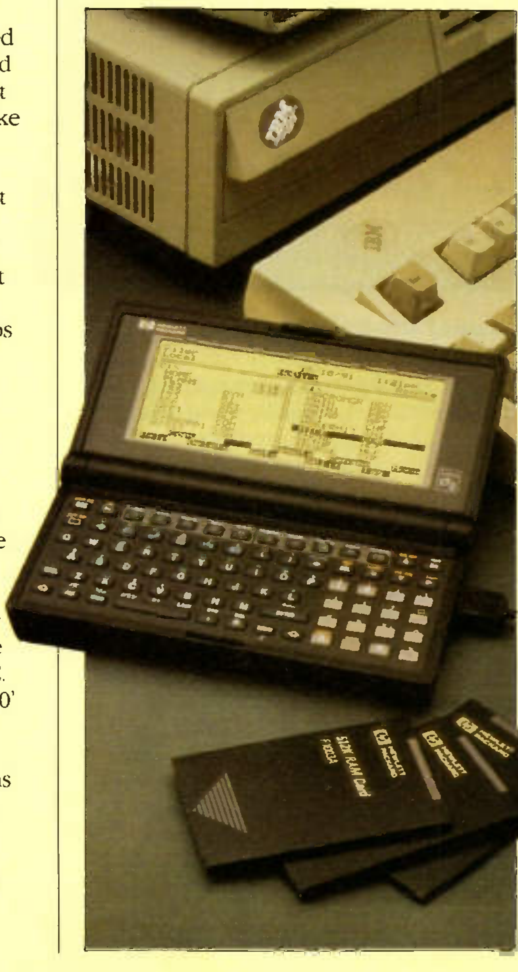
The key breakthrough was the introduction of sturdy, light and compact hard disk drives. Coupled with the advances made in the miniaturisation of the PC's essential components, the result was that manufacturers could build a portable PC which weighed less than 7lbs and was the size of an A4 piece of paper – albeit a thick piece of A4 paper. The intention was to provide users with a microcomputer roughly the size of a notebook which could fit inside a briefcase with ease.

The first of this type to appear, such as Sinclair's 'Z88' and Atari's 'Folio', were more suited to the personal organiser market, and not the serious PC user. A characteristic of the notebook computer is that it needs to be compatible with the standard business computer, the IBM PC. The exceptions include the Psion 'MC400' and Cambridge 'Z88'.

IBM PC compatibility is important because there are thousands of programs written for the PC's 'MS-DOS' operating system, including word processing packages, and spreadsheets like 'Lotus 1–2–3'. These will all run on notebook computers. With machines such as the 'Z88', users have to be content with the built-in applications marketed with the devices.

"Some notebook PCs save significantly on weight by dispensing with a built-in 3·5in. floppy disk drive," says Tony Beswarick, Sales and Marketing Director of Intral Products of Esher, Surrey. Intral is aiming to become the premier specialist seller of notebook PCs, and its major objective is to service those users who see the advantages to portable computing.

The company markets three ranges of notebook PCs, from Vortec, Texas Instruments and NEC (see later). The intention is for Intral to have a notebook PC for the user who requires a low-cost, entry level machine; for the power user who wants the latest technology, and for the user who needs something in between.



To compensate for the lack of a floppy disk drive, these notebook PCs come supplied with a file transfer facility such as Travelling Software's 'Laplink' program which enables the transfer of programs from a desktop computer onto the notebook. An alternative option is to purchase an external floppy disk drive, but this is defeating the original objective of the device.

A PC without a built-in floppy disk drive will make it very difficult to install programs which have been copy protected. The buyer will have to decide between lightness and the inconvenience of not having a floppy drive.

However, whatever else is packed into the PC, it all depends on what microprocessor is at the core. Some notebooks have an Intel 8086 or an NEC V20 chip, while others have an Intel 80286, which means the machine is equivalent to an IBM PC AT class device. Generally speaking, the more powerful the processor, the faster the computer works.

Currently the fastest chip found inside a notebook is an Intel 80386 SX chip which is particularly power hungry. Intel has now developed the 80386 SL which is scheduled to be fitted in machines expected on the market in late 1991.

The weight behind the 386 SL is impressive. It runs 386 compatible programs, uses complex graphical user interfaces and maintains compatibility with other 386 computers, operating systems and applications. Intel has integrated all the components needed for an ISA (Industry Standard Architecture) bus compatible computer within two components called the '386 SL microprocessor SuperSet'. The first device

Top left: NCR 'Pen Point' PC.
Top right: Kyocera notebook PC.
Left: Hewlett Packard HP95LX notebook PC.

includes a CPU core with integrated cache controller, memory controller and bus controller; the second chip supports CPU, memory and peripherals.

There is a new CPU mode for power management, which means the firmware can control CPU, memory and peripherals based on power usage, computational load and unique preferences.

The catch is however, in moving to high grade processors is that you have to pay extra for a machine with a really fast microprocessor. In reality, an 80286 based machine is considered more than adequate for the average user. But to run 'Microsoft Windows 3', for example, to its full potential an 80386 chip is required. If the machine is the only PC you intend to buy and use for a few years, then having a 386 chip makes sound sense.

Currently there are so many similarly specified machines that choosing one becomes difficult. But there are certain things to look for: the feel of the keyboard is important as is the quality of the screen. Most portables have been supplied with LCD screens, usually backlit. Until recently the choice has been between gas plasma and LCD, although the LCD is favoured because it uses less power. Further, screens have been exclusively monochrome until recently, although it was possible to emulate IBM's EGA and VGA graphics resolutions.

Hitachi were the first to launch a portable with a 6·33in. colour LCD screen. Others – like NEC and Toshiba, which had a joint venture with IBM in Japan – were not far behind. Sharp Electronics launched its PC–8501 colour laptop computer in February this year, which uses active matrix 'Thin Film Transistor' (TFT) LCD technology for the screen. Weighing in at 15·2lbs, the unit does however, cost £8,000 and is mains powered!

Whatever type of technology or colour capability the device's screen has does not matter one iota when it comes to readability. You should be able to read the screen comfortably. It is no good having the fastest portable around if it is impossible to carry it or see the information it contains.

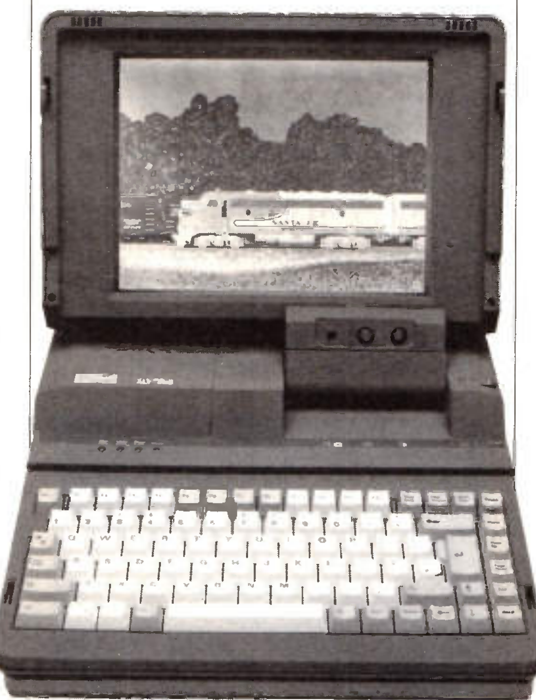
For a notebook type computer, compatibility with IBM's 'VGA' standard is advisable, although a screen compatible with the less sophisticated 'CGA' standard is considered quite acceptable. There are no notebook PCs with a colour screen currently on the market, and indeed, it is hard to ascertain when such devices will be available (and affordable).

Tony Beswarick of Intral ventures that they may be two more years hence. There are other points for you to look out for too. Does the machine have a good range of interfaces which will allow you to attach an external disk drive and a colour monitor? But with so much competition on the market, you should really be looking for good support. If you happen to select a dealer who specialises in selling notebook PCs together with their attendant peripherals and specialist software, you could have made a good move.

Pen-input devices are the latest technology to take computing away from the desk-top. Offering a growing number of business users the opportunity to work more efficiently, the units are constituting a class known generically as 'palmtop computers'. A radical new technology has emerged which will enable people whose jobs are geared to pen and paper to use a portable computer and transform their working lives.

Notepad sized computers that can read your handwriting are now on the horizon. These machines do away with a conventional keyboard. Instead you touch the screen or write or draw on it with a special stylus, and the computer reads your scribble and translates it into data and commands (you hope).

Pen-based computers use pattern recognition software, developed using artificial intelligence. The computer recognises different letters and marks, and can be further trained to recognise more idiosyncratic aspects of your handwriting within a short space of time. The screen is liquid crystal, like those found on most laptops, and fitted with a transparent additional layer formed by a grid of fine wires. This detects the presence of the special stylus which gives off a faint signal from its tip.



Amstrad ALT–286 laptop PC.

As well as interpreting pressure on the screen, the computer can interpret gestures such as tapping with the stylus or flicking it to indicate that you want to turn a page.

The rapid expansion of the portable market during the rest of the decade has already been decreed. According to Dataquest, by 1994 portables will make up 37% of the PC market, up from 17% today. However, notebook and hand-held computers that both make use of pen technology, look set to take the lion's share of the portable sector. BIS Strategic Decisions predicts that sales of pen-based machines will top $1·5 billion by 1995, and could become a $7 billion market by the end of the decade. A more modest $3 billion in sales is forecast from Prudential Bache in the same time frame.

The list of people at which pen-based systems are aimed encompasses the likes of sales persons, police, traffic wardens, delivery staff, doctors, nurses and insurance assessors, and is growing all the time. The key point is that you should be in a job where technology could improve your efficiency, and where computers with a keyboard are inappropriate because most of the time you do not work sitting down.

That being said, what about software? Californian company Go, with backing from IBM, has set up the 'PenPoint operating system' with application programming interfaces written in 'C', while Microsoft has produced 'Pen Windows'. Microsoft argues that 'DOS' is the industry standard, and 'Windows' is catching on rapidly. A pen-based system born of the same environment will maintain complete compatibility with an existing office set-up, and the same applications can be run across the board.

Go makes the point that writing applications will not be a massive chore because developers can use familiar tools to port large chunks of existing code across for writing 'PenPoint' applications.

The pros and cons of 'PenPoint' versus 'Pen Windows' will go on just as the arguments for other standards have gone on elsewhere in the industry. The machines running either system will need powerful 386 processors though, and relatively expensive hardware. Then there are those who say a 'DOS' based machine (e.g. Kyocera's 'Refalo' and Grid's 'GridPad') sits in the market as a corporate IT tool, whereas a 'Windows' type unit sits at the top end as a personal productivity tool.

That is, the DOS-based unit is for the delivery man, while the powerful beast is for the manager. The argument goes that the pen-based machines will have to be part of a corporate IT strategy, which means being part of an office local area network. And this means interfaces. Without networking, pen-based systems are pretty useless.

Over 30 hardware and software companies are committed to developing systems for 'PenPoint'. Some 21 companies attended a conference in Seattle, sponsored by Microsoft to support 'Pen Windows'. Some companies are supporting both. NCR and Grid are committed to building systems that support both 'PenPoint' and 'Pen Windows'. Kyocera has a long-term commitment to build for 'Pen Windows'. But volume shipments are not really expected until next summer.

So if you want to go out today and buy a portable, be it laptop, notebook or palmtop, what should you beware of? First, you should look beyond the specification of the machine and to the reputation of the supplier, and make sure there is a good warranty. Consider the applications that are to be run – will there be just word processing, or also spreadsheets and databases? Do not be sidetracked with the 'more megahertz, more power' syndrome. Also you may have to consider how easy it is to upgrade.

Whatever machine is chosen will depend on your budget, the performance required and the size of the beast. The boom in portables looks set to continue, with technological advances leading to a rush of new releases. It is also predestined that the market will ultimately be dominated by the Japanese manufacturers.

Some Specifications

(All prices quoted exclude VAT)

VORTEC

Laptec 1220 (£1,495), 286 processor, 5M-byte maximum memory, 7lbs weight.

Laptec 1620SX (£1,995, 20MHz version £2,149), 386SX processor, as above.

Laptec Executive SX (£3,495), 386SX processor, maximum memory 8M-byte, weight 6·6lbs, first notebook with SCSI interface for attaching to high capacity drives.

All Vortec models include DR DOS 5·0 and offer Lotus Works. Hard disks are 20M-byte or 30M-byte, and feature options of 40M or 60M-byte. Displays are backlit 10in. Supertwist LCD. Compatibility is VGA/EGA/CGA/MGA Hercules.

TEXAS INSTRUMENTS

Travel Mate 2000 (£1,995), 286 processor, 3M byte maximum memory, 4·4lbs.

Travel Mate 3000 (£3,395), 386SX processor, 6M-byte maximum memory, 5·7lbs weight.

Software included is MS DOS 4·01, options are Laplink 3, Battery Watch, Laptop Manager. 20M-byte hard disk standard, 3000 offers up to 60M-byte. Displays are sidelit 10in. triple Supertwist LCD. Compatibility is VGA/EGA/CGA.

NEC

UltraLite 286F (£1,795), 286 processor, 5M-byte maximum memory, 6·6lbs weight. 20M-byte hard disk standard, 40M-byte option. Display is backlit 10in. Supertwist LCD. Compatibility is CGA/MGA Hercules.

LIBREX

286 and 386SX Notebook Computers, weight 6lbs.

AMIT

NB−3sx (£1,499), 386SX processor, offers MS DOS 4·01 and Lotus Works, VGA FSTN display (16 grey scales). AMIT stands for Advanced Machines for Information Technology. Also offers two laptops, the LT−2 and LT−3sx (£1,199 and £1,399).

NCR

NCR 3125 (£3,195), 386SL processor, supports up to 16K-byte of cache memory, standard 4M-byte memory supplied is user expandable, pen-based and supports both Pen Windows and PenPoint operating systems; 3·9lbs, data auto-save capability.

KYOCERA

Refalo (less than £1,000), NEC V30 microprocessor − 8086 compatible, operating system is MS DOS 3·22, pen based, Pen Windows variant is expected; 1·65lbs, data storage is by solid state memory cards instead of floppy disk (applications software can be downloaded via one of two JEIDA format IC card interfaces – JEIDA is the Japan Electronic Industry Development Association fully compatible with its US counterpart PCMCIA – PC memory card international association), addresses up to 12M-byte on its expansion bus; optional keypad is available.

AST

Premium Exec 386SX/20, 386SX processor, 2M-byte RAM, and up to 60M-byte hard disk, 7·3lbs.

OLIVETTI

Three notebooks (A12, V16 and S20) and two laptops (Laptop S20 and D33). Notebooks weigh 6·6lbs and V16 and S20 feature high resolution LCD display offering 32 shades of grey; S20 uses 386SX processor. Top-end laptop features 386DX processor with 4M-byte of base memory. Both laptops have a VGA compatible high resolution LCD display.

POQET COMPUTER

Poqet, an MS DOS PC at 1lb and offering up to 6M-byte of removable storage to handle Wordperfect 5·1, Lotus 1−2−3, etc, and most PC applications, full 80 × 25 screen and keyboard (in a VHS cassette size).

HEWLETT PACKARD

95LX, developed by HP and Lotus, distributed by DIP Ltd to corporate users.

KAMCO COMPUTER SYSTEMS

86DX, £2,295, and 386SX, £1,595, have the 33MHz and 20MHz 386 chip respectively, both have 40M-byte hard disk, 2M bytes RAM, VGA screen and DOS 4·01. Both are expandable to 16M-bytes on the motherboard and can be fitted with 80M-byte hard disks. A4 size, they weigh 2kg without batteries. Back-lit LCD display offers a choice of VGA or CGA screen in 16 shades. Full size keyboard.

AMSTRAD

ALT−386SX 40M-byte drive £1,699; ALT−286 20M-byte drive £1,299. ALT−386SX with 2M-byte RAM, 80M-byte drive £1,999; ALT−286 40M-byte drive £1,599. Earlier this year Amstrad took 33% of the UK portables market, equal top with Compaq, according to market researcher Romtec.

ADVANCED MICRO DEVICES – Am386 USERS

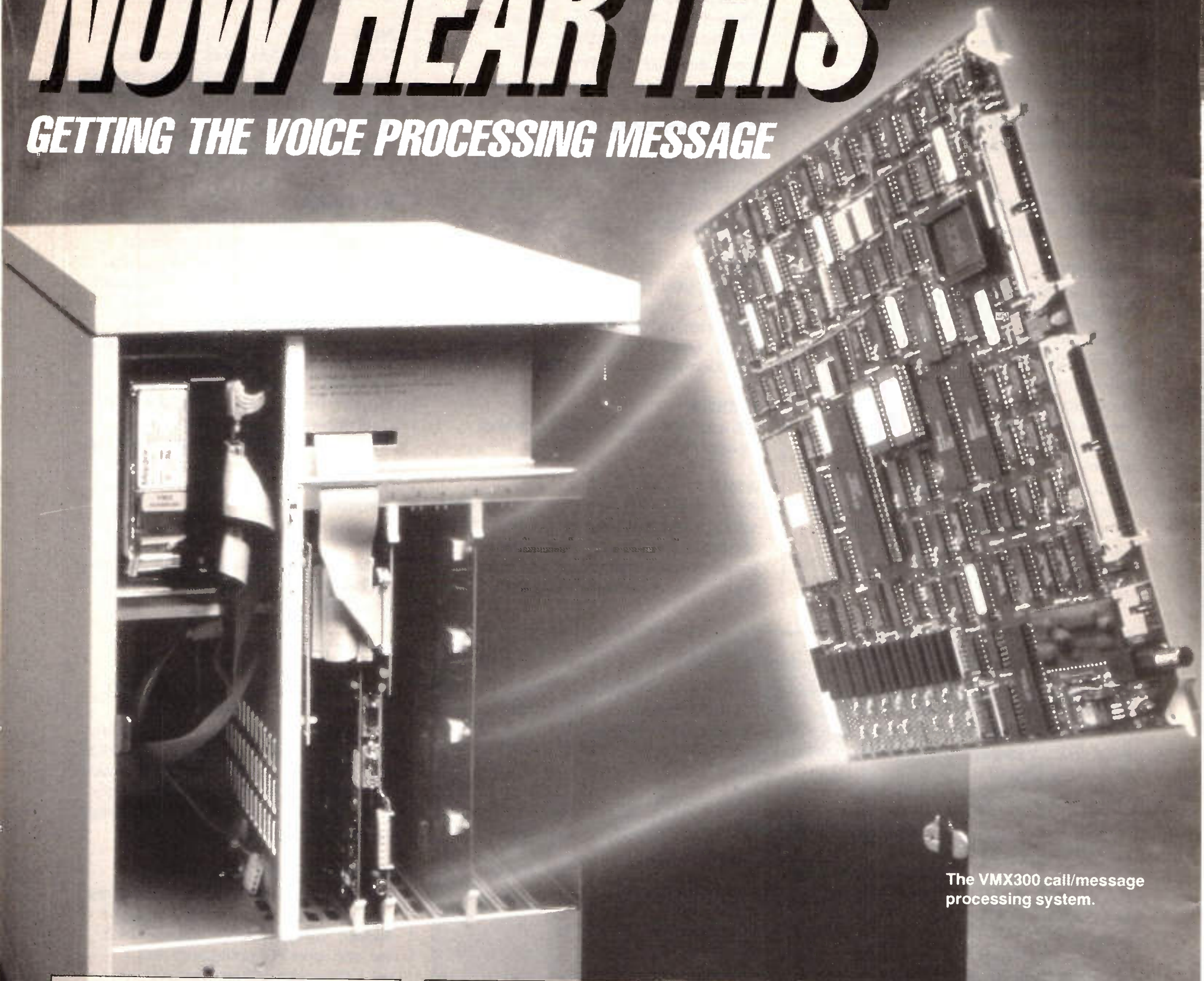
The major OEMs (Own Equipment Manufacturers) are ALR, Dell, Grid, Epson, Everex, NCR, NEC, Sharp, Toshiba and Zenith, plus 30 'second tier' companies. The following is a list of PC manufacturers who have or are planning to introduce AMD (Advanced Micro Devices) based products for 1991, as seen in the Comdex show 1991.

	DX-40 desktop	SX-25 desktop	DXL-33 notebook	SXL-25 notebook
US				
AST		★		★ (colour)
Everex				★
Grid		★		
ZDS		★		★
Europe				
Array Consultants	★			
Dawn Systems			★	
Triumph Adler				★ 20MHz
Asia				
Arche				★
Asis	★			
Auto Computer	★	★		
Chaintek		★		
Chaplet			★	★
Chicony				★
Clarian	★	★		
Crete			★	★
DTK		★		
King Phoenix	★			
Mycomp	★			
NTC			★	
Sunrays				★
Toplink			★	
Twinhead		★		★
Wang	★	★		
Japan				
IDC				★
Soke				★

(Soke is Japan's leading notebook manufacturer, and 80% of systems produced by them are badged by other OEMs.)

NOW HEAR THIS

GETTING THE VOICE PROCESSING MESSAGE



The VMX300 call/message processing system.

by Alan Simpson

Voice Messaging – computer systems that talk back to you – are in the fast growth league. As the National Computing Centre (NCC) point out, voice is the most natural way for people to communicate with computers. In this respect, they are not referring to the ritual abuse and thumping that we all deal out to our PCs, but to developments in ICs which can store vocal messages. This has been made possible by the ever-decreasing cost of data processing power and computer storage media, together with the rapid improvement in data compression techniques.

Thanks are also due to the more relaxed attitude that we now have towards answering machines. (Although those involved in the industry would not welcome the suggestion, voice processing systems are basically an advanced form of answering machines). The times when callers felt uncomfortable when talking to an answering machine (even to the extent of hanging up) are becoming a factor of the past. With the profusion of answering machines, even Aunt Beatty is having to get used to talking to an electronic machine. Hopefully she will not come 'face-to-face' with the programmed message on a colleague journalist's answerphone: "On the third bleep, your phone will implode. Kindly replace the receiver without delay!".

Even so, there is no getting away from the fact that we all feel more comfortable communicating through speech, rather than by the user-unfriendly means of computer keyboards, monitors, modems and databases. The telephone is a natural communication tool, whether the caller is talking to another human, a programmed voice or an automated information processing system. Speech, it is widely predicted, will be the chosen interface of the future.

Making Words Work

However, comparing voice processing to an answering machine does little justice to the services that sophisticated voice mail, messaging and processing systems are capable of providing. As the NCC somewhat laboriously state; "A voice processing system combines both computer and telephone technologies. The user of a VMS (voice messaging system) can create and receive voice messages from the convenience of a telephone, whilst having the ability to integrate such messages with delivery capabilities similar to those offered by text mailbox systems". In other words, voice messaging allows two users to communicate verbally, with only one of the parties being present.

Getting to Terms

Voice messaging is a term which, perhaps unhelpfully, embraces audiotext, call completion, call answering and real-time digital dialling. Input access to computer databases by telephone is normally made by means of DTMF (Dual Tone Multiple Frequency) dialling, a feature which has become a near-standard fitting on modern telephone handsets. However, where the phone is a 'loop-disconnect' type (for example, one of the older-style rotary affairs), VMS can be triggered by means of a small tone-generator, which is held against the mouthpiece.

Certain banking and finance companies already supply their customers with these telephone tone-pads. One leading building society charges a £10 deposit for a pad, which enables the customer to get in touch with its computer. Such a system allows users to obtain details of their bank account, and to pay bills. In fact such a product, a Pocket Tone Dialler Pad, is available from Maplin, by ordering ZB19V (£8.95).

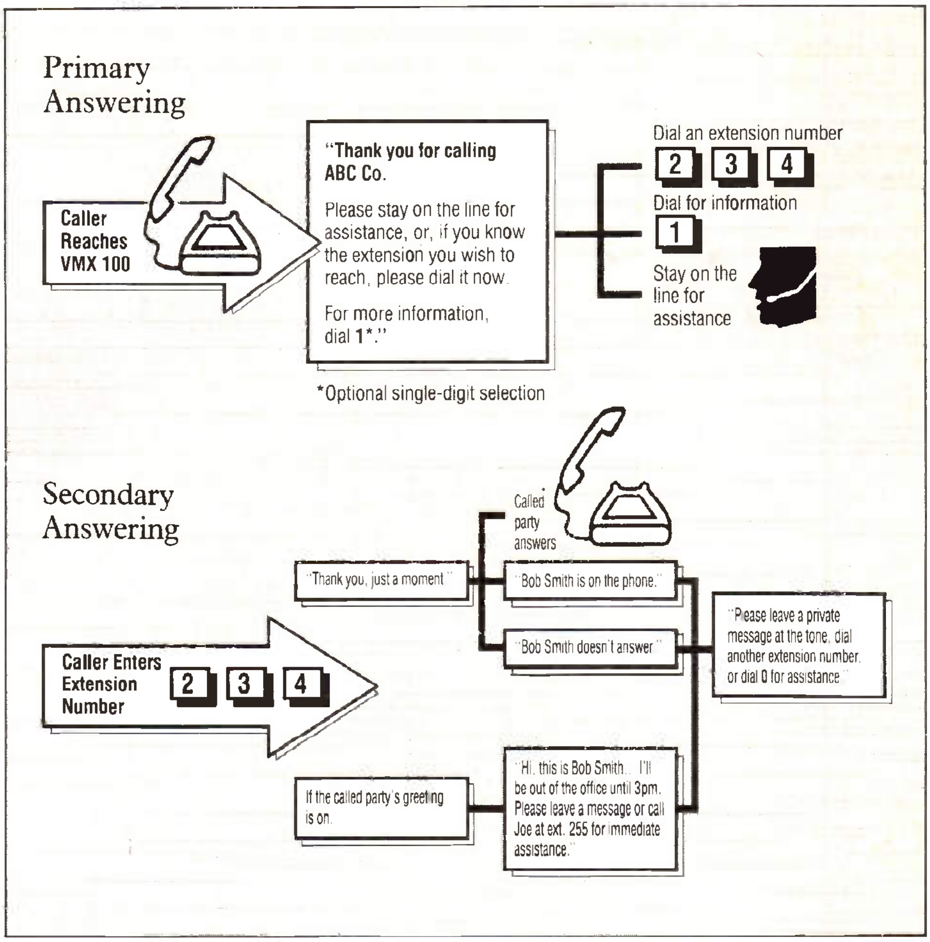
Fully Flexible

As Paul Chisel, managing director of VMX (UK) – one of the major VMS international players, comments: "Voice messaging systems certainly replaces the technologies that other methods cannot reach! Whether the message is being routed to a bureau or an end-user, or by cellular, charge-free or public telephone networks, the system is fully flexible".

VMS is also secure, a necessary requirement in certain business environments. In the case of company users, all that is needed to establish contact is a personal identity number (PIN), which again can be entered through the telephone or by means of a tone dialling pad. In fact, one of the areas where voice processing has seen the greatest growth is as a value-added feature to the PABX. Memory cards containing digitally-stored pre-recorded voices, and ICs with the capacity for recorded messages, allow digital messages to be put onto the system. For users with a need for basic 'store and forward (this communication)' messaging, 'toolkits' are available which allow users or dealers to construct their own programs.

Voice messaging, say Mercury Communications (who market the VMX system), dates back to 1978 when VMX obtained basic patents for call processing and voice-messaging systems for business use. The original voice-messaging system was designed to eliminate the expense and inconvenience of dealing with routine paper memos, and to improve private communications between members of executive management teams. Any messages recorded onto the system were stored in totally private 'mailboxes' – and eliminated any difficulties caused by receiving ambiguous, scribbled, and easily misplaced notes.

Following the success of the original voice messaging system, VMX developed call processing – the



A 'flowchart' to show the sequence of events that take place during primary and secondary answering.

ability to handle incoming call traffic. Call processing is comprised of two elements, primary answering and secondary answering. The technology is designed to enhance customer care by increasing responsiveness to incoming telephone calls. In 1984, the VMX Dial system incorporated all five features needed for efficient voice communications, which are:

★ Primary answering
★ Secondary answering
★ Volume call-processing
★ Voice-response applications
★ Voice messaging, mailing and processing facilities.

Simply stated, primary and secondary answering facilities ensure that the telephone is answered by a personal company greeting, with the caller then being directed by the system to the correct extension. If the person being called is unavailable, secondary answering takes over. Here, the caller is greeted, given instructions on how to leave a message, or referred to a further extension.

Volume call-processing and voice-response applications direct the caller quickly to the required information, or the correct extension. The facility can be used in the order department where the system asks the caller for the order details, these being recorded and processed at a later date. A more advanced system was introduced by Maplin to meet anticipated demand for the GK05F floodlight security system, amongst other items. Here, the customer is asked to enter the order code and quantity of each item required. These items are checked against existing stock levels; if available, the customer is invited to enter the relevant credit-card details.

Voice messaging, mailing and processing guide the caller to a personal mailbox when the person required is unavailable. Users can access the system remotely, to process messages left in the mailbox.

Reaching Areas that Other Methods Cannot

"The use of voice messaging in Europe," says industry authority Michael Naughton of the Applied Network Research consultancy, "is only one fifth of one percent of that in the US". Yet it can handle up to 30% of the functions of human respondents. However, the voice processing message is being received; Frost & Sullivan are forecasting a surge in sales of voice processing systems throughout Europe. This will see the market leap from the 1990 figure of $146 million, to $780 million by 1994. At the moment the UK market, at $70 million, accounts for 44 per cent of European sales. One research organisation suggests that the development and introduction of 'intelligent' voice processing systems will considerably boost the market-place.

Frost & Sullivan see voice messaging, a sophisticated answering machine that can be networked on PABXs, as having the largest application usage. Systems which are accessed via a DTMF telephone keypad, and are capable of handling high-quality speech (making use of advanced data compression techniques), are identified as a high-growth market. In message-generated terms, a recent BIS report suggested that the total number of messages handled in this way, in Europe alone, will have risen by some 73% to over 30,000 million in 1996.

Yet more statistics are provided by the Financial Times, who report that 12,000 3M staff, based in the USA, already use voice messaging technology. They also state that, given present trends, the system within the EC will equal 0·7% of the gross national product by the year 2000 – presumably a somewhat significant figure.

Not So Basic Technology

The basic technology which drives voice processing is the ability to digitise speech. By means of Pulse Code Modulation, large volumes of data can be generated which need to be stored. This is the first major snag, as each minute of speech requires some 720 Kbytes of storage. However, at this point, time compression techniques come into play, helping to reduce the storage requirement by a factor of four (or even more) without an audible impairment of the quality.

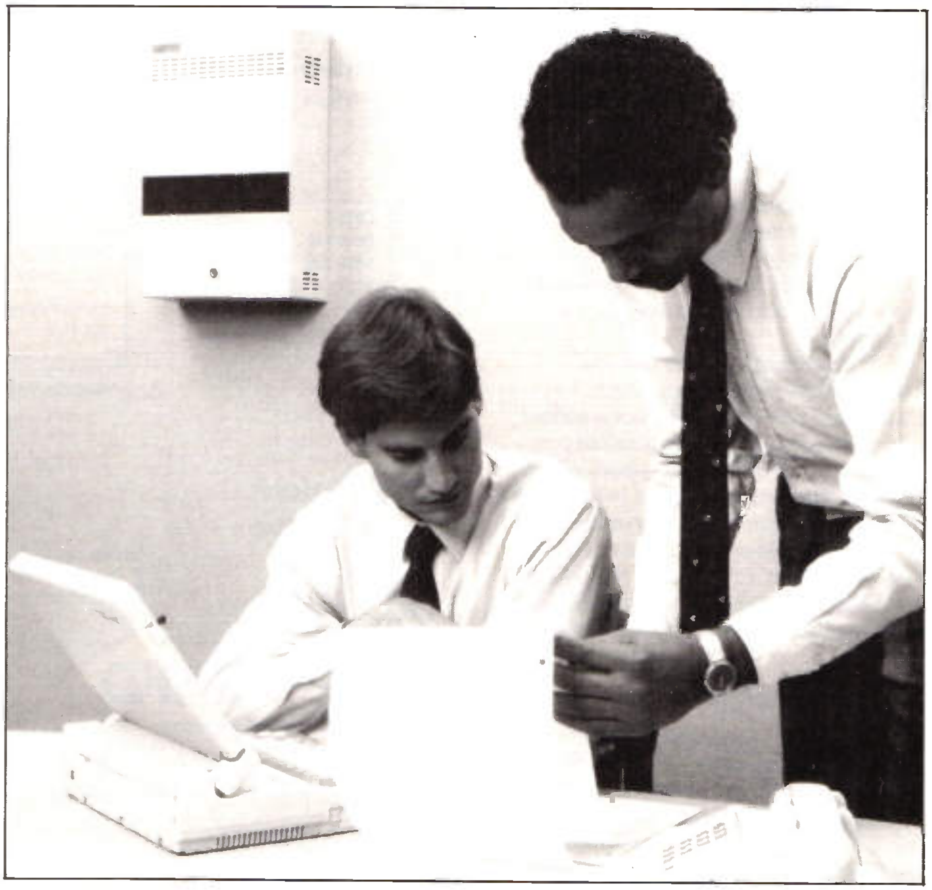
Tennis Scores VMS Points

Quality is certainly a feature of at least one user application. When the world's top tennis players meet to compete in the US Open in Flushing Meadows each year, the stakes are high. Up for grabs are millions of dollars in prize and sponsorship money, the chance to capture the Open Crown and perhaps set a new record, plus the excitement of appearing before thousands of fans and a vast TV audience. Over the two weeks of the Open, some 800 matches are played. Yet the exact schedule of games, court bookings and opponents cannot be arranged in advance – each day's schedule depends on the results of the previous day's matches. Until this year, this meant that a few hundred players called the umpire's office every day of the tournament to find out the time, location and name of their opponent for the next day's match. By the time some players had finished their matches, the umpire's office had closed! This problem was apparently solved by the installation of a VMX call processing system. After the day's matches, a brief message for each player is left in their individual mailboxes. The players and officials then call their mailbox, at their convenience, for accurate information, night or day.

Boxing Up the Office

Meanwhile, a Hewlett-Packard voice processing system (VPS) is being used by Warner Brothers to capture and analyse box-office data from cinemas, throughout the UK, on a daily basis. The company is providing each cinema manager with a DTMF-dialling telephone, from which they call the London-based system. The caller is asked a series of pre-recorded questions, and responds with the audience figures. Once the VPS has received all the data, a number of HP minicomputers process it overnight and produce management reports for executives in the UK and US, by the following morning.

In fact, the potential applications of voice messaging are endless. As Paul Chisel of VMX reports, voice processing provides the communications channel, whether it is phoning your bank to order a new cheque book, ordering mail order goods, broadcasting a message to all sales staff without the need for individual calls (most users are connected by pager to alert them to a message left in the system)...



Reading a status report generated by a VMX100 call/message processing system (shown mounted on the wall).

Factfile

According to ANR, business communications score several bonus points from the introduction of voice processing. Facts and figures demonstrating this are:

★ 65% of all calls taken are less important than the work they interrupt.
★ 50% of calls can be classified as being one-way transfers of information.
★ 75% of calls fail to arrive at the correct person at the first attempt.
★ Business users spend a period of time equal to seven whole working days a year, waiting to speak on the phone.
★ 70% of all calls do not succeed in getting the right information to the right person.
★ Some 20% of messages go astray.
★ In the US, telephone operator Pacific Bell estimates that, by the year 2000, some 75% of the total number of calls it handles will be non-simultaneous – that is, to a call-processing system.

Computers that Talk and Listen

While voice processing is already a major business in the US, the UK is only just starting to realise the benefits of this technology. To date, as David Hoskins of Mercury comments, only the larger UK companies have been able to afford voice-messaging systems, while the smaller companies have had to make do with services provided by bureaux. Even so, as BIS state, there remain profound cultural, sociological and regulatory differences between the two continents which will prevent voice processing services proliferating in Europe to the same extent as they do in North America.

This situation, however, is set to change if the numerous companies operating in the field have their way. VMX and Hewlett Packard apart, suppliers now include IBM, Alcatel, Northern Telecom, Siemens, Philips and GPT. Asked to list the high-technology items in their home or office, subscribers would almost inevitably overlook their telephone. The arrival of voice-processing systems could change all that – the spoken word still rules!

A readers forum for your views and comments.
If you want to contribute, write to:

The Editor, 'Electronics – The Maplin Magazine'
P.O. Box 3, Rayleigh, Essex, SS6 8LR.

AIR YOUR VIEWS

Dear Editor

NICAM LEDs Put to Work

Dear Sir,
I currently use your surround sound processor in conjunction with your NICAM decoder board kit (hard-wired to my video's IF stage and 12V rails; it's simpler than you may think!). Used in conjunction with two decent pairs of speakers, I cannot praise the sound enough. Full marks for the NICAM board.
Incidentally, it seems that BBC and IBA (now NTL – Ed.) always flag their transmissions as 'Stereo', even when they are not. The two 'Mono' LEDs can be put to good use very easily. Bend legs 23 and 24 of IC2 (TC6011) to an angle of 30° to the body of the IC so that they no longer make contact with the socket. On the solder side of the PCB, join IC2 socket pin 19 to pin 24 and join pin 20 to pin 23 (both these are straight across the IC). The 'MONO1' LED now glows to indicate the number of parity errors – useful for setting up an aerial or fine-tuning. The 'MONO2' LED indicates sync errors, which usually means that a station has gone 'off air', or that there is extreme interference present.
This simple modification would, I believe, make your NICAM board not only the cheapest available decoder, but also the only one with an indication of the quality of the NICAM signal received – maybe something to shout about.
Daniel Greenspan, Middlesex

Thanks for your useful tip! Indeed, the NICAM board works extremely well when integrated into existing equipment; that was a primary design consideration. A member of the Editorial team incorporated one of these units into a fairly old Ferguson 3V43 Hi-Fi VCR (JVC HRD725) – with excellent results! Interestingly, with this model of VCR there was a space (originally intended for a decoder compatible with the inferior German subcarrier based stereo sound system) which accommodates the NICAM board very well. In addition, its power supply will also cope with the additional loading of the additional board. The result – a worthwhile (and economical) update for a VCR whose picture quality still compares favourably with today's VHS machines. We have received highly favourable reports from others who have successfully used the Maplin NICAM decoder with existing equipment, although in several cases the board had to be housed separately and/or powered by an additional 12V DC supply.

S·T·A·R L·E·T·T·E·R

This issue, Roger Hine from Gwynedd, Wales, receives the Star Letter Award of a £5 Maplin Gift Token for his letter, on finishing off projects.

£5 Gift Token

Finishing Off 'Finishing Off'

Dear Editor,
I would like to make a constructive comment or two regarding the article 'Finishing Off' in Electronics No.53.
The article stresses the importance of using a centre punch. What I feel *should* have been pointed out was the importance of having a solid surface at the back of the panel when the punch is used – otherwise it is only too easy to end up with a far from flat panel! This is especially true with the type shown, which has a flange all around; it must have something inside for support when centre punching.
If you want a really nice drilled hole in aluminium then I find it helps to use a little of natures cutting fluid i.e. spit! Try it, and I think that you will be surprised at the easier cutting of the drill.
As an alternative to the hand nibbler and punch for large holes, I would suggest a fret-saw with a metal cutting blade, or an abrafile of the type that fits into a hacksaw frame. Both are easy to use (with a little practice) and are much cheaper than a set of chassis punches. The abrafile does not even need turning as it cuts in any direction.
Hoping these comments are of some use.
Thank you for your helpful comments and suggestions.

Long Range Burglar Alarms

Dear Sir,
Now that the restrictions on long-range burglar alarms have been lifted, how about some projects from the Design Lab?
As well as a basic single alarm system, an 'extended' version capable of monitoring several different areas could be designed, the transmitter of each area producing a uniquely coded signal. For example, individual cars in a car park could be monitored from a central point. Similarly, a group of houses in a Neighbourhood Watch scheme could be monitored from whichever house is occupied at the time. I am not aware if any such systems are already available commercially, but nevertheless it would make an interesting exercise for the home constructor.
The magazine is even more enjoyable since some of the pages are less blue!
Peter Lincoln, Colchester.

The systems you mention are very interesting, but Maplin could never produce them as kits. The DTI's 'ending of certain restrictions on radio alarms', as mentioned in June's 'News Report', is concerned with manufactured equipment only – it could never apply to DIY projects. With a few exceptions (low-powered 27MHz radio-controlled equipment, for example), it is illegal to use home-built radio equipment; if Maplin sold a kit for such equipment, it could be falling foul of the law – and its unfortunate builder/operator would be infringing the Wireless Telegraphy Acts! The restrictions that the DTI have lifted apply, in the main, to the way in which equipment is submitted for approval – this is now somewhat easier; the Government (presumably?) want to encourage the use/manufacture of such equipment – maybe they feel that industry stands to gain a great deal from producing/exporting it! Specification tolerances, however, are kept just as rigid as previously – if anything, they will get tighter as the bands get more crowded. Note that specialised equipment is used for the alignment of RF equipment; radio amateurs (a licensed group of people allowed to build a limited range of RF equipment) frequently use such expensive items as frequency counters, wavemeters and RF power meters. By law, they are supposed to regularly check the third harmonic output of their transmissions! Building radio transmitter kits would necessitate the begging, stealing or borrowing of such equipment – and you would have to be able to use it as well! Maplin could in theory sell pre-aligned modules – but once it has done this, you would probably be better off buying a commercially available system.

