No 36

ELECTRONICS
The Maplin Magazine

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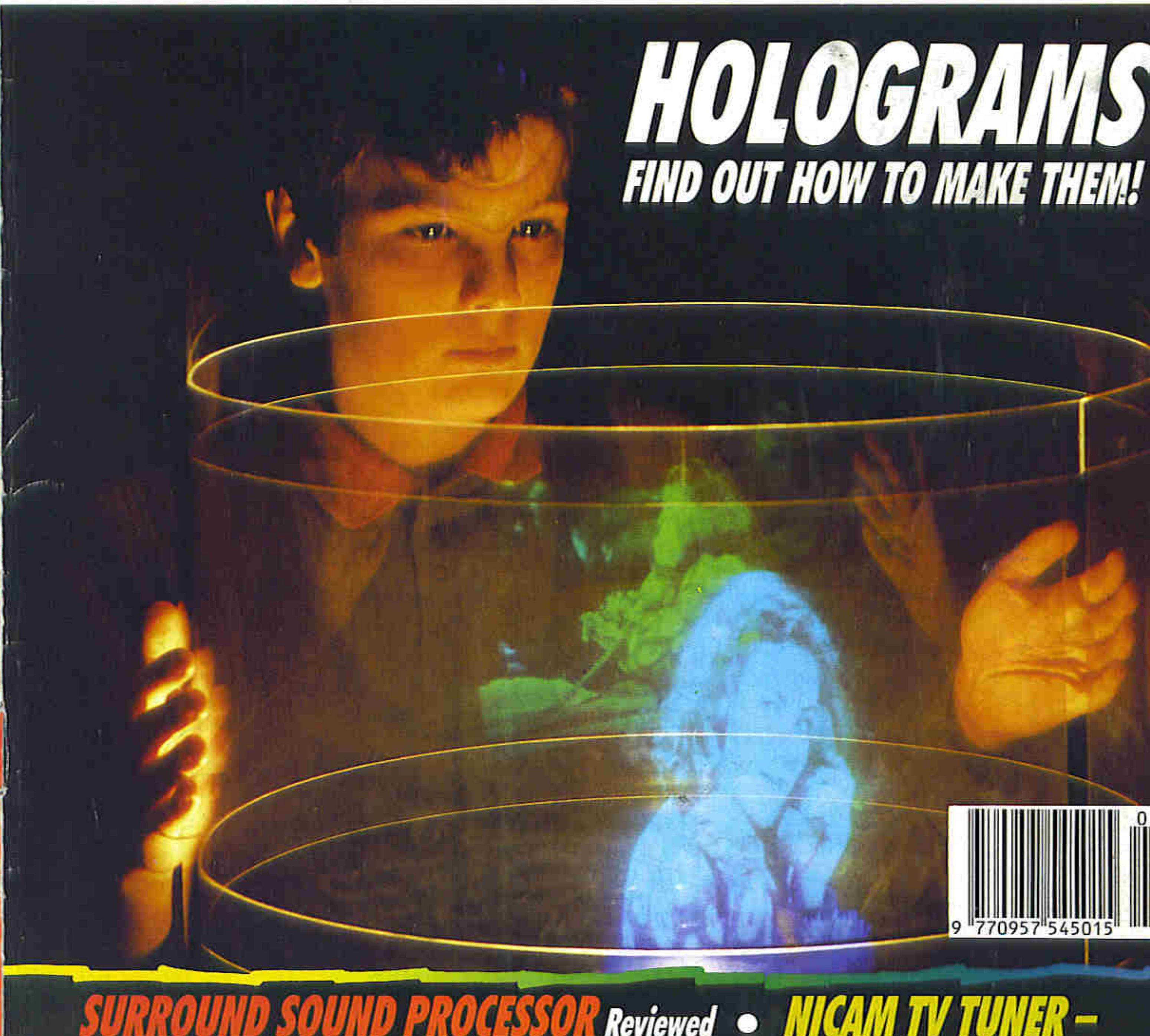

HOLOGRAMS
FIND OUT HOW TO MAKE THEM!

SURROUND SOUND PROCESSOR Reviewed • **NICAM TV TUNER** – full construction details! • **WIN TICKETS** to the **LONDON HIPPODROME** • Build a **SPEECH SYNTHESISER** • Beginners project: **3 GUN SOUNDMAKER!**

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CONTENTS

FEBRUARY TO MARCH 1990 VOL.9 No.36

EDITORIAL

Welcome to another project-packed edition of 'Electronics'. In this issue we present a TV tuner which can be used with our NICAM decoder, thus avoiding the possible dangers of fitting the NICAM decoder inside your TV set! There is an in-depth article on how to build your own holographic work-bench, and tips on producing good quality holograms. Also in this issue we present a 'surround sound' project which is becoming very popular with hi-fi enthusiasts at the moment. And on top of all that, we visit the London Hippodrome and take a look at 1992. Together with all our regular features, such as Electronics by Experiment, Computers in the Real World, Measuring Distortion in the Home Workshop, plus another four great little circuits from Robert Penfold making this issue another fascinating read. Read on and enjoy!

R.T. Smith

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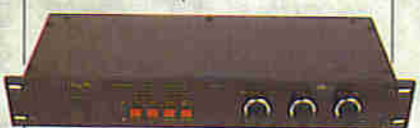
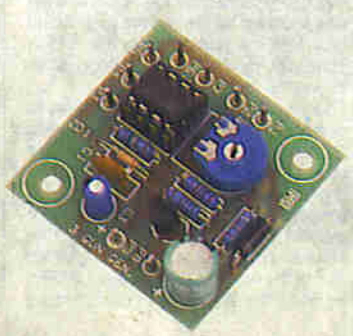
PROJECTS





FEATURES

REGULARS

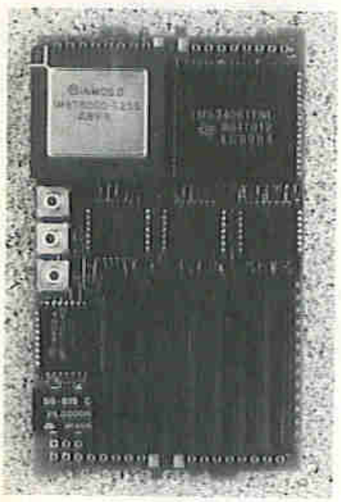
NEWS REPORT

All Purpose Visual Aid

Every year, the Telecommunications Managers Association hold their jamboree at Brighton. This year was noted for presentations by the heads of both BT and Mercury. However, the third keynote speaker, Michael Naughton of consultancy Applied Network Research rocked the delegates by announcing that he was dispensing with standard issue 35mm slides and was going to substitute an all purpose visual aid. This turned out to be a yellow, wooden arc which represented the bits which could be transferred down a line – 10 to the three in 1975 , and 10 to the seventh in 1990. The same arc represented the forecast growth in Videotex terminals in the UK in millions. He continued to rotate the arc to the next position and to give somewhat improbable but always perceptive comments at each point.

However, commenting that one disadvantage of the new visual aid was that it was somewhat heavy to hold, the speaker reverted to 35mm overheads. The theme incidentally of the ANR presentation was that the Inter Enterprise Electronic Culture (or IEEC) was here and was going to impact the telecomms function. Companies would be judged by the way they responded to their customers precise requirements particularly in design and distribution. (Details: and copies of the presentation: 01-892 9165.)

Smaller Transputers



Transtech Devices of High Wycombe have developed the TTG1 Graphics Module, possibly the smallest Transputer graphics hardware product available. This 53.3 x 93.0mm daughterboard consists of an IMST800-25 floating point Transputer with 1M-byte of video memory suitable for user code, data and screen data. The display resolution supported is 512 x 512 8-bit pixels, allowing up to 256 colours from a maximum of 16.7 million on the screen simultaneously. (Details: 0494-464303.)

BT Matters

Apparently it is not just Pirelli calendars which are collectors items. Phonecards are also in the collectors category. But not all is well. BT are being accused of implementing collection boxes for discarded cards in their call boxes. But as cards supplier Landis & Gyr point out, with over 150m phonecards already sold, there should not be any immediate shortage.

Meanwhile, New Zealand are not taking any chances at upsetting prospective collectors. The NZ Telecom company have just ordered 2,500 of BT's "payphone" kiosks.

Paging Long Distance

British Telecom have launched the world's first transatlantic radiopaging service, called Metrocast. The system allows customers to be connected anywhere within the UK or US using the same alphanumeric pager. Until recently, most wide area paging systems have been confined to national boundaries because they operate on different frequencies. Metrocast scans the 14 major paging frequencies to monitor messages. The next stage says BT will allow the direct input of messages by means of a touch-tone telephone pad rather than using the services of a bureau. Rental fees are £48 per week plus connection charge of £45 and subscription fee of £45 per month. Don't all rush at once!

Facts and Figures

While TI have been eliminating the need for reading lamps, Siemens have been designing a range of 'green' fluorescent lamps. Their Osram company have developed lamps which consume 75% less energy than incandescent lamps, and last up to 13 times longer. The light source features electronic ballast that uses the latest in chip technology to guarantee flicker-free instant starts and exceptionally economical operation.

Chip technology of a particularly high order is promised by supplier Intel. Speaking in London the chairman of Intel, Gordon Moore forecast that by the year 2000, processor chips would be delivering 2,000 MIPS (million instructions per second), run at 250MHz and accommodate some 100m transistors in each die. If this is in fact the case, then transistor density will need to double every 16 months or so to meet the forecast.

According to a recent Frost & Sullivan survey, European electronics manufacturers are not about to ditch their soldering irons yet – despite all the hype about gluing surface-mount devices onto circuit boards, a prime contributor to what will be a 1993 market of $343m in board assembly equipment. There is, says the report, an increasing trend toward mixed technology – combining conventional and surface-mount assembly. This has been brought about by the lack of availability in certain surface mount components and also the increased cost and difficulty in handling those components, even if they are available. (Details: 01-730-3438.)

A further Frost & Sullivan Survey tackled the world of relays. The report notes that relays, as practical components, go back to Samuel Morse's "writing telegraph" in 1837. The technology has advanced just a bit since then, and now incorporates integrated circuits for savings in cost, energy, and space occupied. However, most relays today are, and will continue to be, essentially electromechanical devices. Solid state relays were only 6% of the total $1.13 billion 1988 European market, and by 1994, the market will total $1.43 billion – of which solid state relays will still constitute only 6%. (Details: 01-730-3438.)

More Storage

Following much research and development, the first practical commercial product based on whole-wafer integration is available. The Cambridge-based company, Anamartic, Wafer Stack storage system, offers up to 100 times the speed of traditional disk drives that store information on magnetic rotating disks. The Wafer Stack drive which can access data in around 0.2ms (compared to about 20ms by standard rotating disks) contains one or more 40M-byte storage modules and a wafer controller which can store approximately 16,000 typewritten pages of information. Tandem Computers are involved as a joint development partner. (Details: 0799 26699.)

Industry Fringe Benefits

A further diversion at the TMA event was provided by Pirelli Focom who were holding a prize draw for their parent company's infamous calendar. There was no shortage of business cards being dropped into the goldfish bowl and early next year, many communications companies will be providing some interesting dates alongside their chips, bauds, and bytes.

Canon Shoots with The World's Smallest Laser Printer

Canon's new LBP-4, a four pages per minute laser printer, is smaller than any other laser printer currently available. The printer is driven by Canon's new LX engine, which prints at the industry standard 300 dpi. The enhanced graphics and scalable fonts are made possible by the printer's 32-bit processor, and 0.5 MB of memory, expandable to 2.5 MB for memory-intensive graphics. The price has been set at £1310 but it could be worth shopping around. (Details: 01-773 3173.)

Cellular Operators Rapped

Cellular operators Cellnet and Vodafone are to be spoken to about the levels of their performance by no less than Sir Bryan Carsberg, Director General of OFTEL, the UK comms regulatory authority. He is somewhat disappointed by the results of a recent report on the quality of service and in particular in the level of congestion during the 'busy periods'.

Congestion – the inability of users to initiate a call because a communication channel is not available (excluding the case of calls being 'dropped' due to no channel being free when users move to a new cell) is apparently one of the main causes of dissatisfaction with the service. The average of 4% congestion during the working day is, says OFTEL, higher than the level that should be experienced by users. Given that the level of call blockage can and often does exceed 8%, says Bill Loose of the PA Consulting Group, and that certain operational areas record even poorer figures, the need for discussion is vital. Meanwhile, OFTEL publish, free of charge, "A Guide to Cellular Radio", a 24-page, illustrated booklet for consumers. (Details: 01-822-1665.)

Adverts Sound-Off

In what is being claimed as the world's first talking magazine advertisement, Texas Instruments ran a four page insert in Business Week late last year. The spoken message is triggered when the reader removes a label which covers the switch. A voice then speaks the printed 42-word text in 15 seconds. The ingenious electronically-synthesised speech is delivered by a TI integrated speech synthesiser chip about the size of a small fingernail. The power, supplied by three tablet-sized batteries, allows the corporate message to be played some 650 times. Sound is provided by a one-inch piezo-electric speaker embedded in the module. Assisting the project was a producer of pop-up childrens books and a major advertising company. But don't expect to hear the dulcet tones of our editor addressing his readers just yet. Producing speech in this manner says TI costs about $4 per unit – for large scale volumes. However TI expect a strong move towards higher performance and lower costs will open up all manner of innovative uses for synthesised speech products.

BT Gets Into The Picture

In our last NEWS REPORT, we mentioned recent developments in the videophone market. Now BT are getting into pictures and have released details of their small desktop video phone which will allow users to see moving pictures of each other. Future wrong numbers should have an interesting added dimension.

BT See Merit in Minitel

It is possible that BT saw our article on the French Videotex system Minitel published in the Oct/Nov issue. BT's US subsidiary Dialcom Inc, are offering electronic mail services on the Minitel viewdata system. And it could be that Mercury also saw our feature. Negotiations are taking place which could result in Mercury adapting Teletel technologies for its own Videotex network. Currently, Mercury provide users access to the Minitel service by means of the packet-switched gateway Minitelnet.

The Mainframe Computer Is Not Dead

For some time now, the microcomputer industry has been forecasting the demise of the mainframe processor. But there is life in large scale systems yet with both Tandem and Digital Equipment entering the market-place. DEC in particular is looking to compete head-on with IBM by releasing the VAX series 9000, an air-cooled single processor which is some four times more powerful than DEC's previous high-end system.

According to Geoff Shingles, managing director, Digital Equipment, the new system has been produced in response to customers demands. "Their businesses have been prospering, growing and changing. One change they've decided they need is the option of being able to run some of their larger applications – faster. Much faster. So we've obliged."

Prices are equally jumbo sized. They start at £800,000 and zoom up to £3.25m. (Details: 0734 868711.)

Soho Fax

The new Toshiba A4 facsimile machine is called the "soho", a name more suggestive of fun and games than serious information transmission, priced at just under £900. The company are hoping to capture a large number of the 600,000+ small UK businesses who have not yet got the fax message.

PCs Unlicensed

Hard on the heels of the DTI relaxing export controls on Personal Computers, came the news that the hard-pressed Amstrad company are in line to supply much of the $1,000m requirements for PCs by the USSR. The relaxation order applies to most 16-bit personal computers or their equivalent. To be eligible the equipment must be a standard PC system which is commercially available. The DTI do point out that export licenses are still required to export full 32-bit PCs such as those using an Intel 80386 microprocessor. PCs with high clock rates, large memory size, or high specification hard disks are not eligible for the changed rules.

Satellite Times

Satellite TV company BSB (British Satellite Broadcasting) must be breathing more easily of late. Not only did their Marcopolo 1 satellite make a perfect lift-off from Cape Canaveral, but the company have now successfully tested a 40cm square antenna. Once technical performance details had been agreed with the IBA, full scale production will be put in hand.

Meanwhile, satellite rival SKY Television has announced that just nine months after launch, one million homes are now reached. The SKY network comprised 365,000 home dishes and 635,000 cable homes in the UK and Eire. SKY must also be pleased that their channel Eurosport is one of the top European channels, watched by over two million people in the course of a recent four week period.

DTI Increase Radio Spectrum Licenses

It must have been a busy time recently for the DTI's Radiocommunications Division. The department currently issues 47 different categories of licence to some 300,000 firms and individuals each year. The good news is that ten of the categories served are having fees abolished but the not so good news is that the remainder are being increased. The fees range from £12 for Amateur Radio users to £500,000 for Band III Private Radio Mobile Radio National Trunked Service. (Full details: 01-215 2352.)

Facilities Management To The Rescue

At a time when more and more companies are turning to a facilities management service to take over and run their computer and communications operations, Andersen Consultancy leader in the FM field, have introduced what can best be described as a work-bench designed to take computer operations out of its craft image into that of professional engineering. The new product "Co-Operate" does for computer operations what Computer Aided Software Engineering (CASE) tools are already doing for software design. Computer operations, says Andersen, are fast becoming the powerhouse of business. The Co-Operate approach produces real benefits by ensuring that computer operations can quickly respond to changing business requirements and contribute productivity savings of up to 75% in some areas. (Details: 01-438 0211.)

Fully Comprehensive Training

Europe's largest consultancy and training organisation, The Federation of Microsystems Centres have announced a fully comprehensive series of training courses organised by their Washington Centre. Courses cover database, spreadsheet, word processing and desk top publishing applications. Per day costs including lunch and documentation £120. (Details: 091-417 8517.)

The Canon Bubblejet

Never a company to do things by half, Canon have added ten new machines to its calculator range. Three of the new desktop calculators incorporate Bubblejet printing technology. The high speed, non-impact system silently sprays the ink on to the paper roll thus eliminating distracting noise and giving a quicker, cleaner high quality printout at a speed of 5 lines per second. Each model has two independent memories, allowing users to sub-total or total data as well as storing data. (Details: 01-773 3173.)

Electronic Law

According to the ever watchful industry newsletter "Computergram", about 99% of Americans would cheer if all the lawyers were to be replaced by computers. Apparently one enterprising individual has set up such a service charging a legal advice-by-telephone service supported by a computerised legal database. At an average 15 minute call at $3 per minute, this works out cheaper than normal consultation which averages $100. How long before we hear the defendant state "My computer says I am innocent and I agree".

A Fault-Free BT

The latest BT Quality of Service Report highlights the rapid progress being achieved by BT Customer Services. More than 96% of faults which affect telephone service are now cleared within two working days. During the same six months period, the percentage of national calls which failed because of defective equipment or congestion dropped from 2.4% to 1.7%. At the same time, 95% of all the 88,000 public payphones were in working order. Not surprisingly, payphone revenue is up by 50% in the past two years.

Somewhat more debatable are the claims that 82.6% of directory enquiry calls are answered within 15 seconds and 80.6% of calls for other forms of operator assistance are answered within the same time.

Diary Dates

March 1st and 2nd 1990 sees the first European Advanced Procurement and Logistic Support Systems Conference. The event brings out the way in which advances in transmitting drawings, images, and logistics information is vital to the efficient running of organisations which handle large quantities of information to be transmitted both internally and externally. The event takes place in London. (Details: ANR. 01-892 9165.)

March 7th and 8th are the dates when the electronics industry tackles the threat to the ozone layer. "Electronics Manufacturing and the Environment" is the title of a special conference scheduled to be held in Bournemouth. Sponsored by the DTI and such companies as ICI and Multicore Solders, the conference will focus on the use of CFCs (Chloroflurocarbons) in the electronics manufacturing processes. (Details: 0202 842250).

Picture Caption Challenge

This issues challenge involves a British Telecom test program.

What on earth – or rather above earth – is happening?

★ The world's longest car park, the M25 has finally run out of space.

★ A local university prank got out of hand.

★ The driver didn't have a hands-free cellular radio.

★ James Bond was here.

Improbably, the-test-bed-in-the-sky car helps determine various types of cellphone aerials. I'm glad we know.

The Changing Face of Maplin – Opening of the New Maplin Distribution Centre

Reported by Robert Ball A.M.I.P.R.E.

Just a corner of the new warehouse

Resistors & Runways

Maplin Electronics was founded in 1972, by Doug Simmons, Roger Allen and Sandra Allen. The name 'Maplin' was chosen because of the planned siting of London's third airport on land to be reclaimed from the Maplin Sands, which are situated in the Thames Estuary. The airport however, was never built. In contrast, as plans for the Maplin Sands Airport sunk into the tidal waters of the estuary, the Maplin Electronics business venture took-off. Albeit, in a manner akin to the Wright Brothers early attempts at flight! The early years of the company, were fraught with problems, such as obtaining supplies from manufacturing companies and funding from banks.

As the years progressed, Maplin began to establish a reputation with its customers; good quality components, fast service and reasonable prices. Hobbyists and small businesses alike, soon switched from buying dubious quality, second hand and ex-equipment components, to Maplin's brand new, guaranteed and speedily delivered products. As well as mail order with the Maplin pledge of 'Same Day Service', customers were (and still are) able to have personal service at the Westcliff-on-Sea Shop. Since the first shop opened, many others have opened around the country, with knowledgeable staff always available to help customers select the correct component for the job and answer questions of a technical nature.

Maplin started up to offer components to the hobbyist and small business, but Maplin's customer base now includes thousands of industrial and commercial customers, some of whom are the best known companies in this country. The company now has a country-wide chain of eleven retail shops in major towns and cities, and of course still provides the excellent mail order service. Maplin currently stocks a total of 7,000 product lines, which are described in detail in the annual Maplin Catalogue, which at present has 576 pages. The front cover of the 1990 issue continues the familiar 'Space Craft' theme.

Unveiling the plaque are (left to right) Terry Patchett MP, Roger Allen; Mayoress and Mayor of Barnsley; and Mrs Patchett.

Expanding

As Maplin's business has expanded, and so has the volume of stock that needs to be held, in 1988 it was realised that the existing head office site could not be expanded any further. Another site for storage of stock, collection and dispatch of orders would have to be found. It was also realised that this was the opportunity to provide for the future, not only in terms of further growth, but also to establish a purpose built, centralised distribution centre. The location would need to be close to the UK's main road links and positioned so that export to Europe and the rest of the world could flow unhindered. A suitable location was found near Barnsley in South Yorkshire. After the formalities of planning permission and site surveys were completed, the building work began. The fine spring and summer weather enabled work to be completed ahead of schedule. Praise is due to all those involved in the project, for both speed and quality of workmanship.

From wasteland to finished unit

The Mayor of Barnsley welcomes Maplin to South Yorkshire

A. Storey. Member of Parliament for Barnsley Central, Mr Eric Illisley MP. Member of Parliament for Western Penistone, Mr Allan McKay MP. Numerous councillors and representatives from local authority, trade, commerce, trade press, private and trade customers also attended. Heading the cast from Maplin were the Company Directors: Managing Director, Mr Roger Allen. Marketing Director, Mr Doug Simmons. Production Director, Mrs Sandra Allen. Sales Director, Mr David Snoad. Non-Executive Director, Mr Roy Parker. Departmental managers and other company employees were also present.

After the opening ceremony, all the guests were conducted on a guided tour around the new building, where they were shown the stores, order printing, collecting, packaging and dispatch areas, then onto the computer room where they met the Information Technology Manager, Mr Nigel Fawcett. Nigel's role is particularly important as he has coordinated the writing of the software necessary for the new 'slave' computer to communicate with the main computer at head office. All orders are received and processed at the familiar P.O. Box 3, Rayleigh address. Then the orders are electronically zapped over private land-lines at lightning speed to the new distribution centre, where they are collected, packed and dispatched. Customers orders are held in duplicate on both systems, and as soon as any information changes, both computers are automatically updated. The system was developed so that data flowing up and down the land-lines is minimized, avoiding data congestion, thus ensuring fast operation of the computer system.

Maplin's investment in the distribution centre is a clear indication of the company's commitment to customers, both trade and retail. As we step into the 1990's Maplin will continue to offer products and service that are worlds apart from anything else. Maplin – the way to the future.

The new Maplin Distribution Centre became fully operational on Monday 23rd October 1989. To ensure that disruption to customer orders was minimized, the move from the old site near Rayleigh, Essex, to the new site was conducted over the preceding weekend. A mammoth fleet of removal lorries conveyed all of the stock over the two hundred mile journey. The new site provides a total of 95,000 square feet of storage space, the main floor area is 65,000 square feet in area, with a further 30,000 square feet mezzanine floor (one of the largest in Europe). There is room on-site for expansion by a further 100,000 square feet. The location places the distribution centre between Britain's two main road links, the M1 and the A1. Thus facilitating excellent road communications the length of the country.

Inside the warehouse there is a hive of activity! Collecting and packing your orders as quickly as possible

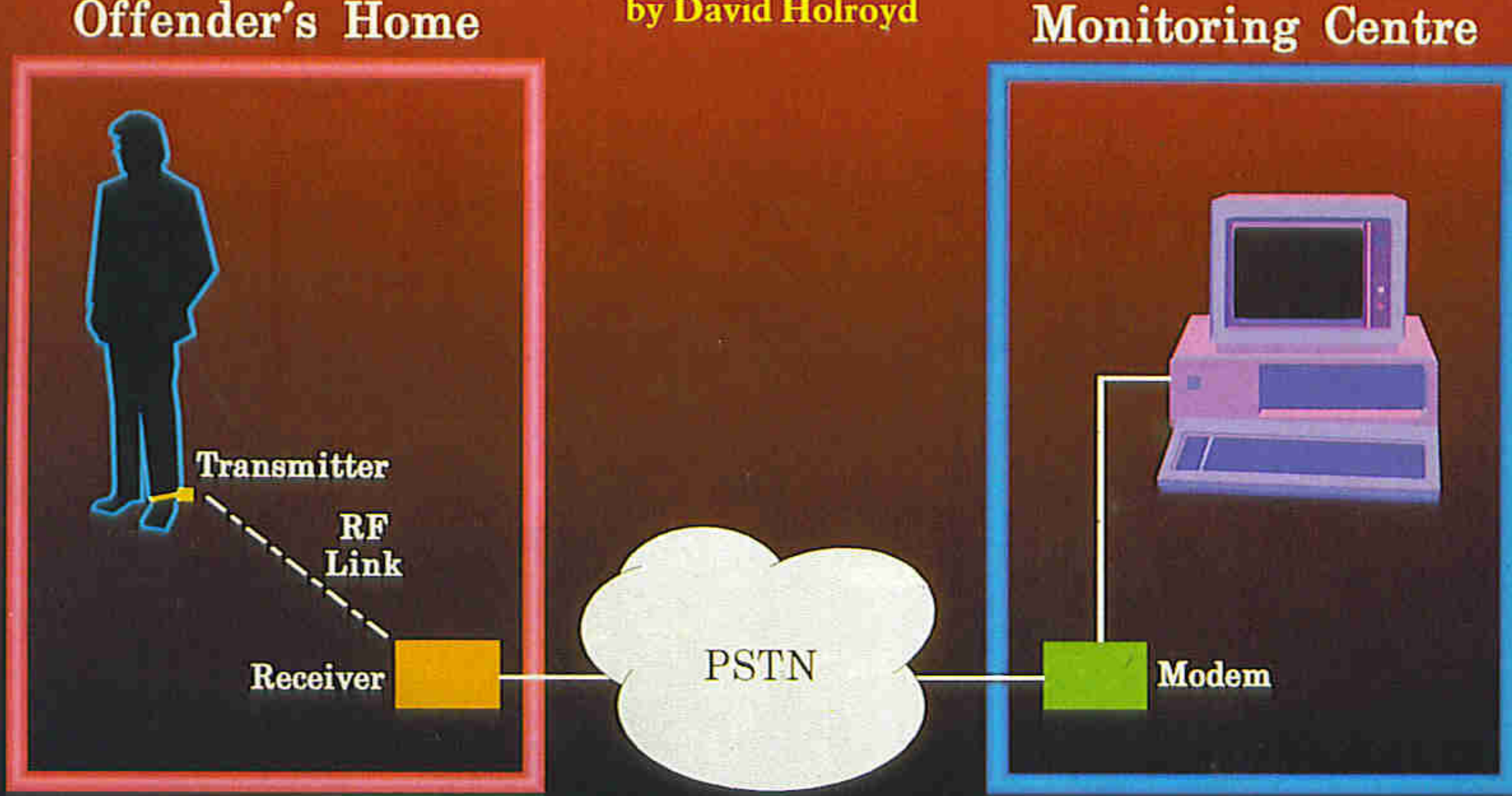
Open!

The distribution centre was officially opened by the Member of Parliament for Barnsley East, Mr Terry Patchett MP, at 2pm on 11th December 1989. Guests of honour that were present: Mayor and Mayoress of Barnsley, Councillor and Mrs

Automatic box-sealing machine

ELECTRONIC HOME MONITORING OF OFFENDERS

by David Holroyd



On 12th October 1988, the Home Secretary announced there would be experiments in electronic surveillance of offenders. The electronics industry has responded with an array of suitable products. The announcement of three trials starting in August 1989, suggested at least two main types of Electronic Monitoring Systems (E.M.S.) are being seriously examined.

Benefits

The general benefits of Electronic Monitoring Systems have been well recorded. There are reported to be some form of electronic surveillance system in many parts of the United States, particularly California, Michigan, Tennesee and Colorado. Most other states are seriously examining options.

A first and powerful argument for the systems is their impact upon prison numbers. The prisons of the United Kingdom are around 30% overcrowded. The prison population continues to grow. Many of those in prison could well serve their sentences in the community provided there was sufficient confidence in the alternatives. The Government published a Discussion Paper in 1988 setting out some options for more effective punishments in the community. These included schemes of reparation and Community Service and paved the way for experiments in Electronic Monitoring.

The avoidance of prison also means that important links such as family, job and social ties can remain intact. The use of an alternative to prison also means that the likelihood of re-offending is reduced. For some groups of ex-prisoners the re-offending rate can be as high as 75%. This is often due to the mixing of first time, often young offenders, with more seasoned criminals. Sometimes the only lessons learnt through prison are improved criminal techniques and dodges.

Clearly prison will always be needed for certain types of offender. However, as just over 10% of men and only 6% of women are imprisoned for acts against the person, there is room for some reduction in the prison population.

As well as the saving on human misery there is a financial incentive. The average cost per week of a British prison place is £250. A community alternative will cost little more than one third of that.

The systems being offered can be programmed for the demands of any individuals sentence. Thus serious football hooligans could, for example, be monitored only at times when football matches were being played. The Electronic Monitoring Systems on offer claim all the penal policy advantages. They also show excellent technical benefits.

Two Systems

The systems operate in one of two ways, conveniently known as 'Active' and 'Passive'.

Common to both systems is the use of conventional telephone lines (by implication, any candidate for E.M.S. has to be confined to a location where there is a telephone.) The systems communicate with a central processor which holds the database of offender specifications, times they should be monitored and telephone numbers to be called. Both systems use a form of wrist or leg worn unit or tag, hence the term 'Electronic Tagging'. The units weigh approx 0.12kg and measuring 7.2cm x 6.1cm x 2.5cm are about the size of a small travel clock. They have a tamper loop and are robust and water and shock resistant. They are all medically approved and held by a single strap. The home based contact or receiver units are the size of a conventional modem and normal telephone use is not impaired.

The active system works from a Programme Contact Receiver unit which is stationed in the offenders home. The central control will initiate a tone call to the distant offender. This will cause an audible alarm or bell placed near the telephone to sound. He will then acknowledge that call by placing the wrist worn contact unit into the receiver. The term active coming from the need for the monitored person to have to respond to the check on his whereabouts. The centre will then register that the wearer is where he should be.

If this is not the case, the violation procedures common to both systems will then apply. The offender units are individually encoded and are reuseable when the sentence has been completed. This transmitter and receiver having a typical range of only 10mm and broadcast between 270kHz and 330kHz. Contact can take place through cloth or air up to 10mm from the receiver unit.

The passive system has the same main components. However, instead of the offender knowing the check has been made, it is undertaken without his knowledge.

The home unit receives continuous signals from the offenders wrist or ankle unit. A range of up to 200 feet from the home unit is claimed. Transmission frequencies vary with manufacturer, Marconi operate at 318MHz to 350MHz. Checks on the state of the system are made at random from the central control. This uses auto dialler and reportedly simple IBM compatible software. The body unit incorporates an anti-tamper loop to prevent it merely being left in close proximity to the home unit. Breaking this loop will register a violation in the same way.

The manufacturers involved are Marconi, Chubb and F.K.I. Communications. The individual specifications vary slightly. One system offers an audible alarm if a violation is about to be reported. Another will trigger the home unit for each violation. A further option is the automatic reporting, to the central control, of a system failure.

All three manufacturers seem well able to meet the specification. Probably price, not yet disclosed, will tell all.

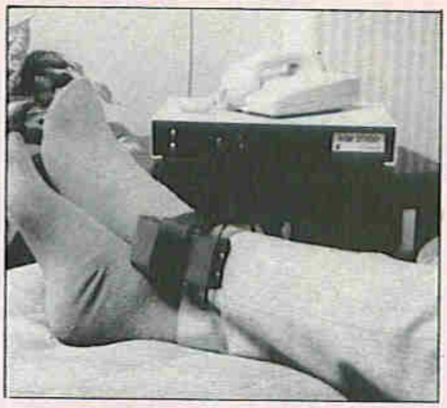


Photo 1. Chubb alarms HM2000 continual monitoring system.

Other Uses

Offender tagging may start out as only part of the story. Trials on wandering elderly people are already well advanced in Humberside. There is loose talk of tagging providing a monitoring facility for discharged hospital patients and a variation around the electronic shop, stock control systems has been designed for use in old peoples' residential homes.

Whatever the outcome of the tagging trials it seems very likely that electronics will start to play an increasing role in helping those who care for the more frail members of our society. This help is not without controversy, but it is a real example of how electronics can improve the quality of life and make the lot of those involved in caring, a much more rewarding one.

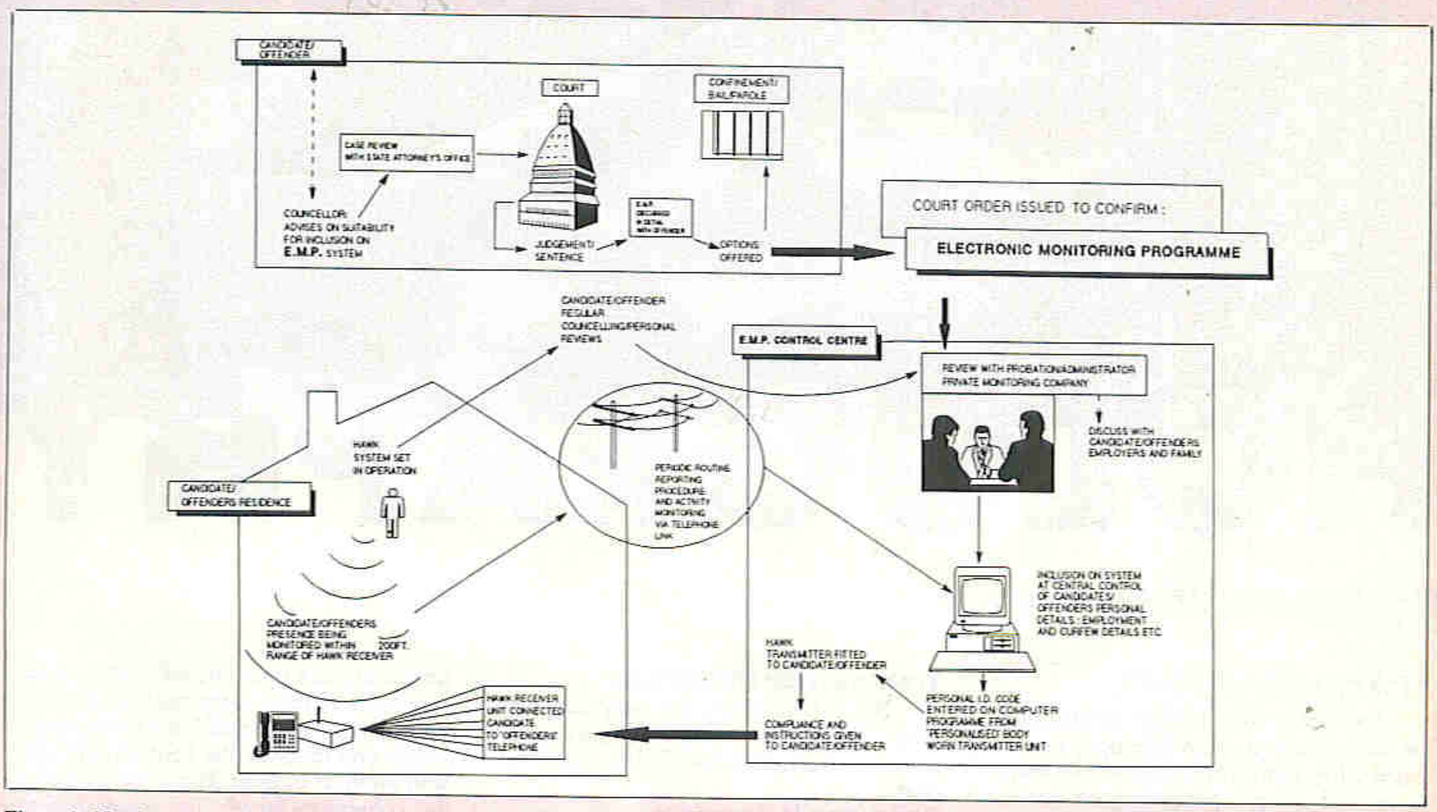
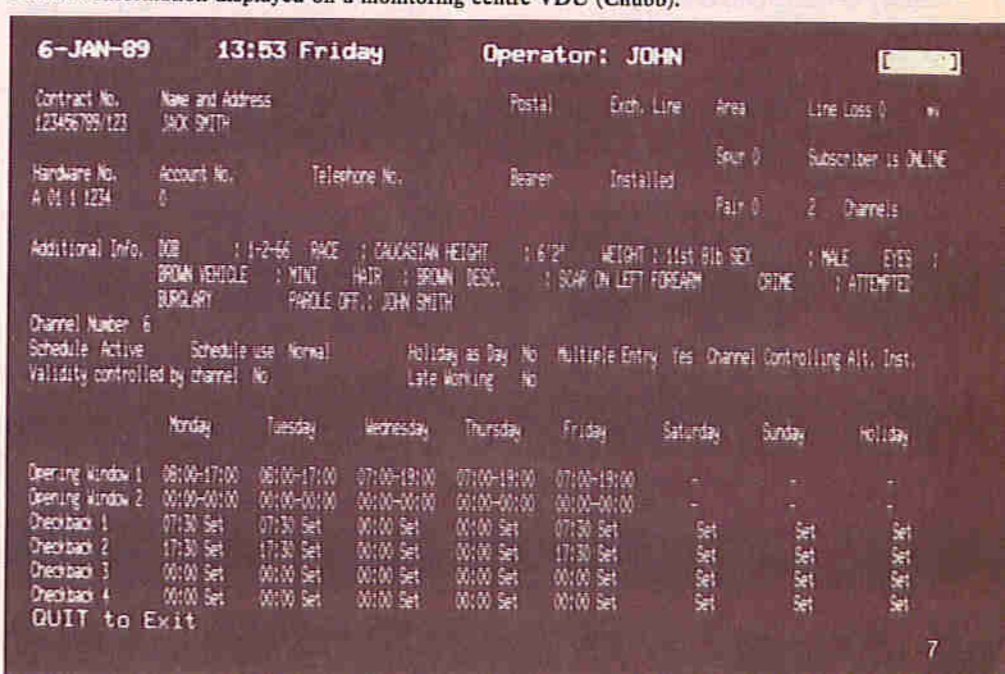


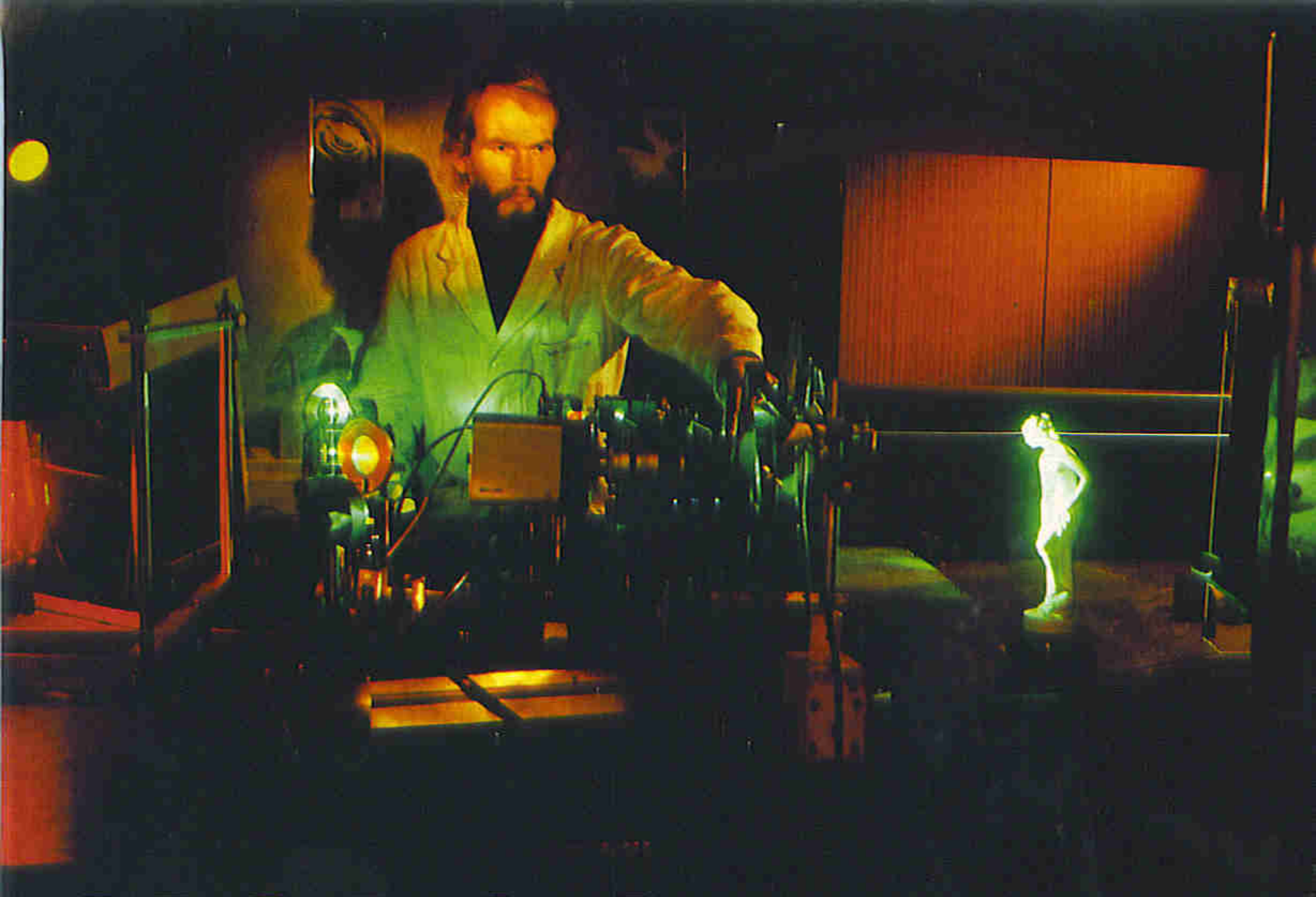
Figure 1. Hawk monitoring programme – typical operating practice (Marconi).

The central units can be programmed to allow for first or second contacts before violation is recorded. Upon violation being recorded the central control contacts the person designated and the violation message is transmitted. Although unclear at present, it would seem to be possible for the notification to be undertaken from within the computer programme. Chubb in particular stress the human element and confirm they would run the monitoring through their extensive burglar and fire alarm control operation.

It now seems likely that the Home Office will opt for the passive system in the three trials to take place in Nottingham, Newcastle and part of London. The exact trial specification has not been revealed but it is clear only passive systems will be tested. Who will be the winners in the scramble for what could be a very lucrative and growing market is anybody's guess.

Photo 2. Information displayed on a monitoring centre VDU (Chubb).





HOLOGRAPHY

By Steve Wiseman

Introduction

The aim of this article is to introduce the concept of popular holography and to dispel a few of the myths that would seem to prevent people producing, at home, holograms to rival those produced commercially. A good case is given by the display of holograms currently on show at the Science Museum in London – you can achieve better results for more than 90 percent of these holograms on a budget of far less than £100 once you have acquired a Laser.

Maplin have been selling a Laser for many years, but the new model is far more suitable for holography as it has more than twice the output and costs much less than its predecessor. It also has an aluminium jacket which protects it from damage in the darkroom environment. It is available in kit form or as an assembled unit and it also has its own power supply built-in. The order code for the kit is LM72P and it costs just £104.95 plus 75p order handling charge. The assembled version costs £179.95 and its order code is XM14Q, the 75p handling charge also applies (unless you go to one of Maplin's many shops to buy it).

The holograms this article describes can be divided into two separate types:

Transmission Holograms

These holograms are very easy to make, and can be viewed with any point source of monochromatic light – a laser is best.

Reflection Holograms

These holograms are not so easy to make, but the results are more impressive as they can be viewed in sunlight, and the playback colour can be chosen during development.

There are six main requirements for producing a good hologram:

A Laser.
Stability.
Optical components.
Darkroom.
High resolution film.
Processing chemistry.
The object.

Considering each of these requirements in turn:

The Laser

As mentioned above, the Maplin Laser is very suitable – I've used it with no real problems. For anyone aiming to use another laser, it should have an output power of more than one milliwatt, to keep the exposure times reasonable in complex set-ups. The laser should have a coherence length (the distance the light stays in step with itself) of at least 30cm – the greater the coherence length, the easier it is to obtain deep holograms. The laser should also operate in TEM00 mode – this is the lowest order Transverse Electro-Magnetic mode. If this means nothing to you don't worry, the Maplin Laser is suitable. A comparable laser from any other supplier would cost more than £400 without power supply, making the Maplin Laser the best option by far. Despite the note in the Maplin catalogue that the laser's output beam is randomly polarised, it can be shown that the beam is totally polarised using a piece of polaroid plastic from a pair of sunglasses, see Figure 1. The polarised output is marginally better for holography, but is not really relevant in simple set-ups.

Stability

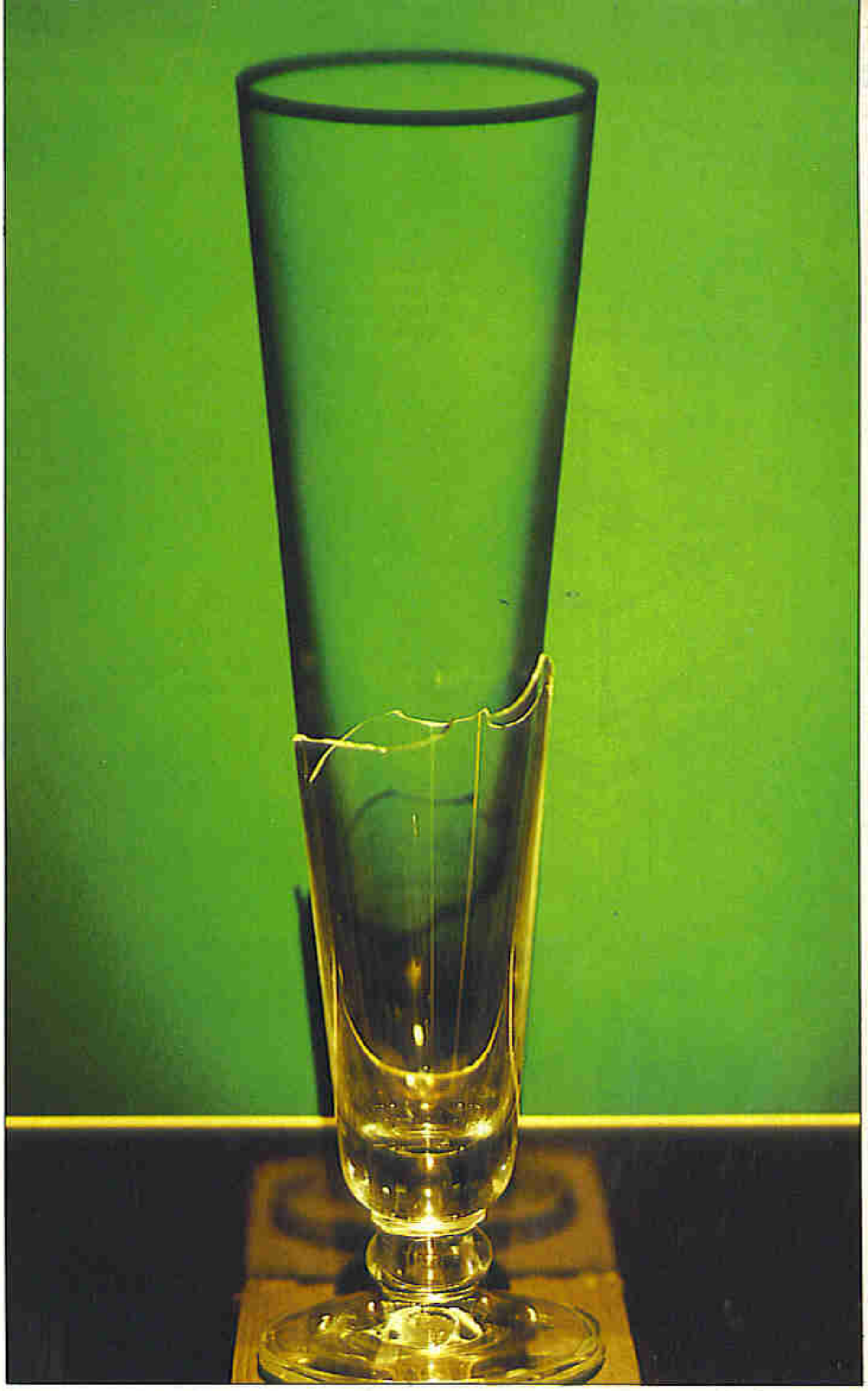
No component in the whole holographic set-up is allowed to move more than half the wavelength of the light used (632.8nm) and for the ultimate brightness, the components should be stable to within the wavelength ÷ 20 (3×10^{-8}m). (With reflection holograms, the stability requirements are far greater.)

Despite these very tight tolerances, this level of stability can be achieved with very little money. The essentials for a stable working surface are a heavy rigid surface which, being heavy will have a high inertia (resistance to movement) and low internal vibrations (a condition of rigidity and internal damping), and a vibration isolation system to support this massive rigid surface off the vibrating ground. Industry uses massive granite tables (up to 8ft x 12ft x 18in) supported on active pneumatic suspension units. However, if you do not have about £50,000 to spare, it just so happens that wood is a heavy, rigid and very well damped surface and car inner tubes make very good vibration isolation systems. A suitable working surface would be an old kitchen work-surface 1in thick, with the surface painted black with blackboard paint, although thinner wooden panels would probably be rigid enough. As mentioned before, wood is almost ideal as the working surface – the only reason the industry does not use it is that it warps after several years – its damping properties rival those of even the best composite honeycomb materials. The car inner tubes isolate the working surface from any vibrations travelling along the ground caused by passing traffic, trains or just people walking near the system. A better system, but nowhere near as portable, is to use a wooden box full of sand instead of the wooden working surface. We used a wooden box 4ft x 4ft x 18in filled with just over 1 tonne of sand, this was excessive – it flattened the inner tubes, but because of its immense inertia, it remained very stable. A box between 4in and 6in deep would have been adequate and there would have been a lot less sand to shovel around. The methods of providing a stable working surface are shown in Figure 2a and Figure 2b.

Optical Components

Each optical component in the set-up needs to be stable on the work surface, so the mounting method needs to be different for each type of component. All of the mounts described can have blunt 4 inch nails sticking out of the bases if a sand table is being used, to provide even more stability.

Film Holder – the film holder is the most critical component for stability, especially in reflection holograms. Its job is to stop the film moving during exposure, and to do this, it sandwiches the film between two sheets of glass, which are tightly clipped together, see Figure 3. It is important to keep the glass scrupulously clean, especially the sides in contact with the film. This avoids particles of dust or sand separating the film from the glass, allowing it to move around during



The real lower-half of a broken champagne glass and its hologram before it was broken!

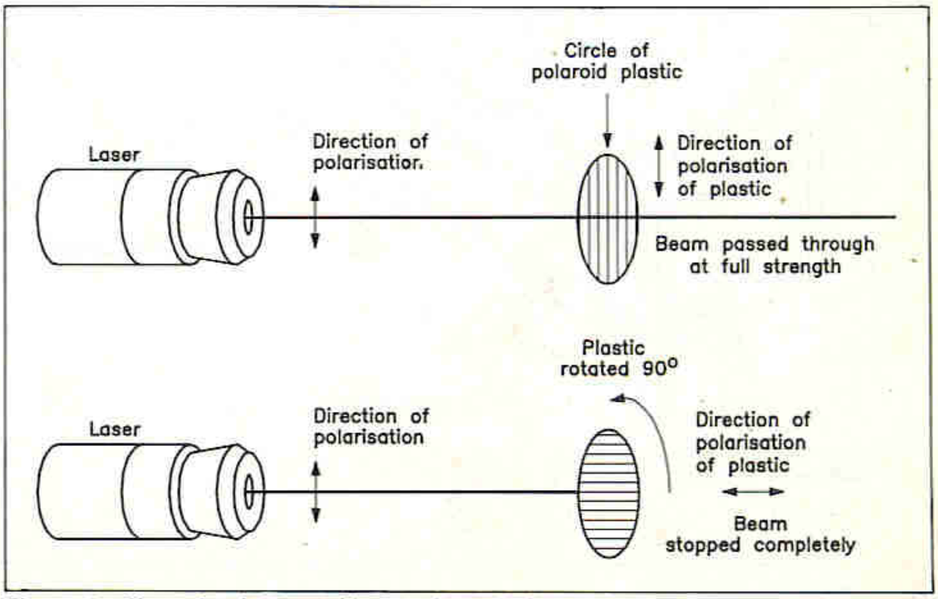


Figure 1. Effect of polarising filter on laser light.

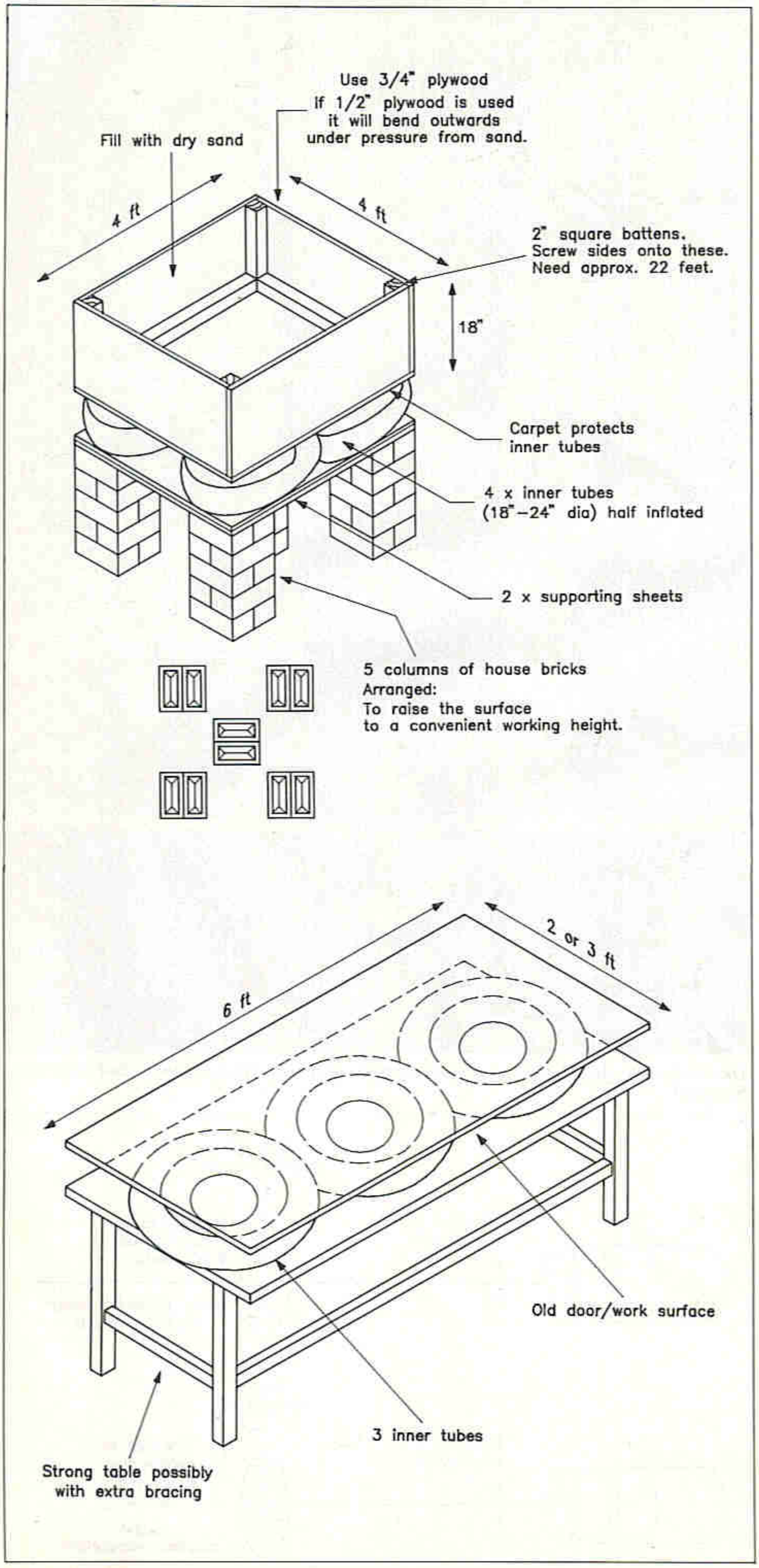


Figure 2. Methods for preparing a stable working surface.

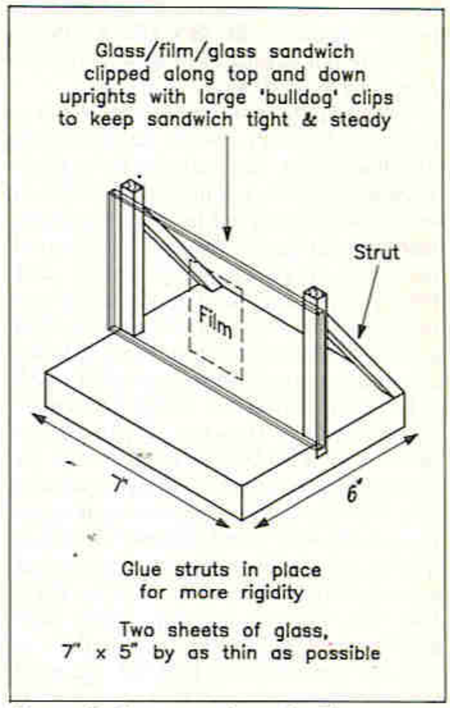


Figure 3. Construction of a film holder.

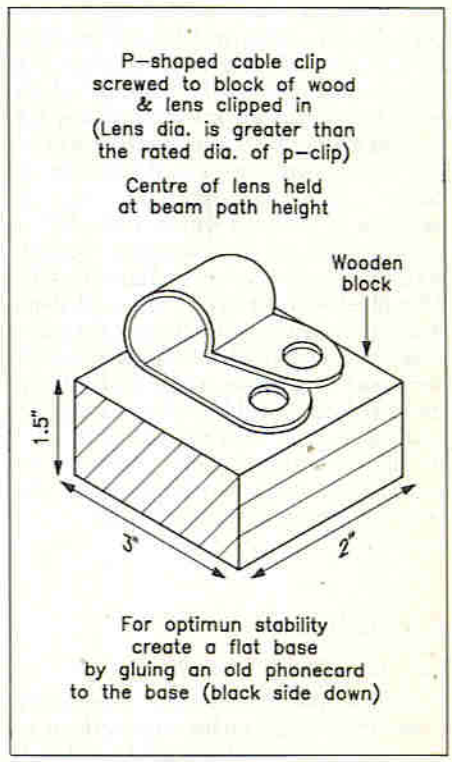


Figure 4. Holder for a small lens.

exposure. It is also a good idea to squeeze the glass plates together around the film to remove any pockets of air after the film has been clipped in. It took us a long time to discover the problem, which causes otherwise perfect holograms to be ruined.

