AUTOMOTIVE · SECURITY · RADIO · COMPUTERS

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ELECTRONICS

The Maplin Magazine

Britain's Best Selling Electronics Magazine

How to 'Listen in' on Aircraft Radio Transmissions – Build Your Own Airband Receiver Project!

Intermittent Wiper Controller Project for your Car

See Who is at Your Door with a CCD Camera Modulator Project

Discover the Secrets of Remotely Operated Vehicles

PLUS... How to Use Audio Preamp ICs, Build a Sub-woofer System, Tune into the HF Bands, Use Programmable Unijunction Transistors and Much, Much More!

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MARCH 1994
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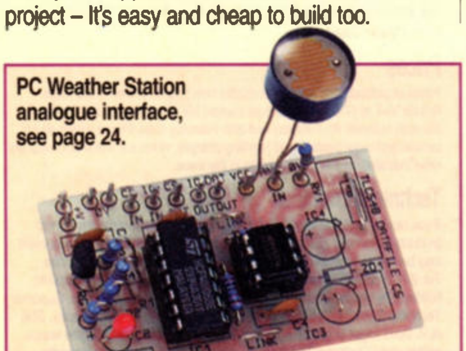

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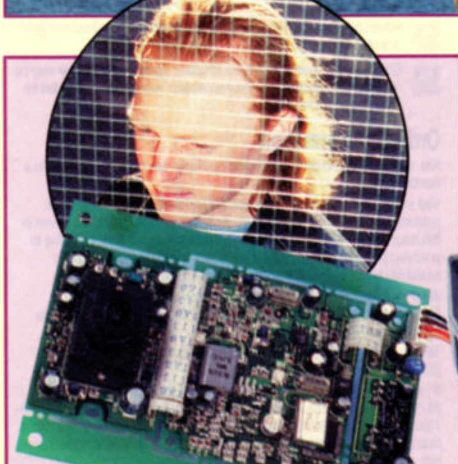

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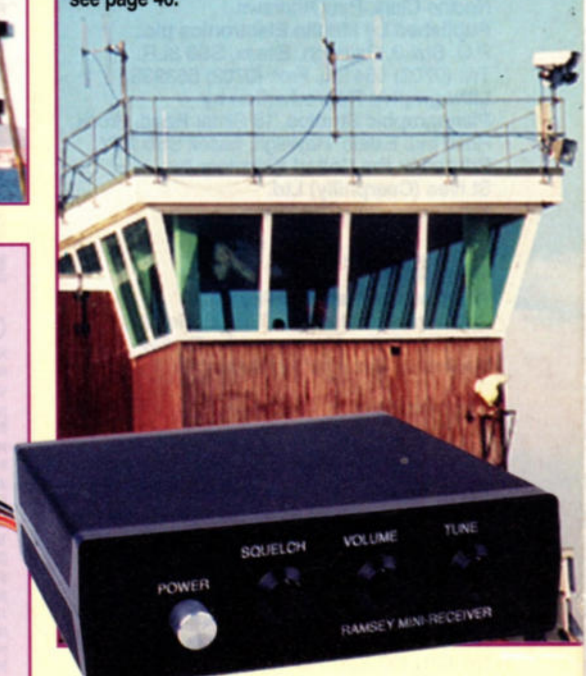

ABOUT THIS ISSUE . . .

Hello and welcome to this month's issue of *Electronics!*

On the 1st of January 1995 the nominal mains voltage supplied to our homes, as specified in the Electrical Supply regulations, will be *decreased* from 240V AC ±6% to 230V +10% –6%. This change will bring the UK into line with a similar *increase* from 220V to 230V in the rest of Europe. Does this mean that if on the 31st December 1994 we connect our multimeters across the mains that on the stroke of midnight, when most people will be singing *Auld Lang Syne*, we will see a sudden drop of 10V? In actuality, no! It is anticipated that there will be little change in the *actual* supply voltage in many people's homes for quite a few years to come. What will probably happen is that as new distribution equipment is built, or old distribution equipment (such as substation transformers) is replaced or adjusted, the mains voltage supplied from that equipment will be nearer to 230V. A quick bit of mental arithmetic (use a calculator if you must) shows that 240V will still be within the new supply voltage upper and lower limits of 253V and 216·2V (the current limits are 254·4V and 225·6V).

The whole idea stems from the Single European Market, where equipment should be able to be bought and subsequently used in any European country without problem. Presently, mains powered equipment bought in the UK and used in continental Europe may be *understressed*; conversely, equipment bought in continental Europe and used in the UK may be *overstressed.* This applies mainly to equipment that uses mains frequency motors, transformers, heating elements, filament lamps, etc. Equipment that incorporates a switched mode power supply, such as TVs, VCRs, computers, etc., is much more tolerant of supply variation and often unaffected. So it is clear to see that it makes good sense to standardise the mains voltage, it does beg the question, why on earth did countries *choose* to have similar but different voltages in the first place? Ours is not to reason why!

However, there is one fly in the ointment and it only really affects the UK. Generally speaking, in the UK most appliances are connected to the mains by means of a 13A plug fitted with a fuse, the value of which is chosen (or should be!) to suit the appliance and protect the *cable* between the plug and appliance from overload (if the *appliance* itself requires protection then an internal fuse is fitted). Okay, so what's the problem? Take, for example, a 3kW electric fire designed to operate on 240V, it will draw 12·5A from a 240V supply. A 3kW electric fire designed to operate on 230V will draw 13A from a 230V supply and 13·6A from a 240V supply. Hopefully you can see the problem, the current drawn exceeds the rating of the 13A plug and it's even worse if the mains supply is at the top end of its limit (253V), the current drawn will be 14·3A. The result will be a rather warm plug (the fuse won't blow because the overload is not severe enough). In Continental Europe this problem doesn't exist because their mains plugs are rated at 16A and do not have fuses. The Institution of Electrical Engineers (IEE), in a report to the House of Commons Trade and Industry Committee, comments, 'The proposed 16A plug [Europlug] and socket [would] overcome the problem'. The subject of the Europlug has been discussed in Keith Brindley's *Technology Watch* over the last couple of issues. The report also adds in respect of the Europlug, 'As is often the case, good initial engineering design has provided the means to cope with the change to the new system, but the economic and commercial considerations are not so straightforward. It also reminds us that although the 13A fused plug has been the UK standard since 1946(!), the 5A and 15A round pin plugs are still in use in around 225,000 UK homes!

Last year we reported that legislation was being put in place to require the prefitting of mains plugs to domestic electrical appliances (the Plug and Socket Regulations), this would reduce the number of deaths and injuries caused by incorrectly fitted and fused mains plugs. Currently, according to a Department of Trade and Industry (DTI) Consumer Safety Unit spokesperson, this legislation is on hold because of questions raised by the European Commission (EC), even if the EC is satisfied by the answers given by the DTI, implementation will be at least six months away. Just as manufacturers and retailers have got used to this good, hopefully imminent, idea and taken the necessary steps to comply, the proposed Europlug has come along!

If the Europlug is adopted, it is probable that appliances would be supplied prefitted with 16A Europlugs and *adaptors* supplied so that they could be used with existing 13A sockets. I am sure that many people would cut off the Europlug and fit (perhaps wrongly) a 13A plug instead, which defeats the whole idea of the Plug and Socket Regulations! The DTI spokesperson also commented that the UK could decide *not* to implement the Europlug, if this were the case the EC could issue a directive requiring the UK (and any/all other countries in the European Community) to adopt it! Either way the likely timescale to complete implementation would be similar to the last change – thirty to forty years – achieved in the course of normal rewiring and refurbishment to premises.

But, since the final specification for the Europlug is still to be finalised by the International Electrotechnical Committee (IEC), because of concerns for safety, and yet to be adopted by CENELEC (the European Committee for Electrotechnical Standardisation) any changes will be a long way off! Well laid plans . . .

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

ABC CONSUMER PRESS

Front cover picture: Michel Tcherevkoff © Copyright 1994 The Image Bank. *Safe air-travel in our modern world requires effective communications between pilots and control towers.*

CORRIGENDA

Issue 71/November 1993

Digital Train Controller, page 6, Table 2; the pulse widths are shown incorrectly and should read: Logic 0 = 51µs, Logic 1 = 34µs and Inter Packet Gap = 102µs.

Issue 74/February 1994

Millennium 4-20 Valve Amplifier Part 2, page 46, Table 1; second line at top of table referring to potentials at two points in the supply rail divider chain are incorrect and should read: Junction of R13 & C7 = 380V. Junction of R6 & C1/C2 = 150V.

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Project Ratings

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

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

Ordering Information

Kits, components and products stocked by Maplin can be easily obtained in a number of ways:

Visit your local Maplin store, where you will find a wide range of electronic products. If you do not know where your nearest store is, refer to the advert in this issue or Tel: (0702) 552911. To avoid disappointment when intending to purchase products from a Maplin store, customers are advised to check availability before travelling any distance.

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

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

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

If you have a tone dial (DTMF) telephone or a pocket tone dialler, you can access our computer system and place orders directly onto the Maplin computer 24 hours a day by simply dialling (0702) 556751. You will need a Maplin customer number and a personal identification number (PIN) to access the system. If you do not have a customer number or a PIN number Tel: (0702) 552911 and we will happily issue you with one.

Full details of all of the methods of ordering from Maplin can be found in the current Maplin Catalogue.

Prices

Prices of products and services available from Maplin, shown in this issue, include VAT at 17·5% (except items marked NV which are rated at 0%) and are valid between 4th February and 28th February 1994. Prices shown do not include mail order postage and handling charges, which are levied at the current rates indicated on the Order Coupon in this issue.

Technical Enquiries

If you have a technical enquiry relating to Maplin projects, components and products featured in *Electronics*, the Customer Technical Services Department may be able to help. You can obtain help in several ways; over the phone, Tel: (0702) 556001 between 2pm and 4pm Monday to Friday, except public holidays; by sending a facsimile, Fax: (0702) 553935; or by writing to: Customer Technical Services, Maplin Electronics plc., P.O. Box 3, Rayleigh, Essex, SS6 8LR. Don't forget to include a stamped self-addressed envelope if you want a written reply! Customer Technical Services are unable to answer enquiries relating to third-party products or components which are not stocked by Maplin.

'Get You Working' Service

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

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

Readers Letters

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

TECHNOLOGY WATCH!

with Keith Brindley

A New Era Dawns

I consider myself quite fortunate. At a number of points in my life I have been lucky to be there when revolutions occurred. Not instant revolutions like the French one (I'm not *that* old, I hasten to add), but revolutions nevertheless which had far-reaching social and political implications every bit as important as the likes of France's burgeoning democracy.

For instance, I witnessed the revolution in electronics which began with the changeover from transistorised circuits to those using integrated circuits. When circuits only designable and buildable if you had a thorough background in electronics, could then be designed and built by the amateur with ease.

I was there too when the personal computer revolution started. I remember working with the Commodore Pet on its launch which – despite what devotees of Sir Clive Sinclair might have you think – I believe was the machine which really began it all. When computers which might have been lucky to fit in a room the size of an office suddenly became small enough to fit on an office desk, yet powerful enough to do office tasks.

So it is that I find we are now at the beginning of a new revolution. And I feel privileged to have held it quite literally in my own hand. I have scheduled my work on it. I have written letters on it – indeed I am writing some of these very words on it – and printed them, and faxed them, directly from it. I have drawn simple technical drawings on it. I have kept a database of names and addresses on it. It tells me when appointments are to be kept. It connects to a desktop computer (of Windows or Macintosh format) and downloads or uploads information directly from and to it. It will electronically mail information to people and receive mail electronically from others. It understands (with a few quirks) my ordinary handwritten scrawl. Shortly it will respond to messages paged over the 'phone network, and even be usable over the cellular network. And more. Much more. The potential is just unbelievable.

It, as you've probably already guessed, is a personal digital assistant or PDA. And the PDA in question is the MessagePad – the first member of Apple's Newton family of planned PDA products. It is available too in a badged version by Sharp – the *Expert Pad.* It is, of course, in all but name, a palm-sized computer which masquerades as an electronic file-of-facts cum mobile fax machine cum pocket-sized secretary (I tried sitting it on my knee but it didn't feel quite the same!)

There are other pretenders to the PDA crown. Amstrad's PenPad is one. AT&T's Personal Communicator is another. But the rest simply pale by comparison. None can accept ordinary handwritten input in the way Newton does. (I can't deny its handwriting translation isn't immediately perfect; you ought to see my handwriting. But Newton learns. The more you use it, the better Newton gets at understanding individual handwriting.) None are anywhere near as user-friendly. None seem to have Newton's in-built potential. And certainly none have Newton's style.

Much the same things I felt when standing looking at the dawn of the new integrated circuit electronic era, and that of the personal computing era, I feel now. The potential for electronics when integrated circuits appeared was huge. The potential for computers when personal computers arrived was massive. And the potential for PDAs now that Newton is here is simply too large to yet comprehend. PDAs and their offspring are set to rule our lives just as much as (if not more than) the electronic and computing gadgets do, which we already take for granted.

Everybody knows that computing size is going down while power is going up. The next logical step in the computer evolution (desktop computers, portable computers, laptop computers, notebook computers . . .) is the PDA. That's undeniable after all. But it's the keyboard which has stopped the evolution so far. Miniaturised keyboards (in the form of, say, Psion's Series 3 or Sharp OZ/IQ's) are almost impossibly difficult to use at any speed, so computer miniaturisation had temporarily halted.

But at last, the expected miniaturisation evolution has occurred and as a result started the PDA revolution. At last, the means of communicating with a computer is not restricted to just a keyboard. This thing is almost an *extension* of your computer which you can pull out of your pocket at any time. At last, the computer almost thinks for itself, planning your tasks with you in mind. Newton's digital assistant even pre-empts your very thoughts, stepping in to do automatically what you were planning to do next. The first time it does that as you are working with Newton is an eerie moment. If this is just the first step of the expected revolution, which Newton *is*, it's going to be *some* revolution.

The opinions expressed by the author are not necessarily those of the publisher or the editor.

NEWS Report

Simplified Signal Analysis

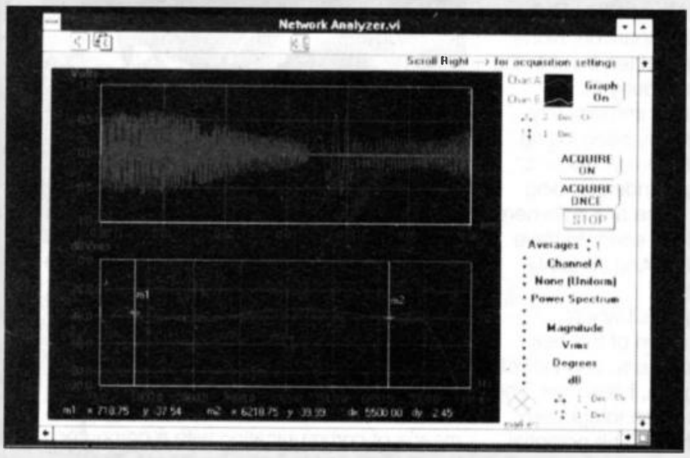
National Instruments has released 'SpectrumWare', a dynamic signal analyser for Windows, Macintosh and Sun users.

Built using the company's 'LabView' Application Builder, Spectrumware simplifies the measurement of frequency response, power spectrum, amplitude spectrum, coherence, transient capture and cross spectrum.

Spectrumware is ideal for applications involving electronic filters and networks, audio frequency communications equipment, machine vibration, transducers such as accelerometers and hydrophones, as well as resonance in mechanical structures.

Other applications include the measurement of signal transients or low frequency spectra such as speech or mechanical vibration.

Spectrumware is included with all dynamic signal acquisition boards from National Instruments, or it is available as a stand-alone package. Contact: National Instruments (0635) 523545.



ARM7 Architecture

Advanced RISC Machines has introduced ARM7 (the world's smallest and most powerful low voltage RISC processor available).

ARM7 consists of a core CPU to which peripherals such as cache memory, I/O and write buffers can be added to give a complete microprocessor system on a silicon chip. In addition, ARM7 offers a range of architectural extensions to the CPU core to extend processing capability, while also easing programming, debugging and monitoring during development.

The ARM7D core solves the problem of connecting an external In-Circuit Emulator (ICE) to an embedded CPU, by incorporating its own ICE, 'ICEbreaker'. This is accessed by the host development computer, such as a PC, and an external debug controller, 'BlackICE', giving the complete functionality of an ICE without the expense of additional resources.