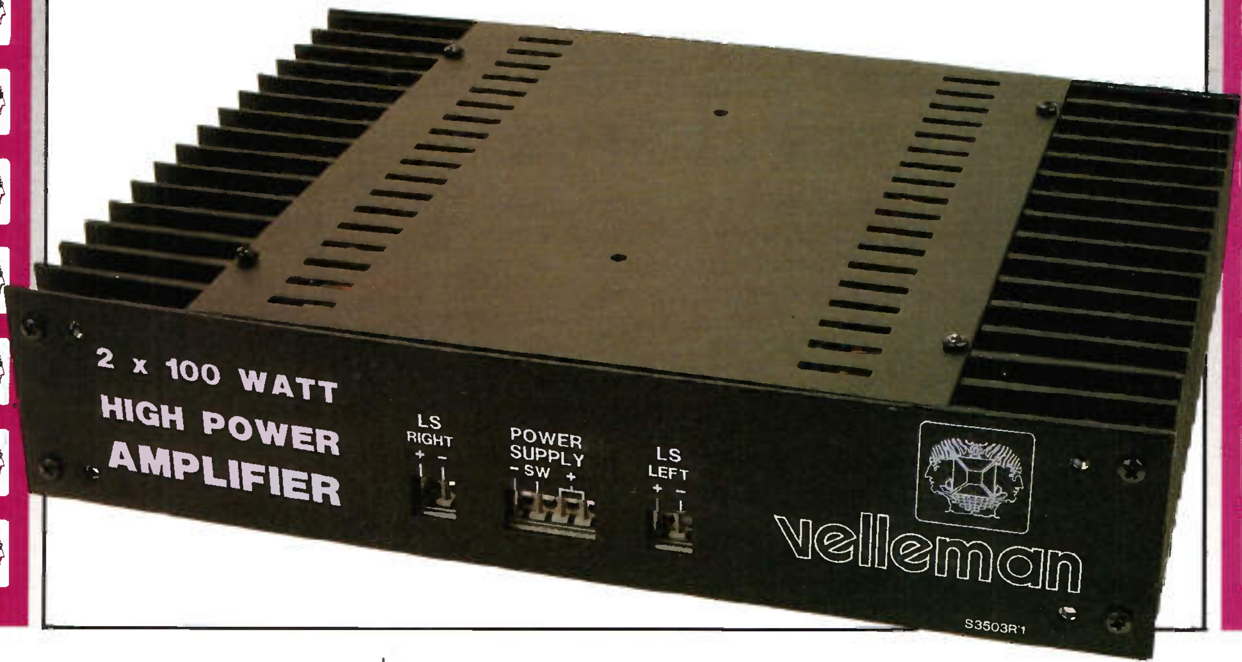
Probing Around

Dear Sir,
With reference to the continuity tester, (May '92) the circuit diagram shows a screened lead going to the trailing probe. Would it not be possible to link P2 with P3 and use a single wire to the trailing probe, so saving the need of the thick wire to the probe?
R. Spraston Jnr., Age 16, Newton-Le-Willows, Merseyside.

There's a very good reason for the curiously wired screened lead, though it's not obvious. In fact we don't recommend anyone wiring the tester as you suggest. Using the screened lead ensures accuracy and reliable results. This continuity tester distinguishes four different resistance ranges, the lowest being 0 to 0·5Ω. You will see from the circuit diagram (Issue 53, page 17) that, as a current flows via TR1 emitter and R3, through the trailing probe to the fixed probe, and thence to R4 and LD1, a long flying lead will add its own impedance to that being measured between the probes. If P2 and P3 were commoned, IC1a will receive an inaccurate reference level which includes the resistance of the lead. Hence, two wires are effectively used for the lead instead, one which carries the current to complete the circuit, the other to return the actual voltage at the probe tip to IC1. For convenience a screened lead is used, which is not only neater but the least resistive screen braid can be used as the current carrier. Ingenious, no?

Text by Tony Bricknell

Stereo 100W Car Amplifier



Producing high power audio in motor vehicles has always been a problem due to the low supply voltage available. This can be anything between 10·5 to 14·4V, depending on the condition of the battery and the power consumption of lights, fans, de-misters, etc. Conventional amplifiers, which are built into most car stereo systems, can only reach output powers of 5·6W RMS into 4Ω. Using an amplifier pair having opposing (opposite phase) outputs between which the load is connected (bridging amplifier), effectively quadruples the output power. However, there is no way of producing a clean, undistorted signal with more power due to the limited voltage available.

The K3503 employs a modern, switching PWM power supply to boost the nominal 12V supply voltage to approximately 33V, enabling the output of much higher power levels. Such SMPS type DC to DC converters deliver rock solid bass response with performance immune to supply-line noise and battery fluctuation. Using FET switching transistors, the K3503 maintains tightly controlled regulation resulting in stable, ripple free supply voltages. Bipolar transistors have been used in the audio output stages as an alternative to FETs as they offer increased output efficiency. The speakers are directly coupled to the outputs to give clean, powerful bass response.

Construction

Figure 1 and Figure 2 show the circuit diagrams for the power supply and power amplifier sections respectively. These should be of assistance if you need to fault find on the completed unit.

The sequence for construction for the 100W power amplifier is critical, so do read through the assembly manual supplied with the kit very thoroughly before commencing assembly. Pay particular attention to any modification sheets hidden between the pages of the manuals! To aid component identification, a small leaflet detailing component outlines, circuit diagram symbols, etc. is included with the kit.

FEATURES

- ★ Switchable Line/CD and Speaker level inputs
- ★ Wide frequency response (10Hz to 100kHz)
- ★ Twin switching power supply
- ★ 12V or 24V operation
- ★ Remote power on/off control
- ★ Push-pull BTL outputs

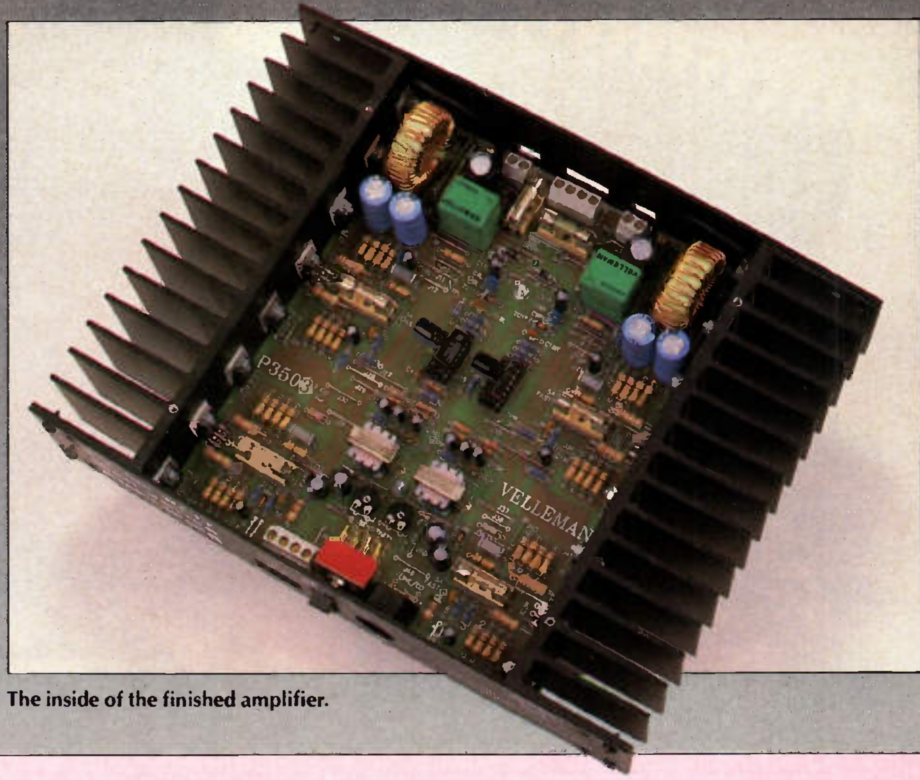
Note that you will need a small tube of heat-transfer compound (Maplin stock code HQ00A), and a small quantity of hard-setting glue (for example, Double Bubble Sachet, stock code FL45Y) to complete construction of the kit.

Take care when fitting the heatsink assembly around the PCB, as the edges of the cooling fins can be quite sharp!

Several of the PCB tracks have no solder resist, and it is along these that lengths of 1·25mm (18swg) TC wire should be soldered. Don't be sparing with the solder, as currents up to 20A have to pass along these tracks.

Wiring and Installation

Before carrying out any form of electrical work on a vehicle always disconnect the battery first (removing the earth terminal is safer in case your spanner/screwdriver touches the car body), and *never* work



The inside of the finished amplifier.

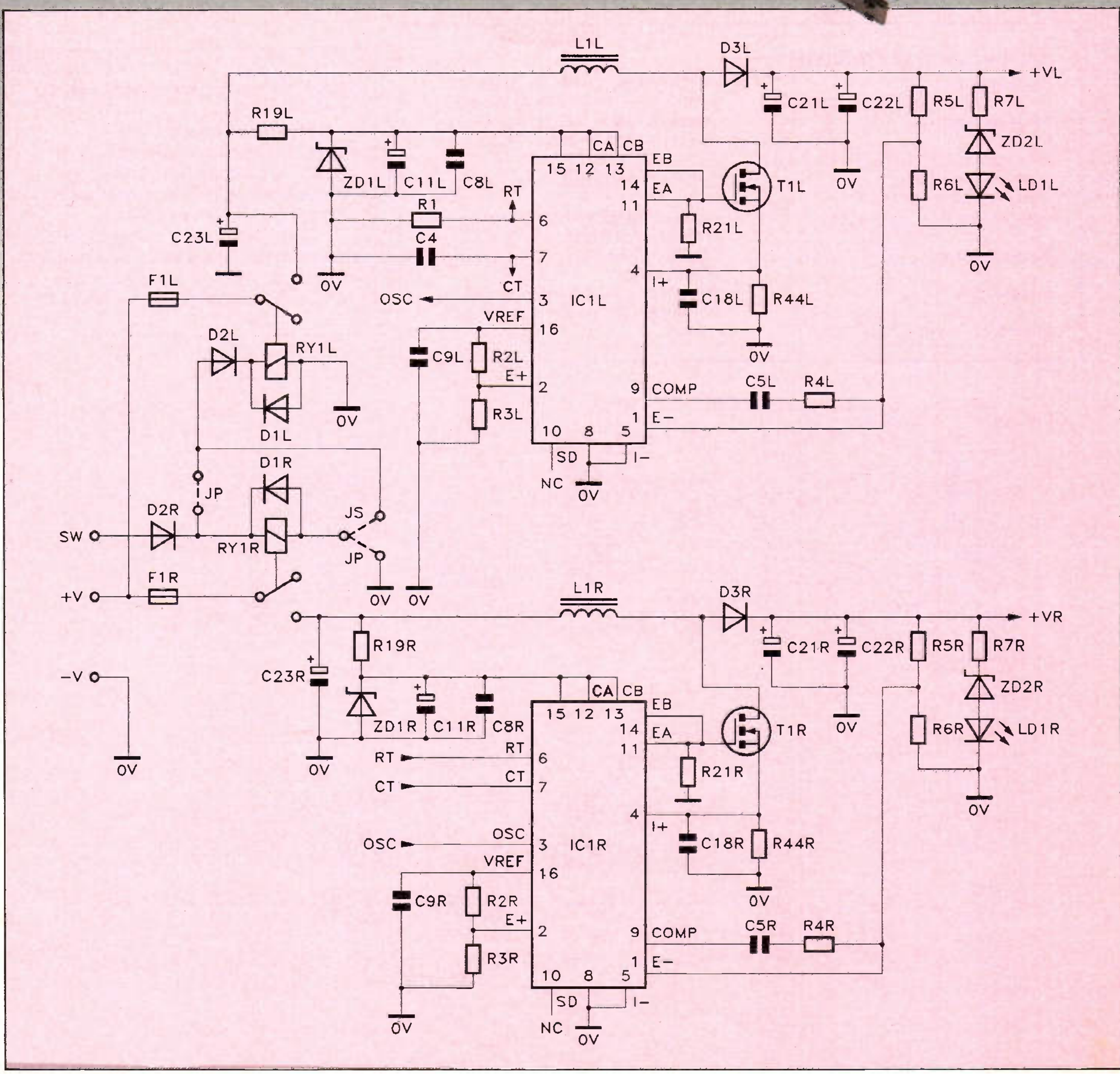
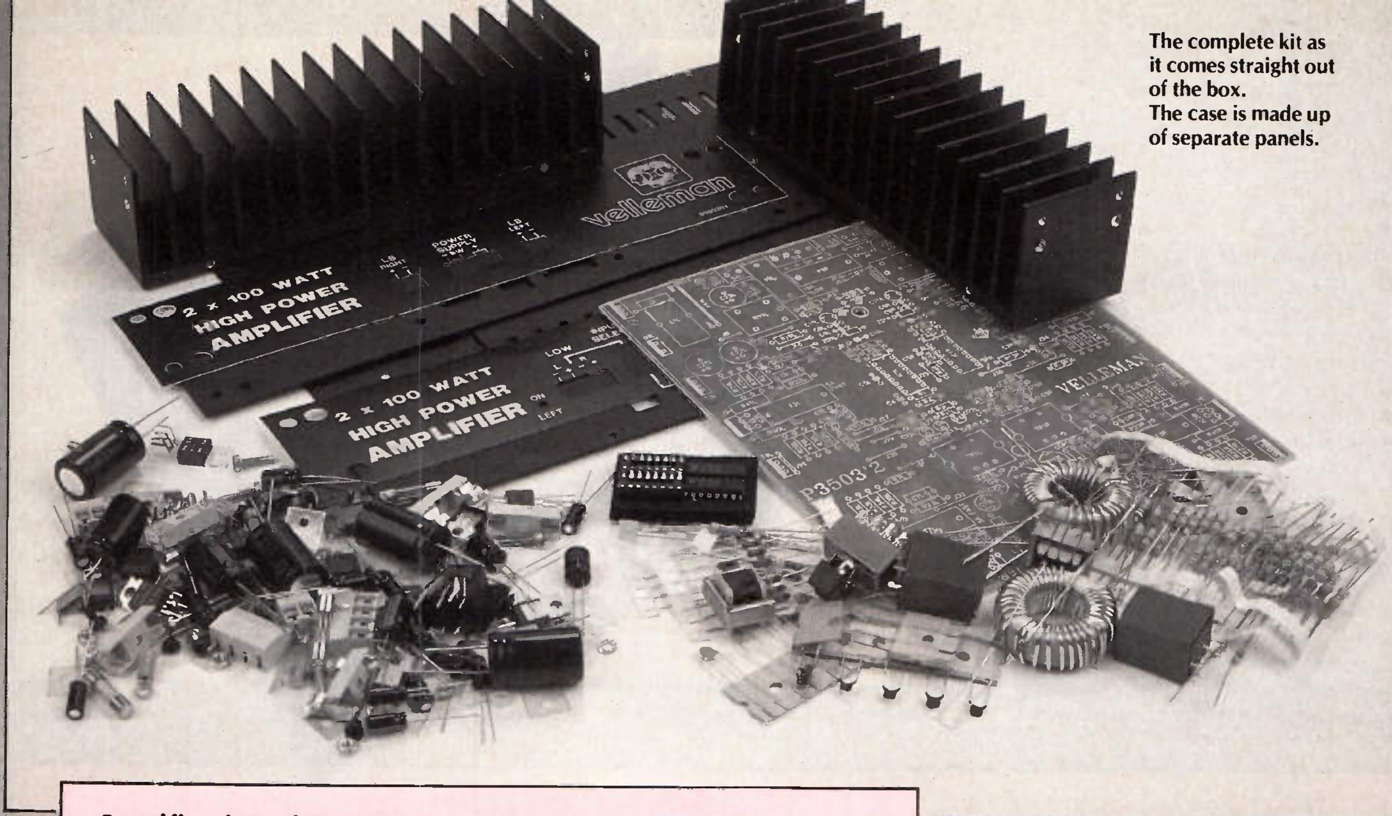


Figure 1. Power supply circuit diagram.



The complete kit as it comes straight out of the box.
The case is made up of separate panels.

Specification of Prototype

Output power:	2×100W peak (2×50W RMS) into 4Ω 2×70W peak (2×35W RMS) into 8Ω
Frequency response:	15Hz to 20kHz (−3dB) LOW input 10Hz to 100kHz (−3dB) LINE/CD input
Total Harmonic Distortion (THD @ 1kHz):	0·15%
Signal-to-noise ratio:	>100dB (A-weighted)
Channel separation:	55dB
Input sensitivity:	LINE/CD: 0·5V RMS (Minimum) LOW: 1V RMS (Minimum)
Input impedance:	LINE/CD: 47kΩ LOW: 135Ω
Power supply:	10V to 16V (14·3V nominal) @ 20A 20V to 30V (28V nominal) @ 10A
Quiescent current:	650mA

inside the engine compartment with the engine running!

For anyone not familiar with automotive electrical installation it is advised that they seek the advice of a qualified person before proceeding to fit the K3503 power amplifier.

Wires that need to be routed from the engine compartment into the passenger compartment should be fed through a convenient rubber seal, either following

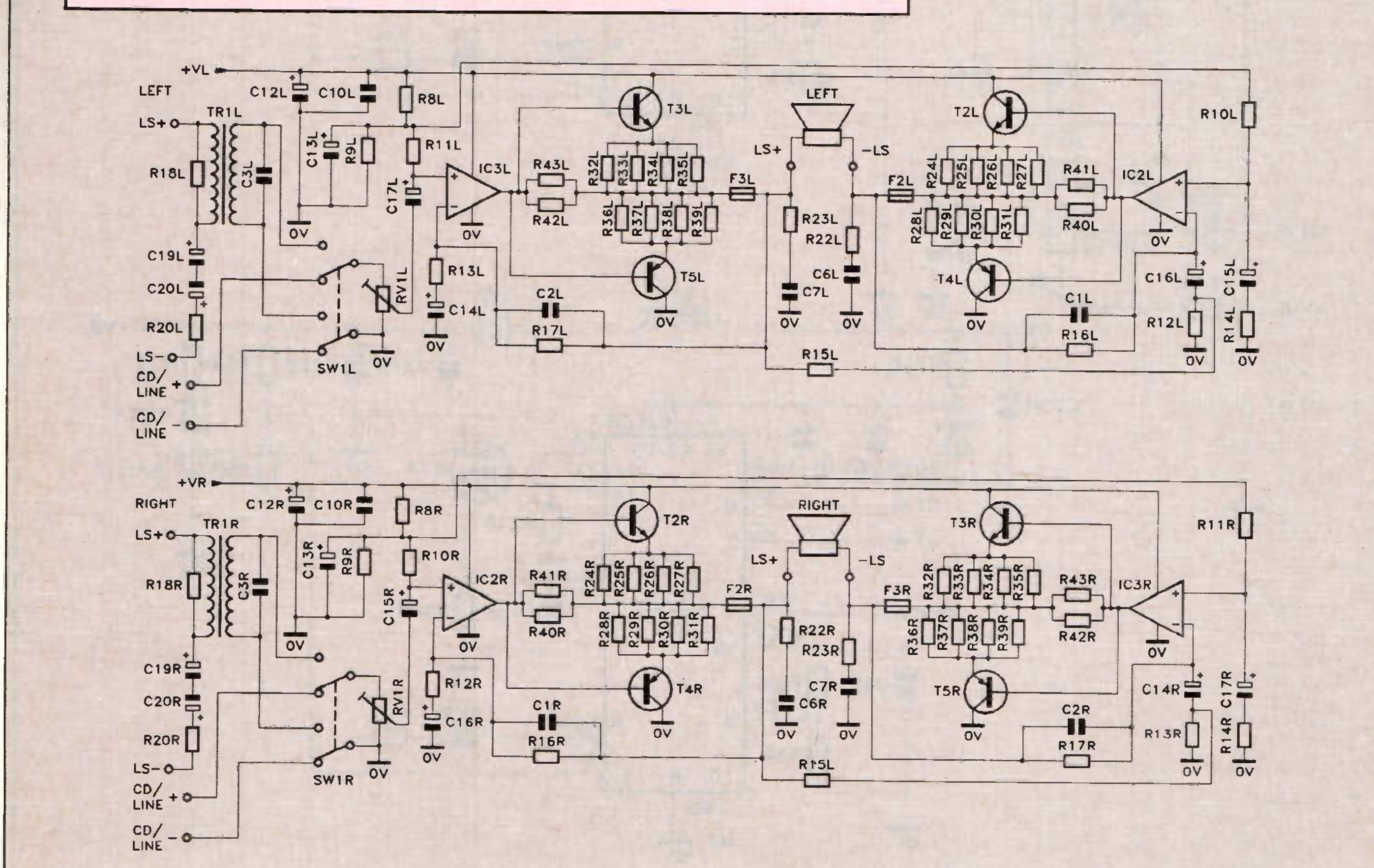


Figure 2. Power amplifier circuit diagram.

existing wiring looms, or via a carefully positioned new hole in the bulkhead.

Find a suitable mounting position to install the amplifier, such as under the seat, in the boot, or under the rear parcel shelf. Holes are provided in the front and back panel of the amplifier for fixing using 'L' shaped brackets. Ensure the amplifier is given enough air to 'breathe' as, at high volume levels, heatsinks can get quite hot.

Check behind panels before drilling any holes, and ensure that no wiring harness or other components are located behind the panels that might otherwise be damaged.

Connect the loudspeakers to the terminals LS RIGHT and LS LEFT using sufficiently thick cable (remember, 100W into 4Ω gives a current flow of 5A).
DO NOT try to simplify the wiring by connecting the negative terminal of the loudspeaker(s) to the vehicle's chassis, as this can damage the amplifier.

Loudspeakers should be suitably rated for high power use. Beware, many car loudspeakers are given misleadingly high power ratings, so try to find out what the true RMS ratings are. Many car loudspeaker ratings are given in peak power; be prepared to divide the rating by 1·4 or even 2·8!

Connect the POWER SUPPLY (+) and (–) terminals direct to the battery posts using wire capable of carrying in excess of 20A (e.g., HC Wire Red and Black, stock code XR59P and XR57M respectively).

With reference to Figure 3, the POWER SUPPLY SW connection should be wired to a source of +12V when the radio/cassette player is on. Some front-end units have a switched output to control external power amplifiers, and it is to this wire that the SW terminal should be connected. Alternatively, connection can be made to the power antenna output provided on most radio/cassette players. However, with some radios, this terminal may only be active when the radio is on and not when the cassette deck is playing.

Another method is to connect the SW terminal to a source that is switched to +12V when the ignition key is moved to position 'ACC' or 'IGN', see Figure 4. Only the SW terminal can be switched, you must not attempt to route the main supply wires via a switch. The amplifier's supply wires must connect directly to the battery. The actual on/off switching of the amplifier is then carried out internally under control of the SW input line.

There are two main methods of connecting the signal output from a radio/cassette player to the K3503 Amplifier:

1. Connect the loudspeaker outputs of the radio to the connector marked LOW using figure–8 cable. If the speaker outputs share a common earth, follow Figure 5, otherwise connection should be made according to Figure 6.

2. Connect the line output (pre-amplifier output) to the DIN connector marked LINE/CD, using screened wire. Ideally use a separate cable for the left and right channels, as shown in Figure 7. If space and cost are at a premium, four-core

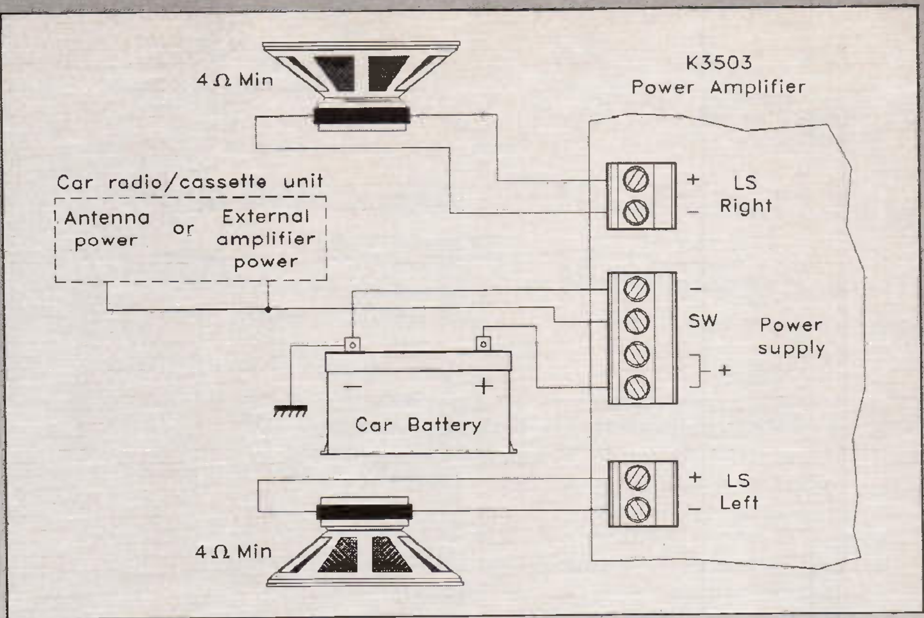


Figure 3. SW connection made to the radio/cassette player.

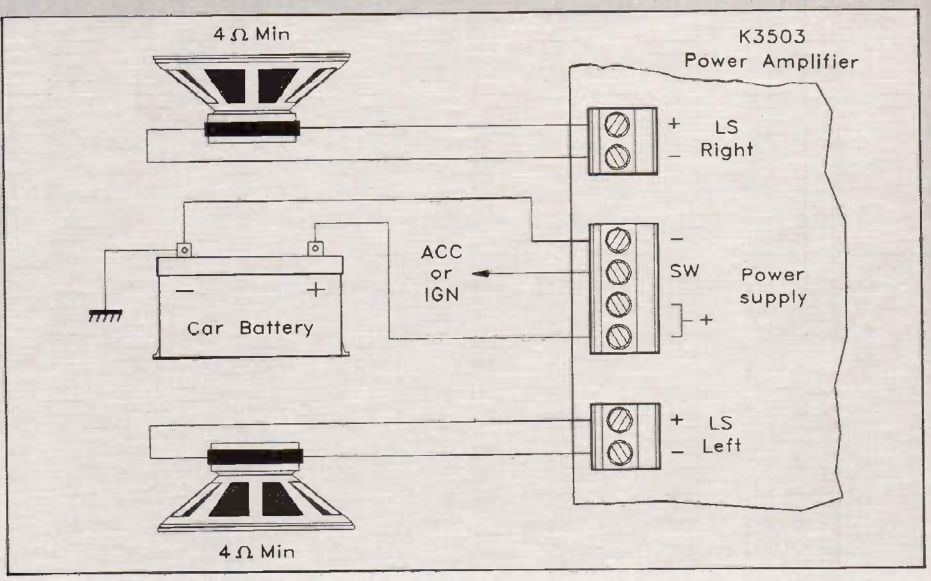


Figure 4. SW connection made to a switched source of +12V.

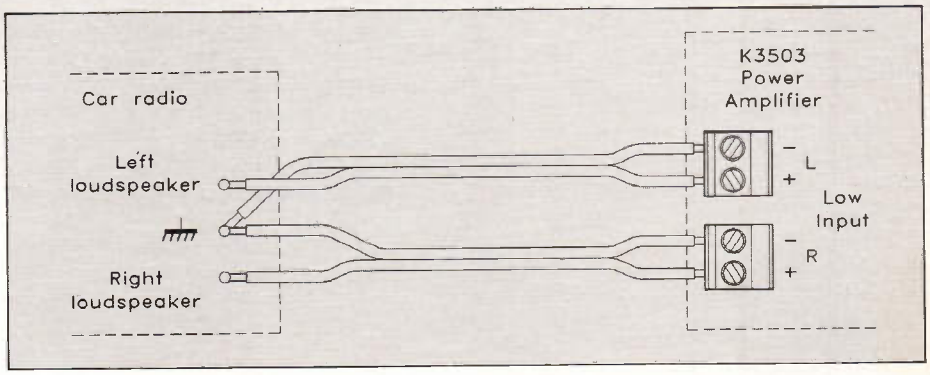


Figure 5. Common-earth loudspeaker outputs connected to the K3503.

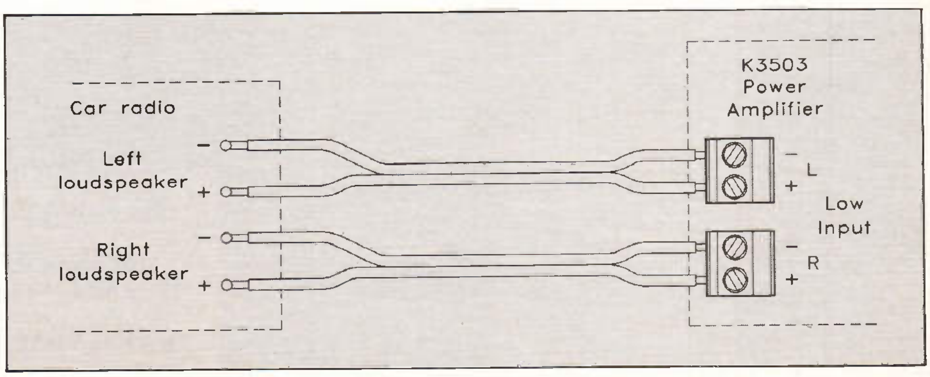


Figure 6. Separate-earth loudspeaker outputs connected to the K3503.

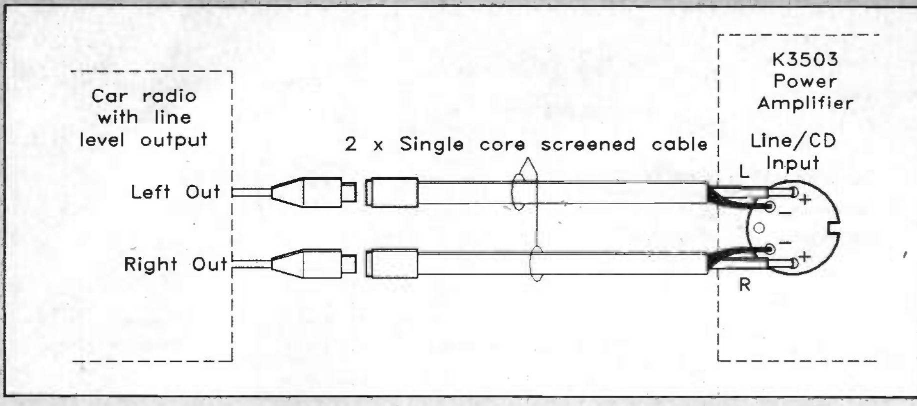


Figure 7. Line-level connections to the K3503 using separate cables.

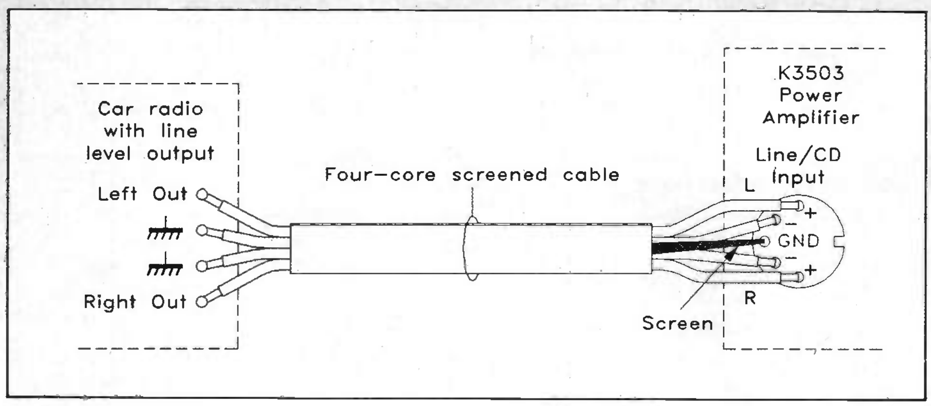


Figure 8. Line-level connections to the K3503 using overall screened cable.

screened cable may be used. However, note that the screen is only connected at the amplifier end, see Figure 8.

When making connections to the K3503, try to run the input signal cables as far away as possible from the main power supply cables. Ideally, the power supply cables should be run down one side of the car and the signal cables down the other.

Select the desired input, LOW or LINE/CD, with SW1 and turn the radio on. After a couple of seconds, the two power supply indicator LEDs should illuminate. Using a small screwdriver, adjust RV1L and RV1R so that a wide volume range is easily provided through the volume control of the radio/source device.

It should be pointed out that excessive sound pressure levels may lead to long term, irreversible hearing problems. High levels of sound may also blot out other external sounds and impair your hearing ability whilst driving, and could be dangerous when on the move.

Availability

The Velleman K3503 is available as a kit from Maplin Electronics by mail-order or through their numerous regional shops.

STEREO 100W CAR AMPLIFIER PARTS LIST

RESISTORS		
R1	8k2 5%	1
R2L,R2R	4k7 Metal Film	2
R3L,R3R	5k6 Metal Film	2
R4L,R4R	33k Metal Film	2
R5L,R5R	22k Metal Film	2
R6L,R6R	2k Metal Film	2
R7L,R7R	390Ω 5%	2
R8L,R8R,R9L,R9R	22k 5%	4
R10L,R10R,R11L,R11R	47k 5%	4
R12L,R12R,R13L,R13R	1k Metal Film	4
R14L-R17L,R14R-R17R	10k Metal Film	8
R18L,R18R	15Ω 5%	2
R19L,R19R	4Ω7 ½W if 12V supply	2
R19L,R19R	220Ω ½W if 24V supply	2
R20L,R21L,R20R,R21R	120Ω ½W	4
R22L-R39L,R22R-R39R	1Ω ½W	32
R40L-R43L,R40R-R43R	2Ω2 1W	8
R44L,R44R	Resistor Wire	15cm
RV1L,RV1R	47k/50k Pre-Set	2
CAPACITORS		
C1L,C2L,C1R,C2R	220pF Ceramic	4
C3L,C3R,C4	3n3 Ceramic	3
C5L,C5R	4n7 Ceramic	2
C6L,C6R,C7L,C7R	220nF Poly Layer	4
C8L-C10L,C8R-C10R	100nF Capacitor	6
C11L-C17L,C11R-C17R	22μF Electrolytic	14
C18L,C18R	1nF Ceramic	2
C19L,C19R,C20L,C20R	220μF Electrolytic	4
C21L,C21R,C22L,C22R	470μF Electrolytic	4
C23L,C23R	1000μF Electrolytic	2
SEMICONDUCTORS		
D1L,D1R	1N4148 Series	2
D2L,D2R	1N4000 Series	2
D3L,D3R	MUR1510	2
ZD1L,ZD1R	16V Zener	2
ZD2L,ZD2R	20V Zener	2
T1L,T1R	IRF540	2
T2L,T3L,T2R,T3R	TIP41	4
T4L,T5L,T4R,T5R	TIP42	4
LD1L,LD1R	Round LED	2
IC1L,IC1R	3524	2
IC2L,IC3L,IC2R,IC3R	TDA2030	4
MISCELLANEOUS		
L1L,L1R	50μH/10A Coils	2
RY1L,RY1R	Relay	2
F1L-F3L,F1R-F3R	20mm Fuse Holders	6
	15A Slow Fuse	2
	5A Fast Fuse	4
S1,S3	Four-Pole Screw Terminal	2
S4L,S4R	Two-Pole Screw Terminal	2
TR1L,TR1R	LT44 Separation Transformer	2
SW1	Four-Pole Toggle Switch	1
S2	5-pin DIN Socket	1
	Front Panel	1
	Back Panel	1
	Front Panel Sticker	1
	Back Panel Sticker	1
	Extruded Cooling Fins	2
	Case Top/Bottom	2
	Self Tapping Screw	16
	Insulation Tube	16
	Lockwasher	18
	12mm M3 Bolt	16
	15mm M3 Bolt	2
	M3 Nut	18
	15mm M3 Spacer	2
	Mica Insulator Washer	16
	Eyelet Crimp Terminal	2
	IC Sockets	2

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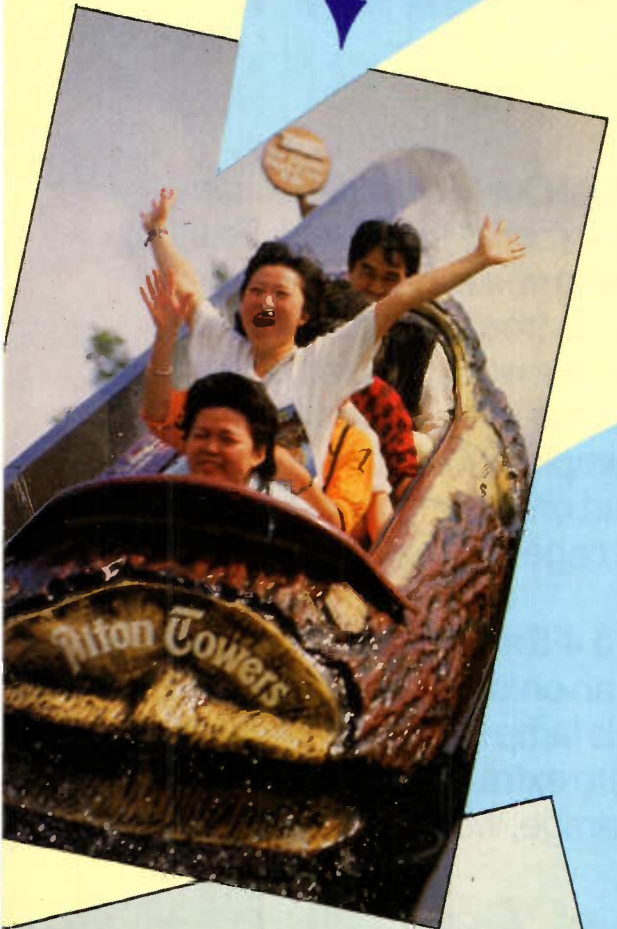
Inspection lamp... Inspect our price!

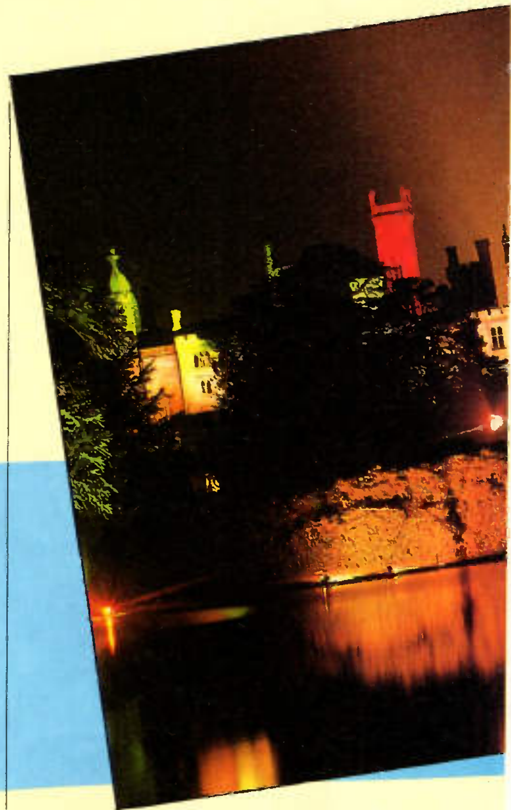
Taken for a ride at Alto



What have the following in common? The Corkscrew, Dragon Rollercoaster, Thunderlooper, Giant Log Flume, Skyride? You've guessed it – these are but some of the 125 or more attractions at Britain's top theme park, Alton Towers. If you didn't get the correct answer, many others would. Over two million visitors enjoy the Alton experience, 'where wonders never cease', each year. The park, situated in the beautiful Staffordshire countryside (well that's what the brochure says) is rated among the world's top *five* theme parks. In fact the 500 acre estate is Britain's top ticket attraction outside London.

Long before today's park was created, the estate was the home of the Earls of Shrewsbury, and renowned for its beautiful landscaped gardens and the awesome grandeur of The Towers themselves, once the largest, privately owned family home in Europe. The façade that forms the impressive backdrop to Alton Towers was the dream of one Charles Talbot, 15th Earl of Shrewsbury. It was this knight who laid the foundations for the magnificent surroundings that can be enjoyed today. His successors carried on the good work and enlisted some of the country's finest architects and landscape gardeners to produce the stunning gardens and grounds of the Alton Estate.

The Estate first opened its gates to the public as far back as Victorian times, over a century ago, when visitors – both local and distant – flocked to see the impressive setting. Quite what they would have made of today's setting however, is a matter for conjecture. Certainly they would be impressed with the general cleanliness – a diligent team of cleaners, as is the case at the Walt Disney complexes, swoop on any litter almost before it can hit the ground. Also they might be grateful for the weather protection. Almost one third of the attractions at Alton Towers are indoors, so even on the wettest days, visitors can still 'have a good day'.