Lenses – the lenses need only have a diameter of about 1 cm, and simple lens holders are shown in Figures 4 and 5. This size lens is the smallest (therefore cheapest) size which can be used to 'steer' the beam, but avoids using the very edges of the lens which is where any chips or defects normally occur. Any defects in the lens (or dirt on the lens) will seriously affect the

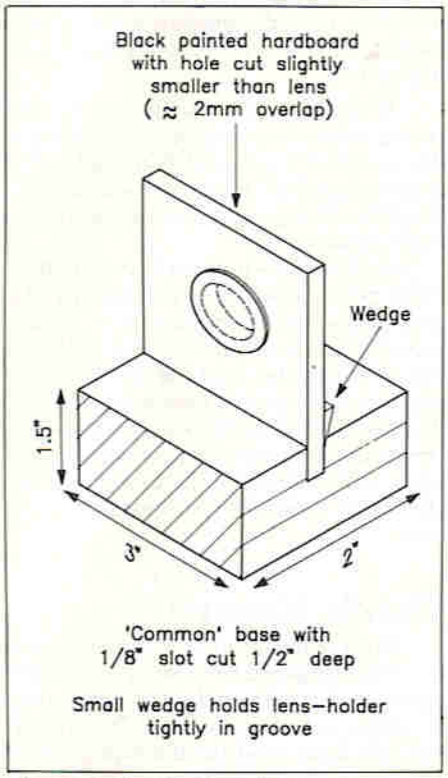


Figure 5. Holder for a larger diameter lens.

holograms – far more than they would in normal photography.

Beam steering with lenses is illustrated in Figure 6, which shows bi-convex and plano-concave lenses.

A standard rule of thumb is that the most curved surface of a lens faces the more distant conjugate. This translates as 'The parallel laser beam should hit the more curved side of the lens.'

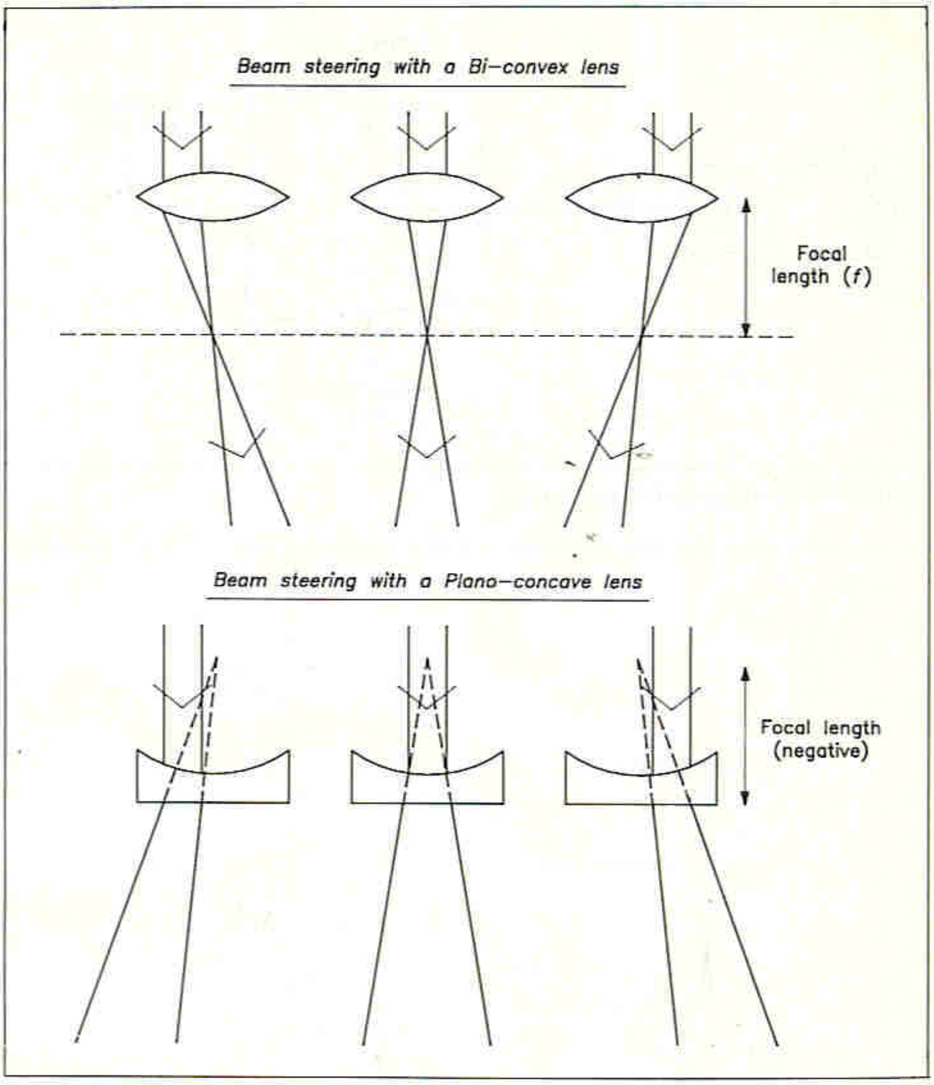
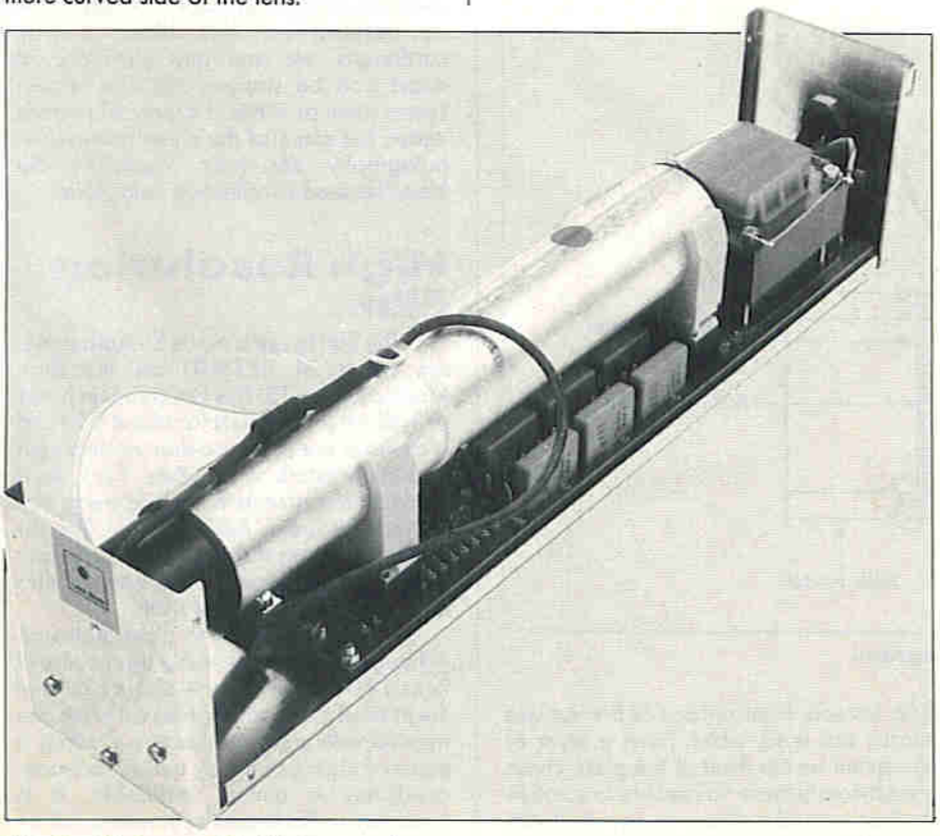


Figure 6. Using lenses to 'steer' laser beam.



The Maplin Laser with lid removed.

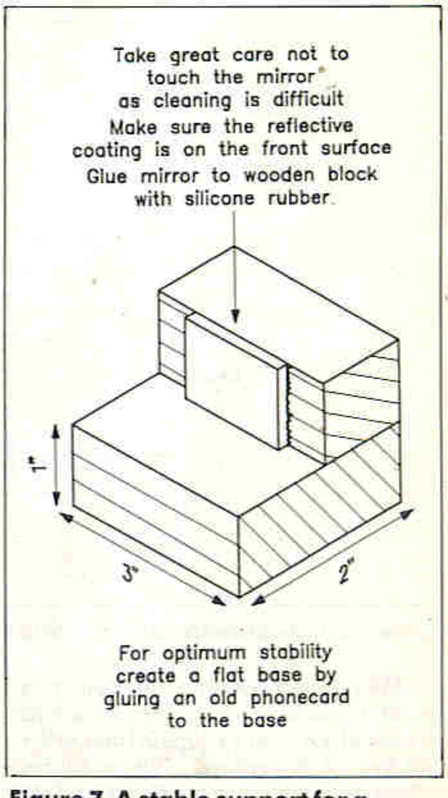


Figure 7. A stable support for a mirror.

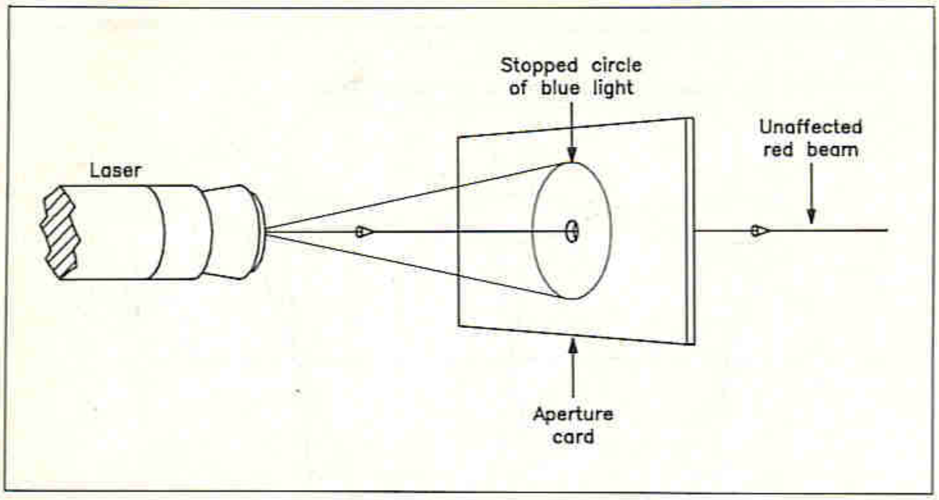


Figure 8. The purpose of the aperture.

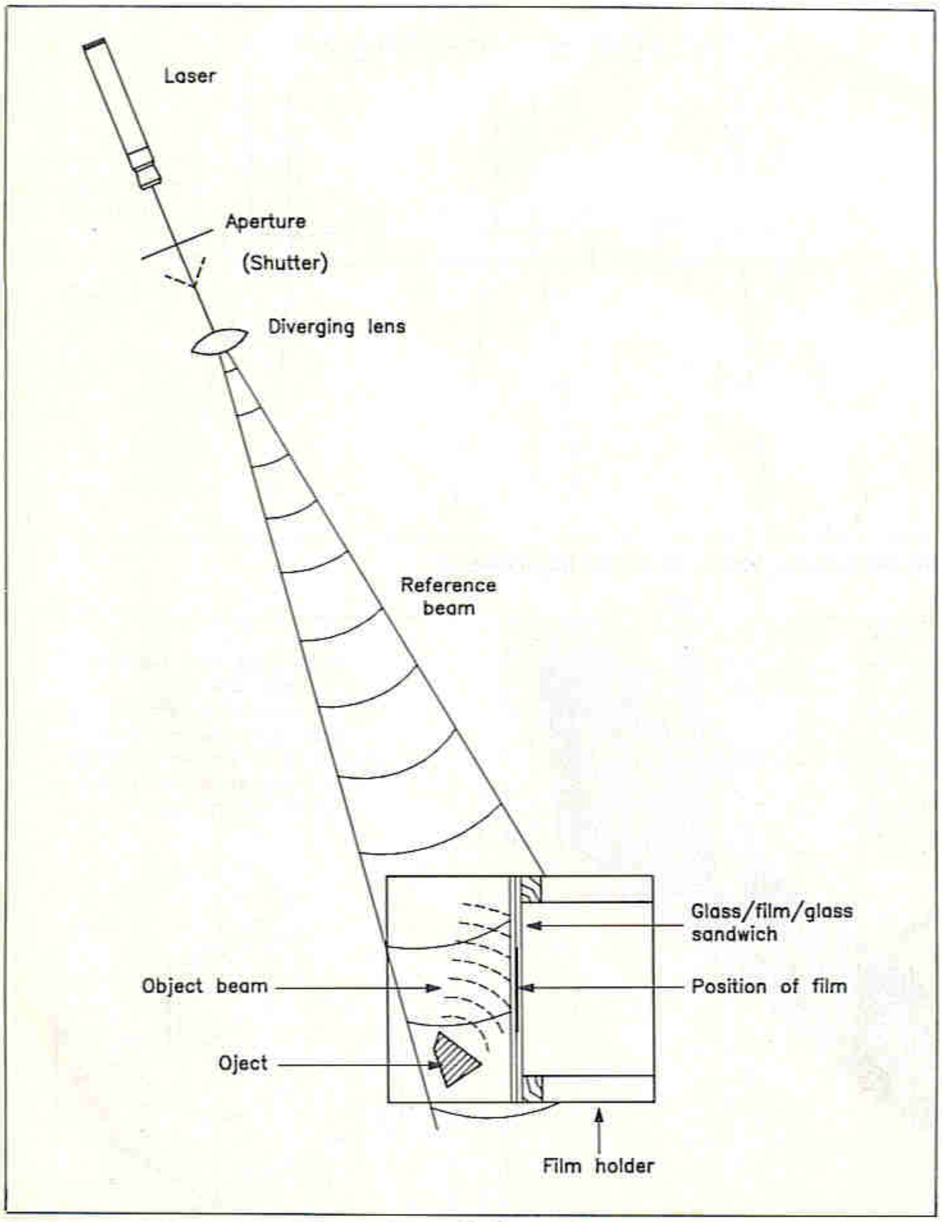


Figure 9. Simplest method for making a hologram.

Mirrors – normal household mirrors cannot be used in holographic set-ups because of the layer of glass in front of the reflective silver surface. This produces multiple reflections, and with laser light causes undesirable stripes to appear in the light. Instead, front surface or first surface mirrors are used, which have a layer of aluminium on the *front* of the glass. These are obviously more vulnerable to scratching than second surface mirrors, which are protected by the layer of glass on one side and a layer of paint on the other. As with the other optical components the mirror needs to be stable, a simple mount is shown in Figure 7.

Shutter – this component is very simple and has no stability requirements – it is a piece of black card, folded into a 'V' shape, placed in the path of the beam. It is lifted clear to expose, then replaced to stop the exposure.

Aperture – before the shutter in the beam path should come the aperture. As well as the red laser beam, the Maplin Laser also emits a cone of blue light, see Figure 8. This blue light will fog the film if not stopped, and so is blocked by passing the laser's output through an aperture. This can be as simple as a hole cut in a sheet of black card, although it is essential that the laser beam does not touch the edges of the hole.

Dark Room

The film used in holography is not very sensitive compared to 'normal' black and white film, but it still needs to be exposed in an almost entirely dark room. The normal red safe lights used for black and white darkrooms cannot be used, as hologram film is most responsive to red light. Instead, a dark green safe light can be used, which only radiates in a wavelength which corresponds to a dip in the film's sensitivity. It is also possible to use an extremely dim source of white light, for just long enough to allow you to load the film holder. Development should be done well away from white light, but a very dim green safe light can be used if needed, to determine the darkness of the film. Any room that can be blacked out almost completely can be used as a holography room. Windows can be covered by thick black curtains, cardboard, etc and any gaps around doors can be stopped up. The kitchen seems ideal as it has a supply of running water, but some of the chemicals used in holography are toxic, especially the bleaches used in reflection holograms.

High Resolution Film

The film to use is made by Agfa under the name of 8E75HD on the thick triacetate base T3. This film comes in packs of 100 4in x 5in sheets for about £60 and is cheaper per unit area than normal high resolution black and white films. It is relevant that, at least in the beginning, you will not be using full sheets of film for exposures – one sheet of film can produce four good holograms, eight smaller ones or twenty 1in square test shots.

Film is preferable to glass plates as, although it is a lot less stable than plates (it flexes) it is a lot cheaper – about a third of the price of plates and can be cut to the size needed with a pair of scissors – cutting a piece of glass accurately under darkroom conditions is almost impossible. It is important not to touch the emulsion side of the film, handle it by the edges.

Processing Chemistry

The processing chemistry described initially is very similar to that used in normal black and white photography. The recommended processing method is explained in the section for each type of hologram.

For simple transmission holograms, only the chemicals needed for normal black and white photography are needed. These are:

Developer – we use Ilford Perceptol, made up as directed, but used in small quantities, diluted down about 15 to 1 before use, then discarded at the end of the evening's work, or before if a lot of processing is done. Any other high resolution high contrast developer should work.

Stop – any photographic stop bath can be used as they are all essentially the same. We discard ours about once every 20 sessions.

Fix – we use Paterson Acufix, used as directed, but diluted to half the recommended strength. This gives more control over the fixing time. Again, any fix should do. We chose these chemicals, apart from the developer, pretty much at random. They work fine, but there may be better chemicals out there for those with the money to experiment. The prepared chemicals are kept in 2 litre ice cream cartons, arranged in a row, in the correct order, working from left to right. If there is any chance of children getting near the chemicals, they should be bottled up after use, labelled and stored out of reach.

The Object

There are limits to the things you can make holograms of, mostly related to the stability requirements. Any living (or recently dead) objects are definitely out, as are pieces of thin plastics. The objects must be reflective to red light, i.e. red, white, yellow or metallic objects. Mirrors do not make good holograms, but do make good diffraction gratings – try it later though, not as a first object. The first object you try should be small – no bigger than 1inch in any direction. A white bodied LEGO man with his feet glued to an old phonecard is ideal. The arms sticking out give a good parallax effect, the object is small, rigid and easily recognisable, especially if the face is visible.

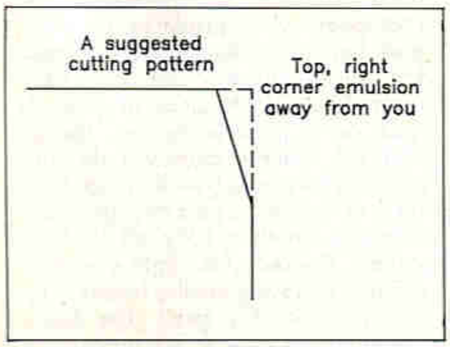


Figure 10. Marking film for orientation.

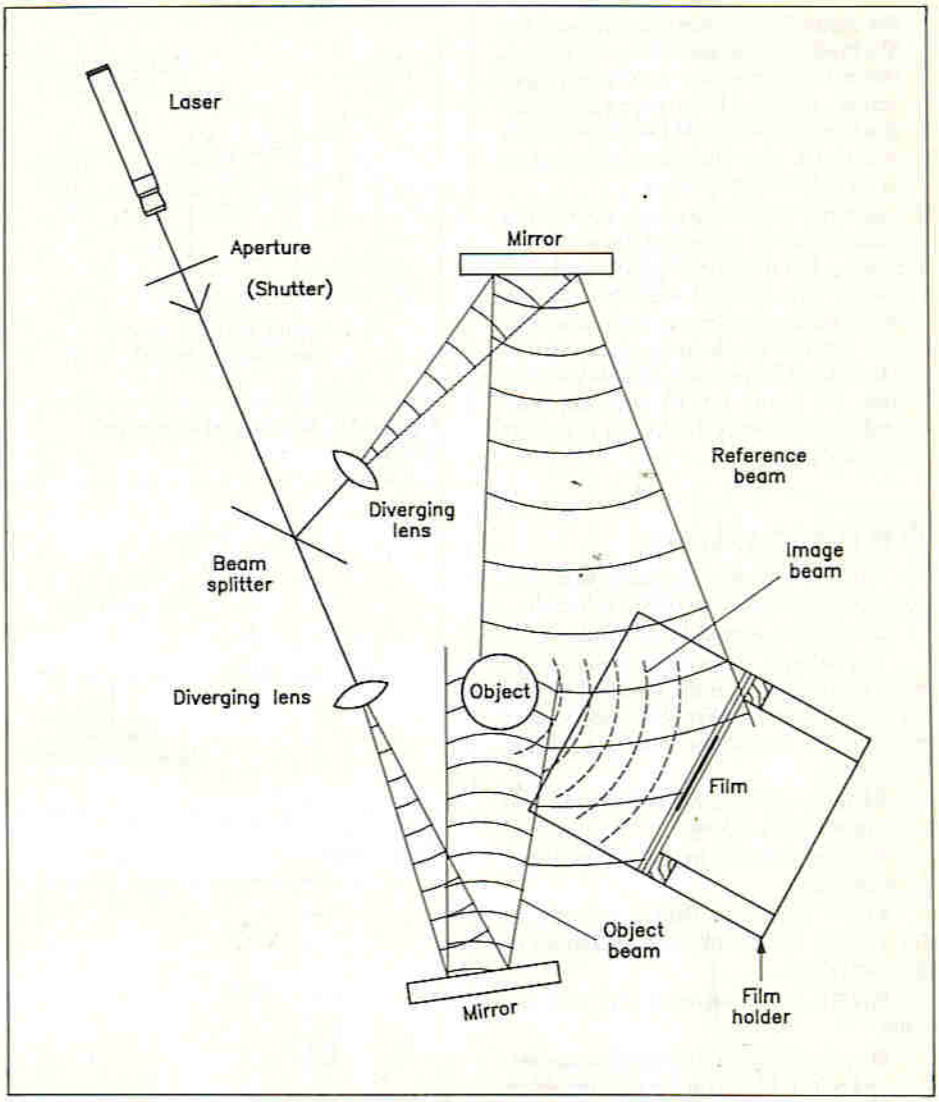


Figure 11. Split beam transmission hologram method.

Making The Hologram

Now that all the components are ready, you can start to make holograms. Assuming that you have at least 2ft x 4ft of available working surface, aim to reproduce the set-up as shown in Figure 9.

1. Position the laser to point obliquely down the surface.
2. Place the film holder so that the beam hits the centre of the glass sheets, about 1½in up from the bottom. Put a 1in square piece of white card in the film holder centred on the spot of the light.
3. Position the object on the film holder about 3cm away from the glass, facing both the glass and the laser.
4. Place a diverging lens in the laser's beam path, to spread the light into a circle about 10cm diameter at the film holder. (Check with a piece of white card with the lights off.)
5. Move the lens to steer the beam, so that it covers the area where the film will be and also the object. The beam should hit the object squarely and graze the film. Looking through the 'window' where the film goes, you should be able to see the object illuminated by laser light, preferably evenly covered. By moving your head, you should also be able to see straight down the expanded beam. This is completely safe as the beam is diverged. WARNING: DO NOT under any circumstances look down the undiverged beam, it is dangerous to do so as it may cause retinal damage.
6. Put the shutter in place.
7. Leave the set up to settle for at least 15 minutes. Make up the chemicals and pour into the developing trays – none need to be more than ½in deep.
8. Return to the set up and cut the film. Cut a 1in square of film for the first attempt, unless you are feeling rich or confident. Find the emulsion side of the film using the 'wet lip test'. Lick your lips, leaving them slightly wet, then close them over one corner of the film. The emulsion side of the film will feel more sticky, and may even stick to the lip. To remember which is the emulsion side it is recommended that you mark the film – cutting one of the corners off is a good way, see Figure 10. (It will save a lot of time later if you can identify which way round the film was when it was exposed.)

Put the piece of film, emulsion side towards the object, in the film holder in place of the card. (It is vital to remove the card.) It is a good idea to keep the film holder clean, especially the sides in contact with the film. Car windscreen washer additive is very good for this. The film holder should be clipped back into place, and should be allowed to settle for a minute or two.

9. Exposing. Walk very gently over to the shutter, and lift it clear of the mounting surface, but still blocking the beam. This allows any residual vibrations to die down before exposure, but make sure you are not touching the table at all. After about 30 seconds, raise the shutter from the beam for 15 seconds, then replace it to block the beam, and start breathing again.

Developing

Now that the film has been exposed, here is a suggested processing schedule.

Expose – About 15 seconds.

Develop – Leave in the developer until it is about 15% dark. A guideline is to wait until the film is noticeably hazy, then to leave it in the developer for another 15 to 30 seconds.

Stop – 30 seconds. This stops the developer from working.

Rinse – Rinse in tap water for about 30 seconds.

Fix – 3 minutes. (This is essential to stop the film from continuing to expose in light conditions.)

Wash – 2 minutes in running tap water.

Dry – Hold the film by one corner, then flick with a finger on the non-emulsion side (the side with the water droplets). This will remove most of the surface water. The emulsion side can then be very gently dried with paper tissues to avoid scratching the soft emulsion. The hologram can then be dried with a hair dryer or a fan heater but care must be taken not to melt the film!

You should now have a grey/green/brown piece of film, possibly with swirling patterns on it. If not, don't panic – something has gone wrong, but no problems are insurmountable in holography this simple. If you do have the grey film, take it back to the table, turn the lights out and the laser on. (You shouldn't turn the laser off during a session – it takes up to half an hour to warm up to complete stability.) Remove the object from the light path, and hold the film up in the reference beam, in the same orientation it was in when the hologram was exposed. (If you marked the film as described, this is much easier). As you now look through the film towards where the object was (you've removed it, remember!), the object should appear to still be there, possibly a little dimmer than the original, but definitely there. If you can't see it, try turning the film around, there are eight possible orientations, four rotations and a flip. Remember also that, if something was wrong with the processing, the image may be very dim, If there is definitely no image, try the error chart.

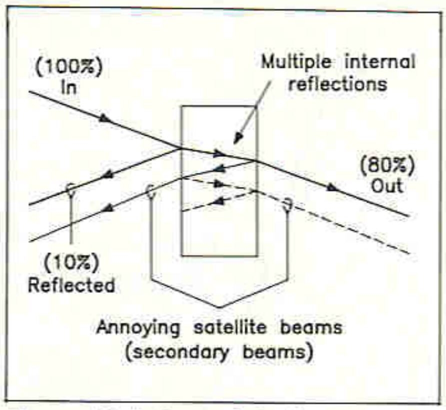


Figure 12. Actions of the beam splitter.

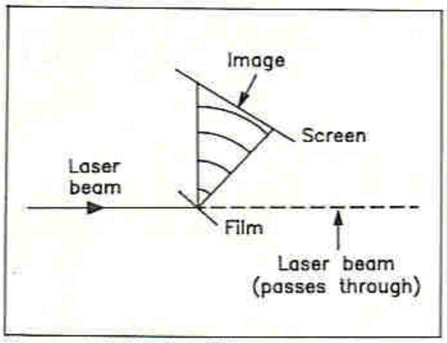


Figure 13. Method for screen projection.

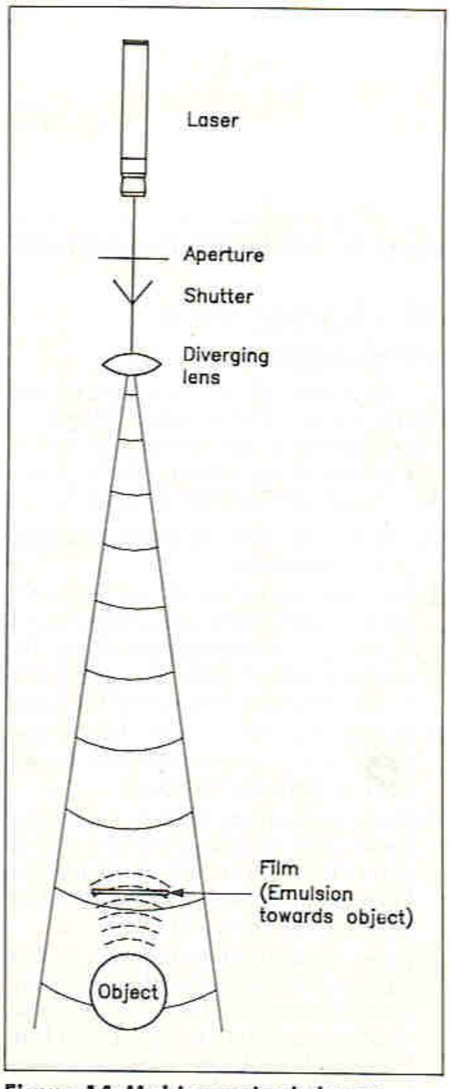


Figure 14. Making a single beam reflection hologram.

Theory

The two sources of light (the reference and object beams), are the two beams needed to interfere to produce a hologram on the film. The beam you can see coming straight from the lens is called the REFERENCE beam, and should be a nice clean divergent beam. (If you project the reference beam onto a piece of white card, it should form a circle fading towards the edges.) The beam you can see reflected off the object is called the OBJECT or IMAGE beam. This beam has been altered drastically by bouncing it off the object, and is now no longer an easy beam to visualise – it is not all travelling in the same direction, nor is it all in step as it was before it hit the object. These two beams interfere in the manner shown below all over the film, producing a record which, although not resembling the object in any way, just so happens to produce a full 3D image when replayed with monochromatic light. (If you want to know more of the theory, there are many good books available on the subject, especially "The complete book of Holograms", mentioned in the references, which deals with making holograms. However, the theory is not needed to make good holograms, and you can always justify not knowing the full theory by mentioning that not many photographers have any idea of the chemistry involved in processing a film.)

Split Beam Transmission Holograms

Once you have mastered the single beam transmission hologram, it is time to progress to the split beam method. In split beam holography, the reference and object/image beams are produced and controlled separately. This gives you much greater control over the hologram, allowing increased possible brightness and greater depth. The most important advantage, however, is that the object can be lit as required, not as dictated by the layout. However, there are drawbacks, which will become clear on looking at the layout, see Figure 11.

1. There are more components; 1 more lens, 2 first surface mirrors and 1 beam splitter.

   The lens and mirrors have been discussed earlier. The beam splitter is the component which produces the reference beam and the illumination beam from the laser's output, see Figure 12. It is simply a CLEAN piece of glass, as thick as is possible to get; double thickness window glass will do. This glass has the property of allowing about 80% of the light to pass through it, and reflecting another 10% off its front surface. The rest of the light is wasted, either as annoying satellite beams or by absorption in the glass. The beam splitter can be wedged in a groove in a block of wood for stability.

2. Because of the greater number of components, less light reaches the film – be prepared for longer exposure times.
3. Stability is now slightly harder to achieve as there are so many more components which may move during exposure.
4. Distances – Now that the reference beam and illumination beam are separate, it is vital that they travel the same distance before they reach the film holder. This is a function of the coherence length of the laser, on no account must the difference in path lengths be greater than half the coherence length. There is no published coherence length for the Maplin laser, but it is at least 30cm.
5. Light Ratios – Now that you have some control, these become more critical. The light ratio is the difference in the amount of light measured at the film arriving from the object beam and the reference beam. For transmission holograms, it should be 1:4 (object:reference). However, without a light meter it is not easy to be accurate, although looking at the brightness on a piece of white card is often adequate. To alter the ratio, you can move the object towards or away from the film (while keeping the distances constant), change the object for a smaller/less reflective or larger/more reflective one, or move the lenses back and forth to waste light.
6. Stray Light – With all these components on the table, it is essential that the only laser light reaching the film is either the reference beam or the object beam. The illumination beam must not be allowed to touch the film directly, although the reference beam is allowed to hit the object. Any other light such as flashes from edges of lenses or the beam splitter must be stopped with pieces of black card placed on the table. This process is called carding off, and is vital to prevent 'dead' patches on the hologram. Pieces of matt black card, bent into a 'V' shape, then stood on end are ideal for this purpose.

The procedure for making these holograms is exactly the same as for the single beam transmission, except that the exposure time should be extended to about 30 seconds.

Projection of Transmission Holograms

If the hologram is cut up, each piece will still allow you to see the whole object, but from a limited range of viewing positions – it is like looking through a keyhole – you have to move your viewpoint to see different parts of the room. It is this property of holograms which gives them their ability to show an object from many viewpoints which makes them much more interesting than ordinary photographs, and which permits the following demonstration.

If a good, bright hologram is illuminated from the 'wrong' side with an undiverged laser beam, it can project an image onto a screen, see Figure 13. A lot of the laser light is lost, passed unaffected through the film. A proportion, however, is deflected onto the screen to produce an image. If the film is now moved so that the spot lands on a different section, the projected image is now that of the object seen from a different viewpoint. In this way, it is possible to 'fly' round the object, looking at it from different places, just by moving the film. (Impressive isn't it?) If you have the mercuric chloride bleach needed for reflection holograms, you can bleach the hologram. This will greatly increase the projected image brightness, although the hologram will be destroyed for normal viewing it is well worth it.

Reflection Holograms

As mentioned earlier, there are two types of holograms. By now, you should have mastered the two fundamental types of transmission holograms (single and split beam), but there are an enormous number of variations to this theme: curved film, cylindrical film to allow you to look all round the object, holograms which move as you look at them from different angles and many other derivations. These all take a lot of time or money, and will be left out of this article, although "The Holography Handbook" by Bob Schlesinger, Jeannene Hansen and Fred Unterseher, is a very good guide for those with money/time to spare.

As can be seen from the layouts of transmission holograms, the object beam and reference beam both hit the emulsion from the same side of the film. In reflection holograms, the reference light comes in from the other side, creating interference patterns actually embedded inside the film emulsion. It is this effect which produces the characteristics of the reflection hologram, and the problems involved in making them. Reflection holograms can be viewed with any point source of white light, the sun is ideal, car headlight lamps are almost as good and a lot more convenient. Fluorescent tubes are the worst of all light sources. Reflection holograms 'play back' in any colour, not necessarily the colour they were exposed in. This colour can be chosen during development and processing, although there is usually a large element of luck involved in the procedure. As the interference patterns are stacked through the emulsion, not just on the surface as with transmission holograms, stability becomes much more critical. Stability of lambda over twenty is essential to produce a decent hologram, so much greater care must be taken. The set-ups, however, are much simpler and the results are spectacular, even with single beam set-ups. Split beam set-ups are very unstable, and we have not found the results worth the amount of film wasted in unusable exposures.

Making Single Beam Reflection Holograms

Set up the components as shown in Figure 14.

1. Position the laser pointing straight down the table.
2. Position the film holder to intercept the beam.
3. Position the object behind the glass to stop the beam.
4. Put the diverging lens in the beam to spread it to at least twice the diameter of the film. (This produces a much more even spread of light across the film.)
5. Check every component to ensure it is stable. If not, change it until it is (glue it down if necessary).
6. Close the shutter.
7. Leave to settle for 10 minutes.
8. Load the film holder, emulsion side towards the object.
9. Hold the shutter off the table for 1 minute.
10. Expose for 30 seconds.
11. Process. NOTE: This is not the same as for transmission holograms.

Processing Chemicals

These are the same as for transmission holograms, with two additions.

Bleach – This vastly increases the brightness of the hologram. We use mercuric chloride and potassium bromide. 1 tablespoon mercuric chloride, 1 teaspoon potassium bromide in ½ litre of water. This reagent is VERY TOXIC, there are safer bleaches, all of which suffer from cost or shelf-life problems (shelf lives are as low as 5 minutes). With safe handling (wearing rubber gloves, avoiding inhaling the dry powder and other common-sense

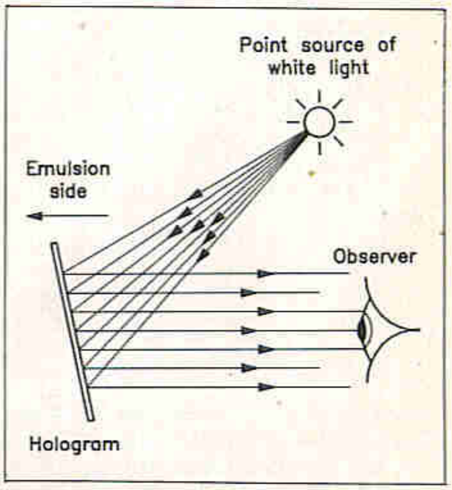


Figure 15. Viewing a reflection hologram.

Continued on page 46.

Surround Sound Processor Kit

REVIEWED BY DAVE GOODMAN

Introduction

The Surround Sound Processor from Sound Master adds 'depth' and 'ambience' to stereo music sources allowing the listener to hear the spatial richness, or thickening, of reproduced sounds – such as that of a live performance. Line-level signals (0/+3dB) are filtered and delayed by the pre-amplifier to produce a four channel 'sound field'. Two of the output channels then drive the usual 'front' stereo amplifier and speakers, while a further two outputs drive a second stereo amplifier and 'rear' mounted speakers, as in Figure 1. The system is further equipped with a Dynamic Noise Reduction (DNR) system, to reduce cassette tape noise and unwanted background hiss and can be switched in or out from a front panel control. In use, the surround sound effect, effect volume and delay time can all be set according to personal requirements, via three rotary controls on the front panel. Any one of three separate input sources can be selected from front panel mounted latch switches, e.g. Compact Disc, Laser Disc or VCR.

Specifications (test sample)

Frequency response:	20Hz – 100kHz (±1dB)
THD (front channel):	0.025%
THD (rear channel):	<0.25%
Input signal level:	0.1V – 3.5V
Output signal (front):	0.1V – 3.5V
Output signal (rear):	5.5V
Delay time:	5ms – 50ms
Input impedance:	47kΩ
Power requirements:	240V AC 50Hz mains
Case dimensions:	360 x 127 x 53mm

The Circuit

Figure 2 shows the circuit diagram for the processing system. Two input switches are used in combination to select one of three input signal sources and a third 'defeat' switch routes input signals to the processing filter either directly, or via the Dynamic Noise Reduction system, IC1.

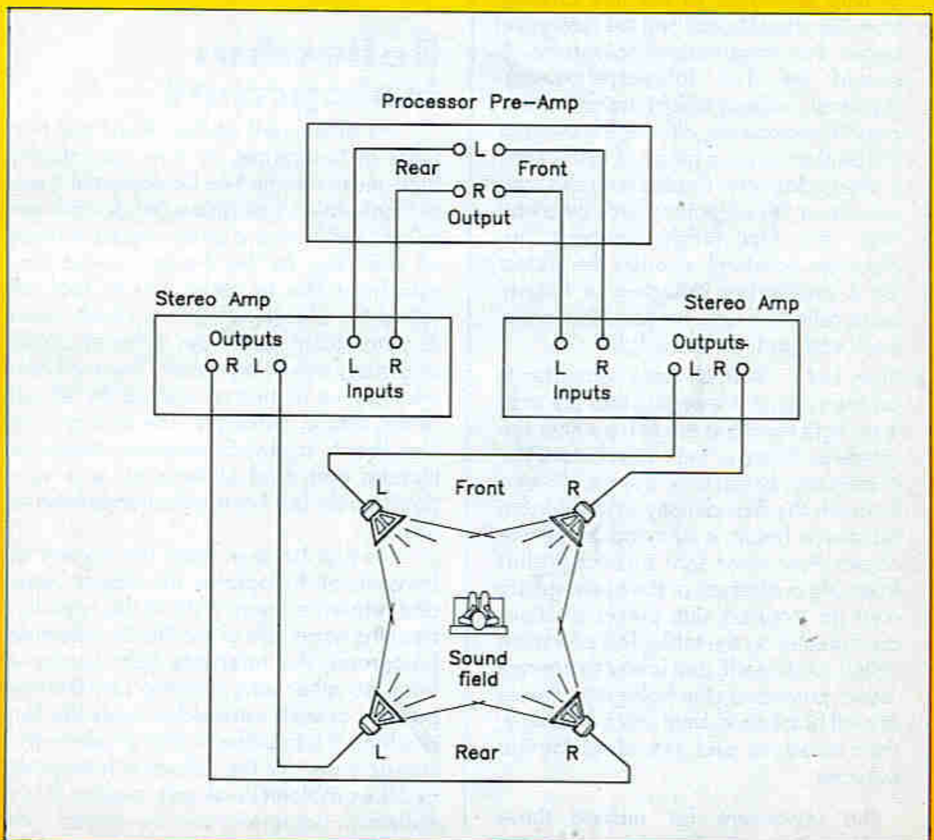


Figure 1. A four channel set-up.

The input signals are split two ways and connected to buffers IC4a and b and from here, the left and right signals are output to the front power amplifier and speakers. With the DNR system switched in, all input signals are processed by IC1 first, before distribution through the system. This particular noise reduction system comes under the term 'psychoacoustics' and is based on the fact that the sensitivity of the human ear increases between 2kHz & 10kHz and noise in this area becomes extremely audible. As the perception of noise is dependent on how the noise energy is distributed through the system, IC1 low-pass filters the signal and reduces (or increases) the bandwidth accordingly – hence the term 'dynamic'.

The other half of the split input signals are buffered by IC2 and IC3 and output to the rear power amplifier and speakers. Both left and right channel signals from IC2a and IC2b are mixed into a composite signal and low pass filtered by IC7a and b. The signal bandwidth is limited before delay processing by the 'BBD', IC9, to reduce H.F distortion, noise generation and aliasing. This is a 512 stage Bucket Brigade Device which capacitively stores a small sample of the incoming audio signal for a short period before passing it along to the next stage. The storage – or delay – period is determined by an externally generated square wave oscillator, IC8 in this case, whose clock frequency is varied by the delay control VR3 between approximately 14kHz to 75kHz. The output from IC9 is

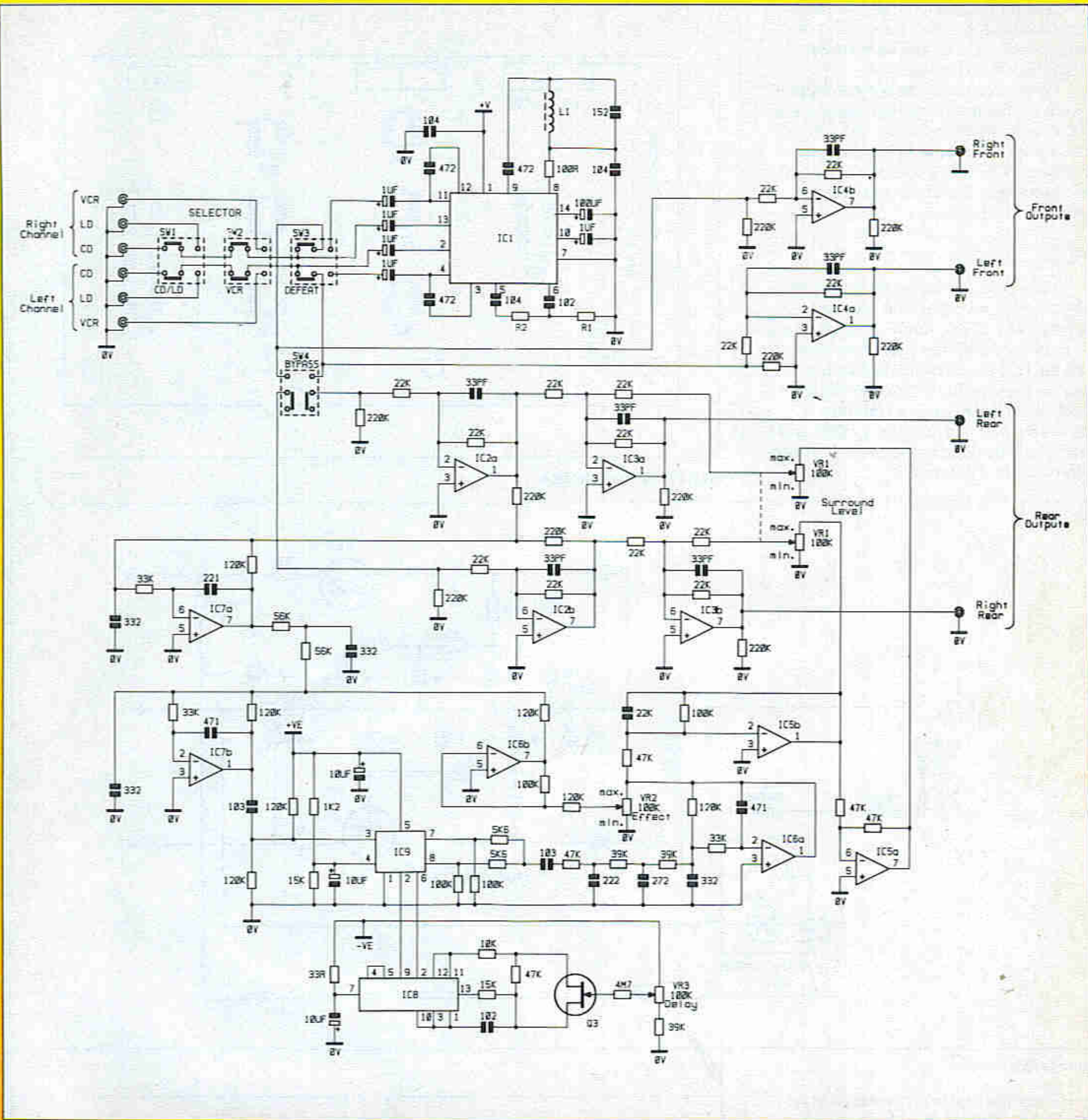


Figure 2. Surround sound processor circuit diagram.

typically 'D to A' with a stepped waveform reconstruction of the original signal superimposed with clock pulses, as shown in Figure 3. The clock pulses are then removed and the signal 'cleaned up' by low-pass filter IC6a. Delay line circuits such as this one are usually run with a clock frequency two to three times that of the audio signal being processed, and this limits the frequency spectrum – or bandwidth – of the signal. The maximum number of delay stages (512) and the delay clock frequency all play a part in determining the bandwidth as well.

The delayed, composite signal is connected via the effect level control VR2 and inverter IC6b as part of a feedback loop to the input of the BBD stage. The combined effect is that of many short echo's being continuously delayed and fed back in varying phase relationships to produce reverberation. The reverb is added to the original signal and taken via pre-amp IC5b and surround sound level control VR1, to the rear Right Channel output buffer IC3b. With VR1 set to minimum the output is 'clean' with only the original input signal available at the rear channel outputs; VR1 set to max adds the full processed signal to the original at the output of IC3. IC5a inverts the processed signal and adds it to the original signal to produce the rear Left Channel output. Because of the complex relationships between reverberation, left and right stereo and inverted composite waveform signals, the rear output channel signals vary from the front channels – and

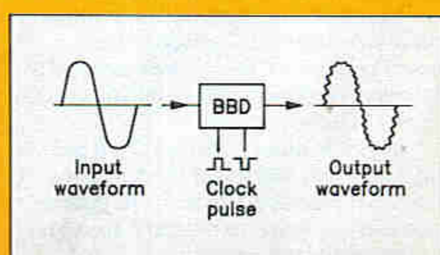


Figure 3. Bucket-Brigade-Device.

from one another – quite considerably and therefore generate a pseudo stereo effect.

CONSTRUCTION NOTES

This kit is easy to build if you have experience of project building, but may pose a few problems for beginners as the manufacturers assume a knowledge of resistor colour codes and component identification and orientation!

Once unpacked, the project supplied for our evaluation contained: seven packs of components and miscellaneous items, mains transformer, pre-drilled and legended PCB, rotary pots, switches and phono sockets, and six screened metal panels for the case.

PCB

Wire links are not supplied and you will have to find/make your own; use 22 or 24 S.W.G. B.T.C. for this job. There are 23 links in all and they should be fitted into the PCB positions marked with a 'J' (Jumper presumably!). Not all links are marked and some share a common 'J' between them; fit a link next to SW1 and a link should be fitted between the two links approx. 25mm below IC2.

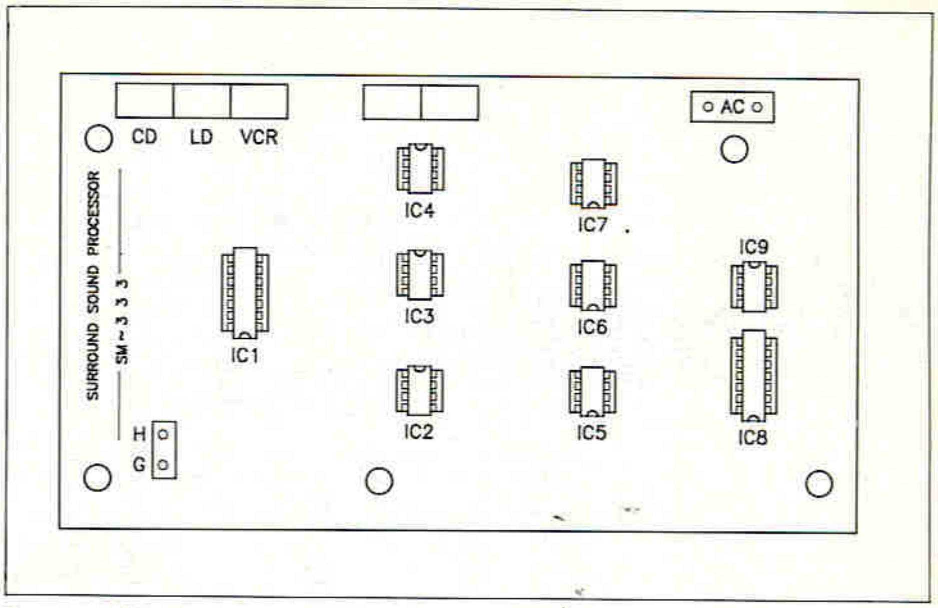


Figure 4. IC identification.

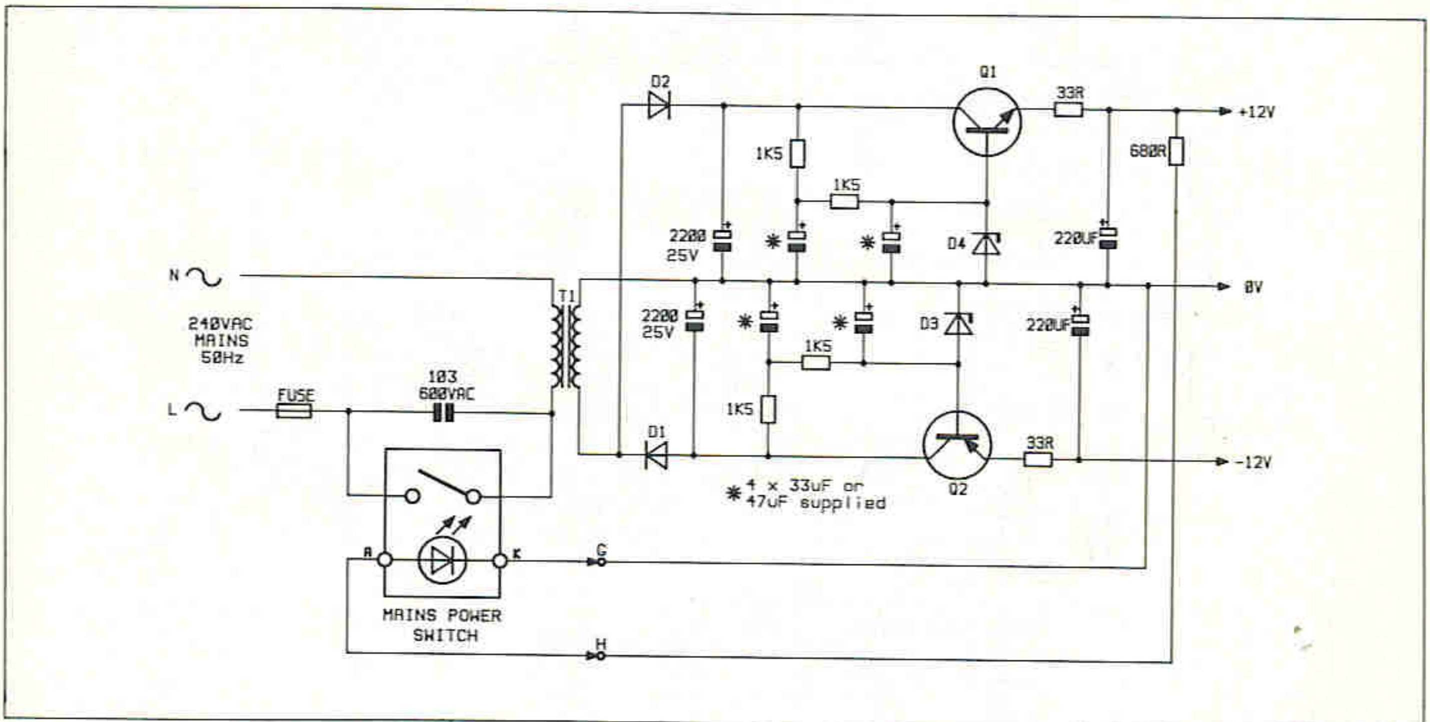


Figure 5. PSU circuit.

There are four brass terminals to be fitted in positions H,Q and AC – insert them from the track side of the PCB and solder their heads to the track pads.

Identify the resistors and place them into twenty individual groups – there should be a total of 68 resistors supplied – fit them according to value (note that there are no circuit references).

Insert the nine IC sockets (7 x 8 pin and 2 x 14 pin) and solder them in place. Note that the sockets cover the IC number once they are fitted, so refer to Figure 4 for IC placement later on.

Capacitor identification can be confusing, especially when some values differ from those in the circuit diagram. The two 33μF electrolytics in the PSU may be supplied as 47μF 50V types and will therefore be a tight squeeze on the board, see Figure 5 for PSU circuit. Values such as '272' refer to 270pF and '332' as 3300pF – the last figure here refers to how

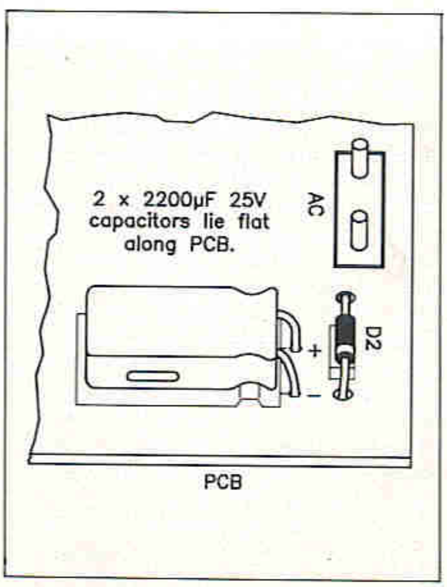


Figure 6. PSU smoothing capacitors.

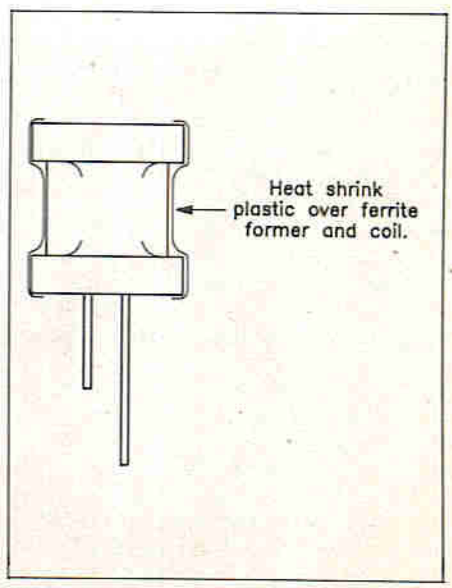
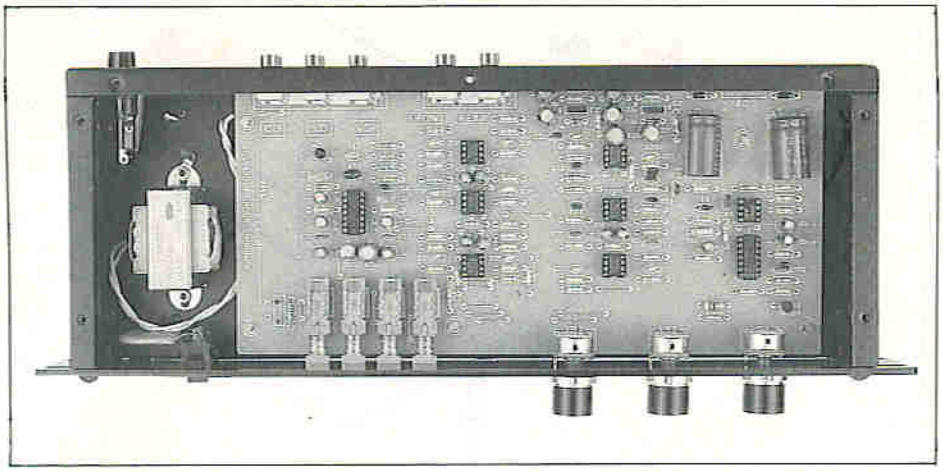


Figure 7. Inductor L1.



Inside the box.

many naughts (0's) are to be added after the number. Some capacitors may be marked 104 (100,000pF) or 0.1μF, the value is the same but the units used are different. Also, values such as '472' and '473' may also be printed as 4700pF or 0.0047μF and 33000pF or 0.033μF on the capacitor body. There are occasions when one wonders if these things are 'sent to try us'!! Lay the two 2200μF capacitors flat on the pcb as shown in Figure 6.

Inductor L1 looks more like a small PC electrolytic – see Figure 7 – but in fact measures 4.7mH. Strange value for a capacitor?

Diodes D1,2 and D3,4 differ in that D1 and D2 are 1N4000-range types with a black body , while D3 and D4 are Zeners (13V or 15V rating) with a red, glass body, see Figure 8.

Both power transistors have their leads identified in Figure 9. They are inserted into the PCB with the front face – opposite side to the heatsink mounting tab – towards the top edge of the board. F.E.T. Q3 should be identified and fitted into the PCB, as shown in Figure 10.

The three, miniature, dual ganged pot's are fitted onto the component side of the PCB, as in Figure 11 – they are all the save value (100k). Try to keep them at right angles to the PCB while soldering, otherwise they will not fit into the case correctly.

Latch switches SW1-4 are also mounted onto the PCB from the component side. Do not overheat the six terminal legs whilst soldering or the plastic body may melt!

Lastly, fit the 3 way and 2 way phono sockets, holes are provided for the plastic locating lugs, and solder these and any remaining components in place on the board. Trim off excess wires and inspect your work. Finally un-pack and insert each IC into the appropriate socket position on the PCB.

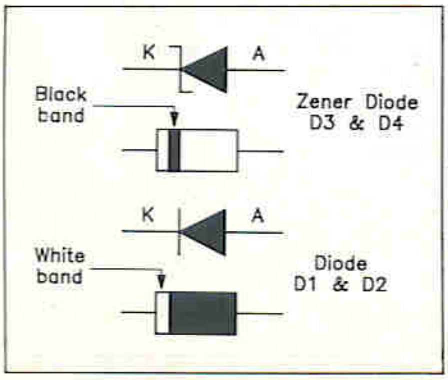


Figure 8. Diode and zener recognition.

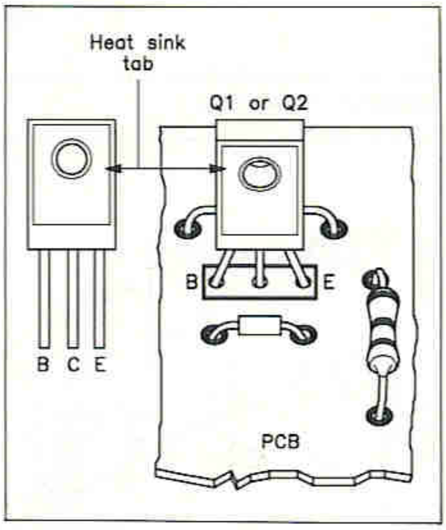


Figure 9. Power transistors Q1 and Q2.

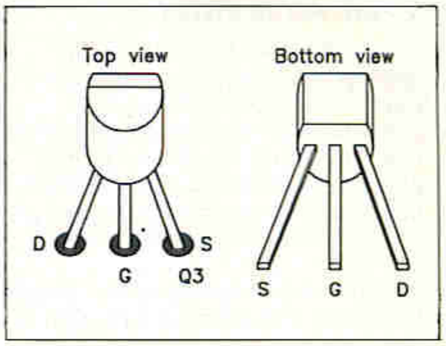


Figure 10. FET Q3.

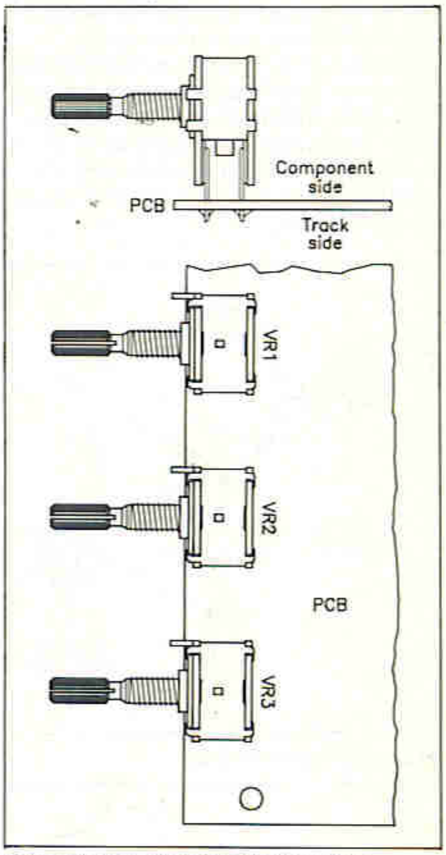


Figure 11. Mounting the potentiometers.