Along with ICE capability, the ARM7DM core includes Digital Signal Processing (DSP) support. Many applications such as data encryption, video manipulation and multimedia processing require dedicated DSP under the control of a microprocessor, implying an increase in cost and size. Combining DSP and a RISC processor on a single die avoids these penalties also reducing programming complexity.

Developed in conjunction with ARM's semiconductor partners (VLSI Technology, Sharp, GEC Plessey Semiconductors and Texas Instruments) the ARM7 family of low power processors has been optimised to operate at both 3V and 5V.

By utilising a 0·8 micron thick, CMOS 2-layer metal process technology, optimising critical paths and including DSP hardware, ARM have developed the world's smallest high performance RISC processor. Running at 30MHz on a 5V supply, the ARM7 consumes 165mW at a load of 1pF. Comparable figures at 20MHz on a 3V supply are 33mW at a load of 1pF. Contact: Advanced RISC Machines (081) 336 1281.

Thorn EMI and IBM team up for ASTOR

Thorn EMI Electronics and IBM Aerospace Systems Integration Corporation have signed a teaming agreement to bid for the UK Ministry of Defence ASTOR programme. An invitation to tender for the project definition stage of the programme is expected within the next few months.

ASTOR is an airborne stand off radar system capable of providing Synthetic Aperture Radar (SAR) imagery and Moving Target Indication (MTI) radar imagery for surveillance and targeting purposes for the Army and the Royal Air Force. The radar is likely to be carried on a high flying aircraft. Radar images will be transmitted via a data link to a ground station where image processing will be carried out. Contact: IBM (0705) 565166.

Correct Address

Companies are able to claim discounts from the Post Office if they address envelopes in a format suitable for automated equipment. To help large companies meet this need, Capscan has launched 'Matchcode 5', a software package that contains all UK addresses in the Post Office format.

Using Matchcode 5, addresses entered into a computer randomly are sorted into the correct format with incomplete or missing data such as postcodes added where necessary. Yet Matchcode 5 is able to offer the Post Office even greater assistance. The package can also sort addresses into geographical areas, saving even more time at the sorting office.

Capscan claim Matchcode 5 sets new standards for address processing with a throughput of up to 20,000 records per hour running on a PC based system.

Meanwhile readers who want to be properly addressed can contact the new Post Office Postcode line. Charged at local rates, callers between 9.00am and 5.00pm can obtain postcode and addressing details for any UK address. Contact: Capscan (071) 267 7055, Post Office (0345) 111222.

Security ID Tag

Computer theft is running at over £100 million a year. Credit card fraud is estimated at more then £165 million. Theft of mobile phones currently exceeds £50 million. And over a third of all stolen vehicles are never recovered. It all makes for depressing news.

Why are these figures so high? Because identification is rarely positive and ownership cannot be established or proven. But that is about to change with a new read-write integrated circuit tag from Selectamark.

The tag, called Selectatag, is a tiny information carrier no larger than a pinhead. It is paper thin, circled by its own antenna and encased in a robust plastic material. It can read through glass, wood, plastic and metal at a distance of up to seven inches.

Selectatag is a non-contact identification system able to communicate with a PC via a transceiver. The system is based on inductive technology, characterised by low power consumption and high-speed operation.

The tag receives its power from the read head and simultaneously transmits back its identification code. Likewise it is possible to read and write to a programmed tag. Contact: Selectamark (0689) 860757.

PC Loadcell

IMS Ltd. has introduced LCIC-1106 – believed to be the first Loadcell interface card for PC compatible computers.

Until now the only way to handle weighing applications with a PC was by using an external stand-alone weighing indicator to communicate with the computer via a RS232 communication port. For high-speed applications, such as weighing a moving vehicle, external indicators are extremely limited both by their own conversion rates and the relatively slow rate of communication through a serial link.

By contrast the very high conversion rate of the LCIC-1106 (up to 4,000 measurements a second) together the potential for direct communication to a PC bus, make an enormous improvement in the effective data rate of data acquisition.

Virtual Actor

TV personalities of the future could be computer generated characters. British researchers TeleVirtual have already created an animated cat's head for the BBC, called Ratz, that can act alongside other cartoon characters or people, take phone calls from viewers and present shows.

At the heart of the system, called 'VActor' (Virtual Actor), is a supercomputer and an actor called Paul Brophy. Using state-of-the-art virtual reality graphics technology, the actor's movements are copied instantly by the cartoon cat on the screen. Up to eight sensors attached to a helmet allow hundreds of facial expressions to be generated. The character's voice is Brophy's own – a few octaves. Higher!

At the moment Ratz is co-presenting children's programmes on Saturday mornings on BBC 1. The bulk of Ratz's fan mail concerns what sort of body he should have. But, with the hardware and software required to create Ratz's head alone costing £150,000, it could be a while before fans get an answer! Contact: TeleVirtual (0603) 767493.

Fully Encapsulated Contactless Angular Sensor

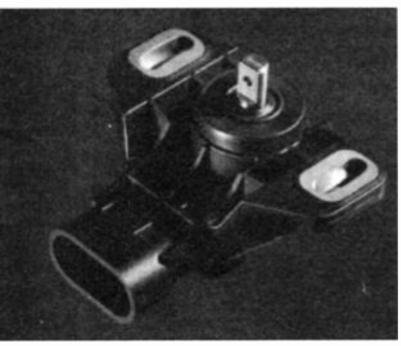
The new KMA10/70 contactless sensor from Philips Semi-conductors provides a fully encapsulated, non-wearing and adjustment free solution to angular position measurement in a wide range of automotive and industrial applications, such as active suspension units, accelerator pedal position setting and servo controlled actuators.

Its sealed housing, wide operating temperature range and high degree of EMI immunity make it particularly useful in safety critical applications where the sensor must be able to survive extreme environmental conditions without failure or loss of performance.

Based around Philips' KMZ11B1 magneto-resistive sensor element, the KMA10/70 angular displacement sensor has an integral input shaft and a sealed bearing magnet assembly which allow the magnet's field to be rotated over the sensor element.

The resultant changes in the resistance of the sensor element are detected by the thick-film hybrid signal conditioning circuit, which produces a temperature compensated 4mA to 20mA output signal corresponding to the angular displacement of the input shaft.

The sensor has an operating temperature range of –40°C to +100°C and a lifetime in excess of 10^8 operating cycles. Its maximum angular displacement speed of $20^\circ ms^{-1}$ far exceeds the inertia of the mechanical system to which it is likely to be connected, making it suitable to high-speed servo-control systems. Contact: Philips (010) 31 40 724825.



Making the Picture

A £160,000 order from Sony Manufacturing has been won by conveyor specialist Sovex to extend a system handling high volumes of cathode ray tubes for Trinitron colour television sets at the company's Bridgend plant in South Wales. The new conveyors form an extension to an existing Sovex system taking tubes away from a sealing oven, thus catering for increased output.

As the original system (which also includes conveyors feeding into the oven) the extension was manufactured at the company's Nottingham factory, before installation and commissioning at the Sony plant during the Christmas shutdown.

Smooth movement along the conveyor lines is a key requirement for these products, especially since it is inside the oven that two key components (the tube's front panel and funnel) are sealed together to form a bulb. An extremely tight tolerance has to be maintained whilst the jig-mounted assemblies are automatically arranged in rows and manoeuvred around right angle turns into the oven.

When they emerge at the opposite end, the rows of completed tubes are manoeuvred back into a continuous line ready for removal from the production line. Contact: Sovex (0602) 616616.

Diary Dates

This feature, which usually occupies space under the 'News Report' banner, has been placed on page 51. This is due to so many interesting news items and events details landing on the News Editor's desk this month! If you have any items for inclusion in 'Diary Dates' send them to the News Editor, *Electronics – The Maplin Magazine,* P.O. Box 3, Rayleigh, Essex SS6 8LR.

Keeping a Clear View

Windscreen wipers that automatically keep pace with the amount of rain falling outside, clearing a windscreen that warms up by itself at the first hint of misting, are now possible thanks to a new device developed by optical engineers at the contract research company Sira.

Small enough to be mounted unobtrusively above the windscreen of a family car, the device detects both misting on the inside of a windscreen and rainwater on the outside. It constantly measures the driver's view through the screen, ensuring that it is as clean as possible.

Developed for a major UK car manufacturer, the sensor works by using infra-red signals. The light from tiny infra-red LEDs buried in the car's dashboard reflects off the inside of the windscreen to the detector mounted inside the car roof. The degree to which the infra-red beam is scattered provides a measure of the rain or the level of internal misting. Contact: Sira Ltd. (081) 467 2636.

Noise Cancellation

The world's first audio headset developed to reduce audible noise electronically has been intróduced by Noise Cancellation Technologies.

The NB-DX headset uses NCT's active noise cancellation technology to remove a variety of annoying noises such as those generated by lawnmowers, strimmers and vacuum cleaners as well as engine related noises from cars, trucks, tractors, railway trains and aircraft. The NB-DX is a lightweight, open backed headset with a 2·8 x 3·2 x 1·1in. active controller, powered by a 9V battery.

According to Irene Lebovics, President of NCT Personal Quieting, the NB-DX headset has only previously been available to specialised users. "The prohibitive cost of these headsets, up to £800, has restricted sales to the industrial and professional market-place. However, we have developed the technology to the point where we can now introduce the NB-DX to consumers in any walk of life for around £150."

NCT's active noise cancellation technology utilises electronic processing to attenuate undesirable noises by producing an equal but opposite sound wave called 'anti-noise'. The NB-DX can reduce noise by up to 10dB, which represents a 50% or more reduction in perceived noise.

The NB-DX headset may be worn on its own to alleviate the nuisance of noise, or it can be connected to a personal cassette or CD player, for listening to music at a more comfortable level.

Contact: Noise Cancellation Technologies (0101) 203 961 0500.

TV Measurement

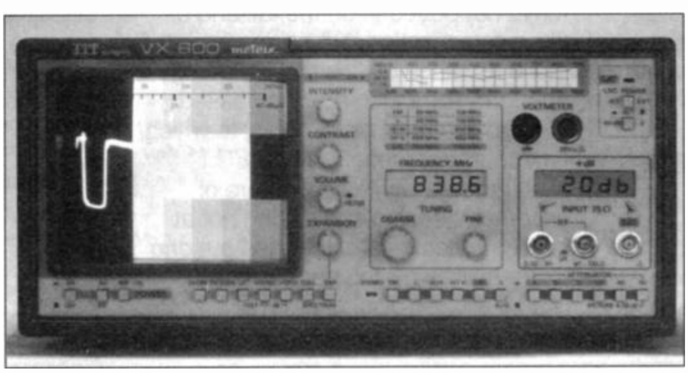
Two new models in the ITT Instruments VX600 Series of TV measurement receivers incorporate a number of features which make them suited to the needs of satellite dish and aerial installation engineers.

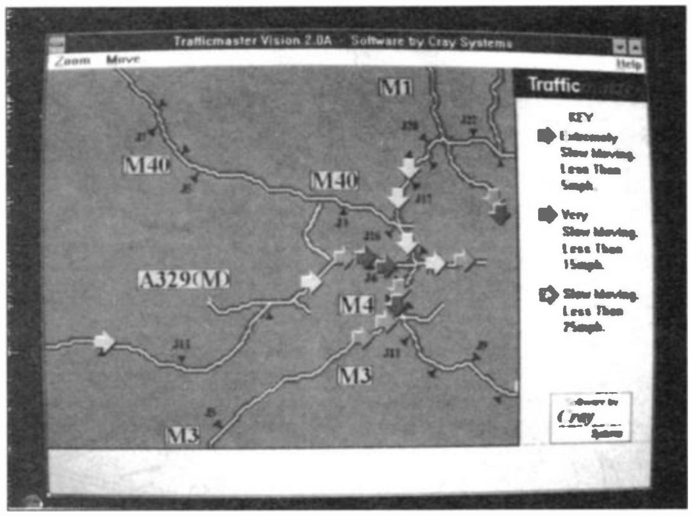
The new VX600S features an extended satellite frequency band covering frequencies up to 2050MHz, plus a satellite sound capability that is fully tunable from 5·5 to 8MHz to cover the multiple sound carriers used on satellite channels.

Also included is a power supply that produces a 10V to 20V output, switchable in 2V steps as well as a variable 0V to 10V supply, thereby covering the needs of all Low Noise Block Converters (LNBs) now in use.

The VS600SD has a similar specification, but with the addition of a built-in D2MAC decoder.

The VX600S costs £1,995 pus VAT, while the VX600SD costs £2,395 plus VAT. Contact: ITT Instruments (0753) 511799.





Traffic Wise PC

General Logistic plc and Cray Systems have launched a full colour PC version of the 'Trafficmaster' traffic information system which gives accurate and up-to-the-minute information on the state of traffic on the UK's motorways.

Trafficmaster works through a network of infra-red beacons (covering over 1,000 miles of motorway) to detect slow moving traffic. The information from the detectors is transmitted to the Trafficmaster control centre in London by the Paknet X.25 packet radio data network, and then passed on to a receiver attached to a PC by Aircall's radio paging network. The colour display then indicates not only where traffic jams are, but the actual speed of traffic movement in real-time.

To coincide with the launch, the area covered by the system has now been expanded beyond Birmingham in the Midlands to the whole of the South East.

The new system is aimed at frequent motorway users, particularly in transport, retail, leisure and tourism sectors. Basic system requirements are a 386 PC, Microsoft Windows and a VGA monitor. Contact: Cray Systems Ltd. (0252) 625121.

Parental Guidance Needed

A lack of parental guidance over children's video and computer games is revealed in an independent study published last month. The exploratory study, 'Children and Video Games', by Aston University's Communications Research Group, found that only 3% of children aged between 7 and 16 reported any parental guidance on the type of video games they could play, compared to 58% who claim their parents restrict the type of TV programmes that they watch.

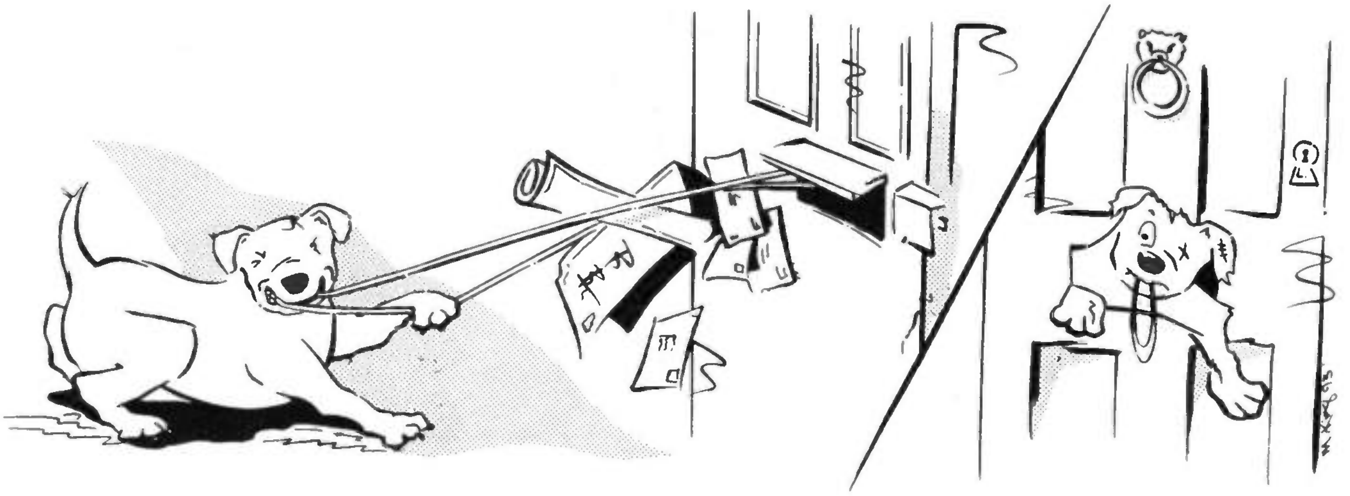
Roger Bennett, General Secretary of the European Leisure Software Publisher's Association (ELSPA), which represents the computer and video games industry said, "What this research shows is that parents are interested in restricting the amount of time children spend on computer games, but not their content."

This is of particular concern since (as reported in Issue 68) software companies are increasingly adding a violent element to computer games. Sega were recently criticised throughout the media for releasing a 'game' in which the sole objective was to murder three partially clad, digitised women.

"The most evident problem about video games is the lack of knowledge we have about them. Adults (especially parents) are very much in the dark about what children do with their machines", said Dr Guy Cumberbatch, Research Director for the study. Details: Aston University (021) 359 3611.