OUT AND ABOUT

...on Towers

Nothing Quite Like It

That there is nothing quite like Alton Towers (outside of the Walt Disney Wonderlands) becomes clear on your arrival. You arrive at the main entrance from the extensive car parks on the Silver Ride Monorail in true space age style. Here a pause is desirable, if only to get your bearings. Attractions come very much 'age and size' wrapped. For children under 14, there is 'Kiddies Kingdom', which includes the Amazing Maze, Cookie Mountain, Fireman's Pole, Astro-Glide, Tarzan Run, Trim Trail and Fun Run to mention but a few. Incidentally, for Maplin model kit enthusiasts, there is even a model radio kingdom. For children under 1·2 metres (presumably in height) there is a Ball Pool, Building Site, Astro-Glide, Bouncy Castle and Net Climb, amongst other things, all of which should keep them happily occupied while you take your turn on the famous Corkscrew Rollercoaster or Octopus.

However, as if 'children grading' was not enough, there are 'themed areas' which include Festival Park, Towers Street, Talbot Street and Fantasy World. Each area provides its own range of rides, shows, live entertainment, restaurants and shopping malls and can be accessed by cable car. There are also fantasy rides like Around the World in 80 Days, (in the high season some of that time might be taken up with queuing), special effects 3D cinema, theatres with delightful dancing waters, an exotic aquarium, Big Top Circus on ice, Motor Museum plus a stunning model railway. Back in the open air, you can enjoy a ride on the Grand Canyon Rapids, the world's longest white water ride; the giant Log Flume (with dinosaurs); the Mississippi Showboat and Jazz Band, and the simply breathtaking Skyride.

where wonders never cease!

Top: Alton Towers, the stately residence. Top left: The Log Flume. Bottom left: The Pagoda Fountain in the gardens. Left: One of the Skyride cars. Right: The Corkscrew ride.

Taking a Ride

Just in case you have granny (as well as the children) with you, there is the TeaCup Ride, the one ride on the Park where you can control just how fast you want to go. Spinning a central wheel controls the speed you travel at. No storm in a teacup this ride.

Also for granny and the kids, there is a full daily schedule of live shows, ranging from live on-stage entertainment to the traditional Grand Parade.

For those visitors who can never get enough shopping, the Park has a fully comprehensive range of facilities, ranging from an Athena poster shop, caneware and exotic gifts shops to pottery, glass and ceramics shops. Certainly the shopping areas have class, as do the mass of restaurants and eating kiosks dotted about the complex. These range from the luxury Swiss Cottage, the Slush Puppy Cafeteria to the Talbot, the biggest fast food restaurant in Europe which, apparently, can feed some 2,000 per hour!

Surprisingly perhaps, peace and quiet *is* available in considerable doses at Alton Towers. You can explore the Gothic ruins which are being extensively renovated, although until this work is completed, you can only stand, climb and admire the grandeur of The Towers at present.

Then there are the gardens. The 200 acre, landscaped gardens are certainly the finest in Europe. They include the spectacular Pagoda Fountain, the Chinese Temple and the Grand Conservatories. There are thousands of trees, shrubs and flowering plants, which include both native and rare, exotic species. The gardens date back to the 19th Century, and are open every day of the year (except Christmas day), and present a surprise around every corner. For those wishing to be organised, there are signed nature trails which lead from the gardens into 200 acres of natural woodland.

High Tech Back Stage

High technology may not be overly obvious at Alton Towers, but it is certainly present. It is also somewhat spread about, having to cover all the 500 acres. As Alan Brown, Operations Director, confirms, they take their electricity supply from both Midlands and East Midlands companies. "If we have a power failure, we can change the whole ring main in the Park within 15 minutes". A more than comforting thought if you happen to be stranded at the top of some exotic ride!

In actual fact high tech drives the whole complex. The Monorail, for example, has its own on-board computer system. Here eight trains operate a closed loop system, with the computers ensuring that no one train can catch up with another. The system monitors the position of each train as it approaches the rear of the previous train, automatically slowing it down if necessary. But just in case, says Alan "we keep an operator on each train who can manually take over if needs be. The control system for rides such as the Skyride and Aerial Ropeway are driven by DC motors through a series of control driven thyristors. These can smoothly vary the speed up or down from full-speed to stop without any strain to the system."

We Count them In – and we Count them Out

In a complex as extensive as Alton Towers, it is essential to keep tabs on the numbers of visitors, says Ian Ineson, Management Information Services Manager. A TOR computer admission system monitors this by means of multiple terminals at the entry gates, and provides an up-to-date total of the number of people present. "At any one time, we can tell how many tickets are sold, and analyse them into categories such as senior citizens, and children. When not counting admissions, the DOS and UNIX PC based real-time system provides data on finance, marketing, merchandising and catering.

"In fact there are 19 PCs permanently on-line to a master computer, plus back-up connected to tills throughout the complex."

At present most of the administrative PCs are stand-alone, but Ian states that there are plans to introduce networking in the near future. Meanwhile, he is looking to link the arcade games via local PCs in order to download usage. The system will monitor the profitability of each machine and sound alarms should the coin box become full or non-operative. Though whether the envisaged system is being designed to combat the professional player is not revealed!

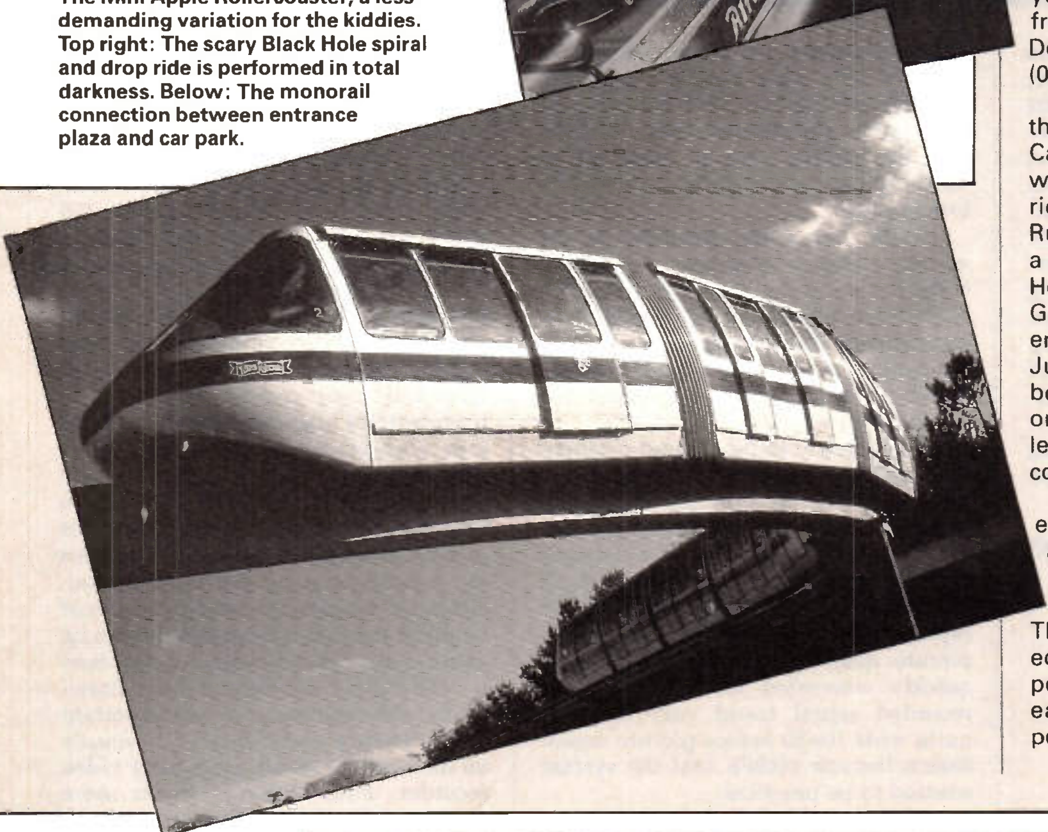
Safety First and Fast

Safety on the rides is paramount at Alton Towers. As Brian Ward, Director of Security and Control, a role which embraces both admission and medical services, confirms, safety comes first. "We operate a rescue team which can evacuate stranded passengers on such high rides as The Skyride and The Rollercoasters in a matter of minutes (although it could seem slightly more than minutes to those unfortunately involved in an incident). The rescue teams, who practice regularly and are drawn from all departments, include individuals with mountaineering skills."

This is particularly comforting when you take a ride in one of the Skyride gondolas. The French-style operating system is very much reminiscent of a ski gondola, except that, rather than piped edelweiss, there is pop music. The gondolas pass over woods, precipices, woods and lakes. When it glides to a halt above a vast chasm, it might be comforting to know that Brian's team do regular maintenance checks every day. Also fear not that you could be left behind in the park. Brian has a special team of guards checking the grounds at closing time as well as regular security teams operating 24 hours a day. Backing this activity are numerous security cameras and fire detection alarms which link to a central security centre. There are also two State Registered Nurses on site permanently, with two doctors on call.

Whether their services were

Left: 'Towers Street', a fairyland setting of cafes and shops. Above: The Mini Apple Rollercoaster, a less demanding variation for the kiddies. Top right: The scary Black Hole spiral and drop ride is performed in total darkness. Below: The monorail connection between entrance plaza and car park.



called for at last year's Firework and Laser spectacular is not revealed. However, for two nights some 27,000 visitors crowded into the Park to see one of the countries most spectacular displays. At Christmas time, when the rides are closed, the Park becomes a Winter Wonderland redolent with Santa and his merry team of helpers, festive shops and a spectacular ice show.

It's a Royal Knockout!

The Park also hosts many events ranging from that famous 'It's a Royal Knockout' starring many members of the Royal Family, to the Radio One Roadshow and classical concerts. Celebrities visiting the Park have included Kylie Minogue, the Chippendales and Eddie 'The Eagle'.

It takes some 1,200 supporting staff to run Alton Towers at the height of the season. You only have to pay the admission price and the Park is yours. All rides and attractions are free, as is the extensive car park. Details of rates etc. are available on (0538) 702200.

This year sees the opening of new themed areas including The Katanga Canyon, a Colonial African village area which incorporates two spectacular rides – Congo River Rapids and a wild Runaway Mine Train ride. There is also a specially commissioned Haunted House ride in the eerie depths of Gloomy Wood, but be warned, you enter on individually controlled cars. Just the place for you and your special boy or girl friend before you take them on to Thunder Valley and the challenge of the Thunderlooper rollercoaster.

However, 'Electronics' has an even greater challenge for you. Just answer correctly the four questions below, and you could find yourself winning a free visit to Alton Towers. The first correct entry drawn out of our editors hat will win entry tickets for 4 people. The next two runners-up will each receive free tickets for two people.

Get entering now!

Alton Towers Competition

To win tickets for Alton Towers, send your entries (remember please your name, address and 'phone number) to:

'Alton Towers Contest', The Editor, Electronics – The Maplin Magazine, P.O. Box 3, Rayleigh, Essex, SS6 8LR.

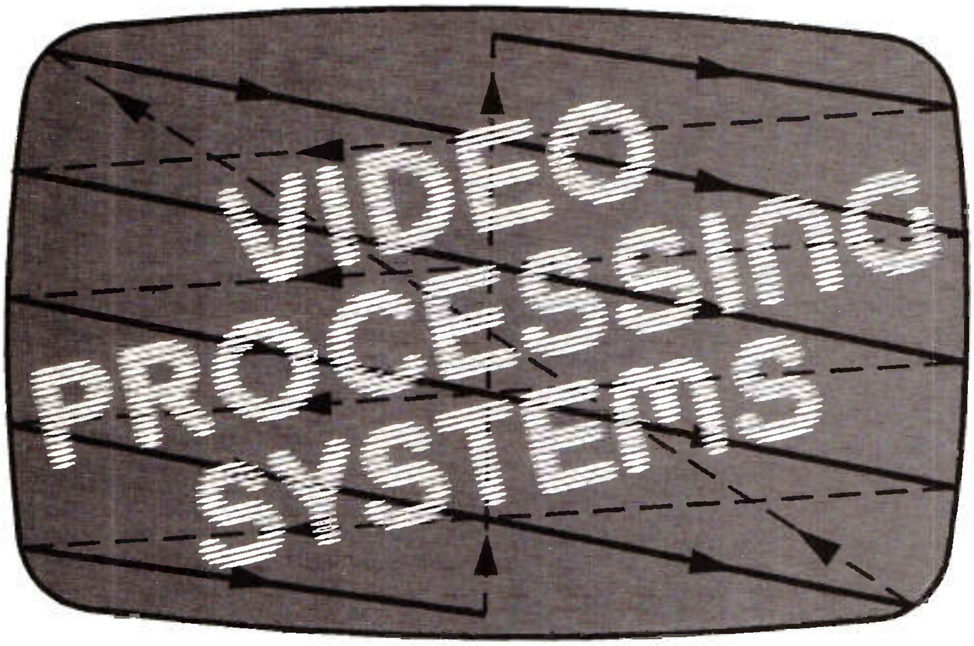
Please note: the contest closes 31st July 1992. Employees of Maplin Electronics and members of their families are not eligible to enter. In addition, multiple entries will be disqualified from the draw.

1. What is the approximate mileage from London to Alton?
a) 50 miles,
b) 200 miles,
c) 400 miles.

2. What term best describes the Park?
a) Magical Kingdom,
b) Faulty Towers,
c) A Staffordshire Rodeo.

3. Is the Corkscrew a
a) Feature of the World's largest fast-food restaurant,
b) A description of the roads leading to Alton,
c) The name given to a popular ride at the Park?

4. Who was Charles Talbot?
a) A pioneer of Billingsgate market,
b) The 15th Earl of Shrewsbury and founder of the Park,
c) The designer of the well-known sports car.



Part Four by J. A. Rowan

As mentioned in a previous issue, the early 50s saw the United States having a problem with television output. Apart from films and a few special television shows recorded onto film, all output was live. The network system was expanding and attempting to transmit its live shows throughout the country. However, the enormous time differences across the USA meant that trying to fit shows into particular time-slots was a non-starter. The pressure built up to develop a quick and easy means of recording and replaying video as conveniently as sound. Appropriately, it was a company in the sound recording business, Ampex, who were first to take up the challenge.

> *With video the problem is far worse; (recording) a frequency range of 50Hz to 4·2MHz being necessary for NTSC, with PAL extending to 5·5MHz. Simple record and replay would require a S/N ratio of over 100dB, which is not possible . . .*

There were two big problems: firstly, a video signal has a very wide bandwidth compared to sound, more than four megahertz for the 525 line system as opposed to the twenty or so kilohertz required for good-quality audio recording. Secondly there was the more subtle problem of having a much greater 'highest to lowest' signal frequency ratio, or bandwidth. If various frequencies are recorded on a magnetic medium at a constant flux level, then the amplitude of a replayed signal will be proportional to its frequency. The record/replay process has a finite signal to noise ratio, and this limits the dynamic range of the replayed signal. In other words, a replayed 20Hz tone will be $\frac{1}{1000}$th the level of a 20kHz tone, or 60dB lower. If the system signal/noise ratio is 60dB and the 20kHz tone is recorded at maximum level, the 20Hz tone will be lost in noise.

With video the problem is far worse; a frequency range of 50Hz to 4·2MHz being necessary for NTSC, with PAL extending to 5·5MHz. Simple recording and replaying would require a signal to noise ratio of over 100dB, which is not physically possible at this sort of bandwidth.

The answer to the second problem is to shift the frequency range until the maximum-to-minimum ratio is much smaller, about two or three to one. Various modulation systems exist, and initially AM was tried. However, there proved to be too much variation in replay level to achieve acceptable picture quality, and the system was quickly converted to FM. Now the recorded signal could vary between quite wide limits before picture degradation became visible, and the system seemed to be practical.

Unfortunately, the solution to the frequency ratio difficulty made the first problem worse. Moving the recorded frequency upward meant that even higher frequencies had to be recorded, but at least this problem could be solved by a great enough effort, whereas recording and replaying baseband video on a magnetic medium was simply impossible. The problem now was that the smallest possible piece of recorded information, in other words a half-cycle of the highest frequency, must magnetise at least one unit of the magnetic material on the tape. At that time this was basically a rust particle, ordinary iron oxide being the material used for sound recording tapes. Therefore the tape had to pass the recording head at about *40 metres per second* if the highest FM signal was to be recorded. Yes, that's metres, not millimetres! The BBC had experimented with a high-speed transport of this sort, but the machine was not very practical and extremely dangerous. Nobody was allowed in the room while it was running, for obvious reasons.

Quad – The First VTR

Lateral thinking was, literally, brought into play. If the tape could not be moved that fast, then perhaps the recording head could. The result was the Quadruplex system, using two inch

> *The (Quad) was huge and mechanically very complex. The bearing for the head wheel ran at 15,000 rpm and used compressed air as a lubricant. To maintain correct head-to-tape contact, the flat tape had to be deformed into a curve . . .*

wide tape and four heads mounted on a disc, or wheel, which turned at right angles to the direction of tape movement. The head wheel rotated 250 times per second and laid down a recorded track about 45mm long across the tape, giving the required head-to-tape speed. The machine was huge and mechanically very complex. The bearing for the head wheel ran at 15,000 rpm and used compressed air as a lubricant. To maintain correct head-to-tape contact, the flat tape had to be deformed into a curve, and this was done using a vacuum system. A single machine, therefore, needed two air pumps in addition to the mechanisms for actually moving the tape around, although savings in weight and cost could be made in a large installation by using central air and vacuum supplies!

The Quad system had many drawbacks, although this was not important as, for twenty years, there was simply *no* alternative, broadcast-quality video recorder. Four different heads were used, and the drives and equalisation had to be accurately matched in order to prevent visible picture defects. Recording was in bursts of about 1mS, with an average of 15·625 lines recorded in PAL by one head before the next took over. Naturally, switching between heads during active video time was not possible, and it was done during horizontal blanking. Each head therefore recorded either 15 or 16 lines at a time. Any mismatch between heads appeared in the picture as horizontal bands, and a head clogging with oxide would cause noise bands. This was not an unusual sight, and usually resulted in a 'Do not adjust your set' message while the head was cleaned or, in extreme cases, the tape was dismounted and moved to another machine. Another problem with the format was that of optimising video performance; the long, narrow oxide particles were laid down on the tape sideways. The audio channels were still recorded longitudinally and had to make the best of it, but audio frequency response and signal-to-noise ratio were poor, even at 38cm/sec. linear tape speed.

A drawback of the very short recorded track was that if the tape was stopped or wound forward or backward quickly ('shuttled'), the picture broke up and became difficult to see. Tape editing was very primitive to begin with, literally being done with a razor blade as with sound tapes. More precise editing requires that the tape be moved quickly to the approximate area of the edit and then stepped forward and backward a frame at a time to find the exact point. This is no problem with film of course, but a Quad with the tape stopped would be able to display only one *twentieth* of a field, making recognition of the edit point difficult! Hence when electronic editing became available, it was still only possible to mark the edit point 'on the fly', that is, with the tape running at normal play speed. When this was done, both VTRs could be rewound and restarted, and the edit could be 'rehearsed' by having the picture monitor of the edit record machine switch to the other machine's replay at the marked edit point. After several tries, nudging the edit point a little either way on each machine, the editor was satisfied and the machines were run again, this time switching the edit machine to record at the mark.

Helical Scanning

The Quadruplex VTR was a wonderful machine, but its enormous cost and sheer size meant that it was very definitely for broadcast use only. It also required constant supervision and adjustment before and during use, and careful cleaning afterwards. Video would be a very useful tool in industry, education and many other areas, not to mention in the home. Once again the pressure was on, this time for a more affordable and less temperamental type of VTR. Ampex themselves worked on the problem, along with the other manufacturers building Quad VTRs. In addition, of course, these other companies were hoping to hit on a cheaper broadcast quality format that would sweep away the Quad and, more importantly, the licence fees they paid to Ampex. The principle of the moving head had to be retained, of course, but it needn't rotate sideways or require such wide and expensive tape. The angle of head rotation could easily be reduced from 90 degrees to a much lower value. The resulting 'helical scan' could work on one inch tape, but the length of the track would obviously increase greatly. Many combinations of head wheel diameter, head width, track angle and speed of rotation were possible, but ideally a video field should no longer be broken up by head switching, but should be recorded in a single pass of a single head. This would allow recognisable pictures to be available with the tape stopped or in 'shuttle', and would greatly simplify editing.

Helical scan machines had two major problems. The head wheel was much larger but turned very much more slowly, reducing the angular momentum considerably. More importantly, the recorded track was very much longer than that of the Quad, and the polyester material used for the tape backing was not noted for its stability under varying tension, temperature and humidity. Timebase errors (the video equivalent of wow and flutter) were therefore very much larger than with the Quad machine. The great length of the track also caused compatibility problems in track following. Two machines had to support the tape in exactly the same way, and the diameters of their head wheels and the positions and orientations of their axes had to be very nearly identical if a track recorded by one machine was to be accurately replayed by the other.

“The available bandwidth was far too low for colour, until 'heterodyne colour' made the cheap colour VTR possible. The actual performance of heterodyne is not very good and indeed it is a wonder that the system works at all. All domestic VTRs are heterodyne colour . . . ”

Getting the Colour onto Tape

Black and white, low-bandwidth industrial helicals came first, since any kind of easily recorded and replayed pictures were better than overhead projector slides for training and for distributing product information within an organisation. Timebase stability was irrelevant, and the track length for this type of recorder could be kept short enough to allow reasonable interchange between machines. The available bandwidth was far too low for colour, until the brilliant idea of 'heterodyne colour' was born (that is, two comparatively low-frequency signals being mixed to produce a summed higher frequency signal, see separate text). However, as previously mentioned, colour decoding requires better-than-crystal stability of the subcarrier frequency and phase, and even Quads came nowhere near this. The expensive broadcast answer was to use a timebase corrector, a device which takes unstable video and makes it stable. Even today, the price of a timebase corrector is likely to exceed that of the VTR with which it is used, and it was totally out of the question to use one with a relatively cheap helical machine.

Heterodyne colour made the cheap colour VTR possible. Chroma bandwidth is seriously restricted by the low heterodyne frequency, and the old problem of maximum and minimum recorded frequencies still causes trouble. Even when recorded at high level, with the luminance FM signal acting as bias, the heterodyne signal still comes off tape at a rather low-level, with a poor signal-to-noise ratio. In addition, being an AM signal, it suffers badly from poor head-to-tape contact, drop-outs and interference from other signals. It is not surprising, then, that the actual colour performance of heterodyne, or 'colour under', machines is not very good and indeed it is a wonder that the system works at all. All domestic VTRs are heterodyne colour machines.

The Arrival of the Cassette

Video cassette recorders first arrived as professional machines from Japanese manufacturers. The U-Matic format uses three-quarter inch tape and mains-powered versions can record up to one hour. Portables use the smaller of the two cassette sizes, recording for twenty minutes. U-Matics were originally used for news gathering, where this rather short time limit is not a problem. PAL U-Matics are further divided into high-band and low-band, which refers primarily to the FM frequency range used. High-band machines also have a higher colour heterodyne frequency, and their improved performance led to their being described as 'broadcast' machines. They have certainly been used in the UK to record material which was later broadcast, and not only news pictures, but their performance comes nowhere near that of a true broadcast VTR. Today, the state-of-the-art in colour under machines is the high-band SP U-Matic, using metal particle tape.

Developed from the U-Matic was the Betamax domestic VTR, with the VHS system appearing at about the same time. Both used half inch tape and had many similarities. Both used a low tape speed to keep costs down and allow an adequate recording time. They therefore used very narrow tracks, a low FM frequency and a low heterodyne frequency. For no very obvious reason, it is VHS which has taken over the world.

The two major analogue component (YUV) recording systems have much in common. Originally based on VHS and Betamax domestic transports, they use half inch tape but with a much higher tape speed than their home video counterparts. Two tracks are recorded at once, one carrying the video luminance signal and the other the chroma, both on FM carriers. The chroma is in the form of U and V components, and to record both together they are time-compressed by a factor of two. The second generation machines can handle a full PAL luminance bandwidth and are considered to be of broadcast quality. In a previous article of this series, the much greater flexibility achieved by handling video in YUV form has been discussed, and the use of these machines is increasing rapidly, among both broadcasters and serious industrial users.

Broadcast Quality VTRs

They are not the first helical scan VTRs to make it into the broadcast world however. In the late seventies, Ampex had pushed their one inch industrial format to the edge of broadcast standards, and were in the process of agreeing a further improved version jointly with Sony. To achieve the necessary head-to-tape speed while recording one track per field, the tape was wrapped almost all the way around

> *"The high speed required to record video had been achieved by moving the* head *quickly rather than the tape. If the track deviated, then why not move the head to follow it? This breathtakingly preposterous idea led to the video head being mounted onto a rather complex piece of piezoelectric material (which) could be waggled by an applied voltage . . ."*

a large head drum, and recording took almost a full revolution of the drum. Most industrial helicals used two heads and recorded a field in half a revolution of the drum, but a direct colour machine needed a much higher head-to-tape speed. The timing errors had been solved by digital timebase correction, and the problem of following such an enormously long track (about 45cm) had received a large chunk of very lateral thinking.

The high head-to-tape speed required to record video had been achieved by moving the *head* quickly rather than the tape. If the recorded track deviated from the normal path of the head, then why not move the head to follow it? This breathtakingly preposterous idea led to the video head being mounted onto a rather complex piece of piezoelectric material. This could be waggled by an applied voltage, and if it were possible to find out where the track was, then the head could be made to follow it. A low-level sine wave of a few hundred hertz was applied to the piezoelectric crystal and the replayed FM signal off the tape was monitored. If the head was centred on the track, then the level would drop off equally at either peak, or extreme head position, and the frequency of the variation would be twice the original 'dither' frequency. If this were not the case, then the servo voltage to the head would be altered to achieve it. If the loss of signal was small, there should be no picture disturbance. Amazingly enough, the idea was a great success, and the tape interchange problem between different machines was solved.

This head moving system had other advantages. The angle of the track laid down by a helical scan VTR depends on both the movement of the drum and that of the tape. If the tape is played back at a different speed, the head can no longer follow the track, but runs off the edge and into the next track. Usually, the next video field is very similar, so the resulting picture looks complete except for a horizontal band of noise. If the speed is very much different from normal, as in shuttle, several tracks may be crossed and several noise bars may appear. A movable head can follow the correct track for small variations in speed, and can either miss out or repeat fields where necessary to maintain a rate of fifty per second. The VTR can then replay noise-free pictures, usually from normal speed in reverse up to three times normal speed forwards.

There is more to it than that, of course: the head will only scan exactly the right length of track at normal speed, and a non-standard speed will result in the wrong number of lines being replayed per field. Part of the picture at one end of the scan may be lost, or extra lines may appear. The wrong field/PAL ID/eight field sequence may occur. A suitably designed time-base corrector is required to sort these matters out and produce a broadcastable picture, but it is the movable head that has made it possible at all. The technology has since moved on from broadcast VTRs to colour under machines and component recorders, and may even be used on up-market domestic and semi-professional machines.

One interesting spin-off of this is the use of a moveable head to achieve the exact opposite of slow motion. Film animation techniques require a film to be exposed one frame at a time while either drawings are exchanged or models are moved. A VTR can be made to record a single field or frame, but if the tape is not moving then the track angle is wrong and normal-speed playback results in a noise bar. Time-lapse VTRs for security purposes do this, and as long as most of the picture is identifiable, nobody minds too much. If, however, a movable head is used and is deflected correctly during recording, then a reasonably accurate track can be laid down, and replay can be noise-free. Such animation recorders do exist, but their development costs must be recovered from a relatively small user market, and they are extremely expensive.

In video production work, a VTR by itself is of use only for recording. If playback video is required as a source for further processing or for transmission then a timebase corrector (TBC) is necessary. Mechanical instability occurs with all VTRs, and machines of different types have characteristic timing problems. The Quad VTR, for instance, has basically very small errors, but each head switch point causes a sudden jump in video timing. Direct colour TBCs must keep subcarrier phase errors down to a degree or two, whilst colour under VTRs produce stable playback chroma and have no such problems.

The Development of TBC

Time Base Correction (TBC) involves the removal of short-term timing errors, keeping the long-term playback video frequency within normal PAL tolerances and finally, actually synchronising the corrected video to the other video sources with which it may be combined. The video signals cannot of course be advanced in time, so the removal of timing errors is carried out by delaying the playback video by varying amounts. The VTR must be persuaded to produce its video earlier than required, and, if the TBC has a limited correction range ('window'), then the amount of VTR advance should be about half the TBC storage

> *"The earliest TBC was a device used to stabilise the output of a monochrome Quad VTR. The VTR servos were driven to replay video only a microsecond or so before it was required, and the TBC only had this sort of window size."*

capacity. Most TBCs today can store at least one complete frame of video, so in theory the VTR can run free and the TBC will still be able to produce video synchronised to the local sources. In practice, the audio output of a VTR will not normally be delayed in any way, for if the TBC video delay is significant then lip-sync problems can occur, particularly in multi-generation work. In addition, every now and then the TBC would have to repeat or drop a field or even a frame, and this would be visible if the picture contained fast-moving details. The VTR is therefore usually driven by a reference sync signal produced by the TBC, typically about 12 lines earlier than local video.

The earliest TBC was a device used to stabilise the output of a monochrome Quad VTR. The VTR servos were driven to replay video only a microsecond or so before it was required, and the TBC only had this sort of window size. This was all that was necessary, fortunately, as the actual delay was achieved using analogue delay lines, switched in or out of circuit during horizontal blanking. Fine continuous adjustment was carried out by a delay line built using varicap diodes giving voltage control of delay. The resulting error after correction was only a few nanoseconds, but this device was still not adequate for colour playback. Off-tape errors can only be measured by examining sync pulses or colour bursts, and the error which builds up between one sync pulse and the next is enough to cause subcarrier phase problems. This error is due to the instantaneous velocity of the video head differing from that during record, and the 'velocity compensator' was therefore developed to remove this error. The assumption was made that the head-to-tape velocity remained constant in the short term, and therefore an absolute timing error measured between one sync pulse and the next could be extrapolated to estimate where the next one would be. The varicap delay line of the colour corrector was then driven with a line-period sawtooth signal to vary the delay, so as to remove the velocity error. Naturally the prediction differed somewhat from reality, but the performance of the system was now adequate for colour playback.

" In 1970 the first commercial digital TBC appeared... the BBC and others were also working on TBCs ... the practical problems were considerable, as the 20MHz flash A/D converter chip you can buy today simply did not exist; it had to be made from discrete resistors and comparators. Lots of them. Several boards full were required to produce two or three lines of delay, just about adequate for a good quality helical VTR. "

This TBC had a very limited range, and since the delay lines operated on the analogue signal they degraded it slightly. Increasing the length of the delay would increase the losses and was not practical for more than the couple of microseconds that a Quad VTR needed. The much larger errors of helical scan VTRs needed a totally different correction technique. It should be remembered that the Quad was developed at about the same time as the transistor, and so the early models used valves only.

Semiconductor memory, now cheaply obtainable by the megabyte, did not begin to displace the magnetic cores in computers until more than a decade later, so it is not too surprising that digital methods of delaying video were slow to arrive. It was around 1970 that the first commercial digital TBC appeared, the CVS 500, though the BBC and no doubt others were also working on them at about this time. The practical problems were considerable, as the 20MHz flash A/D converter you can buy today for twenty pounds or so simply did not exist in chip form at any price, and had to be made from discrete resistors and voltage comparators. Lots of them. Early memory chips were not RAM, but simply long shift registers. Several boards full of them were required to produce two or three lines of delay, just about adequate for a good quality helical VTR operating at normal playback speed.

But once the job had been done, even in a very limited way, then the rapid advance of semiconductor technology, to feed the growing computer industry, allowed TBCs to grow as well. Professional recording formats with timing errors larger than those of the Quad, and that means none of them, would be possible without the digital TBC. Domestic VTRs do not need timebase correction unless they are used for video production work, but even so, without the early industrial helicals there would be *no* domestic machines.

Once replayed and timebase corrected, video from a VTR will normally be combined with that from other sources, either other VTRs, cameras or electronic video generators. The device used to achieve this is the vision mixer: not to be confused with the vision mixer who actually operates it and appears in all the TV credits. It can vary from a simple two-channel unit for a low-budget edit suite, right up to the 'spaceship console' type occupying a couple of square metres of desk space, as seen in shots of broadcast studio control rooms.

Mix, Wipe and Key

The basic mixer usually has three types of effects: mix, wipe and key. The mix is called a dissolve in film circles, and consists of one picture fading out as the other fades in. It is actually the easiest effect to produce, and is simply a linear addition of the two channels. The wipe is an equally familiar effect, where one picture is replaced by another along a moving line. This line may be straight, curved, angled or completely irregular, but the effect is still produced in the same way. It is achieved by a fast electronic switch selecting one or other input source according to a particular drive waveform. If, for example, the waveform is a step at line rate, and at the same position on each line, then the picture will be 'split' between the sources by a vertical line through the picture. If the step occurs at field rate, the split will be horizontal. Various combinations of line and field rate waveforms may be used to generate the switching signal and cause the wipe pattern to be diagonal or circular or indeed any shape imaginable. Some small mixers have a fairly limited range of wipes, but have the provision to connect a 'wipe extender' which generates more complex patterns.

The final major effect, the key, comes in several varieties. Like the wipe, it consists of a switch between sources, but this time it is not for the purpose of changing from one picture to another. It is used to overlay part of one picture on another, usually to add a caption or logo. The switching signal is no longer geometric in nature but irregular, and is derived from the picture being overlaid. It may be generated in the mixer or fed in from outside, depending on whether the overlay source can provide a keying signal. If generated within the mixer, the keying signal may either be derived from the luminance level of the overlay signal or from its colour, the latter technique being known as 'chromakey'.

" Some mixers offer spectacularly silly wipe patterns, or even some built-in digital effects. On the whole, these effects will rarely be used, but they do seem to impress a certain kind of producer. "

This is the method used to overlay people onto exotic backgrounds: the people act in front of a solid blue backdrop, and everything in the picture that is not blue is keyed into the background scene. Finally, there may not be an overlay video source at all. Most vision mixers have a colour generator available as a source, and the key signal may simply switch over to this. This allows a simple monochrome character generator or caption camera to produce coloured characters on screen.

A large mixer will usually accept from eight to sixteen sources of video, but not all can be combined at once. There are typically two to four 'mix/effects units', and any two input channels can be assigned to all but one of them. This last unit will combine two of the others, allowing a composite of up to four input channels to appear in the final output. There may be an additional 'downstream keyer', which is a simple key effect added after all other processing. The more complex chroma keyer will normally operate on a mix/effects unit, but there is often a need for a simple caption inserter which does not tie up a whole mix/effects channel. The 'bells and whistles' attached to a mixer can vary, and indeed some mixers are modular, allowing customer selection of options at the time of ordering. A simple synchroniser will allow 're-entry' or the use of the mixer output as a source to itself. Some mixers offer spectacularly silly wipe patterns, or even some built-in digital effects. On the whole, these effects will rarely be used, but they are simple enough to generate and they do seem to impress a certain kind of producer.

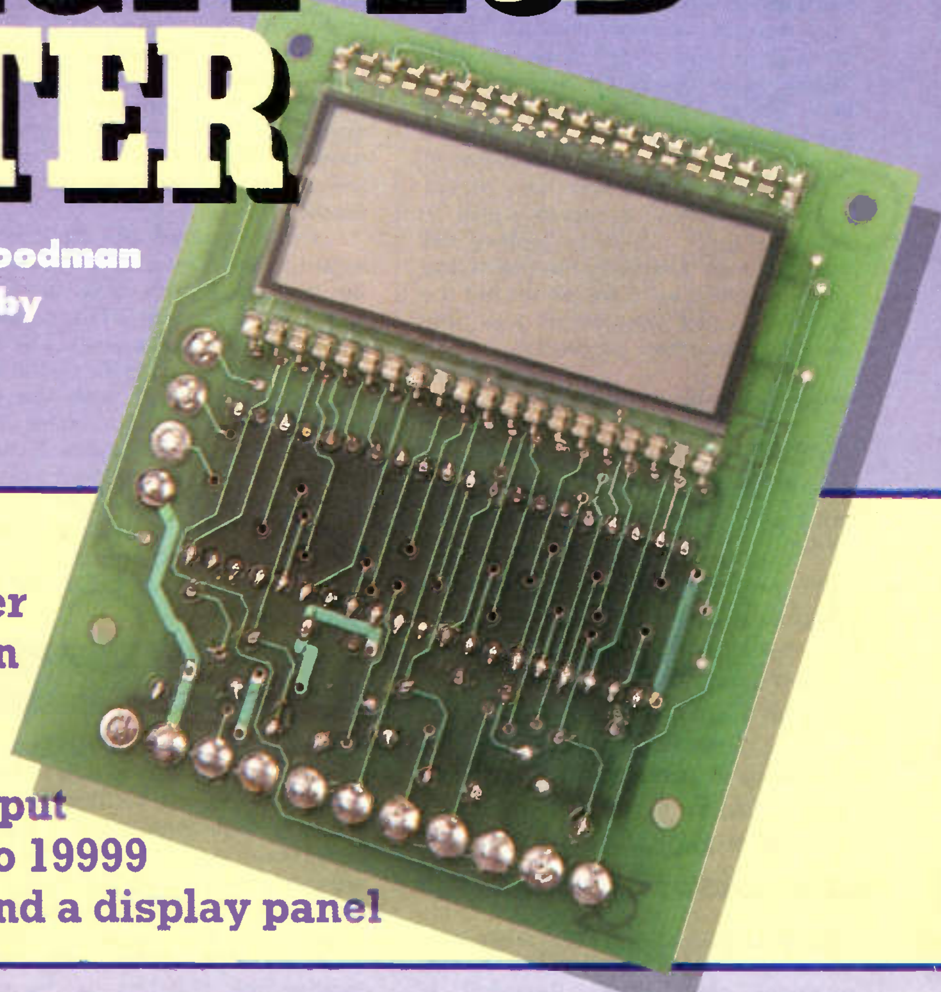
Coming back down to earth, a simple vision mixer is not that difficult

Continued on page 44.

2ND Time Around

Particular projects from the Maplin range have proved themselves to be very popular, but technology and component specifications have a habit of changing, with the result that some of these projects are in danger of becoming obsolete. Even if this were not the case, it may be equally worthwhile improving the project in question in order to increase its versatility and usefulness, and bring it 'up-to-date.' The '2nd Time Around' series is dedicated to reviewing and improving original, popular Maplin projects by republishing them with the necessary updates and improvements, ensuring their continued availability. This time it is the turn of the 4½ Digit Counter.

4½ DIGIT LCD COUNTER



by Mike Holmes and Dave Goodman
based on an original project by
Mark Brighton

FEATURES

- ★ General purpose counter
- ★ Low power consumption
- ★ LCD display
- ★ Buffered inputs
- ★ Schmitt trigger count input
- ★ Will display from 0 up to 19999
- ★ Can be flush fitted behind a display panel

This is a simple 4½ digit counter intended for general purpose applications, which was first published in the March 1987 issue of 'Electronics'. It can be used either as it stands or in the form of a 'building block' module where a counter function is required as part of a larger system. Please note however, that it is not a complete frequency counter or a timer in its own right, but it can be used in these applications if provided with the necessary external gating signals as supplied by a separate timebase of some description.

The counter is built around the ICM7224 IC, which actually contains all the essential circuitry to operate as an incremental counter and simultaneously drive a 4½ digit LCD. The chip includes a 19kHz oscillator and a divide by 128 divider producing a 150Hz signal for the display's AC backplane, making it very easy to use, and requiring only one +5V DC regulated supply and the display to function.

Circuit Description

The 7224 is shown as IC1 in Figure 1. This is a minimum circuit configuration for this device, and makes use of just three main inputs to the chip for the functions COUNT, COUNT/INHIBIT and RESET. Inverter stages TR1 to TR3 have been added to the minimum configuration to provide a measure of immunity to over-voltage signals, by buffering the chip from the board inputs, and enabling the counter to operate over a wide range of input voltage peaks from approximately +2 to +20V. This is a desirable precaution, given that 'general purpose' covers uses that may require signal voltages to be anything but standard logic levels.