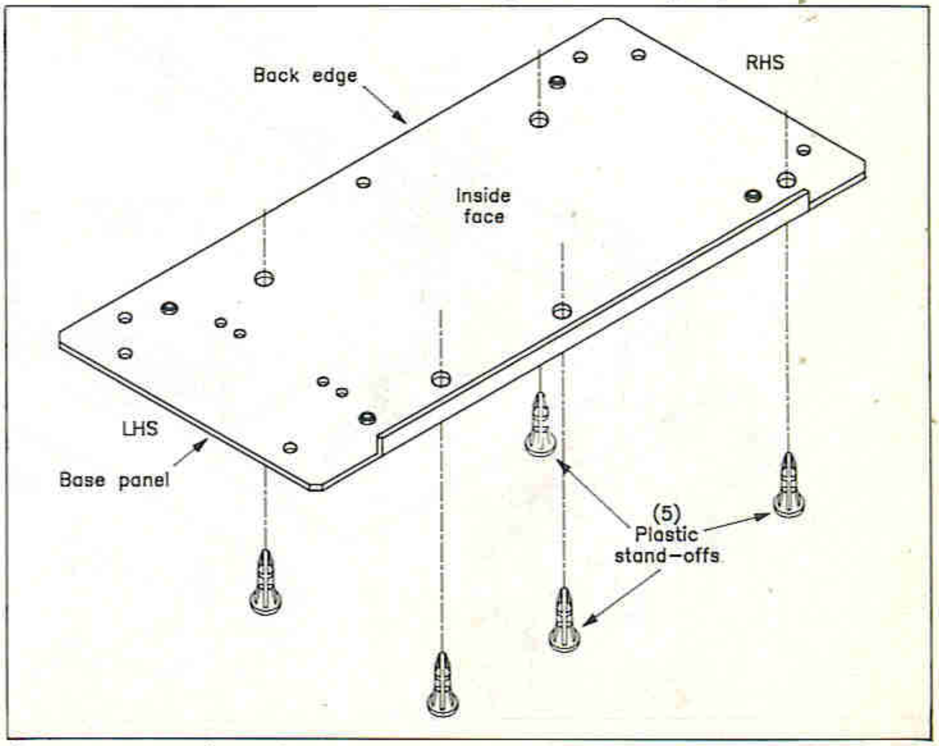


Figure 12a. Base panel mounting.

CASE ASSEMBLY

Of the two large and similar looking panels supplied, the panel with extra holes drilled and four, tapped, corner holes for mounting the rubber feet is the Base panel. Five plastic stand-off pillars are fitted into the panel, from the bottom side first, as shown in Figure 12a. The PCB mounts onto these pillars later on.

Next, mount transformer T1. Identify the primary and secondary wires first; both secondary wires are approximately 350mm in length and may be coloured blue. Two sets of holes have been drilled in the Base panel to accommodate transformers with different mounting hole spacings. Use the appropriate holes and insert the 5mm pozi-screws as in Figure 12b. A tag washer is needed for wiring the mains earth lead to the chassis and also for connecting the phono input 0V to chassis – see Figure 16.

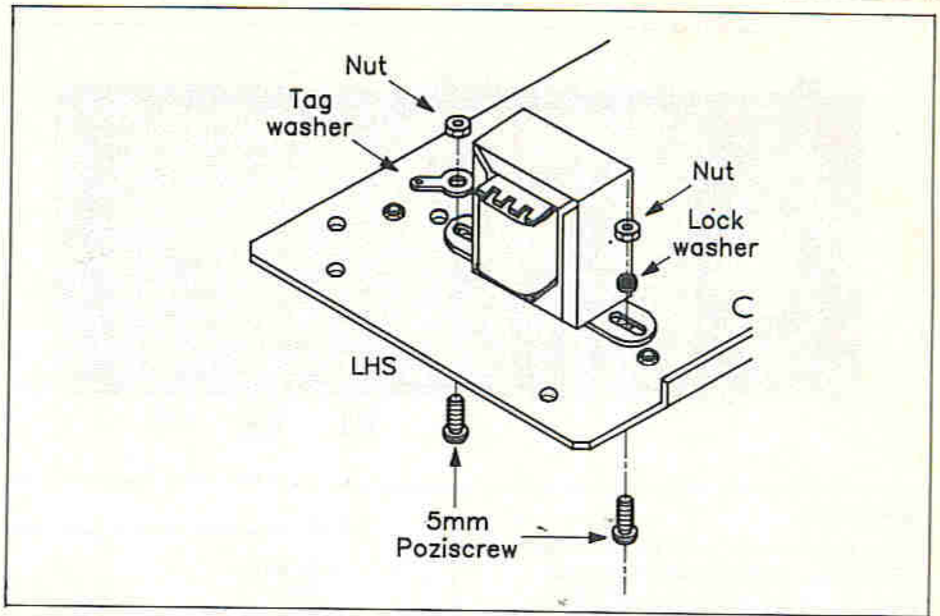


Figure 12b. T1 mounting.

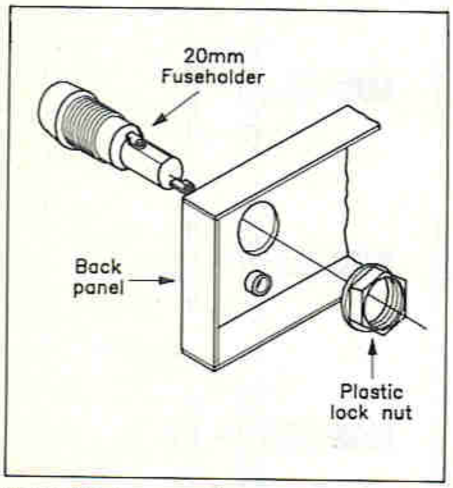


Figure 13a. Fuse mounting.

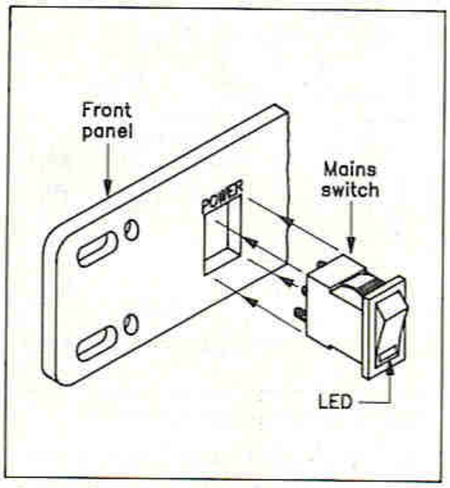


Figure 13b. Switch mounting.

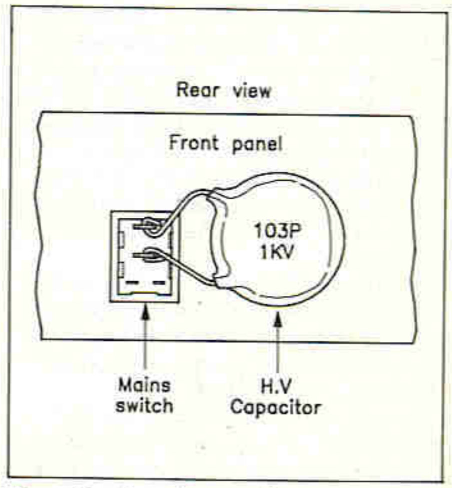


Figure 13c. Mounting capacitor on switch.

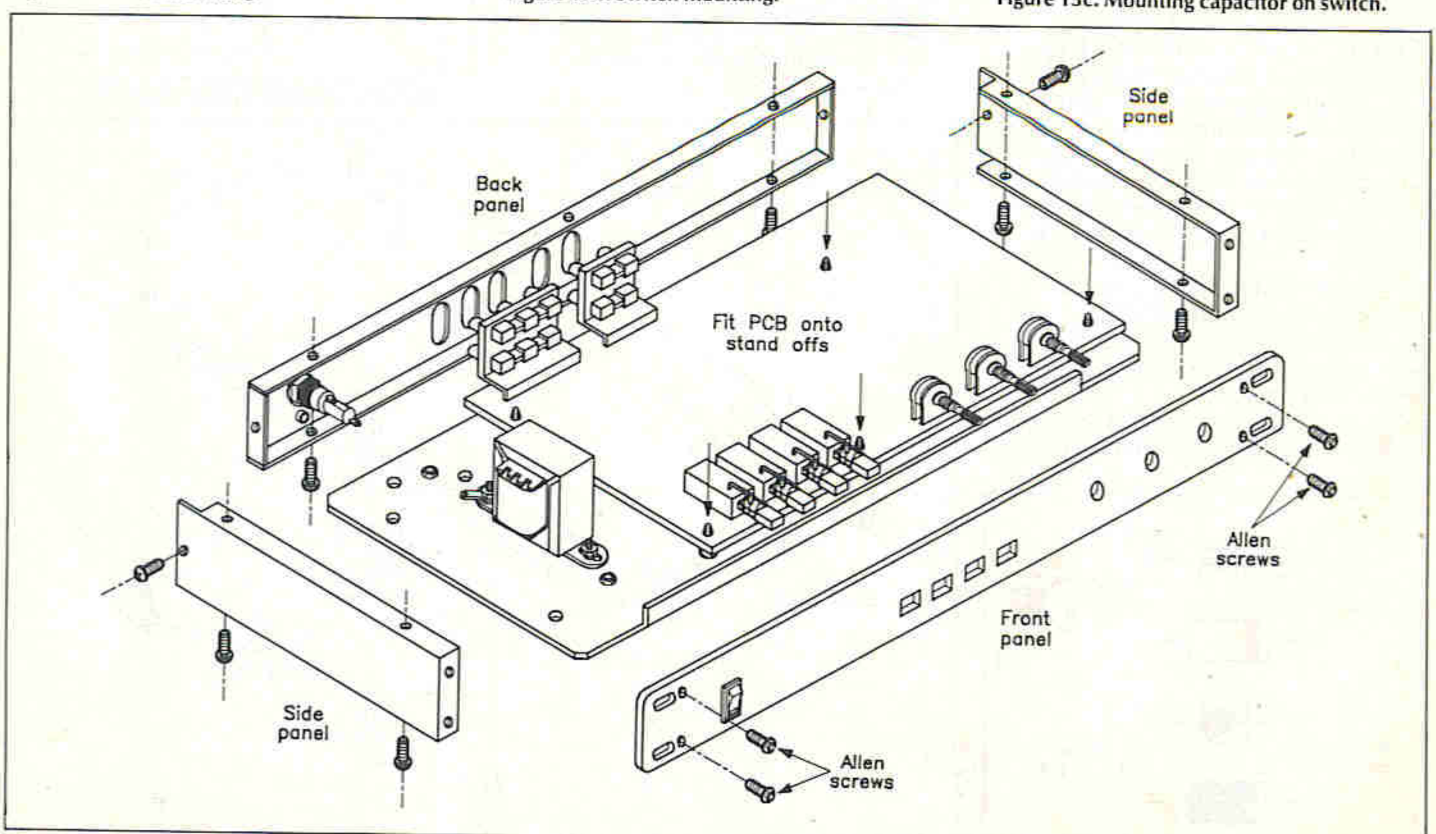


Figure 14. Main assembly.

Fit a 20mm fuse holder into the back panel, shown in Figure 13a, and insert the mains power (on/off) switch into the rectangular slot in the front panel with the LED lens toward the bottom edge, as shown in Figure 13b. Identify the high voltage 0.01μF (103) disc capacitor and referring to Figure 13c, connect it to the mains switch terminals. Position the capacitor body as close to the switch body as possible, to keep the exposed lead length at a minimum – better still, slide a short length of sleeving or wire insulation over the disc leads first – and solder in place. The remaining two, smaller, terminals on the switch are for low voltage LED connections detailed later on.

The PCB can now be fitted onto the five pillars and the Back panel fixed in place with 3 x 5mm pozi-screws – see Figure 14. The two side panels can also be fitted now and you will note that their extended end fits over the side of the back panel and should not be positioned to the front; fix the side panels with 3 x 5mm pozi screws each side. Leave the front panel off until the wiring has been completed. The four rubber feet are fitted beneath the Base panel with a pozi-screw through each foot and into the raised, tapped holes in the panel. A P-clip is used to secure the cable in the case and is positioned over the rubber foot mounting just beneath the 20mm fuse holder – see Figure 15. Insert the cable through the back panel guide hole, into the P-clip and secure the clip with a nut and washer. It stands to reason that the pozi-screw used here should be longer than the other three foot mounting screws.

connections from T1 and the fuse holder to the mains switch can be made later.

Solder a spare length of wire to the chassis solder tag and the 0V common tag on the 3 way CD, LD, VCR phono socket, as shown in Figure 16. Twist the two blue,

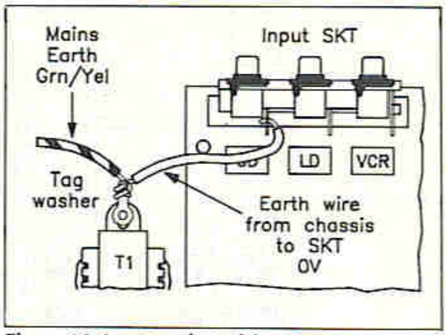


Figure 16. Input socket wiring.

secondary wires, from T1, together and solder them to the two AC terminals shown in Figure 17 and use two spare lengths of wire to connect terminals H and G to the LED on the mains switch. Note that terminal G wires to the LED +V or anode terminal. Now fit the front panel in place and fix with the four Allen screws supplied. If the rotary pot's do not fit the panel holes correctly, then it may be necessary to remove the PCB and re-position them again. Don't be tempted to bend or twist the pot in place as it will damage easily. The four latch switches should also be central to the panel slots before press fitting the red latch buttons! Finally, fit a washer and nut onto each pot and gently tighten up to the panel and fit the three knobs. The top panel can be left off the case until the testing is complete.

and remember to fit the fuse before switching on!

N.B. All measurements referenced to 0V (terminal G) unless stated. Voltages given in V DC unless stated.

Item	Position	Voltage
T1 secondary	Between AC terminals on PCB	18-21VAC
Q1	Collector	+26.5
	Base	+15.2
Q2	Collector	−26.5
	Base	−15.2
IC7	pin 8	+13.2
	pin 4	−13.2
IC9	pin 3	−7
	pin 5	−13.2
	pin 7	−7.8
	pin 8	−8.2
IC8	pin 7	−13
IC1	pin 1	13.2
	pin 2	6.5
	pin 4	6.8
	pin 5	5.6
	pin 8	5.5
	pin 9	1.3
	pin 10	1.3
	pin 11	6.8
	pin 12	6.6
	pin 13	6.6
	pin 14	6.7

Table 1. Test voltages.

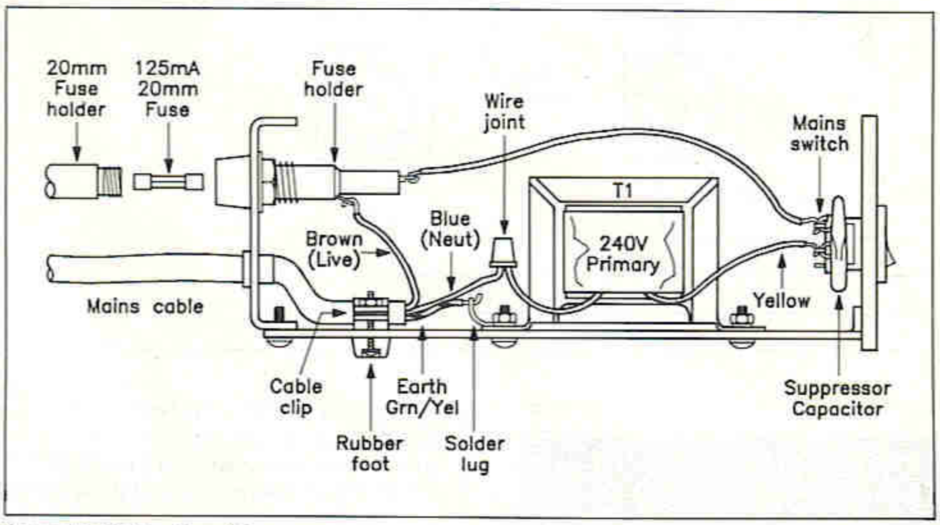


Figure 15. 240V mains wiring.

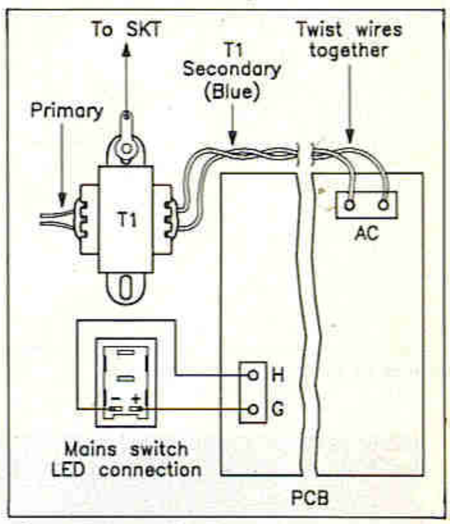


Figure 17. Low voltage wiring.

WIRING

Cut back sufficient insulation from the mains cable to expose approximately 150mm of inner conductors. Refer to Figure 15 and solder the brown (live) wire to the fuse holder and the green/yellow (earth) wire to the chassis solder tag at the transformer fixing point. The blue (neutral) wire connects to one of the transformer primary (yellow) wires; solder the two wires together and screw the joint into the insulated wire-joint cap, to protect against short circuits. The two remaining wire

TESTING

Table 1 lists various voltages that can be checked with a voltmeter. A digital multimeter is best for performing this task as its high input impedance does not 'load' the circuit unduly. Please note that the voltages given are for guidance and are not specific values accurate down to the last microvolt. It often happens that constructors believe their project to be faulty if their readings vary slightly from those given. Allow at least ±10% variation before allowing panic to set in

It is not necessary to test every single one of the voltages given in Table 1, but do check T1 secondary, Q1, Q2 and IC7 voltages as these are the power supply rails.

OPERATION

The processor is not fitted with its own power amplifiers (unfortunately!) so you will definitely need a stereo amp for the rear channels as well as your normal hi-fi set up for the front two channels (Figure 1). The rear speakers are best situated as shown, although in reality they will have to be

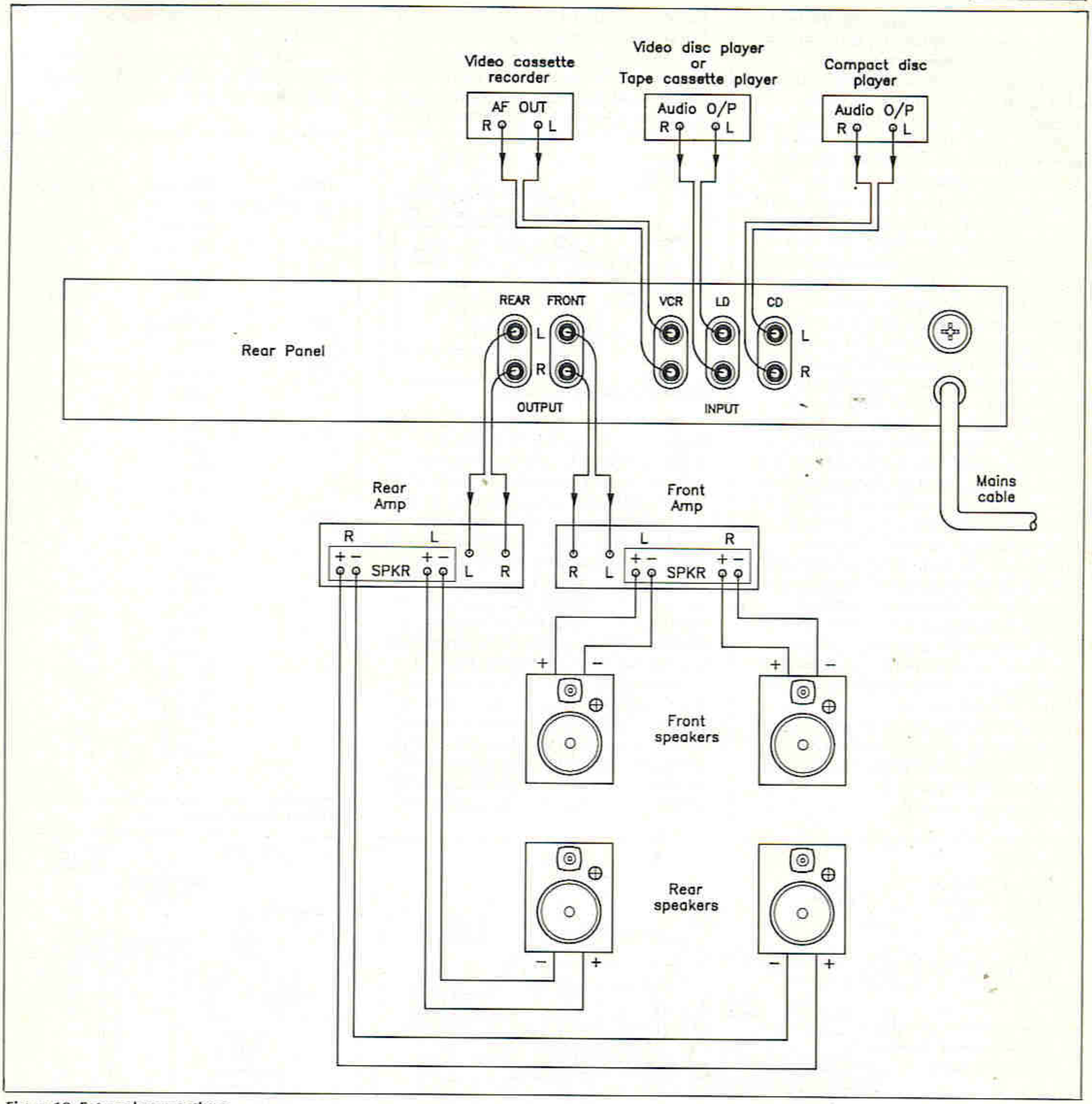


Figure 18. External connections.

Rear view.

positioned according to the room layout. Wall mounted rear speakers may well throw delayed signals onto the front wall which would add to, or subtract from, the general music content; therefore, position speakers close to the floor and behind – or to the side of – your listening/seating area for best results. The surround sound effect can be improved by reducing the rear amplifier output level to 6 – 12 dB below that of the front amplifier level, but this is subjective and really a matter of personal opinion. Connect your music source to the processor as shown in Figure 18. Reference is made to Compact Disc, Video Disc and Video Cassette player outputs but you can connect other sources, such as reel to reel or cassette tape players, equally well. Specifications for input signal levels of 0.1V – 3.5V do not relate to the fact that the DNR chip needs a signal of at least 300mV (0.3V) to be able to process correctly; higher input levels will also improve the signal to noise performance as well and line output levels of 700mV to 1.4V are ideal for connecting into this processor.

CONTROLS AND PANEL LAYOUT

The front panel layout is shown in Figure 19 and a brief description of the operation of each control is shown in Table 2.

The Surround Sound Processor Kit from Sound Master is available from Maplin. Order LP04E price £89.95.

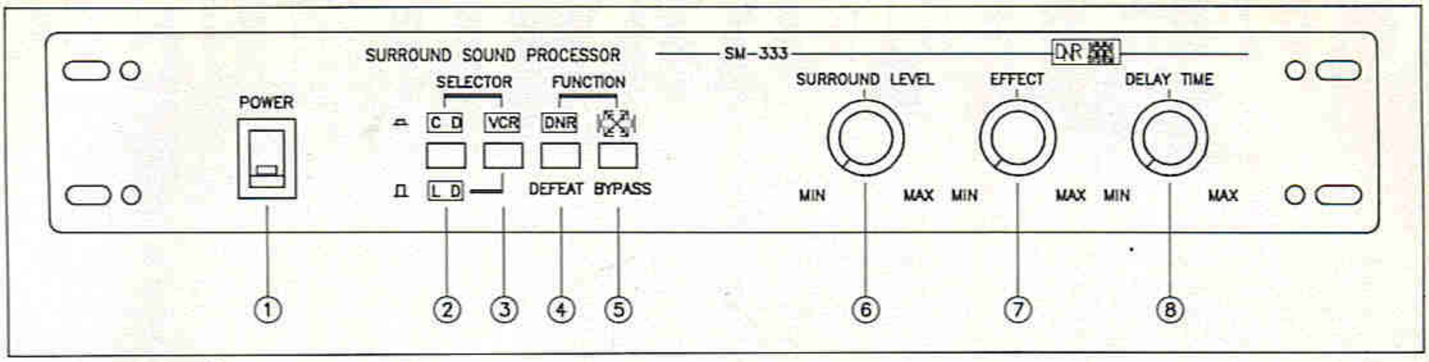


Figure 19a. Front panel.

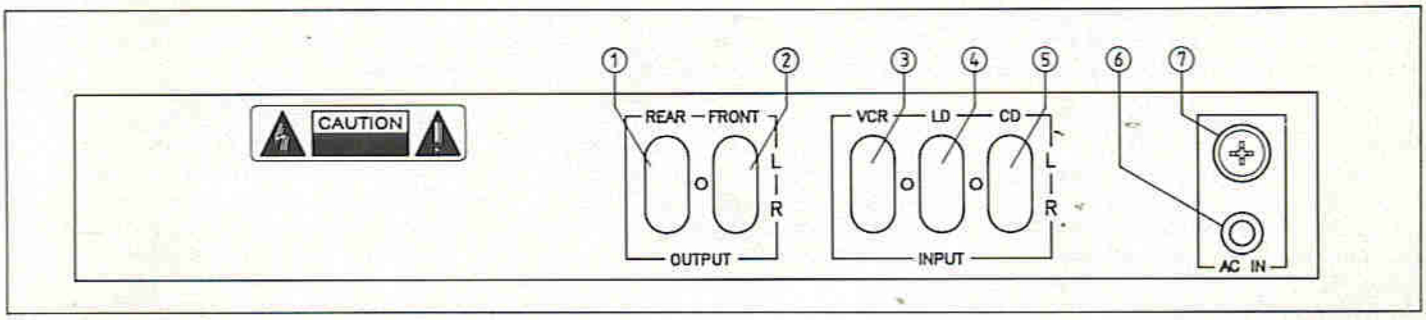


Figure 19b. Rear panel.

Front Panel

Power switch (1):	Press downward to turn on the mains power. A built-in LED indicates power on.
CD/LD selector (2):	Push switch to select CD or out for LD.
VCR selector (3):	Push switch to select VCR, out for CD/LD.
DNR selector (4):	Push switch to place the Dynamic Noise Reduction in circuit.
Surround sound (5):	Push in to add rear channel effect, out to bypass for front channel stereo only.
Surround level (6):	Controls the rear channel volume only – clockwise for max.
Surround effect (7):	Controls the amount of effect (depth).
Delay time (8):	Effect delay variable from 5ms to 50ms.

Rear Panel

Output – rear (1):	Left and Right channel phono outputs to rear power amp.
Output – front (2):	Left and Right channel phono outputs to front power amp.
Input – VCR (3):	Left and Right stereo signal input phono sockets.
Input – LD (4):	Left and Right stereo signal input phono sockets.
Input – CD (5):	Left and Right stereo signal input phono sockets.
Cable Inlet (6):	Entry bush for 3-core mains input cable.
Mains fuse (7):	20mm, 240V 0.1A glass fuse.

Table 2. Front and rear panel functions.

MAPLIN'S TOP TWENTY KITS

THIS MONTH	LAST MONTH	DESCRIPTION OF KIT	ORDER CODE	KIT PRICE	DETAILS IN PROJECT BOOK
1.	(2)	Live Wire Detector	LK63T	£3.95	14 (XA14Q)
2.	(1)	150W Mosfet Amplifier	LW51F	£18.95	Best of E&MM
3.	(3)	Digital Watch	FS18U	£1.98	Catalogue
4.	(10)	Partylite	LW93B	£9.95	Best of E&MM
5.	(9)	Car Battery Monitor	LK42V	£7.95	Best of E&MM
6.	(8)	I/R Prox. Detector	LM13P	£9.95	20 (XA20W)
7.	(5)	15W Amplifier	YQ43W	£5.95	Catalogue
8.	(11)	Car Burglar Alarm	LW78K	£7.95	Comp 2 (XC02C)
9.	(4)	Siren Sound Generator	LM42V	£3.95	26 (XA26D)
10.	(6)	PWM Motor Driver	LK54J	£8.95	12 (XA12N)
11.	(13)	8W Amplifier	LW36P	£4.95	Catalogue
12.	(15)	U/Sonic Car Alarm	LK75S	£18.95	15 (XA15R)
13.	(7)	Mini Metal Detector	LM35Q	£5.25	25 (XA25C)
14.	(-)	TDA2822 Stereo Power Amp	LP03D	£5.95	34 (XA34M)
15.	(17)	I/R Remote Switch	LM69A	£18.95	33 (XA33L)
16.	(18)	27MHz Receiver	LK56L	£9.95	13 (XA13P)
17.	(14)	Watt Watcher	LM57M	£3.45	27 (XA27E)
18.	(19)	27MHz Transmitter	LK55K	£9.95	13 (XA13P)
19.	(16)	Stereo Pre-amp	LM68Y	£5.25	33 (XA33L)
20.	(-)	Slow Charger	LM39N	£5.95	25 (XA25C)

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

COUNTDOWN TO 1992

By Alan Simpson

What have some 325 million people in common? The answer is that they are all part of the twelve nation European Community who will wake up on the 1st January 1993 to find that they are part of the Single Market. The probability is that most will say "so what!" and go back to sleep again. Unfortunately the Common Market – or as it is now called, the Single Market is regarded as being a mega-sized benefit match for bureaucrats, politicians and a favourite few multinational companies.

1992 may be a well known date, but most people would be at a loss to define the implications. This despite the high profile and expenditure generated by the Department of Trade and Industry which included whistle stop breakfasts and briefing sessions for UK businessmen. Even so-called experts views on the meaning of 1992 are seldom consistent. Ray Jones, who heads the JetPrint group in Worcester has suggested that it is "A great experiment in politics, economics and co-operation, but thanks to the long-term run-in period, has become almost a non event for most of us."

Doubts remain that removing trade barriers will enable us to commute to our offices in Paris, Brussels or Amsterdam without passports, visas or even local currency. Will Selhurst Primary become the local international school featuring such subjects as monetary policies, environmental pollution in Northern Italy, traffic congestion in Athens and developments in trans-European auto routes?

Will we in fact be going shopping at the Dover supermarket rather than Calais for our quota of French wine at just £1 per bottle? Will a new Peugeot 205 be available in the UK at the generally lower continental prices? Will our TV programmes feature a range of European commercials or our newspapers give more concentration to EuroNews? Will, come to that, 'Electronics – The Maplin Magazine' be as readily available on the Continent as it is in WHSmith UK?

According to international commentator Martin Griffiths, who is responsible for the new Euro leisure and conference centre at Penrhos, Hereford, the answer to these questions is probably not. What is more likely to be the case suggests Martin, is what the bureaucrats call a harmonisation of prices, which could well see housing costs fall but shopping prices rise. At the same time, national taxes will be up, with local taxes being reduced.

Trade Winds Blowing

What therefore can we expect to see come 31 December 1992 – or as the French prefer – the highlight date of 1 January 1993? We will be able to buy our new car in North London and have it serviced in Nice without problems. You can even expect to find Maplin shops taking root in Europe. And hopefully all our clocks will register EuroTime – no more wondering if the travel agent remembered to allow for that clock change in the middle of our holiday.

Let's hope that the times when we leave Paris airport at 6 p.m. and arrive Gatwick at 5 p.m. are over. Such uniform times will no doubt help the EuroTunnel train timetables. That tunnel incidentally will allow the international jet-setter to have a leisurely breakfast in central London, lunch in Paris and have dinner in Brussels without ever going near an airport. Apart from getting overweight, our traveller will be keeping in touch with business events, thanks to his portable Euro Cellular radio, Euro Fax and Euro Paging equipment.

But even stripping out all the Euro hype, which suggests we will be able to swap jobs with French onion sellers, Barcelona fishermen or German Bierkeller waiters, it does seem a Single Europe is not entirely wishful thinking. In fact, as Ford Motors put it, the 1992 programme for the creation of a Europe 'sans frontiers' has developed a momentum of its own.

Ford suggests that at the heart of the 1992 objectives is the removal of what are known as technical barriers to trade, the plethora of divergent technical standards for individual products and services drawn up by each member state in all four areas involved – people, goods, capital and services.

So just what is the Single Market all about? The intention says the Andersen Consultancy is to remove, by the end of 1992, all those barriers which still fragment the European Community. If all goes according to plan, by the end of 1992 the twelve Member States of the European Community; Belgium, Denmark, France, Germany, Greece, Ireland, Italy, Luxemburg, The Netherlands, Portugal, Spain and the United Kingdom, will constitute a single market of 325 million people. This will mean a market well over twice the size of that of Japan, and nearly half as large again as that of the USA.

It was back in 1982 that the Head of States and Governments of all the Member States made declarations committing themselves to the completion of a fully unified market. In 1985 the Commission put forward concrete proposals to be actioned by 1992. Essentially the elimination of trade restrictions will cover the following areas as detailed by the DTI.

★ European regulations and standards will mean that products approved in any one Community country can be freely marketed throughout the Community.
★ Progressive opening up of Government and other public body contracts to all Community contractors on an equal basis.
★ More competition and efficient Europe-wide services in telecommunications and information technology.
★ Most of the red tape on road haulage will go, shipping services between member countries should be provided on equal terms, competition on air routes will increase and fares will be lower, and the Channel Tunnel will open in 1993.
★ Banks and securities houses authorised in their home country should be free to provide banking and investment services anywhere in the Community. Insurers will have greater freedom to cover risks in other member countries. All restrictions on the movement of capital will go.
★ Protection of ideas will become easier through harmonisation of national laws on patents and trade marks.
★ Professional qualifications obtained in one country will be acceptable in all other countries.

Leaving aside certain obvious limitations to that policy – fares, thanks to the abolition of duty frees, are expected by the industry to go up and quite obviously the Department know more about the progress of The Channel Tunnel than the industry itself, UK business has been told to pull its corporate socks up ready for 1992. If they don't, comments PA Consulting Group UK Ltd, they could loose out to US and Japanese competition.

PA has linked forces with the CBI to boost 1992 awareness to companies, following the release of their survey which revealed that only 11% of companies claim a clear business strategy for the Single Market. More dramatically, one in four companies have no strategy at all.

But any hope that PA may have had of picking up a UK Government merit badge

have probably been dashed by the comment that only sober awareness results have been achieved so far. PA list current skill shortages and the need for better information technology systems as being major hesitation factors. Meanwhile, PA's very recent publication "Information Technology – A Catalyst for Change" should be essential reading for all mangers, both business and hi-tech. Details from the CBI Hotline: 01-836 1992.

1992 – A Confused Race Against Time

The hesitation factor is not surprising given the confused progress being made by the Commission itself. The respected EC ministers seem to be agreeing to differ on such vital Single Market matters as VAT, Excise rates and the always topical subject of duty free allowances. However, you will be relieved to know that harmonisation agreement has now been reached on noise emission from lawn mowers and forklift trucks.

Apart from sorting out such noisy problems, the Commission is focusing on the electronics and communications industries, possibly finding this an easier option than grappling with their European agricultural policies. In the world of communications, the UK has, for once, a positive advantage. Here liberalisation and competition – the focus of the One Market – is already in place, unlike the position in the rest of Europe.

But even so, many observers, including Michael Naughton of consultancy Applied Network Research, wonder whether BT has been concentrating too heavily on stake building in the US, rather than in Europe. Perhaps this can be expected given the deep suspicion of BT by European Telecomms authorities. To them, BT often seems more concerned with profit and loss accounts than serving the needs of the user.

Industry observers also see the present rash of Euro mergers in the telecomms world, currently accounting for 3 out of 10 such alliances continuing. Last year alone we saw the take over by GEC (itself merged with Siemens) of Plessey. Racal and Cable & Wireless meanwhile, are both keenly looking to forge closer European industry links. Similarly, looking to forge close European ties and become major Euro players are such national giants as Olivetti (Italy), Bull (France), Siemens (W.Germany) and ICL (UK). Even A.T & T are trying to get into the European act, and recently took over the UK value-added network supplier ISTEL.

IBM already view the continent as being a single market, but not a uniform market. Europe, says IBM, is being rebuilt from the Channel Tunnel and telecomms networks point to the way business is conducted and even taught. Although such trading links would probably have taken place without the 1992 Open Market movement, the issuing of Community recommendations, backed by European Parliament, has no doubt assisted the merger cause. These recommendations include:

★ The opening of the terminal equipment market.
★ Competition in all value-added network services.
★ The clear separation of the regulatory and operational activities of the telecomms administrations.

A Very Standard Matter

Standards, as Sterlings Management Consultancy confirm, will be a continual problem area for the Commission. Especially as at the last count there were some 100,000 differing technical standards. The problem is not being made any easier by the UK authorities seemingly rushing into new hi-tech areas such as Zone Phones, Personal Networks, international cellular and paging services without waiting for international agreement on standards.

In fact, the whole approach of the DTI to spreading 1992 awareness is being criticised by the authoriative Telecommunications Users Association. "DTI conferences, seminars and regional breakfasts are failing to deliver the goods" suggests the TUA. As a result the organisation has established the International Telecommunications User Group, a pressure group which aims to co-operate with industry on such practical matters as service, training and standards as well as the role and needs of users. Needless to add, the DTI has not given their blessing to the initiative.

So, will the European Commission meet its stated deadlines for the beginning of the Single Market? An opinion poll would probably report; don't knows 60%, indifferent 30% and just about 10%. What is clear, is that the process of harmonisation and liberalisation will stretch far beyond 1 January 1993!

Bob's MINI-CIRCUITS

From Robert Penfold

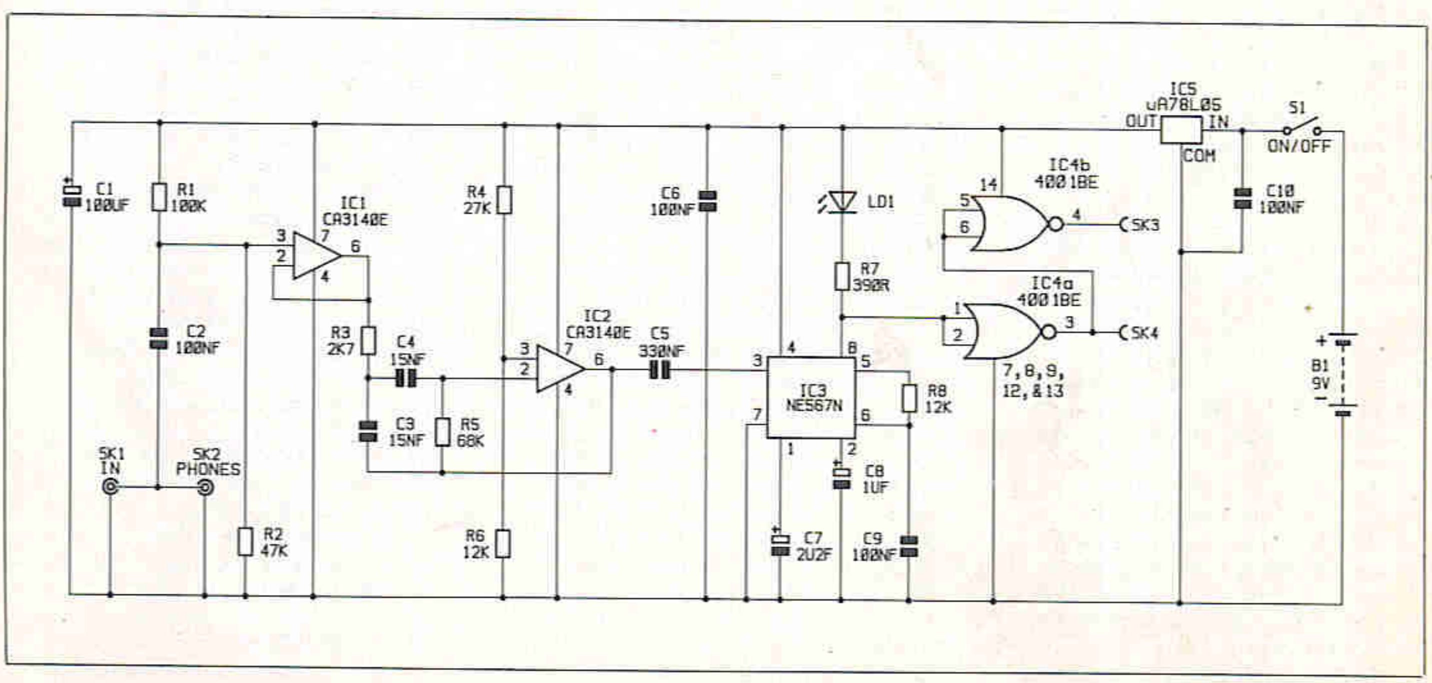
Morse Code Tone Decoder

Equipment to automatically send and decode morse code signals have been in existence for many years. The early designs could only decode the perfect morse code from other morse machines – man-made morse had timing that was far too ragged! Modern morse code decoders are mostly based on microprocessors and are much better at decoding the less than perfect signals produced by hand keying. Home and personal computers are well suited to this application. There is a reasonable amount of morse decoding software available for the more popular computers, including public domain software in some cases. Writing this type of program is also an interesting challenge for the do-it-yourself programmer.

Some morse decoder programs operate by having the audio signal fed to an input of the computer, but this method is not generally very reliable. At the other extreme there are units which detect 'dots', 'dashes', and spaces of various lengths, with these being indicated to the computer via separate inputs. Most systems operate using a simple tone decoder which provides an output of one logic level when the tone is present, and the other logic level when it is absent. It is then up to the software to sort out the 'dots' from the 'dashes', and to work out the various space lengths. The simple tone decoder featured here is for use in systems of this second type.

The headphone socket of the receiver is coupled to SK1, and SK2 then acts as the headphone output of the system. IC1 is a unity gain voltage buffer which ensures that the next stage is fed from a suitably low source impedance. This subsequent stage is a simple bandpass filter based on IC2. It also provides a certain amount of voltage gain (about 20dB). The response of this filter is not particularly 'sharp', and it is not primarily responsible for sorting out the wanted signal from the background noise etc.

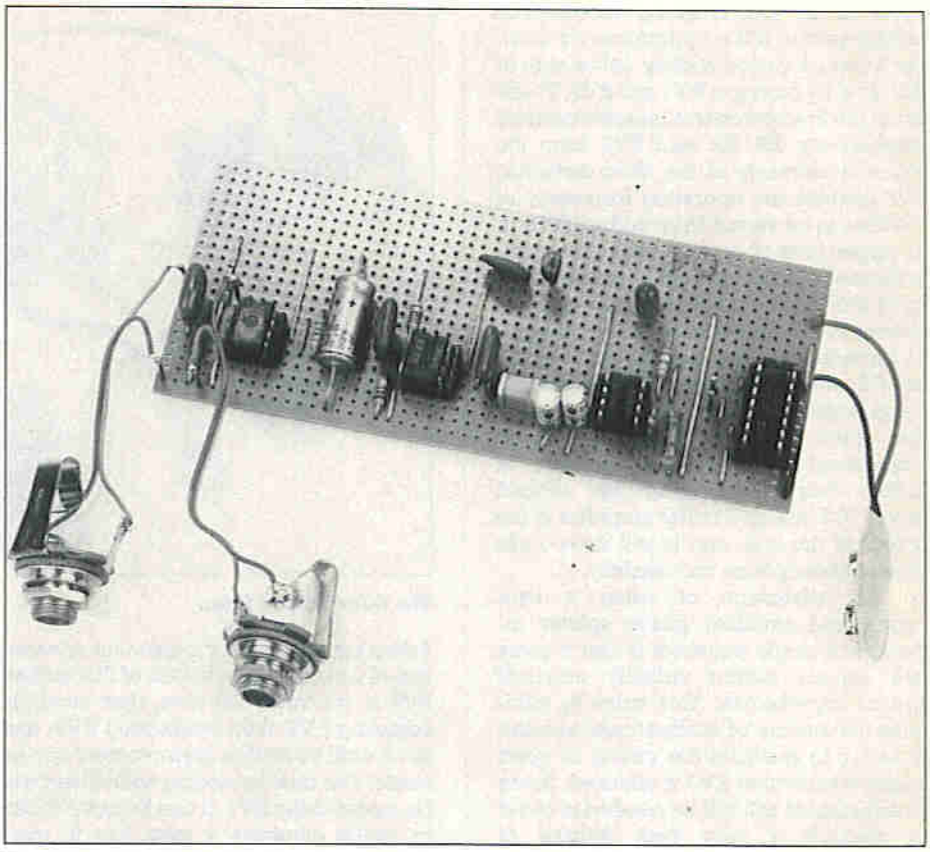
This is the role of the next stage, which is a phase locked loop tone decoder. This is based on IC3 (an NE567N), which is a PLL device that is specifically intended for tone decoding applications. It incorporates a form of synchronous detector, which is basically just an electronic switch through which the input signal is fed. This switch is controlled by the VCO, and is opened on positive VCO half cycles. If IC3 is properly locked onto an input signal, the VCO and this signal will be in-phase, and only positive half cycles of the input signal will pass through the switch. A smoothing circuit at the output of the switch integrates the pulses to give a strong positive bias. If lock is not achieved, the VCO and the input signal will be randomly phased, and the smoothed output of the switch will be insignificant. The signal from the switch is used to turn on an open collector output transistor when lock is achieved. This transistor drives LED LD1, which acts as a sort of tuning indicator.



Morse code tone decoder circuit.

The output signal from IC3 is processed by IC4 to give two outputs at standard CMOS logic levels. SK4 goes 'high' when a tone is detected – SK3 goes 'low' when a tone is detected. For TTL compatible output signals IC4 should be replaced by an LS TTL inverter device (or a suitable gate IC connected to give a dual inverter action). Some decoder programs require the input to be on an RS232C port. Obviously the output of the tone decoder could be fed to a suitable level shifter circuit, but IC4 will drive most RS232C inputs without any problems. Keep the connecting lead quite short though (no more than a metre or two).

The circuit requires a 5 volt supply, and this is derived from a 9 volt battery via monolithic voltage regulator IC5. The current drain is about 14 milliamps under standby conditions, and around 25 milliamps when a tone is detected. It is therefore advisable to power the unit from a fairly high capacity 9 volt battery. The detection frequency is about 850Hz, and the lock-in range is only a few percent either side of the centre frequency. The narrow bandwidth is necessary to give good performance under today's crowded band conditions, but this does mean that signals must be carefully tuned to the correct pitch in order to operate the unit properly.



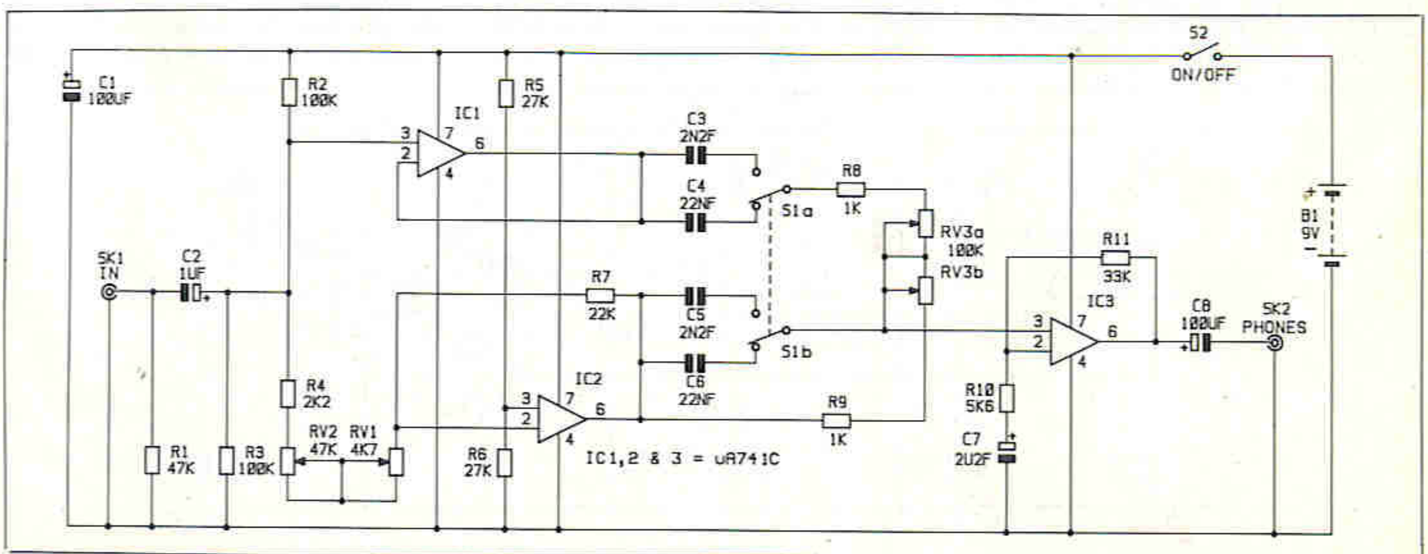
The Morse code decoder.

DXer's Notch Filter

Changes, away from ordinary A.M. to other modes, particularly S.S.B., have reduced the problem of interference from heterodyne 'whistles' when short wave DXing. However, the problem has certainly not been eliminated. Interference from carrier waves is still quite common, as is the allied problem of interference from C.W. (morse) signals. Many older short wave sets have an effective way of counteracting these problems in the form of I.F. notch filters. The type of crystal filter used in these older sets is now little used, and this I.F. notch filter facility is something of a rarity these days. The more normal approach to the problem at present is to use an audio frequency notch filter to remove the unwanted tone, which leaves the rest of the signal as little affected as possible. This filter is sometimes an integral part of a short wave receiver, but in the majority of cases an add-on unit such as the one described here is needed.

The 'traditional' audio notch filter is one which has a single transistor to act as a phase splitter, with the out-of-phase signals being fed to a Wien network. At a certain frequency there is an equal phase shift through both sections of the Wien network, resulting in the signals cancelling each other out. At other frequencies there is little or no cancelling, and the required 'valley' type frequency response is obtained. A 'balance' control is used to optimise the cancelling effect at the centre frequency so that a very deep notch of attenuation can be obtained. Although this type of filter is extremely simple, it can achieve quite respectable Q values and some 80dB or more of attenuation is possible if the filter is carefully balanced.

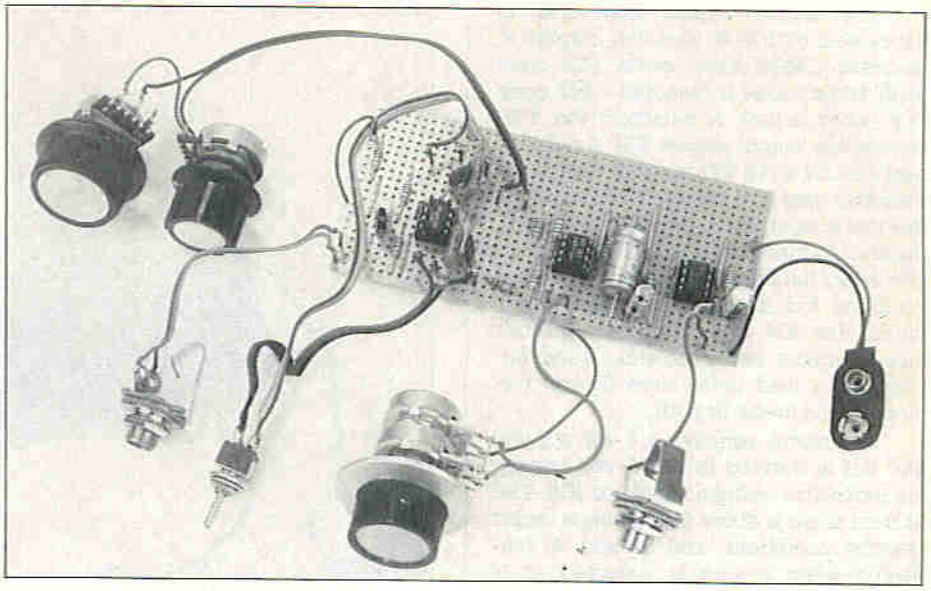
This circuit is almost of the 'traditional' type, but it uses two operational amplifiers to generate the anti-phase signals. IC1 operates as a non-inverting unity voltage gain amplifier, while IC2



DXer's notch filter circuit.

operates in the inverting mode. The voltage gain of IC2 is approximately unity, but it can be varied slightly either side of this level by means of RV1 and RV2. These act as the fine and coarse balance controls respectively. R8, R9, and RV3 form the resistive elements of the Wien network. RV3 enables the operating frequency of the filter to be varied from under 100Hz to an upper limit of around 7kHz. However, adjustment of RV3 at high frequencies is quite difficult as a wide frequency range is crammed into a few degrees of rotation. S1 provides an additional range, (with C3 and C5 switched into circuit) which covers frequencies from around 1kHz to beyond the upper limit of the audio range. Adjustment is significantly easier at higher frequencies using this second range. IC3 acts as a buffer amplifier at the output of the unit, and it will drive most types of headphone successfully.

An advantage of using a twin operational amplifier phase splitter instead of a single transistor is that it gives two signals having virtually identical source impedances. This helps to minimise the amount of readjustment needed in order to maintain the circuit in good balance each time RV3 is adjusted. Some re-adjustment will still be needed in order to maintain a very high degree of attenuation over a range of frequency settings, mainly due to the inevitable slight mis-matching in the two gangs of RV3.



The DXer's notch filter.

Adjusting the unit for maximum attenuation of a tone is just a matter of first setting RV3 to minimise the tone, then similarly adjusting RV2, then readjusting RV3, and so on until no further improvement can be made. The final balancing adjustment will be easier using RV1. It can be quite tricky to totally eliminate a tone, but in most cases only about 30dB to 40dB of attenuation is sufficient to render an interfering signal innocuous.

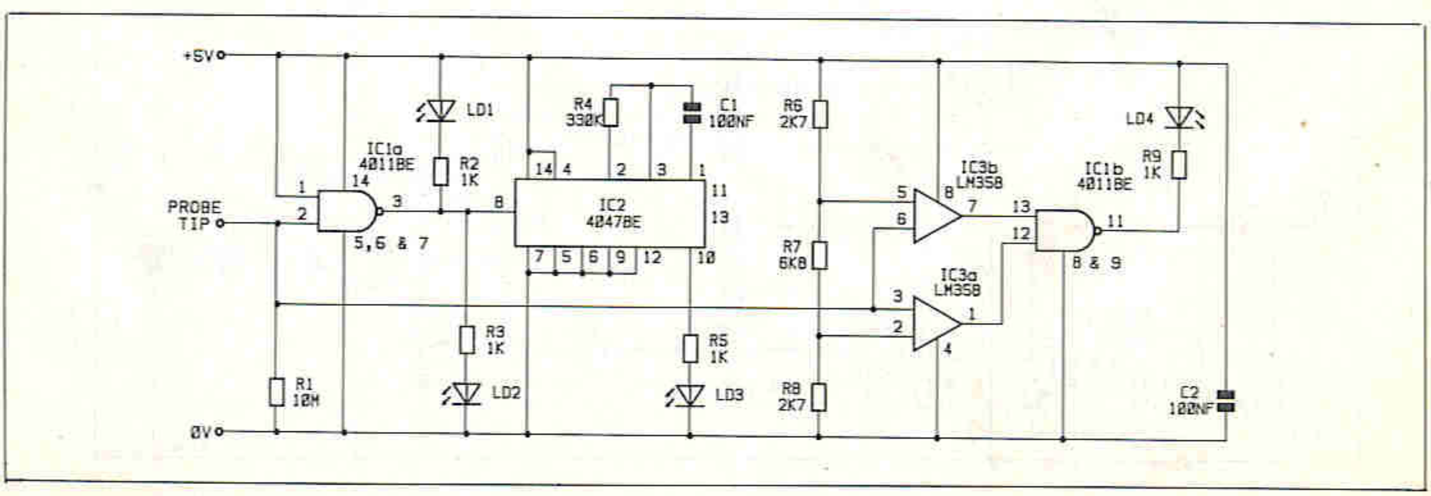
The current consumption of the circuit is only about 2 milliamps, and a small (PP3 size) 9 volt battery is perfectly adequate as the power source. The output of the unit is well suited to medium impedance headphones, which should preferably be series connected. It will also work quite well with most low impedance phones if they are wired in series, or high impedance headphones (preferably connected in parallel).

CMOS Logic Tester

The previous set of 'Bob's Mini Circuits' included a design for a TTL logic tester. This unit is, as near as possible, a direct CMOS equivalent to that unit. For anyone testing logic circuits it is important to realise that the acceptable voltage ranges for the two logic levels depends on the type of logic integrated circuits in use. For circuits that are powered from a standard 5 volt supply, using a checker designed for the wrong logic family might just about give acceptable results, but it would probably be unwise to have complete faith in the results obtained. The main compatibility problem though, is that TTL circuits have a 5 volt power supply, whereas CMOS circuits have supply voltages anywhere in the range 3 to 15 volts or so. A checker for CMOS based circuits should therefore be capable of operating over a similar supply voltage range, and should respond to CMOS logic levels.

IC1a plus LD1 and LD2 are used in the basic 'high' and 'low' indicator part of the unit. IC1 is a quad 2 input NAND gate, but IC1a is only used as a simple inverter. One of its inputs is connected to the positive supply rail so that an inverter action is provided from the other input to its output. Being a MOS device, the input of IC1a must not be left floating, and so R1 is used to tie it to the negative supply rail. R1 has been given a very high value so that it does not significantly increase the loading on the circuit under test. LD1 and LD2 are the 'high' and 'low' LEDs respectively. None of the indicator LEDs in this circuit are driven at particularly high currents when the unit is powered from a low supply voltage, and the use of a high brightness type is recommended.

One inadequacy of a simple 'high' – 'low' detector circuit is that short pulses can be missed. The relevant LED may be switched on for such a brief period it does not visibly light up. This circuit overcomes the problem by using a monostable multivibrator (IC2) as a pulse stretcher.

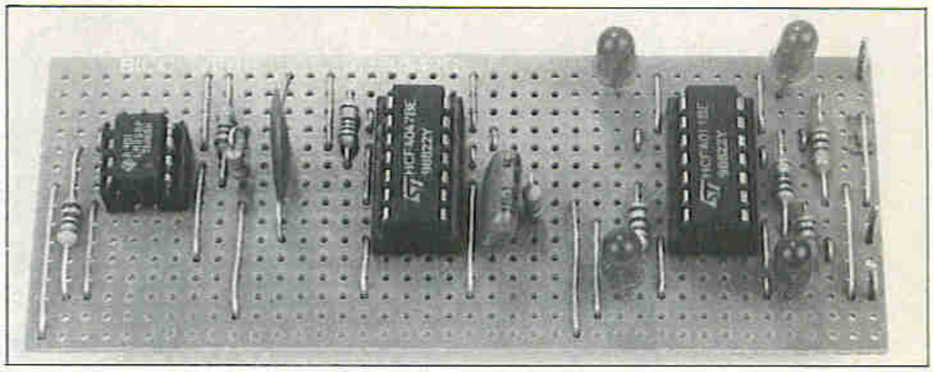


CMOS Logic tester circuit.

This will detect input pulses of under one microsecond in duration, and will activate LD3 for just under one second so that a clear indication of any input pulse is provided.

A further deficiency of the basic level detector circuit is that a static input at an invalid voltage is unlikely to be detected. If the input voltage is steadily increased, there is an abrupt switch-over from one LED to the other at (typically) just below half the supply voltage. It is very difficult to adjust the input voltage to switch on both LEDs so that an illegal logic level is indicated. Anything from about 30% to 70% of the supply voltage should produce an illegal level indication, but clearly this condition is not met. In order to overcome this problem a window discriminator has been included in the circuit. This is based on the two operational amplifiers in IC3 plus one of the gates in IC1. This circuit switches on LD4 if the input voltage is much above 30% of the supply voltage, or much less than 70% of the supply potential, thus giving the illegal input voltage warning.

The circuit is simple enough to be built as a probe style tool without too much difficulty. It must be powered from the same voltage as the circuit under test, and the easiest way of achieving this is to tap off its power from the test circuit. With low supply voltages of about 5 volts the current consumption of the unit is only a few milliamps. At supply potentials of about 15 volts the current drain is significantly higher, and will be about 20 milliamps or so with two LEDs activated. This is still low enough to permit power to be tapped off from most units without any ill effects being experienced. In common with other units of this type, a pulse indication might be produced as the probe tip is placed on or removed from the test point. The probe must be kept in contact with the test point for at least a couple of seconds to reliably test for pulses, and any pulse indications given when connecting or disconnecting the unit should be ignored. Table 1 should prove useful when using the unit. It shows the LED states for various input conditions.



The CMOS logic tester.

Input State	Static Low	Static High	Low Freq. Pulse	High Freq. Pulse	Invalid Voltage
LD1	OFF	ON	FLASHING	ON-OFF	ON-OFF
LD2	ON	OFF	FLASHING	ON-OFF	ON-OFF
LD3	OFF	OFF	FLASHING	ON or FLASHING	OFF
LD4	OFF	OFF	OFF	OFF*	ON

*Note that with a high frequency pulsing signal LD4 may switch on dimly. This is due to inadequacies in the switching speed of IC3 and does not indicate a fault at the test point.