Stray Signals

by Point Contact



PC sometimes daydreams about how nice it would be to discover a gold mine in one's back garden, and have no more financial worries. Actually, one would have to exploit it very much on-the-quiet, because whoever owns the mineral rights pertaining to the land upon which your house stands, it is almost certainly not you, any more than you own the airspace above it. However, PC has *struck* a rubber-band mine, or at least an inexhaustible supply of them for free – useful, but less so than a gold mine. Due to the large quantity of mail which the household receives (about 90% for PC, the rest for the other residents) the postman keeps it all together between the sorting office and our letterbox with a stout rubber band which either comes through the slot with the mail, or finishes up on the ground outside. There *is* a connection with electronics here; the mail consists mainly of freebie electronics magazines, replies to PC's technical enquiries via the 'bingo cards' they contain, unsolicited mail from the sale of circulation lists, and last but not least *this* magazine.

On a more overtly electronic theme, the subject of TV frame linearity came up in conversation recently; usually not a problem nowadays. In the days of valves, a set's vertical linearity would gradually deteriorate as the frame timebase output valve aged, leading to elongated newsreaders' foreheads and compressed necks. In the early sixties, the PC household was without a TV set until long after everyone else in the road had one. Finally, a kindly neighbour, on buying a new set, gave us his old Philips model which was in full working order but suffering badly from the said non-linearity. There was no accompanying technical information, but I soon fathomed out the circuit, not a difficult job in those days with all discrete components. A complicated arrangement of Cs and Rs between the frame timebase generator stage and the frame output valve grid was clearly meant to provide the necessary shaping to give the appropriate 'haystack' waveform for a nice linear display. However, there were no adjustable presets and as the intended mode of operation of the arrangement was not clear, attempts to improve the linearity proved abortive. Not to be beaten, I pulled out all the said Cs and Rs and installed in their place a tone control circuit providing the usual base and treble cut and boost controls. The result was magic: a few twiddles rapidly converged on settings giving a degree of frame linearity that was the envy of all our neighbours who saw it! Moral: when a straightforward approach turns out to be a blind alley, don't be afraid to try an unconventional one.

Joining some friends the other day I happened in on the tail-end of their conversation, not having heard quite as much of it as they evidently thought. Turning to me, they asked if I had ever had *disk* trouble, to which I of course replied, "5¼ or 3½"? I was greeted with a blank stare of incomprehension, they being not at all computer literate. It turned out one of them was having back trouble – with a slipped disc, and not a disk(ette). In print the distinction would have been clear, but in English homophones abound, as a browse through the dictionary soon makes clear.

Further to my comments on Imperial units last time, younger readers who have not had to tangle with them may (or may not) be interested to learn that, at 4,840 square yards, an acre is ten square chains – or 22 yards by 220 yards. Since 220 yards is an eighth of a mile, it follows that there are 8 x 80 = 640 acres to the square mile. According to my dictionary, acre (which can also mean a field, as in *Long Acre*) comes from the Old High German *achar*, from the Latin *ager* – a field – whence we get agriculture. Such etymological snippets are interesting at the time one comes across them, but I never seem to remember them for long. In the words of a famous French philosopher (I forget which one) "Education is what's left when you have forgotten everything you ever learned". On the other hand, I can remember details of circuits I designed thirty or more years ago, not to mention the base pin connections of a 6SL7 and various other valves. Curious how selective my memory is, I guess yours is the same.

Yours sincerely,

Point Contact

The opinions expressed by the author are not necessarily those of the publisher or the editor

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

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

AIR YOUR VIEWS

The Phase-Splitter Debate Continues

Dear Editor,
I think that Graham Dixey is doing a very good job in reviving the old circuit techniques in his 'Valve Technology' series, which might well be lost otherwise.
There are, however, one or two points in his discussion of phase-splitters which might puzzle or mislead, so I would like to comment on the following types:
Concertina: This has the drawback that the source impedance of the cathode is very low, being $1/g_m$, while the anode is very high, due to NFB from the cathode. If the input capacitance of the next stage is not very low, the anode signal has a poor HF response.
Paraphase: It seems very doubtful that a low value for R4 in Figure 7 can compromise the HF response. A more likely cause is (or was) stray capacitances around RV1, which would have been a large metal-encased pot. Figure 8 is better because the pot is eliminated.
Cathode-coupled: This is actually the long-tailed pair circuit, or it ought to be! It has poor balance unless the 'tail' is really long, i.e. R3 is very much larger than 1/gm. It isn't easy to do this with Figure 9, which is why the cited Mullard 5-10 example used DC coupling between the first stage and the phase splitter, bringing the splitter grids up to about +100V, thus allowing a high value for R3. The use of a low g_m (but high r_a) triode 12AX7/ECC83 in this stage helps to obtain good balance.
I don't think there should be any current through R1 to cause imbalance as suggested. The imbalance is caused by V2 being a grounded-grid stage, while V1 is a grounded-cathode stage, and the former has slightly less voltage gain.
John Woodgate, Essex.

Graham Dixey replies:
Over the years some of the finer points of the earlier technology will have grown a little dim in the minds of old stagers such as myself; apart from that, it is necessary to limit remarks on the various principles covered to avoid running out of space and/or boring readers with too erudite a treatment. However, I am obliged to Mr. Woodgate for the trouble that he has taken in raising these points, and I am sure that some readers will find them of interest, a sort of supplement to the series if you like.

More Cat Flak

Dear Sirs,
While I find the illustrations in the new catalogue much clearer than in the old ones, I must support those readers who complain that it is more difficult to find things on account of the re-arrangement of sections and indexing. The original alphabetical order throughout the old catalogues made searching much easier, and I hope you will return to it in future editions.
Dr. J. R. Barker, Chester.

We are sorry that you are unhappy with the layout of the new Maplin Catalogue. When we decided to go to colour we also took the opportunity of changing the layout too, hopefully to make the Catalogue more interesting to the non-technical user. This was the main reason for placing the less technical, ready-made items near the front. We hoped that by colour-coding the sections and providing a comprehensive index that users would not experience too many difficulties. However, your comments have been noted.

S·T·A·R L·E·T·T·E·R

This issue Mr. Brian Adams, of Co. Antrim, wins the Star Letter Award of a £5 Maplin Gift Token, for his suggestion of a cheap and simple way of finding a fault in a coax cable.

Quick and Simple

Dear Sir,
I was interested to read Mr. D. Piper's request in Issue 74 for a device to measure cable lengths. Commercial devices are variously known as 'Cable Testers', 'Cable Scanners' or 'Time Domain Reflectometers' (TDRs for short!).
Many hobbyists may already have the means for a home made TDR – a good 'scope and a pulse generator. The pulses must be very short, e.g., 20 – 500ns, and the 'scope 'fast', about 0·5μs/cm. Connecting the pulse generator to the 'scope and cable under test by a very short test lead will result in an incident and reflected pulse on the CRT, where the time between pulses is proportional to the distance between the 'scope and the fault. Calibration can be done with say a 100m of good coax.
In fact this method is better than a cheap commercial meter, as it will show partial reflections not normally large enough to register. It is not very accurate for distances less than 10 feet, however.

Thank you for your suggestion, which only goes to illustrate yet another useful facet of the versatile oscilloscope!

Home to Roost

Dear Editor,
With reference to 'Valve Technology' Part 7, I plead guilty to the design of the 10W Garner amplifier of Figure 4 (*Electronics* Issue 73, Page 60). It was part of my endeavours to produce a range of audio/visual aids for education in the county of Essex – a good general purpose amplifier was needed for use in conjunction with cine projectors and record players. Needless to say, it had to be cheap and 'teacher proof'!
In answer to Mr. Dixey's observations, the variable NFB was for adjusting the sensitivity for different applications – not very clever really, but better than preset gain controls.
O/P transformers were a big headache. Parallel research into speakers to overcome the poor classroom acoustics led to the involvement of Wharfedale and G. A. Briggs. Briggs produced a transformer for us, it did not pretend to be the ultimate, but was good value for money.
I do not think I have any bees in my bonnet, but the use of squarewave testing of amplifiers seems to me the only way of checking performance. Distortion of the squarewave and nicks and curves on the corners tell their story – get this tidied up and the valve sound is yours. It still exists and is real, you can tell it blindfold. My 2 x 10W leaves my children wondering why they paid £800 for transistor rigs!
Henry H. Garner, Essex.

I agree with you regarding squarewave testing, especially of valve amps (more so than with transistor amps). Not only does this give a good idea of risetime and flatness (or lack thereof) of the response, but as you rightly say the shape of the corners also holds a lot of other meaningful information about how the circuit is operating.

Explain Yourselves!

Dear Editor,
For me *Electronics* is essential reading every month, but may I suggest increasing the educational value of the project articles? Most constructors know how to assemble PCBs, while newcomers have the Constructors' Guide to refer to. So, could we please have constructional detail reduced rather than replicated for every project? Instead, use the space for a fuller circuit description. I'm unlikely to build every project you publish, but I (and, I suspect, many others) do read them all so as to learn how theory translates into practice. It also assists fault-finding.
Dr. G. L. Manning, Middlesex.

Personally I prefer to see comprehensive circuit descriptions too. At the same time, however, since the magazine article invariably forms the basis for the kit leaflet, some emphasis on constructional details are valid also.

COLOUR & BLACK WHITE

CCD Camera Modulator

FEATURES

- LOW-COST
- EASY TO BUILD
- GIVES BOOST TO UPPER VIDEO FREQUENCIES
- REVERSE POLARITY PROTECTION
- REGULATOR ON BOARD

Design by Chris Barlow
Text by Chris Barlow
and Robin Hall

The video output from the Maplin CCD camera modules cannot be connected directly to the majority of domestic TV sets. Some TVs do have a direct video input socket, often known as a Peritel or SCART connector, but most only have a UHF aerial input socket for the reception of TV stations.

To solve this problem, a low cost UHF modulator is required, which superimposes the video signals from the CCD camera, or a wide range of other units, on to a high frequency carrier wave. To simplify the construction and alignment of the project a pre-tuned modulator module (UM1233) has been employed in the design.

The RF output from this modulator is suitable for connection to the aerial input of UK UHF TV sets.

APPLICATIONS

- Allows pictures to be viewed on a normal TV receiver without modification
- Interface video-output only devices to TV receivers
- CCTV security systems
- Ideal for use with Maplin CCD cameras CJ75S (colour) and ZA35Q (b/w)
- Ideal for home security

...see who is at your door!

2
PROJECT RATING

Circuit Description

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

The positive DC power is applied to pin P4 and the negative or 0V ground to P1. This supply must be within the range of 10·5V to 17V and have the correct polarity as this voltage is also fed to the CCD camera module via P5. To prevent reverse polarity damage to the modulator components, a diode, D1, has to have the positive supply applied to its anode before the power can pass to the rest of the circuit.

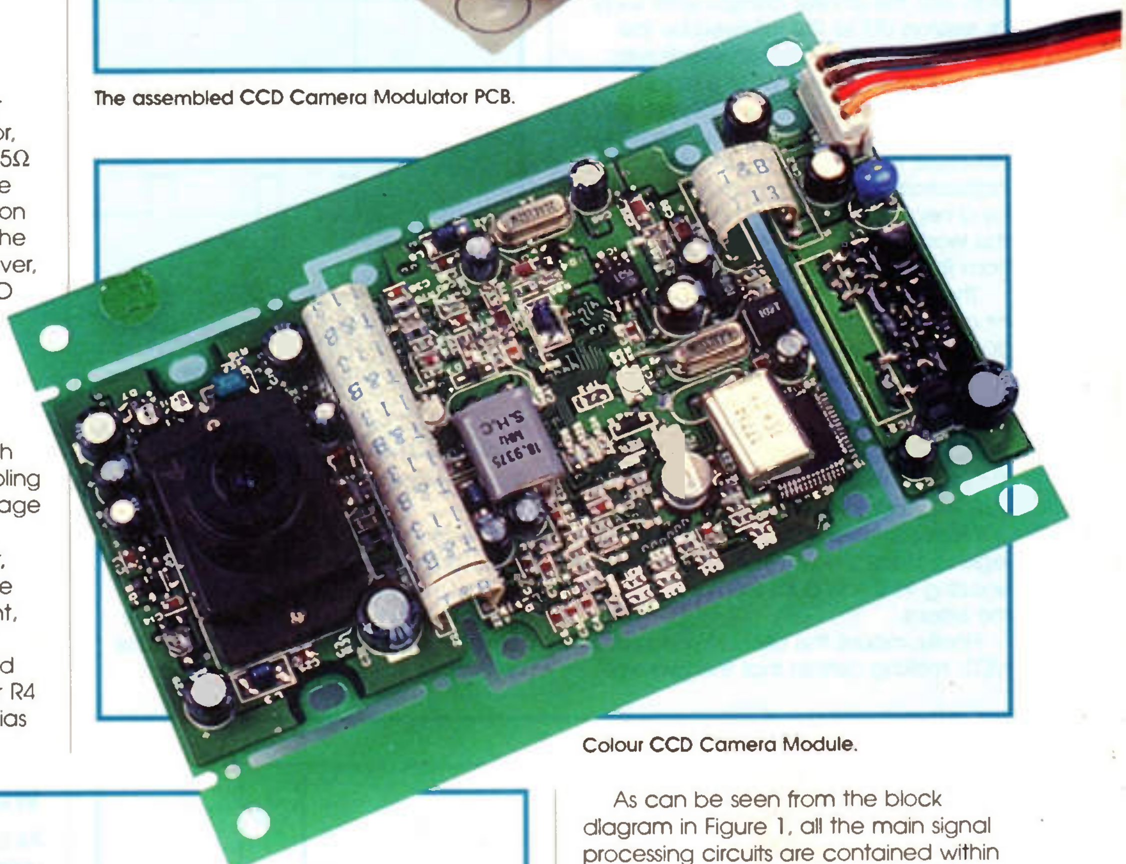
The main supply rail decoupling is provided by C6 with additional high frequency decoupling provided by a 100nF ceramic capacitor, C5. The modulator, MD1, requires a +5V stabilised supply. This voltage is obtained by using a small 100mA regulator, RG1, with capacitors C3 and C4 providing the final decoupling to the power input of MD1.

The video signal from the CCD camera is applied to P3 and its ground is connected to P2. The input impedance of the UM1233 modulator, MD1, is significantly higher than the 75Ω termination resistance required by the CCD camera modules. This termination load is corrected by placing across the video input an 82Ω resistor, R1. However, this resistor can be omitted if the CCD camera is already terminated by some other video device, i.e. VCR or monitor. The terminated video signal is then attenuated by resistors R2 & R3 to drive the video input of MD1 at the correct level, with capacitor C2 providing the AC coupling to this stage. The video attenuator stage is by-passed at high frequencies by a low value (1nF) ceramic capacitor, C1. This has the effect of boosting the upper frequencies by a small amount, producing a slightly sharper picture. If this enhanced image is not required then C1 may be omitted. The resistor R4 is used to maintain the correct DC bias level on the video input of MD1.

Specification of Prototype

DC Power Supply Voltage:	10·5V to 17V
Supply Current at 12V:	8mA
Video Input Level:	1V Peak to Peak
Video Input Impedance:	600Ω (No Termination) 75Ω (R1 Terminated)
RF TV Output:	Channel 36 (591·5MHz)
Output Socket:	Phono

The assembled CCD Camera Modulator PCB.



Colour CCD Camera Module.

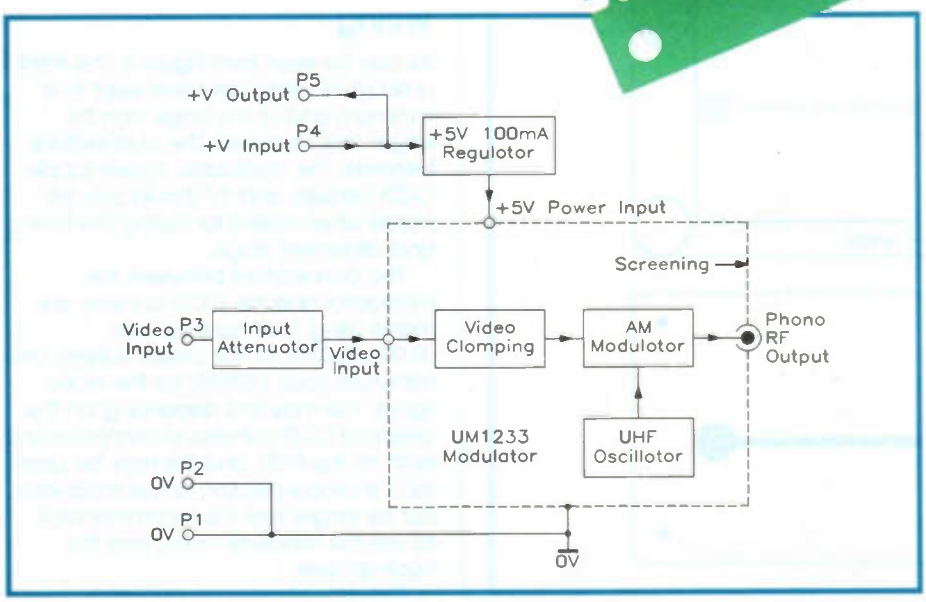


Figure 1. Block diagram of the CCD Camera Modulator.