To reset the counter to zero, the RESET input at TB9 is taken to >+0·7V, which also blanks the display if TB14 is connected to +5V or left floating. In this configuration IC1 is normally in leading zero blanking mode. For all other functions the RESET input TB9 should be grounded or left open circuit to ensure normal counting operations. The COUNT input, TB8, is negative going, that is it requires a positive voltage falling to zero for a count of one to be incremented in the counter. This input need not necessarily be a hard edged pulse or square waveform, since the COUNT input of IC1 incorporates a Schmitt trigger input stage, which, together with the gain of TR2, will allow slower voltage variations. For example, a low level sine wave signal (less than 5V peak) alternating about 0V can be used to trip the counter on each falling positive half-cycle. Moreover, the Schmitt trigger operation offers some

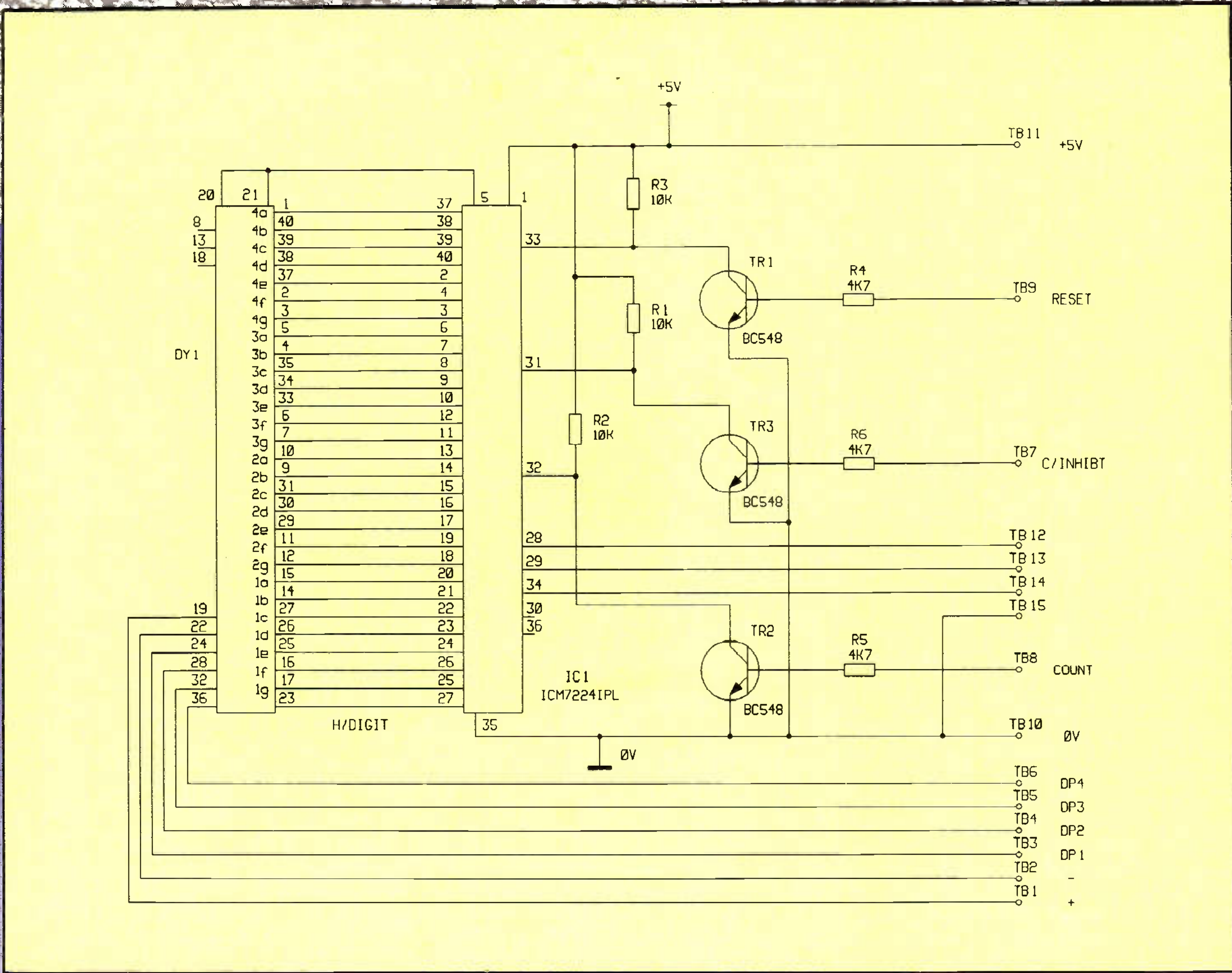


Figure 1. Circuit diagram.

immunity to interference and noise injection, thus preventing erroneous and erratic behaviour of the counter. This flexibility allows a wide variety of COUNT input sources, including various types of sensors.

The COUNT/INHIBIT input at TB7 is used to defeat normal counting operation so that the display remains static without the need to remove the signal at the COUNT input. To do this, COUNT/INHIBIT is taken to >+0·7V. In this condition the last count will be retained and displayed indefinitely, or can be cleared to zero with RESET. COUNT/INHIBIT must be grounded or open circuit at TB7 to enable, or resume, normal counting. In this way the counter can be 'gated' by a means based on a time period or a specific condition (e.g., counting allowed provided condition is true, etc.).

Some additional terminals are provided on the board, which are direct connections to both the LCD array and IC1, and brought out and made available to the user. These include the four decimal point positions TB3 to TB6, the plus sign TB1, and the minus sign TB2. If the counter module is to be incorporated into a system for a particular task, then these can be hard-wired to 0V as required, or temporarily connected for some general purpose use to clarify the display. TB15 is provided as a second

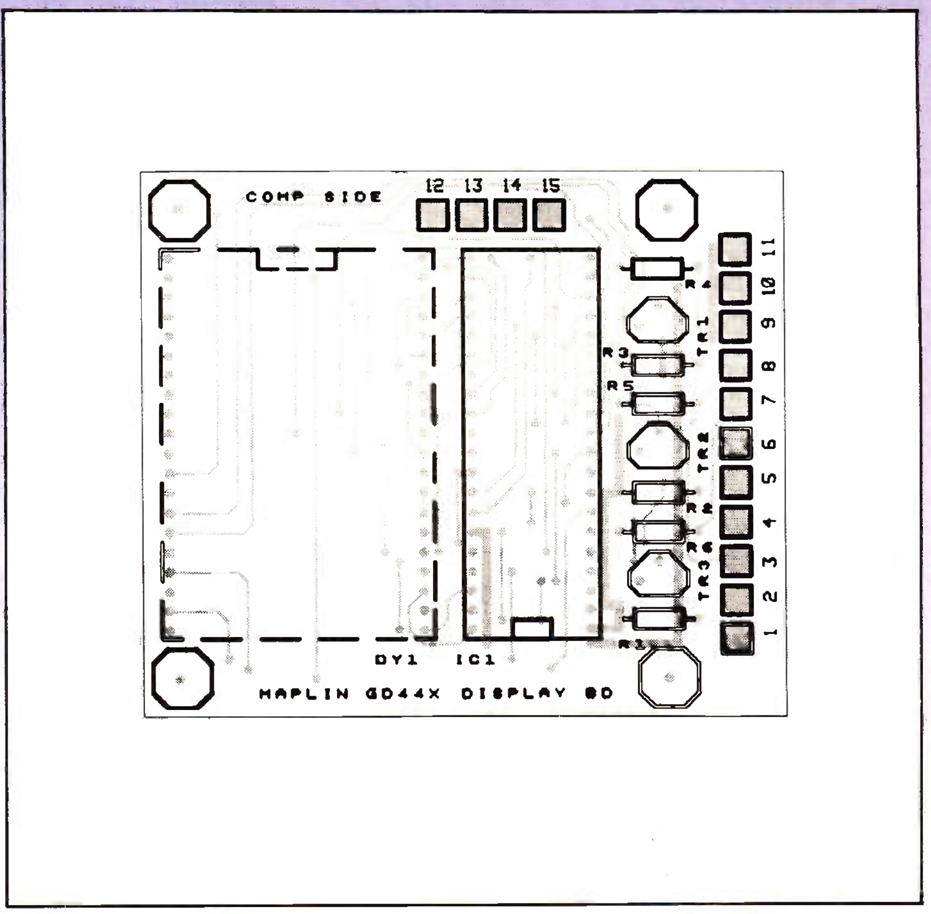


Figure 2. PCB layout.

convenient earth terminal for this purpose. The decimal points may be switched if the module is to form the basis of some sort of frequency or period counter, over several switched ranges. If these terminals are not to be used, they should be left floating.

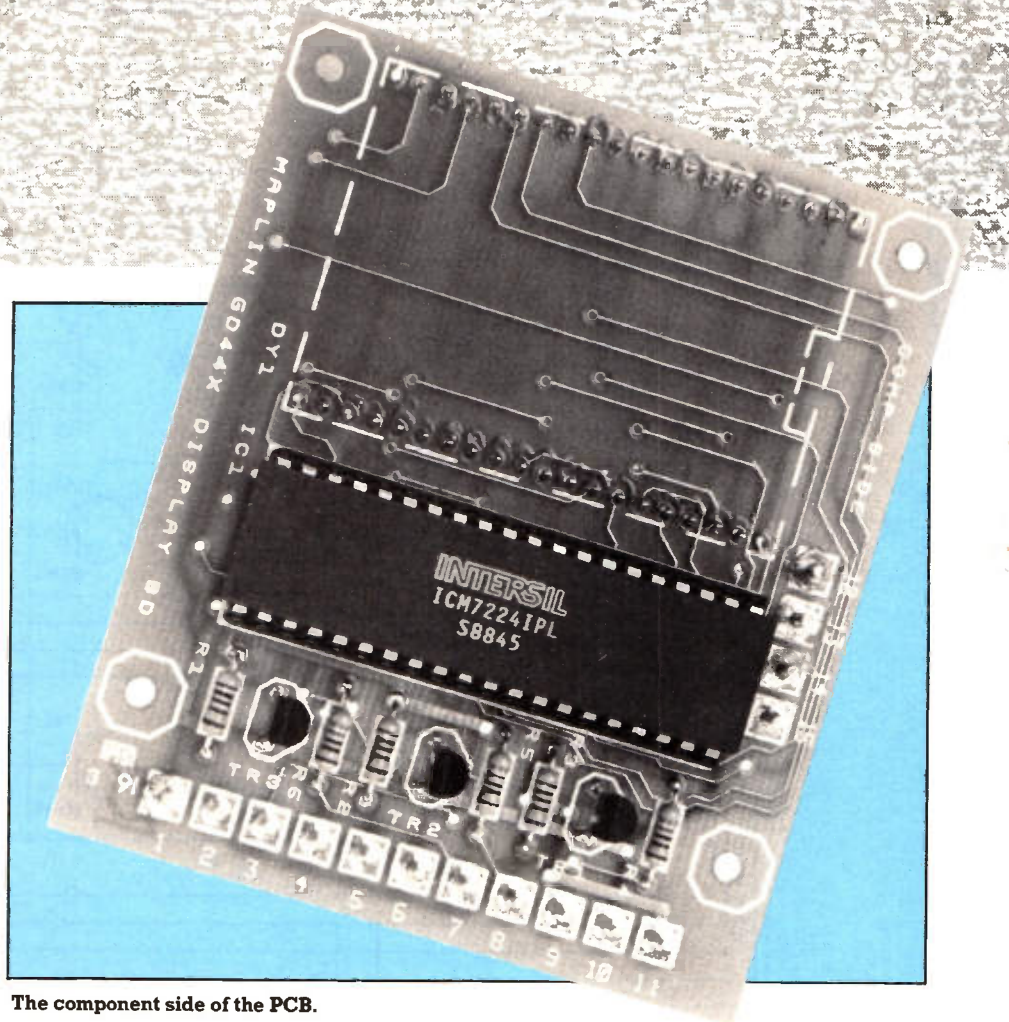
Construction

With reference to the Parts List and the board layout and legend shown in Figure 2, insert and solder all six resistors, then the 15 veropins from the bottom (non-legended) side of the board at the positions TB1 to TB15 using a hot iron to push them home, then solder in place. Insert and solder TR1 to TR3, making sure orientation is correct by aligning their package style with the 'D' shaped legends. Carefully fit the LCD array DY1 to the *underside* of the board, ensuring that the glass pip or similar marker at one end aligns with the rectangular marker on the legend shown in dotted lines on the *top side,* and that all the pins line up with their respective holes. Be *very careful* when soldering that the display does not get hot; if it does, wait between soldering operations until it is cool. It may be helpful to solder each corner pin first to ensure the display is seated properly before soldering all the pins. In fact the pins may be quite long, and if so then it is possible to gain some extra height above the board by slipping a small, rectangular piece of corrugated cardboard underneath the display, which can then be removed after soldering. This will make the top surface of the display approximately 5·5mm above the PCB, and the longer lead length will add extra resistance to heating during soldering.

The same soldering precautions can be applied to the 40-pin DIL socket, which is fitted at IC1 position with its end notch adjacent to the rectangular marker on the legend. Upon completion, check your work for possible short circuits and incomplete solder joints. In particular closely examine the areas between the pins of the DIL socket and the display. When you are satisfied that all is well, carefully insert IC1 into its socket, ensuring that its end notch aligns with that of the socket, and commence testing the module.

Testing

Temporarily connect TB14 to TB10. The module requires a regulated +5V DC supply to operate – *do not* attempt to connect anything other than +5V to the supply pin or damage may occur. Upon switching on a random number may appear on the display. Operate the RESET input by connecting TB9 to TB11 with a test lead. The display should go blank.



The component side of the PCB.

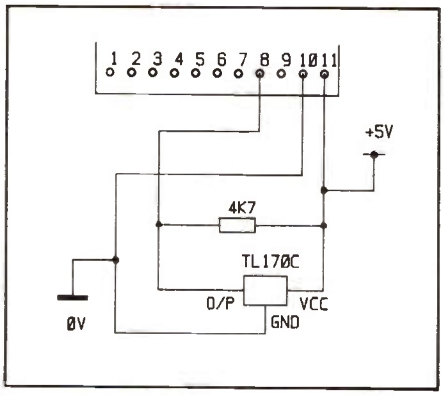


Figure 3. Hall effect device input.

Similarly, pulsing the $\overline{\text{COUNT}}$ input in the same way should cause the module to count up each time TB8 is released. Link the COUNT/INHIBIT pin TB7 to TB11, and the module should not then respond to any further changes at TB8. The display should be 'frozen' showing the last value incremented before COUNT/INHIBIT was taken high.

Pins TB1 to TB6 on the board access the 'plus' and 'minus' signs and the decimal point symbols of the display. Earthing each in turn to TB10 should cause these to appear.

Using The Module

How the module is used is entirely up to the constructor, one of the most obvious applications being of the event counting variety. Means of electrical input to the $\overline{\text{COUNT}}$ pin have already been described, and a mechanical switch can also be used between TB10 and TB8 with a pull-up resistor between TR8 and TB11, to cause an increment of one whenever the switch is closed. The switch may be a thumb operated push-button for counting items by hand, or a micro-switch on a machine. Note however, that some form of 'debouncing' is desirable and a minimum requirement would be a 100nF capacitor connected across the switch terminals. Figures 3 and 4 show alternative arrangements utilising a magnetic hall effect device (with a magnet) and an opto-coupler respectively as sensors. Either of these latter two methods can produce a counter for a hand operated wire winding machine, or for use with a wheel to make an odometer etc.

Some more sophisticated functions are available if desired. TB12 provides access to the CARRY output of IC1 (active low), which can be used to drive an overflow indicator or even a second, cascaded counter module.

Connecting TB13 to ground via a wire link to TB10 defeats the leading zero blanking mode, causing the display to show zero on RESET.

TB14 provides access to the chip's STORE input (active low). The STORE function controls internal latches which transfer decoded display data from the count decoders to the display drivers; whilst TB14 is low the latches are 'transparent' and the display reflects real time counting. On TB14 being high, the last count value is latched, causing the display to hold this value, even though counting is continuing. Pulsing TB14 low will show updates of the count value, remaining static between times. RESET does not effect the display. For continuous real time counting TB14 should be wired to 0V at TB15.

A simple frequency counter can be made using a suitable external clock and logic timebase producing, in sequence, COUNT/INHIBIT (TB7) low for the gating (sampling) period, followed by STORE (TB14) low to update the display, then RESET (TB9) to clear the counters for the next gating period. Signal input is to

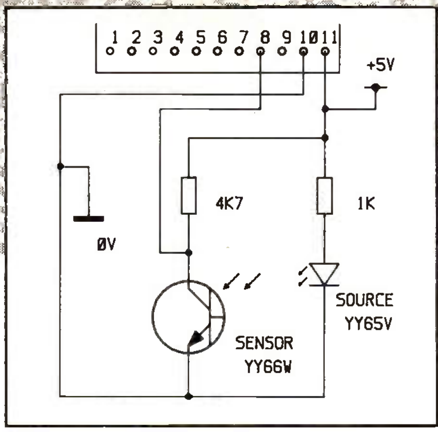


Figure 4. Opto-coupled input.

COUNT continuously. If a gating period of 1 second is used, you will have an AF frequency counter with a resolution of 1Hz and an upper display limit of 19,999Hz, covering the entire AF band with no range switching necessary.

Other applications of this sort include machine rpm indicators, engine rpm and maybe even mph counters using suitable sensors. The LCD is deliberately placed on the underside of the PCB so that it can be incorporated into a front panel display design with the actual LCD mounted flush behind its display window, but leaving all connections accessible.

4½ DIGIT COUNTER PARTS LIST

RESISTORS: All 0·6W 1% Metal Film			
R1-3	10k	3	(M10K)
R3-6	4k7	3	(M4K7)
SEMICONDUCTORS			
IC1	ICM7224IPL	1	(FP62S)
TR1-3	BC548	3	(QB73Q)
MISCELLANEOUS			
DY1	4½ Digit LCD	1	(FP61R)
	PCB	1	(GD44X)
	DIL Socket 40-pin	1	(HQ38R)
	Pin 2141	1 Pkt	(FL21X)
	Instruction Leaflet	1	(XT55K)
	Constructors' Guide	1	(XH79L)

The Maplin Get-You-Working Service is available for this project, see Constructors' Guide or current Maplin Catalogue for details.
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Order As LM19V (4½ Digit Countr Kit) Price £23.95.
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50W COMPRESSION DRIVERS; Fane MD2050 (Maplin Code XJ55K) £25 each, horns £15 each. Tel: Mike, (081) 657 1048, evenings only.

PHILIPS PM6456 FM stereo generator with manual. For aligning and checking FM tuners and receivers. Offers over £150. Tel: (081) 427 3034.

FLUKE 8020A Handheld digital multimeter. 0 to 1000V DC, 0 to 750V AC, 0 to 2A current (AC and DC), 0 to 20MΩ resistance, 0 to 200nS conductance, and diode test. New display, £135. Tel: (0443) 685228 evenings.

YAESU FRG7700M COMMUNICATIONS RECEIVER. Digital readout, AM/USB/LSB/CW/FM modes. Excellent condition. Boxed, with manual. £295.00. FRV 7700 VHF Converter, 50MHz to 150MHz. Boxed £45. Tel: (0622) 745923 (Maidstone).

AM/FM STEREO RADIO. Digital tuning, 10 memory presets. Stereo earphones and batteries. £38 including P+P and free mystery gift! Mr. M. S. Yousaf, 137 The Crescent, Slough, Berkshire, SL1 2LF.

WANTED

SERVICE MANUAL for Roneo Alcatel 880 duplicator. J Parish, 2 Collyers Close, Hurworth, Darlington, County Durham, DL2 2ES.

SERVICE MANUALS for Technics ST-G5(L) tuner and Akai GF-X71 cassette deck. Also Technicolour SVC videocassettes (remember them?), and any information (circuit diagrams, etc.) on SECAM to PAL conversion. Tel: Martin, (0702) 554155 ext. 282 during office hours.

ORGAN ICs; MO 83, M 108, M 208, MK 5083, 50240. Tel: Paul, (071) 274 6087 evenings.

ARCHIMEDES KEYBOARD, preferably keyswitched. Must be cheap – but in good working order. Also RISC OS reference manual. Tel: Steven, (0754) 767890 after 4pm or weekends.

COPY OF BABANI BOOK BP104, or photocopy of article relating to oscilloscope with solid-state display. Contact Scott, 825 Holderness Road, Hull, HU8 9AZ.

MUSICAL

FOR BBC MICRO: Hybrid Music 4000 4-octave keyboard, full size keys, £49. Music 5000 synthesiser, £29. Both with software and manuals. Tel: (0533) 861199 (Leicester).

CLUB CORNER

ELECTRONIC ORGAN CONSTRUCTORS SOCIETY 2.30pm, May 16, St Pancras Church Hall, Lancing St, near Euston station, all welcome. Regional meetings. Tel: (081) 902 3390. 87 Oakington Manor Drive, Wembley, Middlesex.

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 BRITISH AMATEUR ELECTRONICS CLUB (founded in 1966), for all interested in electronics. Four newsletters a year, help for members and more! UK subscription £8 a year (Junior members £4, overseas members £13.50). For further details send S.A.E. to: Mr. H. F. Howard, 41 Thingwall Park, Fishponds, Bristol, BS16 2AJ.

ELECTRONIC UK – the electronics club for the enthusiast, now welcoming new members!! News, views, competitions, projects and loads more. For more information, send S.A.E. to: Electronics UK, 48 Lancing Park, Sussex, BN15 8RF.

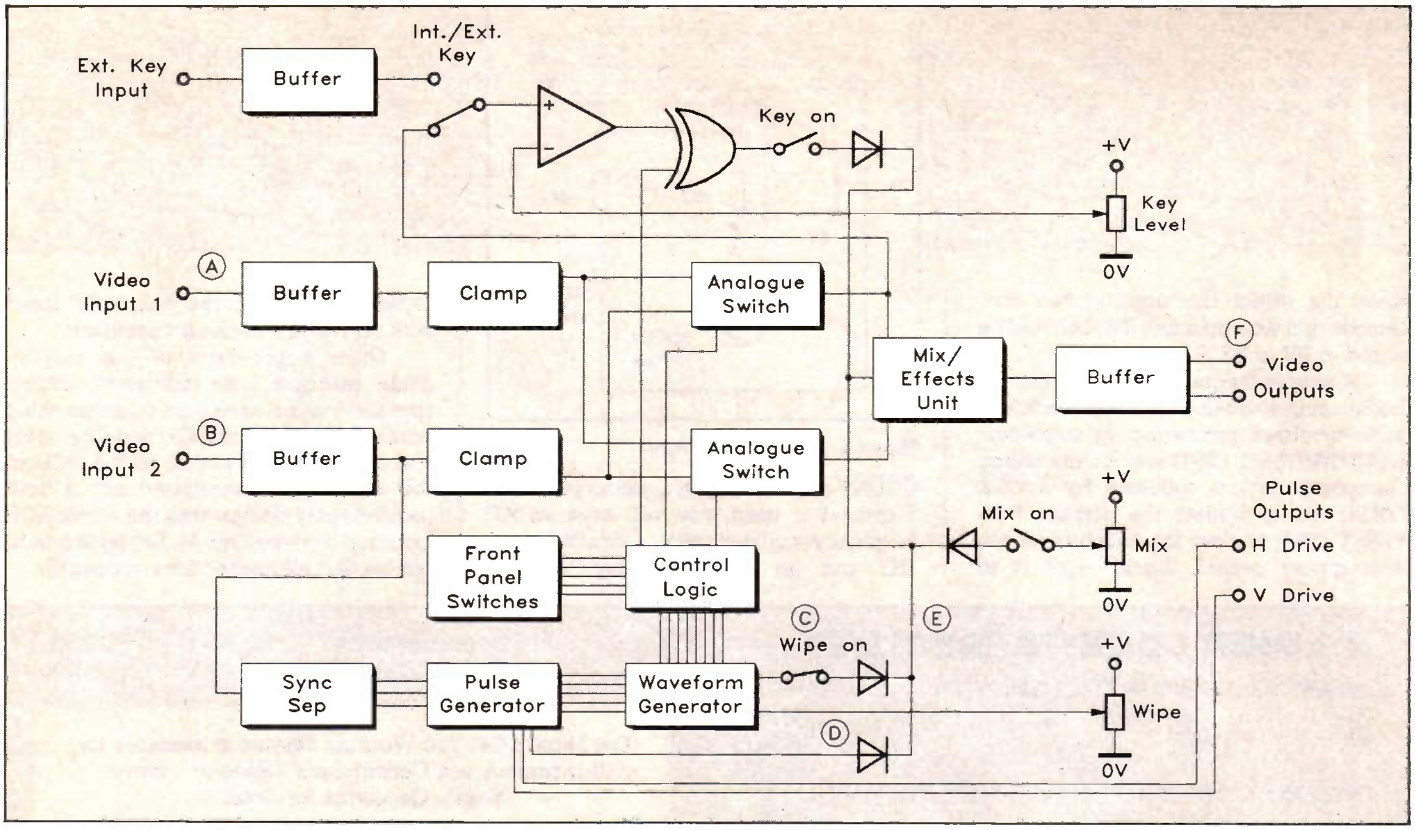


Figure 1. Simple vision mixer.

Video Processing Systems continued from page 39.

to build, an outline of such shown in Figure 1. The heart of the wipe circuit must be a switch, but if this is made in the form of a linear cross-fader then it can also handle the mix effect. A sync separator is necessary for a number of reasons: the wipe patterns must be derived from H and V syncs, the input channel selection must be made during vertical blanking to avoid visible disturbance, and video must be clamped before any effects are applied. Blanking, both horizontal and vertical, must be generated because the video output of the mixer must have sync and burst derived from only one of the inputs. When other sources appear at the mixer output, blanking must be used to switch over to the channel supplying the output sync and burst. More sophisticated mixers will have a built-in sync generator and will not have to steal sync and burst from one of the inputs. In Figure 1 the positions labelled 'A' to 'F' relate to Figure 2 which shows the various waveforms at these points in the circuit.

The video cross-fader can be designed using a variety of components. Maplin has recently started selling several ICs from the Elantec high-speed op-amp range, including a voltage-controlled amplifier. Two of these can be paralleled to form the cross-fader, which will give high performance, though at a price. These devices are current in/current out, so conversion back to voltage will be necessary. What is needed is a multiplier, and the good old 1495 four quadrant multiplier works quite well. Two are again needed, along with a fair number of bias resistors and supply voltages. Finally, half a dozen transistors will do the job reasonably well, since multiplier linearity is not really that important. These transistors should preferably be part of an array, as matching of V_{be} and operating temperature is of some importance. The CA3054 is one such array containing a suitable collection of transistors. Care is needed with temperature compensation, as only a few tens of millivolts will fade fully from one channel to the other, and the mixer will need to work over a reasonable temperature range. A simplified video cross-fader of this type is

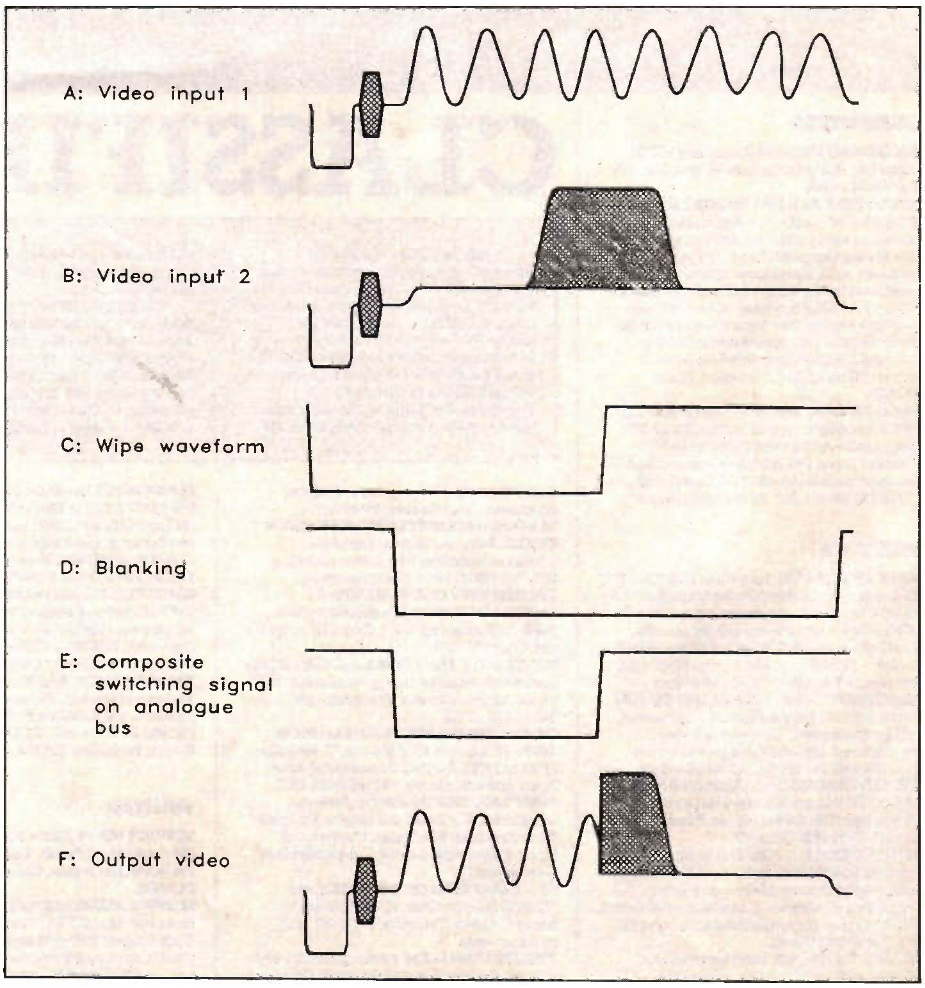


Figure 2. Vision mixer waveforms.

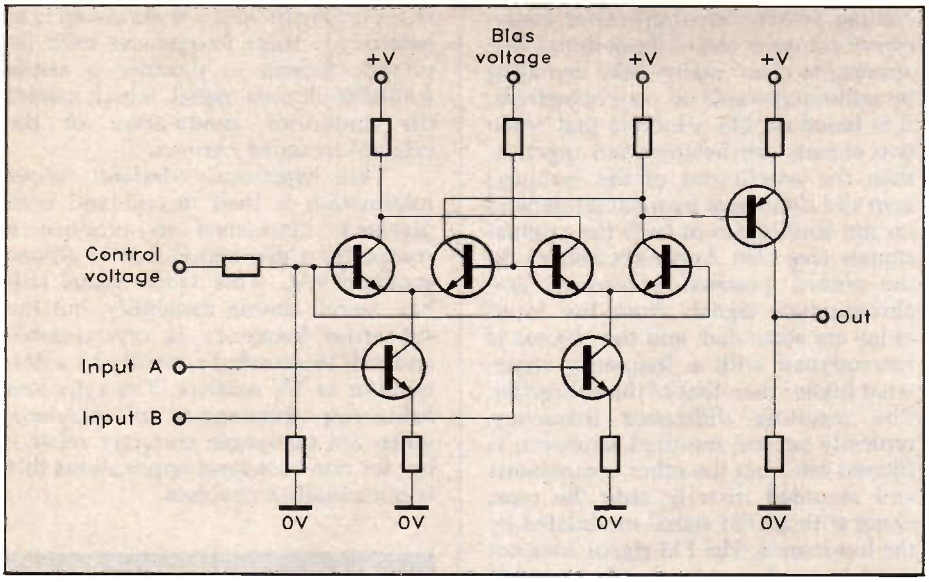


Figure 3. Simplified video cross-fader.

shown in Figure 3.

A simple sync separator is adequate, and the LM1881 is quite suitable. Monostables can be used to generate clamp pulses and blanking, though a little attention paid to temperature stability here will be amply repaid in avoiding problems at the edges of the picture. H and V ramps are necessary for the wipes, a simple comparison to a voltage from a slider pot giving either a horizontal or vertical straight line wipe pattern. Both comparisons, or their logical inverses, can be ORed to produce corner wipes. The ramps can be further integrated to make parabolas, which can be used to generate circular or elliptical wipes.

“Don't even think about (DIY) chromakeying. This is possibly the most demanding application for a PAL decoder, and a unit of good enough quality to allow even indifferent chromakeying will cost several thousand pounds.”

Sine waves can be added in before comparison to make wavy edges, or triangular waves to make zigzags. Instead of a precise comparison, a linear subtraction with voltage limits can be used to give a soft edge to the wipe. A joystick or two pots can be used to offset the ramp timing, and move a circular or rectangular wipe off-centre. A suitably positioned small picture may then be cut into a foreground scene, possibly over the shoulder of a presenter. The possibilities are limited only by the imagination, even using simple analogue techniques. To get really serious, a microprocessor, RAM and fast D/A converter can be used to generate an almost infinite variety of silly wipe patterns.

A simple luminance keyer can be made using a comparator with adjustable threshold, and can give quite good results. A little subcarrier filtering will help, but in general a monochrome key source should always be used, and complete subcarrier removal by filtering will distort the luminance signal too much for accurate keying. An additional input buffer and switching to allow an external key input may be useful, depending on the proposed uses of the mixer.

Don't even think about chromakeying. This is possibly the most demanding application for a PAL decoder, and a unit of good enough quality to allow even indifferent chromakeying will cost several thousand pounds. It is quite definitely not a DIY job. Broadcasters normally use wide bandwidth RGB or YUV to operate chromakeys, and only use decoded PAL in times of desperation, because of the poor results.

A colouriser for the keyer is not that difficult to add, as several ICs are available for producing PAL from three or six digital bits of colour information, for use in home computers. A burst-locked oscillator is also necessary as the colour must be synchronised to the mixer burst, but as we are dealing with stable video here then a colour TV chip is suitable. Ensure that this IC generates subcarrier and PAL ID in the form that the encoder requires, either explicitly or as separate B-Y and PAL switched R-Y subcarriers. If a monochrome camera is used to add captions, then a colouriser is fairly necessary, but even if you do not need to colourise captions you may want to add colour to the edges of a wipe. This technique can be used to decorate or emphasise a circular or rectangular inlay.

Finally, input selection. A very simple two-channel mixer doesn't need input switching, but if the channels have different facilities, for example if keying is only available on one channel, then the video inputs need to be routed to either channel as required. If more than two video inputs are required, then assignment is essential. This routing can be achieved in a variety of ways: there are dedicated routing ICs such as the 45100, which require some complex control logic, and the good old analogue switches such as the 405x series, the 4066 and the 4016. Discrete bipolar transistors or FETs can also be used, and an improvement in performance can be obtained in this way, but at the expense of a much higher component count. Actual switching should take place within vertical blanking, which is simple enough to arrange by passing the selection logic signals through a latch clocked by vertical sync.

A vision mixer may be used to combine two or more video sources, perhaps along with an internal colouriser. It is essential that all such sources are synchronised, that they arrive at the vision mixer inputs at exactly the same time, right down to the phase of subcarrier. If, for example, the output of the mixer carries half of each of two input video signals, then obviously the output colour burst will be used to decode both halves of the composite picture. Both pictures must have correct subcarrier phase and PAL ID relative to the burst, and of course vertical and horizontal sync timings must be the same. This principle naturally extends to all the video sources, including a colouriser if fitted. It is therefore necessary that all inputs are stable and that all, or at least all but one, of these sources are capable of being synchronised with another video signal.

Pulse Trains to Genlock

There was a time when video equipment was synchronised by building up the output video from a common set of timing pulses. With colour operation, six pulse trains plus subcarrier were distributed to every video source in the system, and each unit manufactured its output signal from these pulses. Then, as electronic equipment became more stable and reliable, the units began to incorporate their own pulse generators and to lock them to a single, rather complex pulse train. After a while, it was realised that composite video itself contained all the necessary timing information, and equipment was built to 'genlock' to a reference video source. Today, all professional video equipment has genlock capability, but of course domestic equipment does not.

Genlock circuits are adjustable. Cable delays are significant at video frequencies, so there must be provision for the adjustment of horizontal timing and subcarrier phase to compensate. No delay encountered in a practical system will be more than a couple of microseconds, so no vertical adjustment is necessary. Both adjustments are continuous in professional equipment, though most broadcast units also have their horizontal timing adjustable in steps; fine adjustment occurring automatically as subcarrier phase is varied. This is essential if the recommended EBU sync/subcarrier timing relationship must be maintained, but non-broadcast equipment rarely does so. It must be remembered that cable length variations of a few centimetres will affect subcarrier phase, so if a faulty cable in one of the critical paths in a video system is replaced, genlock phase will need checking. If the cable is part of the genlock reference system itself, then all equipment 'downstream' of the new cable must be readjusted. Some vision mixers have built-in facilities for this adjustment, but if this is not the case then horizontal timing must be compared at the mixer inputs with an oscilloscope or waveform monitor, and subcarrier phase compared using a vectorscope. It is possible to get subcarrier phase fairly close by eye using a good (i.e. unforgiving) colour monitor, but this may not be good enough if more than one recording generation must use that video path.

Next month we will look at a typical small video production system, and begin to look more closely at the expanding range of digital video equipment.

The Heterodyne Colour Principle

It is impossible to put the PAL or NTSC chrominance signal directly onto video tape as the bandwidth is not good enough, so heterodyning is used. Heterodyne colour is one of those things that appears to cheat reality, like levitating by pulling upwards on your bootstraps. It is based on the principle that when two signals are heterodyned together, then the amplitudes of the resulting *sum* and *difference* frequencies depend on the amplitudes of *both* the original signals (see also Appendix below). In the record process, luminance and chrominance signals from the input video are separated, and the *chroma* is heterodyned with a frequency somewhat higher than that of the subcarrier. The resulting *difference* frequency, typically several hundred kilohertz, is filtered out from the other components and recorded directly onto the tape, along with an FM signal modulated by the luminance. The FM signal does not overlap in frequency with the AM chroma, and there is little crosstalk.

Of course on playback both signals have timing instabilities. Luminance is demodulated and further processed, and the replayed horizontal syncs are used to lock a VCO at the same frequency as the heterodyned chroma. The output of this VCO has a constant amplitude, but is varying in frequency to the *same degree* as the replayed chroma. The VCO signal is then heterodyned with a stable 4·43MHz subcarrier, as generated by a crystal oscillator. Again, the sum and difference frequencies have constant amplitude, but the same frequency instability as replayed chroma. The final step is to heterodyne these frequencies with replayed chroma to produce a stable 4·43MHz chroma signal, which carries the amplitude modulation of the original recorded chroma.

This ingeniously derived colour information is then recombined with playback luminance to produce a composite video signal that is almost standard PAL. This video signal still has overall timing instability, but the subcarrier frequency is crystal-stable and will be decoded correctly by a PAL monitor or TV receiver. The sync and subcarrier frequencies of playback video are no longer correctly related, but for non-broadcast applications this is not usually a problem.

Appendix

Heterodyning is a very old technique and is universally used in radio receivers to convert modulated RF into a more manageable, lower frequency signal by 'frequency changing'. The mixer (frequency changer) receives both RF and up-shifted local oscillator RF as inputs, causing it to output the RF, local oscillator RF (LO), the *sum* of these (LO+RF), and the *difference* (LO−RF, as LO is usually higher). Out of these *four* output signals, only the difference output is selected and passed on as IF.