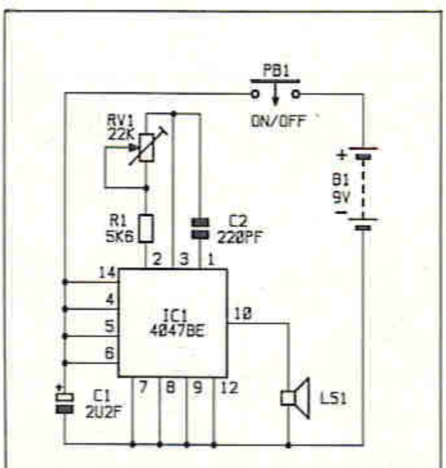
Table 1.

Ultrasonic Remote Control

This ultrasonic remote control system is a simple on/off type, but it provides a toggling action. In other words, when the push button switch on the transmitter unit is first activated, it switches on the relay at the receiver. Even when the push button switch is released, the relay contacts remain closed. In order to switch off the relay, the push button must be operated again. Successive operations of the push button switch cause the relay to switch on again, switch off again, and so on.

The transmitter circuit is based on a CMOS 4047BE astable/monostable multivibrator. In this circuit it is operated in the free-running astable (oscillator) mode. LS1 is the ultrasonic transducer, and this has peak performance at a frequency of about 40kHz. The timing components for IC1 are R1, C2, and RV1. The latter is adjusted to provide an output frequency that gives good efficiency from LS1. The current consumption of the circuit is approximately 3.5 milliamps. This low consumption, combined with the fact that the power is only applied to the circuit briefly and intermittently, results in a very long battery life even using a small (PP3 size) battery.

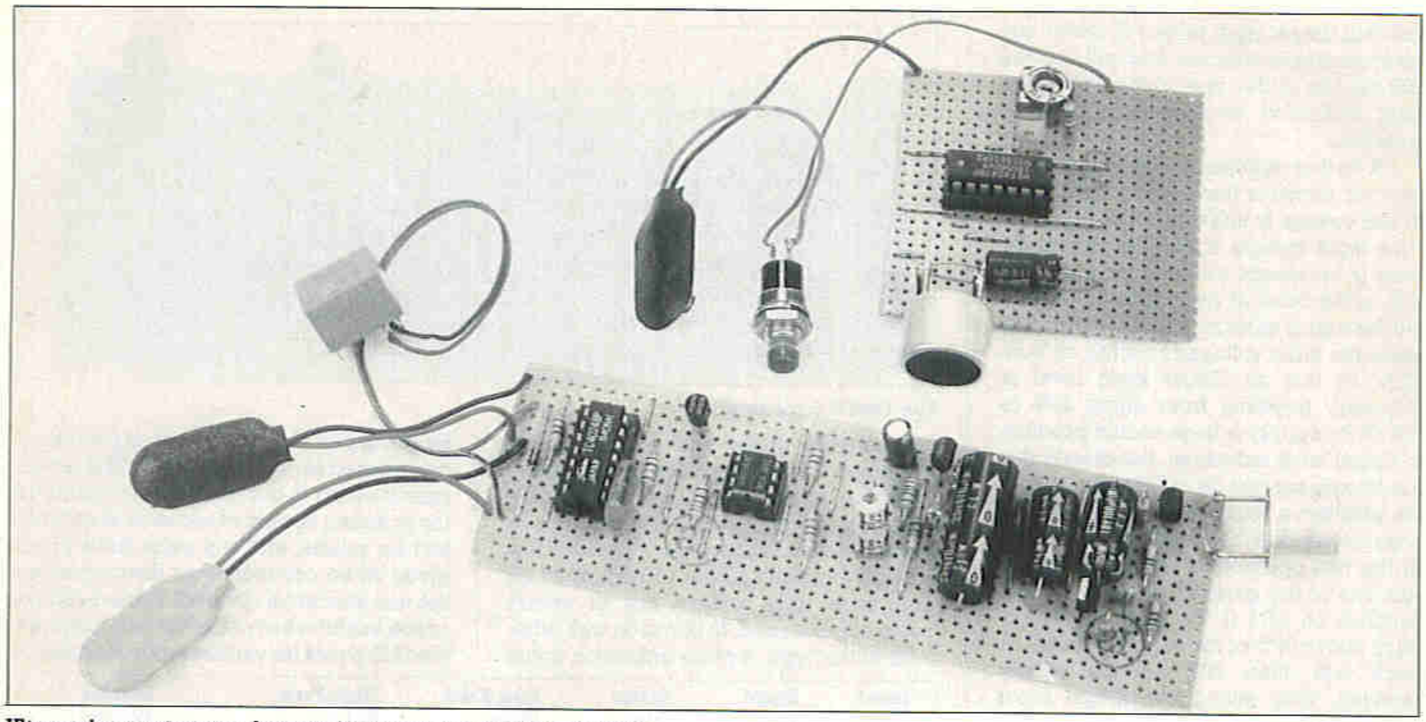
A two stage high gain amplifier is used at the input of the receiver circuit. TR1 and TR2 both operate as common emitter amplifiers having in excess of 40dB of voltage gain. This high gain is necessary because the output from the microphone, even at modest ranges, is likely to be no more than a few millivolts r.m.s. MC1 is a special ultrasonic transducer which, like LS1 in the transmitter, has peak performance at approximately 40kHz. It is a piezo-ceramic device, and so no d.c. blocking capacitor is needed at the input of the circuit. Note that the two transducers are obtained as a pair, not individually. As one would expect, the one having an 'R' prefix on its type number is used in the receiver, and the one having the 'T' suffix is used in the transmitter.



Ultrasonic transmitter circuit.

The output from TR2 is rectified and smoothed to give a positive d.c. signal. With only background noise present, this d.c. signal will be of insignificant magnitude, but with a reasonably strong signal from the transmitter it will bias TR3 into conduction. TR3 drives a simple inverting trigger circuit based on IC1, and having strong hysteresis supplied via the positive feedback through R11. The main problem with a circuit of this type is in avoiding spurious pulses which could result in the relay being set back to its original state instead of being toggled to the opposite state. The smoothing circuit and the hysteresis of the trigger circuit are good at removing unwanted pulses, and the circuit operates very reliably. IC2 is a divide by two circuit, and its output therefore changes logic state each time an input pulse is received. C7 and R12 provide a reset pulse at switch-on, so that the circuit starts out in the state where the relay is switched off. IC2 is actually a seven stage binary ripple counter, but in this circuit only one stage is used. The output from the first stage is used to drive switching transistor TR4, which in turn controls the relay. D3 is the usual protection diode which suppresses the high reverse voltage across the relay coil as it de-energises.

The current consumption of the receiver circuit with the relay switched off is only about 4 milliamps. The current consumption when the relay is switched on depends on the coil resistance of the relay used. With the specified type, (which has a coil resistance of 400 ohms) the current drain is about 30 to 35 milliamps. The circuit should operate properly using any relay having; suitable contacts, a coil resistance of about 200 ohms or more and suitable for 12 volt operation. In the interest of good battery



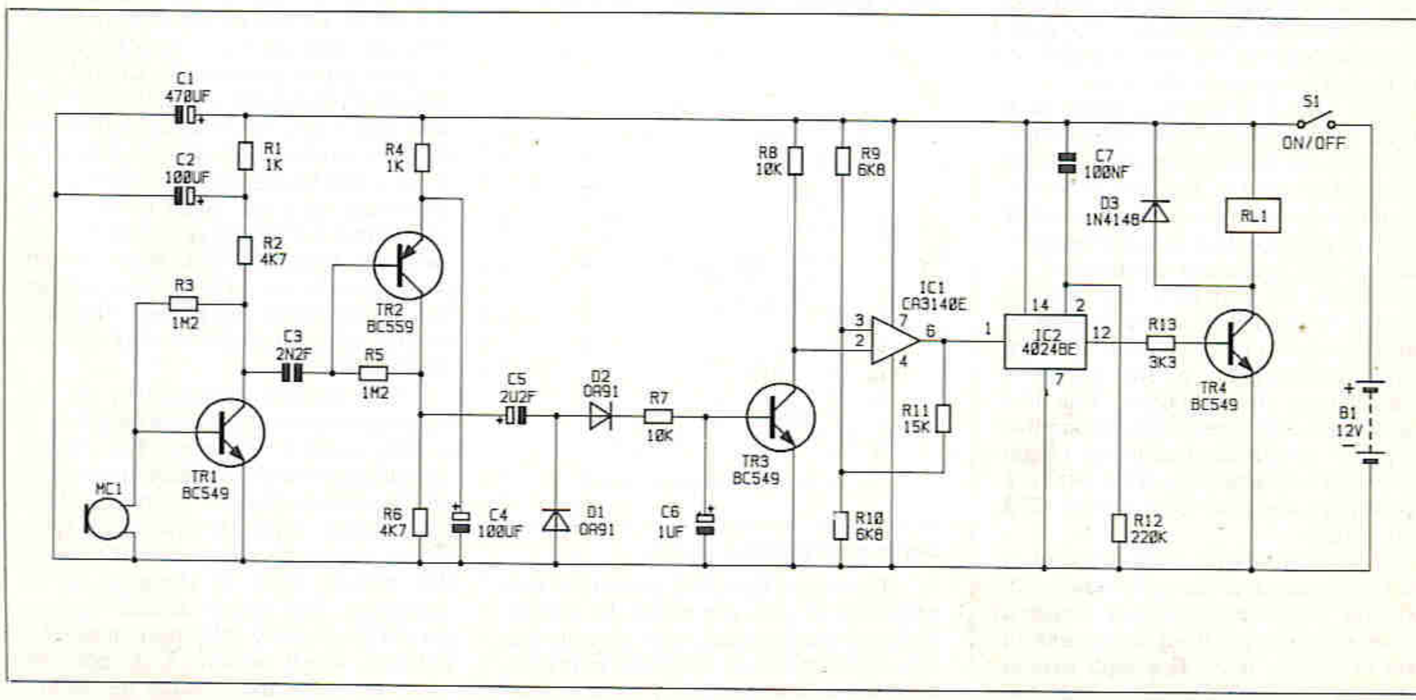
Ultrasonic remote control transmitter (top) and receiver (below).

life, a high coil resistance is to be preferred. It is acceptable to use a 9 volt supply and a 6 volt relay, and this is actually a more convenient combination. However, 6 volt relays having suitably high coil resistances seem to be a rarity these days, and there may be no alternative but to opt for a 12 volt supply and relay. Of course, make quite sure that the relay has adequate contact ratings for your intended application.

A fairly high capacity battery must be used, such as eight HP7 size cells fitted in plastic holders. Of course, a mains power supply could be used, but due to the high sensitivity of the input amplifier, this would need to provide a well smoothed supply. Due to the high gain of the input amplifier, the component layout needs to be carefully arranged so as to avoid any easy feedback paths from the input to the output of the amplifier. A careless layout could easily result in the amplifier becoming unstable. Another point to bear in mind is that acoustic feedback from the relay to MC1 must be avoided, or the circuit will function as a very elaborate low frequency oscillator! The unit has reasonable immunity to audio frequency noises, but strong vibration, from the relay or any other source, should be avoided.

In the absence of suitable test equipment, trial and error can be used to find a setting for RV1 that gives good range from the system. Modern ultrasonic transducers have a fairly narrow 'angle of view', and this makes any controller of this type quite directional in 'open air'. An object between the transmitter and the receiver could prevent the unit from operating. However, units of this type are mostly used indoors, and in anything but the largest of rooms there is usually enough reflected signal to circumvent obstructions and make the system omni-directional. The system is only intended for short range use, but it will operate reliably at ranges of up to about 10 metres or so.

If an a.c. millivoltmeter or an oscilloscope is available, this can be used to measure the signal level from MC1 with the output from the transmitter directed at it from quite short range. RV1 is then adjusted for maximum output from MC1. There should be a very pronounced peak at the optimum operating frequency.



Ultrasonic receiver circuit.

ULTRASONIC RECEIVER PARTS LIST

RESISTORS: All 0.6W 1% Metal Film			
R1,4	1k	2	(M1K)
R2,6	4k7	2	(M4K7)
R3,5	1M2	2	(M1M2)
R7,8	10k	2	(M10K)
R9,10	6k8	2	(M6K8)
R11	15k	1	(M15K)
R12	220k	1	(M220K)
R13	3k3	1	(M3K3)
CAPACITORS			
C1	470μF 10V Axial Electrolytic	1	(FB71N)
C2,4	100μF 10V Axial Electrolytic	2	(FB48C)
C3	2n2F Polyester	1	(WW24B)
C5	2μ2F 100V Axial Electrolytic	1	(FB15R)
C6	1μF 100V PC Electrolytic	1	(FF01F)
C7	100nF Polyester	1	(BX76H)
SEMICONDUCTORS			
TR1,3,4	BC549	3	(QQ15R)
TR2	BC559	1	(QQ18U)
IC1	CA3140E	1	(QH29G)
IC2	4024BE	1	(QX13P)
D1,2	OA91	2	(QH72P)
D3	1N4148	1	(QL80B)
MISCELLANEOUS			
S1	SPST Ultra-min Toggle	1	(FH97F)
MC1	40kHz Ultrasonic Transducer		(see text)
RL1	12 Volt 400 ohm coil, 2A SPDT	1	(YX94C)
B1	12 Volt Battery		(see text)
	DIL IC Socket 8-pin	1	(BL17T)
	DIL IC Socket 14-pin	1	(BL18U)

ULTRASONIC TRANSMITTER PARTS LIST

RESISTORS: All 0.6W 1% Metal Film			
R1	5k6	1	(M5K6)
RV1	22k Sub-min Hor Preset	1	(UH04E)
CAPACITORS			
C1	2μ2F 100V Axial Electrolytic	1	(FB15R)
C2	220pF Ceramic	1	(WX60Q)
SEMICONDUCTORS			
IC1	4047BE	1	(QX20W)
MISCELLANEOUS			
LS1	40kHz Ultrasonic Transducer	1	(HY12N)
PB1	Push Switch	1	(FH59P)
B1	9 Volt (PP3 size) Battery	1	(FK62S)
	DIL IC Socket 14-pin	1	(BL18U)
	Battery Clip	1	(HF28F)

CMOS LOGIC TESTER PARTS LIST

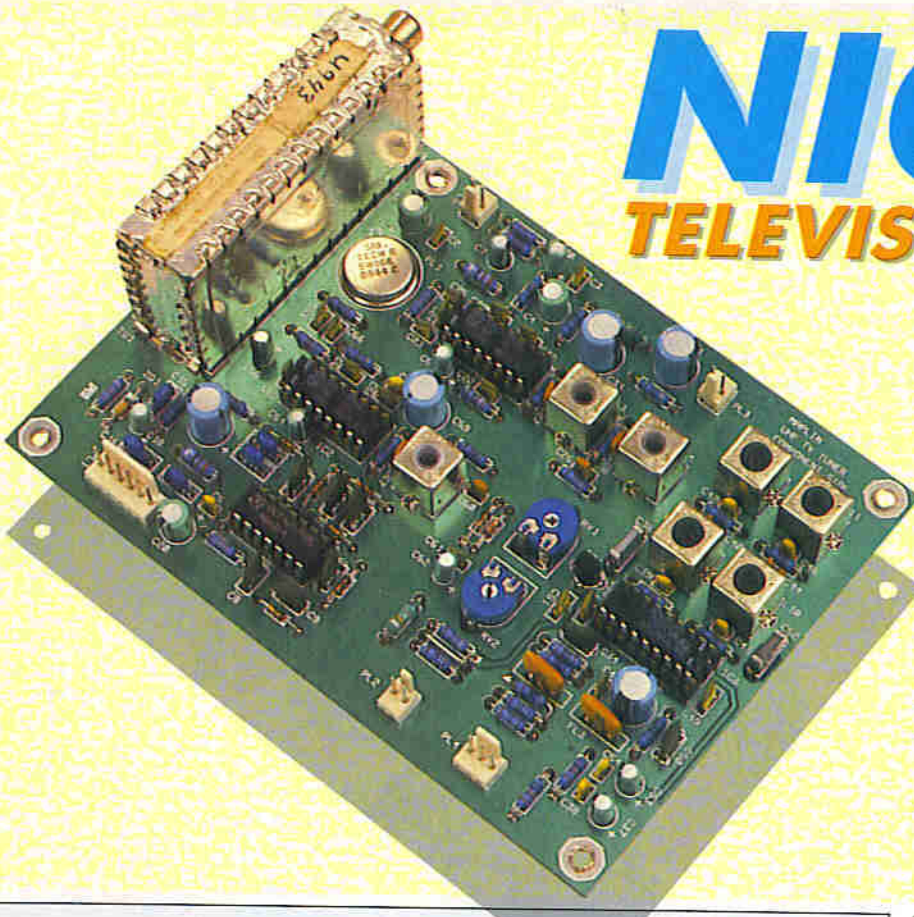
RESISTORS: All 0.6W 1% Metal Film			
R1	10M	1	(M10M)
R2,3,5,9	1k	4	(M1K)
R4	330k	1	(M330K)
R6,8	2k7	2	(M2K7)
R7	6k8	1	(M6K8)
CAPACITORS			
C1	100nF Polyester	1	(BX76H)
C2	100nF Ceramic	1	(YR75S)
SEMICONDUCTORS			
IC1	4011BE	1	(QX05F)
IC2	4047BE	1	(QX20W)
IC3	LM358N	1	(UJ34M)
LD1,2,3,4	Red Panel LED	4	(WL27E)
MISCELLANEOUS			
	DIL IC Socket 8-pin	1	(BL17T)
	DIL IC Socket 14-pin	2	(BL18U)

DXER'S NOTCH FILTER PARTS LIST

RESISTORS: All 0.6W 1% Metal Film			
R1	47k	1	(M47K)
R2,3	100k	2	(M100K)
R4	2k2	1	(M2K2)
R5,6	27k	2	(M27K)
R7	22k	1	(M22K)
R8,9	1k	2	(M1K)
R10	5k6	1	(M5K6)
R11	33k	1	(M33K)
RV1	4k7 Lin	1	(FW01B)
RV2	47k Lin	1	(FW04E)
RV3	100k Lin Dual Gang	1	(FW88V)
CAPACITORS			
C1	100μF 10V Axial Electrolytic	1	(FB48C)
C2	1μF 100V PC Electrolytic	1	(FF01B)
C3,5	2n2F Polyester	2	(WW24B)
C4,6	22nF Polyester	2	(WW33L)
C7	2μ2F 100V PC Electrolytic	1	(FF02C)
C8	100μF 10V PC Electrolytic	1	(FF10L)
SEMICONDUCTORS			
IC1,2,3	μA741C 8 pin DIL	3	(QL22Y)
MISCELLANEOUS			
B1	9 Volt (PP3 size) Battery	1	(FK62S)
SK1,2	Standard Jack Socket	2	(HF91Y)
S1	DPDT Ultra-min Toggle	1	(FH99H)
S2	SPST Ultra-min Toggle	1	(FM97F)
	Battery Connector	1	(HF28F)
	DIL IC Socket 8-pin	3	(BL17T)

MORSE CODE TONE DECODER PARTS LIST

RESISTORS: All 0.6W 1% Metal Film			
R1	100k	1	(M100K)
R2	47k	1	(M47K)
R3	2k7	1	(M2K7)
R4	27k	1	(M27K)
R5	68k	1	(M68K)
R6,8	12k	2	(M12K)
R7	390Ω	1	(M390R)
CAPACITORS			
C1	100μF 10V Axial Electrolytic	1	(FB48C)
C2,9	100nF Polyester	2	(BX76H)
C3,4	15nF Polyester	2	(BX71N)
C5	330nF Polyester	1	(WW47B)
C6,10	100nF Ceramic	2	(YR75S)
C7	2μ2F 100V PC Electrolytic	1	(FF02C)
C8	1μF 100V PC Electrolytic	1	(FF01B)
SEMICONDUCTORS			
IC1,2	CA3140E	2	(QH29G)
IC3	NE567N	1	(QH69A)
IC4	4001BE	1	(QK01B)
IC5	μA78L05	1	(QL26D)
LD1	Red LED	1	(WL27E)
MISCELLANEOUS			
S1	Ultra-min SPST Toggle	1	(FH97F)
B1	9 Volt Battery	1	(FM05F)
SK1,2	Standard Jack Socket	2	(HF91Y)
	Battery Connector	1	(HF27E)
	DIL IC Socket 8-pin	3	(BL17T)
	DIL IC Socket 14-pin	1	(BL18U)



NICAM TELEVISION TUNER

by C.S. Barlow

Features

- ★ Single +12V Power Requirement
- ★ NICAM SAW Filter
- ★ Parallel Vision and Sound IF
- ★ Dual FM Sound Demodulator 6MHz/ 5.5MHz
- ★ FM Squelch Control
- ★ Video and Audio Outputs
- ★ NICAM Carrier Output 6.552MHz

Specification of Prototype

Power supply input voltage:	11V to 13V DC
Current at 12V:	210mA (2.52W)
RF (UHF)	
Tuning range:	Channel E21 to E69 Frequency 470MHz to 860MHz
Aerial input:	75Ω phono
Noise figure:	10dB max
Voltage gain:	40dB
AGC range:	30dB
AFC range:	±120kHz
IF	
Vision carrier:	39.5MHz
Colour carrier:	35.07MHz
5.5MHz mono continental FM sound:	34MHz
6MHz mono UK FM sound:	33.5MHz
6.552MHz NICAM digital stereo sound:	32.948MHz
NICAM (6.552MHz Carrier)	
Output level:	300mV peak-to-peak
Output load:	1kΩ
Audio (Mono)	
Output level:	1V peak-to-peak (50kHz deviation)
Output load:	1kΩ
Bandwidth:	10Hz to 15kHz
Distortion:	0.1% THD
Signal to noise ratio:	(S+N)/N 60dB
Video (Composite)	
Output level:	1V peak-to-peak
Output load:	75Ω
Bandwidth:	7.5MHz
Signal to noise ratio:	S/(S+N) 58dB
PCB	
Type:	Double-sided plated-through fibre glass
Dimensions:	142mm x 102mm
Completed PCB Assembly	
Component height:	40mm maximum
Weight:	160g

Introduction

The Maplin television tuner is primarily designed for use with the NICAM decoder kit (stock code LP02C). However, it can be used on its own to provide a high quality video and mono audio output for both the UK 6MHz or continental 5.5MHz sound channel.

The UHF front-end is a manufactured module which requires no alignment and uses the latest surface mount components. Its output drives a Surface Acoustic Wave (SAW) filter which produces a parallel IF for independent vision and sound processing. To extract the maximum amount of signal for decoding digital stereo, the SAW filter also has a peak in its response at the 6.552MHz NICAM carrier frequency. The tuner unit has Automatic Gain Control (AGC), Automatic Frequency Control (AFC) and audio squelch on the FM demodulator.

Circuit Description

In addition to the circuit shown in Figure 2, a block diagram is detailed in Figure 1. This should assist you when following the circuit description or fault finding in the completed unit.

The DC power for the circuit is applied to PL1, negative (0V) to pin 1 and positive to pin 2. This supply must be within the range of 11V to 13V and have the correct polarity, otherwise damage will occur to the semiconductors and polarised components. The input voltage is decoupled by C20, C21 and further decoupling is provided at regular intervals throughout the rest of the circuit.

The UHF front-end, TU1, is varicap tuned using three BB405 capacitance diodes, a reference voltage of at least +28V is required to obtain the full tuning range of channels E21 to E69. This voltage

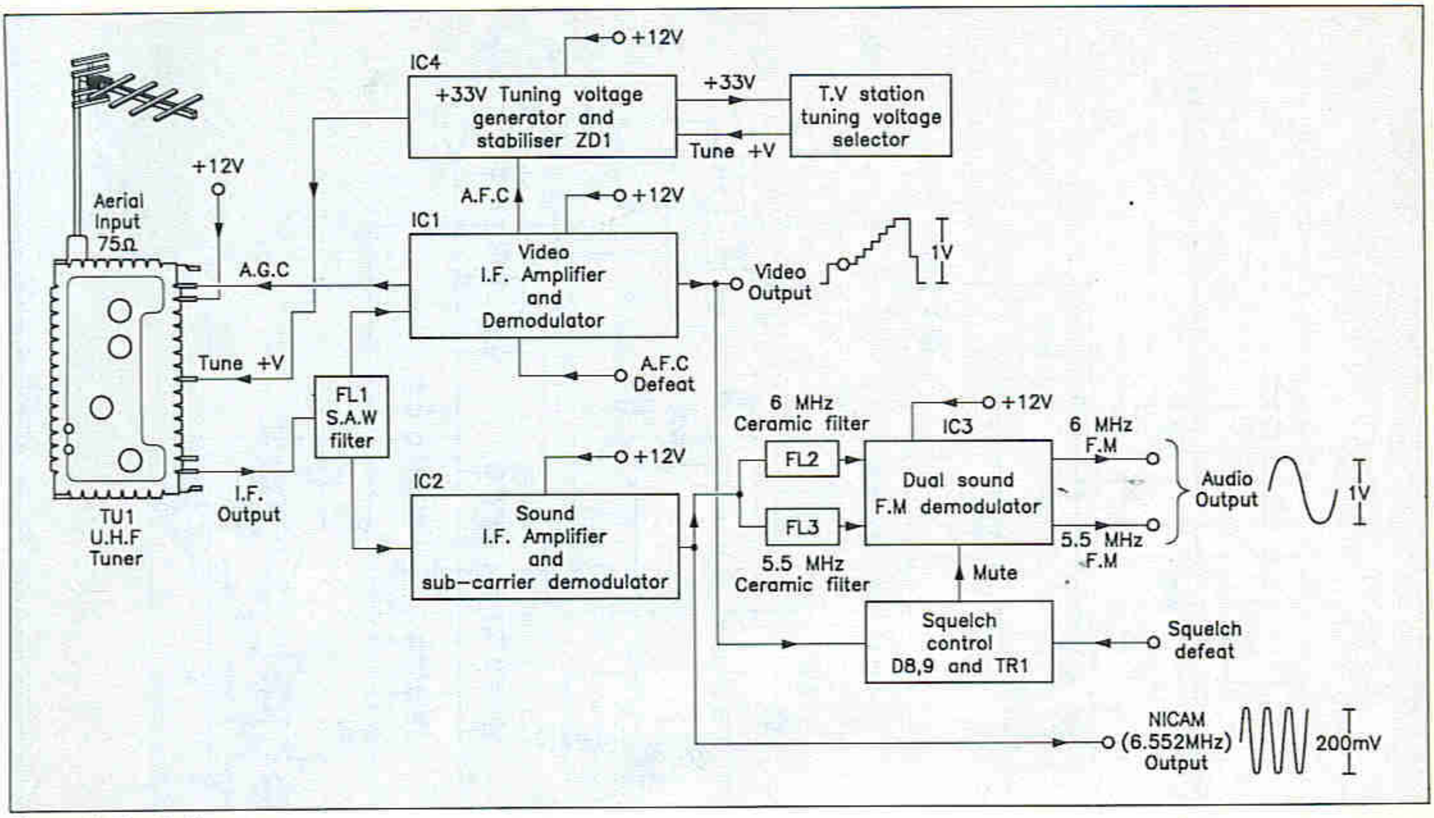


Figure 1. Block diagram.

is generated by IC4, a 40106BE CMOS logic chip used as an oscillator and buffer chain. The first stage of the chip, pin 1 and 2, is the oscillator which runs at a frequency of approximately 160kHz set by the RC time constant of R3 and C5. The square wave output of each buffer is fed to the input of the next and AC coupled in to the diode chain D1 to D7. In this manner the AC signal of each stage is rectified and added to the previous DC level with the final output of approximately +40V appearing on the cathode of D7. Any AC ripple is decoupled by C14, C15 and the clean DC voltage is then fed to the +33V stabiliser diode ZD1. C16 and C18 providing further decoupling on the tuning voltage output pin of PL1.

To select the desired TV channel a tuning control must be placed between the +33V on pin 3 of PL1 and tune input on pin 4. As can be seen from the simple tuning control in Figure 3a, the tuning voltage appears on the wiper of the rotary potentiometer with the 0V ground reference (PL1 pin 5) at the fully Counter ClockWise (CCW) position. As the control is advanced the tune voltage will increase until the wiper reaches the fully ClockWise (CW) setting. Figures 3b and 3c show more elaborate tuning systems using multiturn presets and latch switches enabling rapid station selection. Figure 4 shows the relationship between the tuning voltage, picture carrier frequency and channel number.

The tuner module TU1 has a number of terminals for power, tune voltage, AGC and IF output, with the TV aerial connecting to a phono socket mounted on one side of the module, see Figure 5. Electrical characteristics for the tuner module are given in Table 1. The IF output contains the

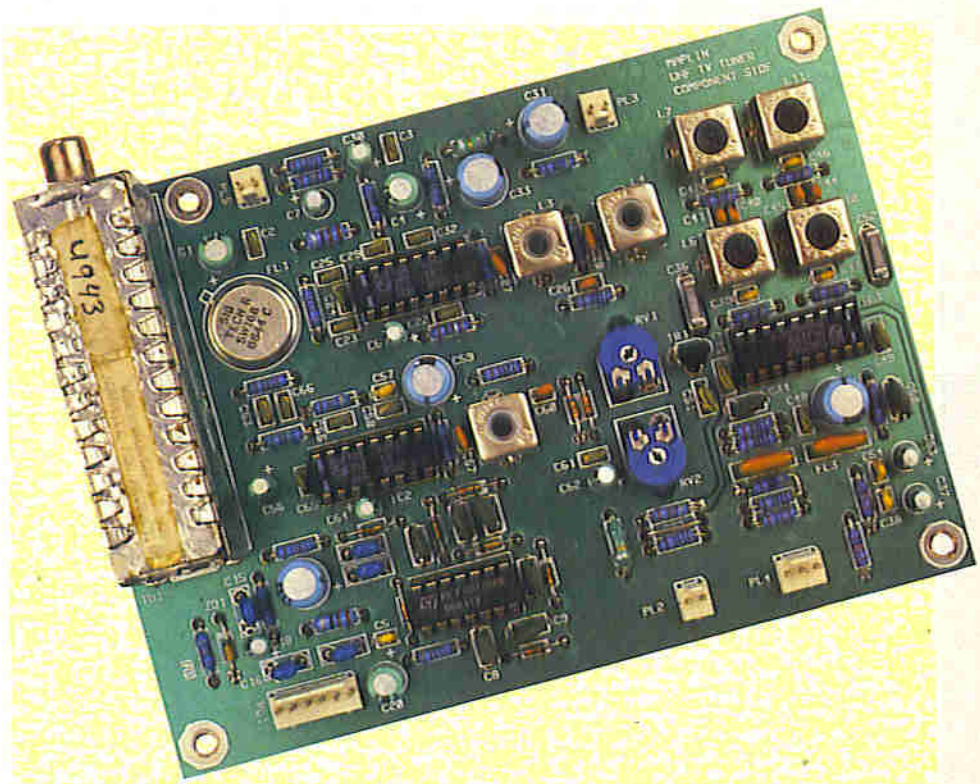


Photo 1. Minicon connectors locking tags facing inwards.

vision, colour, NICAM, 6MHz and 5.5MHz FM sound signals. These signals are split by the SAW filter, FL1, generating two IF outputs one containing vision and colour information leaving the NICAM, 6MHz and 5.5MHz sound on the other, see Figure 6. For a full technical listing of frequencies and signal levels see Table 2, and for mechanical information see Figure 7.

The vision IF is amplified and demodulated by IC1 producing a composite video output on pin 12 which is then fed via L5 and C31 to pin 1 of PL3. In addition, this chip produces the AFC and AGC control voltages which are fed back to TU1. Video demodulation is controlled by a tuned circuit comprising of L3, C27 and R12. A similar tuned circuit L4, C28 and R13 is used to set the AFC tuning voltage on pin 5

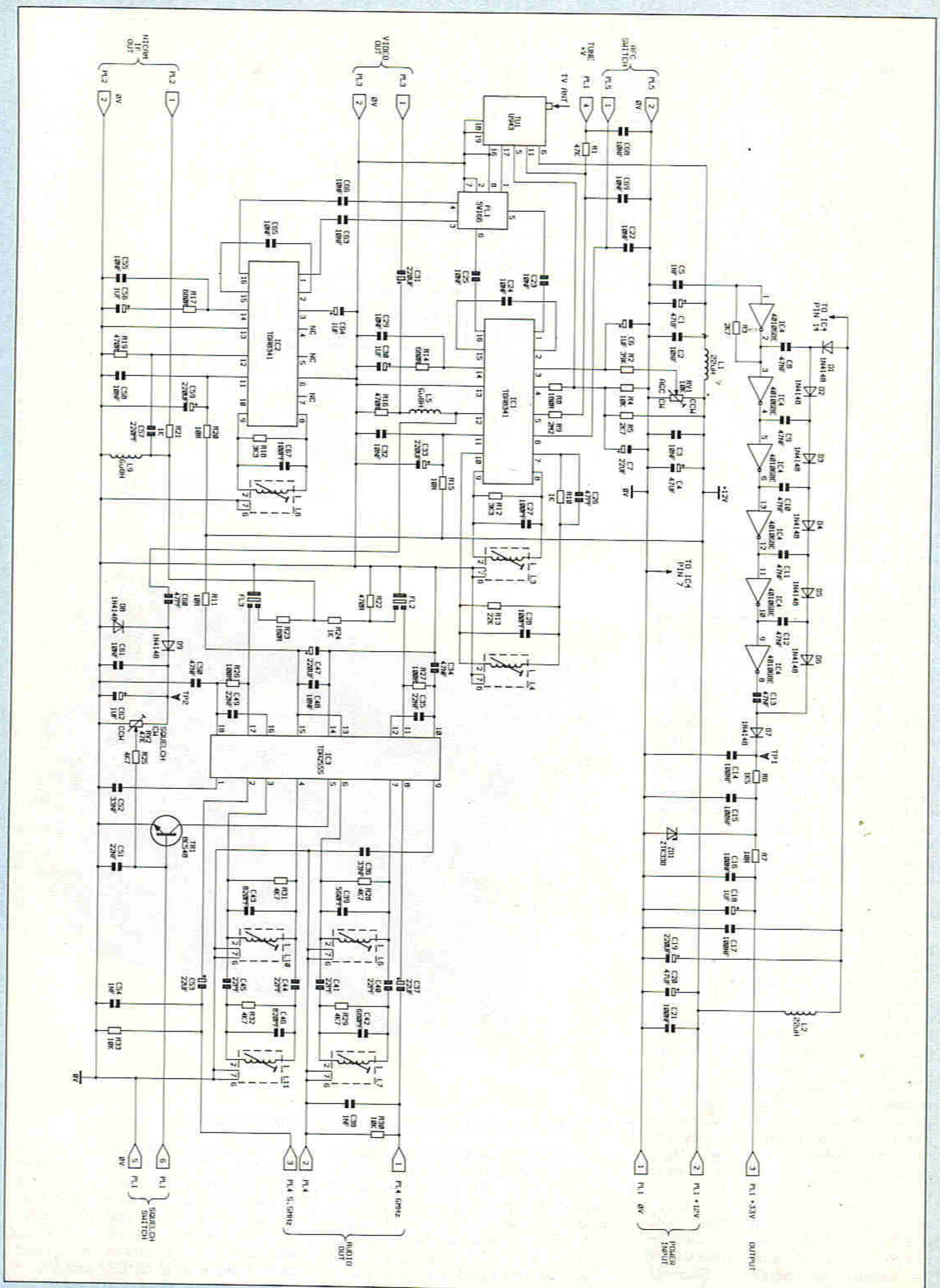


Figure 2. Circuit diagram.

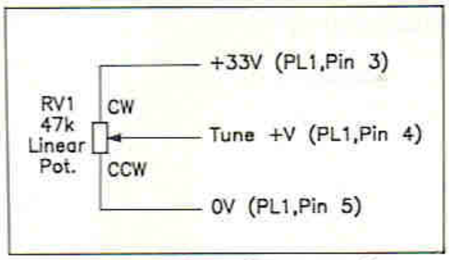


Figure 3a. Simple tuning control.

which is connected back to the tuning voltage input of TU1 via R9. The AFC action can be switched out by connecting pin 6 to the 0V groun, this is achieved by linking pins 1 and 2 of PL5. The AGC output on pin 4 is controlled by the AGC starting point preset RV1 on pin 3 and the gain response curves are shown in Figure 8.

The NICAM and FM sound IF is

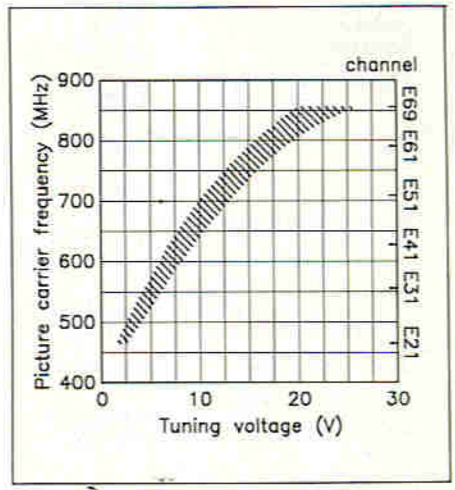


Figure 4. Tuning voltage response.

amplified and demodulated by IC2, producing the sub-carrier frequencies for NICAM decoding and FM demodulation. Sub-carrier retrieval is controlled by a tuned circuit comprising of L8, C67 and R18. The output signals appear on pin 12, then are fed via C57 to the ceramic filters FL2, FL3 and via R21 to pin 1 of the NICAM output connector PL2.

The UK 6MHz FM sound IF passes through FL2 with the continental 5.5MHz sound filtered by FL3, both outputs are then individually processed by IC3. This chip is a dual FM sound demodulator with

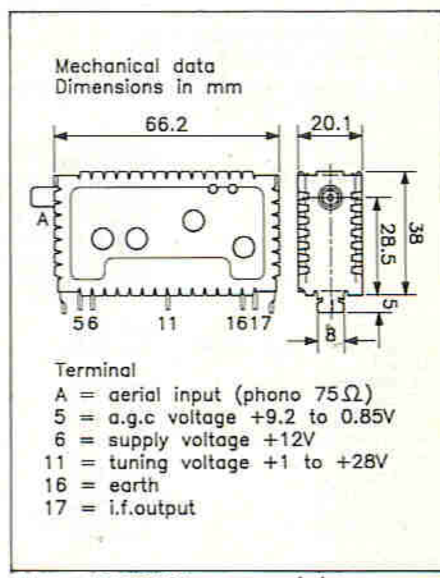


Figure 5. U943 tuner module mechanical data.

an eight stage input limiting amplifier and mute control function. The input level at which limiting occurs is approximately 100μV, enabling IC3 to extract good sound quality from a relatively weak TV signal. The individual audio signals are retrieved using quadrature demodulation followed by de-emphasis and output amplification. Quadrature demodulation is controlled by a double tuned circuit which results in an audio output with less than 0.1% Total Harmonic Distortion (THD). The 6MHz double tuned circuit is comprised of L6, L7 and C39 to C42 with R28, R29 across each coil. A similar set of components are used in the 5.5MHz demodulator made up from L10, L11 and

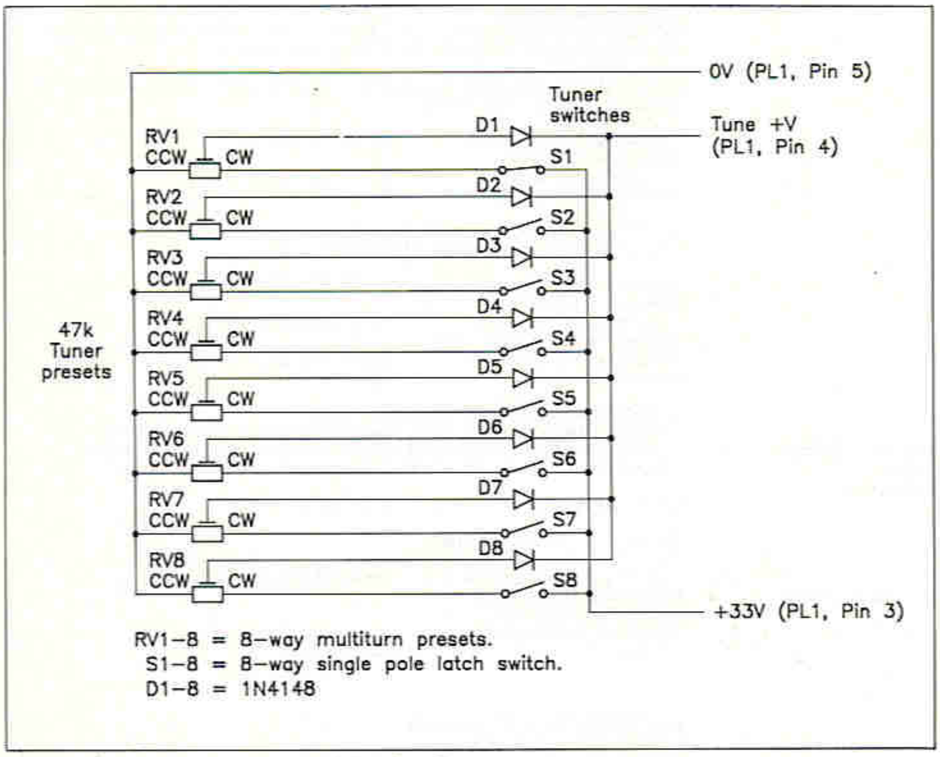


Figure 3b. 8-way preset tuning selector.

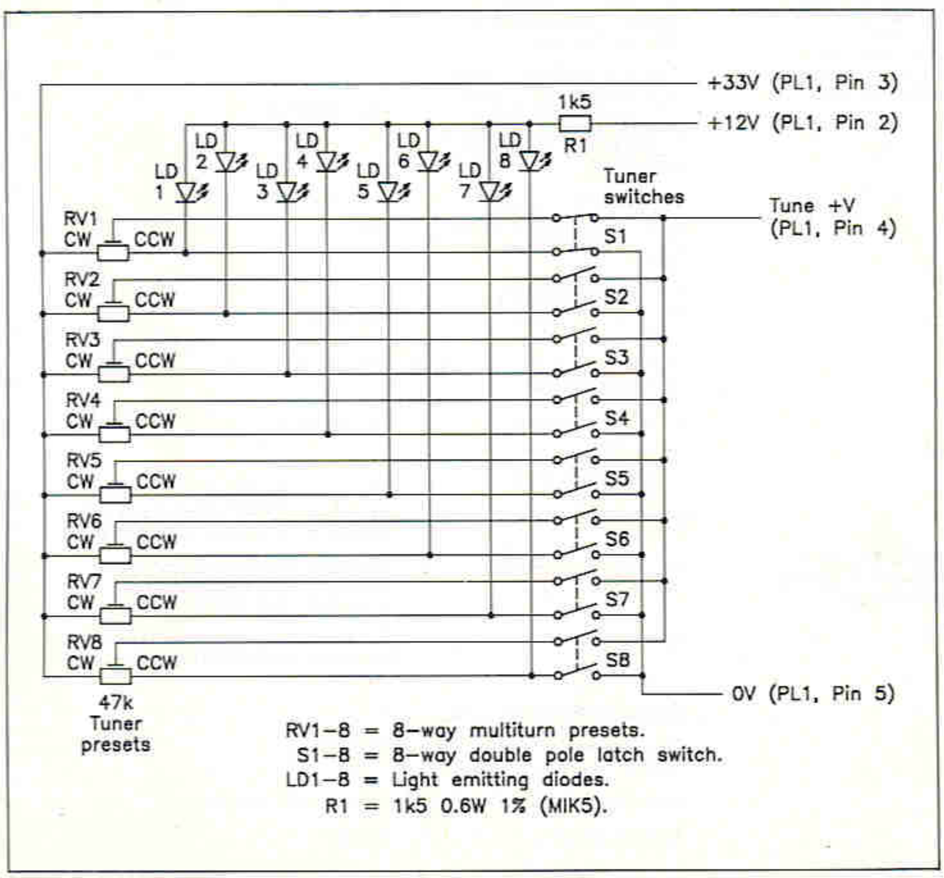


Figure 3c. 8-way preset tuning selector with LED indicators.

Semiconductors	
R.F. amplifier	BF990
Mixer transistor	2SC3545
Oscillator	BF569
Tuning diodes	3 x BB405
I.F. post-amplifier	BF370
Surge protection diode	BAV10
Surge protection diode	BZX79
Ambient temperature range	
Operating	−10 to +60°C
Shortage	−25 to +85°C
Relative humidity	max. 100%
Voltage and currents	
Supply voltage	+12V ± 10% (+10%, −15%)
Ripple susceptibility	min. 3mV peak-to-peak
Current drawn from +12V supply:	
R.F. amplifier, at nominal gain	max. 21 mA
R.F. amplifier, at 30dB gain reduction	typ. 11mA
Oscillator/i.f. amplifier	max. 36mA
A.G.C. voltage (Figure 8):	
Voltage at nominal gain	+9.2 ± 0.5V
Voltage at 30dB gain reduction	min. +1V
A.G.C. current:	
During gain control (0 to 30dB)	max. +15μA
At nominal gain	typ. +11μA
Tuning voltage range (Figure 4)	+1 to +28V
Current drawn from +28V tuning voltage supply:	
at 25°C	max. 0.15μA
at 60°C	max. 0.6μA
at 25°C (relative humidity 95%)	max. 0.6μA
Slope of tuning characteristic	min. 4MHz/V
Frequencies	
Frequency range	Channel E21 (picture carrier 471.25MHz) to channel E69 (picture carrier 855.25MHz). Margin at the extreme channels: min. 3MHz.
Intermediate frequencies:	
Picture	39.5MHz
Sound	35.5MHz
	The oscillator frequency is higher than the aerial signal frequency.
Wanted signal characteristics	
Input impedance asymmetrical	75Ω
V.S.W.R. and reflection coefficient at picture carrier frequency, at nominal gain and at 30dB gain reduction:	
V.S.W.R.	typ. 4
Reflection coefficient	typ. 60%
R.F. bandwidth	typ. 20MHz
Overall curves, tilt R.F. in – I.F. out	On any channel the amplitude difference between the top of the overall curve and the picture carrier, the sound carrier, or any frequency between them will not exceed 3dB at nominal gain, and 4dB in the a.g.c. range between nominal gain and 20dB gain reduction.
A.G.C. range	min. 30dB
Voltage gain (I.F. load = 1200 Ω/15 pF)	min. 40dB
Channel E21	typ. 40dB
Channel E40	typ. 41dB
Channel E69	typ. 42dB
Gain difference between any two channels	typ. 4dB
Noise figure	max. 10dB
Channel E21	typ. 6.0dB
Channel E40	typ. 6.5dB
Channel E69	typ. 7.5dB
Overloading	
Input signal producing 1dB gain compression at nominal gain	typ. 85dB (μV) into 75Ω
Input signal producing either a detuning of the oscillator by +300kHz or −1000kHz or stopping of the oscillations at nominal gain	typ. 100dB (μV) into 75Ω
Wanted signal level of a TV signal (picture to sound ratio of 7dB and picture to chroma ratio of 16dB), which produces an unwanted I.F. component (37.8MHz) 52dB below the I.F. picture carrier, when the tuner is 30dB gain controlled.	
TV signal (picture carrier)	typ. 100dB (μV) into 75Ω
Unwanted signal characteristics	
Image rejection (measured at picture carrier frequency):	
at nominal gain, channels E21 to E60	min. 53dB; typ.60dB
at 20dB gain reduction, channels E21 to E60	typ. 50dB
I.F. rejection (measured at picture carrier and colour sub-carrier frequency)	min. 80dB
1st repeat spot rejection (for I.F. 39.5/33.5MHz) Defined as the input level of the picture carrier of channel N + 2, the sound carrier of which produces an I.F. signal (35.0MHz), which is 52dB below the picture carrier of wanted signal N (picture to sound ratio 7dB; wanted signal 60dB (μV), tuner operating at nominal gain).	
Interfering signal	typ. 80dB (μV) into 75Ω
N ± 4 rejection	
Interference signal for an interference ratio of 53dB referred to wanted picture carrier (picture to sound carrier ratio of 7dB; wanted signal 60dB (μV), tuner operating at nominal gain).	
N +4 rejection	typ. 80dB (μV) into 75Ω
N −4 rejection	typ. 78dB (μV) into 75Ω
Cross modulation	
Input signal producing 1% cross modulation, i.e. 1% of the modulation depth of the interfering signal is transferred to the wanted signal.	
In channel cross modulation (wanted signal: picture carrier frequency; interfering signal: sound carrier frequency):	
at nominal gain (wanted input level 60dB (μV))	typ. 80dB (μV) into 75Ω
at 26dB gain reduction (wanted input level 86dB (μV))	typ.94dB (μV) into 75Ω
In band cross modulation (wanted signal: picture carrier of channel N; interfering signal: picture carrier of channel N ± 5):	
at nominal gain (wanted input level 60dB (μV))	typ. 92dB (μV) into 75Ω
at 26dB gain reduction (wanted input level 86dB (μV))	typ. 95dB (μV) into 75Ω
Out of band modulation, at nominal gain	typ. 100dB (μV) into 75Ω
Unwanted signal handling capability	
The tuner operates together with a standard TV receiver with normal A.G.C. for tuner and I.F. amplifier. Unwanted TV signal 3 channels higher or lower than wanted. Unwanted signal level adjusted for just not visible interference.	
Unwanted picture carrier signal	typ. 96dB (μV)
Oscillator characteristics	
Pulling (Input signal of tuned frequency producing a shift of the oscillator frequency of 10kHz), at nominal gain	typ. 85dB (μV) into 75Ω
Shift of oscillator frequency for a change of the supply voltage of 5%	max. 500kHz
Drift of oscillator frequency	
During warm-up time (after the tuner has been completely out of operation for 15 min, measured between 5 secs. and 15 min. after switching on)	max. 250kHz
For a change of the ambient temperature from +25°C to +50°C and +25°C to 0°C (measured after 3 cycles from +25°C to +55°C) channels E21 to E69	max. 1000kHz
For a change of humidity from 60% ± 15% to 93% ± 2%, measured at T_{amb} = 25°C ± 5°C	max. 1500kHz
I.F. characteristics	
Bandwidth of I.F. output circuit	typ. 9MHz
Note: I.F. output of the tuner terminated with the circuit shown in Figure 7, tuning voltage 10V.	
I.F. output impedance	approx. 100Ω
Miscellaneous	
Radio Interference:	
Oscillator radiation and oscillator voltage	Within the limits of C.I.S.P.R. 13 (1975) + amendment 1 (1983). Use is made of the relaxed limit of 3mV/m (70dB (μVm)).
Immunity from radiated interference	Aerial terminal meets requirements of BS905, provided the aerial cable is connected in a professional manner.
Microphonics	There will be no microphonics, provided the tuner is installed in a professional manner.
Surge protection	
Protection against over-voltage	max. 5kV
Note: Ten discharges of a 470pF capacitor into the aerial terminal.	
E.S.D. protection	min. 2kV

Table 1. U943 tuner module electrical data.

C43 to C46 with R31, R32 across each circuit. The final audio outputs are fed via C37 and C53 to PL4, where the UK sound channel appears on pin 1 with the continental signal on pin 3.

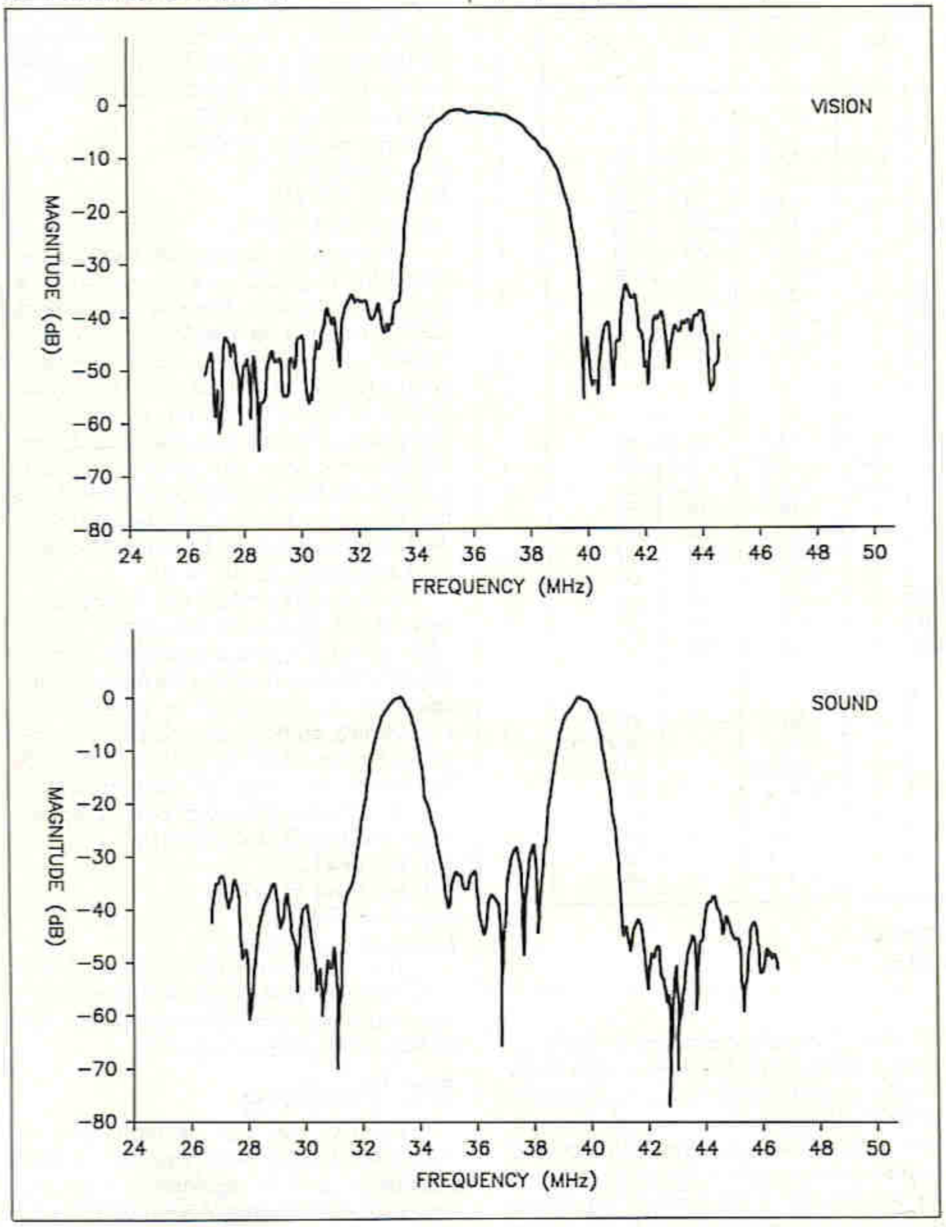


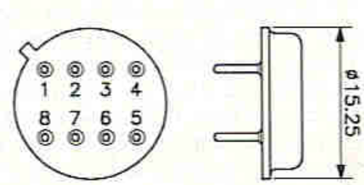
Figure 6. SW166 SAW filter vision and sound response.

The mute input of IC3 is controlled by TR1 with its collector connected to pin 5 and its emitter tied to 0V ground. The +V bias is derived from rectified VIDEO signals using the two diodes D8 and D9. When no TV signal is present, the VIDEO noise is very high and the rectified product can reach as high as plus two volts across RV2. This preset is used to adjust the squelch threshold by feeding a controlled amount of bias voltage via R25 on to the base connection of TR1. When TR1 is turned on, pin 5 of IC3 is grounded and the audio outputs are muted. However, this action can be disabled if the control bias is removed from TR1 by linking pins 5 and 6 of PL1.

PCB Assembly

The PCB is a double-sided, plated-through hole type, chosen for maximum reliability and mechanical stability. However, removal of a misplaced component is quite difficult with this kind of board so please double-check each component type, value and its polarity where appropriate, before soldering! The PCB has a printed legend to assist you in correctly positioning each item, see Figure 9.

CM8 8 Pin metal TO8.



Package viewed from beneath

Pin	Description
1	Input
2	Ground
3	Balanced sound output
4	Balanced sound output
5	Balanced vision output
6	Balanced vision output
7	No connection
8	Input return

Figure 7. SW166 SAW filter mechanical data.

The sequence in which the components are fitted is not critical. However, the following instructions will be of use in making these tasks as straightforward as possible. It is usually easier to start with the smaller components, such as the resistors. When fitting the two similar looking preset resistors RV1 and RV2 ensure that the right value goes in to the correct position on the board. Next mount the ceramic, polylayer and electrolytic capacitors. The polarity for the electrolytic capacitors is shown by a plus sign (+) matching that on the PCB legend. However, on most capacitors the polarity is designated by a negative symbol (−), in which case the lead nearest this symbol goes away from the positive sign on the legend. All the silicon diodes have a band at one end. Be sure to position them according to the legend, where the appropriate markings are shown.

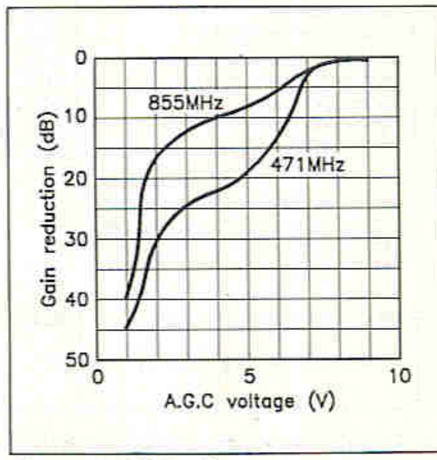


Figure 8. AGC voltage response.

When fitting the three filters FL1, FL2 and FL3 ensure that you don't over heat them. The SAW filter, FL1, will only fit one way, but make certain that it is pushed down firmly on to the surface of the PCB. The 6MHz and 5.5MHz ceramic filters FL2 and FL3 can be mounted either way round but must be positioned as follows: FL2=6MHz, FL3=5.5MHz.

Next install the transistor TR1, matching its case to its outline on the legend. When fitting the IC sockets ensure that you install the appropriate one at each position, matching the notch with the block on the PCB. DO NOT install the IC's until they are called for during the testing procedure. The RF coils L3, L4, L6, L7, L8, L10 and L11 will only fit one way round in the board and when fitting the four chokes L1, L2, L5 and L9 make sure you don't over heat them. Next fit the Minicon connectors PL1 to PL5 ensuring that the locking tags are all facing inwards.

The UHF tuner module TU1 depends on its electrical ground and mechanical support from two large flat solder tags located at each end of the unit. When mounting TU1 you must use a soldering iron rated at 25 Watts or more to ensure sufficient heating of the tag and solder pad on the PCB. The applied solder should then run freely round the joint until

SW166

Test conditions: Ambient temperature 20°C
Source impedance 50Ω
Load impedance 2kΩ

Characteristic	Frequency MHz	Min	Typical	Max	Unit
Sound channel 1					
Insertion loss	39.5	13.0	15.0	17.0	dB
Sound carrier NICAM	32.948	−1.0	–	+1.0	dB
Sound carrier	33.5	−4.5	−3.5	−2.5	dB
In–band trap	35.0 to 38.0	–	−35	−25	dB
Adjacent vision trap	31.5	–	−45	−35	dB
Adjacent sound trap	41.5	–	−50	−44	dB
Lower sidelobe	25.0 to 31.5	–	−39	−35	dB
Upper sidelobe	41.5 to 47.0		−39	−36	dB
Group delay ripple	32.3 to 33.5	–	40	80	ns
Vision channel 2					
Insertion loss	38.0	15.7	17.7	19.7	dB
Vision carrier	39.5	−6.3	−5.3	−4.3	dB
Colour carrier	35.07	−5.5	−4.5	−3.5	dB
Sound carrier	33.5	–	−36	−30	dB
Sound carrier NICAM	32.948	–	−34	−30	dB
Adjacent vision trap	31.5	–	−42	−38	dB
Adjacent sound trap	41.5	–	−41	−36	dB
Lower sidelobe	25.0 to 31.5	–	−43	−38	dB
Upper sidelobe	41.5 to 47.0	–	−45	−36	dB
Group delay ripple	34.5 to 39.5	–	40	80	ns
Spurious outputs:					
1.0 to 4 μs after main peak		–	−50	−42	dB
Temp. coefficient of frequency			−72		ppm/°C
Input impedance	38.0	–	0.58	–	kΩ
		–	//30.0	–	pF
Output impedance (vision)	38.0	–	6.3	–	kΩ
		–	//4.4	–	pF
Output impedance (sound)	39.5	–	1.4	–	kΩ
		–	//11.5	–	pF

1. Amplitude responses relative to 0dB at 39.5MHz
2. Aplitude responses relative to 0dB at 38.0MHz

Table 2. SW166 SAW filter electrical data.

it fills the slot in the board. This completes the assembly of the PCB and you should now check your work very carefully making sure that all the solder joints 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. Further information on soldering and assembly techniques can be found in the 'Constructors Guide' included in the Maplin kit.