As can be seen from the block diagram in Figure 1, all the main signal processing circuits are contained within the UHF modulator block MD1. All the stages are powered from a common +5V supply, RG1, with the 0V ground connection made to its metal screening can. The incoming video information is first passed through a signal clamping circuit. This is to ensure that if overdriven, the RF output of the modulator will not completely break up. The video information is then applied to an amplitude modulator (AM) stage, which receives the output from a RF oscillator running at a frequency of approximately 591·5MHz (TV channel 36). Now the video signal is superimposed on the RF carrier it can be taken out, via the phono connector, to a standard colour or monochrome (black and white) UHF television receiver.

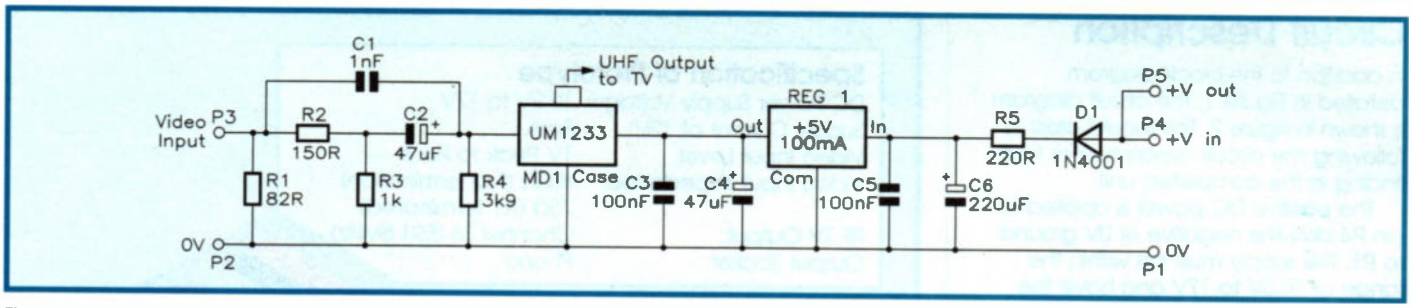


Figure 2. Circuit diagram of the CCD Camera Modulator.

PCB Assembly

Removing a misplaced component can be difficult so please double check the type, value and polarity before soldering! The PCB has a printed legend that will assist you in positioning each item, see Figure 3.

The sequence in which the components are placed is not critical. However, the following instruction will be of use in making the task as straightforward as possible. It is easier to start with the smaller components such as resistors (R1 to R5) followed by the ceramic (C1, C3, C5) and electrolytic capacitors (C2, C4, C6). The polarity for the electrolytic capacitors is shown by a plus sign (+) on the PCB legend. However, the majority of electrolytic capacitors have the polarity designated by a negative symbol (–), in which case the lead nearest this symbol goes *away* from the positive sign on the legend.

The power diode D1 has a band at one end to identify the cathode (K) lead. The legend shows the diode position with a symbol like a resistor, but with the prefix 'D1'. The symbol also has a bar across one end, and this is where the cathode is placed.

Next, install the voltage regulator RG1, making sure that its outline conforms to the package outline on the legend. Install the five pins at P1 to P5 ensuring that you push them fully into the board.

Finally, mount the UM1233 modulator MD1, making certain that the two wire connections are in their correct positions. Mechanical details of the modulator are given in Figure 4. To secure MD1 to the PCB simply bend down the two fixing tags through 90°, and using a fair amount of solder, solder it in place.

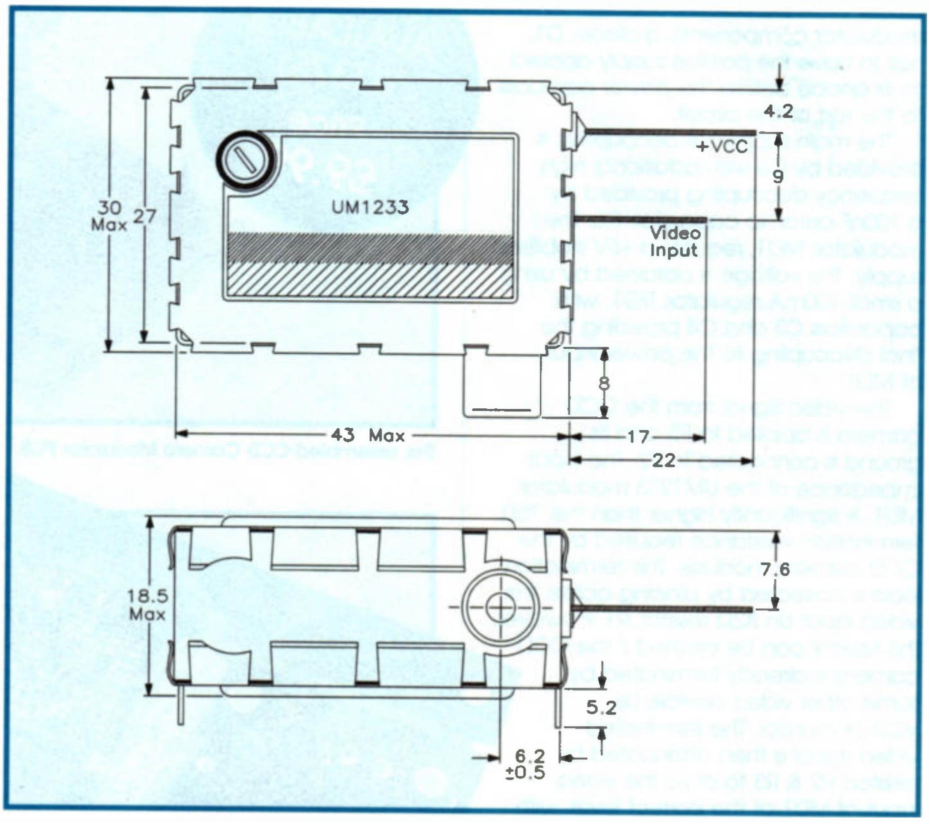


Figure 4. Mechanical details of the UM1233 module.

This completes the assembly of the PCB. 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.

Wiring

As can be seen from Figure 5, the total amount of wiring has been kept to a minimum and at this stage can be longer than required. The connections between the modulator, power supply, CCD camera and TV should only be made when called for during the testing and alignment stage.

The connections between the modulator and the CCD camera are made using 1·4A hook-up wire (BL00A/BL07H) for the power supply; and miniature coax (XR88V) for the video signal. You may find depending on the version of CCD camera, a connecter and lead on the PCB, and this may be used for a short connection to the modulator, but for longer runs it is recommended to use the miniature coax, and the hook-up wire.

The AC-DC adaptor (XX09K) is supplied with a power cable and a

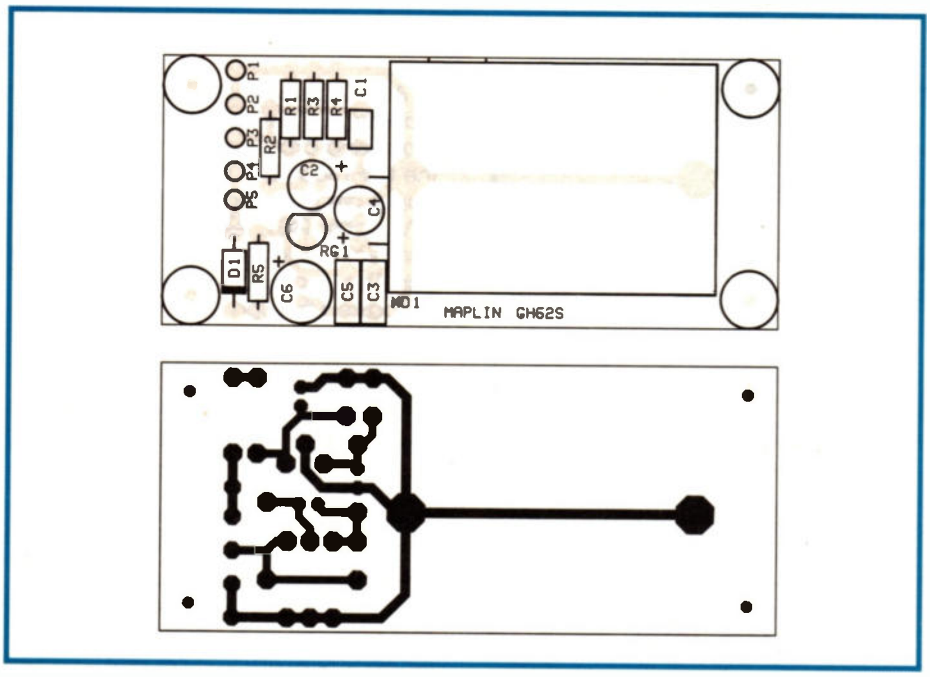


Figure 3. PCB legend and track.

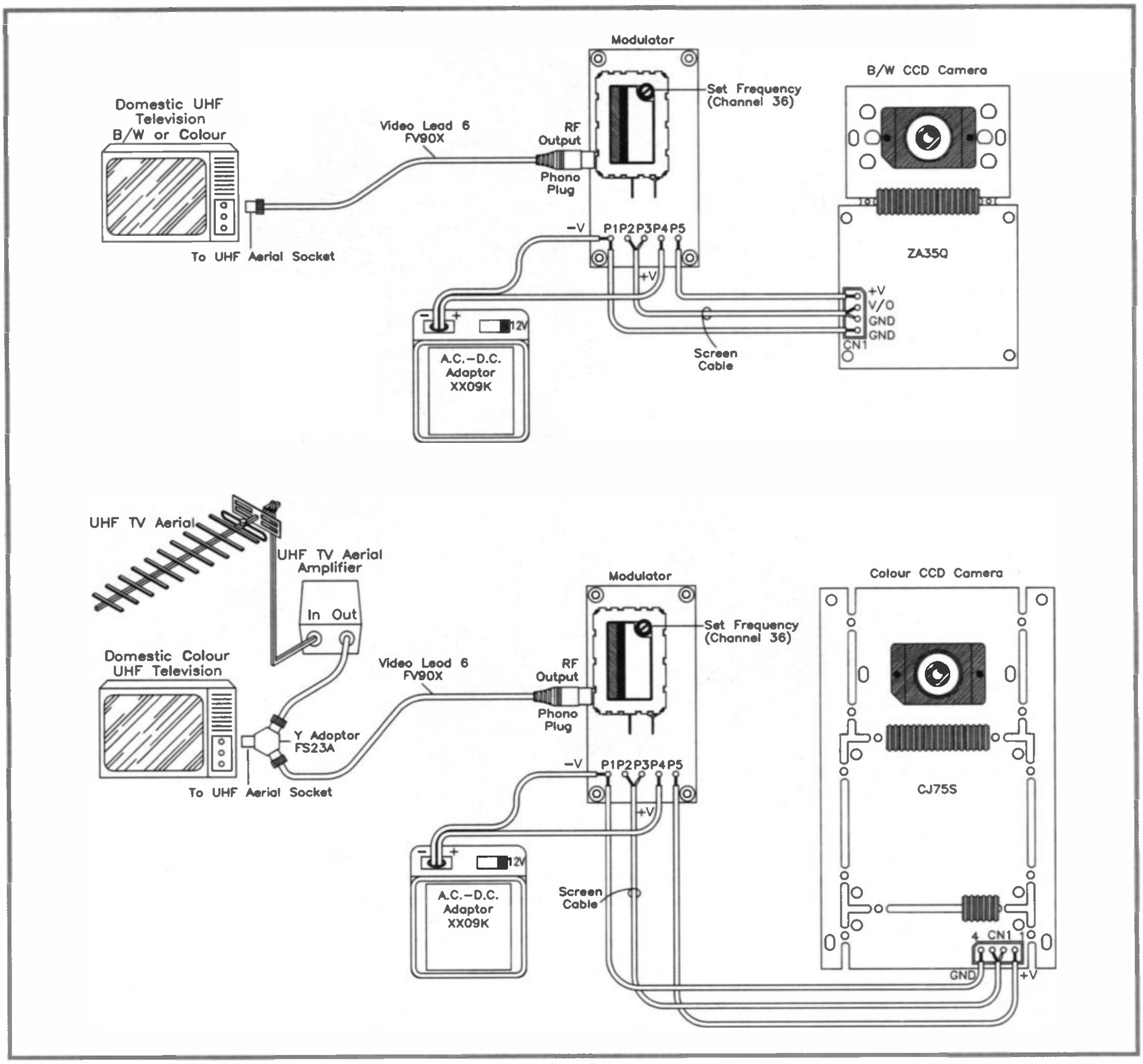


Figure 5. Suggested wiring configurations.

universal plug; these can be removed if direct connection to the modulator PCB is required.

The RF output from the Phono connector on the UM1233 modulator is fed to the UHF aerial socket of your television via a ready made Phono Plug to Coax Plug Video Lead (FV90X).

Testing and Alignment

The initial DC testing procedure can be undertaken using the minimum amount of test equipment. You will need a multimeter and a power supply capable of providing +12V DC at up to 300mA. All the following readings are taken from the prototype using a digital multimeter, and some of the readings you obtain may vary slightly depending upon the type of meter used!

With no wires connected to P1 to P5 carefully lay out the PCB assembly on a non-conductive surface, such as a piece of dry paper or plastic. The first test is to ensure that there are no short circuits before connecting the DC supply. Set your multimeter to read OHMS on its resistance range and connect its two test probes to P1 and P4. With the probes either way round, a reading greater than 100k should be obtained. If a significantly lower reading is registered then check solder joints and component leads for shorting between tracks.

In the following test it will be assumed that the power supply used is the XX09K unregulated AC-DC adaptor set to its +12V output. Select a suitable range on your meter that will accommodate a 300mA DC current reading. Then place it in line with the positive power output of the adaptor to P4 and connect the negative power line to P1. Plug the adaptor into the AC mains supply and observe the current reading which should be approximately 8mA. Unplug the adaptor from the mains, then remove the test meter and connect the positive line to P4.

Now set your multimeter to read DC volts. The voltage readings are positive with respect to ground, so connect your negative lead to a convenient ground point, i.e. P1 or P2. When the modulator is powered up, voltages present on the PCB should approximately match the following:

P1, P2 & P3	=	0V
P4 & P5	=	17V
C2 positive	=	2·68V
C4 positive	=	5V
C6 positive	=	14·75V

Remove the AC-DC adaptor from the mains and connect your Maplin colour, or B/W CCD camera as shown in Figure 5. When the modulator and CCD camera are powered up, the voltages present on the modulator PCB should approximately match the following:

With Monochrome (B/W) CCD camera,

P4 & P5	=	12V
C4 positive	=	5V
C6 positive	=	9·6V
Total current	=	204mA.

With colour CCD camera,

P4 & P5	=	12·6V
C4 positive	=	5V
C6 positive	=	10·2V
Total current	=	176mA.

Next connect the RF output from the modulator MD1 to a colour or B/W TV set tuned to UHF channel 36, and the

TV should display the image seen by the CCD camera. If no picture is visible then try adjusting the channel tuning control on the television.

The frequency output of the video modulator MD1 is factory set to channel 36 (591·5MHz), which should be suitable for most applications. If necessary it can be retuned by adjusting the ferrite core of its oscillator stage, as shown in Figure 5.

As the modulator has no 6MHz FM sound sub-carrier the volume control on your TV should be set to minimum, as all you will hear is a hissing sound.