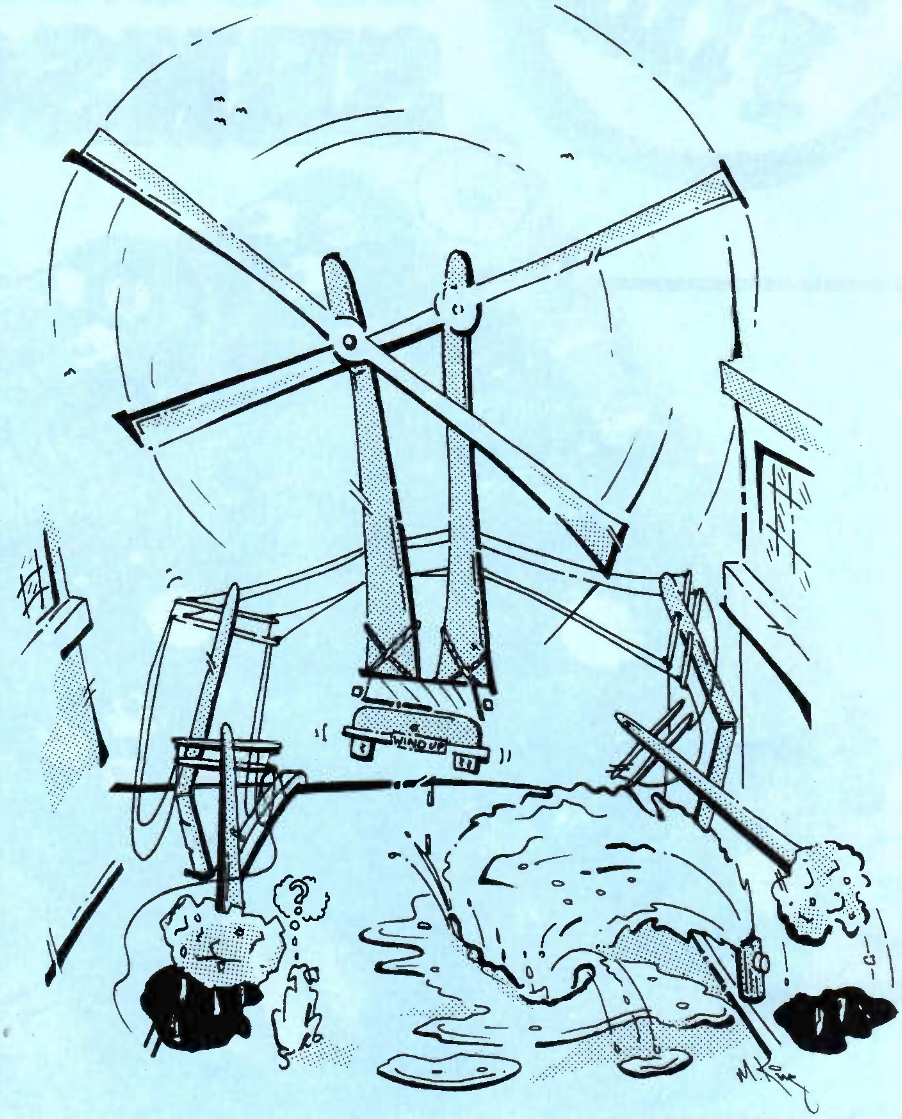
MAPLIN'S TOP TWENTY KITS

POSITION			DESCRIPTION OF KIT	ORDER AS	PRICE	DETAILS IN		
1.	(3)	▲	MOSFET Amplifier	LP56L	£19.95	Magazine	41	(XA41U)
2.	(2)	▲▼	L200 Data File	LP69A	£ 3.95	Magazine	46	(XA46A)
3.	(1)	▼	Live Wire Detector	LK63T	£ 4.25	Magazine	48	(XA48C)
4.	(6)	▲	TDA7052 Kit	LP16S	£ 4.45	Magazine	37	(XA37S)
5.	(4)	▼	Car Battery Monitor	LK42V	£ 7.95	Magazine	37	(XA37S)
6.	(5)	▼	Courtesy Light Extender	LP66W	£ 2.75	Magazine	44	(XA44X)
7.	(8)	▲	Vehicle Intruder Alarm	LP65V	£ 9.95	Magazine	46	(XA46A)
8.	(9)	▲	1/300 Timer	LP30H	£ 4.95	Magazine	38	(XA38R)
9.	(7)	▼	Mini Metal Detector	LM35Q	£ 6.45	Magazine	48	(XA48C)
10.	(–)	NEW ENTRY	Stroboscope Kit	VE52G	£11.95	Catalogue	'92	(CA09K)
11.	(10)	▼	Low Cost Alarm	LP72P	£12.95	Magazine	45	(XA45Y)
12.	(14)	▲	IBM Expansion Sys	LP12N	£18.25	Magazine	43	(XA43C)
13.	(11)	▼	PWM Motor Driver	LK54J	£ 9.95	Best of Book	3	(XC03D)
14.	(12)	▼	Partylite	LW93B	£10.25	Catalogue	'92	(CA09K)
15.	(13)	▼	MSM6322 Data File	LP58N	£11.45	Magazine	44	(XA44X)
16.	(16)	▲▼	TDA2822 Amplifier	LP03D	£ 6.95	Magazine	34	(XA34M)
17.	(–)	NEW ENTRY	8-Bit I/O + RS232	LP85G	£16.95	Catalogue	'92	(CA09K)
18.	(–)	NEW ENTRY	Digital Playback Kit	LM85G	£14.25	Magazine	31	(XA31J)
19.	(15)	▼	LM383 8W Amplifier	LW36P	£ 7.45	Catalogue	'92	(CA09K)
20.	(20)	▲▼	I/R Remote Tester	LP53H	£ 6.45	Magazine	44	(XA44X)

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.

Stray Signals

by Point Contact



I mentioned last time that in early 1992 a wind farm, near Delabole in Cornwall is due to be in operation, generating 4MW – next time we are there Mrs PC and I will definitely keep an eye open for it. Compared to the amount of electricity this country uses this will only be a drop in the ocean, but at least it's a move in the right direction – away from pollution producing coal or gas fired stations. The other great source of pollution, motor vehicle exhaust fumes, is more difficult to do much about. Electric vehicles are a great idea for keeping fumes out of congested city centres and urban areas. In California, where the problem is acute and the smog legendary, the state has mandated that by 1998 2% of all new vehicles sold in the state must be electric, and by 2003, 10% of the vehicles *in use* must be electric; that's half a million electric vehicles! *But* it only transfers the pollution from the exhaust pipe to the power station chimney; the amount of carbon dioxide produced is about the same either way! Apart from which, electric vehicles have a bad image in the eye of the general public at large anyway. Milk-floats, invalid carriages and a certain C5 three-wheeler of a few years ago are electric. Hence, electric vehicles are 'naff'. To prove that they don't all have to be like this however, General Motors built a prototype electric sports car, in the style of a full-size American coupé complete with suitably curvy bodywork. In tests, since an electric motor develops maximum torque from rest, the car consistently managed to beat anything else with a conventional gearbox in a standing start away from traffic-lights. I can't remember off-hand what its top speed was but it was well over 100mph, although the range was limited to 128 miles. At which point recharging the batteries would take considerably longer than a conventional fuel stop.

Another idea, and which has been seriously implemented in Austria recently, is based on the exclusive use of diesel engines, because in the first place a diesel is more fuel efficient than a petrol engine anyway, and secondly, a diesel allows alternative fuels to be used, such as totally natural, environmentally friendly, 100% bio-degradable vegetable fuel oil, such as that from rape seed. 'Biodiesel' is a reality and can be bought, when in Austria, at selected filling station forecourts. The CO_2 emissions don't add to that already in the atmosphere, since the plant absorbed the same amount from the air while growing! Unfortunately quantities are limited. Current production can only cater for some 7% of the total fuel needs, but can be concentrated on commercial vehicles and such, reducing pollution in congested cities.

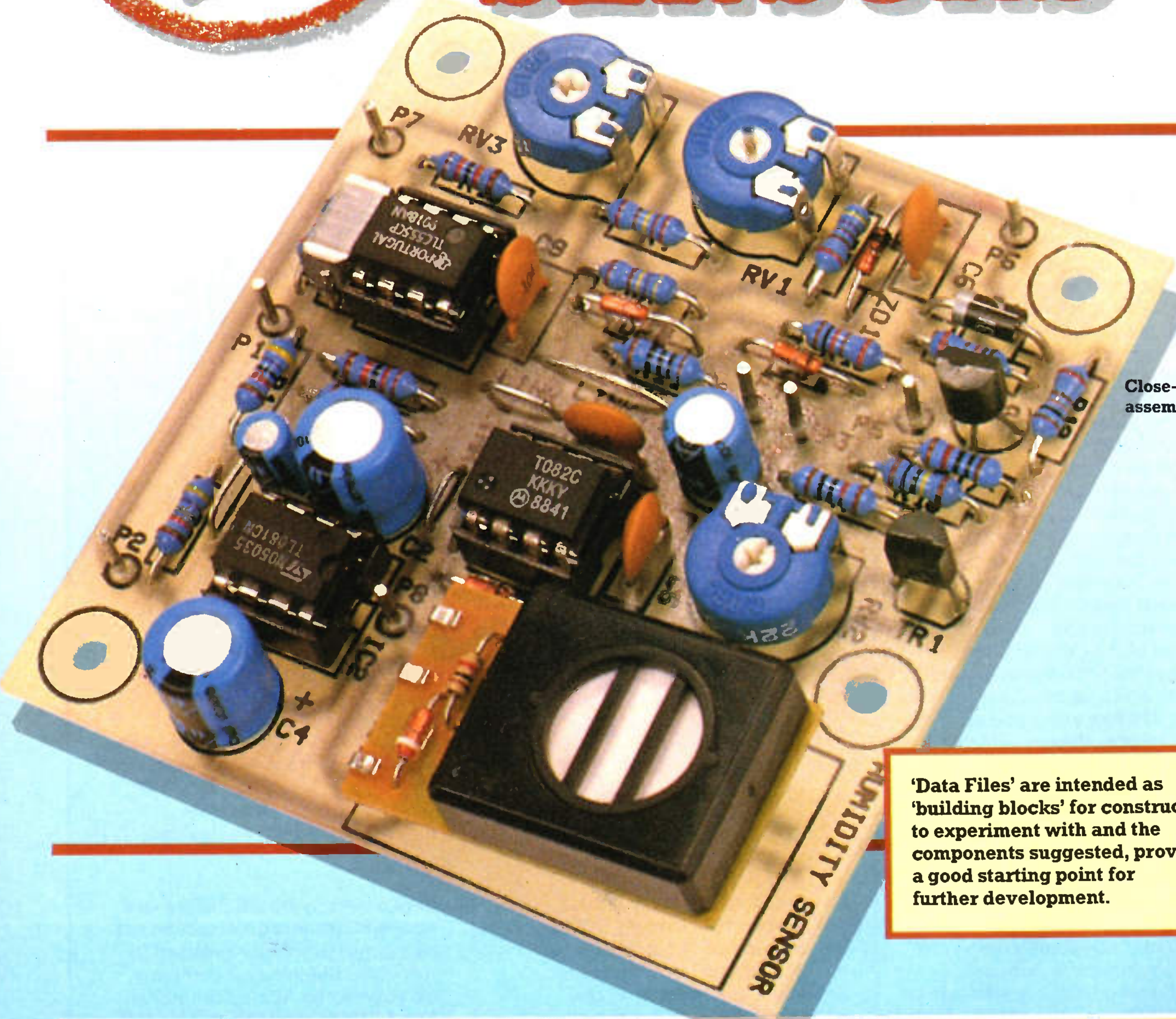
Who would be a sub-editor? Misprints must be the bane of his life. For instance, I read a month or two back in the IEE Review of a new RISC (reduced instruction set computer) processor released by Arm RISC Machines, a company part owned by Apple Computers. The ARM6 is available as an ASIC (application specific integrated circuit) core optimised for embedded control applications, capable of an average 14mips (million instructions per second execution speed) at 200MW! That's a lot of power, far beyond the 4MW capability of the Delabole wind farm; do you suppose they meant 200mW – milliwatts sounds more likely than megawatts in that context?

Yours sincerely,

Point Contact

DATA FILE

H14/H14DL HUMIDITY SENSORS



Close-up of the assembled PCB.

'Data Files' are intended as 'building blocks' for constructors to experiment with and the components suggested, provide a good starting point for further development.

FEATURES

★ Low Hysteresis Sensor ★ High Durability
★ High Accuracy (with suitable circuit design)
★ Fast Response ★ Kit Available

APPLICATIONS

★ Humidity Control and Measurement
★ Replacing Mechanical Sensors

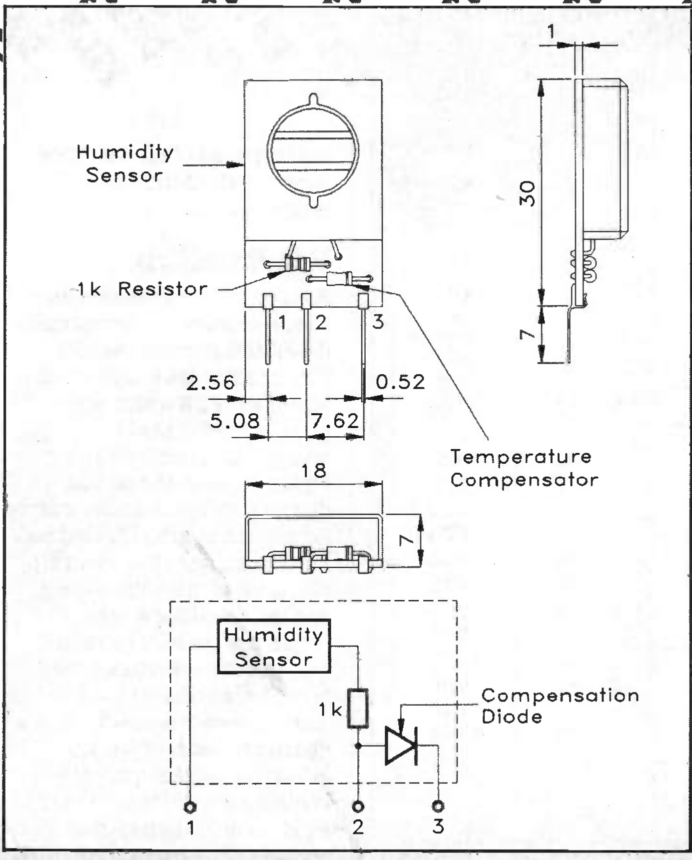


Figure 1. H14DL sensor package style.

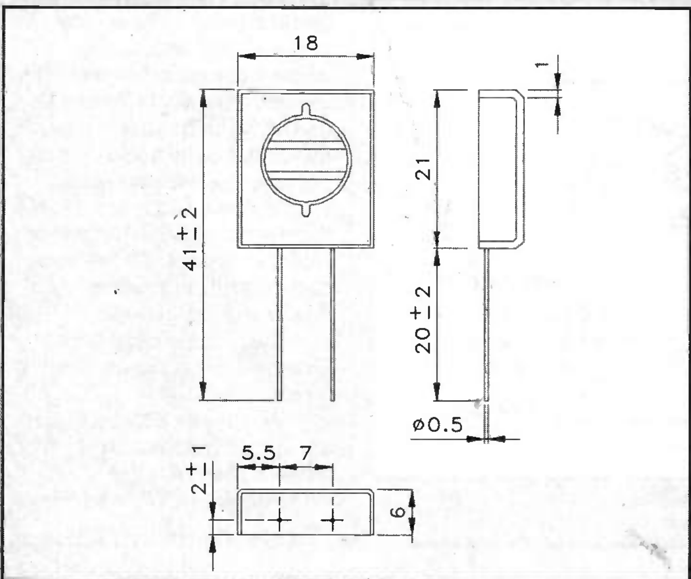


Figure 2. H14 sensor package style.

Introduction

Two humidity sensors are available from Maplin Electronics; one of these consists of just the sensor without any ancillary circuitry (H14), while the other (H14DL) incorporates temperature compensation components. The package styles are shown in Figure 1 and Figure 2. The sensors require an AC input and must *not* be connected to a DC voltage. Table 1 shows a typical specification for the humidity sensor.

Electronic humidity control (using electronic sensors) offers a wide variety of advantages over mechanical humidity control. With optimised circuit design, electronic control allows a high level of accuracy, faster response time and lower levels of hysteresis than its mechanical counterparts.

In addition to humidity control, these sensors may also be used, with additional circuitry, to provide a direct display of relative humidity between 30% and 90%. Figure 3 shows a typical circuit for relative humidity (%RH) measurement using the H14DL sensor. Figure 4 shows a typical response characteristic for the circuit at 25°C.

Compensation

When using the uncompensated H14 sensor, it is necessary to include temperature compensation in the circuit; an example of this, using a thermistor (TH1), is shown in Figure 5. It should be noted that the circuits shown are intended to provide a starting point, and may require modification or 'fine tuning' to achieve optimum accuracy, depending on the individual application.

Practical Points

To prevent erroneous results, it is recommended that the leads between the humidity sensor and any associated circuit are kept as short as possible. If the sensor is mounted away from the main circuit, then screened leads should be used – the maximum recommended length for these is 2 metres.

To achieve optimum results, it is important to allow time for the humidity sensor to stabilise, and this is illustrated graphically in Figure 6. Figure 7 and Table 2 show

General Specification of Humidity Sensors

Storage Temperature Range:	0°C to 50°C
Storage Humidity Range:	10% to 90% RH (No Condensation)
Operating Humidity Range:	30% to 90% RH
Operating Temperature Range:	0°C to 50°C
Rated Working Voltage:	1V AC rms (50Hz to 1kHz)
Rated Power:	0·3mW
Nominal Impedance Value:	60kΩ (at 25°C, 50% RH)
Impedance Value Tolerance:	±30kΩ

Table 1. Typical specification of the Humidity Sensor.

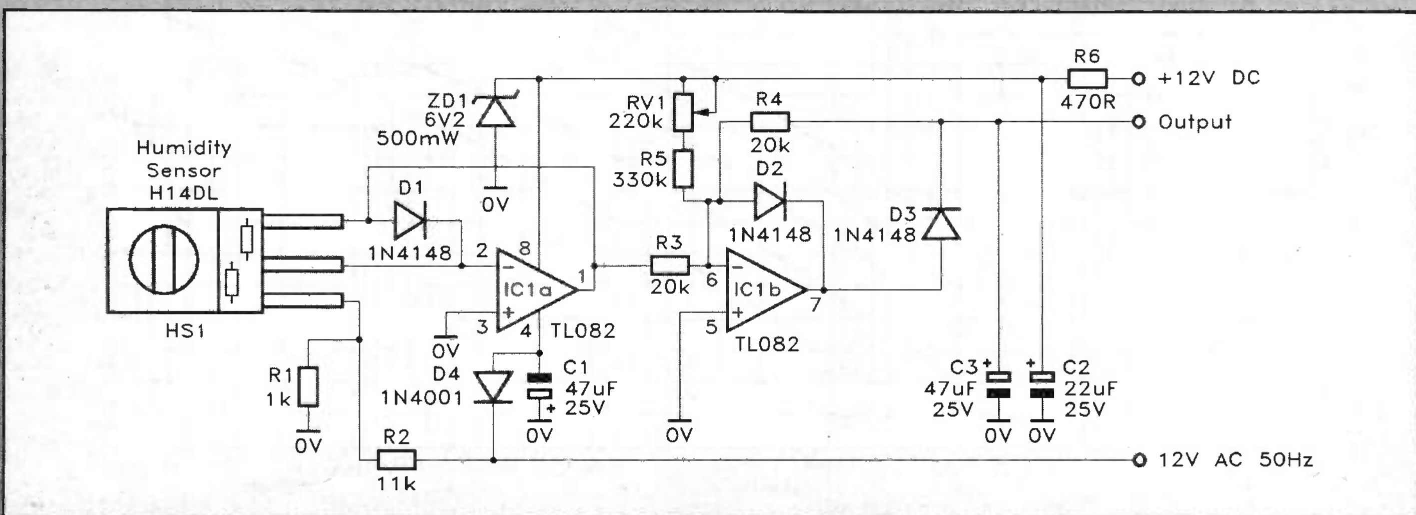
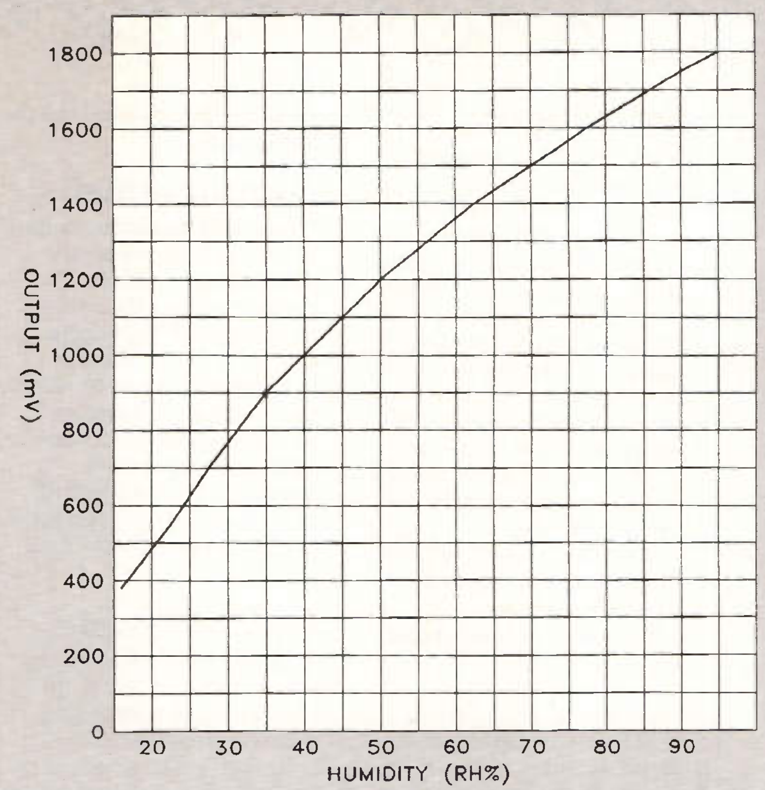


Figure 3. Typical example of circuit for Relative Humidity measurement using H14DL sensor.



% RH	Voutput (mV)
20	470
25	630
30	780
35	915
40	1020
45	1115
50	1190
55	1275
60	1355
65	1425
70	1500
75	1565
80	1630
85	1685
90	1745
95	1795

Figure 4. Typical response characteristics of circuit shown in Figure 3 (at 25°C).

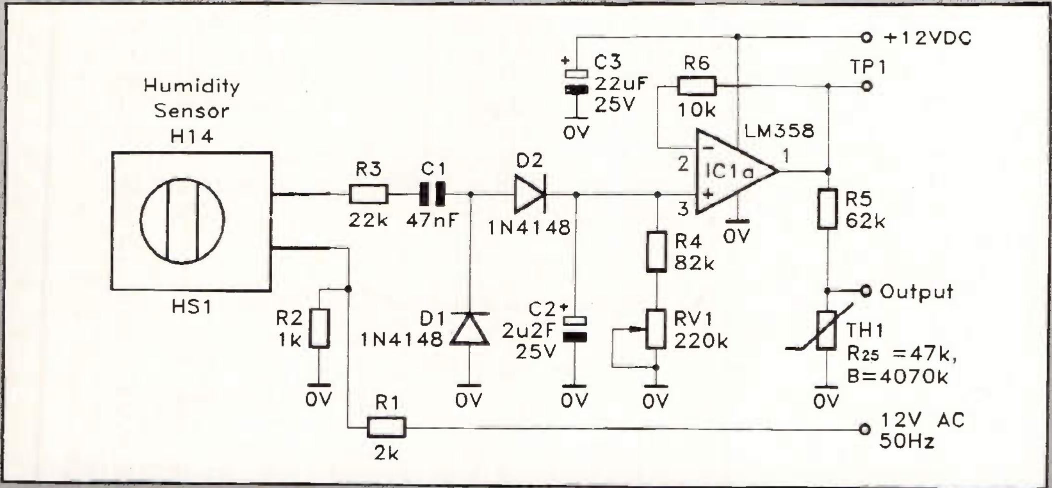


Figure 5. Typical circuit for measuring Relative Humidity (%RH) using H14 sensor.

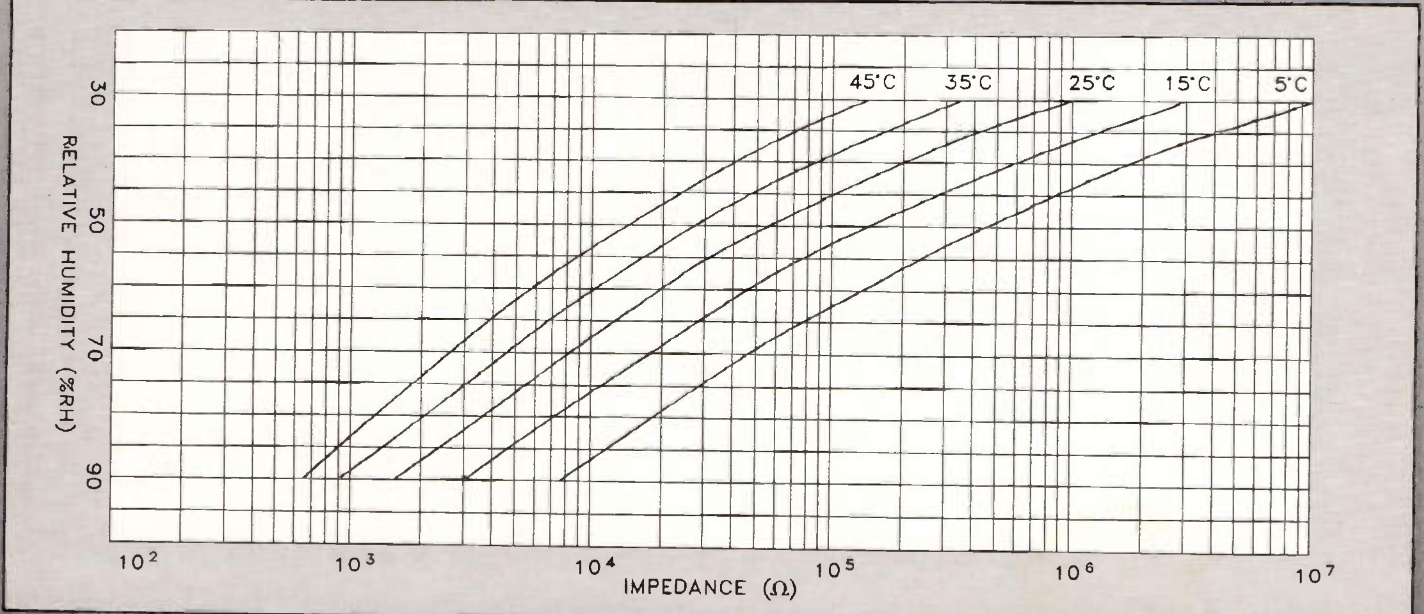


Figure 6. Typical response of humidity sensor with temperature.

the response of the humidity sensor with change in temperature.

Kit Available

A kit of parts is available for a simple application circuit using the H14DL humidity sensor. The kit includes a high-quality fibreglass PCB with a screen-printed legend to aid component positioning. Figure 8 shows the circuit diagram for the module, and Figure 9 shows the PCB legend. The circuit has an on-board oscillator to drive the sensor, and this provides a voltage output between P3 (+) and P4 (−), which increases with %RH. This could be used to drive a voltmeter for measurement purposes, or may be used as part of a control system. Please note: P4 is not at 0V potential and should not be connected directly to 0V at any time. As the module is intended as a general purpose development board for the sensor, the outputs are not calibrated. The overall accuracy is limited by that of the calibration; note that the circuit, in its basic form, is not intended for precision applications, and a degree of variation may be experienced due to component tolerances and differing operating environments. In many low-tolerance applications, however, this does not present a problem.

Preset resistor RV1 adjusts the standing output level, while RV3 adjusts the oscillator level. The oscillator

Typical Humidity Sensor Characteristics AC 1 V. 1kHz unit: kΩ									
	0°C	5°C	10°C	15°C	20°C	25°C	30°C	35°C	40°C
15% RH	–	–	–	–	–	–	185000	9000	4900
20% RH	–	–	–	–	14000	7800	4300	2500	1300
25% RH	–	–	16000	8200	4200	2300	1350	790	460
30% RH	–	11000	5900	3100	1600	890	560	360	215
35% RH	7600	4200	2300	1250	710	410	265	165	105
40% RH	3000	1700	980	560	330	190	128	85	56
45% RH	1450	820	480	270	165	100	68	46	32
50% RH	760	440	245	135	88	55	38	27	19
55% RH	420	235	135	77	49	32	23	16·5	12
60% RH	225	130	77	46	29	19·5	15	10·5	7·6
65% RH	128	77	46	28	18·5	12·3	9	6·7	5·1
70% RH	73	45	28	18	12	8	6	4·5	3·4
75% RH	45	28	18	11·5	7·8	5·4	4	3	2·4
80% RH	28	18	11·5	7·3	5·1	3·6	2·7	2·1	1·6

Table 2. Typical response characteristics of the Humidity Sensor with respect to temperature.

action, and also introduces a degree of hysteresis. Users may wish to change the value of R18, to optimise the circuit for their individual application; however, the value should not be reduced below 10kΩ otherwise damage to the transistors may result. The switching threshold level is adjusted by preset resistor RV2.

Power Supply

The circuit requires a regulated 12V to 15V power supply that is capable of supplying at least 50mA. It is important that the power supply is adequately decoupled to prevent the introduction of mains-derived noise into the system. The power supply is connected between P1 (+V) and P2 (0V). Figure 10 shows wiring information for the module, and Table 3 shows the specification of the prototype circuit.

input level to the humidity sensor may be monitored on P8 if required.

Control

There is in addition an open-collector output available between P5 (output) and P6 (0V), which is suitable for driving a small relay. This output changes from 'low' to 'high' after the humidity level has risen to a pre-set threshold. A suitable relay for switching up to 24V DC at 5A is (Maplin stock code) JM18U. Resistor R18 provides the circuit with a 'snap' switching

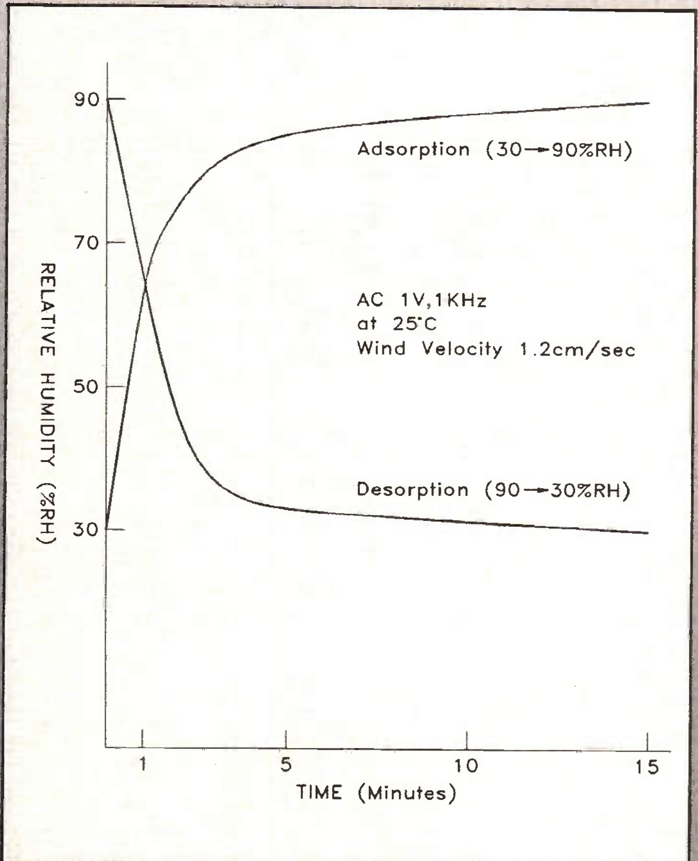


Figure 7. Typical response of sensor to change in humidity with time.

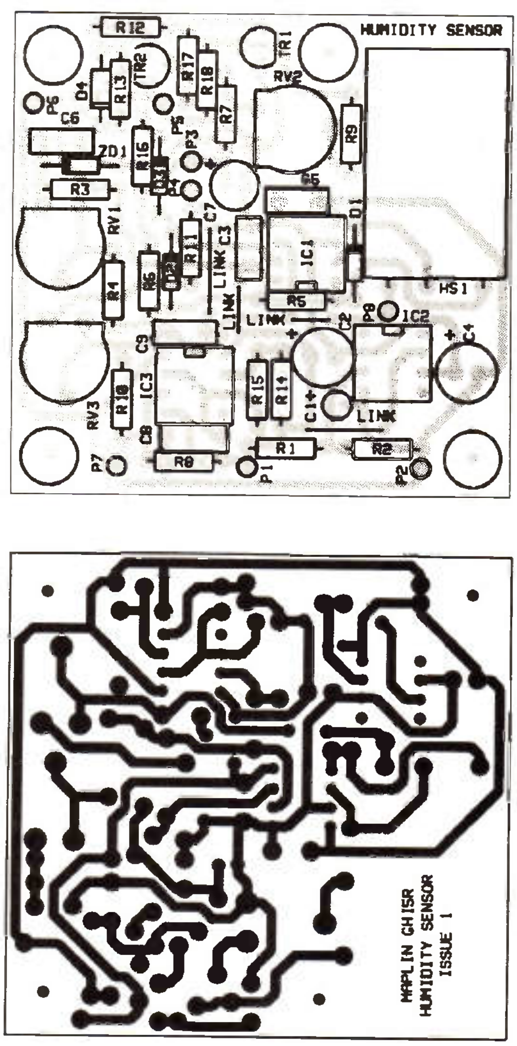


Figure 9. PCB legend and track.

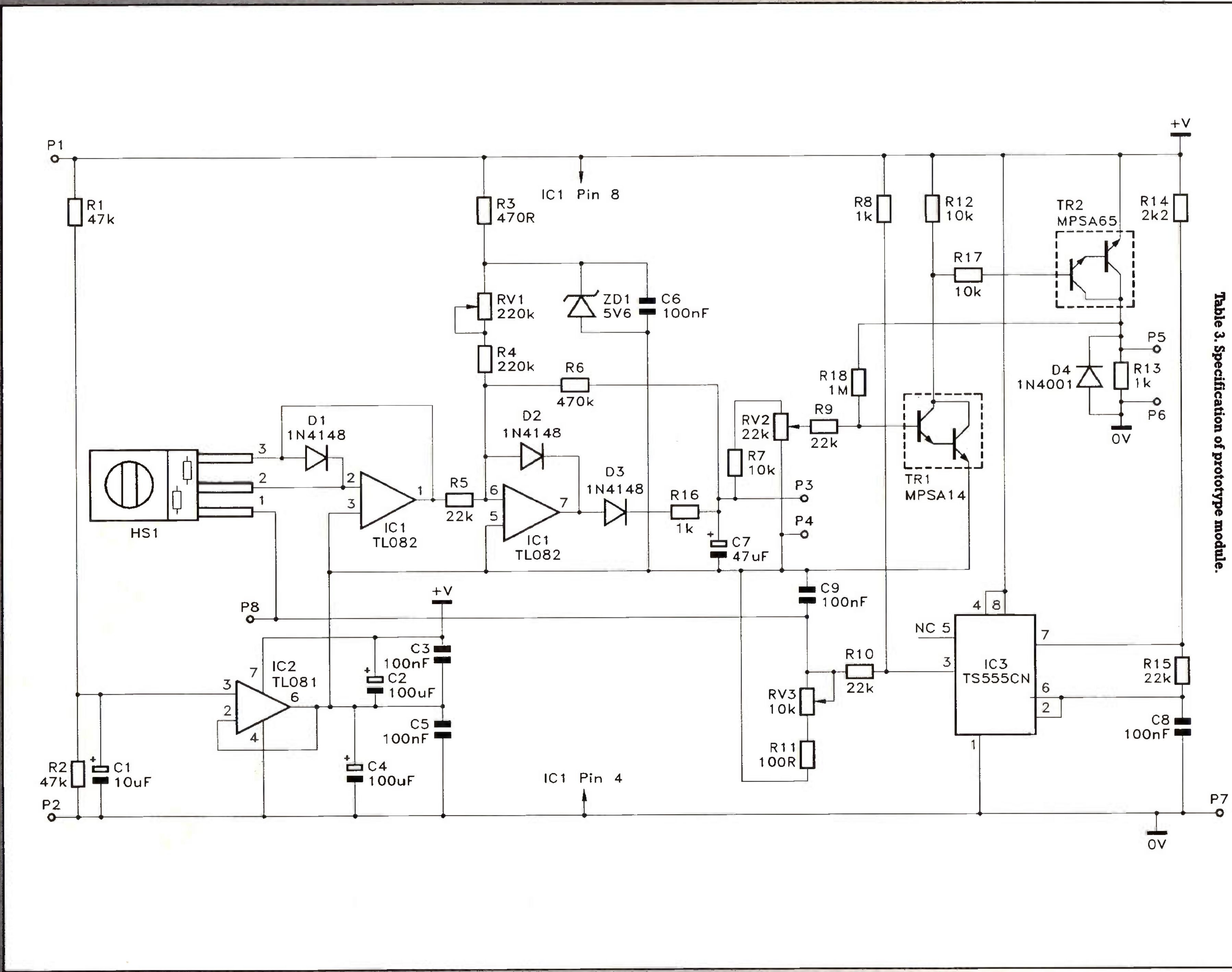


Figure 8. Circuit diagram of module.

Table 3. Specification of prototype module.

Specification of Prototype	
Power Supply Voltage Range:	12V to 15V
Power Supply Current (at 12V):	14mA
Oscillator Frequency:	300Hz
Operating Range of Sensor:	30% to 90% RH
Minimum Load Resistance	
Switched Output (P5 and P6):	100Ω
Analogue Output (P3 and P4):	10kΩ

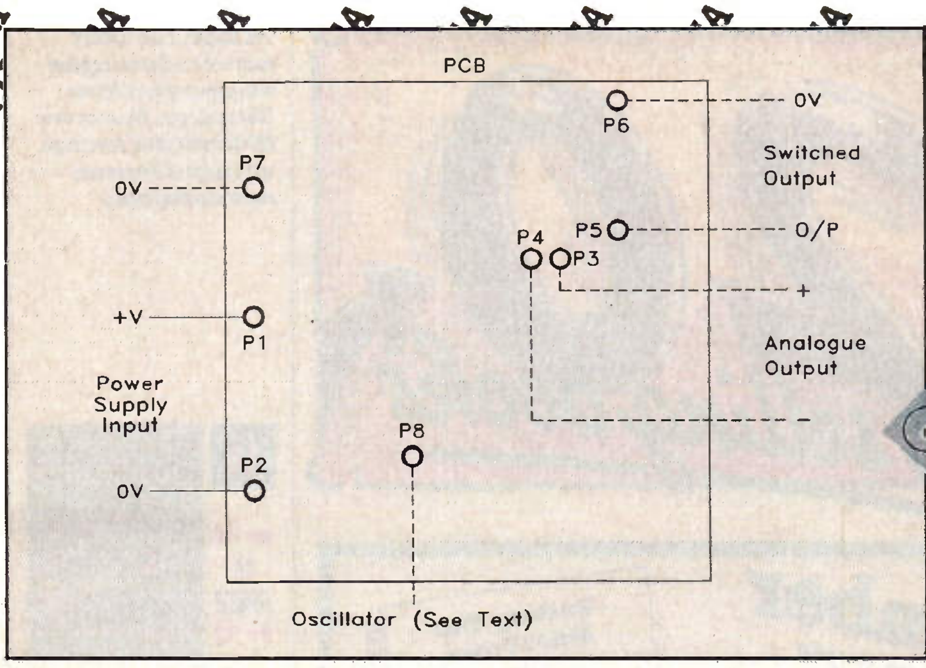
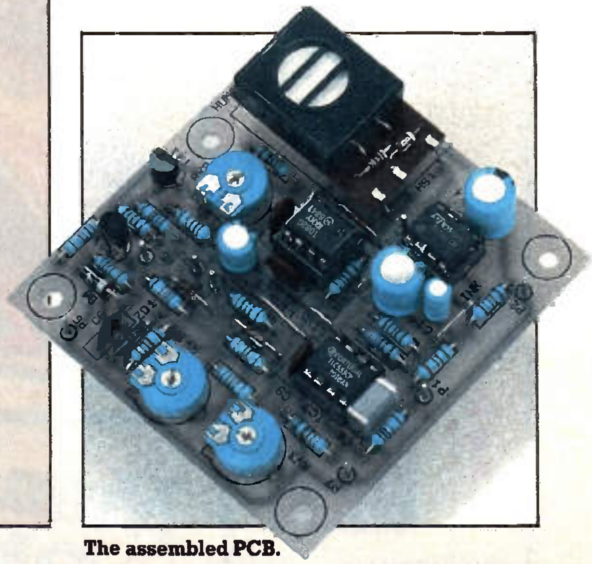


Figure 10. Wiring diagram.



The assembled PCB.

H14/H14DL HUMIDITY SENSORS PARTS LIST

RESISTORS: All 0·6W 1% Metal film (Unless specified)			
R1,2	47k	2	(M47K)
R3	470Ω	1	(M470R)
R4	220k	1	(M220K)
R5,9,10,15	22k	4	(M22K)
R6	470k	1	(M470K)
R7,12,17	10k	3	(M10K)
R8,13,16	1k	3	(M1K)
R11	100Ω	1	(M100R)
R14	2k2	1	(M2K2)
R18	1M	1	(M1M)
RV1	220k Hor Encl Preset	1	(UH07H)
RV2	22k Hor Encl Preset	1	(UH04E)
RV3	10k Hor Encl Preset	1	(UH03D)
CAPACITORS			
C1	10μF 16V Minelect	1	(YY34M)
C2,4	100μF 16V Minelect	2	(RA55K)
C3,5,6,9	100nF 50V Disc	4	(BX03D)
C7	47μF 16V Minelect	1	(YY37S)
C8	100nF Poly Layer	1	(WW41U)
SEMICONDUCTORS			
IC1	TL082CP	1	(RA71N)
IC2	TL081CP	1	(RA70M)
IC3	TS555CN	1	(RA76H)
TR1	MPSA14	1	(QH60Q)
TR2	MPSA65	1	(QH61R)

ZD1	BZY88C5V6/BZX55C5V6	1	(QH08J)
D1,2,3	1N4148	3	(QL80B)
D4	1N4001	1	(QL73Q)
MISCELLANEOUS			
	DIL Socket 8-pin	3	(BL17T)
P1-8	Pin 2145	1 Pkt	(FL24B)
	RH Sensor H14DL	1	(KU67X)
	PCB	1	(GH15R)
	Instruction Leaflet	1	(XT71N)
	Constructors' Guide	1	(XH79L)

The Maplin 'Get-You-Working' Service is not available for this project.
The above items are available as a kit, which offers a saving over buying the parts separately.
Order As LT05F (Hmdty Snsr Data File) Price £14.95.
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, but is not shown in the 1992 Maplin Catalogue:
Humidity Sensor PCB **Order As GH15R Price £2.45.**

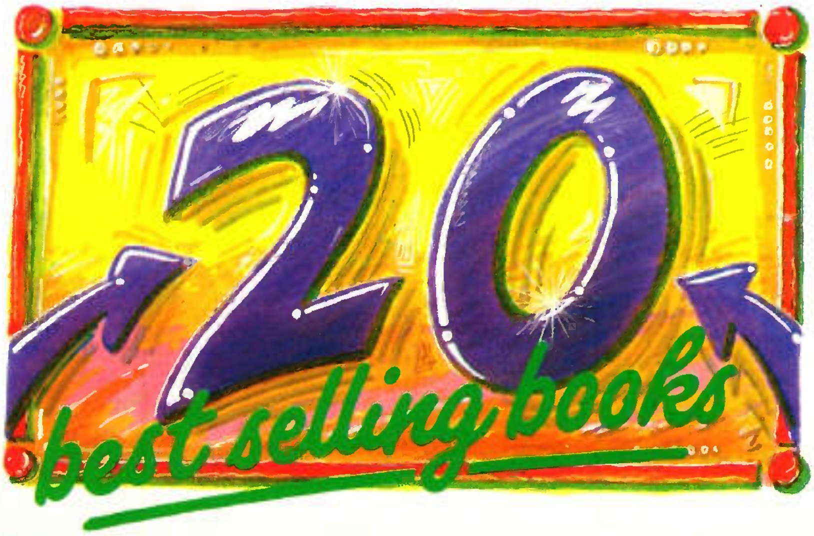
CAPITAL RADIO PRIZE WINNER'S TOUR

It would be hard to find a more suitable winner of the 'Electronics' Capital Radio Competition. The prize, a personally conducted tour of Capital by Chief Engineer Peter Jackson, was won by Richard Aldred, who is currently on a two year electronics and electrics course at Crawley College. "I never realised," he said, "just how much state-of-the-art technology went into a radio station. My Capital tour was a real eye-opener". Richard was reading his father's copy of 'Electronics' – in particular, a feature about Boolean Algebra – when he noticed the Capital contest. The rest, as they say, is history. Richard is already composing a job application to Capital.