Wiring

A wiring diagram showing all the interconnections is given in Figure 10. The wire connections to the PCB are made using Minicon connectors and the method of installing them is shown in Figure 11. When using the screened cable ensure that the braided screen wires are twisted together and are inserted in to the correct terminal housing. If you purchase a complete kit from Maplin it will contain the following one metre lengths of cable:

RF miniature coax (75Ω) XR88V.
AF twin individually screened XR21X.
DC ribbon cable (10 way) XR06G.

The TV aerial is connected to the tuner using a short length (150mm) of miniature 75Ω coax and it is most important that the outer braiding should not be able to come into contact with the centre conductor or anything connected to the centre conductor. At one end of this cable fit the phono plug PL6 and push it firmly in to the socket mounted on the tuner module TU1. At the other end of this cable connect the co-axial chassis socket SK6.

The NICAM output on PL2 also uses a length of miniature coax. However, this time it can be up to 300mm between the tuner board and PL2 on the NICAM decoder (Stock Code LP02C). All or part of the remaining miniature coax is used on the video output connection PL3. The free end of this cable is then to be terminated using one of the following sockets (NOT INCLUDED IN THE KIT):

BNC round FE31J.
BNC square YW00A.
Phono YW06G.
UHF(PL259) round BW84F.
UHF(PL259) square BW85G.
SCART(PCB) FV89W.

The two mono audio outputs on PL4 use the twin individually screened cable. The two braided screen wires are connected to pin 2 (0V ground) of PL4, with the UK 6MHz sound on pin 1 and the continental 5.5MHz sound on pin 3. To select the appropriate sound channel a switch, S3, can be added to the free end of this cable, which should be kept under 200mm long, see Figure 10. The type of switch used is a Single Pole Double Throw (SPDT) and any of the following can be installed (NOT INCLUDED IN THE KIT):

Ultra min toggle FH98G.
Sub-min toggle A FH00A.
Sub-min slide FF77J.
Pushlock FH41U.
Latch 2-pole FH67X.

No specific colour has been designated for each DC wire connection, it is entirely up to you. The use of coloured ribbon cable is to simplify matters, thus making it easier to trace separate connections to off-board components, just in case there is a fault in any given part of the circuit. Strip off from the main group whichever colour you prefer for each installation. The connections to and from the TV station selector will depend upon the tuning method you have chosen, refer back to Figures 3a, 3b, or 3c.

Switches S1 and S2 can be the same type as S3. However, on some TV's the AFC defeat, S1, is a microswitch located behind a door concealing the preset tuning selectors. As this door is opened the microswitch contacts are closed and the AFC is turned off allowing the TV station to be tuned in. Any of the following microswitches can be used for this purpose (NOT INCLUDED IN THE KIT):

Sub-min FP41U.
Sub-min lever FP42V.
Miniature FP44X.
Miniature lever FP45Y.

This completes the wiring of the NICAM tuner and you should now check your work very carefully making sure that all the solder joints are sound.

DC Testing

The DC tests can be made with a minimum of equipment. You will need a multimeter and a regulated +12V DC power supply capable of providing at least 250mA. If you are using the tuner board in conjunction with the Maplin NICAM decoder your power unit will have to be capable of suppling up to 500mA.

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. Double check that none of the IC's have been fitted into the sockets on the board. The first test is to ensure that there are no short circuits before you connect the DC supply. Set your multimeter to read OHMS on its resistance range and connect the test probes to pins 1 and 2 of PL1. With the probes either way round a reading greater than 70Ω should be obtained.

Next monitor the supply current, set your meter to read DC mA and place it in the positive line of the power supply (pin 2 of PL1). When the supply is turned on a current reading of approximately 50mA should be registered. Turn off the supply and install the IC's making certain that all

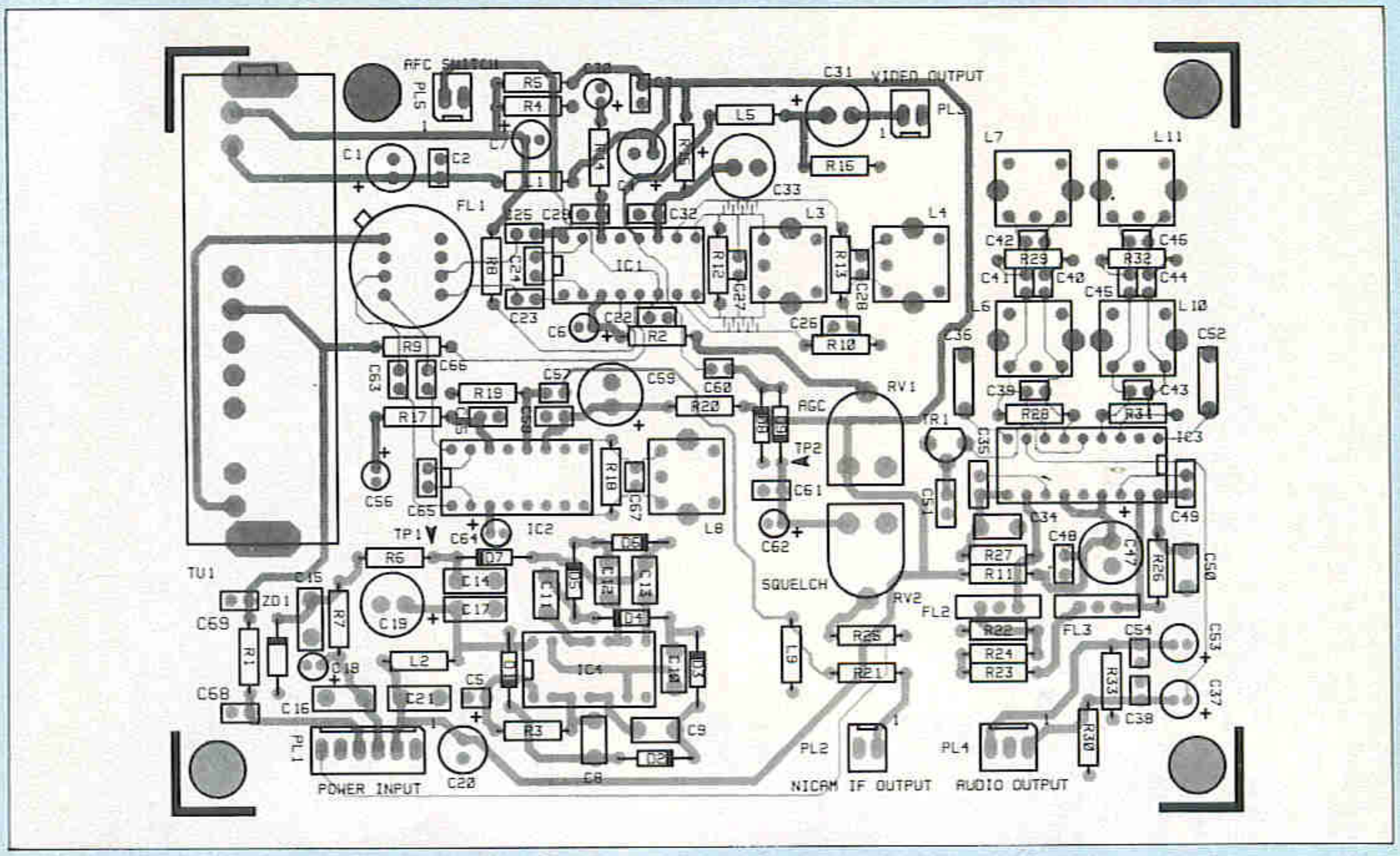


Figure 9. Layout of the PCB.

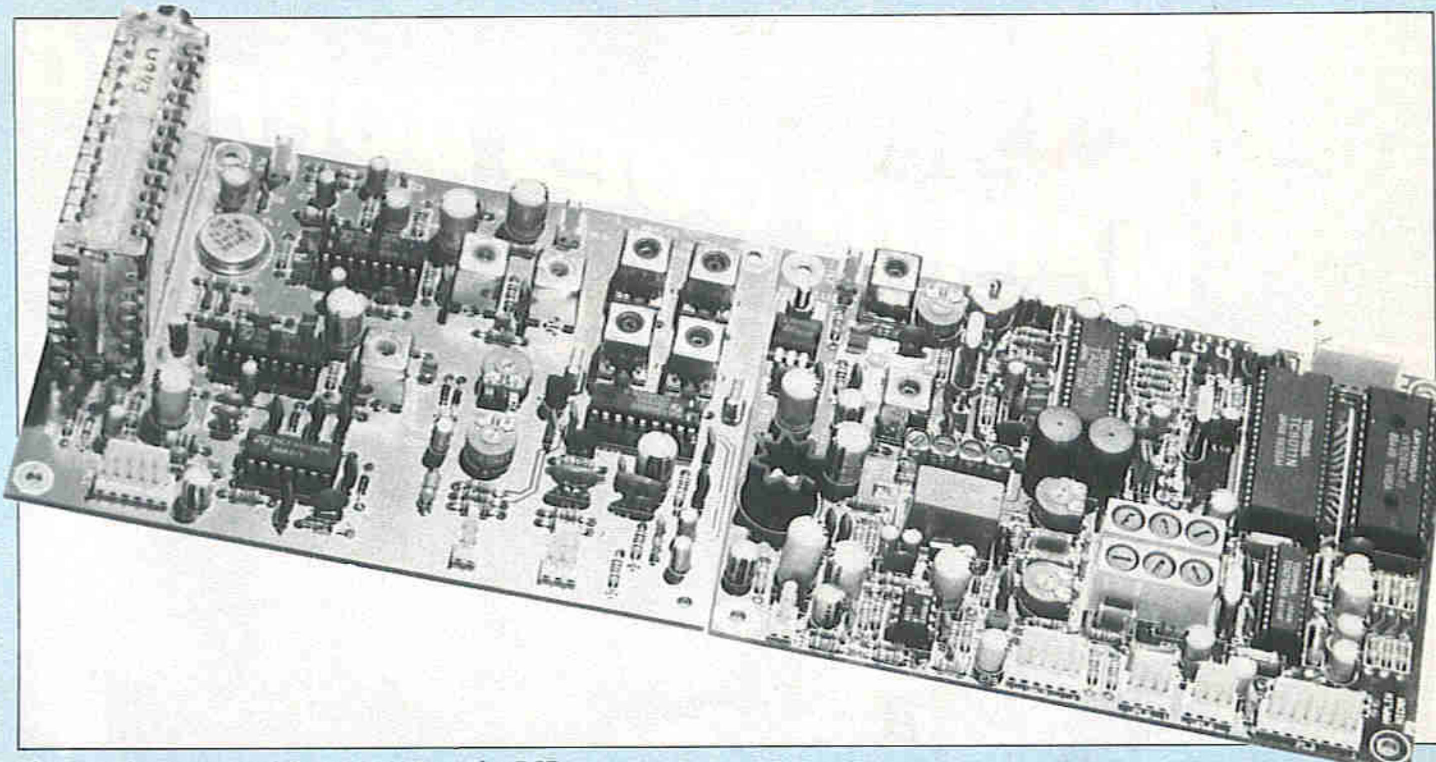


Photo 2. The Tuner and the NICAM Decoder PCBs.

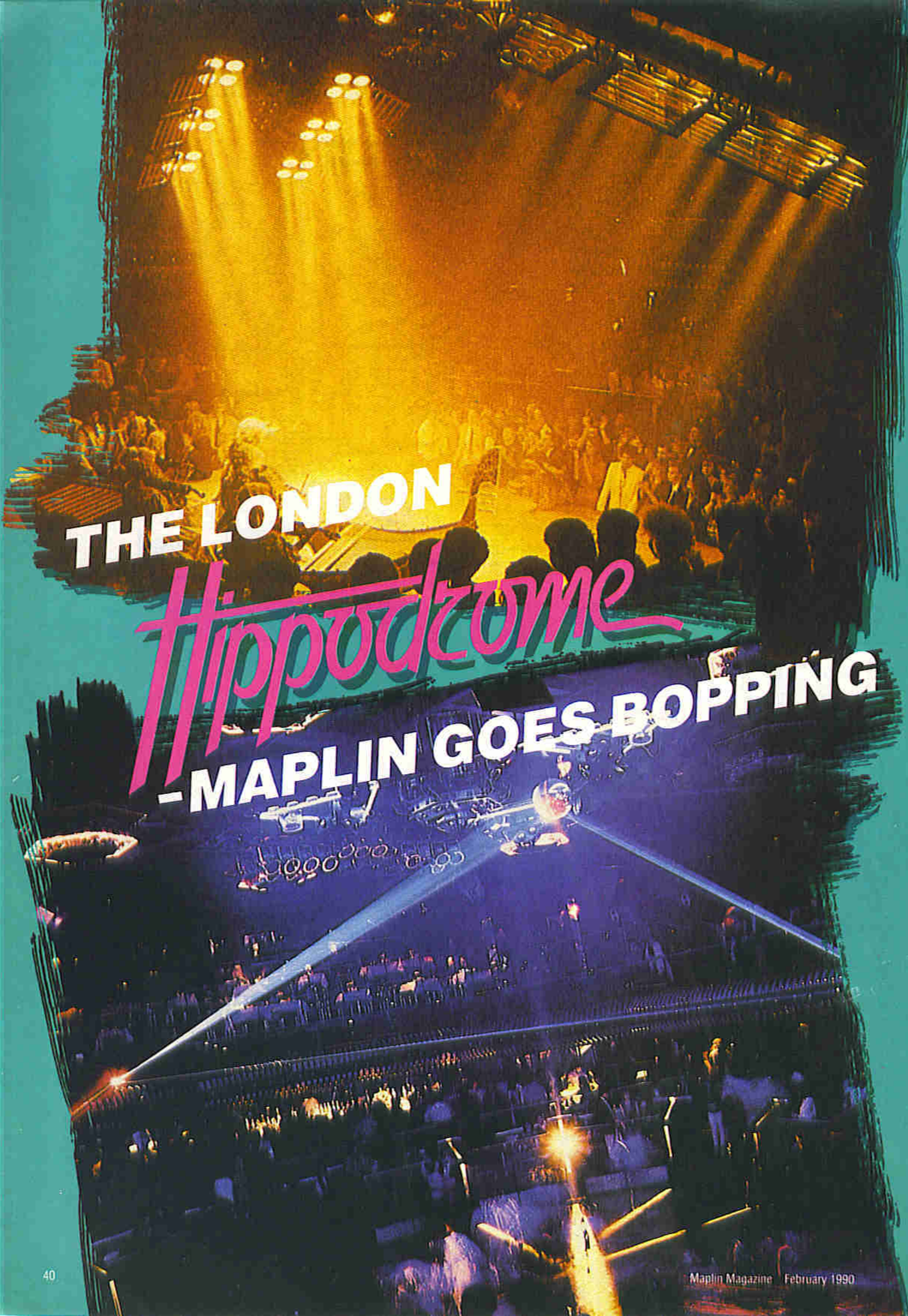
the pins go into their sockets and the pin one marker is at the notched end. Power up the unit and observe the current reading which should now be approximately 210mA. Turn off the power supply and remove the test meter from the line.

Now set your multimeter to read DC volts. All voltages are positive with respect to ground, so connect your negative test lead to a convenient 0V ground point on the PCB. When the NICAM tuner is powered up, voltages present on the unit should approximately match the following readings:

Circuit ref.	Voltage (+V)
TP1	40
PL1 pin 2	12
PL1 pin 3	33
PL1 pin 4	0 (Tune frequency low)
PL1 pin 4	33 (Tune frequency high)
IC1 pin 11	1.5
IC2 pin 11	11.5
IC3 pin 13/15	11.7
IC4 pin 14	11.9
TU1 pin 6	11.9

This completes the DC testing of the tuner, now disconnect the multimeter from the unit. *Continued on page 53.*

THE LONDON Hippodrome – MAPLIN GOES BOPPING



Report by Alan Simpson

To see the legendary London Hippodrome at its best, you will have to be there at the bewitching hour of midnight. It is then that the vast arena is transformed into an alien world of light, satellite and sound. The stage rises, lights decend and general wonderment breaks out which has to be seen and heard to be believed.

For once a venue lives up to its image. It's glitzy, and it's most definitely hi-tech. Six nights a week nearly 2000 starry eyed individuals, bop the night away, where to quote the PR blurb, "The energy, fashion and styles meet with the future in an extravagant atmosphere of adventure and fun". Any resemblance to your average church hall rave-up are many intergalactic light years away.

Controlling all this excitement – sound, vision, movement and smoke production – are computers. Two production consoles – the DJ desk which controls everything – and a lighting and production desk, which are modestly described by the man in charge, Stuart C Lowes, The Hippodrome Production Manager, as being a standard rock and roll rig. From the consoles, the apron stage can be raised from the dance floor in a matter of 20 seconds, while a stage lift can travel down to the loading bay in just 35 seconds.

Watch Your Heads

But even more action of course takes place overhead. Here seven descending satellites, a triangular grid and two spacecraft unfold, displaying some 1800 individual lights and neons, all programmed by custom built computers. The computer can even control four different height points plus the actual satellite petals all programmed in time with the music.

The production lighting rig insists Stuart is a prototype – and will remain that way. Two technicians work on it almost non stop, developing new programmes, new routines, and look after the routine maintenance of such matters as lights, dimmers and circuits.

The Hippodrome laser system is also claimed to be one of the most advanced of its type in the world. For the technically minded, 2 water cooled Argon and Krypton lasers produce a full chromatic range of effects. A digitiser pad facilitates laser writing for company names, logos to be displayed on projection screens. No doubt after this feature appears, 'Electronics – The Maplin Magazine' will be added to the light show.

Once again, the video system is controlled from the DJ desk, or from the comfort of their video production and editing unit. Here a GE 5055 light valve projector, 3 Sony CCD 2000 cameras plus vision mixers are deployed. Sound is similarly in high tech mode. Some 17kW of sound emerges from fully adjustable JBL custom made sub-bass speakers served by Amcron amplifiers. Supporting the sound system are 2 digital delay processors, 4 Technics 1200 decks with digital read out, 2 and 4 track reel to reel tape decks, 3 cassette decks plus CD players. Four separate graphic equalisers, two for disco and 2 for live PA, supplement the operation. And just in case you were wondering, two smoke machines are again controlled from the central DJ desk.

Smoked glasses are more than just a fashion gimmick at the Hippodrome. The venue can call on some 90,000 dazzling watts of lighting, plus with nearly a mega watt of sound available, you will also be deafened. Just in case, there is a standby generator which will provide enough power to keep the club open and near fully functioning.

Safety First

With so many souls gyrating the night away, safety is a major concern to Stuart and his team. The satellites for example are held in place by large steel blocks, and even if one did fall, the petals would automatically fold-up and the collapsible cage would absorb the shock. But as Stuart comments "The Hippodrome is safer than a Volvo – but somewhat more exciting".

Most nights (and days) will find Stuart and his four man crew – 2 technicians and 2 lighting specialists on duty, but for special stage shows or video presentations, additional crew will be involved. Not surprisingly given the creative and high tech nature of the job, crew turnover is quiet small says Stuart.

The Hippodrome attracts a wide range of visitors, tourists keen to see London's biggest and brightest disco. Couples celebrating a special event or regular club members. Every night is party night but each has a special theme. Currently the Wednesday Rock nights are top of the popular charts. Entry prices range from £6 to £12.50 for Saturday and special gala nights.

The Hippodrome also caters for business presentations. Recent events have included Ford, "The Sun Page 3 girl of the year" and Tandem who used the venue to launch its new computer by means of a satellite video conference link to over 130 locations world-wide. Formal meals can be served for some 500 guests with more casual catering for 1350 guests.

Stuart doubts whether we will ever see a comparable venture which at todays prices would cost in the region of £6m to create and develop. So for the present at least, the high tech Hippodrome is probably the closest most of us will get to being put in space.

London Hippodrome Competition

Enter our FREE Hippodrome Competition and you and a partner could enjoy a night out at this luxurious venue!

The London Hippodrome is kindly making available 12 double tickets – for any night of your choice – to the first correct answers drawn.

★ Name two of Michael Jacksons top selling albums.

★ Which US city was featured in the TV series "Fame"?

★ Where was the original Hippodrome located?

★ Who starred in "Dirty Dancing"?

Answers on a post card please to: 'Electronics – The Maplin Magazine', Hippodrome Competition, P.O. Box 3, Rayleigh, Essex SS6 8LR. The first 12 correct entries out of the hat will be the winners. Don't forget to add your name and address! Closing date for entries is 28th February 1990.

ELECTRONICS BY EXPERIMENT

Part 12 by Graham Dixey C.Eng., M.I.E.E.

Introduction

This article, the final one in the series, will look at a few of the many possible circuits for generating waveforms. Some others have already been met, notably the 555 IC square-wave generator, the UJT pulse generator, the monostable and astable multivibrators, the Wien bridge and twin-T oscillators, the latter four circuits making use of operational amplifiers. There are some other circuits, however, that can be useful and these will now be discussed. The expression 'generating waveforms' is a very general one and may refer to any circuit that produces a regularly recurring output, whether sinewave, square or rectangular wave, triangle, sawtooth, pulse, etc. The first circuit to be considered is a very simple one but useful where a sinewave of fixed frequency is required – for practical reasons it isn't very suitable if a variable frequency oscillator is needed.

The Ladder Network Oscillator

A ladder in this context is an arrangement of similar, cascaded RC filters. There can be any number of sections but three is convenient. Figures 1a and 1b show two ways in which a 3-section RC ladder can be constructed. Of the two, that in Figure 1a is usually more convenient because the series capacitors then act as d.c. blocking components in the feedback path as well as helping to produce the required phase shift through the network. In either of these two circuits the following two statements will always be true.

a) The output voltage V2 will be smaller than the input V1.

b) There will be a phase shift between V1 and V2.

The 'magnitudes' of the changes in statements (a) and (b) above are dependant upon frequency. It is possible to draw graphs to show how both loss and phase shift vary with frequency but this is not a very exciting exercise so will be omitted.

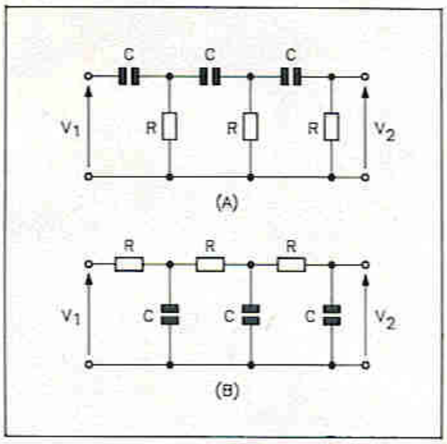


Figure 1. The 3-section RC ladder network. Of the two possibilities shown, (a) is generally the more useful.

Suffice it to say that, at any given frequency, there will always be a particular phase shift and loss between the input and output of the network. To take real values that we can use here, there will be some frequency at which the network of Figure 1a will have a phase-shift of exactly 180°; if the loss of the network was measured at this frequency it would be found to be 29:1. Using this information it becomes possible to design an oscillator that will generate a sinewave of a specific frequency. Figure 2 shows the basis for such a design.

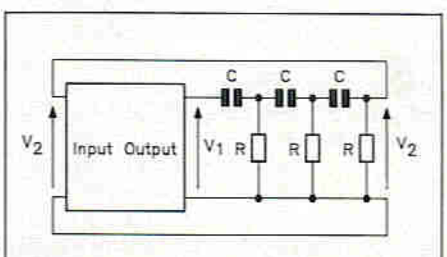


Figure 2. By combining the loss/ phase shift characteristic of the RC ladder with an appropriate 'block', it is possible to construct an oscillator. The ladder forms a feedback path from output to input of the block.

The RC ladder network is connected between the input and output of a block whose principal characteristics are that it also has a phase shift of 180° but instead of having a loss of 29:1, it has instead a 'gain' of 1:29. What will be the result of such an arrangement? To take nice easy figures, suppose that the alternating voltage V1 out of the block and into the ladder has a value of 29V and an instantaneous phase represented by an 'upward' arrow. If the frequency of this voltage has been chosen correctly, the output voltage V2 from the network and into the block will be 1V (the loss of 29:1 giving this) and will have an instantaneous phase given by a 'downward' arrow (the 180° phase shift will rotate the arrow by this number of degrees). What will the block do to this signal? It will multiply its amplitude by 29, because of the gain in the block, so that the 1V becomes again 29V, and a further 180° phase shift will occur, so turning the arrow round through another 180°, causing it to point 'up' again. In short we are back where we started from. Not matter how many times we go round the loop, the voltages at the input and output of the block (and hence at the ends of the ladder) will always be the same, both in amplitude and phase; the circuit is self-sustaining as far as the voltage levels are concerned.

This is a simple physical statement of the criteria for a circuit to self-oscillate. Put more academically, the product of gain and loss must equal unity ($29 \times 1 / 29 = 1$) and the total phase shift must equal zero degrees ($180° + 180° = 360°$), which is the same thing.

The remaining question is, what is the frequency at which these oscillations will occur? For the ladder circuit of Figure 1a they will occur at a frequency given by, $f = 1 / (2 \times \pi \times C \times R \times \sqrt{6})$.

This expression assumes that all stages of the network are identical, that is all three Rs are equal as are all three Cs.

What should the block contain? Something that has a voltage gain of 29 together with a phase shift of 180°. Any ideas? The simple answer is a single-stage

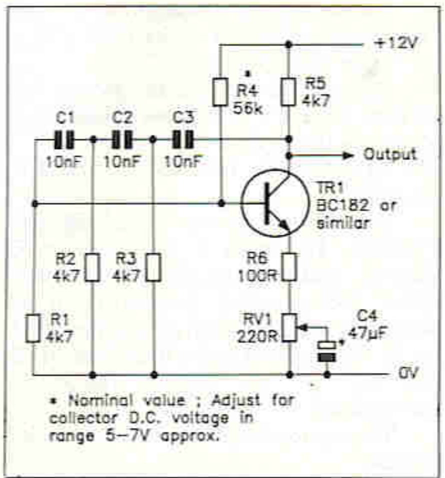


Figure 3. A practical ladder RC oscillator based upon the ideas of Figure 2. The block of Figure 2 is represented by a BJT amplifier whose gain/phase characteristics complement those of the ladder. The actual gain is adjusted by means of RV1.

common emitter amplifier or a common source amplifier, if a FET is used instead. The FET has a higher input impedance than a BJT (bipolar junction transistor), but the latter has a much higher gain usually, so it's a matter of swings and roundabouts. Figure 3 shows a practical circuit for a ladder oscillator that will produce a good sinewave output if the gain is adjusted correctly. If the gain is insufficient the circuit will not oscillate at all; if it is too great a distorted output will be the result. The easiest way of controlling the gain is by varying the amount of negative feedback introduced by the emitter resistor. This can be done by using a potentiometer as part of this resistor which is more or less bypassed by a capacitor, C5, of low reactance (at the oscillatory frequency).

Any transistor of moderate to high gain can be used in this circuit provided that the bias resistor R4 is changed (it may need to be modified slightly from the value given anyway) in order that the collector d.c. potential is about midway between 0V and V_{CC}. The latter can have any value, say in the range 6 to 12V.

A disadvantage of this circuit is that if the load on the output has too low a value, the reduction in voltage gain that it causes may well 'kill' the oscillations. What is needed is a buffer stage to isolate the output of the oscillator from its load. A modified circuit is shown in Figure 4,

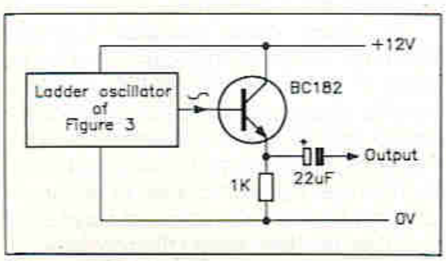


Figure 4. Adding a simple emitter follower as a buffer for the output of Figure 3.

which incorporates a directly-coupled emitter follower presenting a high impedance to the oscillator output (allowing it to have maximum gain) and a low impedance to the load.

It was mentioned that this type of oscillator is not suited for providing a variable frequency output. Why this is so should be obvious. The frequency depends upon the values of THREE resistors and THREE capacitors. To vary the frequency over a reasonable range would mean having to have, say, a 'three-gang' potentiometer, not a stock item. Compare this with the Wien bridge oscillator which uses a two-gang potentiometer, which is readily available. Nonetheless, the ladder oscillator is useful for providing a fixed test frequency, without undue complications. It is possible to vary its frequency slightly by varying just one of the network resistors, say R2. By making all or part of this resistor a preset type, it is then possible to 'trim' the oscillator frequency to a precise value.

A Very Low Frequency FET Pulse Generator

One of the most useful features of the Field Effect Transistor (FET) is its extremely high input resistance. This permits very high values of resistance to be used for timing astable circuits, for example, which would be impossible with conventional BJT circuits because of the shunting effect of the latter on the said resistors. Figure 5 shows a conventional

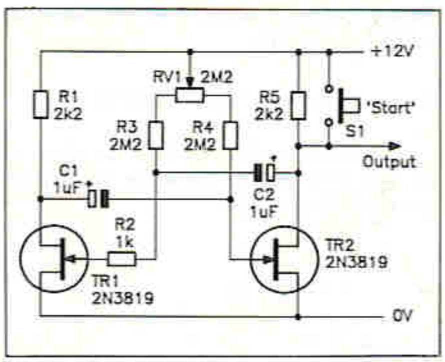


Figure 5. A Very Low Frequency (VLF) Square Wave Generator using FETs. Cycle times of several minutes are possible with such a circuit.

cross-coupled astable multivibrator circuit in which the gate timing components are formed from two fixed, high value resistors, together with a high value potentiometer, and tantalum electrolytic cpacitors. Low leakage capacitors are essential, which is why tantalum capacitors rather than the normal aluminium electrolytics are specified. The potentiometer allows a reasonable range of mark/space variation to be obtained. The cycle time for the values given should be about 6 seconds but can be increased or reduced by changing the values of C1 and C2. Very low frequencies indeed are possible by using high value electrolytics, cycles times of several minutes being capable of achievement. This simple circuit can be made even more useful by switching different values of C1 and C2, by adding a buffer stage on the output, etc. In other words, there is scope for experiment even with such an uncomplicated circuit.

The 'start' push-button switch S1 is included to give C2 a 'kick' to get the cycle under way. The resistor R2 in the gate of TR1 is merely a limiter for the gate current for this FET.

A TTL Ring Oscillator

There is sometimes a requirement for a simple, not particularly stable oscillator, that will generate square wave test pulses in the MHz region. Such a circuit is shown in Figure 6 and consists of a ring of three

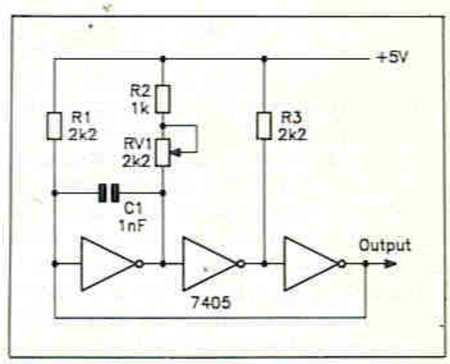


Figure 6. A TTL 'ring oscillator' that produces high frequency square waves.

open-collector TTL inverters. The principle of operation is the same as that of any other oscillator, namely it depends upon the application of positive feedback. The closed ring indicates that feedback is indeed applied; whether that feedback is actually positive as required depends upon the propagation delays of the three inverters. Since these propagation delays are short, the operating frequency can be very high. However, in order to provide a degree of control over the oscillatory frequency, additional components are included.

In the figure, the components C1 with RV1 plus R2 control the frequency. The preset RV1 allows the required frequency to be adjusted. Changing the value of C1 will also, of course, change the frequency. By switching the value of C1 it is possible to have several ranges of frequency, each with upper and lower limits set by the variation of RV1. Appropriate values of these components will allow a frequency range of at least 1 to 10MHz, certainly a very useful test circuit at little cost or time to build.

A CMOS Pulse Generator Circuit

Where good frequency stability is needed the answer is usually to employ crystal control. The circuit of Figure 7 uses a minimal number of components to realise a crystal-controlled oscillator of high performance. A variable capacitor

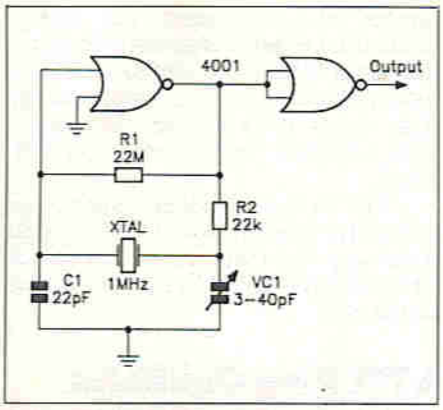


Figure 7. A simple but reliable CMOS crystal controlled oscillator, producing highly stable square waves and capable of driving a single TTL load.

(preset) is used to adjust the circuit to oscillate at the crystal frequency, though the series resistor may also need to be changed if a wide variation in frequency is required. For the component values given the circuit will work reliably at 1MHz and will drive a single TTL load. This can, of course, be increased by following the circuit with a TTL buffer. Either a 7406 (inverting) or a 7407 (non-inverting) would be suitable. Both are open-collector gates so will need an external pull-up resistor from output to the positive supply.

A Two-Tone Alarm Circuit

A two-tone alarm has a distinctive sound that commands attention. It is possible to generate this sound by using one oscillator, at low frequency, to control another that is running at a higher frequency. The 555 IC is a suitable basis for such an oscillator, as has been shown previously. There is a dual version, known as the 556 and this has been used for the circuit of Figure 8.

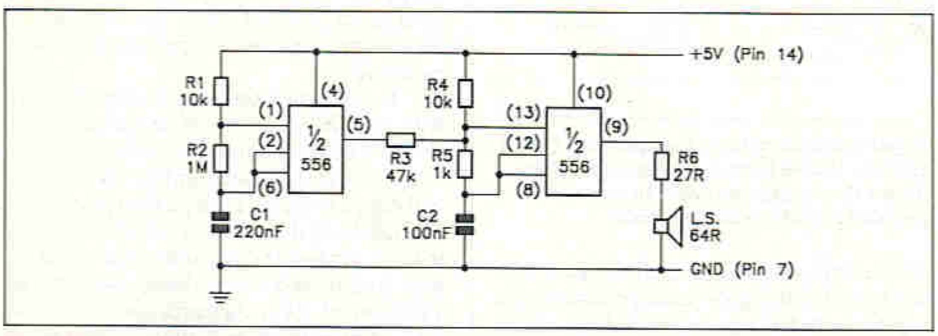


Figure 8. A two-tone alarm using the dual version of the 555 IC, the 556.

The left hand half has a long time constant that sets its frequency at the low value of 4Hz. The output of this half is coupled to pin 13 of the right hand half, which is set to free run at 1kHz. Since pin 13 is the discharge terminal of this right hand half, this means that its natural frequency is constantly being interrupted at the lower rate, giving the characteristic warble sound. A useful circuit to use in alarm systems or as a time-out warning, etc.

Function Generators

Function generators are circuits that are capable of generating two or more different, but frequency-related, waveforms. There are several ICs that can be used as the basis for either quite simple or fairly sophisticated circuits. One of each category will be considered here.

Taking the simple case first, the NE566 (not to be confused with the 556!) is capable of generating a triangle and square-wave at the same time, using very few external components. In spite of such simplicity and its related low cost, the performance is very good. The frequency stability is excellent, the triangular wave has extremely good linearity and it is possible to modulate the outputs in a highly linear fashion using an external voltage source. This makes it suitable for use as more than just a waveform generator. It can also be employed in applications such as Frequency Shift Keying (F.S.K.), Frequency Modulation and as a Sweep Frequency Oscillator. The basic application circuit is shown in Figure 9.

The supply voltage V_S can lie in the range +10V to +24V and the control voltage, V_C at pin 5 must be set by the values of R2 and R3 to lie between $0.75V_S$ and V_S. For the values of R2 and R3 shown, the value of V_C is approximately $0.85V_S$. If a modulating voltage is applied to pin 5 it must either be capacitively coupled as shown or have a mean d.c. level that does not conflict with the bias voltage established by the R2 and R3 potential divider. The formula for the frequency of both output waveforms is given by the following formula.

$$f_{OSC} = (2 \times (V_S - V_C)) / (R1 \times C1 \times V_S)$$

There is a constraint on the value of R1 and that is that its value should lie between 2k and 20k.

It will obviously be useful to design an oscillator for a given frequency under specified conditions. Then that design approach can be used for the design of any other oscillator, whatever the frequency or supply voltage chosen.

As such an example, assume that the required frequency is 400Hz, the supply voltage is to be 12V and the values of R2 and R3 are as shown in Figure 9. This gives immediately the value of V_C as 0.85 x 12V, that is 10.2V.

The formula for frequency now looks like this: 400 = (2 x (12 − 10.2)) / (R1 x C1 x 12) = (2 x 1.8) / (12 x R1 x C1)

The unknown in this equation is the product R1 x C1, which we should now transpose for, to give:

$R1 \times C1 = (2 \times 1.8) / (12 \times 400) = 0.00075 = 7.5 \times 10^{-4}$

This is the product of OHMS and FARADS. To make it the product of kilohms and nanofarads (much more useful for practical purposes), it is necessary to multiply the above result first by 10^{-3} (to convert ohms to kilohms) and then by 10^{9} (to convert farads to nanofarads).

The expression for R1 x C1 now looks like this.

$R1 \times C1 = 7.5 \times 10^{-4} \times 10^{-3} \times 10^{9} = 750$ (kilohm-nanofarads).

Since R1 must have a value between 2k and 20k, the corresponding value of C1 must lie between 750 / 20 = 37.5nF and 750 / 2 = 375nF.

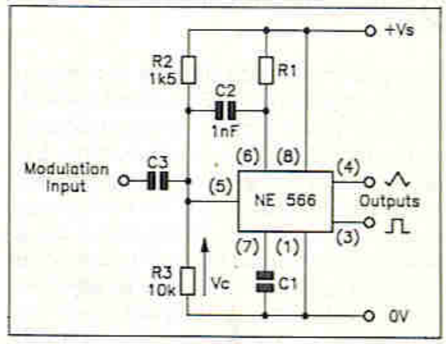


Figure 9. A simple square/triangular generator using the 566 IC.

Where an RC product is known, as in this case, and the individual values of R and C then have to be decided, it is usually a better bet to choose the capacitance value first and then see what resistor value follows from this. Not only is there a wider range of resistor values available anyway, but it is always possible to 'trim' the final value by including a preset as part of the resistor.

In the above case, an obvious capacitor value that lies between 37.5nF and 375nF is 100nF, giving a value for R1 of 750 / 100 = 7.5k, which happens to be an available resistor value. Even so, tolerances on components, especially that of the capacitor, may result in a slight variation from the required frequency. In this case, the 7.5k resistor could be made up from the series connection of a 6.8k resistor and a 2.2k preset, allowing accurate setting of the 400Hz operating frequency to be achieved.

A much more complex function generator is shown in Figure 10. This is based on the well known 8038 IC, which is capable of generating sine, triangular or square waves. The component count of this circuit is, of course, higher than that of the previous circuit, because of the need to switch between the three functions (not available simultaneously) the provision of four frequency ranges and the buffering of the output with a voltage follower. Balanced d.c. supplies are also required but these can be conveniently provided by means of a pair of PP3 batteries, since the current drain is not high. A PCB is available for use with this circuit and a full list of components is given at the end of this article.

The frequency ranges are as follows:
Range 1: 10Hz to 400Hz
Range 2: 100Hz to 4kHz
Range 3: 1kHz to 40kHz
Range 4: 6.25kHz to 200kHz

There is thus some overlapping of the ranges, but a very respectable overall range of 10Hz to 200kHz is the end result. The peak-to-peak output voltage levels are 3.6V for sinewaves; 6V for triangular waves; 14.4V for square waves. The output impedance is 600 ohms.

In the circuit shown, the frequency 'fine' control is the potentiometer RV3 (the range switch is, of course, SW1) and the output level control is RV4. The output is taken from pin 6 of IC2, which is Pin 14 of the PCB. The function required is selected by the three-way switch SW2.

Because of the way in which the sinewave is generated, it is necessary to provide preset resistors to achieve the best waveform. These controls are RV1 and RV2 in Figure 10. While the sinewave can hardly be classified as a true low distortion waveform (T.H.D. lies between 1% and 7% according to frequency), it is still quite satisfactory for a wide range of testing. The linearity of the triangular wave is in the range of <0.1% to <8%, again according to frequency. The rise and fall times for the square waves have a best figure of 1μs and a worst figure of 2μs, quite respectable. Overall, a piece of equipment well worth adding to one's test bench.

A full parts list for the circuit of Figure 10, but not including any case, which is the choice of the builder, is shown.

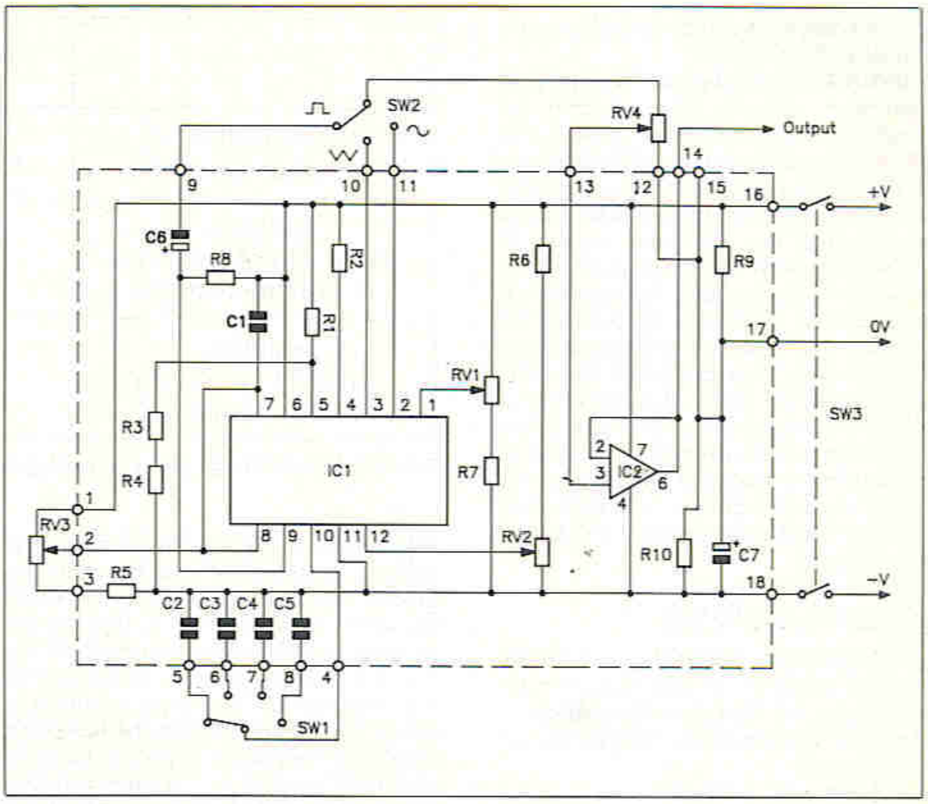


Figure 10. A more complex function generator with three alternative outputs, using the 8038 IC. A PCB is available to make construction of the circuit a simple and useful project.

Once the circuit has been built and found to be working, there remains the matter of calibration. For any piece of test equipment to be useful it must be accurately calibrated. The fine control RV3 will need to have a scale drawn up and calibration marks added. This can be carried out on the sinewave function either by direct comparison with a laboratory signal generator borrowed for the purpose (Lissajous figures), or by means of a digital frequency counter, if one is available. These are the most accurate methods. Alternately, the calibration can be made by using a CRO to measure the periodic time of, say, the square wave output. This is more tedious and less accurate since the CRO timebase calibration accuracy will generally be inferior to that of the other instruments.

That concludes our journey through 'Electronics by Experiment'.

Parts list

R1,2,9,10	Min Res 2k2	4	(M2K2)
R3	Min Res 10M	1	(M10M)
R4	Min Res 4M7	1	(M4M7)
R5	Min Res 22k	1	(M22K)
R6,7	Min Res 10k	2	(M10K)
R8	Min Res 2k7	1	(M2K7)
C1	Poly Layer 1μF	1	(WW53H)
C2	Polyester 0.22μF	1	(BX78K)
C3	Polyester 0.022μF	1	(BX72P)
C4	Polystyrene 2200pF	1	(BX37S)
C5	Polystyrene 220pF	1	(BX30H)
C6	PC Elect 47μF 25V	1	(FF08J)
C7	PC Elect 100μF 25V	1	(FF11M)
RV1, RV2	Hor Sub-Min Preset 100k	2	(WR61R)
RV3, RV4	Pot Lin 10k	2	(FW02C)
IC1	8038CCPD	1	(YH38R)
IC2	LF351	1	(WQ30H)
SW1	Rotary SW4B	1	(FF75S)
SW2	Rotary SW3B	1	(FF76H)
SW3	Sub-Min Toggle E	1	(FH04E)
	8038 PCB	1	(YQ65V)
	DIL Socket 8-pin	1	(BL17T)
	DIL Socket 14-pin	1	(BL18U)
	Pins 2141	1 Pkt	(FL21X)

precautions), the benefits of this bleach can outweigh the dangers.

Colour Change Agent – As the film is processed, silver is removed from the emulsion, which then shrinks. As the colour of the hologram depends on the thickness of the emulsion to produce the image, this is clearly disastrous. The emulsion shrinks so far that the hologram replays in ultraviolet, which is a major problem. To get round this problem, the emulsion is re-expanded chemically to produce an image in a visible colour (yellow and green are common - they are bright and fairly easy to get). The choice of replay colour is limited to colours of the spectrum (white and other non-spectrum colours, such as brown are not available). The chemical we use is triethanolamine – it is toxic. It is commonly available – most schools have it or can get it.

Processing

Develop – Until 90% black – this is hard to judge in the darkroom, but try holding the film up against the safelight, it should be almost opaque, (this can take up to 5 minutes).

Stop – 30 seconds.

Fix – 5 minutes or longer – essential for brightness.

Wash – 5 minutes in running water. This too is essential.

Bleach – Until all the darkness has gone from the film, then 10 seconds.

Wash – 5 minutes in running water.

Expand – See next paragraph.

Dry – Dry as Usual

Expand – The expansion of the emulsion is a matter of trial and error. We use a 5% solution of triethanolamine in water, and vary the colour with the immersion time (from 5 seconds to 5 minutes), and the degree of drying with tissues (from a very gentle swab to a full drying). The simplest way to determine the effects of changes is to refer to Table 1.

The effects of the expansion can only be seen after the film has been blown dry with hot air, so the process of choosing a colour can take some time. However, the process can be repeated many times until the result is satisfactory, as long as the emulsion is not scratched too much during drying, the film should now be dark grey all over and can now be viewed as shown in Figure 15. As can be seen, the hologram should be viewed as a mirror, which is essentially what it is – a very complex mirror which reflects one wavelength of light into an image of the object. This model of a mirror contrasts with a transmission hologram, which models a very complex lens, shaping light which passes through it into an image of the object. The contrast of reflection holograms can be improved by viewing it against a black surface. This is best achieved by painting the back of the film (the emulsion side) with black paint or sellotape it to a piece of black card. Both of these methods protect the emulsion side of the film from moisture and scratches. If paint is used, it should be non-water based, or terrible colour streaks will appear, caused by uneven drying of the emulsion.

We do not recommend the use of split beam reflection holograms – front lighting is adequate for almost all situations, and split beam set-ups are more trouble than they are worth.

The single beam hologram is always contained behind the film, possibly a limitation. There is, however, a method of moving the image forwards through the film, so that is appears to stick out, this process is called image planning, and is not difficult – it involves making a 'master' transmission hologram, then copying it onto a second piece of film, held in the middle of the projected image. This produces a reflection hologram, which can be seen to stick out of the film, although the extent of this is usually small – any point further than about 2cm away from the film is blurred.

	Shift towards Red	Shift towards Blue
Concentration of triethanolamine	*More concentrated*	*More dilute*
solution Time film immersed in triethanolamine	*Longer*	*Shorter*
solution Amount of drying with tissues	*Gentler*	*More thorough*

Table 1. Controlling colour of hologram through emulsion expansion.

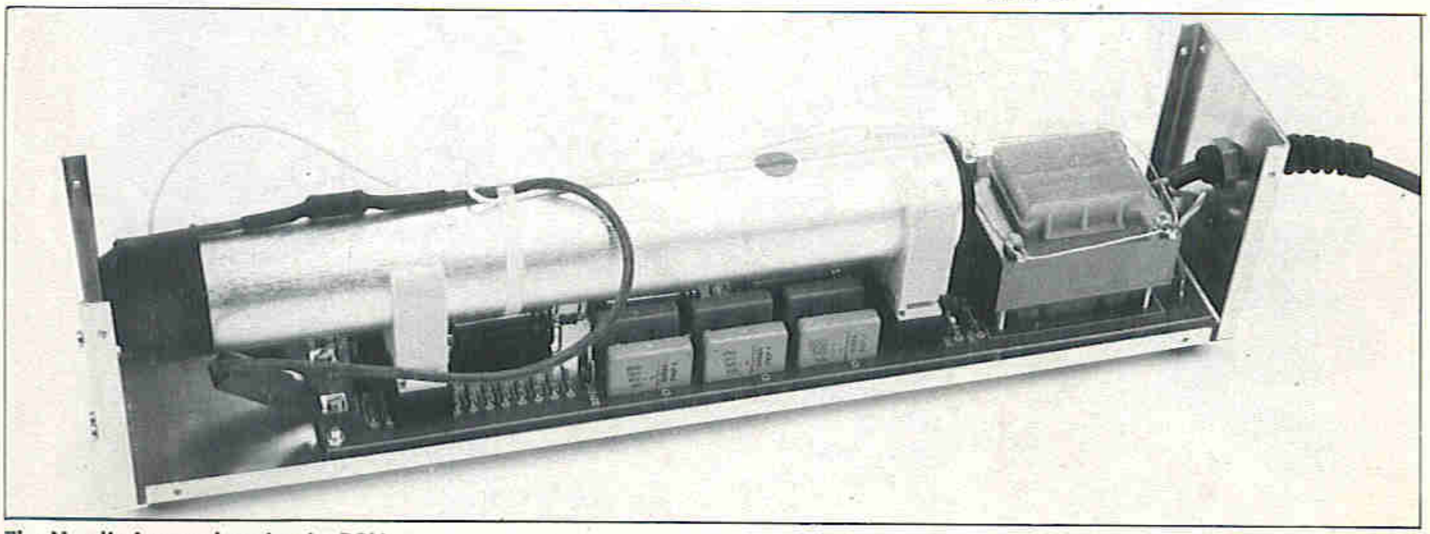
References

Holography Handbook by Fred Unterseher, Jeannene Hansen, Bob Schlesinger published by Ross Books ISBN 0-89406-017-2.

The Open University Course Notes (optics).

The Complete Book of Holograms by J. E. Kasper, S. A. Feller published by Wiley ISBN 0-471-62941-3.

Thanks must go to:
Martin Poyser (co-venturer).
His parents (for the use of the garden shed).
My parents.
Assorted teachers at school.
Agfa, who really got us started.
And a big no thanks to Ilford, who told us to get lost!



The Maplin Laser showing its PSU.

Error Chart – Single Beam Reflection

PROBLEM	CAUSE	SOLUTION
1) Completely clear film after development.	i) No exposure – shutter was not opened at all.	Ensure shutter moves clear of beam.
	ii) Developer unsuitable or too weak.	Use Ilford Perceptal, made up as instructions.
	iii) Very short exposure.	30 seconds is only a recommended time – try 40 seconds.
	iv) Under development.	If coupled with very short exposure, increase the development time rather than the exposure time. Develop until film is almost completely opaque when held up against dim safelight.
2) Completely black film after development.	i) Exposure for too long.	Remedy (if necessary).
	ii) Film fogged in packet.	Unlikely, but try developing a piece of unexposed film – if it comes out black, the film is fogged – no solution. Get new film and be more careful.
	iii) Dark room leaking light/safelight too bright/safelight too close to exposure/development area.	Block off all outside light, ensure that safelight is very dim and green. (You should not be able to see the other side of the room, or your feet.)
3) Black patches on film.	Movement.	Movement is much more critical in reflection set-ups, so re-secure every component, leave longer settling times and make sure the film is held securely.
4) Hologram dim but present.	Processing errors are most likely. i) Wrong order of processing. ii) Wrong chemicals. iii) Insufficient washing. iv) Old chemicals.	
5) Everything else looks OK, but no hologram.	Playback in the wrong colour.	If this is the problem, the processing can be stopped after DEVELOP or STOP or WASH or DRY, then look at the hologram. It should be bright (ish) but will not last long. If there is a good hologram at this stage, but it disappears with further processing, it is probably the fault of the fix (replace it) or the triethanolamine. Try different concentrations/drying techniques.

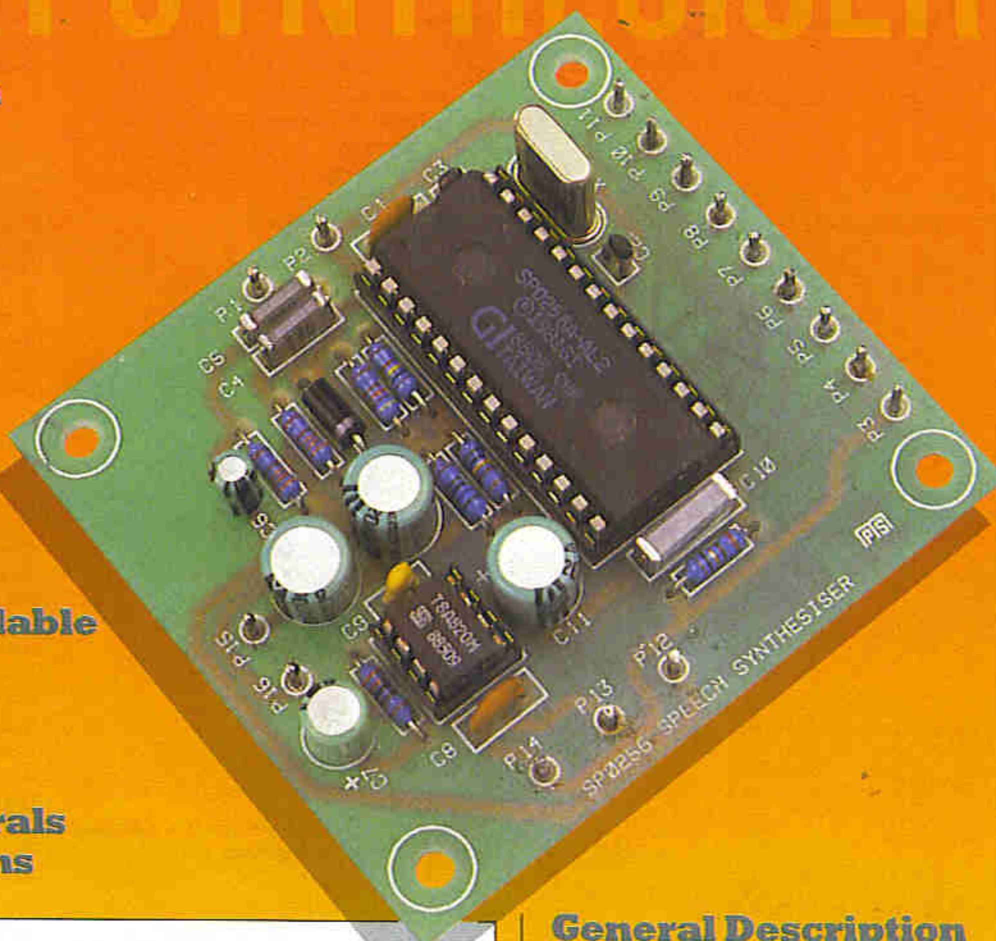
Error Chart – Single Beam Transmission

PROBLEM	CAUSE	SOLUTION
1) Completely clear film after development.	i) No exposure – shutter was not opened at all.	Ensure shutter moves clear of beam.
	ii) Developer unsuitable or too weak.	Use Ilford Perceptal, made up as instructions.
	iii) Very short exposure.	15 seconds is only a recommended time – try 30 seconds.
	iv) Under development.	If coupled with very short exposure, increase the development time rather than the exposure time. Develop until film is clearly visible against bottom of Develop bath even in very dim light.
2) Completely black film after development.	i) Exposure for too long.	Remedy.
	ii) Film fogged in packet.	Unlikely, but try developing a piece of unexposed film – if it comes out black, the film is fogged – no solution. Get new film and be more careful.
	iii) Dark room leaking light/safelight too bright/safelight too close to exposure/development area.	Block off all outside light, ensure that safelight is very dim and green. (You should not be able to see the other side of the room, or your feet.)
3) Film fairly grey, but no hologram.	i) Serious movement during exposure.	Secure all components, make sure the object is suitable (reflective and rigid).
	ii) Laser not in TEM00, or coherence length too short.	Buy the Maplin laser!
	iii) You just haven't found the hologram yet.	This is the most common problem. Keep trying – cutting the corner off the film is a very good idea.
4) Hologram present, but dim.	i) Object too dim/not reflective enough.	Use white, red, yellow or metallic object.
	ii) Object too far for film.	Move it closer.
	iii) Using wrong film.	Use AGFA 8E75HD T3.
	iv) Develop/Exposure times wrong.	Try again.
	v) Overexpectations.	The image will almost always be less bright than the original.
5) Bands of darkness across image, otherwise OK.	Movement – in one of two areas:	
	i) Film moved – with this type of movement, there are 'dead' areas on the film, often in 'rings' around specks of dust.	Clean the glass sheets before the next exposure, and squeeze them together on the film to eliminate any bubbles/pockets.
	ii) Object moved – with this, there are normally straight bands across the object, where it has moved during exposure. These look the same viewed from any angle. It can also produce 'missing' parts of the object – any part which moves too much will be invisible.	Secure the object better (glue it to the film-holder base if necessary). Use a rigid object, and, if possible, reduce the exposure time. Also ensure that the table is not jarred as you lift the shutter.
6) Hologram generally OK, but 'blobs' on film (and in the beam, if projected onto a piece of white card).	Dirt on optics.	Clean lens(es) or use different areas of them.

Error Chart.

SP0256 SPEECH SYNTHESISER

by Gavin Cheeseman



Features
- ★ Minimum Number of Components
- ★ 64 Allophones Available
- ★ Kit Available

Applications
- ★ Games and Toys
- ★ Computer Peripherals
- ★ Telecommunications

Parameters	Conditions	Min.	Typ.	Max.
Supply Voltage		4.6V		7V
Supply Current	Primary Standby			90mA 15mA
Clock Frequency	Crystal Controlled		3.120MHz	
Temperature	Operating Storage	0°C −25°C		+70°C +125°C
Input Capacitance				10pF
Input Leakage Current				±10μA
Output Logic 0		0V		0.6V
Output Logic 1		3.5V		Standby Supply Voltage
Input Logic 0	Pins 10, 11, 13–22	0V		0.6V
Input Logic 1	Pins 10, 11, 13–22	2.4V		Standby Supply Voltage

Table 1. SP0256 electrical characteristics.

General Description

The SP0256 is a single chip speech synthesiser that is capable of producing complex sounds or speech using a program that is stored in internal ROM. It is possible to obtain an output which is equivalent to a flat frequency response up to 5kHz, with a signal to noise ratio of approximately 35dB and a dynamic range of 42dB. Figure 1 shows the IC pinout and Table 1 shows some typical electrical characteristics for the device. The function of each of the IC pins is given in Table 2.