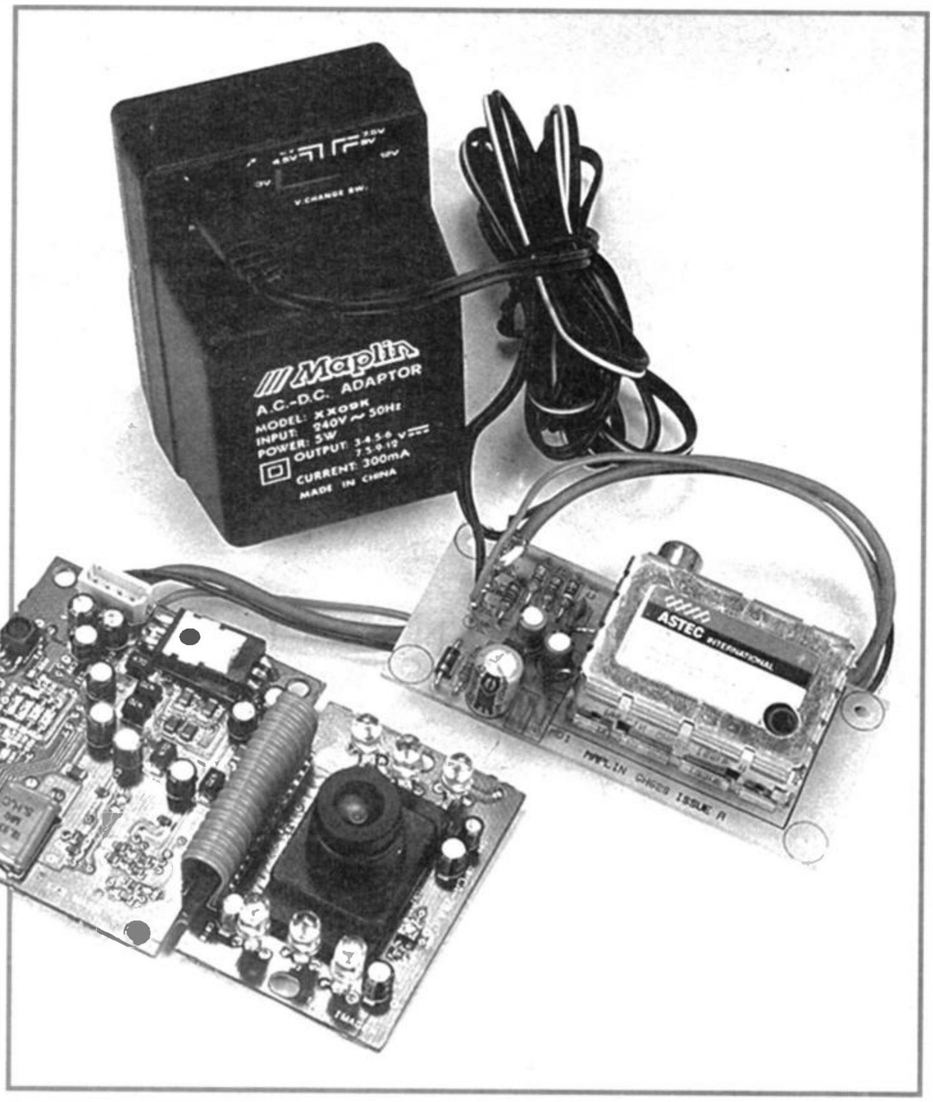
Using the Modulator

No specific box has been designated for the project as your finished unit could contain more than just one PCB. An extensive range of plastic and metal boxes are available from Maplin.

When wiring and installing a camera system it is recommended that the connections between the power supply, modulator and CCD camera are kept to a moderate length, i.e. not more than three metres. If the camera system is to be used at any greater distance from the television, then the RF output lead from the modulator should be extended by using a Coax line socket (YW09K), low-loss Coax cable (XR87U/XR29G) and a Coax plug (HH07H).

There are two basic methods of using the modulator with your TV set. The first and most simple is to just plug the RF output from the modulator lead in to the UHF aerial socket on your TV and tune to channel 36. The only drawback to this is that since you no longer have your TV aerial connected to the set, no UHF TV stations can be received. In the second method, a coax 'Y' adaptor is used to combine the UHF signals from the modulator and TV aerial, thus allowing both to be tuned in. However, to prevent any stray signals from the modulator reaching your TV aerial and being possibly picked up by a next door neighbour, you should use an indoor aerial amplifier. This will have two beneficial effects, blocking the signal from the modulator to the aerial and compensating for the insertion loss of the 'Y' adaptor.

Finally, remember you may have to retune the modulator to a clear channel if it clashes with any TV stations or a VCR/Satellite receiver.



Complete B/W camera system ready for installation and use.

CCD CAMERA TV MODULATOR PARTS LIST

RESISTORS: All 0·6W 1% Metal Film			
R1	82Ω	1	(M82R)
R2	150Ω	1	(M150R)
R3	1k	1	(M1K)
R4	3k9	1	(M3K9)
R5	220Ω	1	(M220R)
CAPACITORS			
C1	1nF Metallised Ceramic	1	(WX68Y)
C2,4	47μF 16V Sub-Min Radial Electrolytic	2	(YY37S)
C3,5	100nF 16V Miniature Disc Ceramic	2	(YR75S)
C6	220μF 16V Radial Electrolytic	1	(FF13P)
SEMICONDUCTORS			
D1	1N4001	1	(QL73Q)
RG1	LM78L05ACZ	1	(QL26D)
MISCELLANEOUS			
MD1	UHF Modulator UM1233	1	(FT30H)
	Single-ended PCB pin 1mm (0·04in.)	1 Pkt	(FL24B)
	Phono Plug to Coax Plug Cable	1	(FV90X)
	PCB	1	(GH62S)
	Instruction Leaflet	1	(XU55K)
	Constructors' Guide	1	(XH79L)

OPTIONAL (Not in Kit)			
	Unregulated 300mA Mains Adaptor	1	(XX09K)
	Monochrome CCD Video Camera	1	(ZA35Q)
or	Colour CCD Camera	1	(CJ75S)
	Two into One 'Y' Adaptor	1	(FS23A)

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

The above items (excluding Optional) are available as a kit, which offers a saving over buying the parts separately.
Order As LT37S (CCD Camera TV Modulator) Price £9.99.

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

The following new item (which is included in the kit) is also available separately, but is not shown in the 1994 Maplin Catalogue.

CCD Camera TV Modulator PCB **Order As GH62S Price £2.45.**

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Constructional details can be found in *Electronics* Issue 26 (XA26).

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REMOTELY OPERATED VEHICLES

ROVs

by William Buloch

MODERN technology is finding its way into most industries today, and the offshore oil and gas industry which operates in some of the world's harshest environments including the North Sea is no exception. It is probably the biggest industry on earth today, and the environment, which it exists in, throws up much unique engineering and technological challenges. The hostile seas can be as deep as 250m and platforms, pipelines and other major structures must be placed, inspected and maintained from the surface. Diving is still carried out in the North Sea, but not on the scale that it was say, five years ago. The reason for this decline in the diving industry is the advent of the Remotely Operated Vehicle (ROV). This was originally developed by various navies to assist in mine hunting, and is the natural progression from the air and saturation diver, and manned submersible vehicles.

Probably one of the most famous uses of the ROV, was in 1986, when Bob Ballard and his team located and filmed the exterior and some of the interior of the S.S. *Titanic*. A manned submersible – named 'Alvin' – located the wreck sitting upright on the seabed and an *eyeball* vehicle named 'Jason Junior' – fitted to the front of 'Alvin' was used to probe the ship's interior on its own umbilical, controlled from inside Alvin. Some of the returned video was breathtaking, including views of the majestic staircase leading to the lavish ballroom, 74 years after the luxury liner and some 1,500 people were lost.

Outside of the oil industry ROVs are also being put to good use. In 1985, the wreckage of an Air India jumbo jet was located in 2,000m of water 200km south-west of Ireland. The vehicle was used to recover vital clues from the wreckage.

Building and Maintenance

Can you imagine the planning that has to go into the building of say a 200m high steel platform on land, loading it onto a sea-going barge, floating it up to 500

A typical *eyeball* type vehicle, although strong enough to withstand the normal depths it encounters, is nevertheless relatively easy to maintain. The fibreglass side panels are bolted on and the motors and electronics secured in pods.

The *Star Hercules* as operated by Star Offshore Services Aberdeen, can be used in a multitude of roles. As a Diving Support Vessel or 'DSV' she can be fitted out to accept ROVs and 'Saturation Diving'. In the ROV role with sophisticated equipment available, the ship can be led by the ROV, interlinked by computer control.

miles out to sea on its side, lifting it from the barge using a huge floating crane barge and lowering it to stand on the seabed all to within a metre or so of its intended position? The platform then forms the key building block for all the production modules and accommodation used in the site's working life.

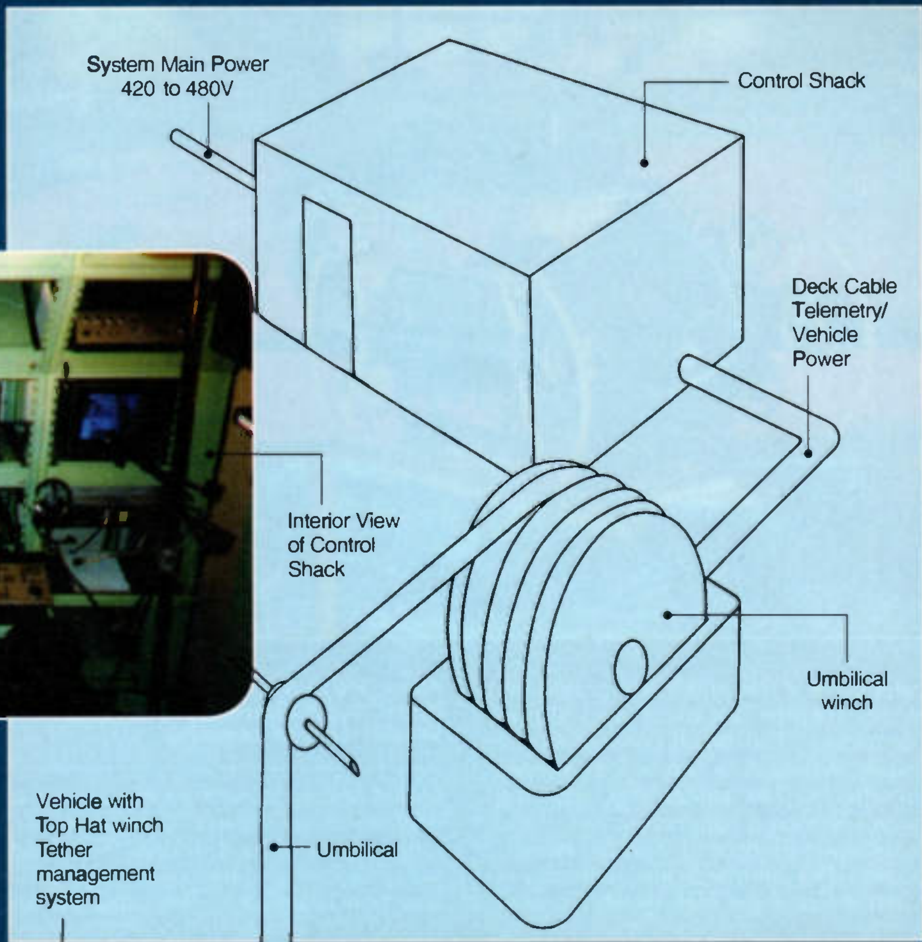


Figure 1. Block diagram.

It is quite a daunting task by any means, but the engineering challenges don't stop there.

What happens to steel when it is immersed in salt water? Simple, corrosion. There are various methods used to combat corrosion at sea, the most popular being the use of sacrificial anodes, but the effect cannot be cancelled completely. Therefore a strict inspection and maintenance plan has to be followed over the period of the platform's life, work which was originally carried out by divers. They carried out both the visual and instrument assisted inspections of the platform structure. But this was a long, hazardous and expensive operation.

Apart from the daily hazards involved in diving, the long term medical effect on divers both physically and mentally is also a source of great concern.

Enter the ROV

The ROV is an unmanned submersible vehicle, controlled from a surface platform, which may be a rig, support vessel, or barge, via a control and power umbilical. The vehicles vary in size from that of a kiddies go-kart to that of a family hatchback car, depending on the particular class of job that the vehicle is required to do. Control of the vehicle is from the surface by a 'pilot' using a joystick fitted within the control console. Its most basic functions are movements as controlled from the surface, and the supply of video pictures.

Figure 1 shows a typical ROV system layout.

Small ROVs

The smaller class of vehicles are normally called *eyeballs*. These are usually fitted with a monochrome camera, an optional colour camera, DC motors for propulsion, lights, a gyro to show the vehicles heading, and a depth transducer. These vehicles are mainly used for inspection purposes and sometimes even to support divers by supplying them with light and safety support from the surface by allowing the surface teams to monitor the diver at work. Typical depth ratings for *eyeball* vehicles are around 400m to 500m.

Large ROVs

The larger class of vehicles are called construction or work vehicles. These can be fitted with a number of cameras, only limited by the number of co-axial cores available in the vehicles umbilical and the capacity of the vehicles' power supplies.

The vehicle propulsion systems are normally hydraulic and controlled by servo valves. The vehicles are also usually fitted with a number of lights some with dimmers to control the amount of light required by the cameras without giving backscatter from particles suspended in the water. An aircraft type gyro gives the pilot an accurate readout of the vehicles heading, while a pressure transducer calibrated to give an accurate depth readout. The hydraulics systems pressure, temperature and volume are monitored by transducers. Grabber arms, boom arms for outboard camera mounting, five or seven function hydraulic manipulator arms and a whole range of survey and sonar equipment can also be fitted to a work class vehicle. These vehicles are mainly used for the heavier construction jobs including sandbag placement adjacent to a pipeline to stop tidal movement undermining the supporting area, seabed debris clearance, wire cutting, and a number of types of seabed and structural surveys. Typical depth ratings for work class vehicles are up to 1,000m for standard vehicles.

Umbilical Construction

Eyeball type vehicles tend to have positive buoyancy polyurethane coated umbilicals or tethers. The umbilicals vary in size and design on different vehicles, but generally are up to about 20cm in diameter. These umbilicals usually contain waterblocks at equal spacing along their length, usually every 10m or so, to stop the whole length flooding through damage to the outer coating. The power conductors form the

Above: Rig Support ROV.
Below: 'Super Scorpio' (Work Class Vehicle) ready for launching.

outer cores of the umbilical to protect the more 'fragile' co-axial and signal conductors. The signal conductors are usually in groups of two or four, twisted together for low signal loss, with the groups sharing a common screen, these are known as twisted pairs or twisted quads. The umbilical also contains a minimum of three high-quality co-axial conductors for the video transmission. The lengths of umbilicals can be up to 500m.

Work vehicle umbilicals are obviously much bigger and can be polyurethane coated or even sometimes armoured in a galvanised steel band. Diameters can range up to around 4cm to 5cm and water blocks are also used. The construction is basically the same for an *eyeball* ROV umbilical, though obviously the size and quantity of the power, coaxial and signal conductors will vary depending on the vehicle's capacity to carry auxiliary equipment. The lengths of umbilical used are usually in the region of 600m to 1,200m.

Communication Systems

There are a number of types of communication systems employed by various manufacturers of ROVs. Different systems are used depending on the amount of information to be passed between the surface control and the vehicle.

Typical up/down data from a ROV control console could include:

Down data to vehicle from pilot's control and display console.
Thruster control signals from the console's joystick and trim controls.
Auto-heading and auto-depth function on/off switching.
Camera power supplies on/off switching.
Camera focusing control signals.
Camera's pan and tilt control signals.
Auxiliary equipment power supplies on/off switching.
Up data from vehicle to pilot's control and display console:
Gyro heading signal.
Depth signal from transducer.
Hydraulic transducer's signals and alarms.
Water leak alarms.

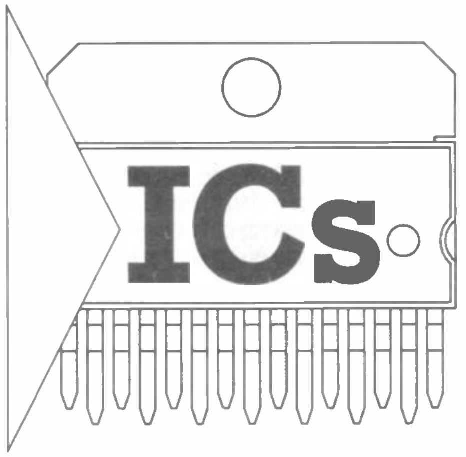
The main communications setups used in ROV systems are:

Frequency Shift Keying

The Frequency Shift Keying (FSK) system is normally used for small *eyeball* vehicles requiring only a few channels of

Continued on page 23.