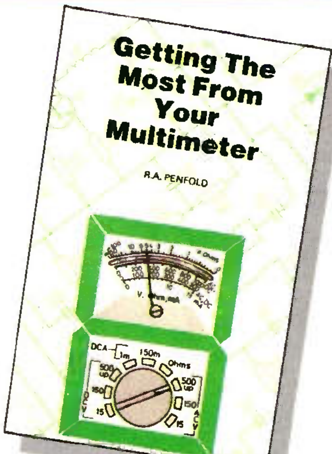
Accompanying Richard was his father Brian, himself a high tech specialist. He is also an early Maplin customer, so early in fact that, when phoning in orders, the operators often query his 4 digit customer number!

These are our top twenty best selling books based on mail order and shop sales during April '92.
Our own magazines and publications are not included in the 'chart' below.

The Maplin order code of each book is shown together with page numbers for our 1992 catalogue. We stock over 250 different titles, covering a wide range of electronics and computing topics.



Number ONE

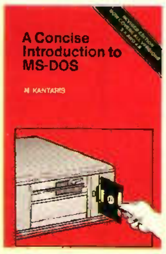


Getting The Most From Your Multimeter
by R. A. Penfold
A unique, and very useful book, showing you how to best use your multimeter.
(WP94C) Cat. P80.
Previous Position: 1
Price £2.95

2

IC555 Projects, by E.A. Parr *(LY04E) Cat. P85.* Previous Position: 3. **Price £2.95.**

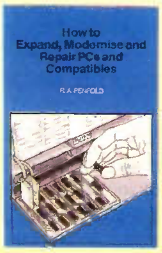
3



A Concise Introduction to MS-DOS, by N. Kantaris. *(WS94C) Cat. P101.* Previous Position: 2. **Price £2.95.**

4

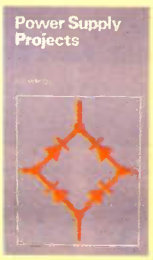
NO CHANGE



How to Expand, Modify and Repair PC's and Compatibles, by R.A. Penfold. *(WS95D) Cat. P104.* Previous Position: 4. **Price £4.95.**

5

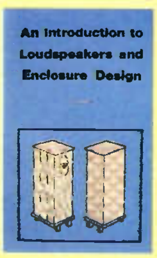
NO CHANGE



Power Supply Projects, by R.A. Penfold. *(XW52G) Cat. P83.* Previous Position: 5. **Price £2.50.**

6

NO CHANGE



An Introduction to Loudspeakers and Enclosure Design, by V. Capel. *(WS31J) Cat. P87.* Previous Position: 6. **Price £2.95.**

7

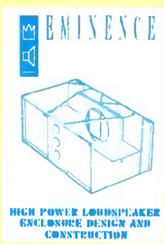
International Transistor Equivalents Guide, by Adrian Michaels. *(WG30H) Cat. P76.* Previous Position: 9. **Price £3.95.**

8

NO CHANGE

How to Use Oscilloscopes and Other Test Equipment, by R.A. Penfold. *(WS65V) Cat. P80.* Previous Position: 8. **Price £3.50.**

9

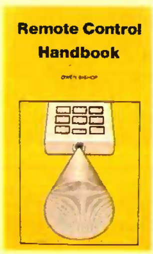


Loudspeaker Enclosure Design and Construction. *(WM82D) Cat. P88.* Previous Position: 7. **Price £9.95.**

10

Electronic Security Devices, by R.A. Penfold. *(RL43W) Cat. P84.* Previous Position: 12. **Price £2.50.**

11

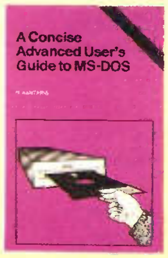


Remote Control Handbook, by Owen Bishop. *(WS23A) Cat. P83.* Previous Position: 17. **Price £3.95.**

12

How to Use Op Amps, by E.A. Parr. *(WA29G) Cat. P79.* Previous Position: 13. **Price £2.95.**

13

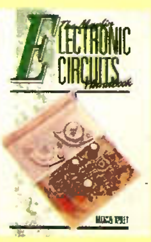


A Concise Advanced User's Guide to MS-DOS, by N. Kantaris. *(WS44X) Cat. P102.* Previous Position: 10. **Price £2.95.**

14

More Advanced Power Supply Projects, by R.A. Penfold. *(WP92A) Cat. P77.* Previous Position: 15. **Price £2.95.**

15



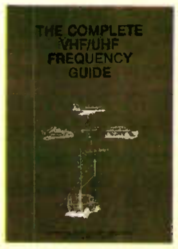
The Maplin Electronic Circuits Handbook, by Michael Tooley. *(WT02C) Cat. P82.* Previous Position: 11. **Price £12.95.**

16

NO CHANGE

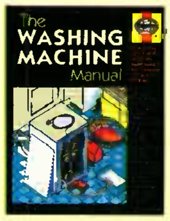
Servicing TV and Video Equipment, by Eugene Trundle. *(WS76H) Cat. P96.* Previous Position: 16. **Price £25.00.**

17



The Complete VHF/UHF Frequency Guide, by B. Laver. *(WT70M) Cat. P93.* Previous Position: 14. **Price £5.95.**

18



The Washing Machine Manual, by Graham Dixon. *(WS98G) Cat. P96.* Previous Position: 19. **Price £11.95.**

19

Electronic Music Projects, by R.A. Penfold. *(XW40T) Cat. P89.* Previous Position: 18. **Price £2.50.**

20

NEW ENTRY

Model Railway Projects, by R.A. Penfold. *(WG60G) Cat. P83.* Previous Position: New Entry. **Price £2.95.**

CIRCUIT MAKER

Circuit Maker is a forum for readers' circuits, ideas and tips. The circuits 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. If you would like your ideas to be considered for inclusion in Circuit Maker, please mark your submission 'Circuit Maker' and send it to: The Editor, 'Electronics – The Maplin Magazine', P.O. Box 3, Rayleigh, Essex, SS6 8LR.

LED Flasher
by Peter Brett

This little circuit provides a bright flashing LED indication, which is visible from several feet away, and yet consumes only about 200μA at 5 to 12V – making it very suitable for use with battery-operated equipment.

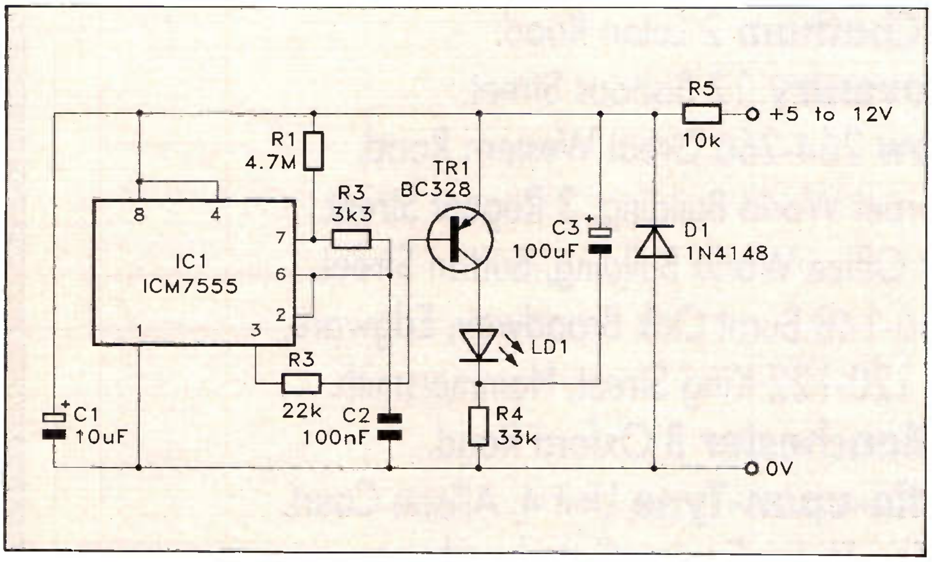
The flasher, switched on by the application of the supply, relies upon two things to make LD1, the LED, appear so bright. Firstly, if the LD1 is given a high pulse of current (in this case, about 100mA for 250μs), it becomes a more efficient producer of light. Secondly, such pulses of light are subjectively bright because of the persistence of vision.

The pulse generator (IC1) is a conventional ICM7555 IC, configured to give three 250μs pulses every second. The output of the generator (on pin 3) drives TR1, a BC328 PNP transistor, producing a 100mA pulse of current through LD1. The best type of LED to use is one of the hyperbright red kind. The pulse of current is drawn from C3, which charges up again during the interval between pulses. In this way, the supply current is a steady 200μA.

The size of the pulse of LED current is directly controlled by the Hfe of TR1, and the value of R3. Almost any small PNP transistor can be used; in this case we have chosen a BC328. The mean collector current can be monitored by the voltage drop across R4. The 1500:1 mark/space ratio used produces about 2V, with a pulse current of 100mA. The Hfe of transistors is poorly controlled in production, and so the value of the base resistor (R3) may need to be changed, or a small resistor placed in the collector lead.

The 10k resistor in the supply lead, and the diode connected to the negative rail, are present to avoid high currents if there is a short circuit, or to provide protection if the supply is reversed. Note that LD1 continues to flash for several seconds after the supply voltage is removed, due to the charge on C3.

RESISTORS: All 0·6W 1% Metal Film				
R1	4M7		1	(M4M7)
R2	3k3		1	(M3K3)
R3	22k		1	(M22K)
R4	33k		1	(M33K)
R5	10k		1	(M10K)
CAPACITORS				
C1	10μF 50V PC Elect.		1	(FF04E)
C2	100nF Poly Layer		1	(WW41U)
C3	100μF 25V PC Elect.		1	(FF11M)
SEMICONDUCTORS				
D1	1N4148		1	(QL80B)
LD1	Red 5mm Hyperbri LED		1	(UK20W)
TR1	BC328		1	(QB67S)
IC1	ICM7555		1	(YH63T)



Circuit diagram of the LED Flasher.

Car Battery Meter
by Peter Brett

This handy gadget satisfies the need for a simple-to-use and accurate meter capable of measuring car battery voltage; it reads from 11·5 to 14V. It is especially useful for use when the engine is running – in this situation, a digital voltmeter tends to show a mass of changing figures!

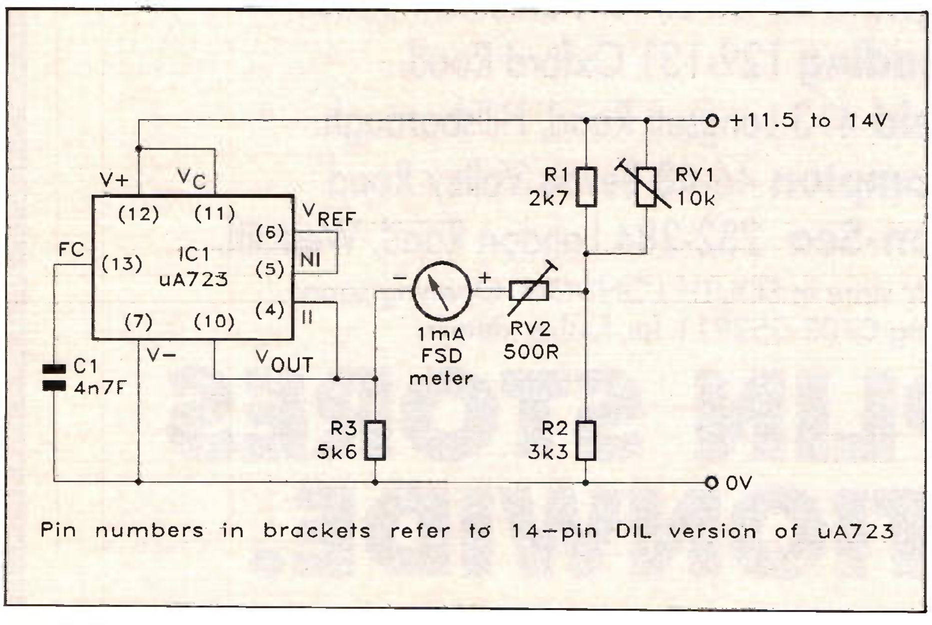
It can form part of a comprehensive automobile test meter; remember that there is a lot of electronics in cars nowadays.

IC1, a μA723C voltage regulator provides a reference, and this is compared with a percentage of the battery voltage, derived via a potential divider. The comparison is shown on a 1mA FSD meter. The variable arm of the potential divider, controlled by RV1, is adjusted so that a change in supply of 2·5V gives full-scale deflection on the meter.

To set up the meter, apply exactly 11·5V, and adjust the 'zero' control (RV2). Apply 14·0V, and adjust RV1 again if necessary. The whole procedure may need to be repeated for optimum results.

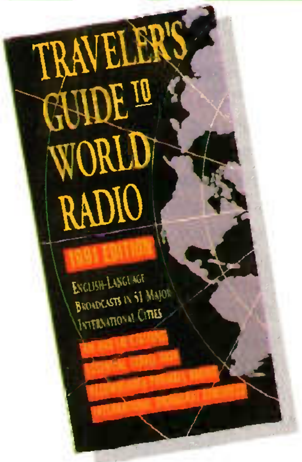
This circuit draws about 4mA from the supply, which is negligible.

RESISTORS: All 0·6W 1% Metal Film (Unless specified)				
R1	2k7		1	(M2K7)
R2	3k3		1	(M3K3)
R3	5k6		1	(M5K6)
RV1	10k Preset		1	(UH03D)
RV2	470Ω Preset		1	(UF99H)
CAPACITOR				
C1	4n7F Poly Layer		1	(WW26D)
SEMICONDUCTOR				
IC1	μA723C		1	(QL21X)
MISCELLANEOUS				
	1mA FSD meter			(RW94C)



Circuit diagram of the Car Battery Monitor.

NEW BOOKS



Traveller's Guide to World Radio

1991 Edition – English Language Broadcasts in 51 Major International Cities

Compiled by Andy Sennitt, Bart Kuperus & Jonathan Marks

A business trip or holiday in a foreign land can sometimes be stressful. The English speaking traveller misses some of the conveniences of home, such simple things as being able to listen to the latest news or sport on the radio.

Often, in cities where English is not the native language, there may still be local radio programmes in English, or a station serving US or UK military personnel for instance, if only you know when and where to tune in. On the other hand, in cities where English *is* the main language, there may be so many stations that it is difficult to find the right one.

If you have a shortwave radio then you have the option of tuning in to the Voice of America, the BBC, or one of the other major international stations, provided, that is, that you know the times and frequencies.

In this book you will find radio information you'll need in an easy-to-use, pocket size, graphic format. At any one of the 51 major travel destinations listed, you can see exactly what English speaking broadcasts are available on AM, FM and international shortwave. The shortwave data will equally be of use to stay-at-home shortwave DXers.

1991. 195 pages. 190 x 96mm, illustrated.

Order As WZ33L (Guide to World Radio) £8.99 NV

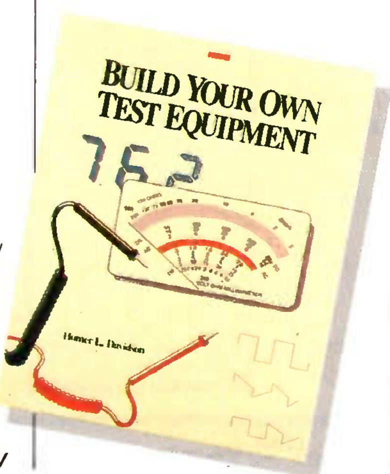
Build Your Own Test Equipment

by Homer L. Davidson

Learn how to build and use instruments for troubleshooting TVs, stereos, computers, CD players, 'ham' radios, microwave ovens, camcorders, electric motors, power supplies and cables and more. Why should you want to build your own test equipment? Well for a professional technician it's fun, and a relaxing way to practice his trade. For the hobbyist, it's an opportunity to sharpen old skills and learn exciting new ones, whilst stocking your workbench with useful instruments that will provide service for years. In any case, whatever your level of expertise, building your own electronic test equipment is a great way to save money on the instruments you need, and for many hobbyists the cost of test gear is a crucial factor.

The book tells you all you need to know about constructing inexpensive, high-capacity, trouble-shooting equipment for almost any purpose, leading you step-by-step through the entire process of finding and buying components, designing PCBs, substituting components, building and testing projects and finally putting your completed instruments to work.

There are projects for everyone, from the beginner to the seasoned professional, all accompanied by simple, easy to follow instructions, photographs and diagrams. Many of the instruments detailed here can be built by novices in one evening, while others require more specialised skills and a few days of challenging work.

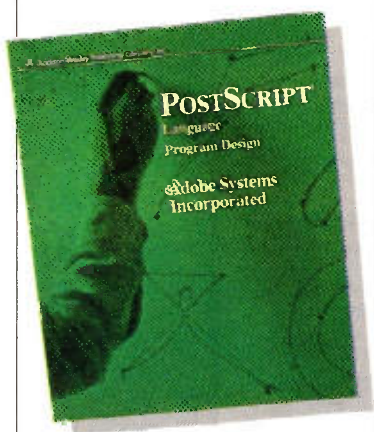


Whichever ones you choose to build, you are guaranteed to possess equipment that's as good or better than most commercially available, but at a fraction of the cost. American book.

Warning: references may be made to the American standard 110V AC mains supply. You should translate these into the English 240V AC mains standard and take the appropriate precautions with the higher voltage level.

1991. 300 pages. 234 x 187mm, illustrated.

Order As WZ28F (Build Own Test Equip) £13.95 NV



PostScript® Language Program Design

Adobe Systems Inc.

The PostScript language has become the industry standard for printing high-quality graphics and text. This powerful language has the ability to describe efficiently the appearance of text, images and graphics on a printed page. The PostScript language is currently incorporated into over 30 different products, including phototypesetters and high-speed laser printers from many well-known computer systems vendors.

From Adobe Systems Incorporated, the inventors of the PostScript language, here is the definitive guide to designing efficient PostScript programs. It teaches the programming principles that are unique to the PostScript language with numerous, usable sample programs and examples of efficient code. In this book, programmers learn techniques for such tasks as setting text, constructing graphics, writing emulators, debugging programs and more. The sample programs are also available on a disk directly from Adobe Systems.

The book is a companion volume to the two other books written by Adobe Systems, the PostScript Language Reference Manual and the PostScript Language Tutorial and Cookbook.

Adobe Systems Incorporated is located in Mountain View, California and was formed in 1982 to meet the growing need of business and industry for the high-quality printing of text and graphics. The PostScript language has been incorporated into laser printers made by Apple, IBM, DEC, Wang and many others. American book.

1988. 238 pages. 233 x 187mm, illustrated.

Order As WZ14Q (PostScript Program) £20.95 NV

Electronic Projects for Home Security

by Owen Bishop

This book deals with many aspects of home security, covering intruder, fire and flood protection, with the emphasis on how to make the best use of electronic devices that you can build yourself. There are 25 constructional projects, ranging in complexity from a single-door protection circuit that can be built in an hour or two, to a sophisticated, multi-channel security system, that most intruders will find very difficult to beat.

Much use is made of the latest in technology to combine simplicity of construction with reliability of operation. Each project is described in detail, with circuit diagrams, full explanations of how it works, complete instructions for building and testing, and, often, suggestions for adapting it to specialised requirements.

The projects can be readily undertaken by the beginner. Even the multi-channel system starts at a simple level and is expandable later as the constructor's experience grows. Since all the projects are powered by battery or from an inexpensive, ready-made mains adapter, they are entirely safe.

1991. 141 pages. 216 x 135mm, illustrated.

Order As WZ31J (Home Security Prjcts) £6.95 NV

Design and Application of SEQUENTIAL LOGIC

PART SEVEN

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

This final part in this series deals with interfacing counters and registers to displays, and other devices. The output of a counter can be considered in one of two ways:

(a) As an n-bit output, obtained by looking at all of the Q outputs simultaneously;

(b) As a single pulse '1-in-n' output that is obtained at the final stage Q output.

One way of using output (a) is to use it to drive some external device such as a display. Because the output code from the counter will rarely match the input needs of the display, it will be necessary to decode it.

To use output (b), on the other hand, we consider that the counter behaves as a divider, generating a single output pulse for 'n' input pulses. No decoding is then necessary. We shall forget this option for now.

Decoding Counters and Driving Displays

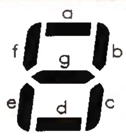
The seven segment display is probably the commonest type in use. This may use either LED or LCD technology, these essentially involving current drive and voltage drive respectively. Whichever type is chosen, the input code required to display any of the possible characters is of a particular pattern, and not directly generated by a counter circuit.

Interfacing to LED 7-Segment Displays

Figure 1 shows the seven segment identification and the table of codes required if the display is of the common anode LED variety. What this means is that all segment anodes are connected together and taken to the +5V supply pin; the cathodes are all brought out to individual package pins, labelled 'a' to 'g'. Therefore, in order to illuminate any given segment, its cathode must be returned to 0V. A resistor, with a typical value of 270 to 330Ω, must be included in series with each cathode line, in order to limit the segment current to a safe value.

It will become obvious from studying the table of Figure 1 that the codes are of an apparently random nature, but actually dictated purely by the spatial arrangement of segments for each character. Designing a decoder to convert between the regular BCD code, for example, and this irregular code would be an interesting (!) exercise. However, it is not a task that we need contemplate, since the job has already been done for us. Figure 2 shows the pin-out diagram for the 7447 BCD to seven segment decoder/driver. This chip will take, as inputs, the BCD groups 0000 to 1001 (denary digits 0 to 9) and decode them directly to drive the relevant output lines of the chip low as required. Each of these lines acts as a 'current sinking' path for a segment. The 'driver' part of the device description covers this ability of the 7447 IC to handle the segment current. Figure 3 shows the operation in detail, where the numeral four is to be displayed. The input code to the 7447 is 0100 and segments b, c, f and g need to be lit. Using the 270Ω resistors shown, the segment current is 3V/270 = 11mA approximately. This is because the chip supply is 5V and an LED needs a forward voltage of 2V when conducting; the excess 3V being dropped across the series resistor.

It might seem, from the above, as if all that we need to do to interface a BCD counter output to a display of the type described is to interpose the 7447 IC directly between the counter output and the display itself. However, this would only be satisfactory in a limited number of situations. A moment's thought shows that the display would only be readable at an instant of time when the counter was 'frozen', a case which might never occur,



Denary Number	a	b	c	d	e	f	g	Hex. Code
0	0	0	0	0	0	0	1	01
1	1	0	0	1	1	1	1	4F
2	0	0	1	0	0	1	0	12
3	0	0	0	0	1	1	0	06
4	1	0	0	1	1	0	0	4C
5	0	1	0	0	1	0	0	24
6	0	1	0	0	0	0	0	20
7	0	0	0	1	1	1	1	0F
8	0	0	0	0	0	0	0	00
9	0	0	0	0	1	0	0	04

Figure 1. The seven segment display and table of codes for the common anode type.

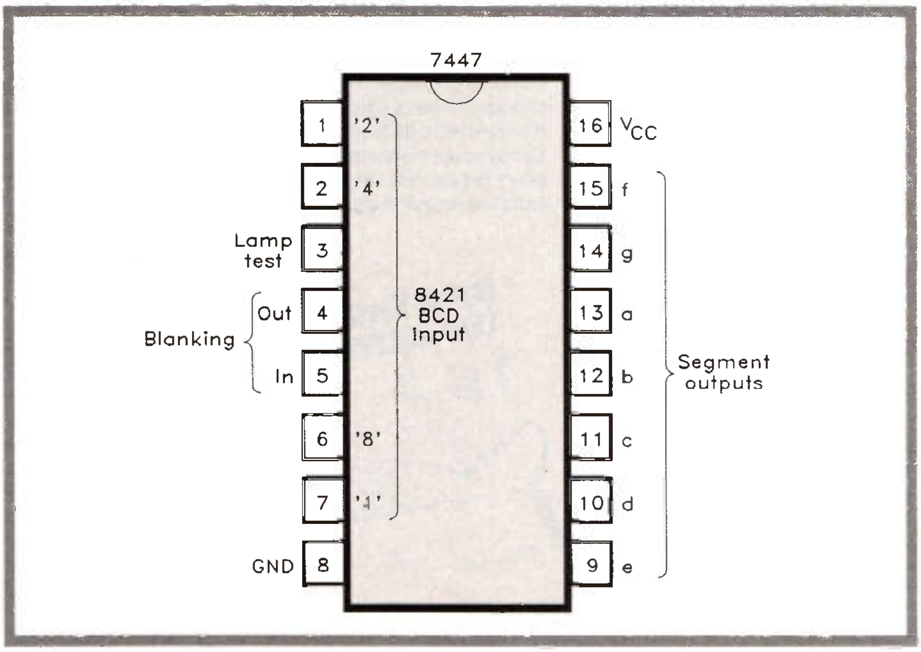


Figure 2. Pin-out diagram for the 7447 BCD-seven segment decoder/driver.

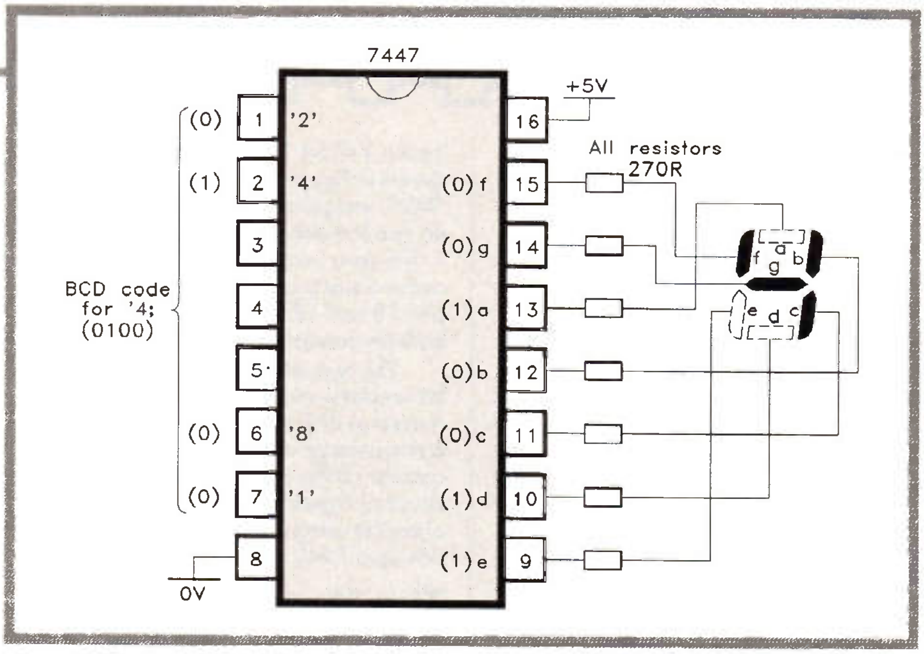


Figure 3. The 7447 IC driving a display: the situation where the numeral '4' is being displayed.

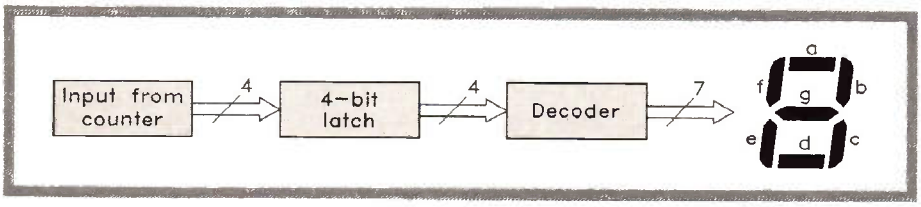


Figure 4. Latching the output of a counter to store the value input to the 7447 decoder.

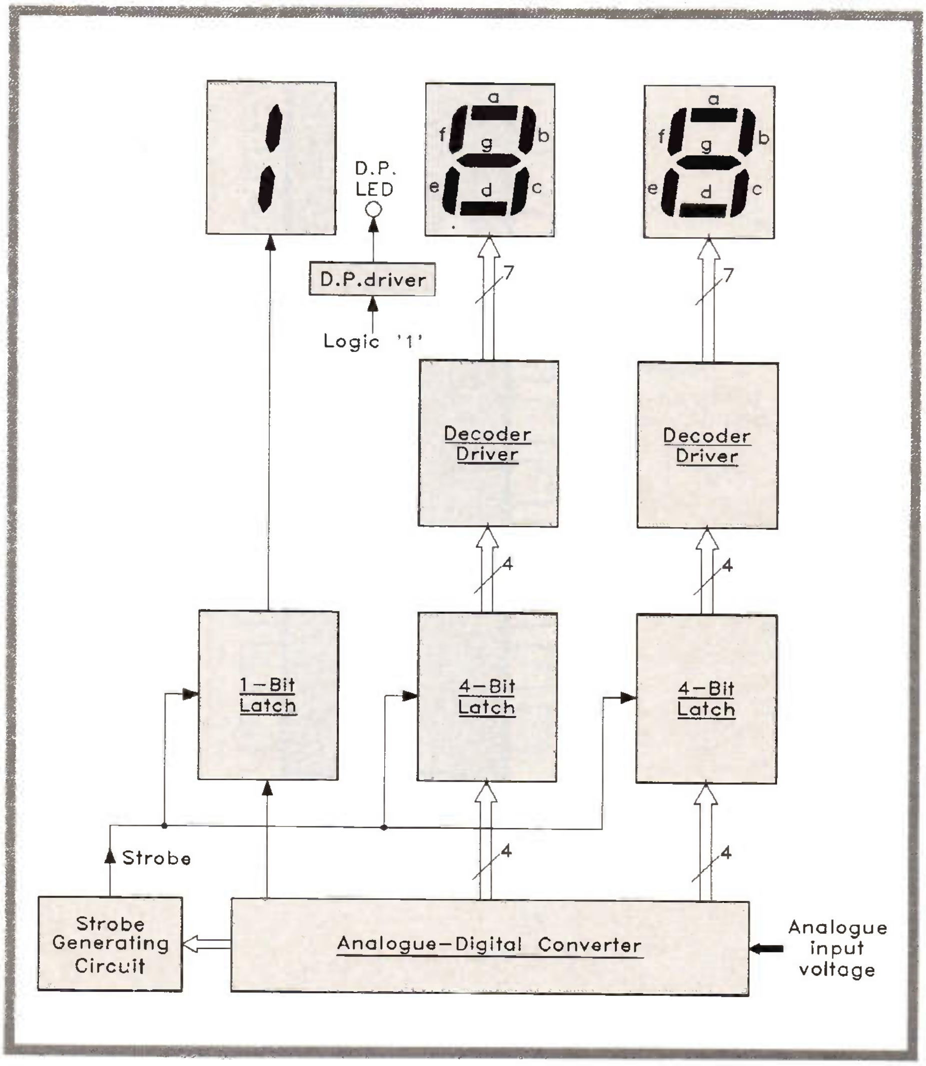


Figure 5. Block diagram for a 2½ digit digital voltmeter.

or if it did, would only last for a very brief time interval. In many applications, the counter output would be constantly changing. Under these circumstances, the decoder output has to be latched, as shown in Figure 4, in order to 'freeze' the value for a specific period of time.

Take the case of the digital voltmeter whose block diagram is shown in Figure 5. The analogue-digital converter includes a counter which, from an initial value of zero, counts up at clock rate until a value is reached that bears an equivalent relation to the DC voltage being measured. Once this value is reached it has to be displayed, and then the counter is reset and goes through another cycle. This process repeats indefinitely, each new value displayed replacing the previous one. The counter outputs from the ADC, for each display digit, are all latched. A strobe line, from a strobe generating circuit driven by the ADC, performs this updating function.

The 7475 IC (the pin-out diagram is shown in Figure 6) is an example of a 4-bit latch that could be used in this type of application. Each latch in this IC can be regarded as an unclocked D-type flip-flop, that is, it has a data (D) input and Q and $\overline{Q}$ outputs; in addition it has an 'enable' input which, when taken high, updates the latch contents, freezing this value when taken low again. In this particular IC the D flip-flops are in pairs as far as the enable line is concerned. Therefore, to use it as a 4-bit latch, it is necessary to parallel the enable inputs (pins 4 and 13).

The provision of the enable line presupposes that a 'strobe' pulse will be available each time that the counter reaches a new 'value to be read'. How this is generated will depend upon the nature of the system. In the case of the digital voltmeter, for example, a comparator determines when the final count is reached, and this event is then used to initiate the generation of the strobe pulse.

Interfacing to Individual LEDs for a 1-in-n Count

It is not always required to convert the counter output to a special code, such as 7-segment code, in order to drive a numerical display. In some applications, all that it is required to do is to output a single bit (either a logic 0 or a logic 1) on one of 'n' output lines, there being one line for each state of the counter. Thus, a decade counter decoded in this way would have ten output lines, labelled 0 to 9, on each of which the said bit appears for each count, all other lines then being at the opposite state. There are several ICs that can perform this function.

An example of one that decodes a BCD input to select 1-in-10 output lines is the 7442 (Figure 7(a)); this is a TTL chip with a current sinking capability limited to

16mA per output. If the binary input exceeds the largest BCD value of 1001, then *all* outputs go to the high state. A chip that combines the decoding and driving functions is the 7445, and this is shown in Figure 7(b). As in the case of the 7447, an output line goes low for a given state of the counter and if it is required to drive an LED (which would be an easy way of signalling the counter state), a current limiting resistor must be included in each line. This chip is able to sink 80mA per output, and in this case an input in excess of 1001 sends all outputs to an open circuit state. Both of these ICs decode BCD inputs but can also decode octal, that is, 3-bit inputs if pin 12 is grounded. If a full-range, 4-bit binary value (that is, states 0 to 15 or hexadecimal) is to be decoded instead, then a separate chip is available to do this.

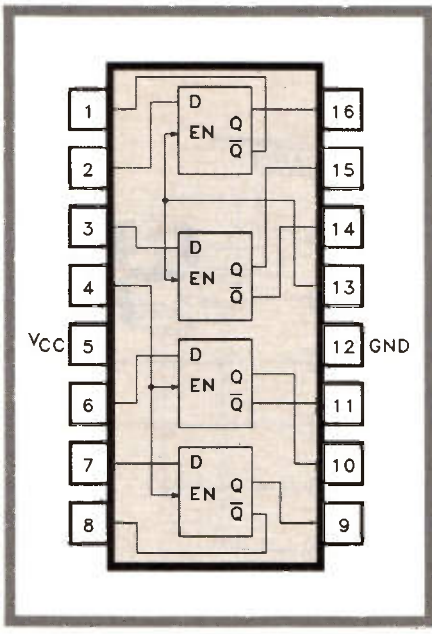


Figure 6. Pin-out diagram for the 7475 4-bit latch IC.

It is the 74154 1-of-16 data distributor shown in Figure 7(c). This accepts a 4-bit, '8421' weighted code, and outputs a zero on one line only, all others being at logic 1. This zero 'walks' along the output lines as the count progresses. For this to work, pins 18 and 19 (enable and data in) must both be grounded.

The type of output in which a single bit circulates along a set of lines may remind us of the ring counter. However, a ring counter with ten output lines would require 10 flip-flops. By contrast, the circuit of Figure 8 achieves the same objective using a 7490 decade counter driving a 7442 decoder.

The Matrix Decoder

The matrix decoder is the answer to large values of 1-in-n, where it is desirable to keep the number of lines, and circuit

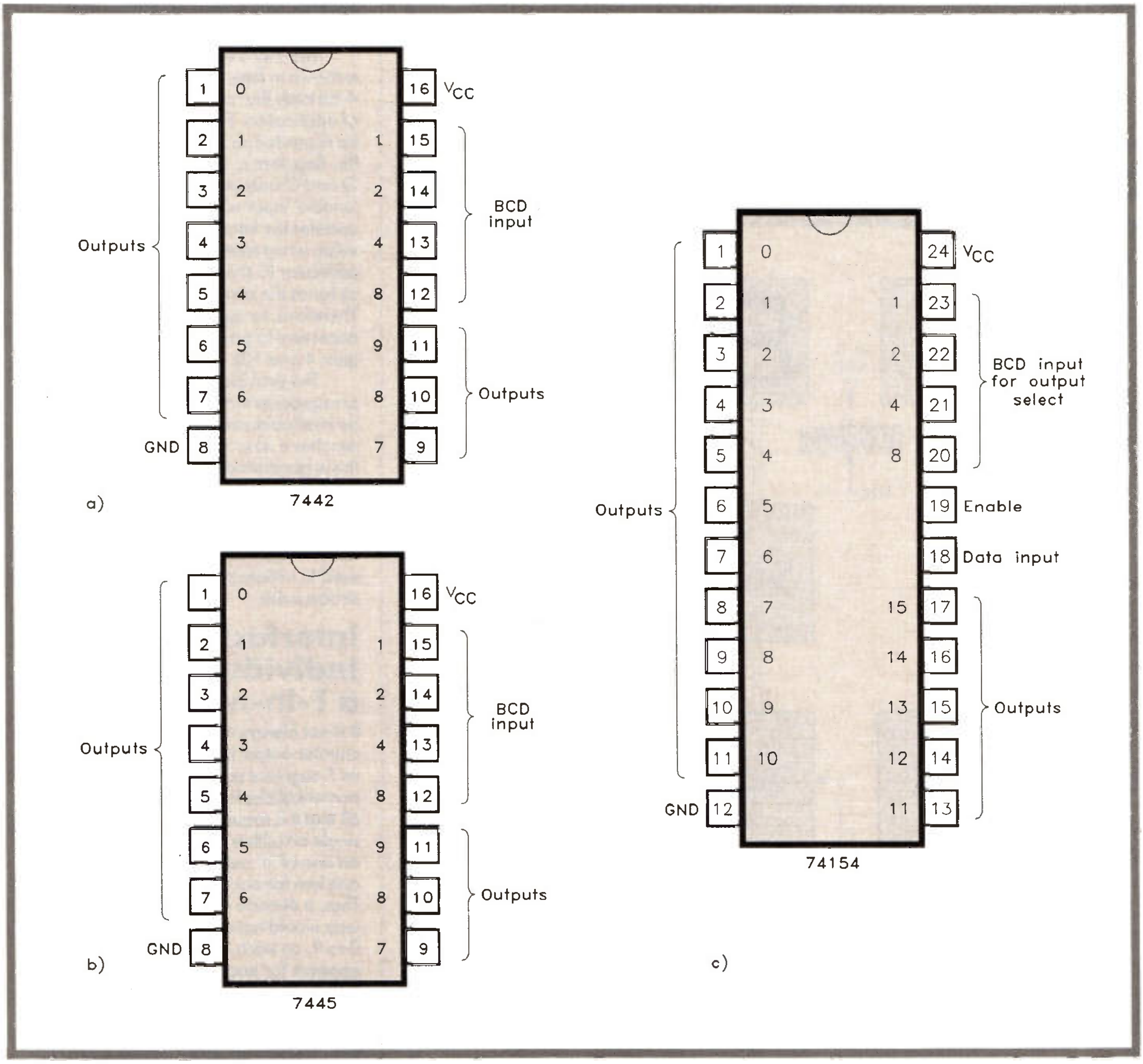


Figure 7. Some chips to decode 1-in-n outputs: (a), the 7442 BCD to 1-in-10 decoder; (b), the 7445 BCD to 1-in-10 decoder/driver; (c), the 74154 1-of-16 data distributor.