IC Description

The SP0256 effectively includes a software programmable digital filter, a 16K ROM, a microcontroller and a pulse width modulator. Figure 2 shows the IC block diagram. The microcontroller regulates the flow of data from the internal ROM (which contains the program) to the

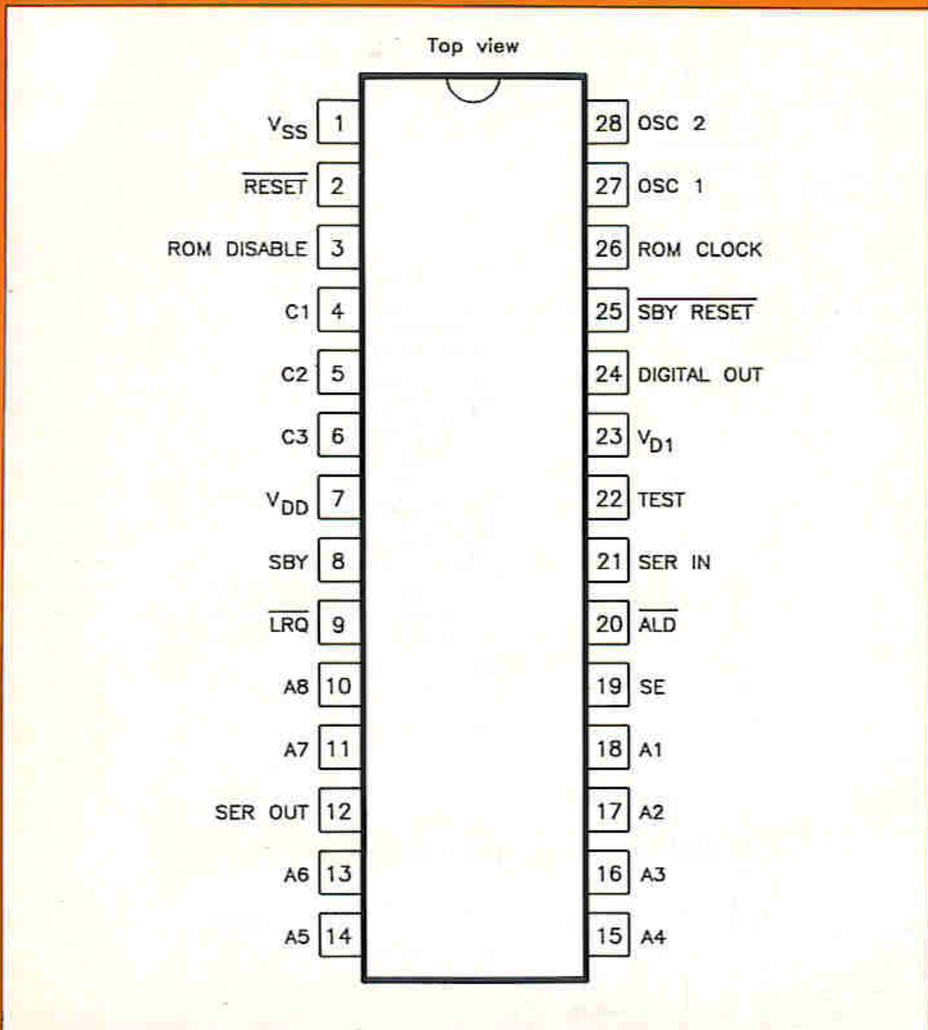


Figure 1. IC pinout.

digital filter and controls the assembly of the word strings which are needed to link individual segments of speech information together in order to make words. A pulse width modulator produces the digital output which can be converted to an analogue signal by an external low pass filter. Figure 3 shows the timing diagram for the IC and Table 3 shows the corresponding AC characteristics.

SP0256 Kit

A kit of parts is available for a basic application circuit using the SP0256 speech synthesiser including a pcb, see Figure 4 for the layout of the board and Figure 5 for its circuit. The circuit includes an additional on-board power amplifier IC which is capable of driving directly into an 8Ω loudspeaker (not included in the kit). Loudspeaker connections are made via P15 and P16.

A regulated 5V power supply is required to power the module and this should be capable of delivering at least 200mA. It is important that the power supply output is adequately smoothed as this helps to prevent any instability that could occur in the power amplifier stage. Power supply connections are made to P1 (+V) and P2 (0V).

Figure 6 shows a typical 'stand alone' test set-up using the module. A binary code is set up on address inputs P4 – P9 and it is this code that determines which of the allophones stored in internal ROM is selected; P4 is the most significant bit and P9 is the least significant bit. The load request output will be at logic 0 (low state)

Pin Number	Name	Function
1	V_{ss}	Ground.
2	$\overline{RESET}$	A logic 0 resets the SP. Must be returned to a logic 1 for normal operation.
3	ROM DISABLE	For use with an external serial speech ROM. A logic 1 disables the external ROM.
4,5,6	C1,C2,C3	Output control lines used by an external serial speech ROM.
7	V_{DD}	Primary power supply.
8	SBY	STANDBY. A logic 1 output indicates that the SP is inactive (i.e. not talking) and V_{DD} can, for example, be powered down externally to conserve power. When the SP is reactivated by an address being loaded, SBY will go to a logic 0.
9	$\overline{LRQ}$	$\overline{\text{LOAD REQUEST}}$. $\overline{LRQ}$ is a logic 1 output whenever the input buffer is full. When $\overline{LRQ}$ goes to a logic 0, the input port is loaded by placing the 8 address bits on A1-A8 and pulsing the $\overline{ALD}$ input.
10,11,13,14 15,16,17,18	A8,A7,A6,A5, A4,A3,A2,A1	8-bit address which defines any one of 256 speech entry points.
12	SER OUT	SERIAL ADDRESS OUT. This output transfers a 16-bit address serially to an external speech ROM.
19	SE	STROBE ENABLE. Normally held in a logic 1 state. When tied to ground, ALD is disabled and the SP will automatically latch in the address on the input bus approximately 1μs after detecting a logic 1 on any address line.
20	$\overline{ALD}$	ADDRESS LOAD. A negative pulse on this input loads the 8 address bits into the input port. The leading edge of this pulse causes LRQ to go high.
21	SER IN	SERIAL IN. This is an 8-bit serial data input from an external speech ROM.
22	TEST	A logic 1 places the SP in its test mode. The pin should be normally grounded.
23	V_{D1}	Standby power supply for the interface logic and controller.
24	DIGITAL OUT	Pulse width modulated digital speech output which, when filtered by a 5kHz low pass filter and amplified, with drive a loudspeaker.
25	$\overline{SBY\ RESET}$	$\overline{\text{STANDBY RESET}}$. A logic 0 resets the interface logic. Normally should be a logic 1.
26	ROM CLOCK	This is a 1.56MHz clock for an external serial speech ROM.
27	OSC 1	XTAL IN. Input connection for a crystal.
28	OSC 2	XTAL OUT. Output connection for a crystal.

Table 2. IC pin functions.

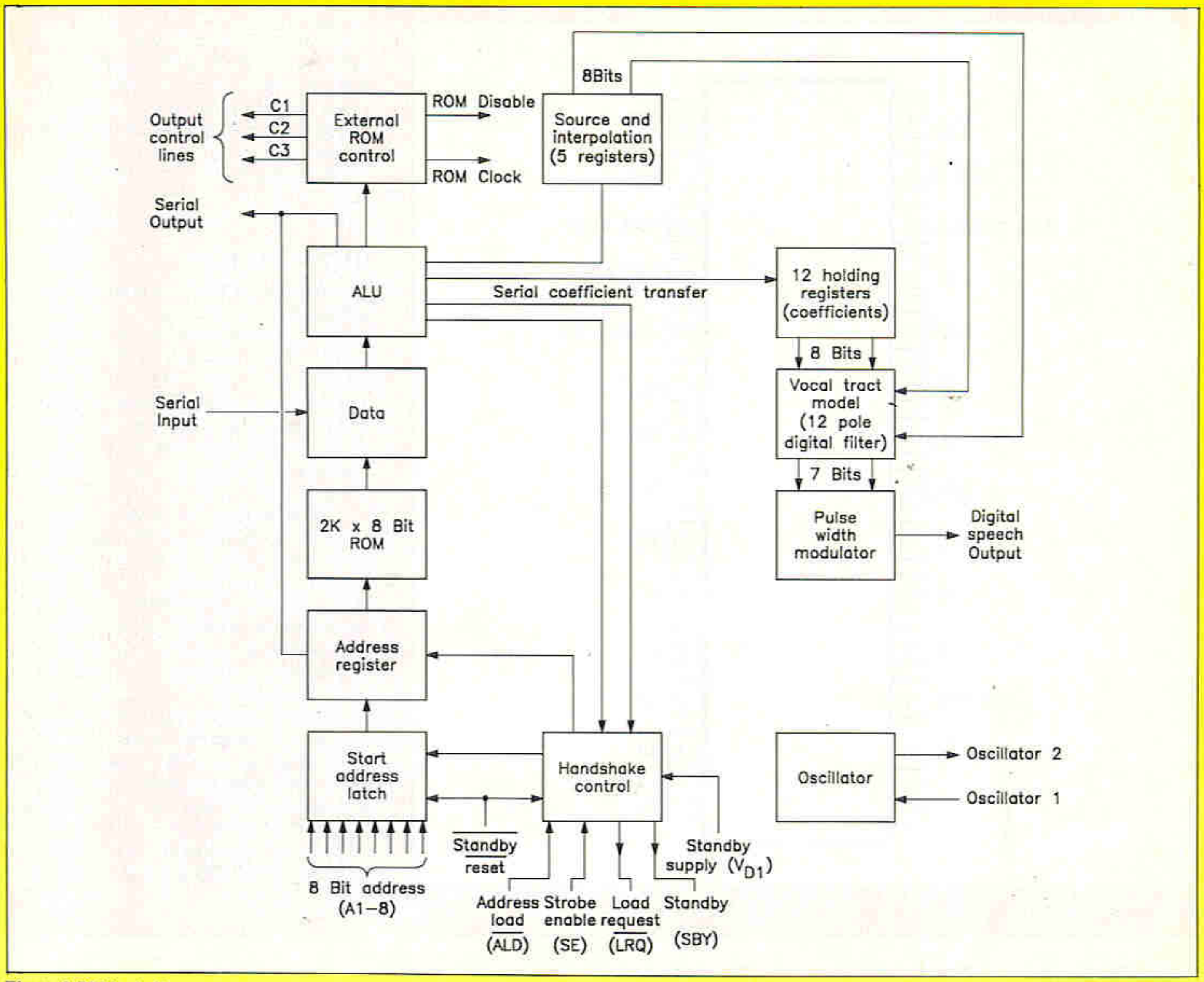


Figure 2. IC block diagram.

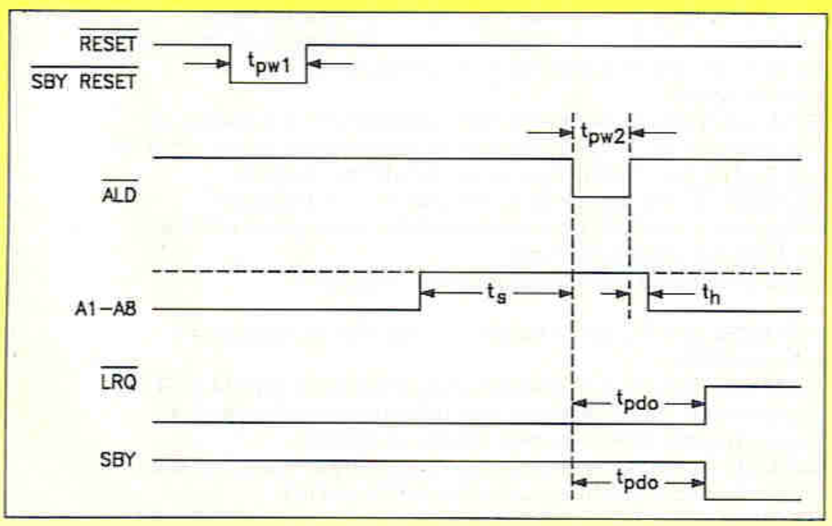


Figure 3. Timing diagram.

AC CHARACTERISTICS

Operating Temperature = 0°C to +70°C

Characteristics	Sym	Min	Typ	Max	Units
Reset, SBY Reset	t_{pw1}	100	—	—	µs
ALD	t_{pw2}	200	—	—	ns
A1-A8 Set Up	t_s	450	—	—	ns
A1-A8 Hold	t_h	0	—	—	ns
LRQ	t_{pd0}	—	—	300	ns
SBY	t_{pd0}	—	—	300	ns

Table 3. AC characteristics.

when the IC is ready to receive an address input. To load the selected address it is necessary to momentarily connect P10 to 0V (pulse P10 low); the allophone corresponding to the code on the address bus will then be executed and during this time the load request output is high. A total of 64 allophones are stored in the IC's internal ROM and a list of these together with the corresponding binary codes is shown in Table 4.

In order to produce the necessary codes fast enough to make intelligible speech, pins P4 – P11 would normally be connected to a microcomputer; however, it is outside the scope of this article to provide connection information for individual computers. Figure 7 shows a typical method of interfacing the module to a computer, using a 7 bit output port and a single bit input port. An example of a program in BASIC for outputing data to a typical I/O ports is shown in Table 5. The program outputs the necessary data to produce the allophones for the phrase 'I am a computer'. A full discourse on how to use allophones is supplied with the kit.

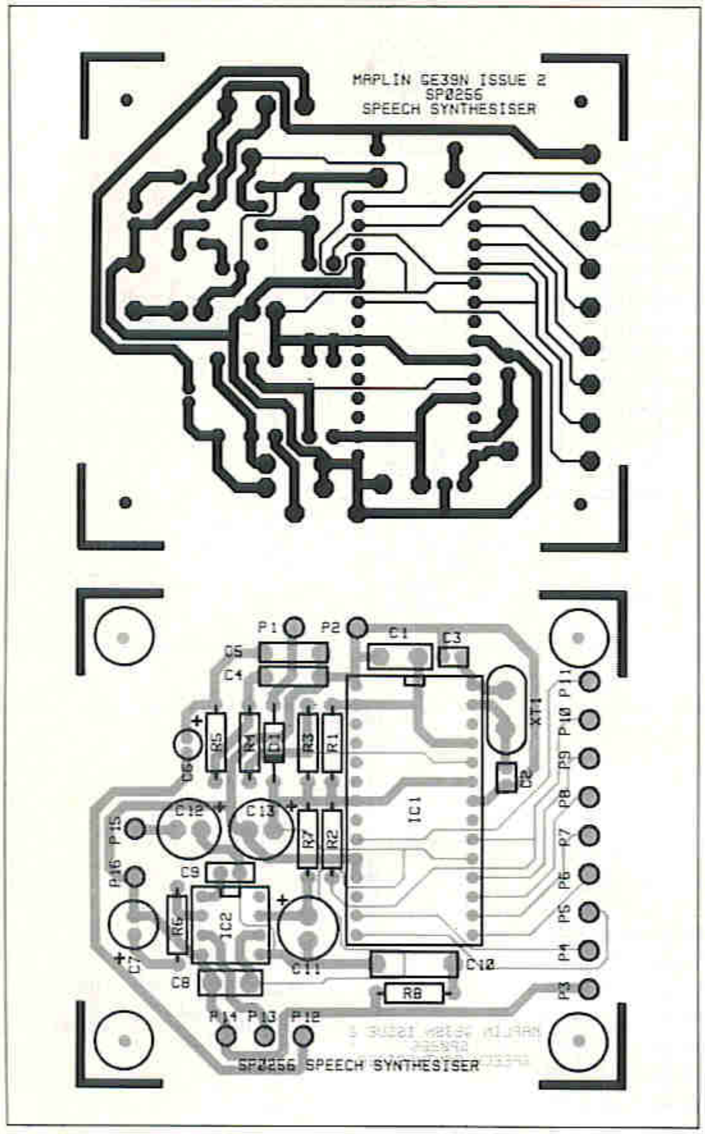


Figure 4. PCB layout.

Code	Allophone	Code	Allophone
000000	PAUSE 10ms	010000	MM
000001	PAUSE 30ms	010001	TT1
000010	PAUSE 50ms	010010	DH1
000011	PAUSE 100ms	010011	IY
000100	PAUSE 200ms	010100	EY
000101	OY	010101	DD1
000110	AY	010110	OOW
000111	EH	010111	AO
001000	KK3	011000	AA
001001	PP	011001	YE
001010	JH	011010	AE
001011	NN	011011	HH1
001100	IH	011100	BU
001101	TT2	011101	TH
001110	RR1	011110	UO
001111	AX	011111	UOO

Code	Allophone	Code	Allophone
100000	OU	110000	WH
100001	DD2	110001	YUH
100010	GG	110010	CH
100011	VE	110011	ERE
100100	GU	110100	ERR
100101	SSH	110101	UO
100110	SZ	110110	DH2
100111	R	110111	SS
101000	FF	111000	NNN
101001	KER	111001	HER
101010	KU	111010	OR
101011	ZER	111011	AR
101100	NA	111100	YR
101101	LL	111101	GGG
101110	WW	111110	EL
101111	RE	111111	BB

Table 4. SP0256 allophone sounds and corresponding binary codes.

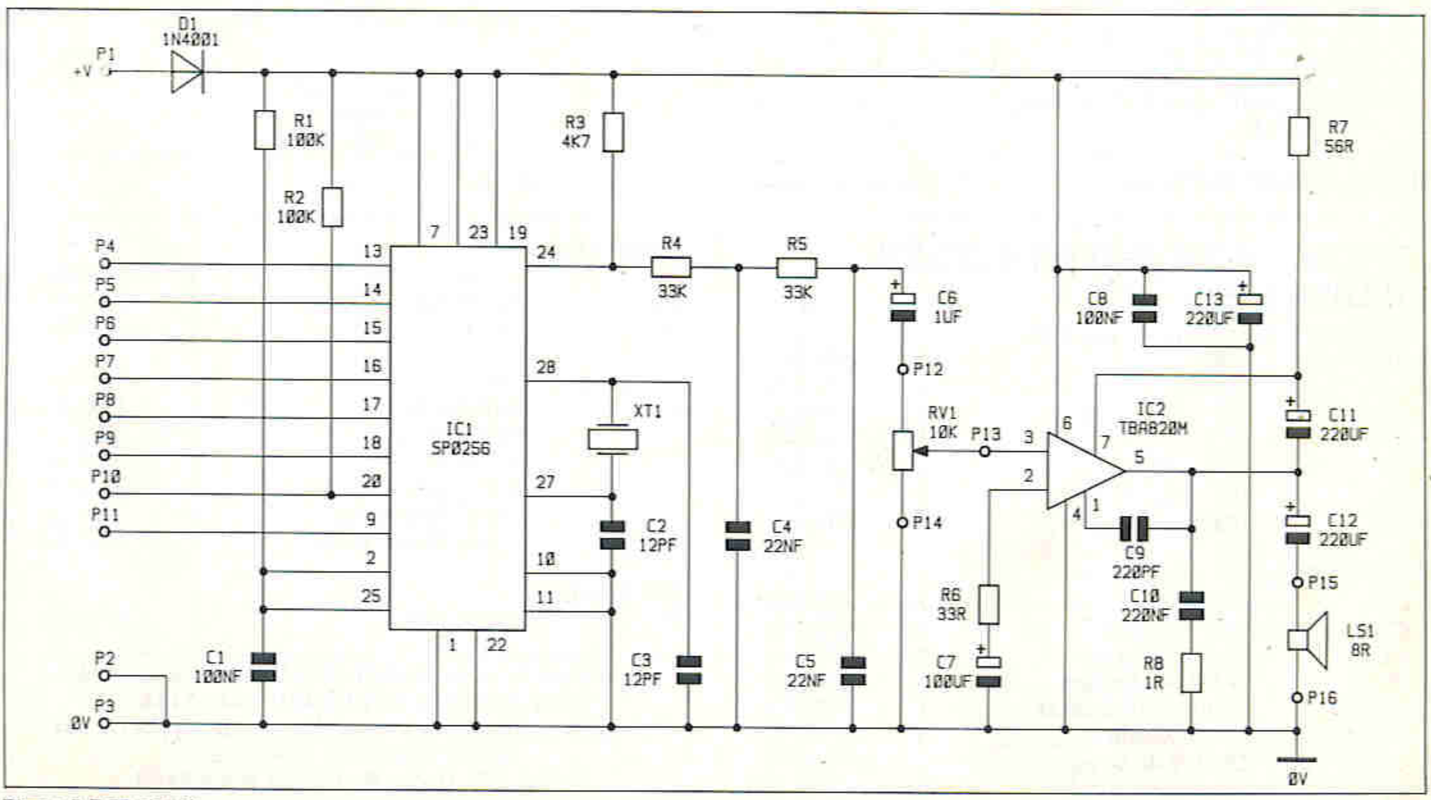


Figure 5. PCB circuit.

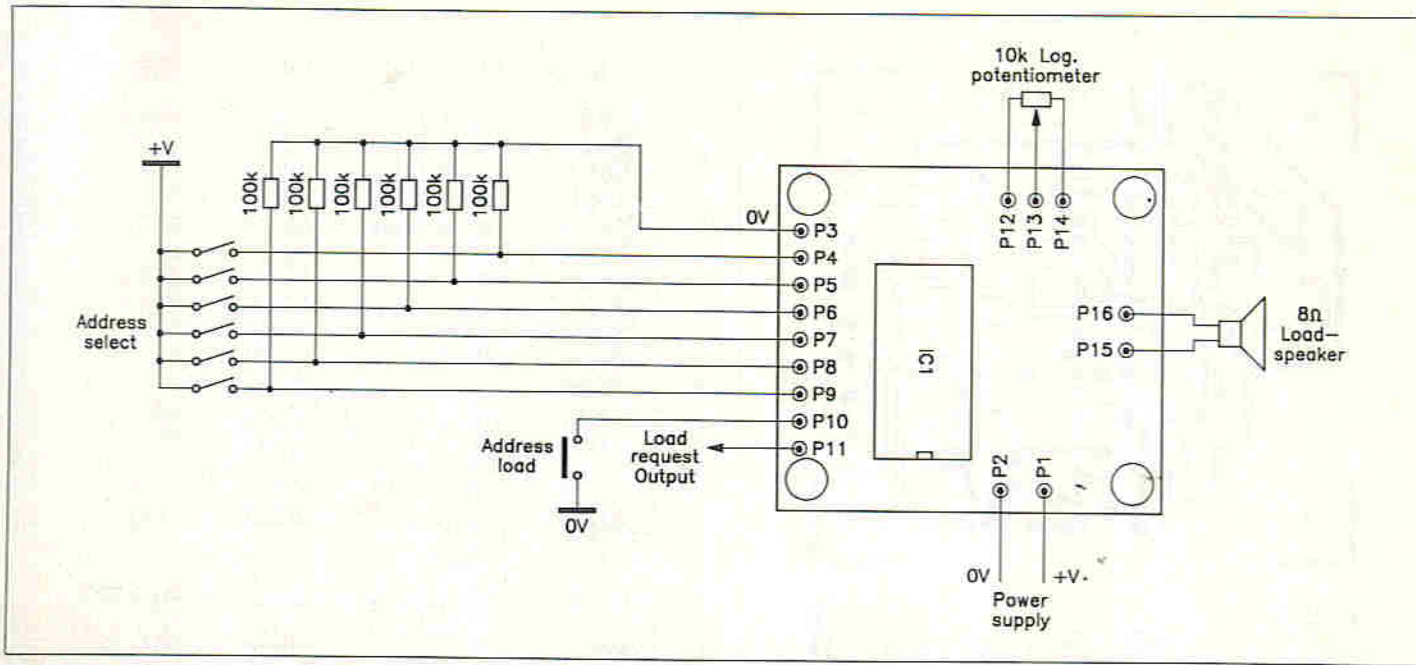


Figure 6. Typical test set-up.

When stringing together allophones to make words, some experimentation is needed to obtain the best results. In practice, it is often necessary to try out different allophone sounds until optimum intelligibility is achieved.

```
10 REM DEMO PROGRAM
20 RESTORE
30 FOR 1 = 1 to 18
   (Number of codes in DATA statement)
40 READ A
50 OUT PORT1, (A+64)
   (Data D0 - D5, D6 high)
60 IN PORT2,B
   (Busy register)
70 IF B> = 128 GOTO 60
   (Wait for busy register free)
80 OUT PORT1, A
   (Data D0 - D5, D6 low)
90 NEXT I
100 DATA 6,0,1,26,16,0,2,20,41,1,24,16,9,
    49,22,13,51,0
```

Listing 1. Example test program.

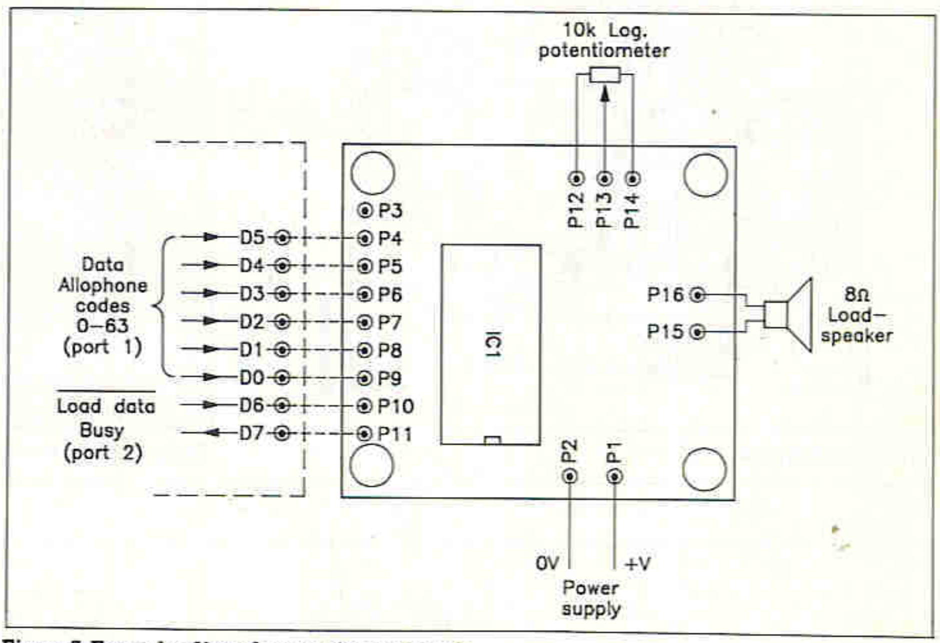


Figure 7. Example of interface to microcomputer.

SP0256 SPEECH SYNTHESISER PARTS LIST

RESISTORS: All 1% 0.6W Metal Film

R1,2	100k	2	(M100K)
R3	4k7	1	(M4K7)
R4,5	33k	2	(M33K)
R6	33Ω	1	(M33R)
R7	56Ω	1	(M56R)
R8	1Ω	1	(M1R)
RV1	10k Log Pot	1	(FW22Y)

CAPACITORS

C1,8	100nF Disc	2	(YR75S)
C2,3	12pF Ceramic	2	(WX45Y)
C4,5	22nF Poly Layer	2	(WW33L)
C6	1µF 63V Minelect	1	(YY31J)
C7	100µF 10V Minelect	1	(RK50E)
C9	220pF Ceramic	1	(WX60Q)
C10	220nF Poly Layer	1	(WW45Y)
C11,12,13	220µF 10V Minelect	3	(JL06G)

SEMICONDUCTORS

IC1	SP0256	1	(QY50E)
IC2	TBA820M	1	(WQ63T)
D1	1N4001	1	(QL73Q)

MISCELLANEOUS

XT1	3.27MHz Crystal	1	(FY86T)
	Pins 2145	1 Pkt	(FL24B)
	PC Board	1	(GE39N)
	DIL Socket 8 Pin	1	(BL17T)
	DIL Socket 28 Pin	1	(BL21X)
	Constructors Guide	1	(XH79L)

OPTIONAL

LS1	Loudspeaker	1	(YT25C)

A complete kit of parts, excluding Optional, is available:
Order As LP10L (SP0256 Kit) Price £14.95
The following item is also available separately, but is not shown in our 1990 catalogue:
SP0256 PCB **Order As GE39N Price £2.25**

NICAM TV TUNER continued from page 39.

Alignment

There are two basic methods of IF alignment:

1. The high accuracy approach using a TV signal generator, oscilloscope and audio distortion meter.
2. Medium accuracy approach using OFF-AIR TV signals.

To observe the final video and audio outputs you will need a composite colour monitor and an audio amplifier, the amplifier will need to be stereo if the tuner is used in conjunction with the NICAM decoder kit.

Before you commence alignment of the unit set the two PCB presets as follows: RV1 almost fully clockwise. RV2 at its half way setting.

Using a trimming tool (BR51F), carefully adjust the iron dust cores of L3, L4, L6, L7, L8, L10 and L11 until they are flush with the top of the screening can. Next adjust each coil in a clockwise direction as follows:

L3 = 4.5 turns.	L8 = 3.5 turns.
L4 = 3.5 turns.	L10= 2.5 turns.
L6 = 1 turn.	L11= 2 turns.
L7 = 1.5 turns.	

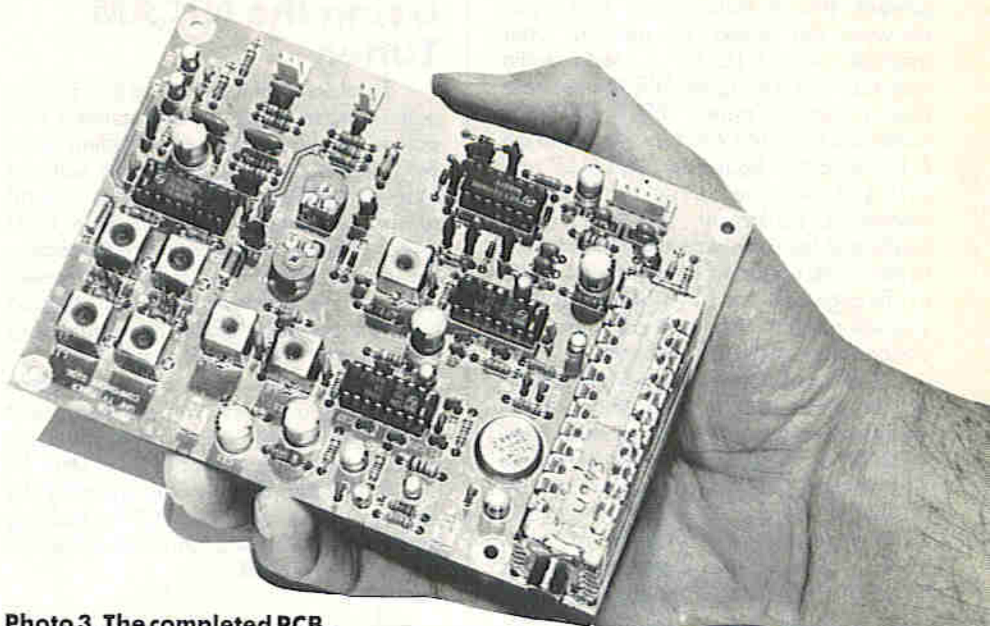


Photo 3. The completed PCB.

Next connect your TV aerial to SK6 and with the AFC switch, S1, in the off position, adjust the tuning voltage selector to a local TV channel. If the picture quality is not as you expected, adjust L3 until no further improvement can be observed. Switch on the AFC and adjust L4 so that the picture is the same with the AFC on or off. To test the AFC action try the following:

1. Switch OFF the AFC.
2. Tune off channel until you lose colour, or the picture begins to break-up.
3. Switch ON the AFC and the picture should lock back in.
4. Switch OFF the AFC.
5. Re-tune the TV channel.
6. Switch ON the AFC.

To set the AGC simply turn RV1 in a counter clockwise direction until the picture starts to become noisy. Then advance it just enough to restore the picture quality and stability.

Next set your multimeter to read DC volts. Connect its positive lead to TP2 and its negative test lead to a 0V ground point. With no TV signal present this reading can go as high as 2V and it's this action that controls the squelch circuit. To set the squelch threshold tune to a clear TV channel, or remove the aerial from SK6. Defeat the squelch by closing S2 and using S3 select the UK 6MHz sound output. When you advance the volume control on your audio system you should hear the familiar 'hissing' sound associated with an 'off station' FM radio. Activate the squelch circuit and adjust RV2 until the hissing noise suddenly stops. When a TV signal is

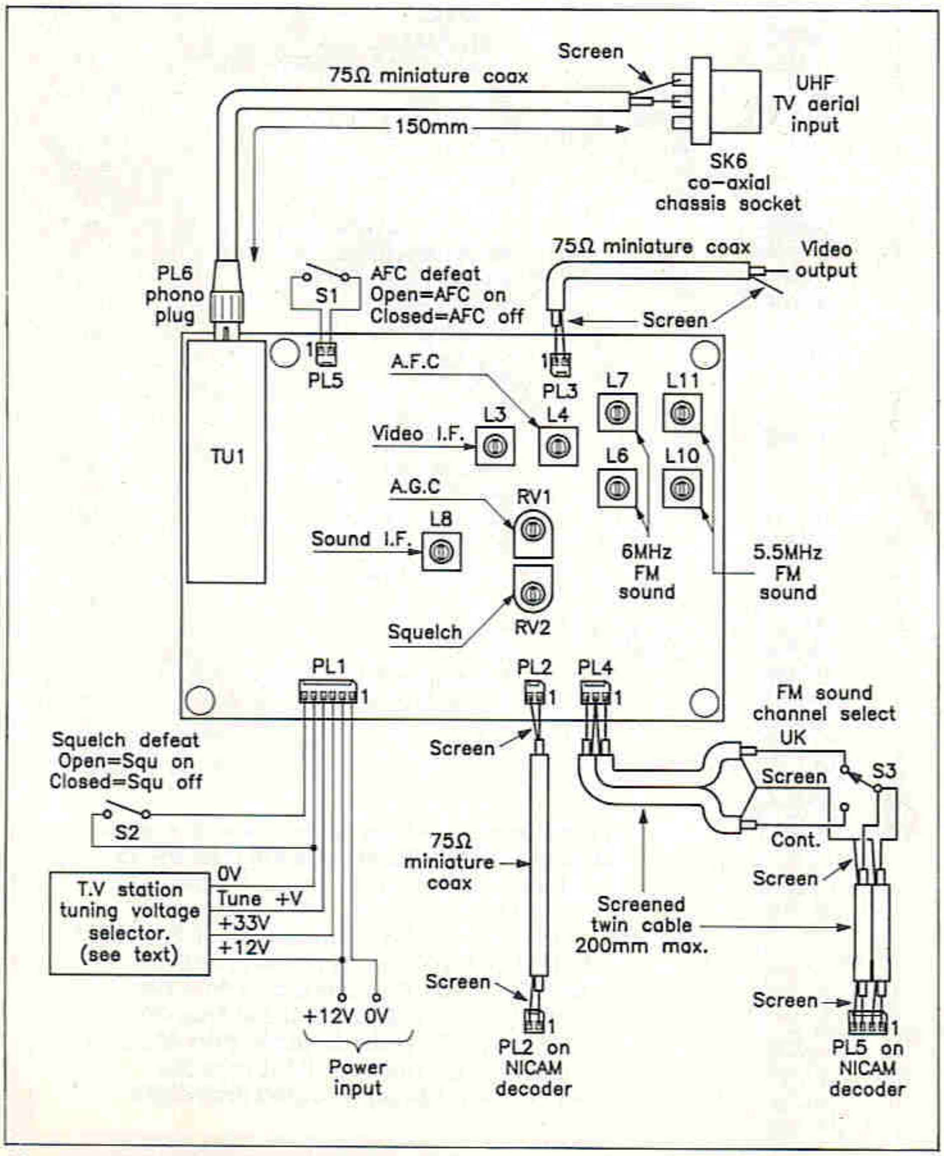


Figure 10. Wiring and alignment points.

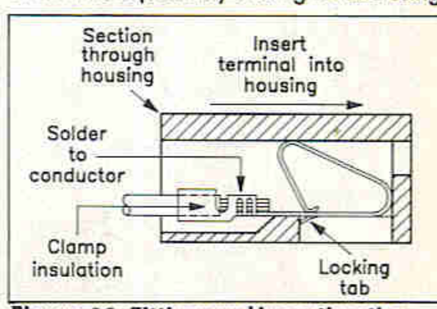


Figure 11. Fitting and inserting the Minicon terminals.

present, the squelch should then open allowing the audio to pass to your amplifier. Adjust L8 for a clean audio response and if using the NICAM decoder ensure that the stereo LED is on when tuned to a NICAM TV station. To obtain the 0.1% distortion figure on FM, L6, L7 and L10, L11 must be set up using special measuring equipment. However, good results can be achieved simply by listening to the audio output while adjusting L6 and L7. To align L10 and L11 without test gear you will need to receive a continental TV station using 5.5MHz FM sound.

If NICAM signals are being transmitted in your region then they should appear on pin 1 of PL2 as a modulated 6.552MHz carrier suitable for decoding. The Maplin NICAM decoder project appeared in the previous December 1989 to January 1990 edition of "Electronics – The Maplin Magazine", copies of which are available on 'back-order'.

Using the NICAM Tuner

To obtain optimum sound and picture quality you must use a well regulated 12V power supply, capable of providing up to 500mA if the tuner is to be used with the Maplin NICAM decoder. The sound reproduction offered by modern Hi-Fi systems should more than accommodate the audio from the tuner. However, ultimately its performance will depend upon the condition of the TV signal being picked up by your aerial system.

If you don't have a colour video monitor, or a TV with an auxiliary input (SCART), the video output from the tuner must be converted back in to a UHF TV signal. This can be achieved by using the external video input of a VCR, or building the Maplin audio and video modulator kit (Stock code LM78K).

Unfortunately, at the time of development, only the Crystal Palace and Emley Moor TV transmitters were equipped with NICAM. However, during the 1990's it is planned that more transmitter sites will come on-line and a map showing the expected dates was included in the decoder project.

In a future issue of this magazine a switch and socket link-up project will be presented with (hopefully) the following features:

Power input protection.
TV station selector and indicator.
NICAM tuner function switches and indicators.
Video and audio outputs using SCART, Phono and DIN sockets.

Until then, I hope you enjoy building this project and the NICAM decoder project published in the last issue.

PARTS LIST

Resistors: All 0.6W 1% Metal Film			
R1	47k	1	(M47K)
R2	39k	1	(M39K)
R3,5	2k7	2	(M2K7)
R4,30,33	10k	3	(M10K)
R6	1k5	1	(M1K5)
R7,11,15,20	10Ω	4	(M10R)
R8,23	180Ω	2	(M180R)
R9	2M2	1	(M2M2)
R10,21,24	1k	3	(M1K)
R12,18	3k3	2	(M3K3)
R13	22k	1	(M22K)
R14,17	680Ω	2	(M680R)
R16,19,22	470Ω	3	(M470R)
R25,28,29,31,32	4k7	5	(M4K7)
R26,27	100Ω	2	(M100R)
RV1	10k Hor Encl Preset	1	(UH03D)
RV2	47k Hor Encl Preset	1	(UH05F)
Capacitors			
C1,4,20	47μF 16V Minelect	3	(YY37S)
C2,3,22-25,29,32 48,55,58,61,63,65 66,68,69	10nF Ceramic	17	(WX77J)
C5,38,54	1nF Ceramic	3	(WX68Y)
C6,18,30,56,62,64	1μF 63V Minelect	6	(YY31J)
C7,37,53	22uF 16V Minelect	3	(YY36P)
C8-13,34,50	47nF 50V Disc	8	(BX02C)
C14-17,21	100nF 100V Monores	5	(RA49D)
C19,31,33,47,59	220μF 16V PC Electrolytic	5	(FF13P)
C26,60	47pF Ceramic	2	(WX52G)
C27,28,67	100pF Ceramic	3	(WX56L)
C35,49,51	22nF Ceramic	3	(WX78K)
C36,52	33nF Poly Layer	2	(WW35Q)
C39	560pF Ceramic	1	(WX65V)
C40,41,44,45	22pF Ceramic	4	(WX48C)
C42	680pF Ceramic	1	(WX66W)
C43,46	820pF Ceramic	2	(WX67X)
C57	220pF Ceramic	1	(WX60Q)
Semiconductors			
D1-D9	1N4148	9	(QL80B)
ZD1	ZTK33B	1	(UF29G)
TR1	BC548	1	(QB73Q)
IC1,2	TDA8341	2	(UL27E)
IC3	TDA2555	1	(UL28F)
IC4	40106BE	1	(QW64U)
Miscellaneous			
TU1	U943 UHF Television Tuner Module	1	(JR59P)
FL1	SW166 SAW Filter	1	(UL52G)
FL2	6MHz Ceramic Filter	1	(UL53H)
FL3	5.5MHz Ceramic Filter	1	(UL54J)
L1,2	22μH Choke	2	(WH37S)
L3,4,8	38.9MHz TV IF Coil (TVIF389)	3	(UL55K)
L5,9	6μ8H Choke	2	(WH34M)
L6,7,10,11	6MHz TV IF Coil (MKANSK1731HM)	4	(UL56L)
PL1	Minicon Latch Plug 6way	1	(YW12N)
PL2,3,5	Minicon Latch Plug 2way	3	(RK65V)
PL4	Minicon Latch Plug 3way	1	(BX96E)
SK1	Minicon Latch Housing 6way	1	(BH65V)
SK2,3,5	Minicon Latch Housing 2way	3	(HB59P)
SK4	Minicon Latch Housing 3way	1	(BX97F)
	Minicon Terminals	2 Pkts	(YW25C)
PL6	Screw-Cap Phono Black	1	(HQ54J)
SK6	Coax Socket	1	(HH08J)
	DIL Socket 14-pin	1	(BL18U)
	DIL Socket 16-pin	2	(BL19V)
	DIL Socket 18-pin	1	(HQ76H)
	Miniature Coax	1 Mtr	(XR88V)
	Cable Twin	1 Mtr	(XR21X)
	Ribbon Cable 10 way	1 Mtr	(XR06G)
	P.C. Board	1	(GE35Q)
	Constructors Guide	1	(XH79L)
Optional			
S1,2,3	See Text		
	Tuning Control 47k Linear Pot	1	(FW04E)
	Pot Core Trim Tool	1	(BR51F)

The parts listed above, excluding Optional, are available as a kit.
Order As LP09K (NICAM Tuner Kit) Price £44.95
The following items are also available separately,
but are not shown in our 1990 catalogue:
U943 UHF Television Tuner Module **Order As JR59P Price £9.95**
SW166 SAW Filter **Order As UL52G Price £4.75**
6MHz Ceramic Filter **Order As UL53H Price 42p**
5.5MHz Ceramic Filter **Order As UL54J Price 42p**
38.9MHz TV IF Coil **Order As UL55K Price 48p**
6MHz TV IF Coil **Order As UL56L Price 56p**
UHF TV Tuner PCB **Order As GE35Q Price £6.95**

Air your views!

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.

Back emf?

Dear Sir,
I was surprised to see an elementary error, in the article Remote Power Switch in the latest issue of your magazine. In the paragraph headed Circuit Description it is stated that "The diode D1 is used to prevent any back emf damaging whichever type of drive circuit (is) used, caused by the collapse of the magnetic field around the coil . . .". Misuse of the term "back emf" in this context seems to be increasingly widespread these days. My mind goes back almost 60 years to the time when, as a 14 year old school boy, I was taught its true meaning by my physics teacher. Its correct application is to the emf generated in an electric motor, where it opposes the supply voltage and progressively reduces the flow of current as the speed of rotation increases. Its consequences are entirely benign, since it serves only to reduce the accelerating torque of the motor as it approaches its maximum intended speed. The unwelcome phenomenon that D1 is there to deal with might, in contrast, be defined as "forward emf". Abruptly interrupting the flow of current in an inductive circuit is somewhat akin to stopping a flywheel by jamming a stick through its spokes. The resultant (and possibly destructive) force may in fact be loosely described as the electromagnetic equivalent of forward momentum. The collapse of the magnetic field generates an emf which seeks to maintain, NOT oppose, the previous current flow. In other words it adds to the supply voltage, whereas back emf subtracts from it. Call me a pedant if you like, but I prefer that words be used with their correct meaning, and it is certainly not correct – though sadly commonplace – to say "back" when you mean "forward". Perhaps the increasingly prevalent confusion in this regard is a consequence of the notorious present day shortage of competent physics teachers in our schools, and my ire should be directed not to you and your colleagues but to a government that has allowed this situation to develop.
Bill Foster, Middlesbrough.

The term 'back emf' in the past has been a cause for controversy, as with any term, its correct interpretation depends on the context in which it is used. Another cause for argument is the term 'current', by convention, an electric current flows through a circuit from the positive supply (or point of higher potential) to the negative supply (or point of lower potential), this is termed 'conventional current flow'. Modern day physics tells us that the converse is true; current flow (i.e. the movement of electrons) through a circuit is from the negative supply (or point of lower potential) to the positive supply (or point of higher potential), this is termed 'electron current flow'. But then, paradoxically, life is full of many 'contradictions'. Returning to the term in question, in the case of the remote power switch: The term 'back emf' is in the context of the voltage developed across a relay coil (essentially an inductor) when the supply to it is removed. The term is NOT used in the context of motors, to which you have made the connection, however, your explanation of back emf in the context of motors is perfectly correct. As you state, the interruption of a current flowing in an inductor is analogous to stopping a flywheel by jamming a stick through its spokes. The inductive relay coil has stored energy which can be released slowly (and safely) by use of a diode, or quickly (destructive to drive transistors) without a diode. Mathematically, the voltage developed across an inductor is equal to the inductance of the coil multiplied by the change in current divided by the time taken for the change to occur, i.e. $E = L \times (I/t)$. The polarity of the voltage developed across an inductor when the supply is removed, is opposite to that of the voltage originally applied. Hence the term back emf or back voltage. As you have stated, the inductor is trying to maintain current flow in the SAME direction, but the term 'forward' is not applicable in this instance.

Page Hunting

Dear Sir,
After reading letters in previous editions of Electronics, all singing the praises of the "new" magazine, I would like to make one criticism concerning the layout, viz: the irritating and (I feel) unnecessary splitting of articles within an issue. Is it not possible for a new article to start after a previous one has finished – and not be scattered throughout the magazine? That said, the content (once I have pieced it together) is always interesting and, in itself well set out.
R. J. Lindsell, Braintree, Essex.

We do not like splitting articles (that surprised you didn't it!), the reason is as follows: 'Electronics – The Maplin Magazine' is 80 pages long, we can have full colour on certain pages, spot colour (single colour and black) on certain other pages and black and white on the remaining. The way the full and spot colour pages are arranged is determined by the printer's press. We like to have the first pages of articles in colour, for photographs etc. The articles have to be slotted in the blocks of pages that are full, spot colour and black and white. What sometimes happens is that an article may run on to the next block of colour pages, the article can either be edited down so it fits, or split with a 'continued on page xx'. Invariably we cannot edit down the article because vital technical information would be lost. At this point the editor juggles everything around, fitting everything in, in the best way possible; this process usually involves large quantities of tea, late nights, burnt dinners and aspirin.

Simple Circuits

Dear Sir,
I am a novice at electronics and the big projects you have are over my head (and budget). Could you consider running a few pages with useful circuits, and in particular how to connect these to other circuits, how to adjust for other voltages and more measurements at various parts of the circuit for fault finding. I would like to see the 555 timer, how to adjust for different times, what triggers to use, how to connect it to a transistor switch, or relay. For car circuits, an interior light extender, an alarm and relay for the car battery to disconnect the caravan load. You must have hundreds of these simple circuits that are really 'kids' stuff to you but if you don't use them to teach me a bit more I will never get to the more complex stuff.
R. Tranger, Horsham, W.Sussex.

For some simple circuits that are cheap to build, try Bob's Mini Circuits. We will shortly be starting a beginners series taking things from ground level (groan! The jokes get worse, Ed.). For other simple circuits try some of the books in the 1990 catalogue, e.g. IC555 Projects, How to use Op Amps, etc.

Telephone Shocker

Dear Sir,
When we returned from a few weeks on the mainland, upon opening our telephone bill we had a very nasty shock. Instead of the usual £50 or so it was £1,170. Complaining to British Telecom resulted in the meter being checked, and they claim it was all in order and please pay up! What appears to have happened was that the person to whom we had entrusted feeding our cats and keeping an eye on the house had enjoyed himself by maliciously running up the bill using 0898 chat line numbers (he is believed to read the Sunday Sport). I am now in dispute with British Telecom – no way am I going to pay this bill. Would it be possible to manufacture and market a device insertable in the telephone line so that if an 0898 number was dialled the line would be disconnected, resettable say when the handset was replaced. By the way, a Catholic Priest in Liverpool had a £6,000 bill after running a youth club on his premises and not keeping an eye on his 'phone. Mr Jack Ashley MP is compaigning on his behalf.
R. C. Eade, Isle of South Uist, Scotland.

The idea is good and perfectly feasible, except that 'Electronics – The Maplin Magazine' could not do such a project to prevent 0898 calls being made because apparatus connected to the public telephone network needs to be approved. However some enterprising manufacturer might like to produce a box and have it approved. Better still BT could provide a service to prevent 0898 calls being made, I am sure that the new all-singing all-dancing electronic exchanges could be programmed for this.

Mixing It!

Dear Sirs,
I wonder if you can help me? Some years ago, I think it was in your 1977/78 catalogue, you advertised a high quality stereo audio mixer designed by Peter Cole, incorporating such facilities as pre-fade listen, foldback, talkback etc. I know that it is asking a great deal after all this time, but are the components still available? I am looking for something with eight inputs, 2 microphone, 2 magnetic record decks, 2 cartridge machines, 2 CD players. Perhaps if the above is not available you could suggest an alternative.
Philip Sharpe, Falmouth, Cornwall.

Yes, the mixer boards are still available, in an improved and revamped form. The original circuits were up-graded using modern components, the circuits are available in kit or ready built form. Details may be found on pages 301 to 303 of the 1990 Catalogue. Full constructional details may be found in Projects books 17 to 20.

Scouts on Air

Dear Sir,
Young enthusiasts may well be interested to know that The Scout Association will be opening its new amateur radio demonstration station at its Gilwell Park Headquarters Campsite, near Chingford, London E4. Amateur radio and associated technologies have a key role to play in the modern Scout training programme. Previous experience has shown that a significant number of young people introduced to technology through Scouting, maintain an interest for life and often go on to make it a career. Gilwell Park is visited by over 20,000 young people each year and it is the intention that as many as possible will be able to gain some 'hands-on' experience of technology as part of their visit. Gilwell also has strong international links and the new amateur radio station will play a major role in maintaining and developing such links and increasing international awareness in the young. The opening ceremony coincides with the Jamboree-on-the-Air weekend when thousands of Scouts throughout the world will be communicating using amateur radio.
The Scouts Association, London.

Professor Writes

Dear Editor,
My name is Lee Reed but I call myself Professor Lee Reed and I am 11 years old. My hobby is electronics, I haven't done any real projects because I haven't got any good equipment (switches etc). I have made an old radio work and I have made lights work but I want to make something better (more interesting). I have a laboratory under the stairs in my mum and dads house. I also like chemistry. My dream is to work in a place about electronics when I am older! I wrote to Smiths Industries, British Aerospace and Defence asking to look round their factory, then they wrote back saying I can come and look round their factory. Please if you have any order forms so I can order equipment, please send me one please.
Professor Lee Reed, Basingstoke.
P.S. Please, please then could I be in your brilliant magazine! Please.
P.P.S. PLEASE!

Congratulations, Lee, you're a success! Your enthusiastic letter is in print and, who know's, in a few years we could be publishing one of your projects!

Maplin's 20 BEST SELLING BOOKS!

These are our top twenty best selling books based on mail order and shop sales during October and November 1989. Our own magazines and publications are not included. The Maplin order code of each book is shown together with page numbers for our 1990 catalogue. We stock over 250 different titles, covering a wide range of electronics and computing topics.

Number One

Loudspeaker Enclosure Design and Construction
by Fane Acoustics

This book contains a broad selection of cabinet designs from small-sized bass reflex cabinets to multi-way power systems. *(WM82D) Cat. P99.*
Previous Position: 1
Price £3.00

2

Getting the Most from your Multimeter, by R.A. Penfold. *(WP94C) Cat. P93.* Previous Position: 2. **Price £2.95**

3

IC555 Projects, by E.A Parr *(LY04E) Cat. P96.* Previous Position 3. **Price £2.95**

4

Power Supply Projects, by R.A. Penfold. *(XW52G) Cat. P95.* Previous Position: 4. **Price £2.50**

5

Introduction to Electronics, by Pam Beasant. *(WP80E) Cat. P93.* Previous Position: New Entry. **Price £3.50**

6

Radio Amateurs Examination Manual, by G.L. Benbow. *(WP87U) Cat. P101.* Previous Position: 11. **Price £5.00**

7

More Advanced Power Supply Projects, by R.A. Penfold. *(WP92A) Cat. P95.* Previous Position: 7. **Price £2.95**

8

International Transistor Equivalents Guide, by Adrian Michaels, *(WG30H) Cat. P89.* Previous Position: 12. **Price £3.50**

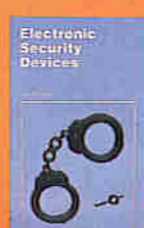
9

Mastering Electronics, by John Watson. *(WM80Q) Cat. P93.* Previous Position: 5. **Price £4.50**

10

How to Use Op-Amps, by E.A. Parr *(WA29G) Cat. P92.* Previous Position: 8. **Price £2.95**

11

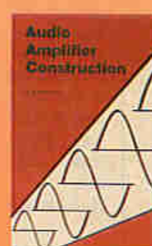


Electronic Security Devices by R.A. Penfold. *(RL43W) Cat. P96.* Previous Position: 13. **Price £2.50**

12

A Z80 Workshop Manual, by E.A. Parr. *(WA54J) Cat. P107.* Previous Position: New Entry. **Price £3.50**

13



Audio Amplifier Construction, by R.A. Penfold. *(WM31J) Cat. P93.* Previous Position: 10. **Price £2.25**

14

Projects for the Car and Garage, by Graham Bishop. *(XW31J) Cat. P96.* Previous Position: 19. **Price £6.95**

15

Home Electrics, by Geoffrey Burdett. *(RQ28Y) Cat. P84.* Previous Position: 14. **Price £4.95**

16

How to Design and make Your Own PCB's by R.A. Penfold. *(WK63T) Cat. P92.* Previous Position: 9. **Price £2.50**

17

A Concise Advanced User's Guide to MS-DOS, by N. Kantaris. *(WS44X) Cat. P108.* Previous Position: New Entry. **Price £2.95**

18

MIDI Projects, by R.A. Penfold. *(WP49D) Cat. P100.* Previous Position: 6. **Price £2.95**

19

Towers' International Transistor Selector, by T.D. Towers. *(RR39N) Cat. P89.* Previous Position: 16. **Price £19.95**

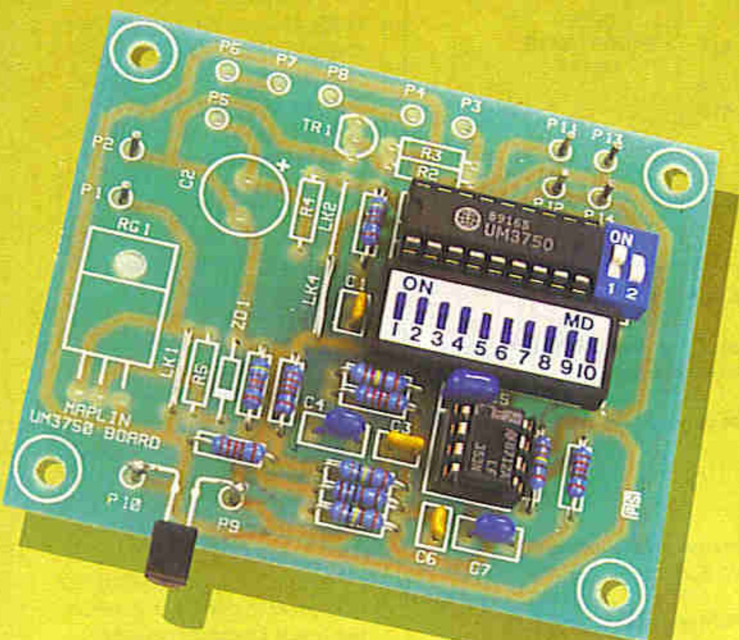
20

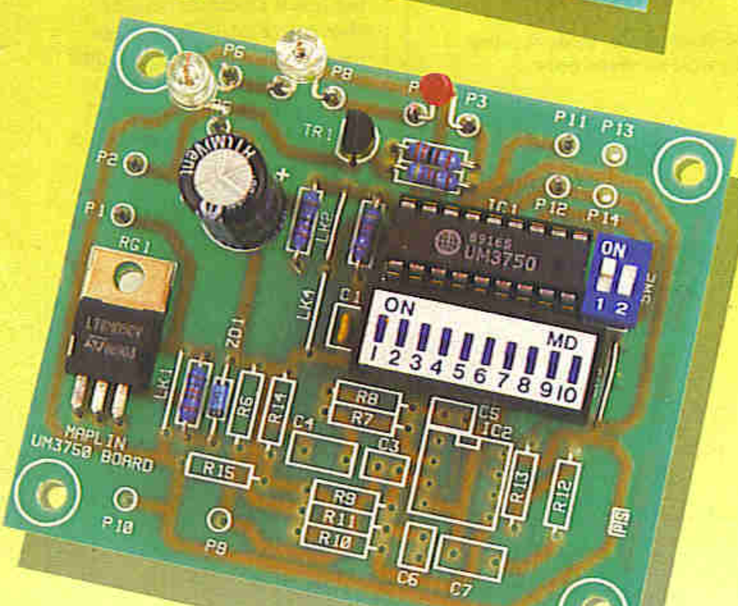
50 Projects Using Relays, SCR's and Triacs, by F.G. Rayer. *(RH30H) Cat. P95.* Previous Position: 17. **Price £2.95**

DATA FILE

UM3750

ENCODER/DECODER





Features

- ★ **Wide supply voltage range**
- ★ **Single chip contains both encoder and decoder**
- ★ **PCB available**

Applications:

- ★ **Alarm control systems**
- ★ **Security systems**
- ★ **Automatic door openers**
- ★ **Remote control**

General Description

The UM3750 Encoder/Decoder is a digital code transmitter-receiver system. Table 1 gives the electrical characteristics for this device and Figures 1 and 2 show the pin-out and pin designation respectively. Working in the transmission mode, the UM3750 will sequentially encode and transmit the twelve bits of data presented to it in parallel on pins one to twelve. Each of the twelve inputs may be a logic 0 or 1 allowing a total of 4096 unique codes. On-chip pull-up resistors are provided so that simple, single pole switches may be used to set the transmitted code. The rate of transmission is set by an external RC network running at a frequency of approximately $\frac{2}{3}$RC. The actual format of the output code is shown in Figure 3. It can be seen from this, that with a 100kHz clock (R=100kΩ, C=180pF), it takes 11.52ms to transmit one word. Each word is separated by a 11.52ms space giving a total transmission time of 23.04ms (43.4Hz). In the receive mode, the incoming signal is compared to the local code in a sequential manner. As soon as an error is detected the system resets and restarts comparison on the next word.

Parameter	Conditions	Minimum	Maximum
Operating Voltage		3.0V	11V
Input Voltage LOW		V_{ss}	V_{ss}+0.5V
Input Voltage HIGH		V_{DD}−0.5V	V_{DD}
Output Logic Level LOW	I_{sink} = 2mA	V_{ss}	V_{ss} + 1V
Output Logic Level HIGH	I_{source} = 5μA	V_{DD}−0.5V	V_{DD}

Note: Above specifications assume a 9V power supply and an ambient temperature of 25°C.

Table 1. Electrical characteristics of the UM3750.

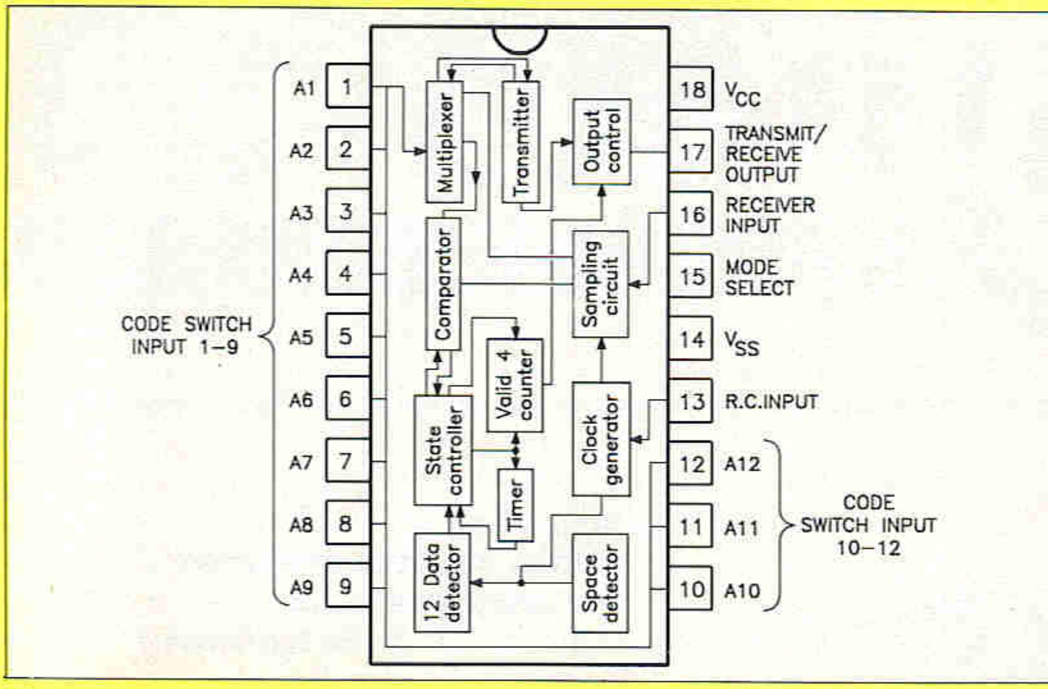


Figure 1. Pin out of the UM3750.

Pin No.	Designation	Description
1-12	A1-A12	These data select lines are used to set the address of the encoder/decoder pair. They have on-chip pull-up resistors.
13	R.C. INPUT	R.C. input pin for single pin oscillator. A resistor is hooked from this pin to (V_{ss}). Frequency = $2/_{RC}$.
14	V_{ss}	The ground pin of the UM3750.
15	MODE SELECT	This pin changes the IC from receiver mode (grounding this pin) to transmitter mode (taking this pin to V_{cc}).
16	RECEIVER INPUT	The receiver's input for the digital PCM waveform.
17	TRANSMIT/RECEIVE OUTPUT	In the transmitter mode this pin is the PCM output. In the receiver mode this pin is active low to signal a valid received code.
18	V_{cc}	The positive supply pin.