USING AUDIO PREAMP ICs



PART TWO

Ray Marston shows ways of using LM387, TDA3401, MC3340P, and NE570/571 ICs in the concluding part of this special two-part article.

LM387 Circuits

Last month's opening part of this 'circuits' feature introduced the LM381/382/387 preamp ICs and, amongst other things, took a detailed look at the internal circuitry of the LM381. The internal circuitry of each half of the LM387/387A is identical to that of the LM381, except for the elimination of certain terminal connections. Because of these eliminations, the LM387 can only be used in the differential input mode, without external compensation. The IC is, nevertheless, quite versatile, and Figures 20 to 26 show some practical applications of the LM387 (or LM387A) IC.

Figure 20 shows how to connect the IC as a non-inverting amplifier with AC gain of 52dB. The DC gain (and the quiescent output voltage) is determined by R1 & R2, and the AC gain is determined by R1 & R3. Figure 21 shows how to modify the circuit for use as a phono preamplifier with RIAA equalisation, and Figure 22 shows how to modify it for use as a NAB tape playback amplifier.

Figures 23 to 26 show various ways of using the LM387 in the inverting amplifier mode for active filter applications. The circuit of Figure 23 is that of an active tone control that gives unity gain with its controls in the 'flat' position, or 20dB of boost or rejection with the controls fully rotated.

The 'rumble' (high-pass) filter of Figure 24 is actually a 2nd-order high-pass active filter that rejects signals below 50Hz, and does so with a slope of 12dB/octave. The 'scratch' (low-pass) filter of Figure 25 is a 2nd-order low-pass filter that rejects signals above 10kHz. Finally, the 'speech' filter of Figure 26 consists of a 2nd-order high-pass and a 2nd-order low-pass filter wired in series, to give 12dB/octave rejection to signals below 300Hz or above 3kHz, this 'extracting' speech only frequencies.

Hints on Using The LM381/382/387

The LM381/LM382/LM387 range of ICs are high-gain wide-band devices, and some care must consequently be taken when using them in practical circuits of the types shown in this, and last month's, articles. The two practical problems encountered most frequently are those of RF instability and RF 'pick-up'.

The RF instability problem is usually caused by inadequate, high-frequency power supply decoupling; note that, in ALL preamp circuits, power supply to the IC must be RF decoupled by wiring a 100nF ceramic or 1µF tantalum capacitor directly across the power supply pins of the IC.

The RF 'pick-up' problem manifests itself in the pick-up and demodulation of AM broadcast signals. This problem can usually be eliminated by wiring a 10µH RF choke in series with the IC input terminal, and if necessary by also decoupling the input terminal (or terminals) with a low-value capacitor, as shown in Figure 27.

The TDA3410 IC

To complete this look at dedicated preamp ICs, Figure 28 shows the outline, pin notations and schematic diagram of

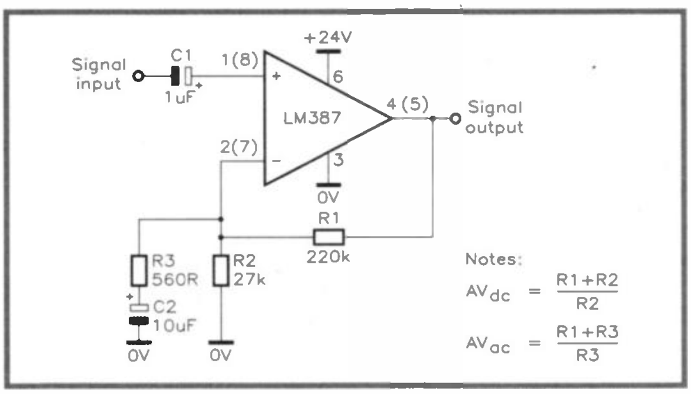


Figure 20. LM387 non-inverting AC amplifier with a gain of 52dB.

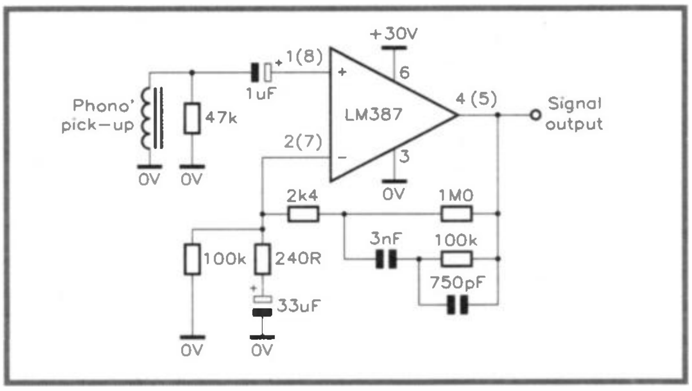


Figure 21. LM387 phono preamp (RIAA).

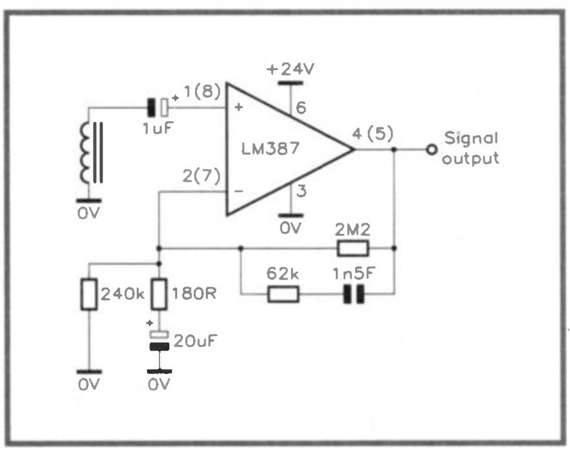


Figure 22. LM387 tape playback amplifier (NAB).

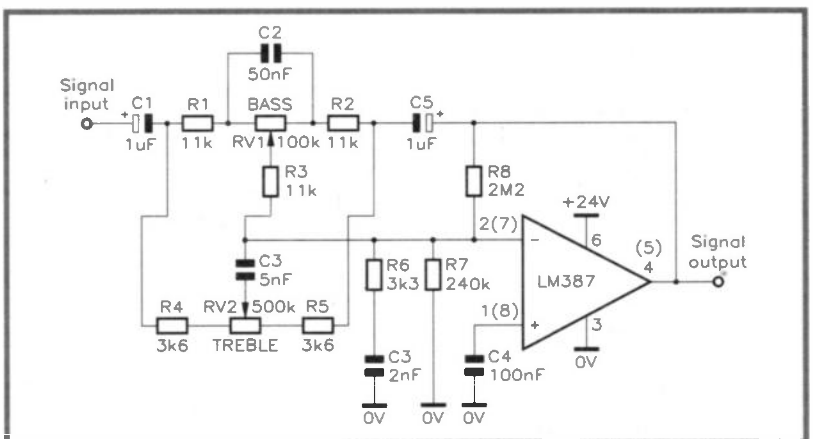


Figure 23. LM387 active tone control circuit.

another popular dual preamplifier, the TDA3410, which is an ultra low noise device that generates very little distortion and can operate from any single-ended supply voltage in the range 8 to 30V. Figure 29 shows a practical application circuit for this IC.

Each channel of the TDA3410 houses two separate amplifiers. The first of these provides a fixed signal-voltage gain of 30dB (= 32 times), and at any given moment can accept one or other of two pairs of stereo input signals, which are applied to pins 7(9) and 6(10); the desired input signal can be selected by applying a suitable control voltage to the input switch pin 12 of the IC. When this pin is grounded (as in Figure 29), internal analogue switches clamp pin 6(10) to ground and pin 7(9) is enabled; if pin 12 is taken above 4V DC, the switching action is reversed, and pin 7(9) is grounded and pin 6(10) is enabled.

At this point it should be mentioned that this facility is provided because the IC was primarily intended to be used as a cassette tape playback preamplifier (which also accounts for its very low designed noise figure), and, more specifically, for in-car cassette players

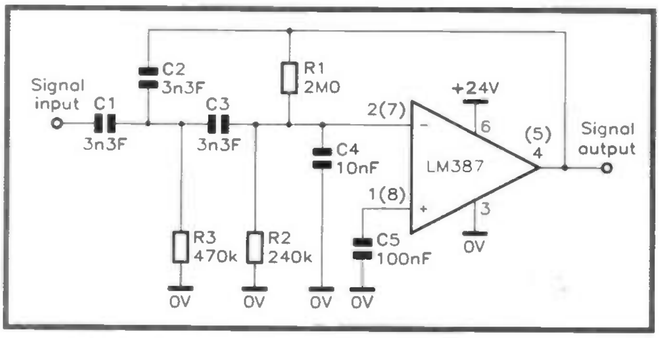


Figure 24. 'Rumble' filter.

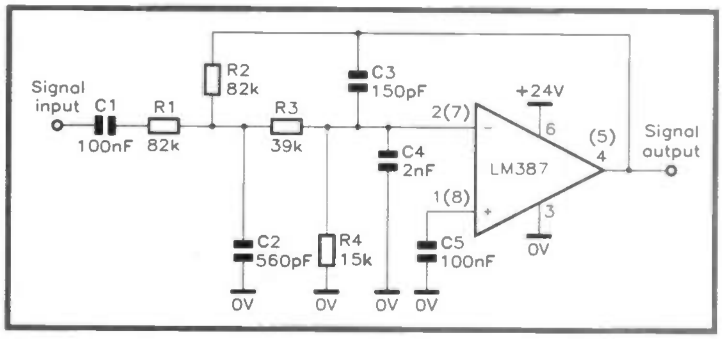


Figure 25. 'Scratch' filter.

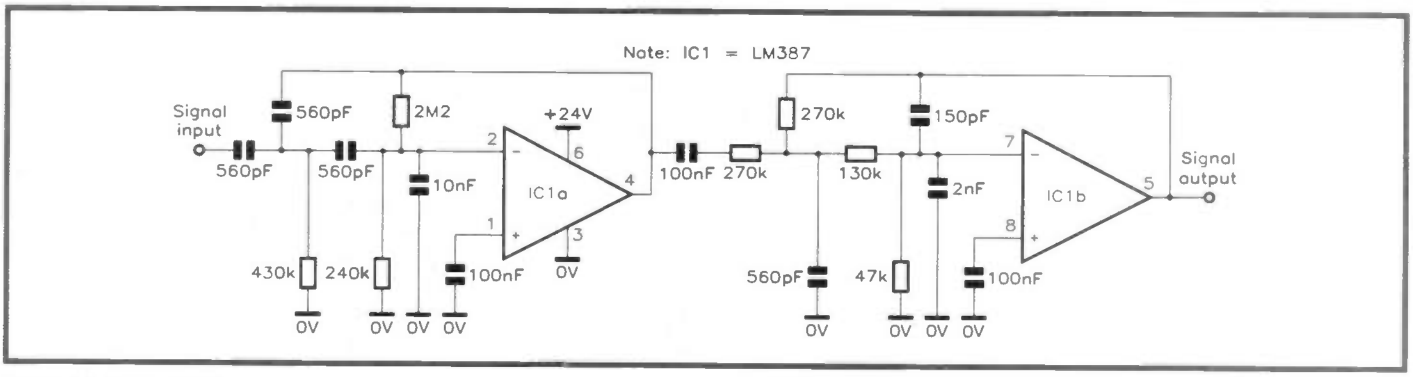


Figure 26. 'Speech' filter.

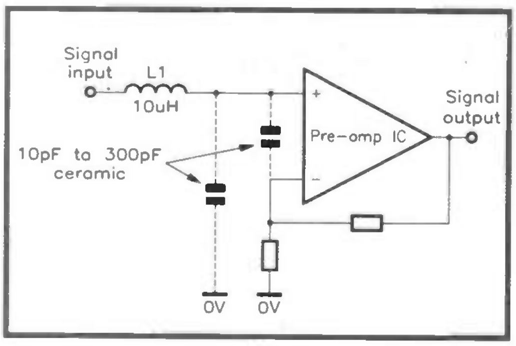


Figure 27. 'RF pick-up' elimination circuitry.

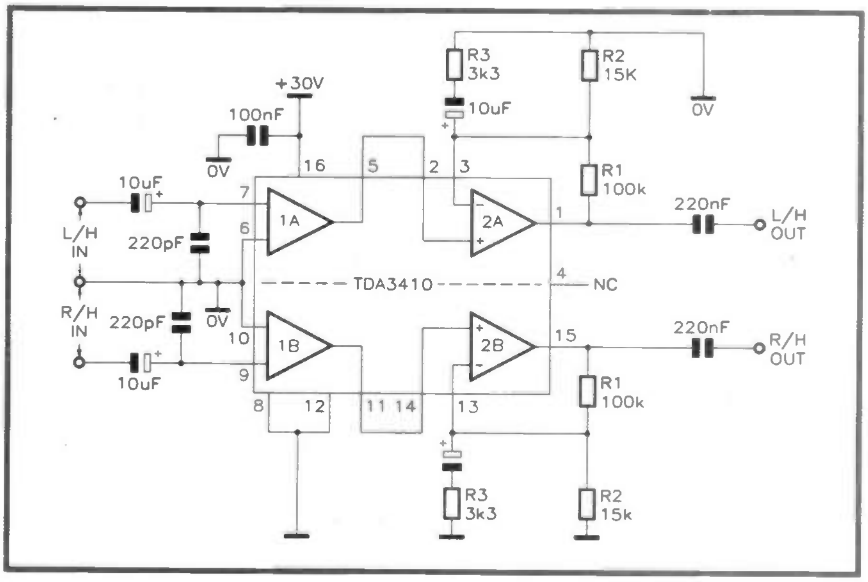


Figure 29. TDA3410 stereo preamp circuit with an overall voltage gain of 60dB (= x 1,000).

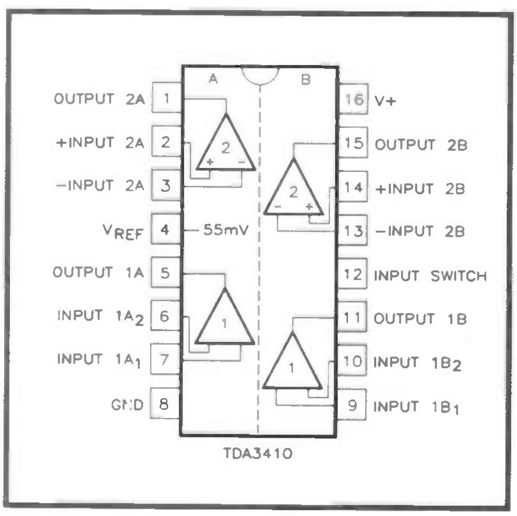
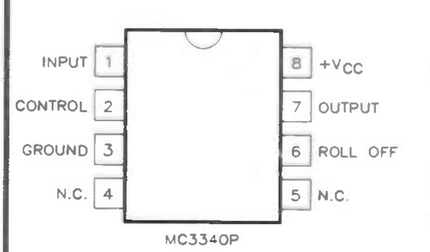


Figure 28. Outline, pin notations and schematic of the TDA3410 ultra low-noise dual preamp IC.



PARAMETER	MIN	TYP	MAX
Supply volts	+9V		+18V
Control pin sink current			2mA
Input voltage, rms			0.5V
Voltage gain		13dB	
Attenuation range		90dB	
Total harmonic distortion		0.6%	

Figure 30. Outline and main characteristics of the MC3340P IC.

having auto-reverse transports. Such transports have dual, stereo playback heads to enable the tape to be played in either direction without physically turning it over. The input switching is then able to select the required head (in stereo) depending on direction under instruction from a single control wire, initiated by a micro-switch on the transport.

The two input terminals of the first amplifier each have an input impedance of about 80kΩ. This amplifier stage can provide maximum undistorted output signal swings of about 2V Pk-to-Pk, and should not, therefore, be driven by inputs greater than 63mV Pk-to-Pk. The output pin 5(11) of the first amplifier can be wired directly to the input pin 2(14) of the second amplifier, if desired, as shown in Figure 29.

The second amplifier can be used like a normal op amp, as shown in Figure 29, where its DC voltage gain (bias) is set via R1 & R2. Note however that the second stage is either DC coupled directly to the output of the first (30dB) stage, or else it MUST be biased from the DC reference, pin 4. For this reason a DC bias chain is required to set the DC voltage level on the output pin; if the output is not set to 50% of the total supply level then the output will not be able to deliver the maximum, symmetrical signal voltage before clipping. The required DC bias will also vary with supply voltage used.