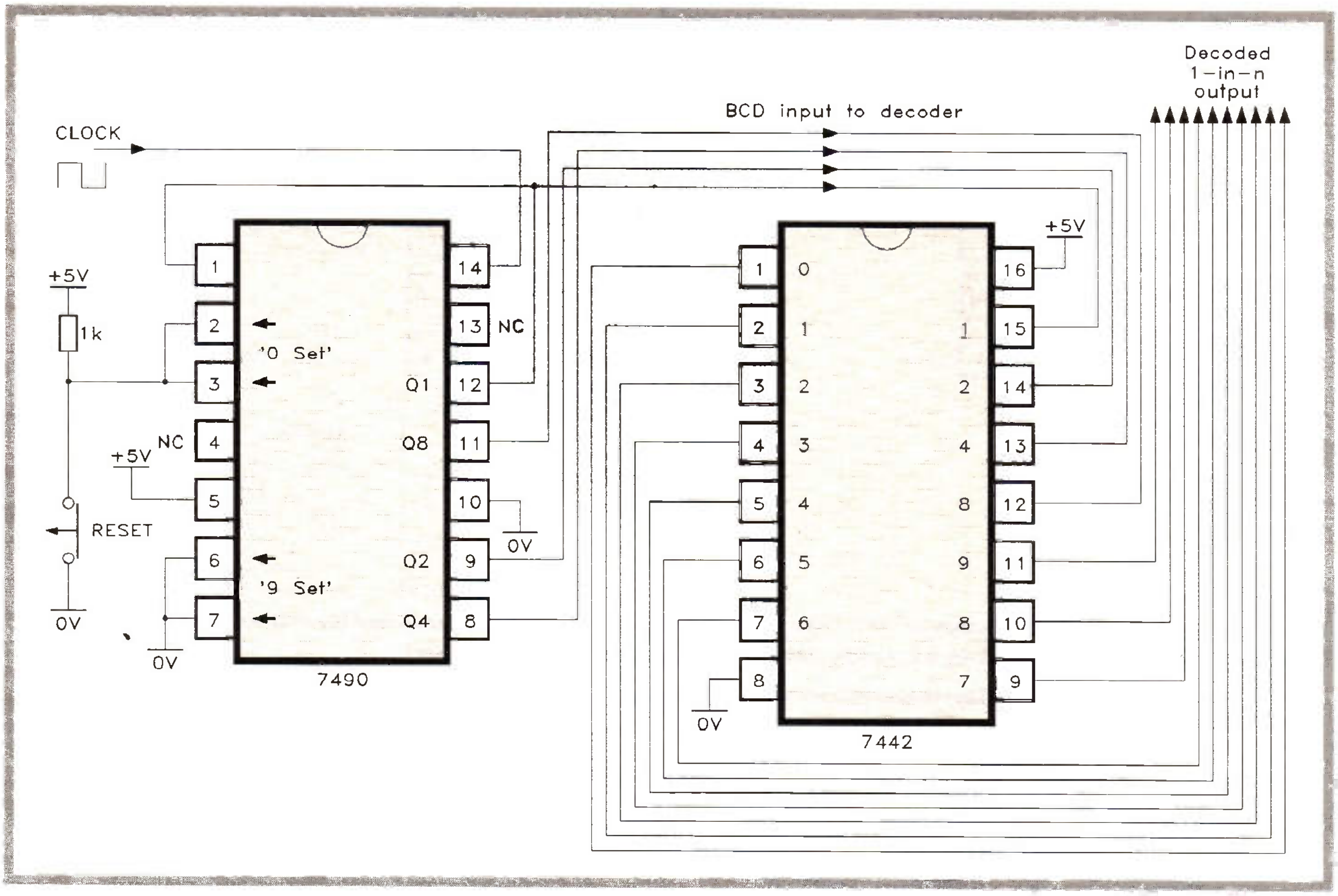


Figure 8. A decoded 1-in-n decade counter.

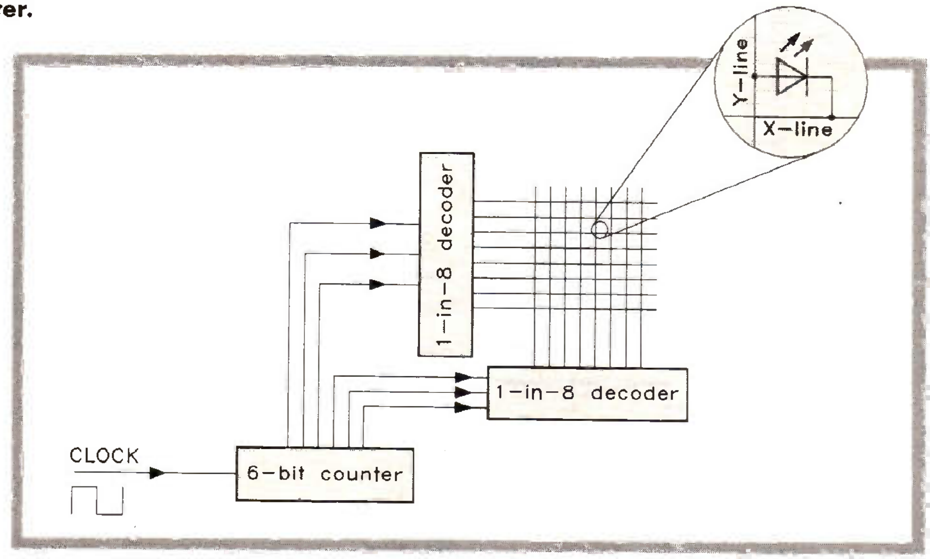


Figure 9. The matrix decoder for large 1-in-n values.

complexity, to a minimum. Suppose, as in Figure 9, it is required to decode the output of a 6-bit binary counter. Using the 1-in-n systems previously described, this would imply 64 separate output lines, each driving its own LED (for example). By placing the LEDs across the junctions of an 8 × 8 matrix, the number of driving lines is reduced to just 16, and only two 1-in-8 decoder/drivers are required. However, one of these needs to be 'output high' against the other's 'output low' type of drive. This is another way of saying that one decoder must be of the current sourcing type, while the other is of the current sinking type. This is evident from the practical scheme of Figure 10, where it is seen that it is the coincidence of the appropriate logic levels on a pair of X and Y wires that energises an LED. A current path must be provided from +5V through the LED and its ballast resistor down to ground. In the scheme shown in Figure 10, one of the 7442 decoders (with pin 12 grounded as explained above) has its driving logic inverted by a set of PNP transistors, these providing the current sourcing requirement. An alternative is the 74240 which can only source 15mA, but even this modest current is enough to drive small LEDs to an adequate brightness level for most uses. In this case, it is only 1mA less than the capability of the 7442 used, though the latter could be replaced by the higher current 7445 if required.

It is probably stating the obvious to say that although the LEDs are shown diagramatically in a square matrix this need not restrict them to the same spatial arrangement. What is shown is, after all, just an electrical connection diagram. In practice their physical disposition can be whatever you like.

Liquid Crystal Displays (LCDs)

The LCD display is an alternative to the seven-segment LED type. A totally different technology gives rise to certain advantages, and also one or two disadvantages. It poses the same essential decoding problems and, hence, will require a decoder chip of some kind in order to convert the BCD input codes into the required segment pattern. However, a little background theory first might not go amiss.

The first primary difference to note between LEDs and LCDs is that, whereas the former 'generate' light, the latter do not – they only control what light is available at the time. Thus, LCDs are not visible in the dark. The LED must be continuously energised by the passage

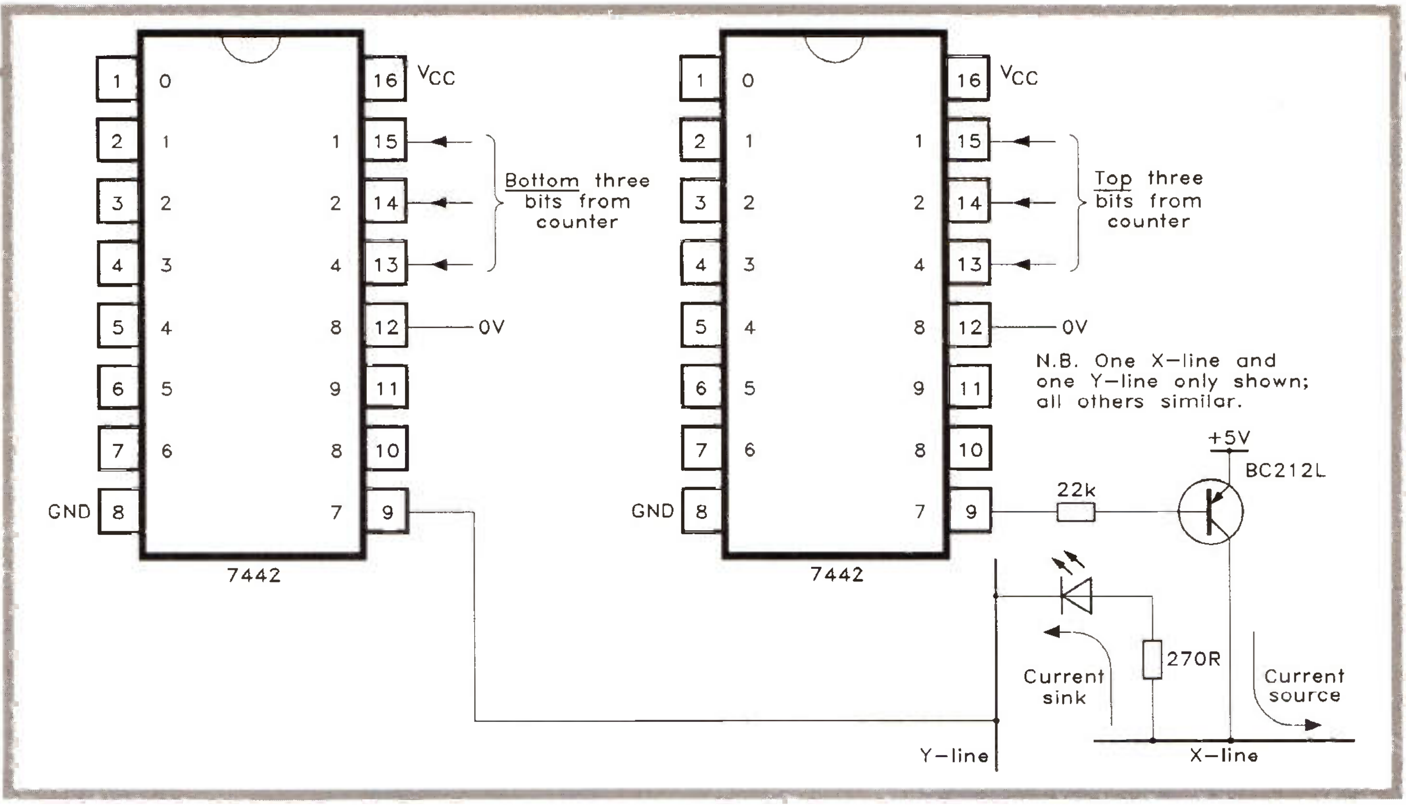


Figure 10. Practical circuit for a 1-in-64 matrix decoder of the type shown in Figure 9.

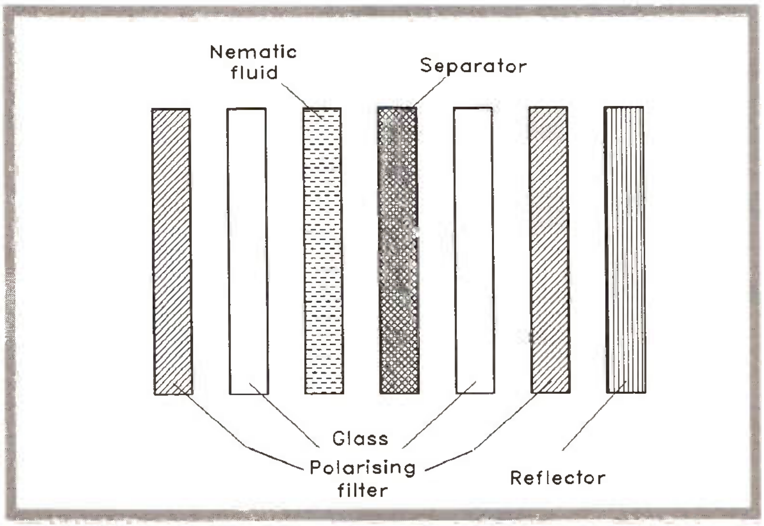


Figure 11. Basic construction of a field effect, liquid crystal display.

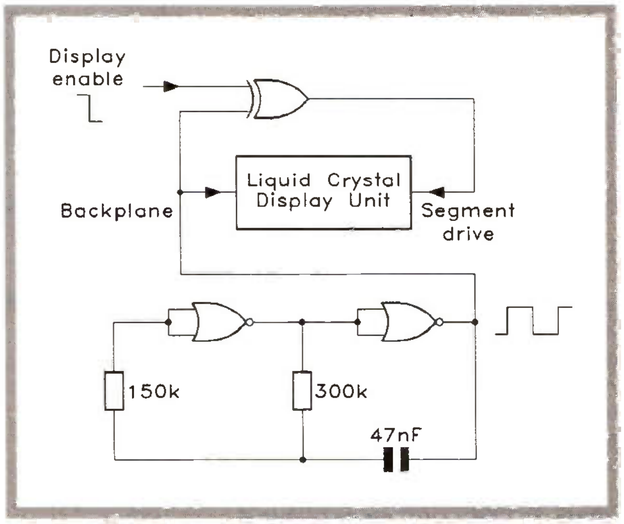


Figure 12. Circuit for driving a liquid crystal display.

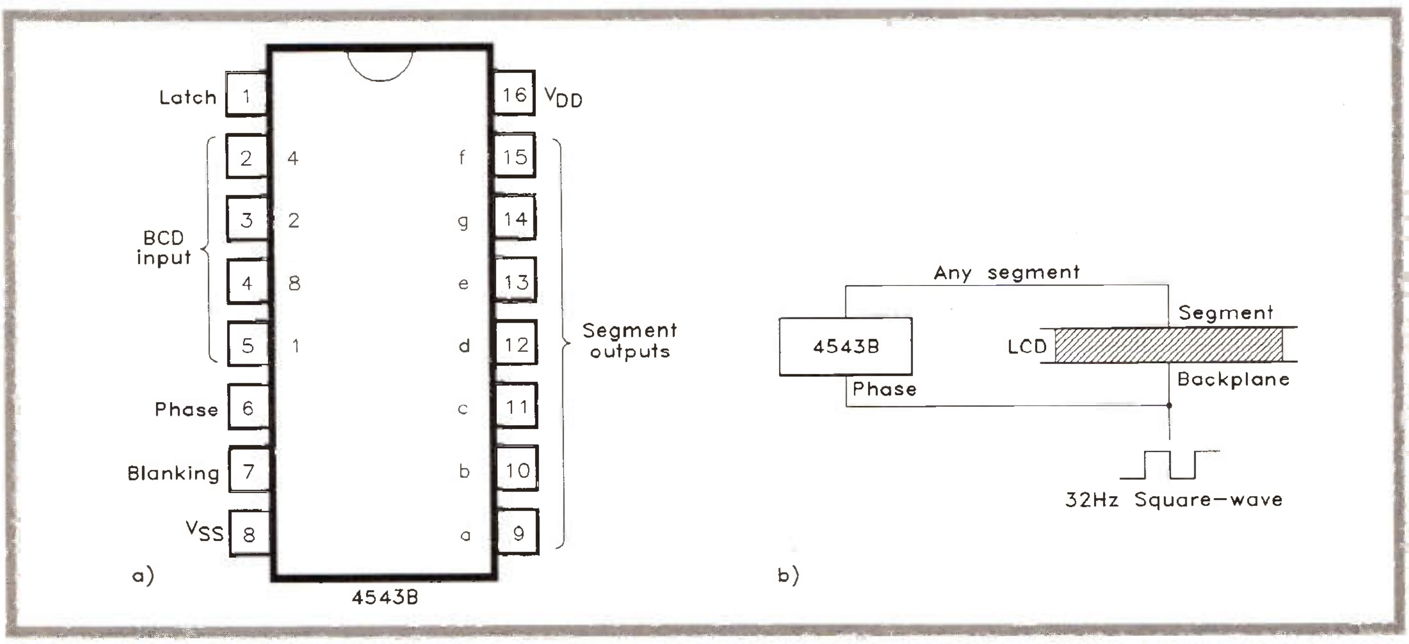


Figure 13. (a), the 4543B CMOS decoder/driver chip for LCDs; (b), connection of the 4543B to a liquid crystal display unit.

of current in a diode in order to display anything. By contrast, the LCD only consumes energy (and very little of that) when actually switching during the 'displayed' state.

There are two basic types of liquid crystal display, and also two basic ways of controlling the light. The two types of display are known by the terms 'dynamic scattering' and 'field effect'. The methods of light control are known as 'reflective' and 'transmissive'. In the case of reflective displays, incidental light travels from front to back of the unit, and is then reflected back towards the viewer. In the transmissive case, a light source behind the display is controlled as it is transmitted directly towards the viewer. The field effect reflective type is particularly popular because it is very economical with power and reflects the ambient light, thus requiring no separate light source.

In terms of construction, the field effect LCD consists of two pieces of glass separated by a special crystal liquid known as a 'nematic fluid'. One piece of glass is metallised all over, while the other is metallised only with the seven-segment pattern itself. Polarising filters are also fitted in front and behind the display. This sandwich construction is illustrated in Figure 11. While the segments are not activated, the molecules of the nematic fluid arrange themselves more or less at random attitudes and are transparent to light. When a voltage is applied across the nematic fluid, the resultant electrostatic field causes the molecules to align themselves and become opaque, but *only if* aligned polarising filters are present in front and behind the display. Sufficient interference of the polarised light causes contrasting characters to be seen, but only while the fluid is continually 'on the move' by the application of a slowly alternating electric field. Dark characters on a light background, or vice versa, are possible.

The voltage drive to the display must be alternating, usually a 5V square wave with a frequency in the range 30 to 100Hz. The presence of a direct voltage in excess of a very small specified maximum (25mV typically) causes reduced life or even rapid, premature death for the display. For this reason the square wave drive should have a mark-space ratio of precisely 1:1. Figure 12 shows a suitable circuit for driving a liquid crystal display, which includes a CMOS switch and oscillator. It works as follows.

When the display enable line (one per segment) is taken low, the square wave at the other input of the XOR gate appears in the same phase at this gate's output. Because both backplane and segment of the LCD are driven by waves of the same phase, this segment is not displayed. However, when the enable line is taken high, there is then a phase inversion between input and output of the XOR gate, and hence also between backplane and segment. This turns the segment on.

A Decoder/Driver for LCD Displays

The 4543B is a CMOS decoder/driver designed specifically for liquid crystal displays (Figure 13(a)). In addition to the 4-bit BCD input and seven-segment output, there are three pins labelled 'blanking', 'phase' and 'latch'. The blanking pin can be used to turn the display off completely, such as when the numeral '0' would be displayed as the leading character of a number. The latch pin allows display data to be held in the chip's internal latch and updated as required. The use of the phase pin is shown in the diagram of Figure 13(b).

That completes this particular series, and it only remains to give the answer to last month's brain teaser! The two codes that will not be detected and cleared are, of course, 0000000000 and 1111111111. A little thought should make it obvious why this is so.

NEXT issue

In next month's super issue of 'Electronics – the Maplin Magazine', there are some really great projects and features for you to get your teeth into! To whet your appetite, here's a taste of *some* of the goodies on offer:

100W PRO-AMP

At last! A professional-quality amplifier suitable for stage, fold-back/monitoring or PA use. Based around existing Maplin modules, the Pro-Amp is built into a standard 19in. rack-mounting case (2U high) and offers an XLR balanced-line input in addition to a host of circuit protection facilities. What's more – you build it as a kit, saving pounds over comparable commercial units.

RADIO CONTROLLED CARS

Trevor Tennant passes on some of his vast experience in the field of electric scale-model racing. Starting with a fascinating history of the subject, he then goes on to discuss the Traxxas range of vehicles – and how to make the best of them.

FAX DEVELOPMENTS

Regular technology correspondent Frank Booty examines facsimile – from both market and technical perspectives.

MELODY MAKER

When is a remote control not a remote control? When it's a Maplin Melody Maker! The Melody Maker is a fun musical instrument based around the UM3511A IC. It has 15 tunes already programmed in, and you can even store your own in its 47-note memory.

HIT FACTORY

Roving reporter Alan Simpson makes tracks down to the Hit Factory recording studio complex in London's West End, claimed to be the UK's most up to date, and discovers the advanced technology behind today's hit records.

DATA FILE: μA3730

The μA3730 is a single-chip electronic code-lock IC utilising CMOS technology. Code number (up to 12 digits long) entry is by keypad – and there are 1012 different combinations. There are three different logic outputs – suitable for most applications.

Plus of course there's all the usual features for you to enjoy!

'ELECTRONICS – THE MAPLIN MAGAZINE'

BRITAIN'S BEST SELLING ELECTRONICS MAGAZINE

FINISHING OFF

PART THREE
by David Smith

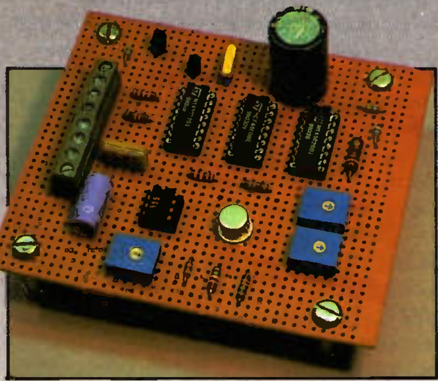
This month, in the third part of our series on improving the visual appearance of home-built electronic projects, we look at the many varieties of panel-mounted controls and components available to the home constructor. We also show how projects constructed on stripboard (more commonly known by the trade-name 'Veroboard') can be made to look more pleasing to the eye.

The Board Stripped Bare

Stripboard has been around for many years now, and will no doubt be around for many more. There is no denying its versatility, with its ability to offer the home constructor a quick and efficient way of producing a circuit board. However, by its very nature (that of being full of holes), it can never look as attractive as a glass fibre PCB which has undergone silk-screen printing. We can nevertheless improve on the appearance of Veroboard before mounting any components onto it, and this can be done as follows:

Start by cutting the board to size and drill any holes required for fixing(s) etc. Then, before mounting the components, cover the top surface of the Veroboard with a layer of white Fablon, or similar vinyl-type covering. Take care to smooth it down flat to eliminate any air bubbles which may have been formed. You now have a clean, flat surface on which to mount your components. All unused holes are now invisible to the naked eye. However, to make the holes temporarily visible, so that components can be fed through their appropriate holes, simply hold the board up to a light source and you will see exactly where to pierce the plastic skin.

What you do next depends on how far you are determined to go to make your project look more accomplished. You could start to mount all the components at this stage, or you could go one step further and lay down some Maplin graphic transfer lettering to indicate where the components need to be placed, marking in the circuit references (R1, C3, IC4, etc). This is the equivalent of silk-screen printing similar lettering onto a glass fibre PCB. You could also transfer your company logo, a telephone number (to contact in case of trouble), or the board's function(s). It's your choice entirely what information you put on, or indeed leave off, the board – but it is worth studying the methods used by professional board makers.



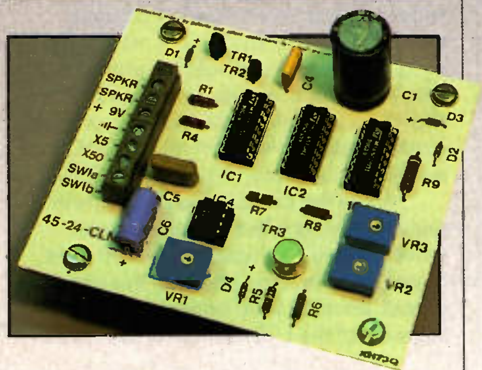


Photo 1a. (top) Typical stripboard circuit construction, showing how a project would normally be finished off.
Photo 1b. (above) This shows the neat way in which stripboard can be presented. Note the way in which Maplin graphic transfer lettering has been added to aid the identification and location of all components. An additional trick is to make the board appear more 'professional', by adding a few obscure words or numbers around the board in any free areas. This suggests that some sort of coding may be in progress.

Of course, lettering is not placed onto professional PCBs to make them look more pleasing to the eye. It is very useful when one is trying to identify components from circuit diagrams, during servicing. You may feel that after spending many weeks on a project, you would know the board(s) and circuitry inside out, but come back to the project in a few months time (when it refuses to work, perhaps), and you will be surprised at how much information you have forgotten! Don't, therefore, under-estimate the value of any time spent now in producing the board – you will be fully rewarded for your efforts in the future. Photo 1a illustrates the conventional way of finishing off a stripboard project, while Photo 1b shows what can be achieved with a little extra effort.

Design and Layout of Controls

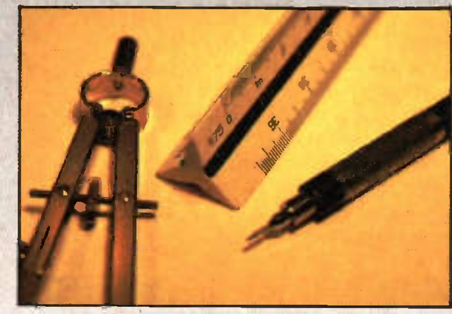
Designing the front control panel of one's project can be a fascinating adventure, but there are pitfalls to look out for. Firstly, there is a great temptation to ignore all the planning and drawing stages, and go straight ahead with the fitting of all controls, switches and sockets required. If the project is simple, and uses only a few items, then you may get away with it. However, should it be a more complex design, such as the 'Benchmaster' project, then the following scenario could develop:

You may, perhaps, start off by fitting various bits and pieces at one end of the panel, only to find yourself running out of space at the other end. I know that if I had started to build the 'Benchmaster' project before putting pen to paper, there would be no doubt as to how I would have started. Thinking logically, (or so one always assumes!), I would have fitted the meter in the centre of the front panel. That would have been the first mistake, as I wouldn't have thought far enough ahead to know exactly where all the audio sockets were to be fitted. After such a mistake, everything else fitted to the front panel would have been a compromise. As this example illustrates, it just isn't worth taking any short-cuts. You cannot 'undrill' holes later on, so make doubly sure that you are happy with the layout on paper – before the first cut is made.

If you have ordered the components ahead of time and have them to hand, then it is a good idea to lay them all out temporarily along the surface of the front panel, trying them in different positions to find out which layout is most pleasing to the eye, whilst at the same time bearing in mind any operational needs. I used this method when designing the Benchmaster, as you can see from Photo 2.

If some components are oddly-shaped and are difficult to stand upright, then use a small amount of 'Blu-Tack' to keep them in position. Do not bother to lay potentiometers

Photo 2. (above) Setting out the various controls on the case can give you the opportunity to try out different arrangements before finally committing yourself to drilling any holes.
Photo 3. (right) Drawing implements, including a three-sided scale rule with different scales on each of its sides. These items are available from all good stationers.
Photo 4. (below) A small cross-section of a wide variety of types and styles of switches.



onto the panel; put their control knobs there instead. If lampholders have removable lenses, then remove them, and lay them flat onto the panel. After all, what you're trying to achieve is an idea of what the project would look like should you decide to go for that particular layout. Therefore, the more controls, or whatever, that are placed in their 'natural' positions on the panel, the easier it will be to visualise the end product.

However, should you be in the position of not having any of the components to hand at this time (thereby having to rely on drawings), then *draw* the plans to scale (rather than using 'freehand'). If your design is complex, like that of the 'Benchmaster', then don't be tempted to do a rough sketch of 'what goes where'. If space is tight, there is a psychological tendency to draw the fittings smaller in size and shape, in order to make them fit the space available. Graph paper is cheap, so why not buy a pad of it? You can then lay your designs down onto it, using suitably scaled dimensions. If you prefer to draw on plain paper, special rulers are available which will certainly make life easier. These rulers enable you to choose from a selection of scales. The one that I use is triangular in cross-section, and offers the following scales along its three sides; 1:1, 1:20, 1:25, 1:50, 1:75 and 1:125.

If you've never attempted any technical drawing before, don't worry – it's really very simple! Have your case in front of you, along with a piece of A4 drawing paper and a scale ruler.

A tri-square and a pair of compasses would also be useful additions at this stage, but are not absolutely necessary. You will also find it easier to work in millimetres, rather than inches. Photo 3 shows a selection of drawing implements.

Firstly, measure the width and height of the box. Then look to the scale ruler to find which scale allows your drawing to fit onto the page, without it being too large or too small. All you have to do from then on is to use that particular scale when drawing all the components. Do not forget, though, to measure your actual components using a normal millimetre scale. This measurement is the one which should then be transferred to your new, chosen scale for drawing purposes. For example, let us assume that your case is 300mm in length. You will find this measurement just a fraction too long to enable it to fit onto a sheet of A4 on a one-to-one basis. Therefore, you have to use a different scale, and the best one for this application that I have found is the 1:125 scale which will result in a margin, on either side of an A4 sheet, of about 25mm.

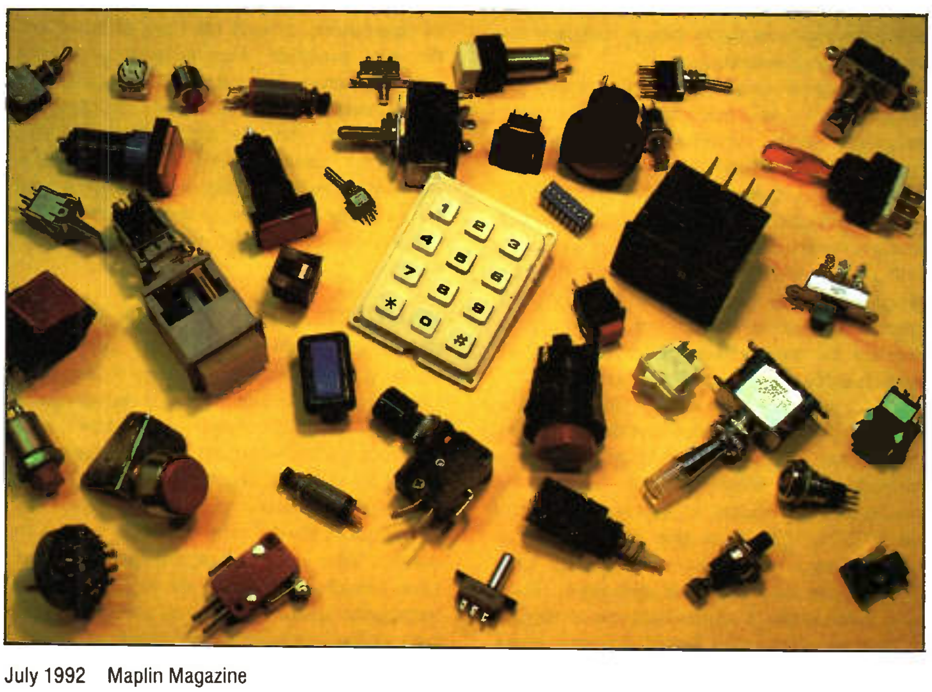
You can choose either to draw your design in pencil, making alterations as you go, or you can alternatively cut out cardboard shapes to represent the various controls which you intend to use, and move these around on the sheet of A4, within the scale-drawn dimensional area of the case. Of course, all this presupposes that you have chosen all the controls for your project already, but in case you haven't, we're going to take a look at that area next, to help you make your choice.

Selecting Components for your Projects

Switches

When it comes to deciding what type of switch to choose for your project, you can be forgiven for feeling somewhat overwhelmed at the vast amount that there are on offer. They come in all shapes, sizes, and a wide variety of electrical ratings – a small selection from the Maplin Catalogue is shown in Photo 4. So what criteria do we need to make the choice? Paramount must be the electrical safety ratings of a switch, with respect to the chosen application. It would be downright foolhardy to choose a switch because it looked 'pretty', only to see the device disintegrate upon switch-on because of it not being 'man enough' (or 'switch enough', perhaps?) for the job. At the other extreme, it is possible to use a 25A 1000V rated switch to operate an LED. It will work, and it will be safe, but it would hardly be practical!

It is therefore important to choose the correct switch for the job. Select one which you think would look attractive on your project and, above all, check its electrical characteristics to be sure of its suitability. Let us now consider the different types of switches available to the home constructor:



Mains Switches

Switches, designed for use at mains voltage, fall roughly into the following categories: rocker; toggle; rotary; push-button; slide; and those operated by use of a security key.

When choosing a switch, you may have a preference for a certain type. However, it is most important that you not only weigh up its aesthetic qualities, but also look closely at its colour, size and design in relationship to the other controls on the front panel (assuming that you are placing the mains switch on the front panel, of course). For instance, will you want a separate 'mains-on' indicator? – or could this indicator be integral with the switch itself, in the form of a neon? There are no hard and fast rules. It's also possible to make the appearance of a switch similar to that of other controls. Say, for instance, that you wanted to fit a line of rotary controls on your front panel. Then why not make the mains switch a rotary one, giving it a similar control knob to all of the others.

Another point to bear in mind is that mains switches have to be physically strong in order to perform their function correctly. As a result, they often require a substantial force to operate them, so be careful where you situate them on your case. On larger projects, the problem is not so significant as the force required in operating the switches can be absorbed by the weight of the box itself. Smaller projects, however, might find themselves toppling over when the mains switch is operated, causing great annoyance to the user!

For your own safety, and the safety of others, please use a double-pole mains switch wherever possible. This will reduce the chance of an electric shock. Using a single-pole switch would only isolate one side of the mains; if there should be an accidental reversal of the mains wiring (in the 13A plug for instance), it would leave the live wire unswitched inside the case! It is also a good idea to cover all mains terminal wiring with rubber sleeving – with reference to the on/off switch, fuse holder, transformer connections, and anything else at mains potential.

Push-Button Switches

Let us leave mains switches to one side for the moment, and discuss other forms of switching. I speak for myself at least when I say that I become most frustrated when unable to emulate the incredible precision offered by commercial manufacturers on their products. I'm referring particularly to the huge variety of push-button switches located on Hi-Fi gear. These usually take the form of slim, elegant plastic buttons, which are oblong in shape and protrude just enough through a pre-punched front panel for you to operate them. The accuracy re-

Photo 5. (above) A view of a front panel showing how *not* to fit an on-off switch. In this instance, the second securing nut (which normally fits behind the panel) has been omitted, leaving too much threaded switch shaft on display.
Photo 6. (below left) This shows the switch with the rear nut correctly fitted. Notice that the front nut has been tightened to its final position so that the square side of the nut ends up in a horizontal position.
Photo 7. (below right) This shows how *not* to finally tighten the frontal nut of the on/off switch. It looks untidy and unprofessional.

quired when punching a line of oblong slots into a front panel like this is quite phenomenal, and the larger manufacturers spend vast amounts of money in accomplishing this. If you think that you could do as well, then take a look at the cheaper end of the Hi-Fi market, in those situations where the more expensive equipment has been emulated. It's easy to see where tolerances have been compromised, leaving the gaps between the push-buttons and their respective holes slightly wider. This, in turn, allows the oblong push-buttons to appear less than straight, giving the unit a somewhat sloppy appearance. Remember – this level of quality is offered from manufacturers who have access to engineering workshops!

In other words, don't attempt this sort of frontal switching arrangement, unless you are extremely proficient at metal work. I have found it far more rewarding to use the type of switch that has an escutcheon because when fitted, it will overhang that hole slightly, to disguise any drilling inaccuracies that may have occurred. There are plenty of switches on the market which offer this sort of fixing.

To summarise then, if you are really good at metalwork and have a need to fit a push-button type switch to a front panel, then you could comfortably choose one such as FF87U (This is the format of a Maplin order code – refer to the Catalogue for further details). This is a click-effect push-button switch, which requires an 8mm square hole to be cut in the control panel for it to fit through. However, if you are *not* very good at metalwork, then I suggest you choose FA78K, another push-button switch, which also has an escutcheon that overhangs the panel hole. These are not the only two alternatives, of course, and a further study of the 'Switches and Relays' section of the Maplin Catalogue will give you a complete understanding of what is on offer.

Toggle Switches

Unless you need the current-carrying capacity of large toggle switches, it is best to stick to the smaller variety for your projects. These come in all sorts of configurations, from a straightforward 'on/off' type, to those offering locking, non-locking and centre-off alternatives. There is also a range of coloured toggle covers (as well as a splashproof one) that fit over the dolly of a switch. Another common problem associated with toggle switches, is that too much shaft is often left to protrude above the panel, leading to a sloppy appearance – see Photo 5. To offer a finishing touch to the appearance of a toggle switch, adjust its rear fixing nut (the one that ends up behind the control panel) just enough to enable the front fixing nut to come to rest with one of its flat sides in a horizontal position, as shown in Photo 6. Alternatively, align one of the 'points' of the nut to face straight upwards. Never fix the frontal nut somewhere between the above two positions, as it makes the switch look sloppy and untidy – as shown in Photo 7.

Slide Switches

Slide switches offer a very quick visual confirmation of their state, but do require quite precise oblong holes to be cut in the panel if they are to look visually appealing. They can be quite stiff to operate, and so should be only be used on larger projects where the forces required in operating them can be absorbed, or on smaller hand-held projects where this same force can be dissipated into the hand. Trying to use them on small free-standing projects usually means that the operator has to use his other hand to steady the box – not a satisfactory way to design or use a control unit!

Illuminated Switches

Illuminated switches can be quite spectacular if used in any quantity, although trying to make your project look similar to the flight-deck of a 747 should be avoided! The illumination of a switch, when operated, does give a very positive sign of its state and there are various ways in which this can be achieved. One of the simplest types of push-button indicator uses no power at all. These are called 'magic light' buttons, and are very effective in operation. They work by employing a bright orange (or yellow) reflective coloured disc, situated (but hidden from view) in the transparent tubular casing of a push-button. When the button is pressed downwards, two jet-black covers, which up to this point have been concealing the brightly coloured disc, are mechanically moved sideways to reveal it.

Please note that this type of push-button can only be used with the Maplin interlocking push-button switch system. However, such a system does offer an almost infinite variation of configurations, fulfilling practically all the requirements of a quality push-button switch installation.

Push-buttons with Electrical Indicators

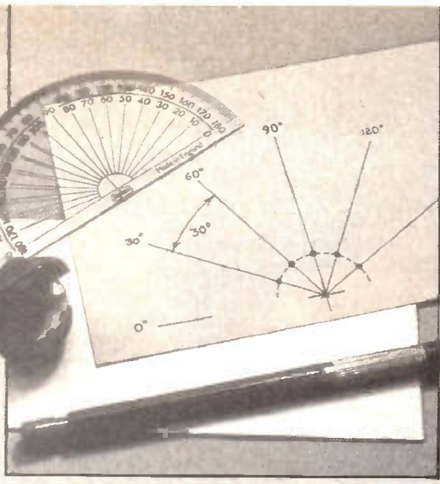
Moving onto the more common type of push-button switch and complementary indicator, there is a choice between using filament bulbs or LEDs for illumination. These indicators can either be integral to the switch itself, or placed adjacent to the switching device.

When designing your project, think about what it will be used for, and the environment in which it will find itself. For example, if you are building a heavy-duty control box to be used in a factory, then you should perhaps choose one of the larger types of filament indicator assemblies. This would enable any factory workers to check the console at some distance. If, on the other hand, your project is destined for the office or home environment, then consider using one of the Maplin range of modular switches which feature an LED. These offer a much gentler way of informing the end-user of a particular function's on/off state at any time.

Rotary Switches

When marking out a panel prior to fitting a rotary switch, care must be taken to get the indexing correct. You can do this by checking the specifications of the switch when you buy it.

For example, Maplin's FF73Q rotary switch has an index number of 30°, which means that for every click forward of the switch, the pointer knob attached to the switch shaft would sweep through an arc of 30°, before coming to rest at its next position. You need this information to enable you to produce the artwork for the panel. It enables you to place a dot or mark at each stop position, along with any switch function information. A protractor should be used for this operation rather than guesswork (see Photo 8); there is nothing more tacky than operating a switch where the markings on the panel do not line up with the position of the pointer knob. Alternatively, if you have the switch to hand, you could fit it temporarily into position along with the pointer knob, and mark where the knob settles at every click stop. After doing this, remove the switch and continue to mark up the artwork accordingly.



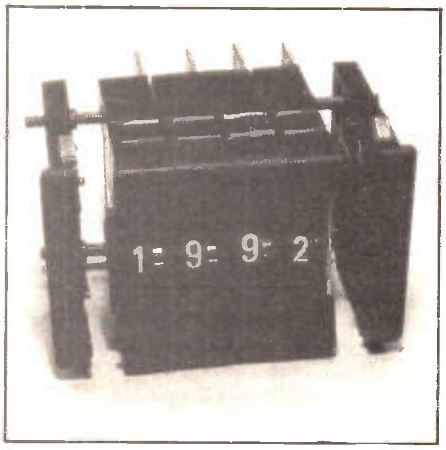


Photo 8. (top) Marking out the positions that a rotary switch will come to rest at, before transferring them to the front panel of a project. In this example, the switch has indexing marks of 30° per position. A protractor is used to measure these angles.

Photo 9. (middle) This photograph highlights the extra hole required when fitting a potentiometer or rotary switch to a control panel. The peg, when located in the hole, prevents the control from rotating from its original position.

Photo 10. (above) Set of thumbwheel switches, showing the end cheeks.