Figure 2. Pin designation of the UM3750.

If all 12 bits are received correctly a three stage counter is triggered and after receiving a further 3 consecutive valid codes, the receive output pin goes low. After this pin goes low, one in five codes are required to be valid to maintain this condition (one valid code has to be received in 11520 clock pulses or the receive output changes back to its high state).

Using the UM3750

The basic circuit configuration for the device is shown in Figure 4. Up to 4096 receivers can be used at one time by setting a unique code at each unit. If a large number of receivers are driven from the same source it is important to ensure that the transmission line provides sufficient drive capability. The frequency of the transmit and receive clocks need to be matched to within ±50% to allow for the use of multiple Tx/Rx links without any fear of crosstalk.

A high quality fibre-glass PCB is available allowing both an infra-red transmitter and receiver to be constructed on the same board, but not at the same time! Figure 5 shows the combined circuit diagram that was used to produce the PCB, the track layout of which is shown in Figure 6. Both the receive and transmit circuits have provision for a voltage regulator, zener diode, and resistor (RG1, ZD1 and R5) to

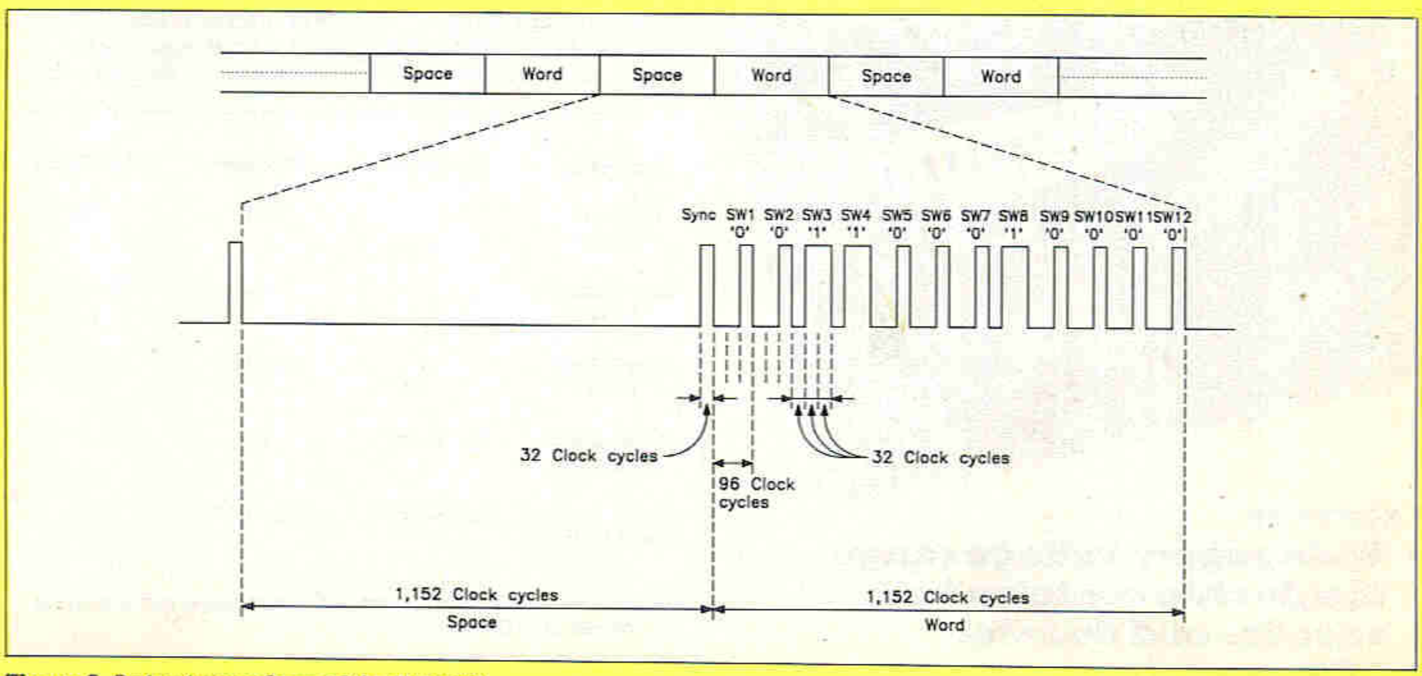


Figure 3. Output waveform of the UM3750.

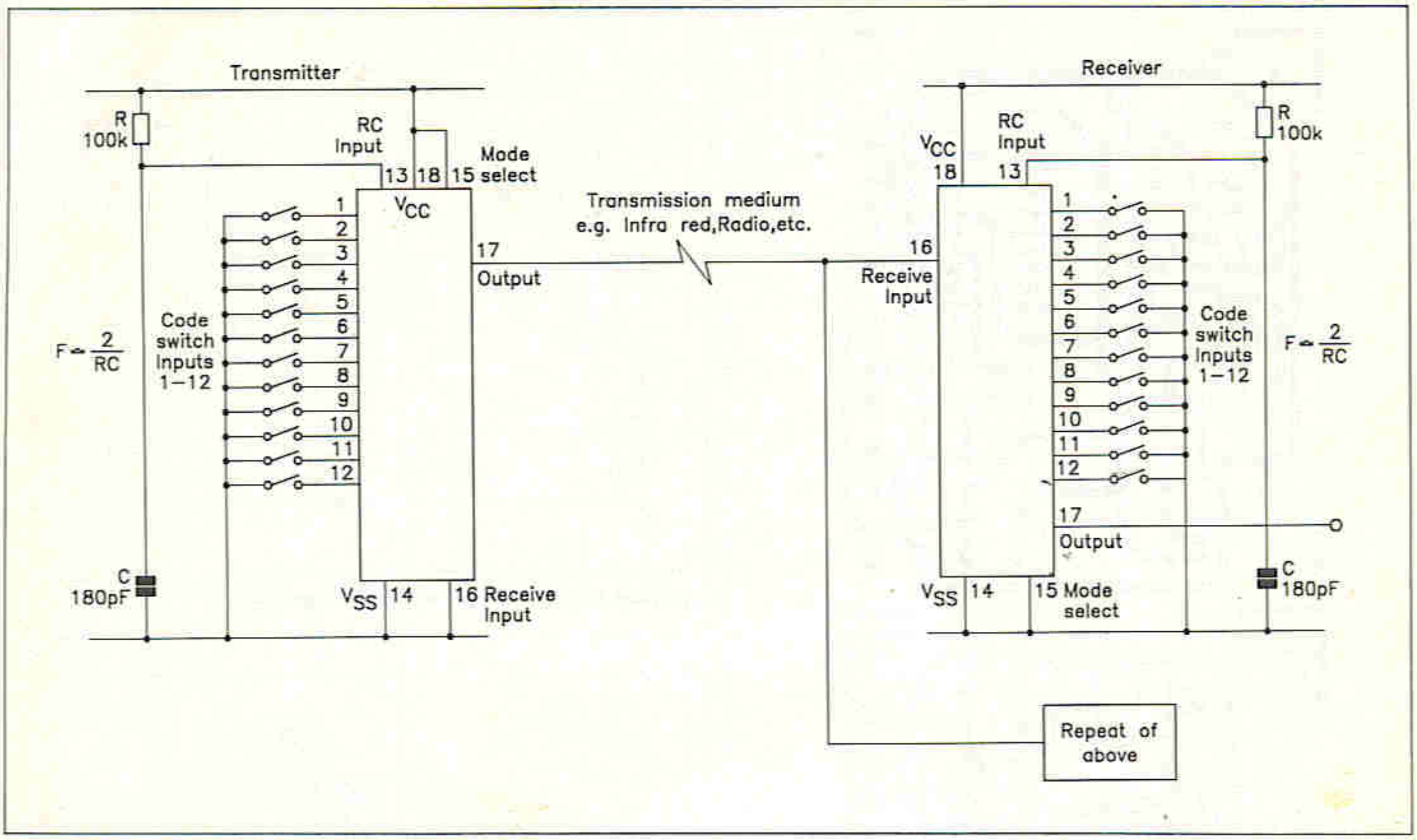


Figure 4. Basic circuit configuration for the UM3750.

allow operation at supply voltages up to 35 volts.

Figure 7 shows the circuit diagram for the transmitter and Figure 8 shows the PCB wiring. The circuit shown is designed to operate at a supply voltage of 9 volts. For supply voltages below 9 volts, R3 and R4 need to be changed to the values shown in Table 2. If the supply voltage is in excess of 11 volts, omit link LK1, insert RG1, ZD1, and R5 and change R3 and R4 to the values shown in Table 2. Two additional pins, P11 (signal) and P12 (ground) are available on the circuit board to allow the output of the UM3750 to be taken to the input of a fibre optic or RF link etc. These pins may also be used (without the UM3750 inserted) as the input for the infra-red link.

The circuit diagram for the receiver is given in Figure 9 and Figure 10 shows the PCB wiring. This circuit can be driven from a supply voltage between 6 volts and 35 volts. It should be noted that at supply voltage levels in excess of 11

Power Supply	Comments	R3	R4
6V	Fit LK1	18Ω	8.2Ω
9V	Fit LK1	33Ω	18Ω
12-35V	Fit RG1, ZD1, R5	39Ω	22Ω

Max Frequency (F=2/R1C1)

Table 2. Selecting R3 and R4.

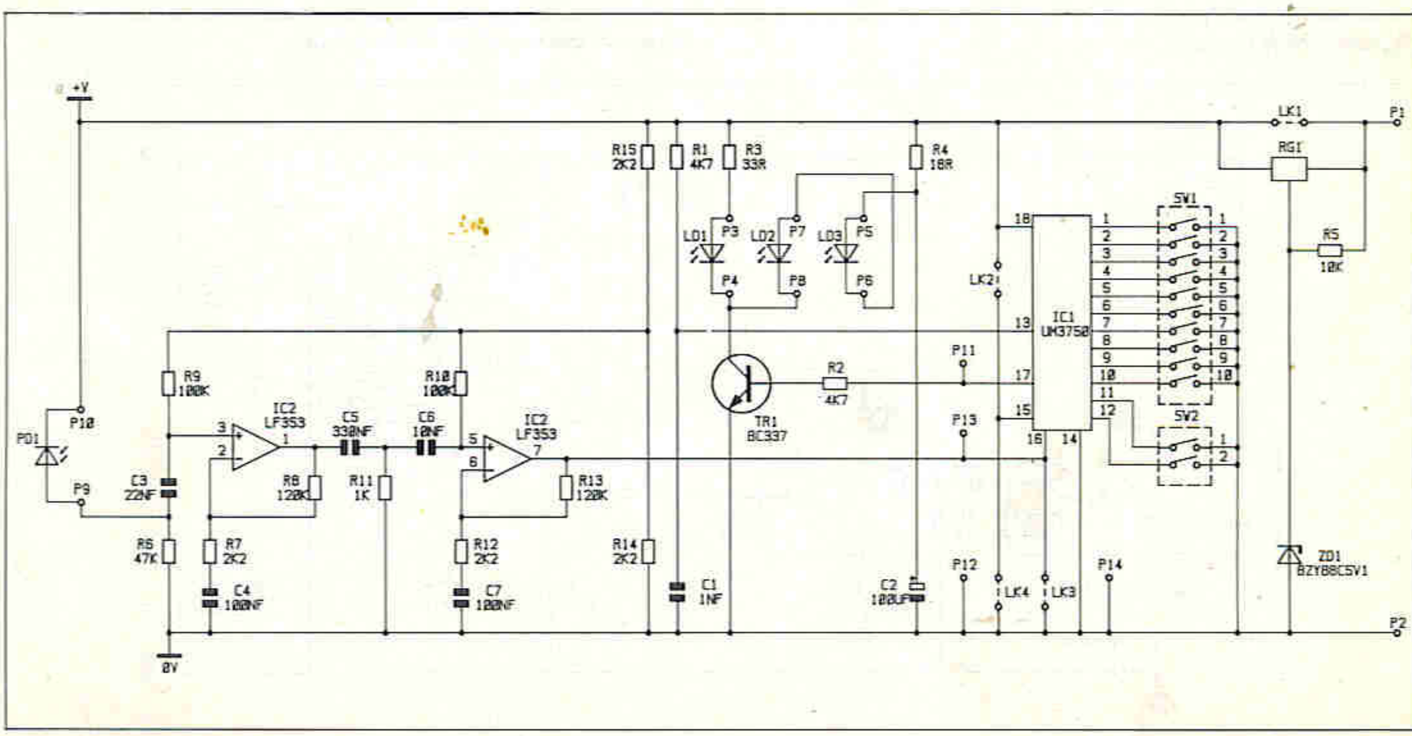


Figure 5. Combined circuit to which the PCB is designed.

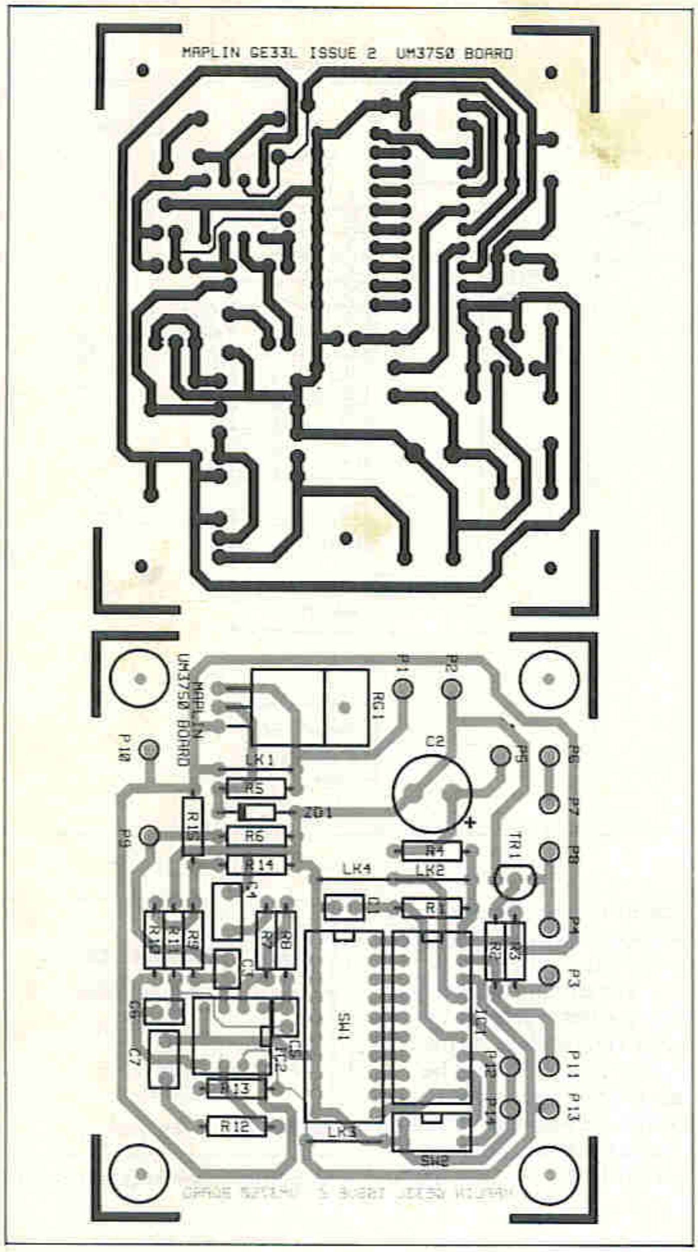


Figure 6. PCB layout.

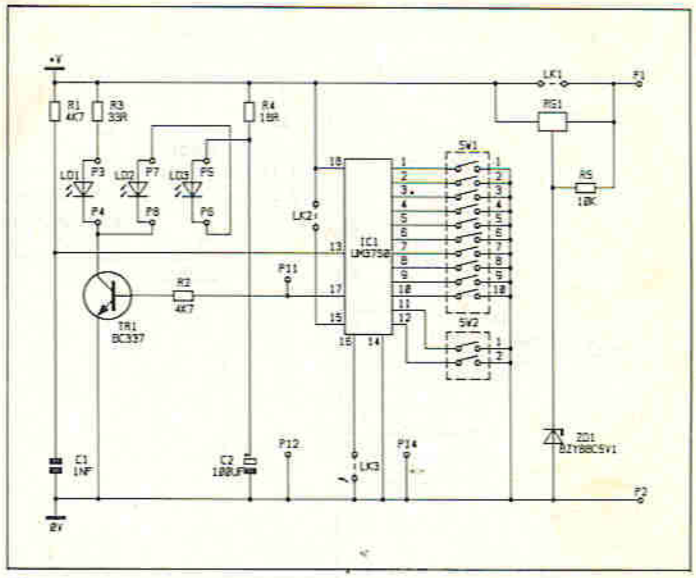


Figure 7. Transmitter circuit diagram.

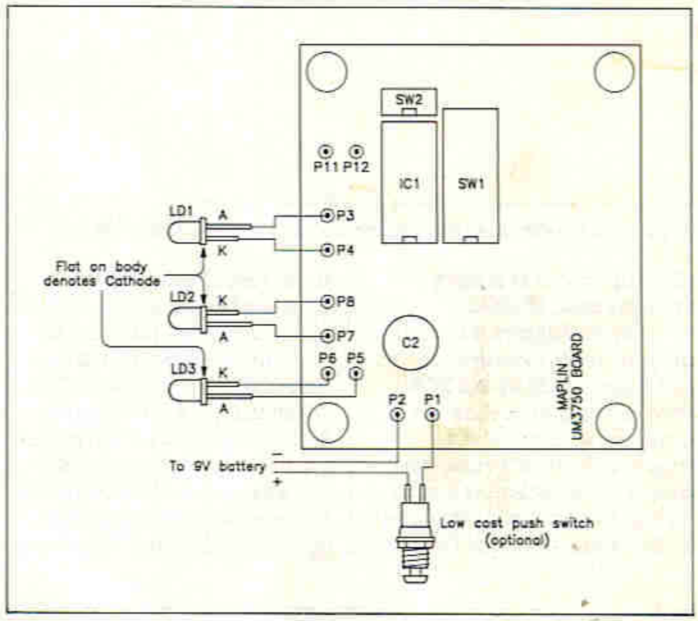


Figure 8. Transmitter PCB wiring.

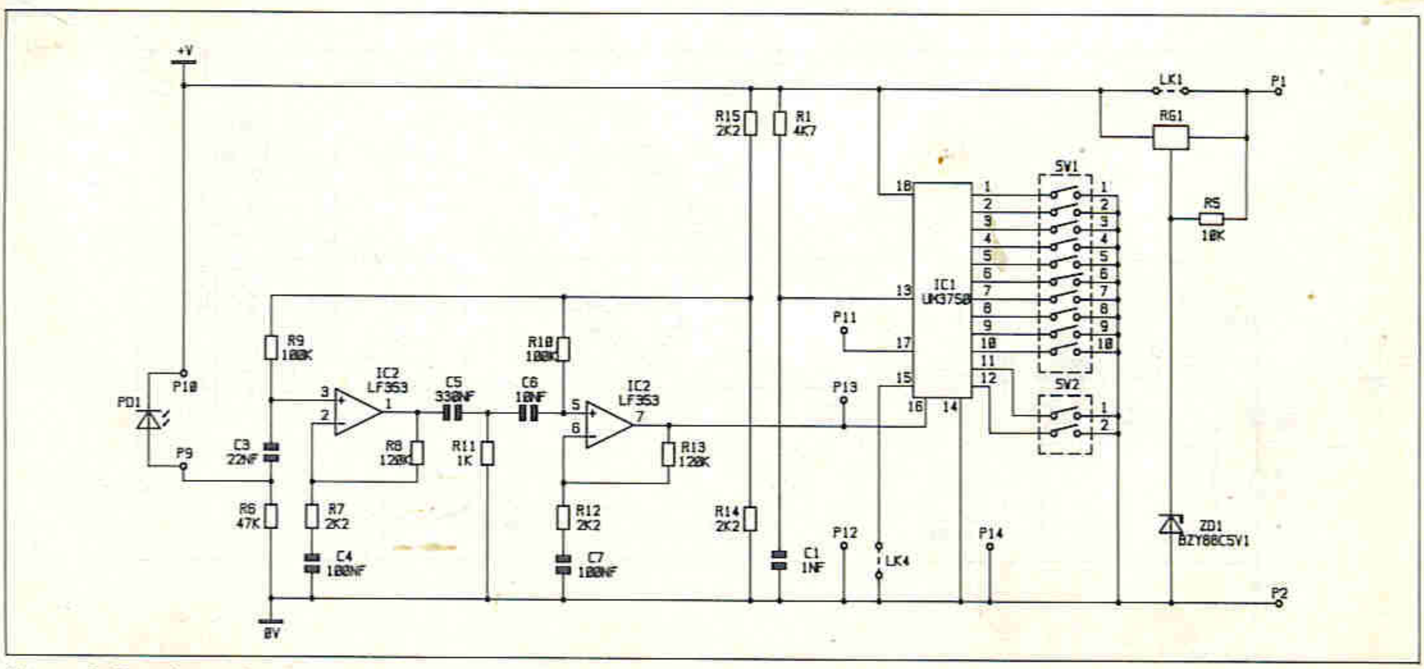


Figure 9. Receiver circuit diagram.

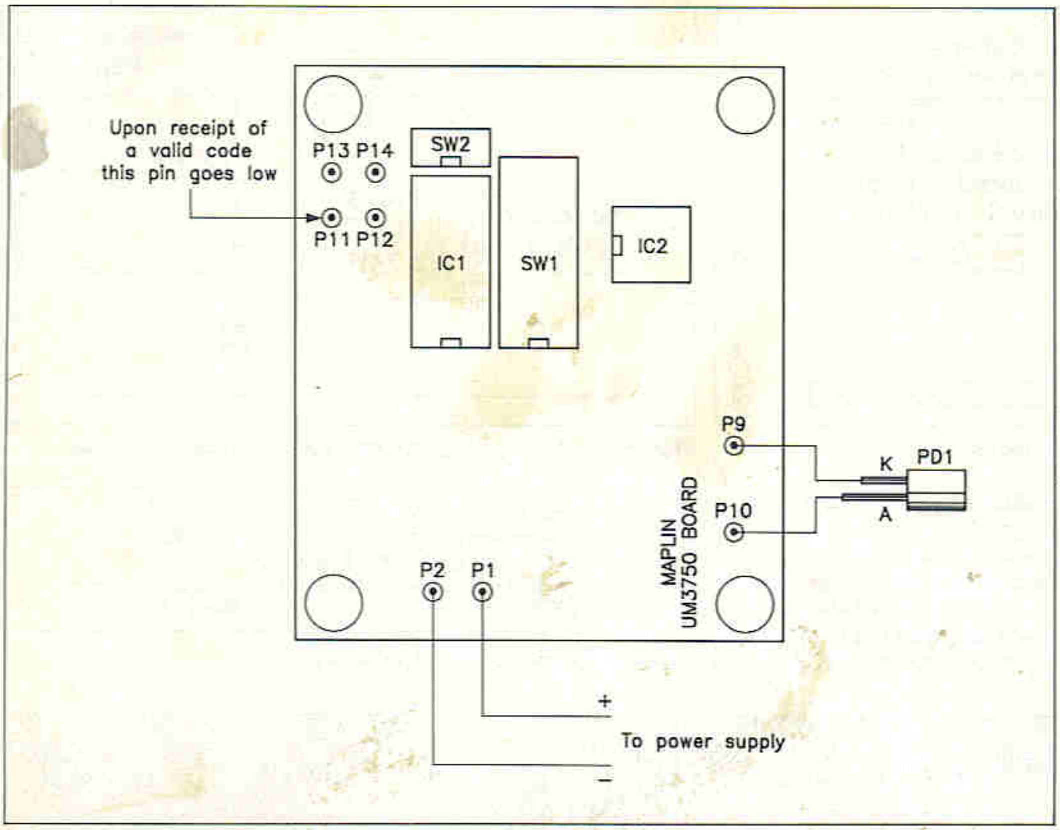


Figure 10. Receiver PCB wiring.

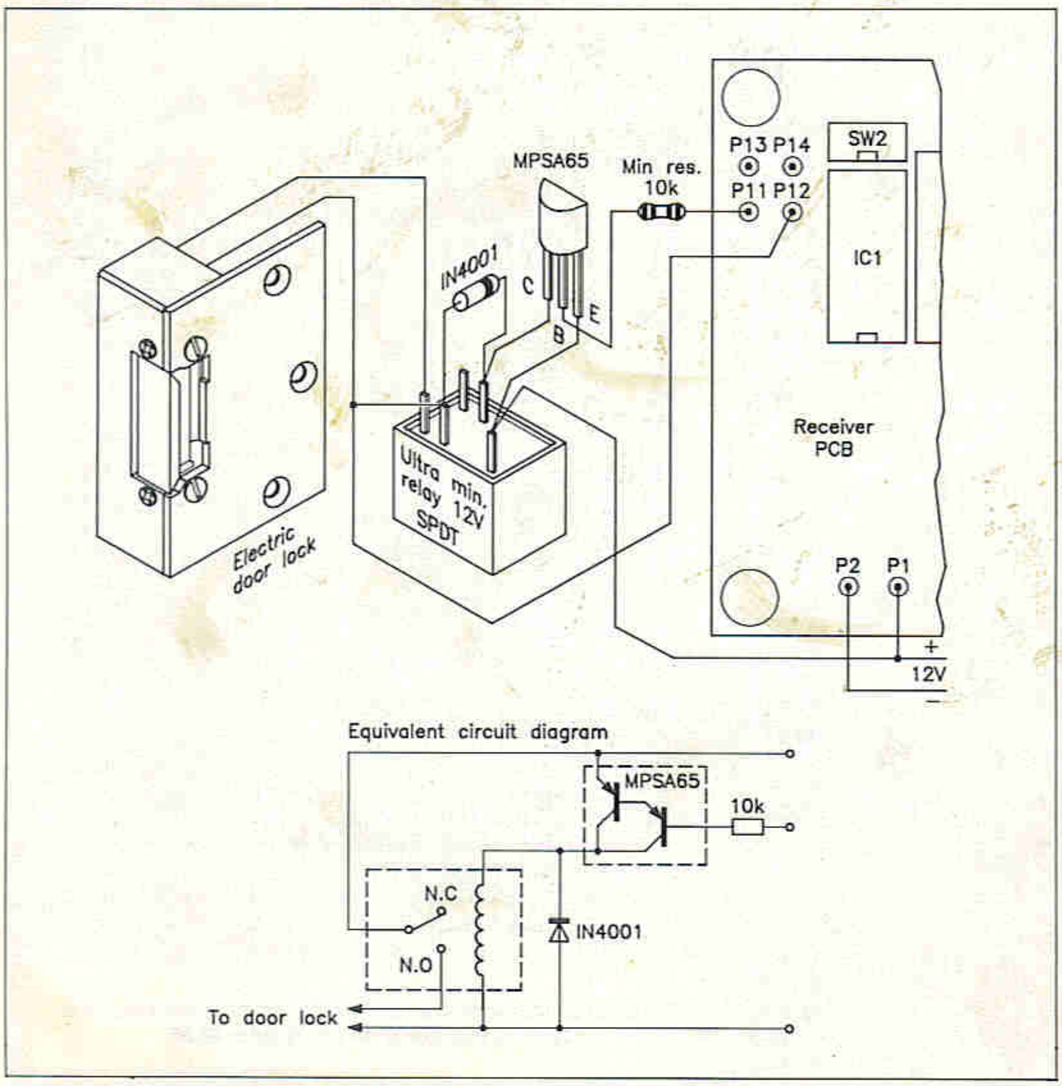


Figure 11. Connecting an electric door lock.

volts, omit link LK1, and insert RG1, ZD1, and R5. The receiver output is taken from pins P11 (signal) and P12 (ground). This pin is normally held high at logic 1, but, on receipt of a valid code, changes to logic 0 until the valid code is removed, when it reverts back to logic 1. Pins P13 (signal) and P14 (ground) are provided, allowing the output from fibre-optic/RF receivers etc. to be connected to the input of the UM3750 (do NOT insert IC2 or its associated components). These pins may also be used as the output of the infra-red link.

Applications

A simple application for the device is an electric door lock. In order to open the door you aim the transmit unit at a box mounted on the wall. If your transmitted code matches the code set in the receiver then the door lock will operate. The typical wiring of such a system is shown in Figure 11. Note that as this system operates at 12 volts, RG1, ZD1 & R5 need to be inserted. If mounting the receiver out-of-doors it is best to shield the photodiode from direct sunlight by mounting it recessed (as shown in Figure 12).

A further application of the UM3750 would be to remotely activate/deactivate an alarm system. In an ideal system the user would press the 'Transmit' button once to activate the alarm and again to deactivate it. Most alarm systems require the active line to be logic 1 when the alarm is activated, and logic 0 when deactivated. The output of the UM3750 is, as previously stated, normally logic 1 and only changes to logic 0 for the duration of a valid code being received. Just connecting this output to the alarm system would result in it being deactivated for as long as somebody stood outside the premises with their finger firmly pressing the 'Transmit' button. The action of deactivating an alarm generally means that entry to the building is required, which can be quite difficult if you have to stand outside holding the transmit button! By placing a bistable circuit between the receiver and the alarm system, every depression of the

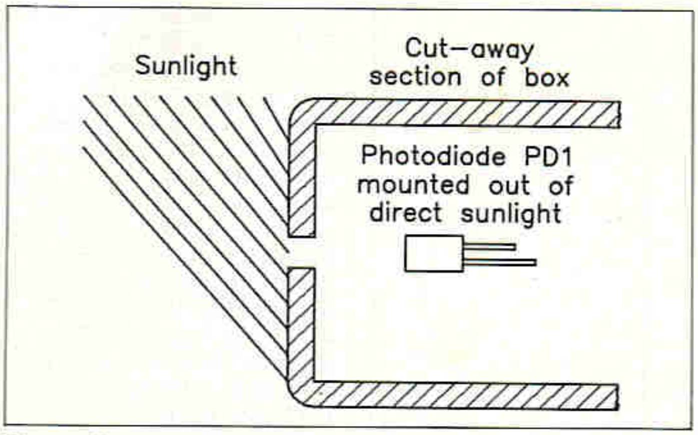


Figure 12. Mounting the photodiode PD1.

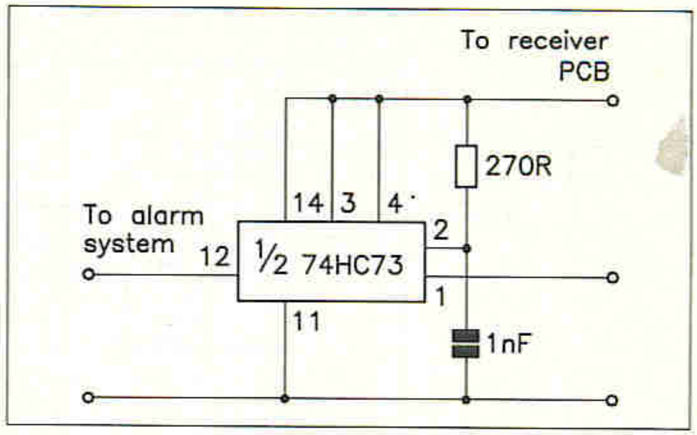


Figure 13. Connecting the UM3750 to an alarm system.

'Transmit' button will toggle the alarm between its activated and deactivated states. Figure 13 shows the basic configuration for such a system. Due to the vast number of alarm systems available it is beyond the scope of this article to describe how to connect the UM3750 to your alarm system.

Finally, Table 3 shows the specification for the prototype circuit built using the PCB.

Operating voltage	6V - 35V
Operating frequency	400kHz
Current consumption of transmitter	115mA
Current consumption of receiver	7mA
Effective range	40cm - 2m

Table 3. Specification of prototype.

LM3750 PARTS LIST

Transmitter

Resistors: All 1% 0.6W Metal Film

R1,2	4k7	2	(M4K7)
R3	33Ω (see text)	1	(M33R)
R4	18Ω (see text)	1	(M18R)
R5	10k (optional)	1	(M10K)
Capacitors			
C1	1nF Monolithic	1	(RA39N)
C2	100μF SMPS	1	(JL49D)
Semiconductors			
IC1	UM3750	1	(UK77J)
TR1	BC337	1	(QB68Y)
RG1	μA78M05UC (optional)	1	(QL28F)
ZD1	BZY88C5V1 (optional)	1	(QH07H)
LD1	Mini LED Red	1	(WL32K)
LD2,3	Infra-Red Emitter	2	(YH70M)
Links			
LK1	See text		
LK2	Fitted		
LK3	Fitted		
LK4	Not fitted		
Miscellaneous			
P1-8,11,12	Pins 2145	1 Pkt	(FL24B)
SW1	DIL Switch SPST 10 Way	1	(FV45Y)
SW2	DIL Switch SPST Dual	1	(XX26D)
	Push switch	1	(FH59P)
	DIL Socket 18 Pin	1	(HQ76H)
	PP3 Battery Clip	1	(HF28F)
	Zinc Chloride K9VHZ Battery	1	(FK62S)
	PC Board	1	(GE33L)
	Constructors Guide	1	(XH79L)

Receiver

Resistors: All 1% 0.6W Metal Film

R1	4k7	1	(M4K7)
R5	10k (optional)	1	(M10K)
R6	47k	1	(M47K)
R7,12,14,15	2k2	4	(M2K2)
R8,13	120k	2	(M120K)
R9,10	100k	2	(M100K)
R11	1k	1	(M1K)
Capacitors			
C1	1nF Monolithic	1	(RA39N)
C3	22nF Monolithic	1	(RA45Y)
C4,7	100nF Monolithic	2	(RA49D)
C5	330nF Monolithic	1	(RA51F)
C6	10nF Monolithic	1	(RA44X)
Semiconductors			
IC1	UM3750	1	(UK77J)
IC2	LF353	1	(WQ31J)
RG1	μA78M05UC (optional)	1	(QL28F)
ZD1	BZY88C5V1	1	(QH07H)
PD1	Infa-Red Photodiode	1	(YH71N)
Links			
LK1	See text		
LK2	Not Fitted		
LK3	Not Fitted		
LK4	Fitted		
Miscellaneous			
P1,2,9-14	Pins 2145	1 Pkt	(FL24B)
SW1	DIL Switch SPST 10 Way	1	(FV45Y)
SW2	DIL Switch SPST Dual	1	(XX26D)
	DIL Socket 18 Pin	1	(HQ76H)
	DIL Socket 8 Pin	1	(BL17T)
	PC Board	1	(GE33L)
	Constructors Guide	1	(XH79L)
Optional			
	Min Res 10k	1	(M10K)
	MPSA65	1	(QH61R)
	IN4001	1	(QL73Q)
	Electric Door Lock	1	(YU89W)
	Ultra-Miniature 12V SPDT Relay	1	(YX94C)
	Min Res 270Ω	1	(M270R)
	1nF Monolithic	1	(RA39N)
	74HC73	1	(UB18U)

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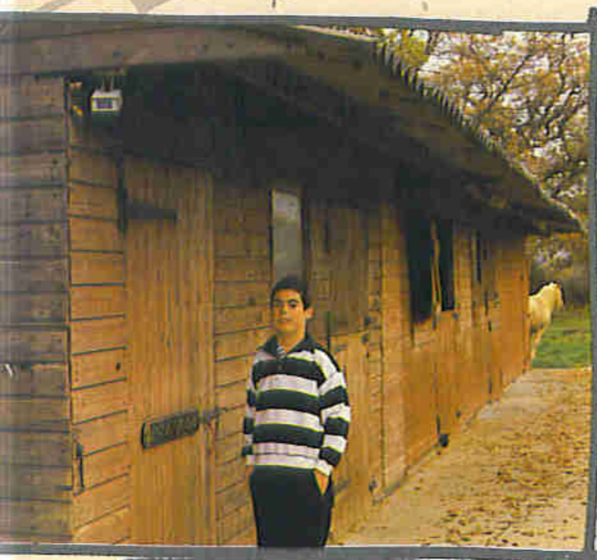
HOBBYIST IN ACTION

Reported by
***Robert Ball** A.M.I.P.R.E.*



The stables protected by Ian's security system.

House extension in which Ian installed an external telephone bell, and PIR operated security light.

In recent years, more and more people have adopted electronics as a hobby. With today's technology and the availability of quality electronic components at reasonable prices, interest is growing fast. Usually this interest germinates from either working in the 'technology industries' or from studying at school, college or university. Electronics appeals to a wide age and ability range, where limits are set only by an individuals ingenuity and bank balance! It is however unusual to find young people with broad and in-depth knowledge of electrics and electronics.

All Things Electrical

Sixteen year old Ian Connelly from Smallfield in Surrey, has been interested in all-things-electrical since the age of four, when he first perfected the art of wiring 13A mains plugs (something that a lot of adults have not yet got the hang of!). Soon after, he was experimenting with simple low voltage circuits; using lamps, switches and batteries to build model traffic lights and other similar things. Trips to the local library became frequent, where he borrowed and studied books on electricity and electronics, much to the amazement of the librarian. By the age of seven, Ian's visits to the library were becoming more and more frequent as his insatiable thirst for knowledge continued to grow. Ian said that when he was younger the maths proved to be a big hurdle, but as he grew older, his school mathematics tutorials helped tremendously. Radio became another fascination, sparked-off by wondering how signals from a transmitter mast could radiate and be received many miles away without any direct connection.

Inside the extension, where Ian indicates the wiring prior to the walls being plastered.

Lighting circuits.

Ian's workbench.

Ian sitting at his workbench.

The mains isolation unit under construction.

Reading up on NICAM.

Burglars Beware!

Ian first started building electronic projects when he was ten and in 1984 his Christmas present list included a request for the electronics hobbyist's 'bible', the Maplin Catalogue. From then on his scope knew no bounds. A local horse owner employed his skills to provide a security system for his stables after some horses were stolen. The system monitors the four doors and drives two very loud piezo sounders, and a tamper loop is provided for additional protection.

At home he has installed telephone extensions and provided an ingenious multiway switching system for lighting the outside of the garage. Ian also looks after the normal day-to-day electrical problems, such as changing light bulbs, fitting plugs and changing fuses. One home venture was building fully operational TV sets from broken ones, Ian then sold the working ones to boost his pocket money.

Repairs and Rewiring

In his locality, Ian is known as the Mr Fixit, repairing everything from washing machines and food processors to personal stereos and televisions. He has wired two house extensions, providing such facilities as multiple switching on lighting circuits, PIR operated security lighting (with manual override) and an external telephone bell. Ian places electrical safety very high on his list of priorities, this soon became apparent as he described the merits of PME (protective multiple earthing) and installation of RCCBs (residual current circuit breakers). Ian ensures that his electrical work complies with the requirements of the 15th edition I.E.E. wiring regulations.

Projects

As with most hobbyists, Ian has built a variety of different projects. Amongst many things, he devised an overhead projector protector for use at his school and a sound operated 'clap' switch to provide amusement for friends. He built a simple 'stylus' organ, but that now finds a more practical use as a 555 timer tester. For testing mains sockets, Ian has built a tester unit, this simply plugs in and indicates whether live, neutral and earth are properly connected. His current project is a mains isolation unit for his workbench. Ian is particularly interested in the NICAM-728 Decoder project, so when the local transmitter starts to broadcast NICAM signals, he may build a decoder.

Ian certainly has an excellent grasp of electronics and with his tremendous enthusiasm, he is without a doubt a 'Hobbyist In Action'.

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COMPUTERS IN THE REAL WORLD

Part 4 By Graham Dixey C.Eng., M.I.E.E.

Introduction

A computer can only perform a useful function by interacting with the 'real world' around it, which really means with its 'peripherals'. To perform this process of interaction it must be able to communicate with these peripherals, either to know when they need attention or to pass data to them. A common way of establishing this necessary means of communication is by the method of 'interrupts'. The interrupt technique forces the computer to respond to a request from a peripheral, at a specific time, whether because the particular peripheral needs to pass data to the computer or requires data from it. To see more clearly how interrupts work and why they are used, it is worth looking first at an alternative scheme called 'polling'.

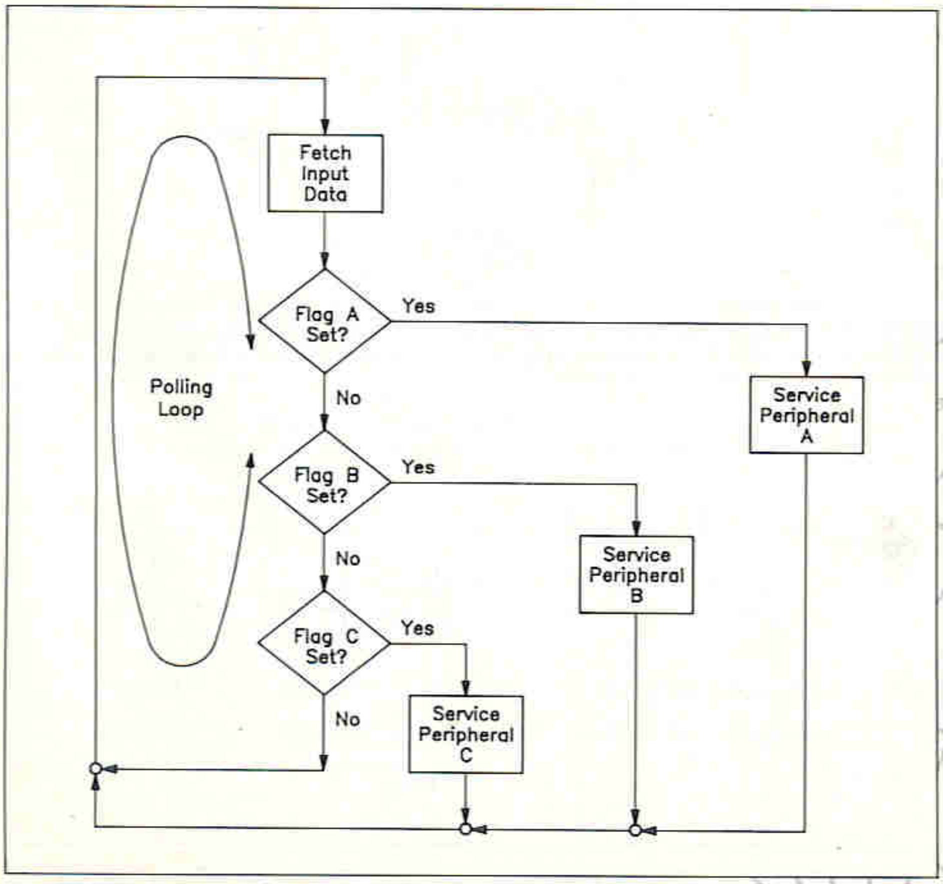


Figure 1. Flow chart for polling a computer's peripherals.

Software Polling

Supposing that a computer is connected to several peripherals, the computer has to know, in some way, when any one of these devices needs service. Polling is a continuous process in which the computer keeps 'asking' each peripheral in turn whether it needs attention. Because the speed at which the computer works is so much greater than that of the majority of peripherals, the answer is invariably 'no'. In this case, the computer moves on to the next peripheral and repeats the questions, and so on. After interrogating the last peripheral in line the computer goes back to the first one and starts the process again. Such a polling procedure can be executed by a simple segment of machine code that just keeps on looping until a 'yes' answer is obtained from one of the peripherals. At this point the computer exits the polling program and jumps to a routine that handles that particular peripheral. The flowchart of Figure 1 should make it clear how polling works. There are disadvantages to the polling method, though for some applications it is attractively simple.

For a start, it ties up the computer completely. It is either running the polling program (most of the time) – thus doing nothing very useful – or it is handling a peripheral. There is no chance for the computer to perform any other function during the time that peripherals don't actually need its attention.

Another disadvantage is the relative slowness of response, which is limited by the time taken to run the loop. Supposing that peripheral A requires attention 'just after' it has been checked, it will now have to wait for all the other peripherals to be checked (and perhaps be serviced too) before the loop returns to this peripheral again. Obviously the more peripherals that there are in the queue the slower the possible response.

In the polling method the onus for initiating a routine for handling a peripheral rests squarely on the computer. The peripheral provides a signal (known as a 'flag') when it needs attention but the computer knows nothing of this until that part of the program is reached that checks this specific peripheral. The idea is illustrated diagramatically in Figure 2. Each of the peripheral flags is connected to a single input line on a computer port, and all that the polling program has to do is check each of these lines in turn to establish whether it is 'high' or 'low'. Assuming that a high state signifies the need for service, on detecting the presence of a high level at one of the port input lines, the program jumps to another area of memory where that peripheral's 'handling' routine is stored.

By contrast, in the interrupt method the responsibility is shifted from the computer to the peripherals themselves. The computer is no longer required to run a polling program and is, in fact, free to pursue some other, perhaps totally unrelated, task. How then do the peripherals force the computer to acknowledge their need for service?

The answer is simply that the peripherals need do no more than they did before, that is to set a flag to an agreed logic level. The difference is in the way the computer reacts to the flag signals.

Figure 3 again shows three peripherals, known as A, B and C, connected to a computer. However, now the flag lines a do not merely go to a port for status checking but to a 'wired OR' logic circuit as well. The output of this wired-OR arrangement drives a special input to the computer marked '$\overline{\text{INT}}$'. The abbreviation '$\overline{\text{INT}}$' naturally stands for INTerrupt and the bar over these letters means that the input so designated is 'negative-acting', meaning that it needs to be taken to logic zero in order to initiate the interrupt sequence. This sequence can be summarised as follows:

(i) The MPU finishes its current instruction.
(ii) Various registers, especially the Program Counter (PC) and status register, have their contents preserved by 'pushing' them onto a special area of RAM known as the 'stack'.
(iii) The program counter is loaded with the start address of the 'Interrupt Service Routine' (ISR) and the peripheral is then handled.
(iv) At the end of the ISR the various registers have their contents retrieved from the stack by a process known as 'popping' or 'pulling' the stack; the computer is then able to carry on with its original task just as if nothing had happened.

At this stage someone is no doubt wondering how the computer knows which of the peripherals has to be serviced. After all, the interrupt line from the wired-OR logic is common to all peripherals. True, but the flags still go to separate port lines as well, at least in the case of the system shown in Figure 3, since there are other methods that can be used.

In this simple scheme the initial response of the computer, after performing steps (i) and (ii) in the previous routine, is to go to an address known as the 'interrupt vector'. Instead of this address pointing directly to any specific ISR it is used to run a polling program to check the status of the peripheral flags in turn. On finding a flag set high the program will be directed to the relevant ISR.

In terms of software, this polling procedure is no different from that described previously. The difference, and it is a very important one, is that it doesn't run continuously but is only called when a interrupt request is received. There is no need whatever for the computer to keep on checking the peripherals. Figure 4 shows a hypothetical situation where interrupts from the three peripherals of Figure 3 arrive quite randomly and are dealt with as they occur. In between times the computer carries on with some other task, known here simply as the 'main program'.

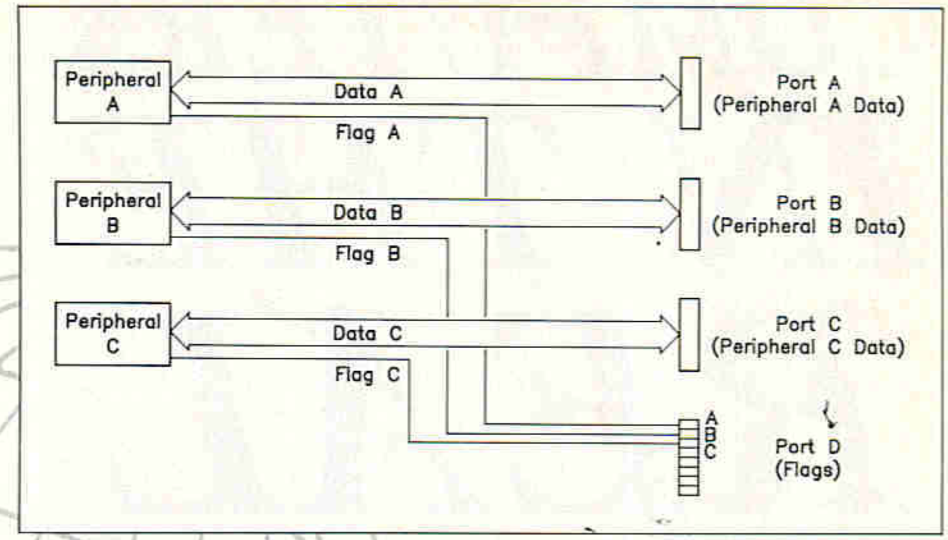


Figure 2. Port connections for polling method of servicing peripherals. Port D is checked regularly by the polling program.

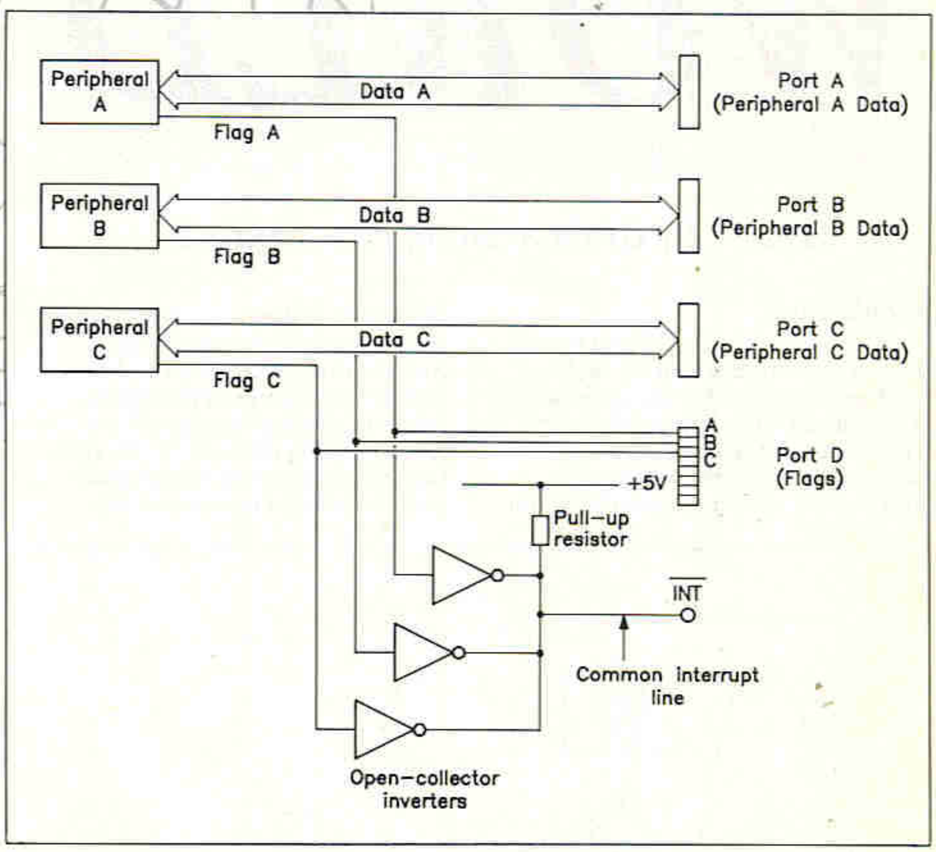


Figure 3. Port connections for interrupt servicing of peripherals. Any flag being set (peripheral requiring service) takes the common interrupt line low. Port D is then polled to identify peripheral.

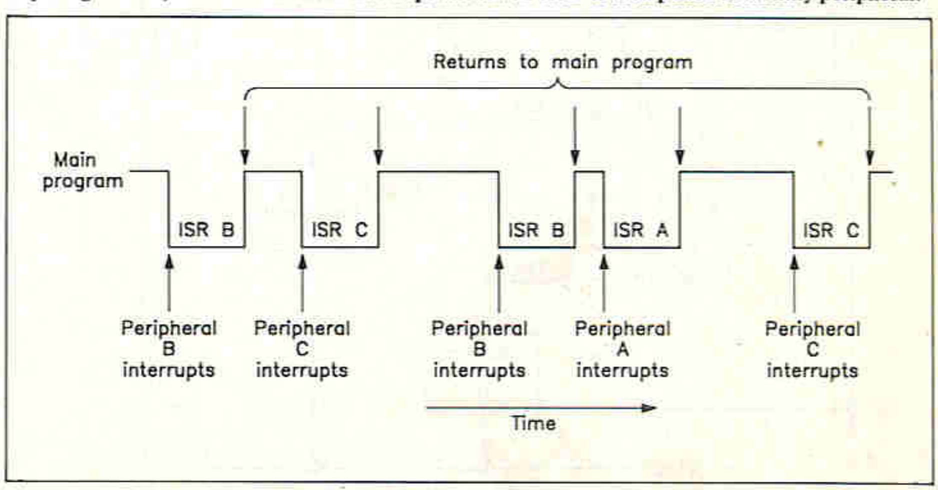


Figure 4. Showing how the main program may be regularly interrupted by peripherals requiring service. The instants of time are often quite random.

Other methods of determining the identity of the interrupting peripheral will be described shortly but first it is worth looking at the idea behind 'priorities'.

Prioritisation of Interrupts

In any system controlled by a computer it is likely that some inputs, or peripherals, will have more urgent needs than others. Any potentially hazardous situation, such as over-voltage, loss of power, excessive temperature rise, etc., must take precedence over the more routine checking of input variables or sending data to a printer, and so on. It must, therefore, be arranged that high priority devices have preference over less vital inputs even to the extent of being able to override their interrupt routines.

The diagram of Figure 3 shows only one interrupt connection to the computer, namely the one labelled '$\overline{\text{INT}}$'. In practice, there is usually a second line frequently known as '$\overline{\text{NMI}}$', which stands for Non-Maskable Interrupt. This is the line that is reserved for higher priority inputs. Without prior knowledge, the title Non-Maskable Interrupt isn't exactly helpful. It obviously refers to some operation called 'masking', but what exactly is it?

Masking

This is the name given to the setting of a flag, known as the Interrupt Mask Flag, in a special register of the microprocessor, in order to prevent a new interrupt routine breaking into one that is already running. Whether this new ISR 'should' be able to break into an existing routine depends upon whether its priority is higher or not less than that of the peripheral whose routine is running. When an interrupt is received on the '$\overline{\text{INT}}$' input, the microprocessor automatically checks to see if the mask flag is 'set' or 'clear'. If it is clear, it will allow the interrupt on the '$\overline{\text{INT}}$' input to continue; if it finds the flag set, it will not allow it to. So, how does this flag get set in the first place? The answer is that it is set by an instruction right at the beginning of an Interrupt Service Routine. This routine could be the '$\overline{\text{NMI}}$' routine or even one of the '$\overline{\text{INT}}$' routines.

To take an example of the way in which masking works, suppose that a low priority interrupt is received on the '$\overline{\text{INT}}$' input and is being serviced. During this time, that is before this ISR has had a chance to finish, another interrupt, also on the '$\overline{\text{INT}}$' line but of much higher priority, is received but will be ignored because it has been 'masked out'. However, if an interrupt is received on the '$\overline{\text{NMI}}$' line, this will take over immediately since it cannot be masked out. Once the '$\overline{\text{NMI}}$' routine is finished it will clear the mask bit and the ISR that it interrupted can resume. This process of one ISR breaking into another and 'stealing' its time, so to speak, is known as 'nesting'.

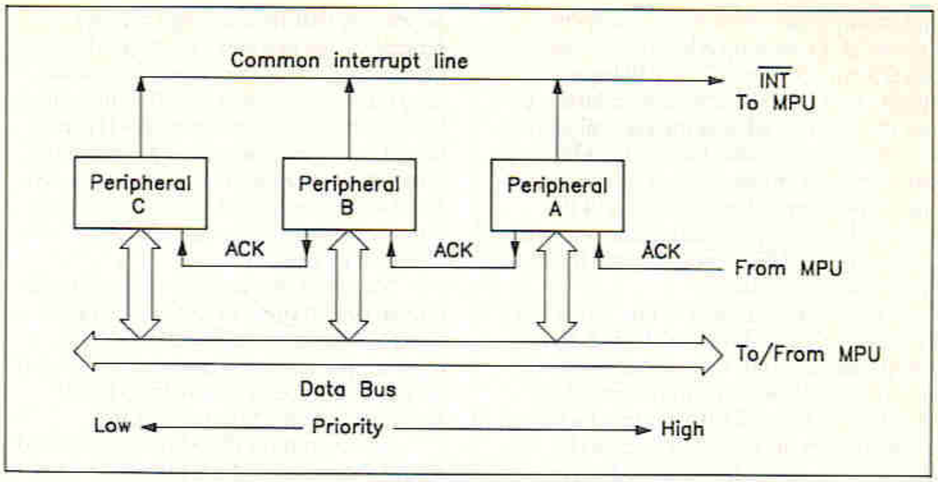


Figure 5. Daisy-chaining of three peripherals; highest priority is established for Peripheral A.

From the above it can be seen that the difference between the '$\overline{\text{NMI}}$' and '$\overline{\text{INT}}$' interrupt procedures is that, when an '$\overline{\text{NMI}}$' interrupt signal is received it makes no difference whether the mask flag is set or not. This fact is totally ignored and the '$\overline{\text{NMI}}$' routine immediately breaks into the existing routine and assumes command. In other words, the mask has no effect on the '$\overline{\text{NMI}}$' input, hence the name, Non-Maskable Interrupt.

Now that it can be appreciated that the '$\overline{\text{NMI}}$' interrupt line will always take precedence, it is then possible to develop the argument a bit further and explain how a system of priority may exist among the peripherals connected to the '$\overline{\text{INT}}$' input.

Suppose that there are three peripherals all wired-OR connected to the '$\overline{\text{INT}}$' input line. First it is logical to designate them alphabetically in their priority order so that A has the highest priority and C the lowest. The polling program that is called after the '$\overline{\text{INT}}$' line has been pulled low by a peripheral will naturally be written so as to poll them in this order also. This means that, if it happened that two peripherals called for attention at the same time, the higher priority one would be interrogated first and would therefore be serviced first. When its routine had been completed the '$\overline{\text{INT}}$' line would still be found to be low, initiating another go at the polling program which would find the other peripheral still waiting for attention; this it would then receive.

However, a moment's thought will show that this has assumed only the simplest of situations. If A is more important than B then if B is already receiving attention, say, at the particular instant that A requires it, it ought to be possible for A to take over from B. This it will do as a matter of course provided that the interrupt mask flag mentioned earlier has not been set by B's interrupt routine. If it has been set, then A would have to wait until B had finished, not really the response that is wanted. On the other hand, if A is receiving attention and B then tries to interrupt, it is essential that it cannot do so. This implies that A's interrupt routine 'must' set the interrupt mask flag.

Summing up, the Interrupt Service Routine for A must include the instruction for setting the interrupt mask flag (SEI in 6502 code) at the beginning of the routine, so preventing any further calls on the '$\overline{\text{INT}}$' line from having any effect while the routine for A is running. At the end of this ISR the instruction must be included that clears the mask flag (CLI in 6502 code), otherwise all subsequent calls on the '$\overline{\text{INT}}$' line will be 'locked out' for evermore! The ISR for B, on the other hand, must not include these instructions since it is required to allow A to interrupt if necessary. The problem is that there will be nothing to prevent C from taking over from B either! Obviously such simple systems have their limitations. One solution would be to connect peripheral A to the '$\overline{\text{NMI}}$' line, giving it the highest possible priority, and B and C to the '$\overline{\text{INT}}$' line with the routine for B written such that it can mask out C.

Daisy Chaining of Peripherals

Another method of determining which peripheral has initiated an interrupt is the connection of peripherals in a 'daisy chain' according to their priorities. This daisy chain is effected by the line called ACK in Figure 5. When an interrupt occurs on the '$\overline{\text{INT}}$' line the microprocessor goes into its usual sequence of preserving registers, etc., and then generates an 'interrupt-acknowledge' signal on the ACK line. This is gated to the first peripheral in the chain; if this was the peripheral that iniated the interrupt then it will respond by placing an identification number on the data bus, which the microprocessor will read and use to determine which routine to go to. If the first peripheral was not the one that iniated the interrupt, then the ACK signal will be passed on to B in turn, which has the same choice, either to respond or pass the signal on to C.

The identification number placed on the data bus by a peripheral can easily be used by the microprocessor to access a look-up table which will, in turn, supply the information regarding which peripheral it is and where in memory its ISR can be found. A quicker response can be obtained if the number supplied by a peripheral points directly to the ISR, so giving immediate access to it rather than by way of the look-up table. This is called a 'vectored interrupt'. The Z80 has a facility of this type but because addresses are 16 bits in length and the Z80 only has an 8-bit data bus, only half of this address can be placed on the data bus by the interrupting peripheral. The rest of the address has to be pre-loaded into a special register of the Z80; in practice this is the high byte of the address.