In the example shown, the AC gain is set at about 30dB, and under this condition the amplifier's power bandwidth exceeds 22kHz. This amplifier can provide maximum undistorted (THD less than 0·05%) output signals of about 6V Pk-to-Pk. Thus, in the application circuit of Figure 29, the IC gives an overall voltage gain of about 60dB (= 1,000 times), and hence a 1V Pk-to-Pk output from a 1mV Pk-to-Pk input. Under this condition the circuit's 0·5dB frequency response extends from 25Hz to 20kHz; the signal distortion (THD) is less than 0·05%, and the signal-to-noise ratio is better than 65dB; the equivalent total input noise of each channel of the amplifier is less than 0·5µV (microvolts) when using an input source resistance of less that 1kΩ.

When considering using the TDA3410, note that this IC incorporates a voltage regulator (to give a very high 'supply voltage rejection' figure) that also provides a 55mV voltage reference that is brought out at pin 4 (mentioned previously). This reference voltage can be used to bias the second amplifier by connecting a 22k resistor between pins 2(14) and 4, which is the recommended option if you are not going to connect the second op amp to the output of the first stage.

The MC3340P

This is a popular and simple, dedicated 'electronic attenuator' IC that is often used within the 'pre-amp' sections of various types of audio-amplifying system. Figure 30 shows the outline, pin notations and basic details of the device, which is housed in an 8-pin DIL package; only six of these pins perform useful functions, and two of these are used for power supply connections. Of the remainder, pins 1 & 7 provide input and output signal connections, pin 6 controls the roll-off of the device's frequency response, and pin 2 is the device's gain-control terminal.

The basic action of the MC3340P is such that it acts as a simple linear amplifier with 13dB of signal gain when its control, pin 2, terminal is either tied to ground via a 4kΩ resistance, or is connected to a DC potential of 3·5V. This gain decreases if the control resistance/voltage is increased above these values, falling by 90dB (to –77dB) when the values are increased to 32k or 6V. The device's attenuation (or gain) can thus be controlled over a wide range via either a resistance or a voltage.

Figure 31 shows a practical example of a voltage-controlled MC3340P electronic attenuator, together with its performance graph, and Figure 32 shows a resistance-controlled version of the device. Note that in both these circuits the large-value capacitor C2 is wired to the control terminal; this helps eliminate

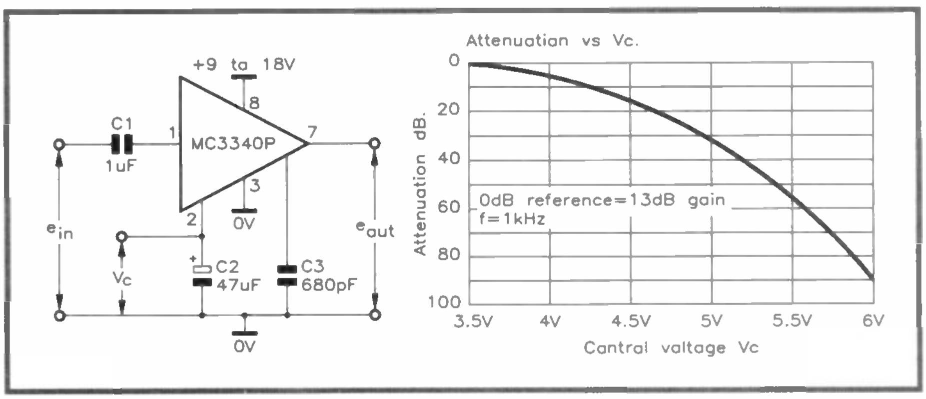


Figure 31. Circuit and performance graph of a voltage-controlled electronic attenuator.

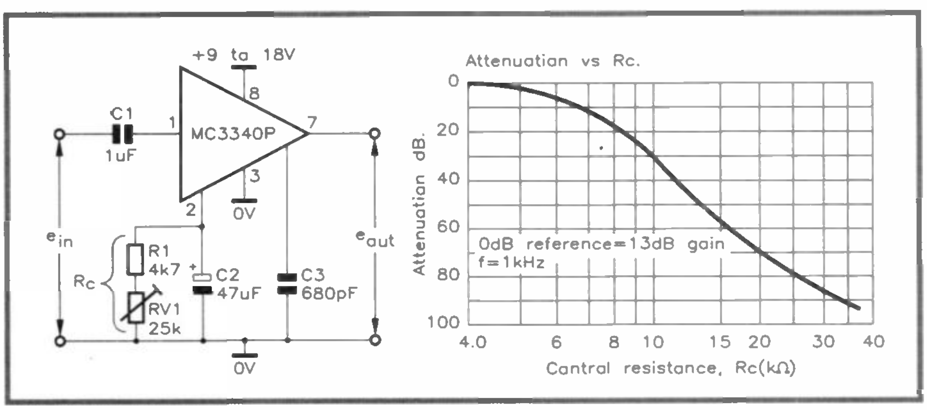


Figure 32. Circuit and performance graph of a resistance-controlled electronic attenuator.

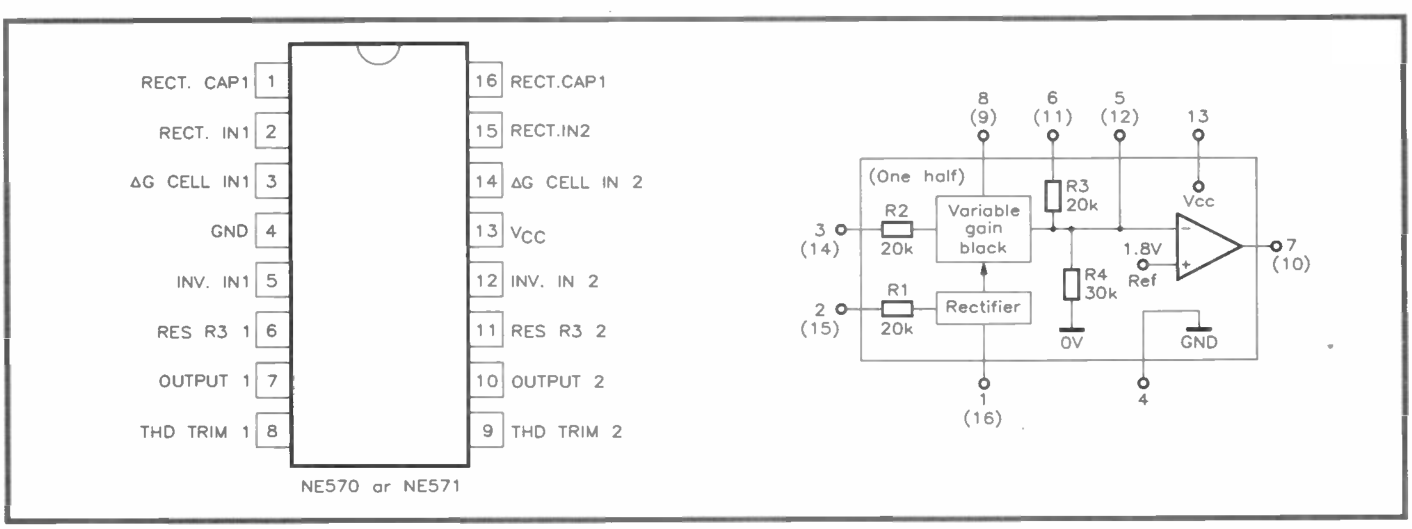


Figure 33. Outline, pin notations and block diagram of the NE570/571 dual compander IC.

control noise and transients, thus giving a 'noiseless' form of gain control and enabling the control resistance/voltage to be remotely located.

Also note that, in these circuits, a 680pF capacitor C3 is wired to pin 6 of the IC; this limits the upper frequency response of the circuit to the high audio range. Without C3, the response extends to several MHz, and the circuit tends toward instability. Finally, note that this IC gives very little signal distortion at low levels of attenuation, but that distortion rises to about 3% at maximum attenuation levels.

The NE570/571 IC

The NE570 is known as a dual 'compander' but is really a rather sophisticated dual Voltage-Controlled Amplifier (VCA) IC. Each half (channel) of the IC contains an identical circuit, comprising a full wave rectifier, a variable gain block, an op amp, a precision 1·8V reference and a resistor network. These elements can be externally configured so that each channel acts as either a normal VCA or as a precision dynamic range compressor or expander (hence the 'comp-ander' title).

The NE571 is identical to the NE570, but has a slightly relaxed specification. Both ICs are housed in 16-pin DIL packages. Figure 33 shows the outline and pin designations of the package, together with the block diagram of one IC channel, and Figure 34 lists the basic characteristics of the two ICs. Note that in the block diagram (and following circuits) pin numbers relating to the left-hand channel of the IC are shown in plain numbers, while those relating to the right-hand half are shown in bracketed numbers (as was used earlier in this text for the TDA3410).

The operation of the individual elements of the block in Figure 33 are fairly easy to understand. Input signals, AC coupled to pin 2 (or 15), are full-wave rectified and fed to pin 1 (or 16), where they can be smoothed by an external capacitor to generate a VCA control voltage on this pin.

Input signals which are AC coupled to pin 3 (or 14) are fed to the input of the variable gain block, which is a precision, temperature-compensated VCA with its gain controlled via the voltage at pin 1 (or 16). Its output is fed to the inverting input of the IC's op amp stage. Signal distortion of the gain block is quite low, and can be further minimised by feeding a 'trim' voltage to pin 8 (or 9).

The channel's op amp is internally compensated and has its non-inverting input tied to a 1·8V precision reference. The inverting input is directly connected to the output of the gain block, is also externally available, and then connected to the resistor network. The op amp output is available at pin 7 (or 10).

A Stereo VCA

Figure 35 shows how a NE570 or NE571 can be used to make a stereo voltage controlled amplifier/attenuator. Here, the internal rectifier is disabled via C2, and a 0 to 12V DC control voltage is fed to pins 1 & 16 via R6 & C3, to give direct

PARAMETER	NE570	NE571
Supply voltage range	6V to 24V	6V to 18V
Supply current	3·2mA	3·2mA
Output current capability	±20mA	±20mA
Output slew rate	0·5V/µS	0·5V/µS
Gain block distortion:		
Untrimmed	0·3%	0·5%
Trimmed	0·05%	0·1%
Internal reference voltage	1·8V	1·8V
Output O/C shift	±20mV	±30mV
Expander output noise	20µV	20µV

Figure 34. Basic characteristics of the NE570 and NE571 ICs.

control of the variable gain block. The output of the block is fed to pin 7 (or 10) via the op amp, which has its AC and DC gain set to 2·56 times, via R4 to R7, and thus generates a quiescent output of 4·62V (= 2·56 x 1·8V). Both channels of the circuit are identical (the control voltage is fed to pins 1 & 16), and give about 6dB of gain with a control input of 12V, or 80dB of attenuation with a control input of zero volts.

Compander Theory

In acoustics, the term 'dynamic range' can be simply described as the difference between the loudest and the quietest sound levels that can be perceived or recorded. When listening to music, the human ear has a useful dynamic range of about 90dB (= 50,000:1 ratio). All practical recording systems generate inherent noise, which limits the minimum strength of signals that can be usefully recorded, and this factor (in conjunction with practical limits on maximum signal strength) places a limit on the useful dynamic range of the recording system.

Simple tape recorder systems typically have a useful dynamic range of only 50dB, and thus cannot directly record and replay high quality music. One way around this problem is to use a compander system to compress the 90dB dynamic range of the input signal down to 45dB when recording it (thus giving a 2:1 compression ratio), and then using a matching 1:2 expander to restore its dynamic range to 90dB when replaying the signals. This same technique can be used to improve the quality of telephone signals, etc., and the NE570/571 ICs are specifically designed for use in these types of applications.

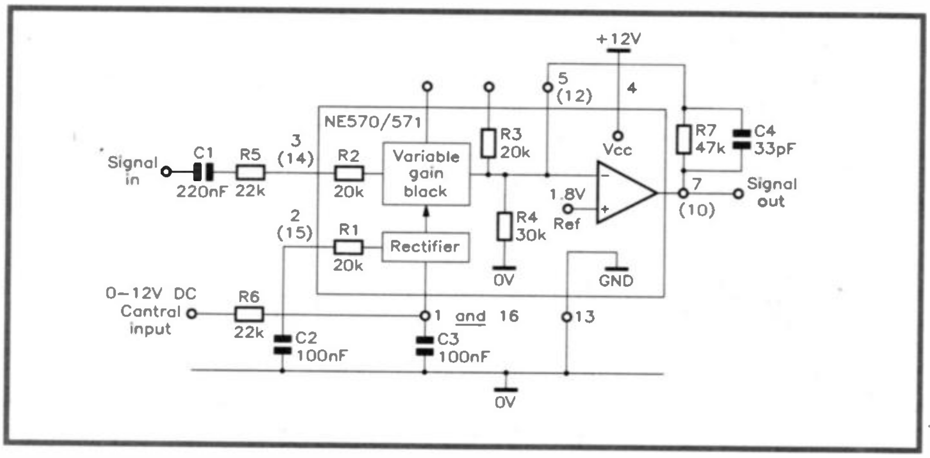
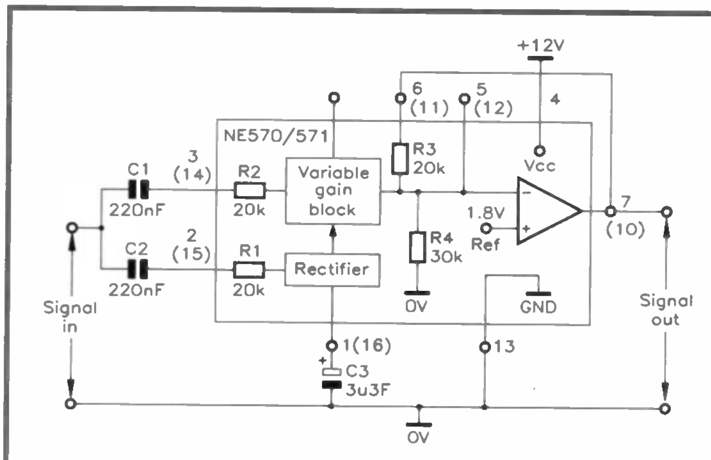
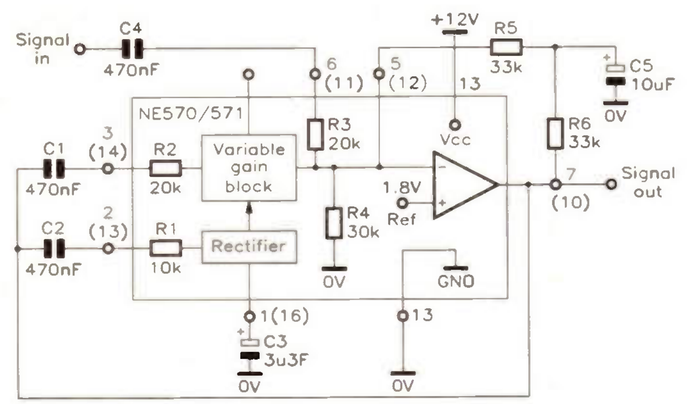


Figure 35. Stereo voltage controlled amplifier/attenuator (only one channel shown).



SIGNAL IN	LEVEL OUT
+10dB	+20dB
0dB	0dB
−10dB	−20dB
−20dB	−40dB
−30dB	−60dB
−40dB	−80dB

Figure 36. NE570/571 'Expander' circuit and performance table.



SIGNAL IN	LEVEL OUT
+20dB	+10dB
0dB	0dB
−20dB	−10dB
−40dB	−20dB
−60dB	−30dB
−80dB	−40dB

Figure 37. NE570/571 'Compressor' circuit and performance table.

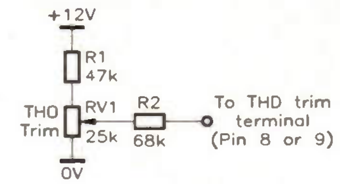


Figure 38. THD trim network.

An NE570/571 Expander Circuit

Figure 36 shows a practical NE570/571 'expander' circuit and its performance table. Here, the input signal is fed to both the rectifier and the variable gain block, and their action is such that circuit gain is directly proportional to the average value of the input. Thus, if the input rises (or falls) by 6dB, the gain also rises (or falls) by 6dB, so the output rises (or falls) by 12dB, giving a 1:2 expansion ratio. Note that in this circuit (because of the ratio of R3 & R4 the op-amp output takes up a quiescent value of 3V, and therefore can only deliver modest peak output signals. If desired, the quiescent output can be raised to 6V (giving a corresponding increase in peak output levels) by wiring a 12k resistor in parallel with R4 via pins 5 (or 12) and 13.