Just one other point. To prevent rotary switches from turning away from their original setting (normally caused by undue force being exerted on the knob), there is a small lug on the device which must be located in a secondary hole, drilled adjacent to the main hole in the front panel. This can be seen from Photo 9. Most rotary switches (and potentiometers) have these lugs, and it's well worth using this facility, even if it means having to drill a few more holes. If you try to fit the control without first drilling this extra hole, you may find that it doesn't seat very well against the panel, and you will probably have to break the lug off before being able to fit it properly.

The only time I prefer doing it the 'wrong' way (i.e. snapping off the lug) is when the knob being fitted to the control does not cover the hole drilled to take the lug. I would prefer chancing the control inadvertently turning, to having a small hole showing in the panel. I suppose the answer is, wherever possible, to use larger knobs!

Remote Switching

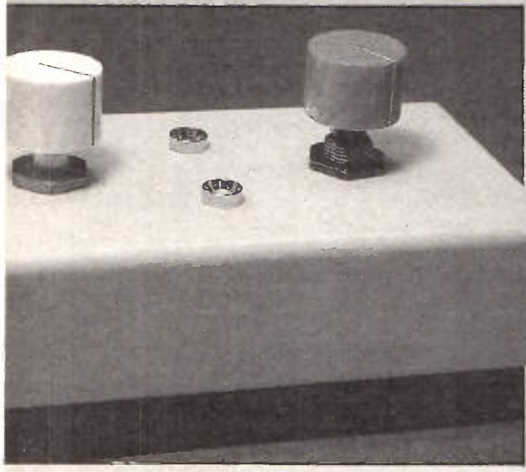
Always bear in mind that you don't *have* to switch whatever it is you are switching, directly from the front panel. Think along the lines of using a small panel-mounted control to actuate a relay, which in turn is used to switch any heavy currents required. The same goes for cross-point switches, opto-isolators, or any other remote control device. This opens up the idea of being able to use touch control-type metal pads in order to operate functions remotely. If you use Maplin's touch pad (HY01B), then you would have to use a plastic or other suitably insulated front panel.

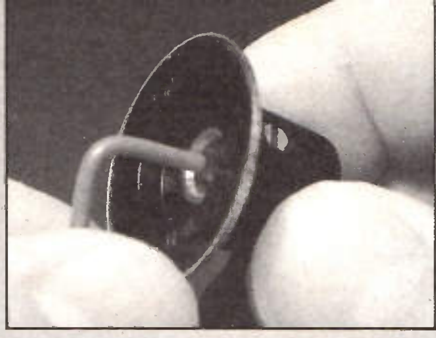
Other Switches

Thumbwheel switches can be fitted quite easily but when buying them, don't forget to add two 'end cheeks' to the order. These 'end cheeks' are used to complete and enhance the final appearance of the block of switches. Once the switches are fitted into place, they will look good, because the hole you have to cut out for them to fit into will be hidden behind the switch's escutcheon, which you can see in Photo 10.

Potentiometers

Rotary pots, such as volume and tone controls, should pose no problem in fitting. The shaft of the pot should be cut just short enough to allow its control knob to sit just above the surface of the panel. Projects can look most unprofessional with knobs that sit away from the panel because the control shaft has not been cut short enough – these are reminiscent of tin cans stuck on the end of broom handles! An example of this effect can be seen in Photo 11. An easy way to measure just how much shaft needs to be removed from a control is to take a piece of stiff, PVC connecting wire, and insert it into the control knob until it touches the back of the inside of the knob, as shown in Photo 12. Then bend the wire through 90°, and transfer that measurement to the control shaft of the potentiometer (see Photo 13).





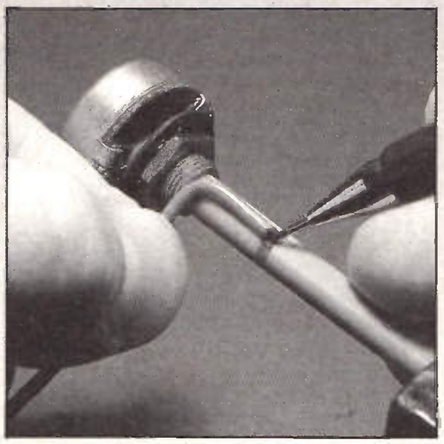


Photo 11. (top left) On this project, the control shafts of the potentiometers have been left too long. As a result, the knobs protrude clumsily above the top surface of the case.

Photo 12. (top centre) To find out how much shaft needs to be cut off a new control, first measure the depth of the intended knob's fixing hole by using a stiff piece of wire, bent at right angles as shown here.

Photo 13. (above) Transferring the measurement, made in Photo 12, to the shaft of a potentiometer. The shaft can then be cut at this point using a junior hacksaw.

Photo 14. (top right) A selection of optical indicator devices available from Maplin.

The thickness of the wire's PVC sleeving will enable the control knob to sit proud of the panel by that same amount. Use a junior hacksaw to cut the shaft of the control, filing the cut edge of the shaft afterwards to smooth away any burrs.

When fitting slider controls, the easiest way to cut the required slot is to first drill a small hole, and then use a metal nibbler (covered in Part 1) to elongate that hole into the desired length of the slot. If your slider control is supplied with an escutcheon, then so much the better because any discrepancy incurred whilst cutting the slot will be hidden by the accurately machined slot of the escutcheon. It is also a good idea to fit some black felt cloth behind the slot under the escutcheon. Fitting an oblong strip of this material on either side of the slider will help to hide the hardware of the potentiometer as the slider is moved up and down the scale. Do allow the two pieces of cloth to touch down the centre, so that as the slider's shaft moves up and down, it will part the felt, but only under the knob.

Seven-Segment Displays

Any seven-segment displays that you use can be made to look a lot nicer by surrounding them with some form of escutcheon.

One of the easiest ways to do this is to buy some plastic edging strip from a model shop, and fit lengths of this around the perimeter of the cut-out. There are various shapes and thicknesses to choose from, offering scope for experimentation. Always fit some anti-reflection filter film over the displays themselves, because this greatly improves the contrast of the LEDs, as well as serving to hide all the joins in between the LED casings. Choose the filter colour that is closest to the display colour i.e. red or green. Alternatively, there is a neutral density filter available which can be used with either.

LEDs

Although ordinary LEDs can be fixed into position using plastic clips, I think that those fitted with chrome bezels look far more attractive. Remember, there are also LEDs made that are able to change colour as you reverse the polarity of the voltage feeding them. On occasions, therefore, one panel-mounted LED can do the work of two, or even three, individual LEDs. This can sometimes be beneficial if space is limited.

Maplin offer an incredible range of LEDs. You have a choice of red, orange, yellow, green or blue colours; round, rectangular, square, cylindrical, triangular or arrowhead shapes; 3mm, 5mm, 8mm, or 10mm sizes with clips or bezels; continuous/flashing or continuous green/flashing red; bi-coloured or tri-coloured; superbright, ultrabright or hyperbright; low current or constant current; multi-array; dot matrix; bargraph or 7-segment. Photo 14 shows a selection of the lamps and LEDs that are available from Maplin.

In all, the 1992 Maplin Catalogue lists a total of 119 different types for you to choose from! Why they don't offer the complete range of LEDs by including the Outer Mongolian gas-driven Splatter-puffa LED, I'll never know!

Design Considerations

It cannot be over-emphasised that to design your project to look professional, you must study the professional market. Next time you visit a Hi-Fi store, take time out to look very carefully at the design of everything on offer, instead of checking out the specifications of the latest amplifier or whatever. Scrutinise the way in which switches are fitted, and ask yourself why you think *that* particular amplifier uses *those* particular knobs. Look at colour schemes, the shape of cases, the size and shape of lettering employed on the case etc. The list of things to look for is virtually endless.

When you've finished there, wander down the high street and into your local photographic store, where hopefully you will be able to investigate all the little 'gizmo' boxes that are produced to help video enthusiasts and amateur photographers part with their money. If the store doesn't stock any of these, then perhaps you could peruse through a catalogue or two. Video catalogues often have lots of devices for the remote control of equipment, or to enable time-lapse photography to be undertaken. All of these are housed in little boxes of roughly the same sort that you or I would end up using to house something.

I'm not advocating direct copying of these products, but seeing them from a designer's point of view will enhance your knowledge of the techniques that are

Continued on page 72.

Ideal for beginners – No soldering required.

All You Need to Build Your Own

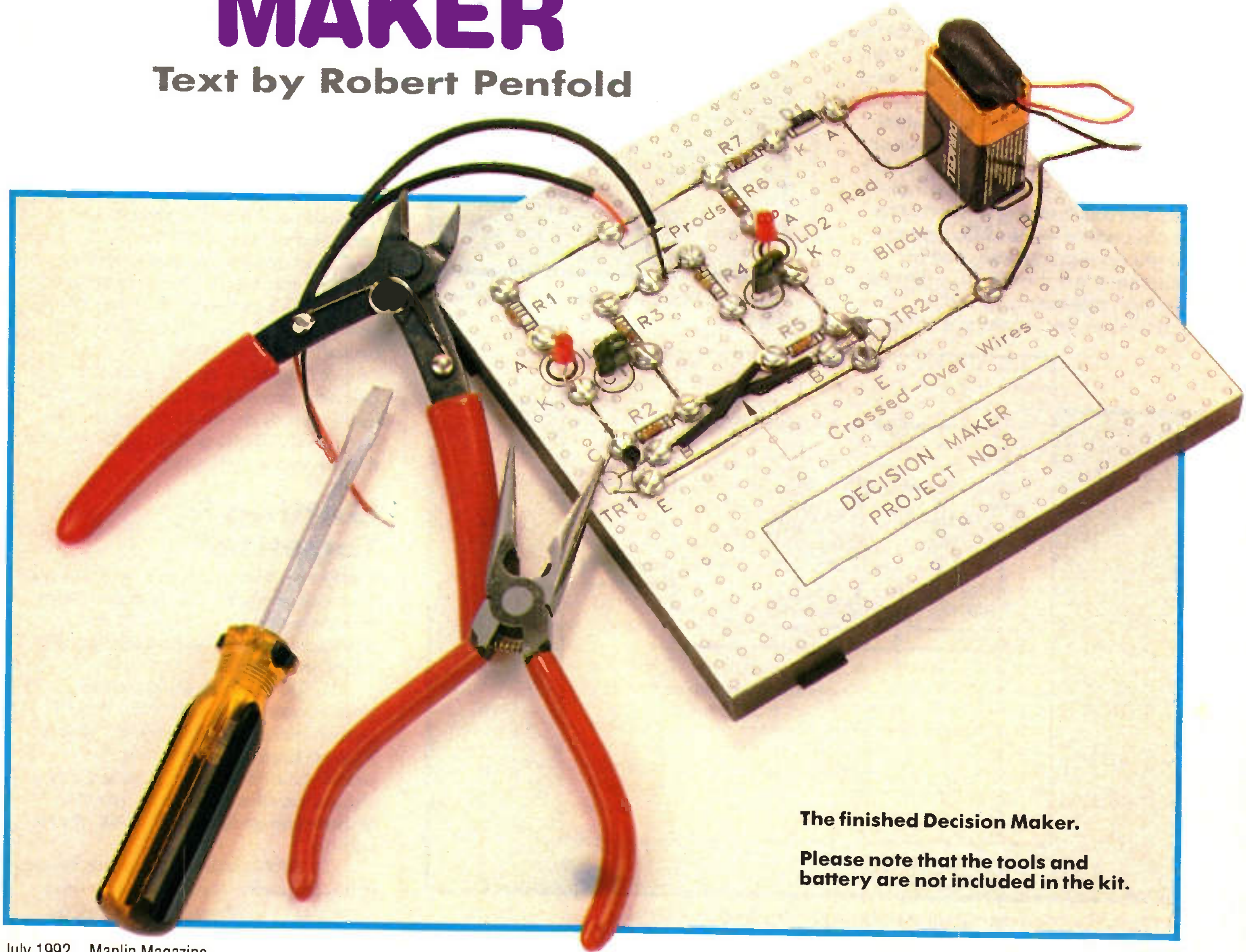
FUN TRONICS PROJECT No8

DECISION MAKER

Text by Robert Penfold

Do you take an unnecessarily long time to make a simple decision? Well, for all you indecisive people out there, this month's Funtronics circuit is just for you. It has two LEDs which you can label 'yes/no', 'in/out', 'heads/tails' (or whatever), and when operated will light up either one. You start the unit by touching two prods together, causing both LEDs to switch on. However, when you separate the prods, only one of the LEDs will remain switched on, and there is no way of predicting which one it will be. Like tossing a coin, the unit produces a random result. To be strictly accurate, however, the unit will almost certainly show a very slight bias to one LED or the other. Simulating the tossing of a coin electronically is actually much more difficult than you might think! This unit is quite simple, but any bias to one LED or the other should still be very small. You would probably have to activate the unit a few hundred times to reliably demonstrate any slight bias!

Apart from obvious uses in sporting games of chance, some people (hopefully not those that run the country – or predict the weather!) use units of this type when



The finished Decision Maker.

Please note that the tools and battery are not included in the kit.

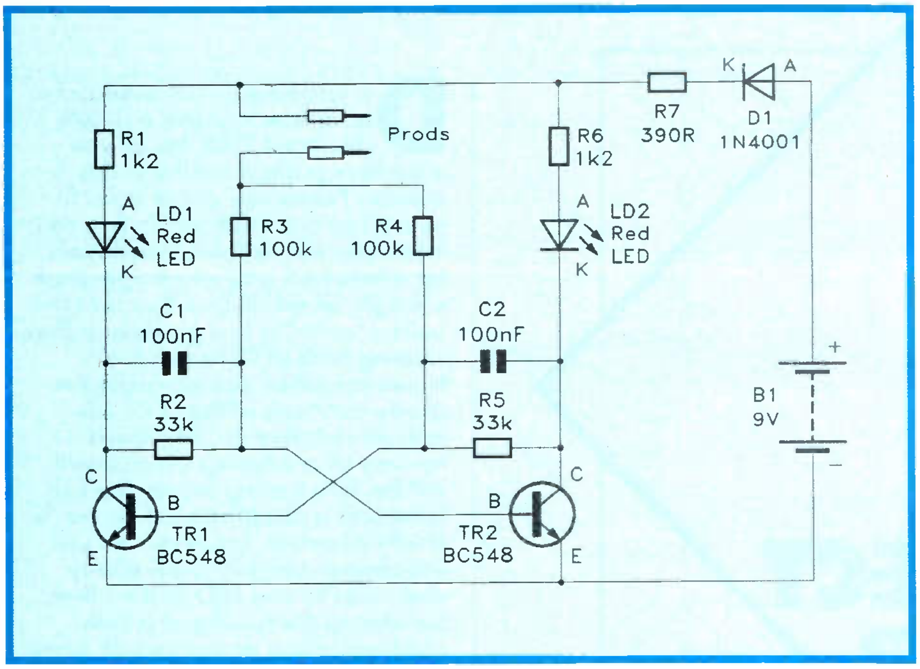


Figure 1. The Decision Maker circuit diagram.

they cannot make up their minds. For example, if the result is 'heads', then I will buy the ice cream; if it is 'tails', then I will buy the bar of chocolate.

How it Works

Figure 1 shows the circuit diagram for the Decision Maker. This combines two well-known forms of circuit. One of these is the astable multivibrator, as used in some of the previous 'Funtronics' projects. With the prods connected together (and R2 and R5 ignored for the moment), we have a simple oscillator which generates several hundred pulses of electricity per second. LEDs LD1 and LD2 will flash on and off at this rate, but this flashing is too fast to be noticeable – the LEDs appear to light up continuously, but at something less than full brightness. This high operating speed is essential, or you could cheat by waiting for the desired LED to light up before separating the probes!

As described so far, the circuit will not provide the required action. When the prods are disconnected, both LEDs simply switch off. A simple 'memory' action is needed so that the LED that was activated at the instant the prods were separated, remains on. This memory action is provided by R2 and R5. When the prods are separated, the circuit is effectively converted into one known as a 'bistable multivibrator', or 'flip-flop' as it is sometimes known.

Assume that LD1 is switched on and LD2 is switched off when the prods are separated. In this case, the voltage at the collector of TR2 will be at just under 9 volts (i.e. nearly the supply voltage). As a result, TR1 will be turned on, causing LD1 to glow. The voltage at TR1's collector will be very low, and so TR2 will be switched off. In other words, the required memory action is produced with the LEDs being held in whatever state they happen to be at when the prods were separated. If it is LD1 that is switched off and LD2 that is switched on, the memory action is still obtained. TR2 will be turned on by TR1's collector, but the low voltage at TR2's collector will not be sufficient to turn on TR1.

R7 and D1 are included to provide protection for the circuit in the event of an error being made, such as the battery being connected the wrong way round.

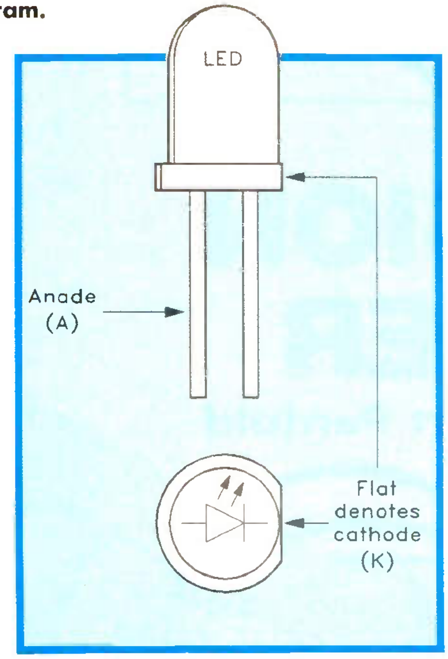


Figure 3. LED symbol and connections (LD1, 2).

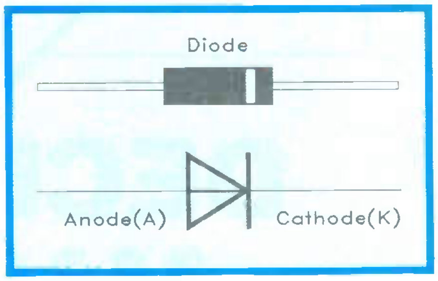


Figure 4. Diode symbol and connections (D1).

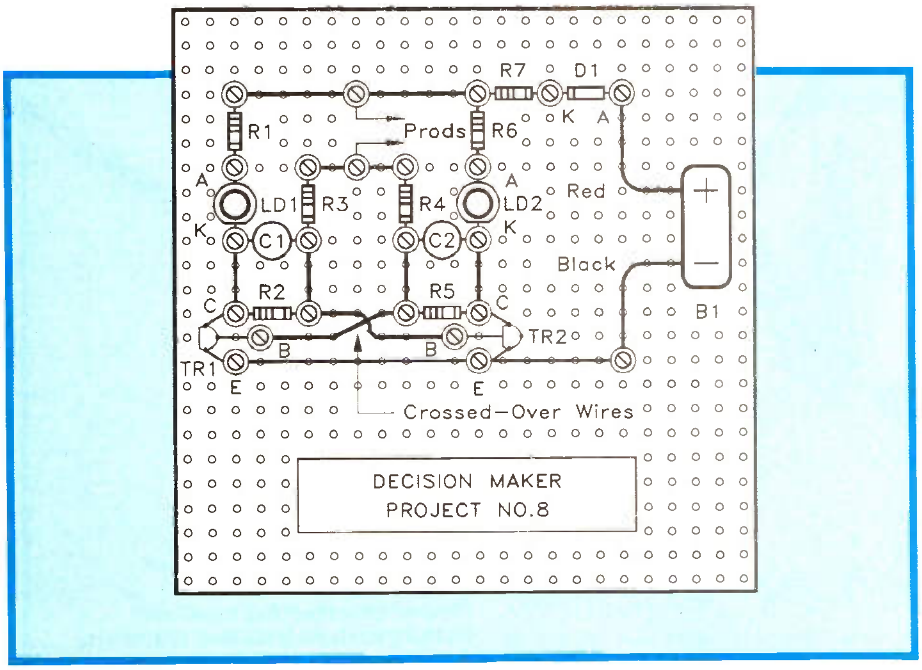


Figure 2. The component guide-sheet for the Decision Maker.

Getting it Together

Firstly, read through this section and then *carefully* follow its instructions, one step at a time. Refer to the photographs of the finished project if this helps.

1. Cut out the component guide-sheet provided with the kit (which is a full-size copy of Figure 2), and glue it to the top of the plastic board. Paper glue or gum should be okay. Do not soak the paper with glue, a few small 'dabs' will do.

2. Fit the link-wires to the board using the self-tapping screws and washers provided. The link-wires

are made from bare wire. Loop the wire, in a *clockwise* direction around each screw to which it must connect, taking the wire under the washers. Do not fully tighten a screw until all the leads that are under it are in place, and do not over-tighten the screws, otherwise the plastic board may be damaged. Be careful not to trap the bodies of any components under washers when tightening the screws.

Just below TR1, one wire crosses over another, and it is very important that these wires do not touch together. For this reason, some sleeving is supplied in the kit to cover the bare wires.

3. Recognise and fit the components, in the order given below, using the same method as for the link wires. Cut the components' wires so that they are just long enough to loop around the screws; otherwise long leads left flapping around may touch each other (this is known as a 'short-circuit') and stop your circuit from working. This is particularly important in the sections of the board around TR1 and TR2.

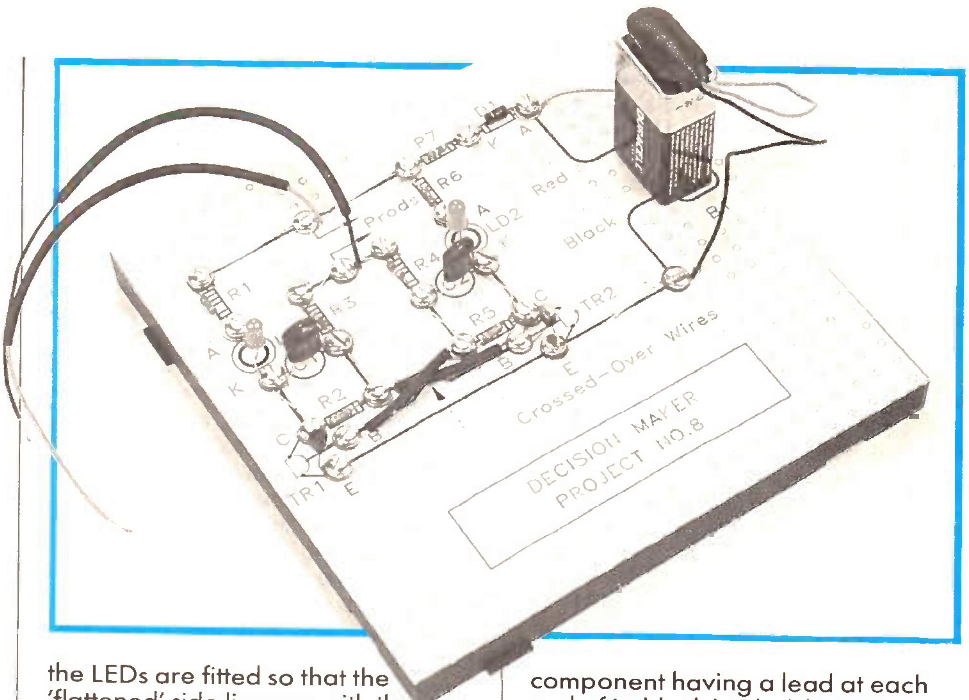
Components

a) The first components to be fitted are Resistors R1 to 7. These are small sausage-like components having a leadout wire at each end, and several coloured bands around their bodies. These coloured bands represent the value of the resistor; the resistor colour code is featured in the Constructors' Guide. For each resistor, the colours (and value) are as follows:

Resistor	Band Colours	Value
R1,R6	brown, red, red	1k2
R2,R5	orange, orange, orange	33k
R3,R4	brown, black, yellow	100k
R7	orange, white, brown	390Ω

For each resistor, there is a fourth band, coloured gold, which tells us how near to the given value the resistor is likely to be (in this case, there may be a difference of 5% or less) This fourth band is known as the 'tolerance' band, while the first three bands, shown in the above table, tell us the value of the resistor. Unlike diodes or transistors, it does not matter which way round resistors are connected.

b) Next fit the LEDs, LD1 and LD2, which are 'blobs' of clear red plastic with two wires coming out of one end. They are fitted in the position shown on the guide-sheet, and *must* be connected the right way round – or they will not light up. One side of each LED is flattened (the lead on this side of the LED is known as the cathode (K), while the lead on the other, rounded, side is called the anode (A)). The LED, circuit symbol and connections are shown in Figure 3. Make sure that



the LEDs are fitted so that the 'flattened' side lines up with the drawing of the LED printed on the guide-sheet.

c) The next component to be fitted is D1, which is a small tube-like

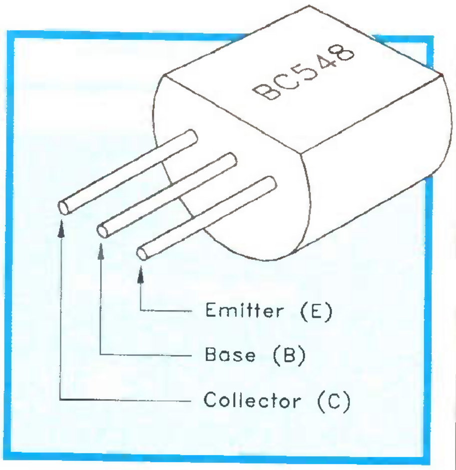


Figure 5. BC548 transistor circuit symbols and lead identification (TR1).

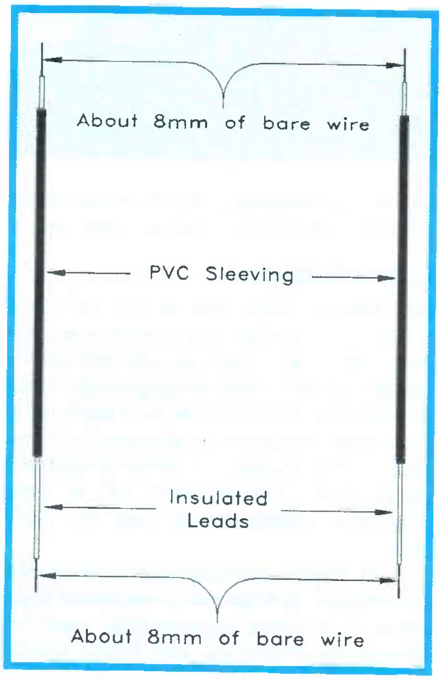


Figure 6. Preparing the probes.

component having a lead at each end of its black body. Like LD1, it must be connected the right way round (In other words, D1 is a 'polarised' component). Its 'polarity', which tells us the way in which it must be positioned, is indicated by a white (or silver) band close to one end of the body. D1, its circuit symbol and connections, are shown in Figure 4. The diode should be fitted so that the band lines up with the band on the drawing of the diode on the guide-sheet.

d) C1 and C2, the capacitors, look like little green blobs with two wires coming from the base. As with most capacitors (with the exception of electrolytic and tantalum bead types) it does not matter which way round they are connected. Each should have its value of 0·1μF included amongst its markings. In most cases this will be shown as 104 (10 with 4 '0's at the end, meaning 100,000 picofarads, which represents the same value.)

e) TR1 and TR2 should be fitted to the board next; these have a small black plastic body and three leadout wires. They are marked with their type number, which in each case is 'BC548'. Other markings may also be present; you will have to get used to picking out the important markings on chips and transistors (and ignoring the others!). You must ensure that TR1 and TR2 are fitted to the board correctly. Figure 5 shows which lead is which, making this task easy.

f) The probes are made up from two pieces of insulated wire (coloured red and black) and two pieces of hollow insulated sleeving (also coloured red and black). The wire is multi-stranded, which means that the metal core consists of several very fine wires. The probes should be made up as shown in Figure 6, use wire strippers to remove the insulation where shown. The bare ends of the leads should be twisted together to prevent the wires from splaying apart and breaking off. Slide the red sleeving over the red wire and the black sleeve over the black wire. Connect the two wires to the screws on the board marked 'Probes' – the red wire should go to the screw between those holding R1 and R6/7 in place. The free ends of the two wires are touched together to activate the circuit.

g) Lastly, fit the battery connector and battery, B1; the connector must be attached to the board with its coloured leads the correct way round.

The battery connector has two press-stud clips on a piece of plastic and two wires coming from it, coloured red and black. The red and black leads should be connected as shown on the guide sheet. The 9V PP3 type battery should be connected to the battery connector, it will only fit properly one way round.

Testing and Use

When the battery is first connected to the circuit, one LED will switch on while the other remains switched off. If the bare ends of the prods are touched together, both LEDs should then light, but at something less than full brightness. When the prods are released, one of the LEDs will remain switched on, and it should be at full brightness. Repeat this process a number of times and you should find that LD1 is left switched on for roughly the same number of times as LD2. The nature of randomness is such that with only a few operations of the unit, you may well find a strong bias to one LED or the other. The same thing could happen when tossing a coin. Activating the unit a large number of times should always show a (more or less) equal score for the two LEDs. If the unit is clearly not functioning properly, disconnect the battery at once. If it is failing to do anything at all, then D1 is probably connected the wrong way round. If one, or both, LEDs switch on at some stage, but the correct action is not obtained, check the connections to TR1, TR2, LD1, and LD2. In addition, check that both LEDs are fitted the same way round.

Double-Headed Coin

You can cheat by making the unit always produce a 'heads' result, like a double-headed coin. However, being an honest sort of chap I am not going to tell you how. You will have to work that out for yourself (and no cheating)!

Availability

The Funtronics Decision Maker is available from Maplin Electronics, through our chain of regional stores, or by mail order, **Order Code LT04E, Price £2.95.**

Next Month

If you are a budding amateur radio enthusiast, you will be eagerly waiting for next month's Funtronics project – a Morse Code Communicator. This circuit will be of help to you in learning this famous code, which is a requirement of the novice amateur radio licence, as well as the more established 'Class A' licence.

Finishing Off continued from page 68.

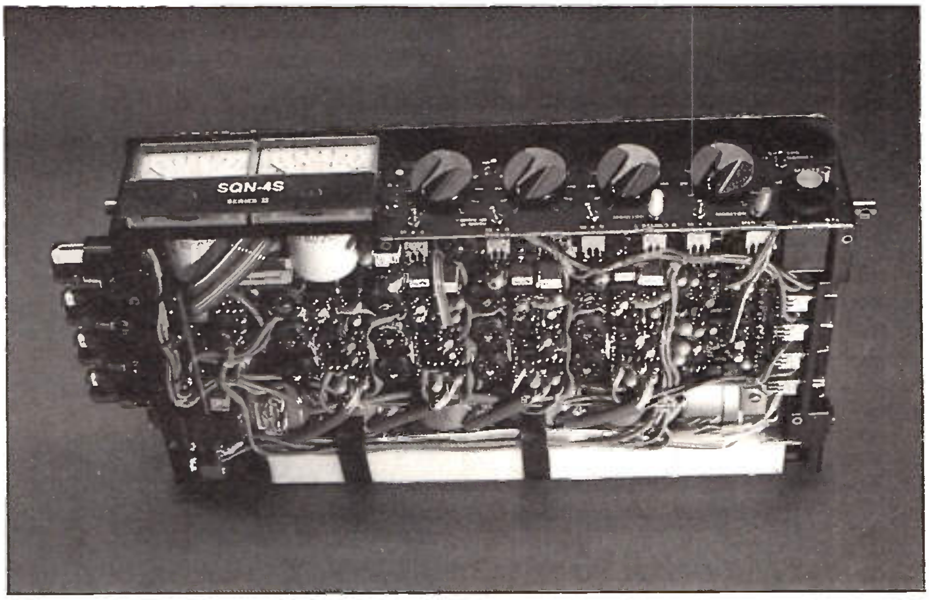


Photo 15. (right) Looking at this broadcast-quality 4-channel stereo mixer instantly tells you that it is professionally manufactured. Finding out what has given it this professional look will help you decide the best way to give your own projects a similar appearance.

used. Perhaps they will give you food for thought when it comes to sitting down with that blank sheet of paper. For example the audio mixer of Photo 15 is a veritable cornucopia of ideas!

Over the years, you may find yourself building a lot of test gear, so it's a good idea to study the commercial equipment market, to help you to get the feel of design principles along those lines. Examine as many leaflets, brochures and advertisements as you possibly can, which relate to test gear. Most of the gear featured will probably be out of your reach financially, but that doesn't matter. What you are doing is looking for clues and ideas to incorporate into your own projects. You must not copy an idea directly, as this would infringe that product's design copyright. However, let us suppose, for example, that you saw a certain manufacturer using 3 knobs in a particularly agreeable way, and that another manufacturer had laid out a set of sockets in another interesting way. Under these circumstances, there is nothing wrong with using these ideas on your project – what you must avoid, for instance, is designing a multimeter project which ends up looking exactly like an AVO 8!

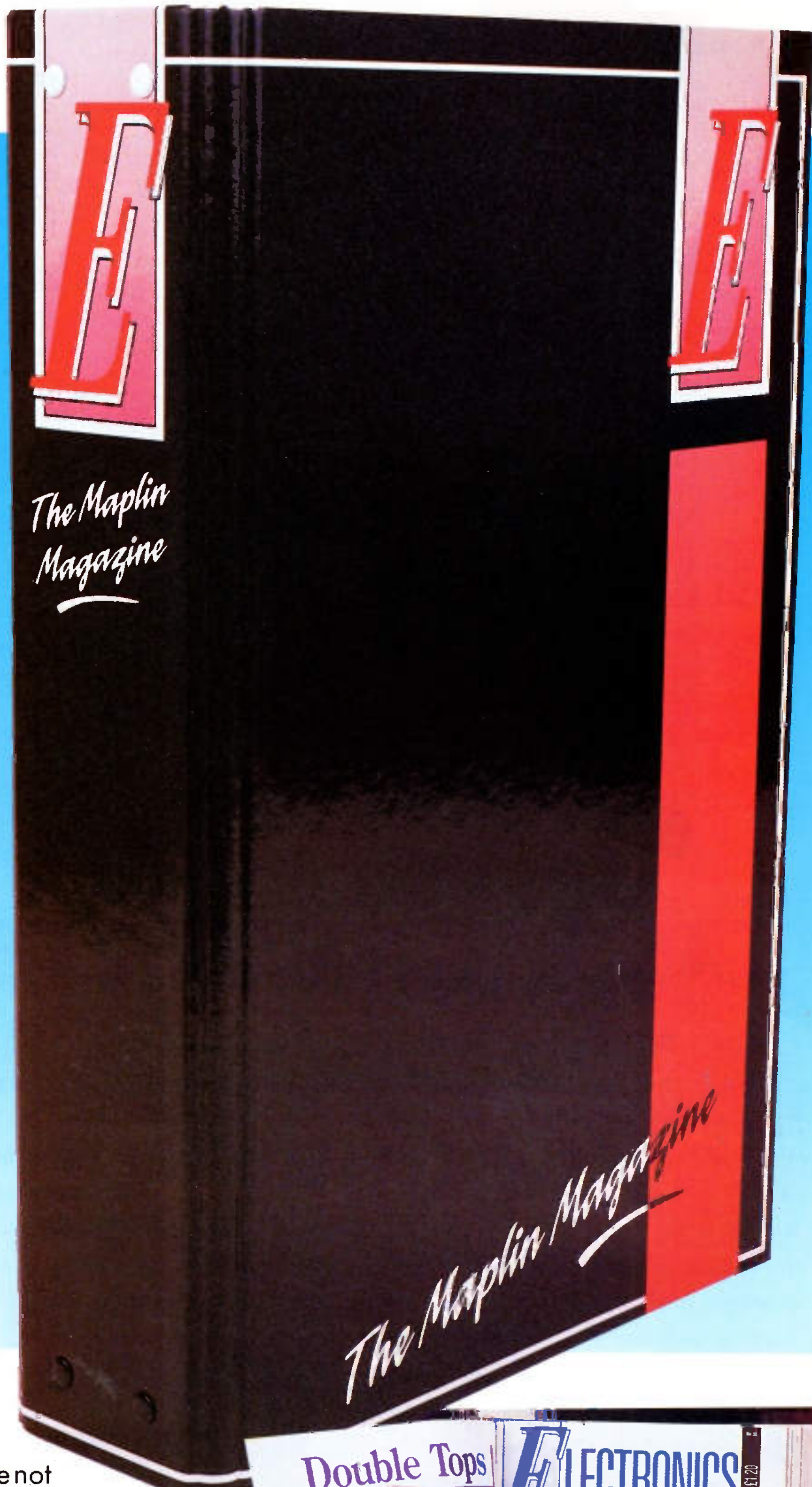
Conclusion

By taking that extra bit of care when designing and building a project, you can possess something to be proud of – something that other people can stand back and admire! It isn't easy though, as the dividing line that separates amateur-looking gear from equipment of a professional appearance can be very thin.

At times throughout this series of articles, it may have seemed that what we were suggesting was no less than frivolous, but think about two cars, one of which looks cheap, while the other looks somewhat expensive. What makes those two cars appear different on the surface can be difficult to put into words. They both have four wheels, glass, windscreens and doors etc., but the subtleties and quality engineering of the better model speak for themselves. You, the customer, pay for those differences as you would if you wanted your projects to be finished off in a more professional way. So look to those finer details of construction as a means of achieving such a goal!

Next month, in the final part of this series, we will look at the techniques of painting, artwork, labelling – and many more aspects of giving your project that extra special look.

Twelve great reasons to get Electronics under cover...



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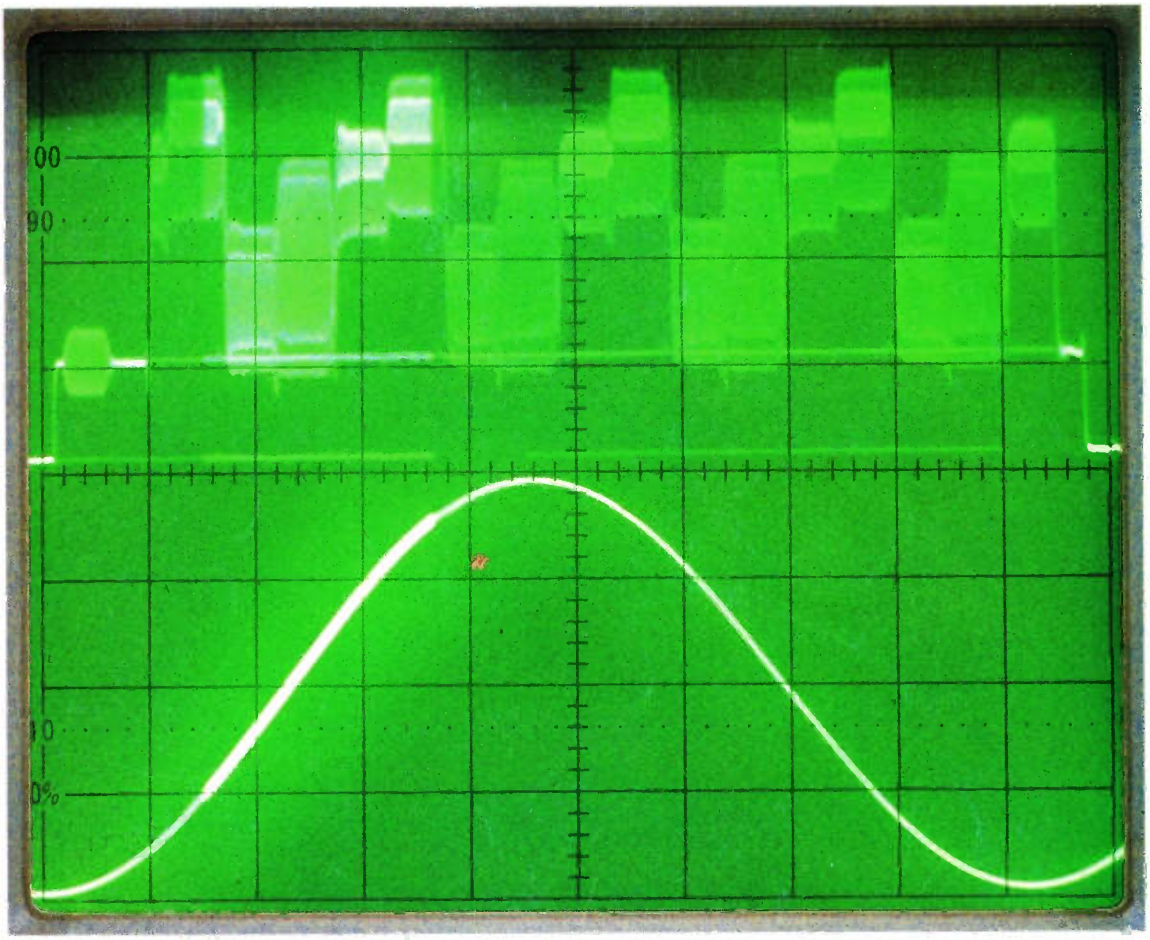

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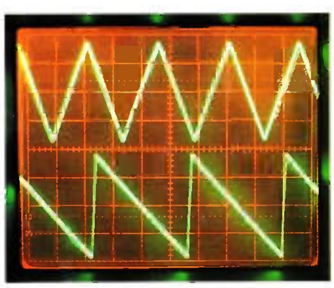

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