The address formed in this way is not actually the start address of the ISR but merely an 'interrupt vector' that points to it. This should be clear from Figure 6 in which an address 5C40H is formed which, together with the next address 5C41H, provides the actual ISR start address, namely A120H. In other words, the byte 40H supplied by the peripheral is added to the contents of the I Register (5CH) so as to form the address 5C40H. The bytes that comprise the address A120H, already stored at the successive memory addresses, 5C40H and 5C41H, then point to the ISR for that particular peripheral.

The Z80's method of performing Vectored Interrupts (known as Mode 2 interrupts) is illustrated in Figure 6.

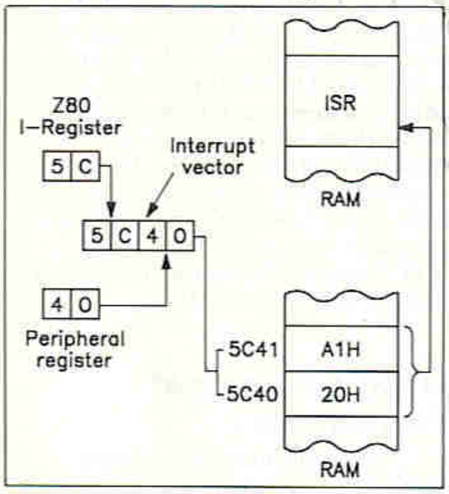


Figure 6. The Z80's interrupt Mode 2 in which the interrupting peripheral supplies the low byte of the interrupt vector.

Priority Interrupt Controllers (PICs)

It is possible to establish interrupt priorities by means of hardware, the 'priority interrupt controller' being an example of this. The basic PIC logic is shown in Figure 7, which shows how either interrupt lines, number 0 to 7 are handled. Each of these lines is ANDed with the appropriate bit of an 8-bit Mask Register. The contents of the Mask Register are determined by the program which loads a byte into this register as required from time to time. Thus, to enable all eight interrupts to be effective, the Mask Register would be loaded with FFH, that is all 'ones'; loading 00H into this register would disable all interrupt lines. To take a further example of this, if 0FH is loaded, the lower four interrupt lines (0-3 inc.) will be enabled while the upper four lines (4-7 inc.) will be disabled.

Being able to mask out interrupts at will within the program leads to a powerful and flexible interrupt handling scheme. Supposing that the interrupt priority scheme is that line 0 has the highest priority and line 7 the lowest then, if an interrupt is received on line 0, it has only to load the Mask Register with 01H and lines 1-7 inc. are immediately masked out. Similarly, any other interrupt routine can be written so as to load the required byte into the Mask Register in order to maintain its priority.

Naturally, lower order priorities will only mask out those below them and not those above, since the latter must be allowed to interrupt them in turn. Thus, if an interrupt is received on line 3 it will mask out lines 4-7 but not lines 0-2.

The outputs of the AND gates are fed to an 8-bit register which provides two outputs, as follows.

(a) An interrupt request to initiate the interrupt sequence. (b) An 8-bit code which, in effect, identifies which peripheral has initiated the interrupt.

From this 8-bit code a corresponding 3-bit code is generated, using an 8-to-3 line encoder, which can then be compared with the contents of a 3-bit Priority Register, the contents of which have been specified by the programmer. It is possible to use this result to prevent lower priority interrupts from having any effect. This together with the Mask Register is very powerful in establishing priorities. The 3-bit code here described is known as a 'level vector' and, since a 3-bit code can take up eight different values, in some designs of PIC it is used to access 'one-of-eight' 16 bit registers, each of which has previously been loaded with the start address of an Interrupt Service Routine for one of (up to) eight different peripherals. Thus, an immediate branch can be made to the appropriate ISR. This more detailed scheme for a PIC is shown in Figure 8.

Direct Memory Access (DMA)

Interrupts guarantee a very fast response to a call for service from a peripheral but the overall speed is limited by the use of software in the polling and handling routines. Disk drives and monitors may need a faster response than the above method is capable of giving. Since hardware is inherently faster than software, the answer is obvious. Bypass the software aspect with a specialised hardware device. This piece of hardware is known, logically enough, as a Direct Memory Access Controller, or DMAC. This DMAC is, in effect, a processor that is designed to perform high speed data transfers between the computer RAM and the peripheral itself. Obviously, in order to carry out this transfer it needs to have control of both the computer's address and data buses during the time of the transfers. There are various ways of doing this.

The DMAC may suspend or stop the operation of the microprocessor; it may 'steal' some of the memory cycles; it may gain time by stretching some of the clock cycles; some 'intelligent' DMAs actually use portions of the instruction cycles when they 'know' that the buses are not actually in use. It is appreciated that some of these ideas are somewhat difficult to grasp! The most common method, and the easiest to implement is just to suspend the operation of the microprocessor.

A simple concept of a DMAC in operation is shown in Figure 9. The operation is as follows.

A significant difference between the

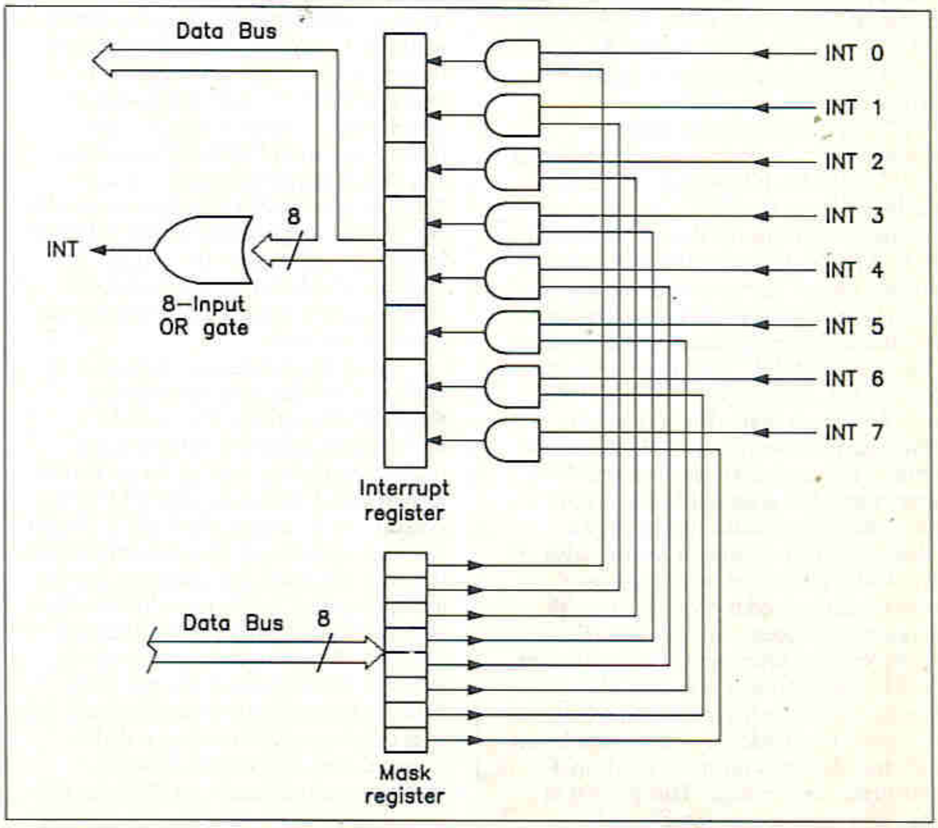


Figure 7. PIC (Priority-Interrupt-Controller) logic allowing eight interrupts to be handled; priority can be established by the mask register.

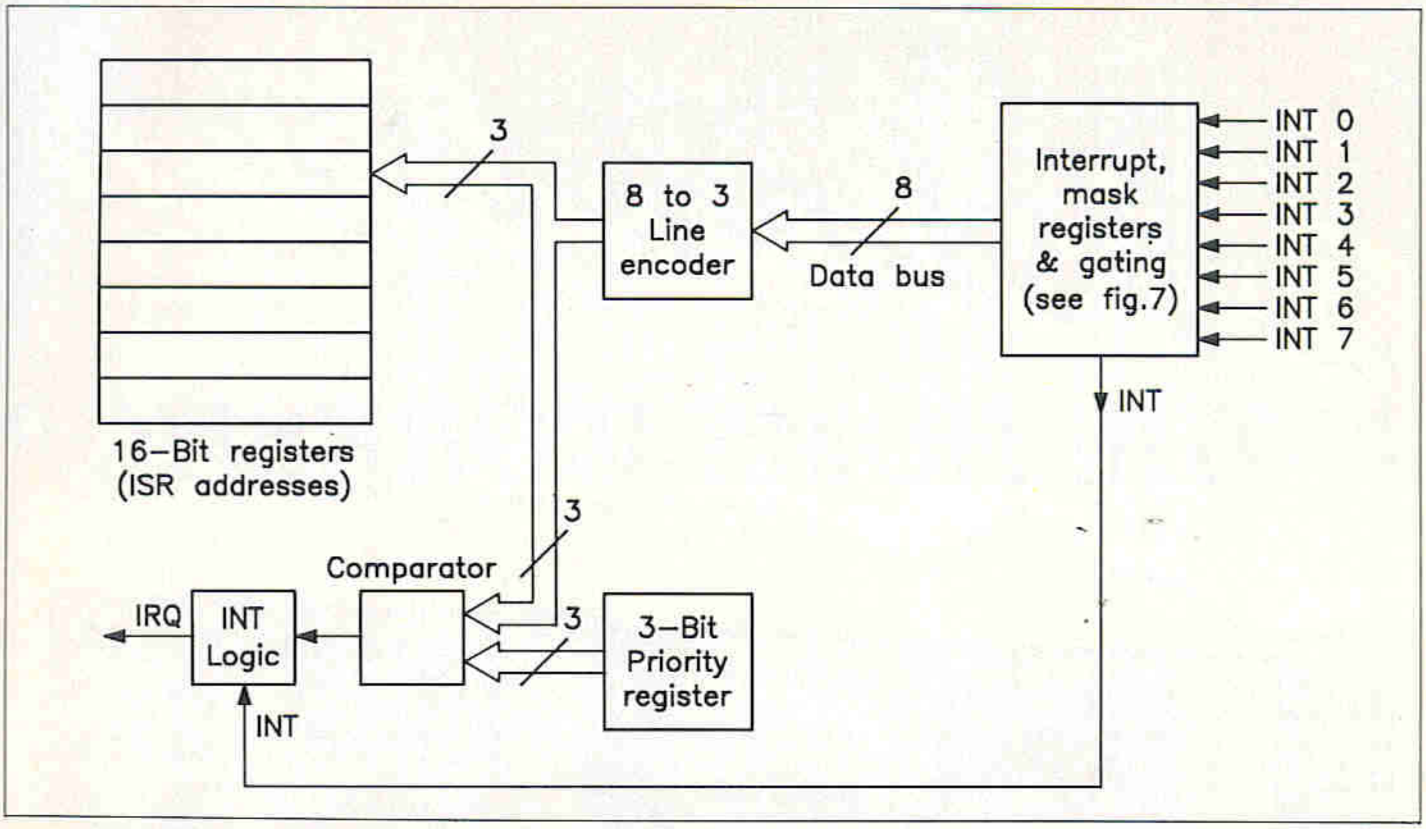


Figure 8. The PIC system of Figure 7 expanded to provide direct addressing of ISRs (via the 16-bit register block). Each of eight such registers can be selected by the 3-bit priority register.

operation of a DMAC system and a normal interrupt-driven system is that the interrupt lines from the peripherals no longer go to the microprocessor, but directly to the DMAC. When the latter receives an interrupt request from a peripheral it sends a HOLD signal to the microprocessor which places the latter 'in limbo'. However, before it actually enters this suspended state it does three things.

(a) It completes its current instruction.

(b) It allows the address and data buses to 'float', that is they go into the third, high impedance, state since they are tri-state devices.

(c) It sends a 'hold acknowledge' (HOLDA) signal to the DMAC to inform it that the buses are now available for its use.

The first action of the DMAC is to place an address on the address bus that specifies the memory address at which the data transfer is to take place. This address is contained in a special 16-bit register in the DMAC; it follows from this that there must be one of these registers for every peripheral connected to the DMAC. The programmer pre-loads these registers as part of the normal 'boot-up' program. The DMAC next sends a READ or WRITE signal, as appropriate, via the peripheral driver to memory so that data can then be transferred on the data bus. A useful facility of the DMAC, that allows it to handle the transfer of blocks of data, is an automatic sequencing mechanism, controlled by a counter-register, that keeps track of the number of bytes being transferred in a particular block. As an example of the possible speed of such devices, the Motorola 6844 is capable of transferring 1Mbyte of data per second.

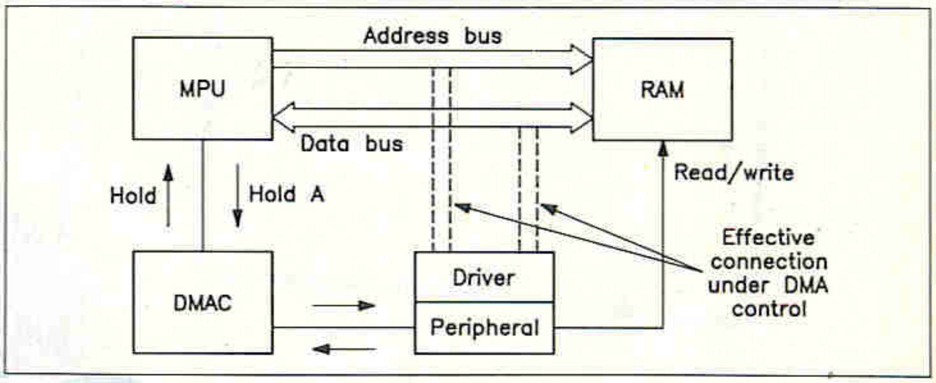


Figure 9. Basic scheme for a Direct Memory Access Controller (DMAC).

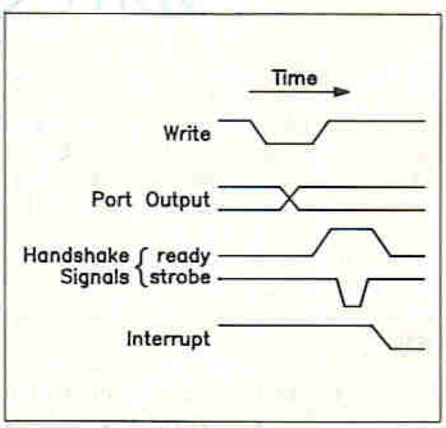


Figure 10. Timing for output handshaking.

Handshaking

Any reference to input-output transfers between a computer and its peripherals invariably includes the rather colourful term 'handshaking'. This is nothing more than a means of timing the transfer of data to suit both a slow peripheral and the fast processor. Some idea of how this is done can be seen from the timing diagrams for output transfers (Figure 10) and input transfers (Figure 11). A feature of hand-shaking is that the input-output port of the computer is connected to the peripheral and not merely by the data bus on which the transfers will be made but also by two hand-shaking lines, known as READY and STROBE.

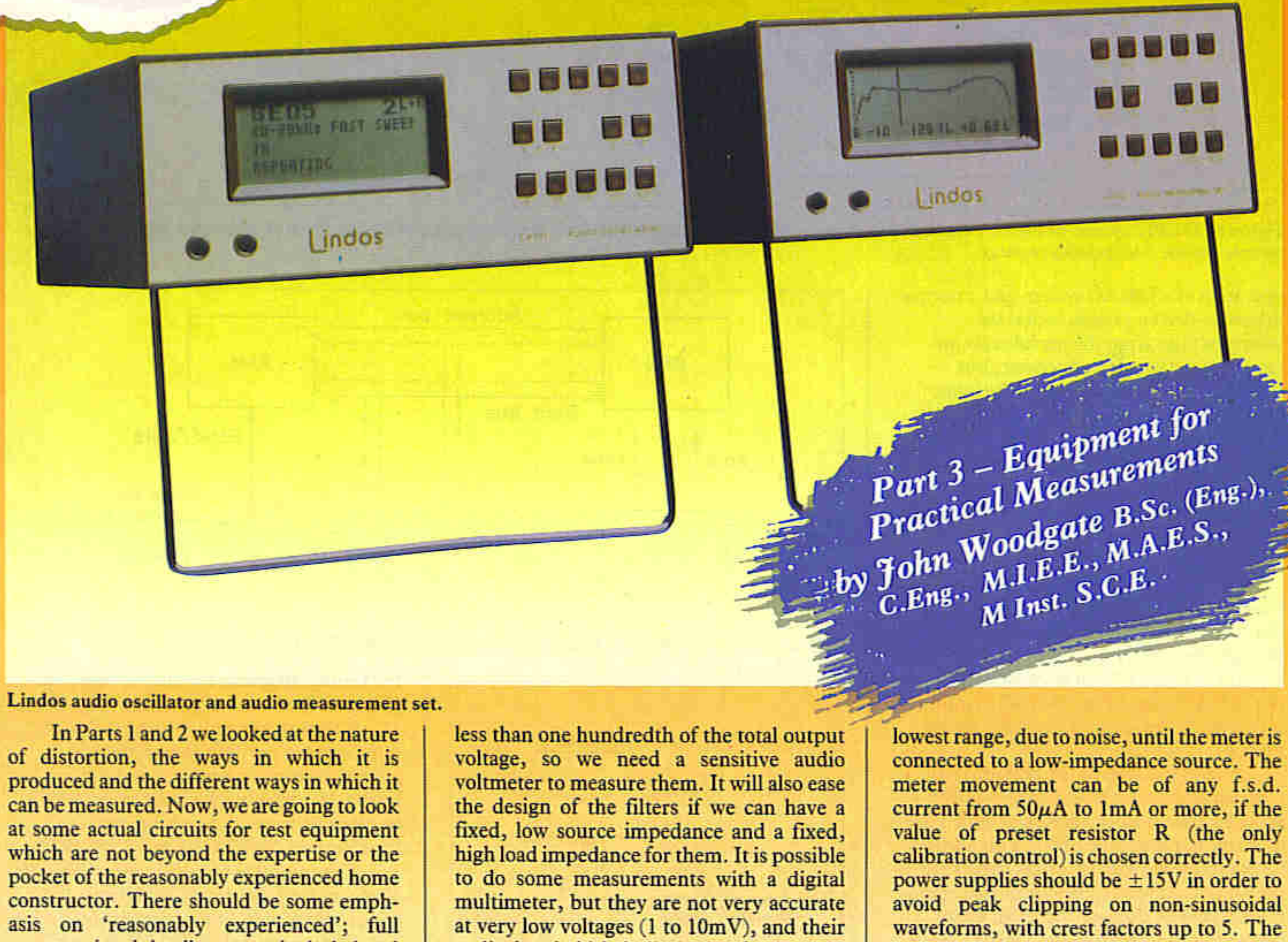
The output timing diagram of Figure 10 shows the logic states, with time, for various lines as follows, starting at the top.

First there is the WRITE line which goes low when fresh data is available to be transferred to the peripheral. Next there is the data at the port output itself, the loading of new data into the port register being indicated by the crossing over of the two lines. The next two lines are the handshaking lines themselves and, finally, there is the interrupt line.

The action of outputting the data to a peripheral device implies a 'writing' operation from the MPU to the peripheral. Thus, the WRITE line will be taken low to initiate the sequence. During the period when the WRITE line is low the new data

Continued on page 75.

MEASURING *Distortion* IN THE HOME WORKSHOP



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

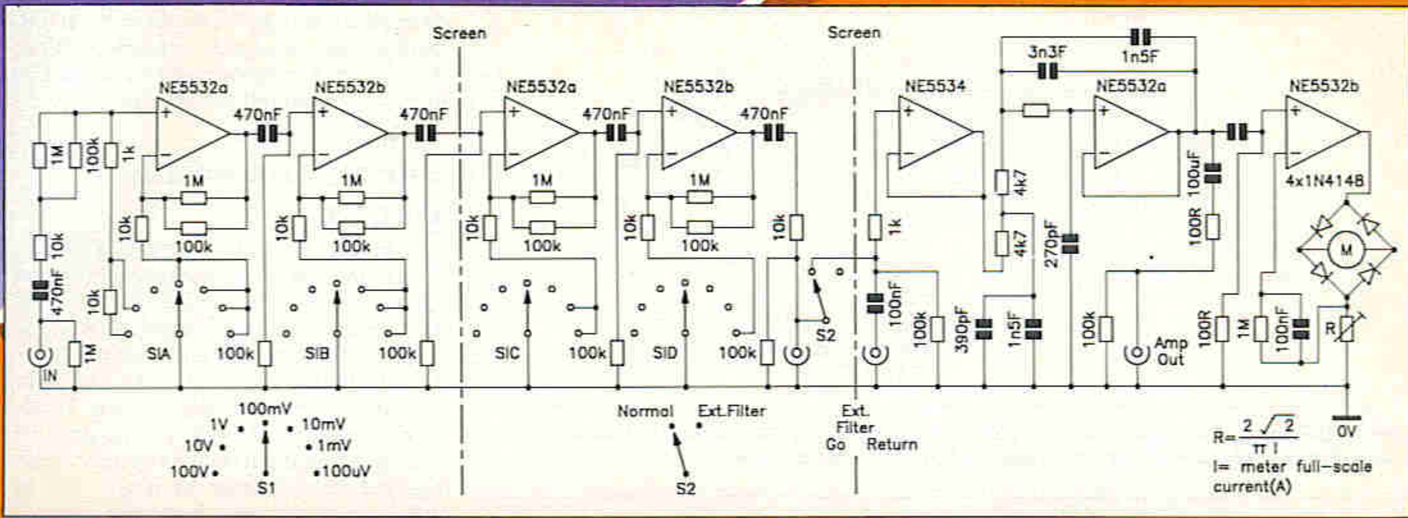
Lindos audio oscillator and audio measurement set.

In Parts 1 and 2 we looked at the nature of distortion, the ways in which it is produced and the different ways in which it can be measured. Now, we are going to look at some actual circuits for test equipment which are not beyond the expertise or the pocket of the reasonably experienced home constructor. There should be some emphasis on 'reasonably experienced'; full constructional details are not included and details such as power supplies, and the need for 100nF decoupling capacitors on the power supply lines to every two or three ICs, will only be mentioned in general terms.

Basic audio meter

To measure distortion, we have seen in Part 2 that either balanced-bridge techniques or various different types of filter are used. In both cases, we have to measure the amplifier output voltage and the output voltages due to the distortion components alone. For a good amplifier, these will be less than one hundredth of the total output voltage, so we need a sensitive audio voltmeter to measure them. It will also ease the design of the filters if we can have a fixed, low source impedance and a fixed, high load impedance for them. It is possible to do some measurements with a digital multimeter, but they are not very accurate at very low voltages (1 to 10mV), and their audio bandwidth is limited, often to less than 1kHz.

The circuit of a basic audio voltmeter is given in Figure 6. This is built around three NE5532 low-noise dual op-amps and one NE5534. The pairs of amplifiers in the input section require careful screening between them to prevent instability on the high-gain ranges. For the same reason, the two sections of the range switch must be on separate wafers, such as FF81C, one on each side of the screen, and the whole circuit must be built in a metal box to prevent hum pickup. The decade ranges extend from 100V to 100μV full scale. There will be a continuous reading on the lowest range, due to noise, until the meter is connected to a low-impedance source. The meter movement can be of any f.s.d. current from 50μA to 1mA or more, if the value of preset resistor R (the only calibration control) is chosen correctly. The power supplies should be $\pm$15V in order to avoid peak clipping on non-sinusoidal waveforms, with crest factors up to 5. The built-in filter gives a response which is less than -1dB at 20kHz, and -3dB at about 25kHz (provided that accurate component values are used!), to reduce the effects of noise and out-of-hand signals. Without this filter, the response extends to over 100kHz and all the noise in this bandwidth will obscure the wanted signals. To avoid d.c. offset problems, a.c. couplings are included, but the l.f. response is more limited by the meter tending to follow the waveform than by the gain roll-off. The output marked AMP OUT can be used to connect an oscilloscope, and full scale on the meter corresponds to 2V rms at AMP OUT. Note that this output, unlike those



$R = \frac{2\sqrt{2}}{\pi I}$

Figure 6. Basic audio voltmeter with filter insert point and 20kHz low pass filter.

on some other voltmeters, is not taken from the rectifier driver amplifier and is thus free of 'inverse crossover distortion' (where the amplifier gain tends to approach infinity near zero-signal when all the diodes are non-conducting).

It may seem a rather complicated matter to build this voltmeter, but there is really no substitute if you want to make measurements that are accurate enough to be useful and, more to the point, not misleading. There is no satisfaction in fruitlessly chasing a measured 1% distortion in your new amplifier design if it is actually pickup of Essex Radio or mains hum!

Unless otherwise stated, each of the filter circuits mentioned below should be connected between the 'External Filter' points of the basic voltmeter. This technique is the same as that used by Bruel and Kjaer in their well-respected audio test equipment, and controls the signal level applied to the filters. Some of the filter circuits are rather noisy, and thus need a fairly large signal input, while others have high internal voltage gain (which may well not be apparent from a comparison of the input and output voltages) and therefore must not be presented with too large a signal.

Balancing acts

Our first technique does not use a filter; it balances out the fundamental component of the output voltage by using the input voltage. For this to happen, the amplifier must be of the inverting type, or the two voltages must be applied to the two inputs of a low-distortion differential amplifier. To obtain some practical results for this article, an amplifier based on the LM380 was made up, using positive feedback to obtain a gain of about 40dB. It was expected that this amplifier would produce significant amounts of distortion at levels below overload, but it proved better than that, having a distortion of the order of 0.3%, which is on the limit of what can be measured with 'breadboarded' circuits. (To realise the full potential of many of the techniques described, it is necessary to build the circuits carefully, with accurate component values, in metal boxes). Nevertheless, the amplifier showed an interesting effect in its distortion characteristic when operated from a particular power supply, the advantage that it can be operated as an inverting or a non-inverting amplifier, and the capacitor values can be chosen to illustrate some useful points.

The basic circuit is shown in Figure 7a, while Figure 8a shows the connection of this amplifier into the simple balancing circuit for an inverting amplifier of low phase-shift. The capacitor C in Figure 7a has to be 2mF (2000μF) in order to obtain a low phase shift at 1kHz. The output voltage was adjusted to 3.3V at 1kHz, so that the output was just clipped. With the switch in the 'balance' position, the 1kΩ potentiometer was carefully adjusted for minimum voltage on the voltmeter, and the 220pF capacitor was found by trial to give the best (lowest) minimum. The voltage at the balance output was measured at 350μV, while 10.0mV was obtained with the switch in the 'reference' position. This gives a total harmonic distortion of 3.5% or −29dB. Measurement on a Lindos audio test set (which uses a combination of a notch and high-pass filter to eliminate the fundamental component of the output signal) gave 3.6%, which is in good agreement. The 220pF capacitor compensates for the phase-shift due to the 2.2mF capacitor feeding the 15Ω load resistance. The interesting effect mentioned above occurred in this way. The frequency response of the amplifier is very nearly flat between 315Hz and 1kHz, but, using a particular power supply, the power supply voltage fell when the signal frequency was lowered, causing the amplifier to overload at an output level 1dB lower at 315Hz than at 1kHz. 1dB represents about 10% in voltage, the amplifier gave 1% THD at

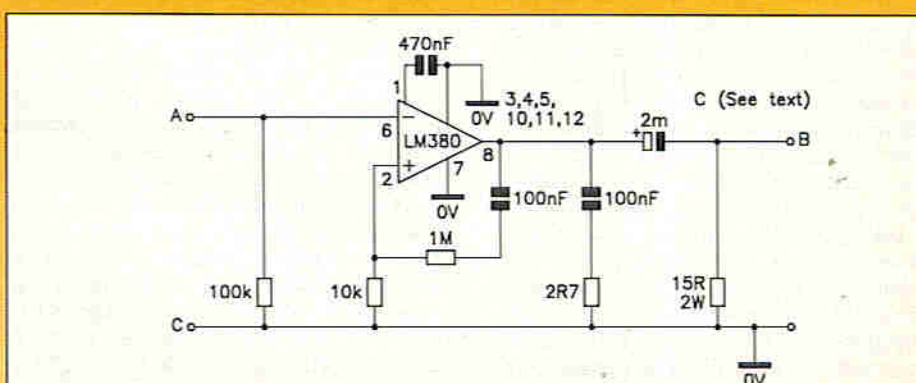


Figure 7a. LM380 test amplifier with positive feedback, in the low phase shift, inverting configuration.

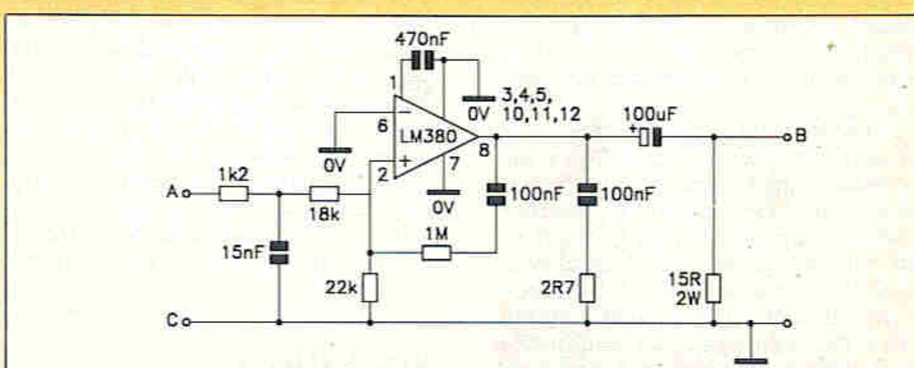


Figure 7b. LM380 test amplifier with positive feedback, in the high phase shift, non-inverting configuration.

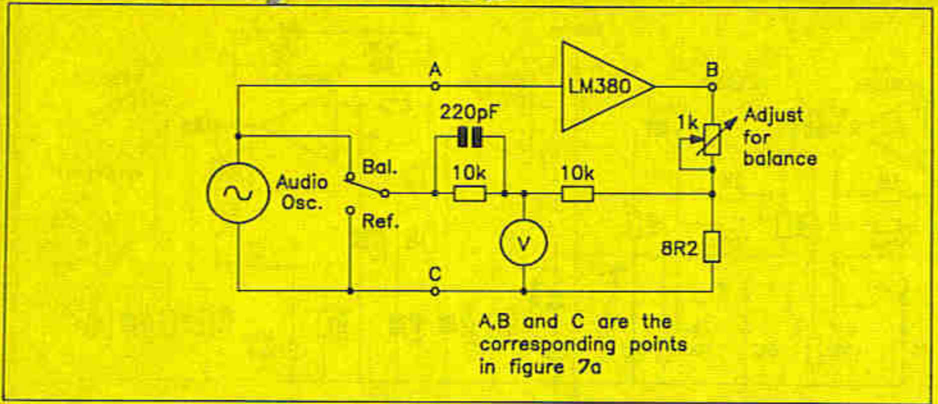


Figure 8a. Balancing network for measuring THD of the amplifier in Figure 7a. V is the voltmeter shown in Figure 6. The '220pF' capacitor value may vary between amplifiers.

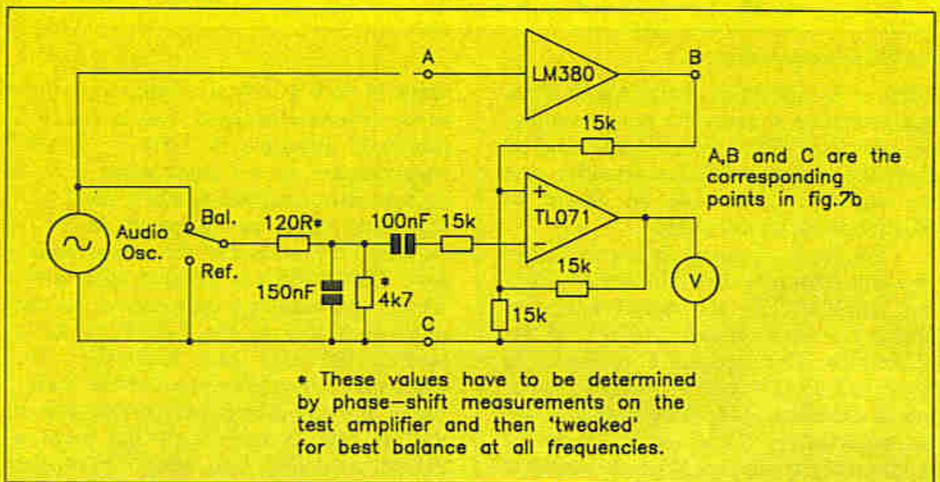


Figure 8b. Balancing network for measuring THD of the amplifier in Figure 7b.

1kHz but 4% at 315Hz. Clearly, it is not enough to measure THD at only one signal frequency! To avoid complications, a different power supply was used for the following tests. The amplifier configured with only one coupling capacitor, and with inversion from input to output (Figure 7a), is relatively easy to measure using the balancing technique. Figure 7b shows the same basic amplifier, but now operated in non-inverting mode and with an output coupling giving significant phase-shift even at 1kHz, together with an input filter, which could be included to reduce r.f. pickup. This filter introduces considerable phase-shift at high frequencies, and practically cancels the phase-shift at 1kHz due to the output coupling. This latter phase-shift still becomes evident at low frequencies, of course. In a discrete amplifier, the input filter might be represented by the h.f. cut necessary to preserve stability with negative feedback. There is such a cut inside the LM380, but it operates at too high a frequency for it to affect our measurements.

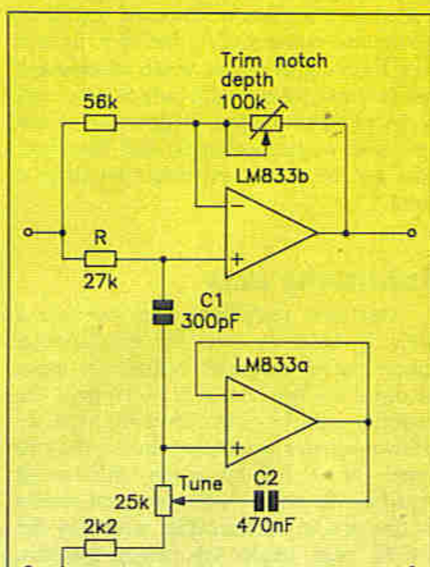
In order to do our balancing act with this amplifier, we have to subtract the attenuated 'output' signal from the 'input' signal, using the differential amplifier shown in Figure 8b, and we also have to shift the phase of the 'input' signal with respect to the true input signal, by exactly the same amount as the amplifier shifts the phase of the output signal. We could just do this at 1kHz by trial and error, but if we want to measure at several different signal frequencies, we should have to go through the trial and error procedure for each one. It is rather more businesslike to put into the circuit some components that will compensate the phase-shift correctly at all frequencies of interest, and we can do this as shown in Figure 8b. An interesting advantage is obtained, when we have tweaked the circuit values to get a good minimum at the balance point at all frequencies. We can then apply programme signals to the amplifier, and those signals themselves will cancel at the balance point, leaving the distortion by itself, which we could amplify and listen to! If we adjust the gain of the added amplifier so that we get normal listening level from the whole programme with the switch in the 'REF' position, and the distortion alone is inaudible when we switch to the 'BAL' position, we can be pretty sure that the distortion will also be inaudible when we are listening to the programme. This form of the balancing test was advocated many years ago by Quad, to prove the quality of their amplifiers. Recently, David Hafler has produced an amplifier with very low distortion and phase-shift (the XL-280), and has promoted a similar test on this product. A balancing netw rk in a box (XL10) is supplied to Hafler dealers, who can lend it to XL-280 buyers to check out their units. The phase-shift is so low that no capacitor compensation is needed in the network.

Notch filters

Balancing is one way of measuring THD, and notch filtering is the other. In this technique, we simply remove the component at signal frequency from the amplifier output signal, and what is left is the distortion, together with noise and any hum that the amplifier may inject.

The series-resonant gyrator

Before op-amps became available, THD meters were almost invariably based on the twin-T notch filter, but there is another possibility now, which we will look at first. If we connect an op-amp as a +1 gain amplifier (i.e. with 100% negative feedback), and then apply some POSITIVE feedback through a capacitor, the non-inverting input draws a current which lags the input voltage by nearly 90°. In other words, the input looks like a high-Q inductor with one terminal earthed. Effectively, the circuit turns a capacitor into an inductor, and it is called a 'gyrator'. If we connect a capacitor in series with the input, we get a series-resonant circuit, and the resonant frequency can be tuned by varying the positive feedback and thus varying the equivalent inductance. This circuit is often used (with fixed notch frequency and variable Q) in graphic equalisers. Figure 9 shows a practical distortion-measuring circuit giving a notch-depth of 46dB at 1kHz, and unity gain at 2kHz. The latter is an important point, for we do not want to attenuate the second harmonic component of the distortion. This filter has −3dB points at 940Hz and 1060Hz. Clearly, the notch depth of 46dB (200:1, or 0.5% leakage of fundamental) will not be sufficient to measure distortions below about 5% accurately, so for measuring good amplifiers, we need two of these filters in tandem. They could be tuned in step with a well-matched dual-gang poten-



$$f = \frac{1}{\pi R \sqrt{C_1 C_2}}$$

$$Q = \frac{1}{R1+R2}\sqrt{\frac{C2 \; R1 \; R2}{C1}}$$

Where R1 is the 'top' arm of the Tune control and R2 is the 'bottom' arm.

Figure 9. Series-resonant gyrator notch filter for 1kHz.

tiometer, but a fine trimmer will probably be needed as well, in order to reach a true minimum. It is extremely advisable to use wide-band op-amps, such as LM833 or NE5532 for all notch-filter circuits, because phase-shift in the op-amp can produce the most strange errors in filter response. We also have to take care that the filter does not introduce noise, radio pickup or hum that might be blamed on the amplifier. For this reason, a metal box construction is necessary.

The twin-T notch filter

The original passive twin-T was discovered by H.W. Augustadt in 1934. While it gives a good, deep notch (theoretically infinitely deep) when built with accurate components, it has a fixed Q of ¼, which means that it attenuates the second harmonic by about 9dB, and even the third harmonic by over 6dB. It is possible to overcome some of this by adding a peaky low-pass filter, but this complicates tuning. It is better to sharpen the notch with positive feedback, and Figure 10 shows this in a practical form. It is practicable to obtain notch depths exceeding 80dB (0.01% residual fundamental) with one of these filters, which is just as well, considering that three elements have to be adjusted. The two series arms can be ganged, but to get fine enough control, either multi-turn helical potentiometers, or

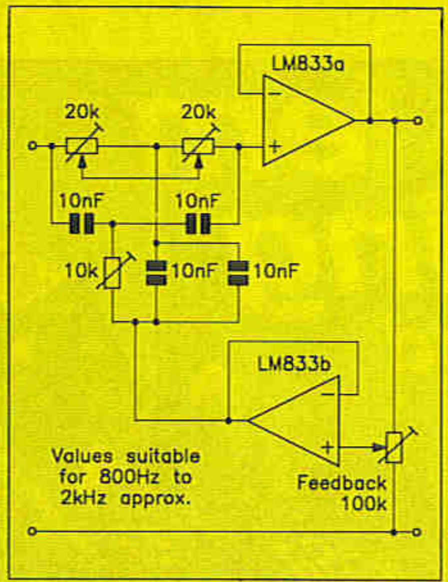


Figure 10. Twin-T notch filter with positive feedback.

up to three 'coarse, medium and fine' controls for the series arms, and another three for the shunt arm, are required. In a practical circuit, it is essential to take care that the physical layout of the components corresponds with the circuit diagram (an unusual requirement), because stray capacitances and other effects can degrade notch depth, symmetry and Q greatly at the higher audio frequencies.

The 'state-variable' or 'biquad' filter

We shall have much more to say about this type of filter later on, both in its completely analogue form and in the 'switched capacitor' form represented by the MF10CCN IC. At present we can note that is is possible to build very accurate, high performance notch filters using this circuit configuration, which, in the notch-filter form, uses four op-amps (or half an MF10 and one op-amp) for each second-order filter section. With several sections, it is possible to produce a filter response that has a 'flag bottom', i.e. a band of high attentuation that is several tens of Hz wide, rather than the very narrow notch produced by the gyrator and twin-T circuits. This considerably eases tuning, and allows the measurement of distortion components which vary slightly in frequency, such as those from an analogue disc record (which are affected by wow and flutter). The MF10 has the particular advantage that the notch frequency can be varied simply by changing the clock frequency.

. . . And there's more

Next time, we shall be looking at some more sophisticated filters, which prove rather easy to make, and at the results of measurements on the test amplifier.

COMPUTERS IN THE REAL WORLD *Continued from page 71.*

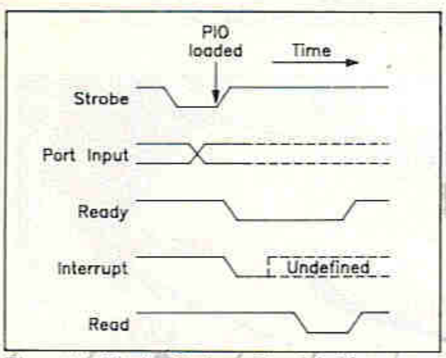


Figure 11. Timing for input handshaking.

will be loaded into the output port; after a short time interval this data will be considered 'valid', that is the data bus lines will all settle down and it is reasonable to suppose that what is on the data bus is the required byte of data. This will be latched into the output port. The WRITE line then goes high again, immediately after which the READY line goes high to signal to the peripheral that fresh data is available. When the peripheral has accepted the data, it takes the STROBE line low to signal the fact to the MPU. At the end of the strobe pulse the output port is cleared and a new interrupt is generated.

A similar diagram (Figure 11) is used to explain the inputting of data from a peripheral. The latter takes the strobe line low and presents data to the computer's input port, which is immediately latched in. At the end of the STROBE pulse the READY line goes low to generate an

```
00002                               ;A Polling Program for Z80 Microcomputers
00003
00004   5C00   (5C00)                         ORG     &5C00
00005   5C00   (0000)     PORTA       EQU     &00
00006   5C00   (5D00)     ISRA        EQU     &5D00
00007   5C00   (5D10)     ISRB        EQU     &5D10
00008   5C00   (5D20)     ISRC        EQU     &5D20
00009   5C00   DB 00      AGAIN       IN      A,(PORTA)
                          ; FETCH PORT A DATA
00010   5C02   CB 47                  BIT     0,A
                          ; TEST FLAG A
00011   5C04   C2 00 5D               JP      NZ,ISRA
                          ; IF SET GO TO ISRA
00012   5C07   CB 4F                  BIT     1,A
                          ; TEST FLAG B
00013   5C09   C2 10 5D               JP      NZ,ISRB
                          ; IF SET GO TO ISRB
00014   5C0C   CB 57                  BIT     2,A
                          ; TEST FLAG C
00015   5C0E   C2 20 5D               JP      NZ,ISRC
                          ; IF SET GO TO ISRC
00016   5C11   C3 00 5C               JP      AGAIN
                          ; NO FLAGS SET SO GO  AGAIN
```

Listing 1. A polling program for Z80 microcomputers.

interrupt; note the '$\overline{\text{INT}}$' line going low at this time. The READY line remains low during the time that the MPU is reading the data at the port. The read operation, of course, takes place during the period when the READ line is low. This occurs quite late in the cycle to allow the data bus to settle down after the new input data has been presented to it. When the READ line goes high again the READY line also goes high, which signals to the peripheral that it is now able to accept more data if required. The subsequent state of the '$\overline{\text{INT}}$' line will depend upon whether a new interrupt is initiated.

It is hoped that the foregoing explanation of the role of interrupts in interfacing a computer with the real world has aroused some interest in what is a fascinating topic, and perhaps cleared up a few misunderstandings as well. In the next part of this series we shall be looking at the serial and parallel transmission of data between the computer and its peripherals and examining some of the variety of interface chips that exist for this purpose.

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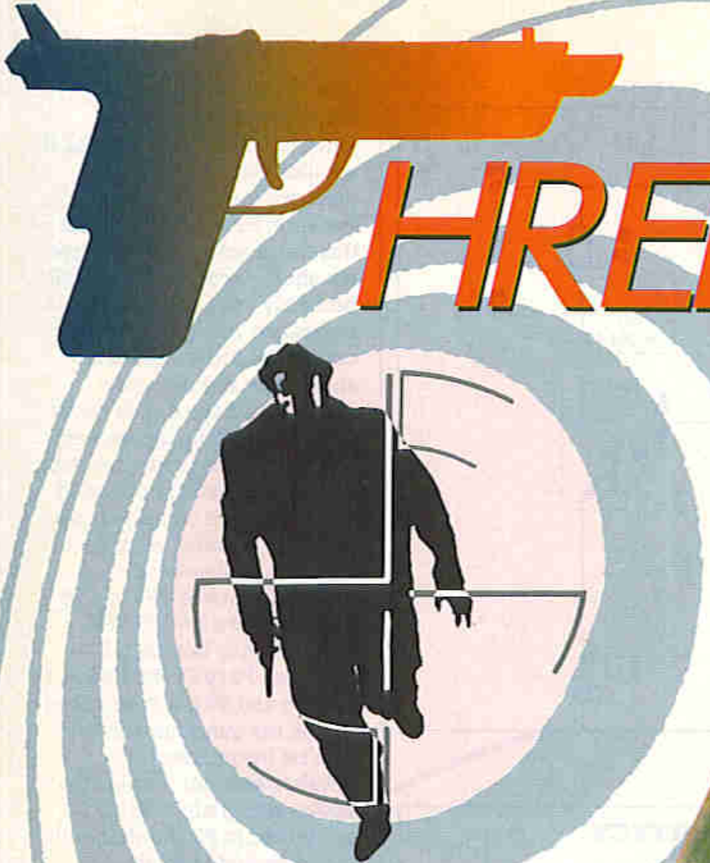

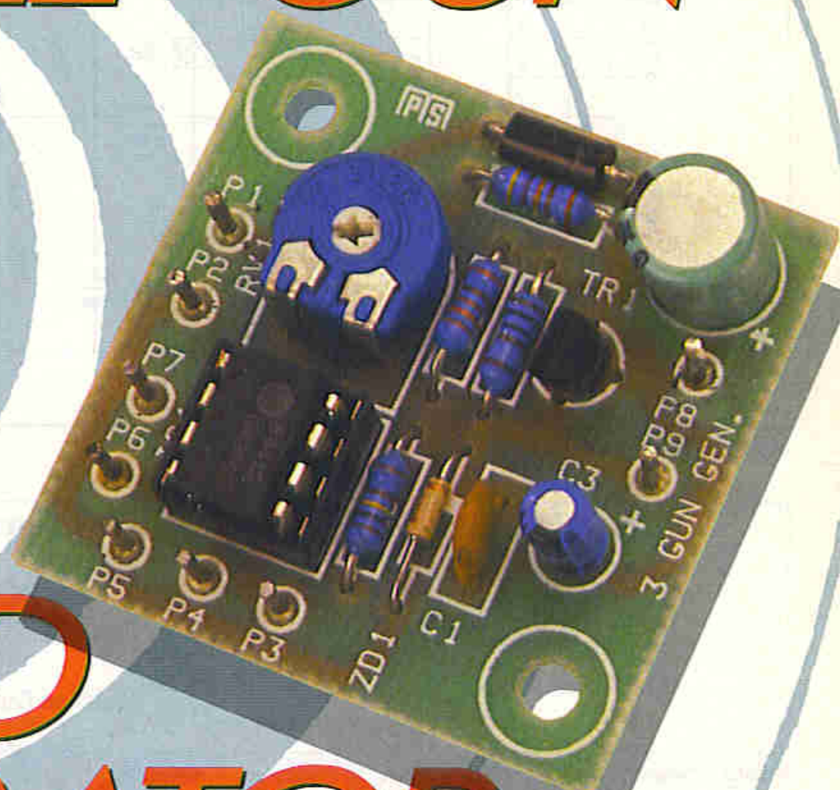

by Gavin Cheeseman

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Introduction

The Three Gun Sound Generator kit is a simple sound effects synthesiser using the UM3562 CMOS integrated circuit. Any one of three different gun sounds can be produced using the module, which is capable of driving a piezo sounder (included in the kit) or a 64 ohm loudspeaker directly. The module will operate over a wide range of power supply voltages between 2.5V and 12V with an option for low current operation if required.

Circuit Description

Referring to Figure 1, it can be seen that the module uses very few components; this is due to the fact that IC1 performs most of the functions in the circuit. Transistor TR1 acts as a buffer, giving the module a higher drive capability allowing it to be used with either a piezo sounder or a 64 ohm loudspeaker; a darlington transistor was chosen because it requires very little base current. Resistor R3 sets the transistor base current and R4 ensures that the transistor switches properly when driving into high impedance loads (such as piezo sounders). Preset resistor RV1 and resistor R1 are used to adjust the clock frequency which in turn determines the pitch of the sound effect. The nominal power supply voltage for the IC is around 3V, so zener diode ZD1 is included in the circuit to make provision for higher voltage power supplies, the current limit for ZD1 being set by R2.

Capacitors C1 and C3 provide decoupling for IC1 and C2 decouples the main supply rail. Rectifier diode D1 is included in the circuit to prevent any damage occurring if the polarity of the power supply is accidentally reversed. The state of pin P4 (the select pin) determines which of the three sound effects is produced (see Table 1). If P4 is connected to P3 (IC +V) then a 'rifle gun' sound is selected; however, if P4 is connected to P5 (0V) then a 'machine gun' sound is

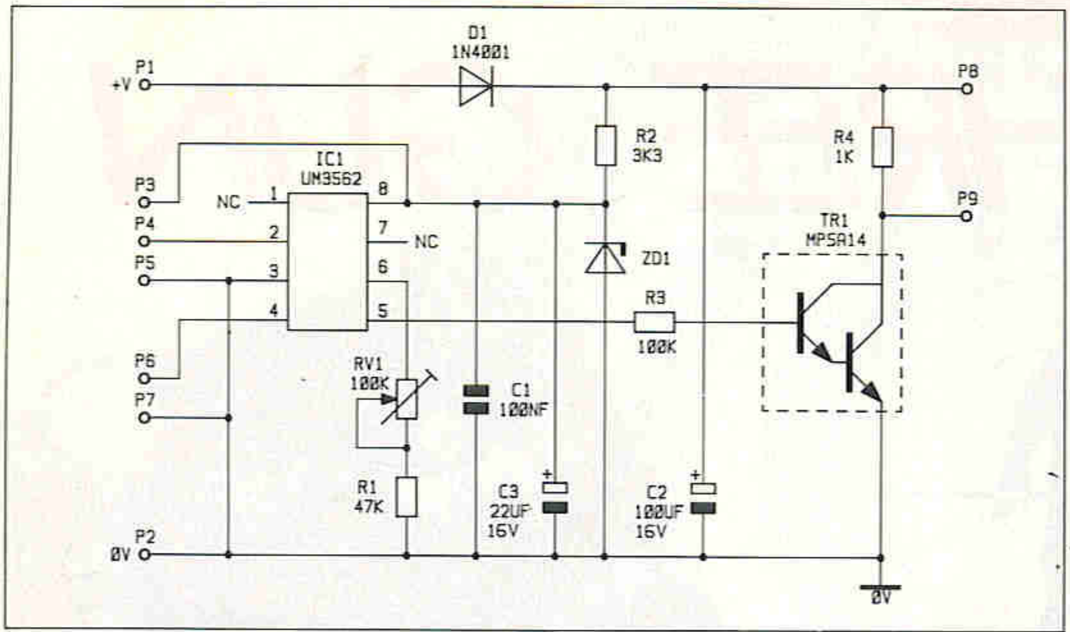

Figure 1. Circuit diagram.

SELECT INPUT	SOUND EFFECT
P4 connected to P3	Rifle Gun
P4 floating (not connected)	Ray Gun
P4 connected to P5	Machine Gun

Table 1. Selecting the sound effect.

selected. To obtain the third 'ray gun' sound P4 should be left floating. In order to trigger the sound effect it is necessary to connect P6 to P7. The machine gun effect continues as long as P6 is connected to P7 but the other two effects are single shot (that is to say the effect occurs once every time a trigger pulse is received).

Construction

The Three Gun Sound Generator uses a high quality fibreglass PCB with a screen printed legend. Insert and solder the components onto the PCB referring to the component layout diagram (Figure 2). Start by fitting the IC socket, ensuring that the notch at one end of the socket corresponds with the outline on the legend. Insert the PCB pins and press them down into place using a hot soldering iron; once in place the pins can then be soldered.

Resistors R1 to R4 and preset resistor RV1 may then be fitted. Next fit capacitors C1 to C3. C2 and C3 are electrolytic capacitors and therefore it is important that these are fitted observing the correct polarity; the negative lead (usually marked by a '−' sign on the capacitor case) should be inserted away from the '+' symbol on the PCB legend.

The polarity of the semiconductors is also important and care is required to make sure that the case of the transistor and the polarity markings on the diodes match the appropriate outlines on the legend. Some caution is also needed when soldering the semiconductors as they can be easily damaged if overheated.

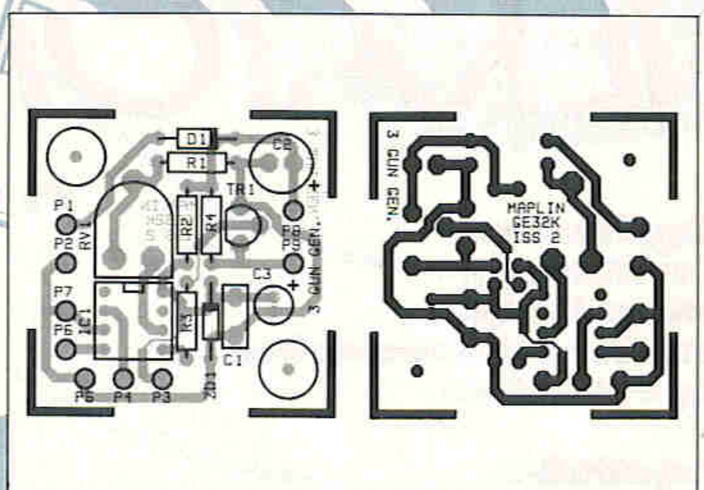

Figure 2. Component layout.

Finally, when you are sure that all the other components are fitted correctly, install IC1 into the IC socket, making sure that the notch at one end of the IC corresponds with that in the socket. For further information regarding construction techniques, reference should be made to the constructors guide included in the kit.

Testing

Before applying power to the module check to make sure that there are no dry joints or solder short circuits. If a multimeter is available, measure the resistance between P1 and P2 to ensure that the power supply rails are not short circuit; the meter will probably indicate a low resistance when it is first connected but the reading should rise rapidly as the capacitors in the circuit begin to charge and should exceed 100 ohms within a few seconds of the meter being connected.

To test the circuit, connect the piezo sounder supplied or a 64 ohm loudspeaker (WF57M) between P8 and P9 and connect a 2.5V to 12V power supply between P1 (+V) and P2 (0V). If P4 is left floating and P6 is connected to P7, the ray gun sound should then be heard from the speaker/sounder. Repeat the above test, firstly with P4 connected to P3 and then with P4 connected to P5; the appropriate sound effect should then be heard in each case. The current consumption of the module is approximately 2mA in the standby mode but this increases substantially when the unit is actually operating, depending on the type of load being driven; this should be taken into consideration when choosing a power source.

Using the Module

The Three Gun Sound Generator is a useful general purpose module that could find varied uses in many applications including games, toys and models. IC1 draws very little current and this makes the circuit useful for battery powered applications.

If very low current drain is required and a power supply voltage between 2.5V and 3.5V is acceptable, then the current consumption of the circuit in the standby mode can be substantially reduced by omitting ZD1; for example, this option is ideal when powering the module from 2 x AA cells. To prevent damage to IC1 when operating the circuit without ZD1 fitted, make sure that the power supply voltage does not exceed 3.5V. For general purpose use, it is probably a good idea to fit a 3 way switch for sound effect selection and a push button switch to trigger the unit (see Figure 3). Preset resistor RV1 can be adjusted until a suitable pitch for the sound effect is obtained. In order to avoid any damage to TR1, make sure that any load connected between P8 and P9 exhibits an impedance in excess of 50 ohms. If a lower impedance load is connected between the output terminals, the power rating of the transistor could be exceeded. It should also be borne in mind that although the Three Gun Sound Generator operates satisfactorily when driving into a piezo sounder, improved performance and increased volume is obtained when a loudspeaker is used.

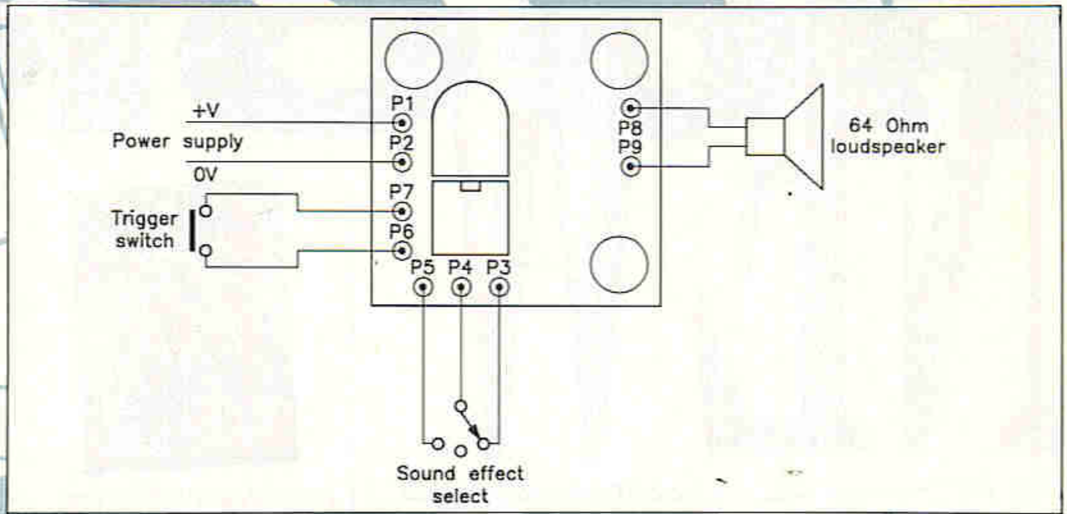

Figure 3. Wiring diagram.

3 GUN SOUND GENERATOR PARTS LIST

RESISTORS: All 1% 0.6W Metal Film

R1	47k	1	(M47K)
R2	3k3	1	(M3K3)
R3	100k	1	(M100K)
R4	1k	1	(M1K)
RV1	100k Hor. Encl. Preset	1	(UH06G)

CAPACITORS

C1	100nF Minidisc	1	(YR75S)
C2	100µF 16V Minelect	1	(RA55K)
C3	22µF 16V Minelect	1	(YY36P)

SEMICONDUCTORS

IC1	UM3562	1	(UL24B)
TR1	MPSA14	1	(QH60Q)
D1	1N4001	1	(QL73Q)
ZD1	BZY88C2V7	1	(QH00A)

MISCELLANEOUS

Pin 2145	1 Pkt	(FL24B)
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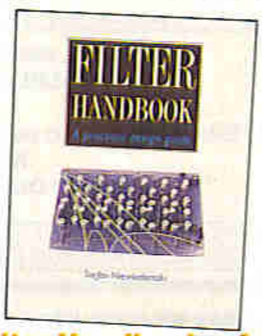

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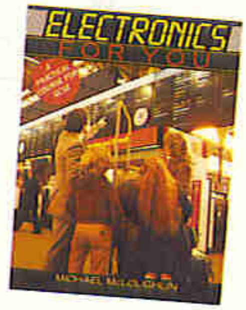

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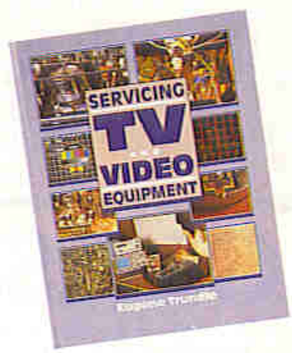

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Edgware.
Tel: 01 951 0969.
159-161 King Street, Hammersmith.
Tel: 01 748 0926.

MANCHESTER
8 Oxford Road.
Tel: 061 236 0281.

NEWCASTLE-UPON-TYNE
Bennetts Electrical Superstore,
136-168 Shields Road, Byker.
Tel: 091 224 0990.

NOTTINGHAM
86-88 Lower Parliament Street.
Tel: 0602 410242.

READING
129-131 Oxford Road.
Tel: 0734 566638.

SOUTHAMPTON
46-48 Bevois Valley Road.
Tel: 0703 225831.

SOUTHEND
282-284 London Road,
Westcliff-on-Sea, Essex.
Tel: 0702 554000.

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

For mail order enquiries, please DO NOT call our shops as they will be unable to help you.

- ★ **Expert Help & Advice**
- ★ **Credit Facility Available** (written details on request)
- ★ **Self-Service – browse at leisure**
- ★ **Open SIX days every week**
- ★ **Shop with confidence with the Maplin Guarantee**

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

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

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

BRIGHTON: Opening early 1990
Tel: 0702 552911 for details

POP IN TO A Maplin SHOP TODAY AND DISCOVER A UNIQUE SHOPPING EXPERIENCE!