A Compressor Circuit

Figure 37 shows a practical NE570/571 'compressor' circuit and its performance table. Here, the input signal is fed to the op amp's inverting input via C4 & R3, but the variable gain block and rectifier circuitry are connected in exactly the same way as in the above expander design, and are AC coupled into the op amp's output-to-input negative feedback loop, and the circuit consequently gives a performance that is the exact inverse of the expander, i.e. it gives a 2:1 compression ratio. R5 & R6 form a DC feedback loop (AC decoupled via C5) that biases the op amp output at a quiescent value of about 6V.

A THD Trimmer

Finally, Figure 38 shows a THD trim network that can be added to the above expander or compressor circuits to minimise their total harmonic distortion figures. To adjust this trimmer, feed a fairly strong 1kHz sinewave to the input of the compander, and then trim RV1 for minimum output distortion.

Remotely Operated Vehicles (ROV's) *continued from page 18.*

communication. The system involves taking the down data as a serial bit-stream and modulating it, using different frequencies for each individual channel, onto existing AC power supplies going down to the vehicle along power conductors within the umbilical. Because this method of communication does not require its own designated conductors it is therefore especially suited to the smaller umbilical fitted to *eyeball* class vehicles.

The 20mA Current Loop

The 20mA current loop system is also usually used for smaller size vehicles and is also a very popular means of communication used by the work class vehicles auxiliary equipment such as profilers, bathyscopes and pipe-trackers.

It does, however, require its own dedicated twisted pair and a 20mA current generator at either the surface or vehicle end.

Multiplexed System

The multiplexed system is used by some of the larger vehicles and typically gives 32 up-data and 32 down-data channels. This is expandable to 64 or even 96 channels in each direction with both the up-data and the down-data sharing the same twisted pair. The multiplexing electronics in the vehicle are identical to the electronics at the surface with both units communicating to each other by taking turns between transmitting and receiving the serial bit streams.

Fibre Optic System

The fibre optic system is again used by some of the larger vehicles requiring a lot of communications channels. The system has advantages such as virtually zero signal loss over long umbilical lengths, smaller umbilical diameters due to less signal conductors being required and system speed.

It also has several disadvantages such as more difficult field servicing, the fibres fragility and cost. Some systems also use fibres to transmit the video picture from the vehicle to the surface and this can give an excellent low-loss video picture. Another big drawback in using fibre-optics is when the fibres reach the systems umbilical-winch. 'Fibre-optic sliprings' are very difficult to manufacture and have also proved comparatively unreliable, therefore at the winch the fibre-optic signals have to be demodulated and converted back to transmission on normal conductors.

Vehicle Control

When the individual channels have been separated they then go onto perform their various functions within the vehicle via dedicated switching or control circuits. This could be relay switching to switch cameras or auxiliary equipment on or off, or it could be to control dimmer circuits in the vehicle's lighting system. The 'thruster control' signals can be processed to drive DC motors directly or by using control systems such as Pulse Width Modulation (PWM). On a hydraulic propulsion system the control signals can be boosted to drive hydraulic servo systems or solenoid valves.

The Future

Anyone who may have seen the movie *The Abyss* will have seen a futuristic vision of ROVs in use. Also in the TV series *SeaQuest DSV* watch out for ROVs in action. Truly remote vehicles, without the need for an umbilical or tether, has always been an ambition of many systems' designers. Control over the vehicle by radio frequency signals can be accomplished over a certain distance, but the bandwidths required for video transmission from the vehicle to the surface appears to cause the most problems. The use of fibre optics in ROV design is increasing and most large systems at least include it as optional. Increasingly auxiliary equipment is being designed and upgraded to make sub-sea construction, inspection and survey work more accurate and faster. At the moment new offshore installations and structures are being designed to be more 'ROV friendly', in some cases by just the simple placing of valves and 'intervention' points in ROV accessible positions can make a huge difference to the operator in time, safety and expense. Things are changing for the better. Offshore projects can now be faster, more accurate and above all much safer if the existing tools are used to their full potential. Hopefully ROVs will prove to be a positive landmark in the 'man replaced by machine' dilemma.

DATA FILE

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

2 PROJECT RATING

TLC548I 8-bit Analogue-to-Digital Converter

KIT AVAILABLE (LT51F) PRICE £7.99

FEATURES

* Cost-effective with high performance
* Low power consumption
* Conversion time 17μs Max
* Differential reference input voltages
* Serial interface with 3-state data output
* 8-bit resolution Analogue-to-Digital converter

APPLICATIONS

* Interface sensors to the PC Weather Station

Design by Dennis Butcher

Text by Robin Hall and Dennis Butcher

The TLC548I is based around an 8-bit successive approximation sample and hold analogue-to-digital (A-to-D) converter. It makes 8-bit A-to-D conversion easy, cost-effective and usable. The device is capable of up to 45,500 conversions per second, and actually needs only one external control signal. The TLC548I is a very powerful IC and is suited to a multitude of tasks. The information given in this article should be enough to allow you to tailor the specially designed PCB for any task within the device's specification. The applications for the TLC548I, as described, are mainly in the context of PC Weather Station add-ons.

The TLC548I 8-bit ADC with Serial Data Output

The TLC548I is a complete data acquisition system on a single chip. The design of which is mainly for serial interfacing with a microprocessor or computer through a 3-state TTL compatible data output port and an analogue input port. Figure 1a illustrates the functional block diagram of TLC548I, and Figure 1b the timing diagram. The device requires an external I/O clock input along with Chip Select ($\overline{CS}$) input for data control; Figure 2 shows the TLC548I pinouts. The maximum guaranteed I/O clock input frequency is up to 2·048MHz. There is an internal system clock which operates typically at 4MHz and requires no external components. The I/O clock together with the internal system clock allows completion of high-speed data conversion rates in 17μs or less, whilst the complete input-conversion-output cycle

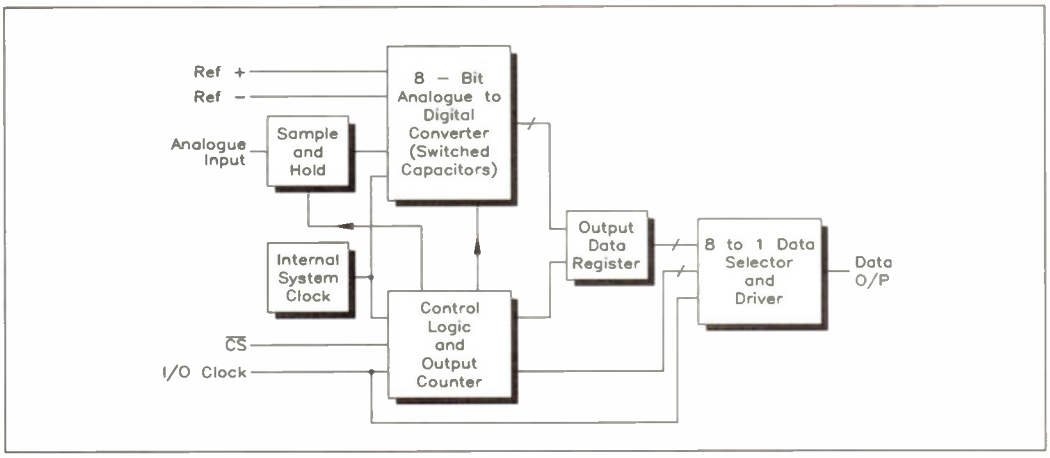


Figure 1a. Functional block diagram of TLC548I.

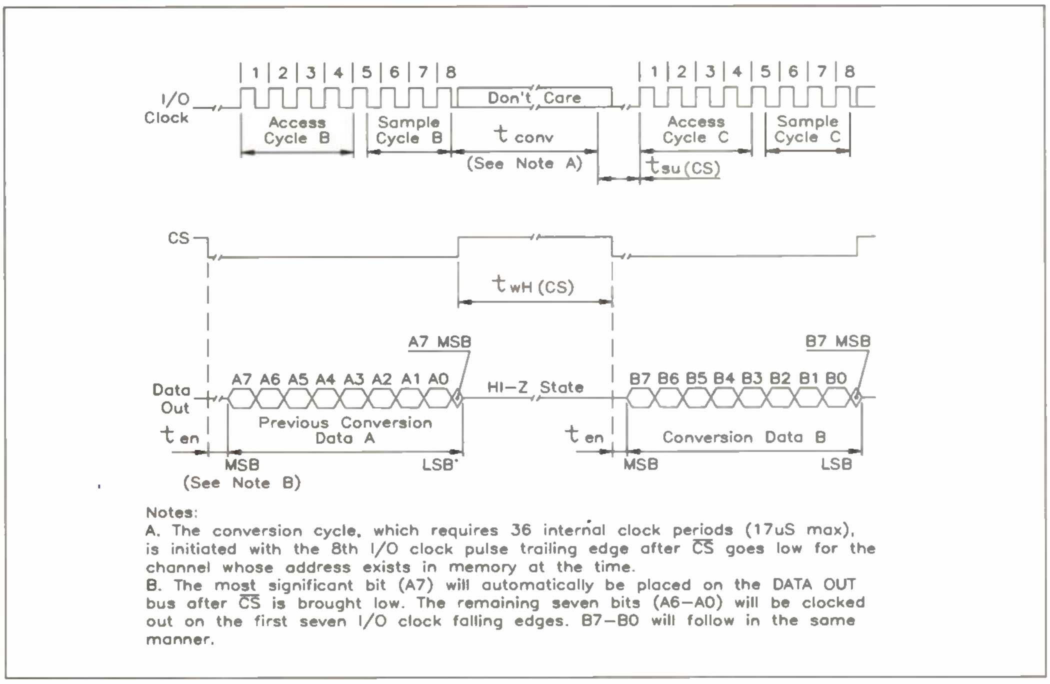


Figure 1b. Timing diagram of TLC548I.

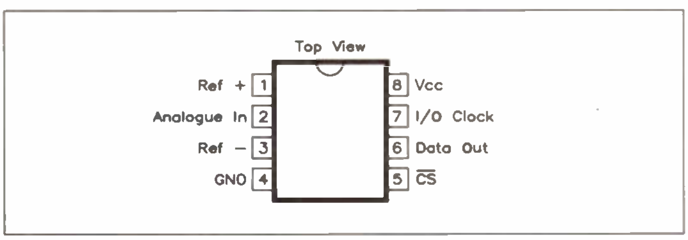


Figure 2. TLC548I pinout.

is in 22µs. The TLC548I includes versatile control logic, an on-chip sample-and-hold circuit that can operate automatically, or under microprocessor control, and with differential high impedance reference inputs provide circuit isolation from logic and supply noise. The voltage requirement for the IC is between +3 and +6V DC, with, typically, a low power consumption of 6mW. (For the electrical and operating characteristics refer to Tables 1a and 1b.)

The Universal TLC548I PCB

Referring to Figure 3, the upper part of the diagram shows the power supply section. A DC supply of +9 to +16V is applied to $+V_{in}$ and is regulated down to +5·6V (±0·2V) by RG1, where the output voltage (V_{CC}) being set by R1 & R2. An input supply of up to +40V can be used, but C1 would have to be changed to a higher voltage type. Also the extra heat dissipated by RG1 may cause problems in a confined space. C1 & C2 provide the necessary filtering for RG1; C3 & C4 are decoupling capacitors for the two ICs. The current supplied at V_{in} varies according to the method(s) used for providing reference voltages to the TLC548I, but in any case is no more than 100mA absolute maximum. Incorporated into the design are different methods of obtaining the reference voltage to the TLC548I.

A maximum of two external control signals are required for IC2, again referring to Figure 3 these are:

IO IN – This should be a TTL compatible square wave of up to 2·048MHz and will determine the final data rate.

$\overline{CS}$ IN – The Chip Select line must be taken LOW to enable both sampling and data conversion. If this line is *held* LOW, the IC will (after an initial set-up period) continuously sample and convert data. For most applications it is easier to 'frame' the data by taking $\overline{CS}$ low for 8 IO clock cycles whenever data is required.

These input signals to the PCB are pulled up by R3 & R4, and then buffered and squared by four segments of IC1, a Schmitt inverter. An output is taken from each buffer section which enables the signals to be daisy-chained on to the next A-to-D PCB if required. A pull-up resistor R5 is used to ensure that IC2 is always disabled except when required. If IC2 is to be permanently enabled, just connect $\overline{CS}$ IN to 0V.

The legend and track for the TLC548I PCB are shown in Figure 4.

For the analogue input any device capable of providing us a voltage output within the range of the chosen converter can be used. In this case, anywhere between 0V to +5V DC can be connected to it. The corresponding digital output will to be a number with a value of between 0 and 255, proportional to the input voltage. A quick calculation (+5V ÷ 255) shows that each 'step' in this case will equal 0·0196V, so if the input is, say, +2V then the computer would read 102 (+2V ÷ 0·0196V).

Just to complicate things very slightly, we can also set two voltage references (V_{REF}+ and V_{REF}−) which enable us to alter the *scale* of the input. For instance if we set V_{REF}− to 0V and V_{REF}+ to +2·5V the input range now becomes 0V to +2·5V DC, and for a corresponding step

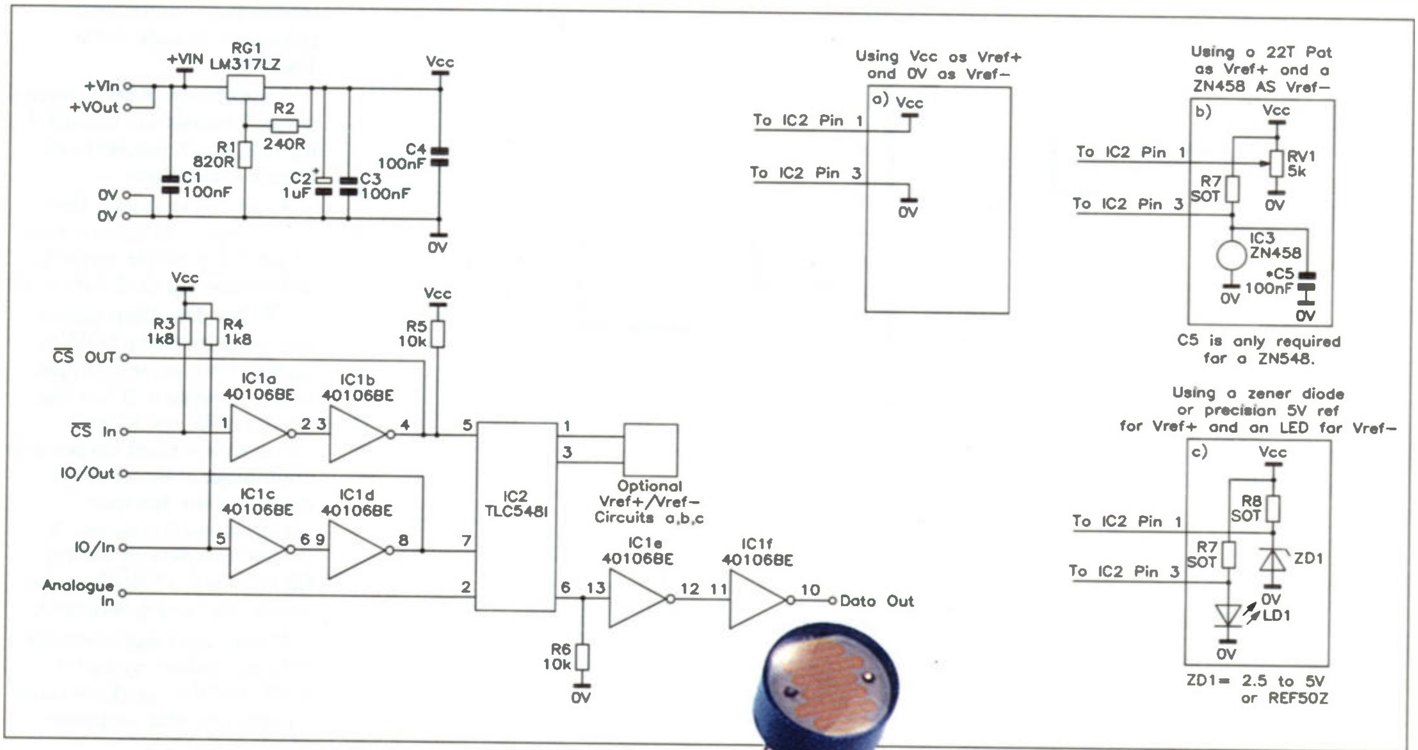


Figure 3. Circuit diagram of TLC548I module.

output of 0·0098V, an input of +2V would read 204 on the computer.

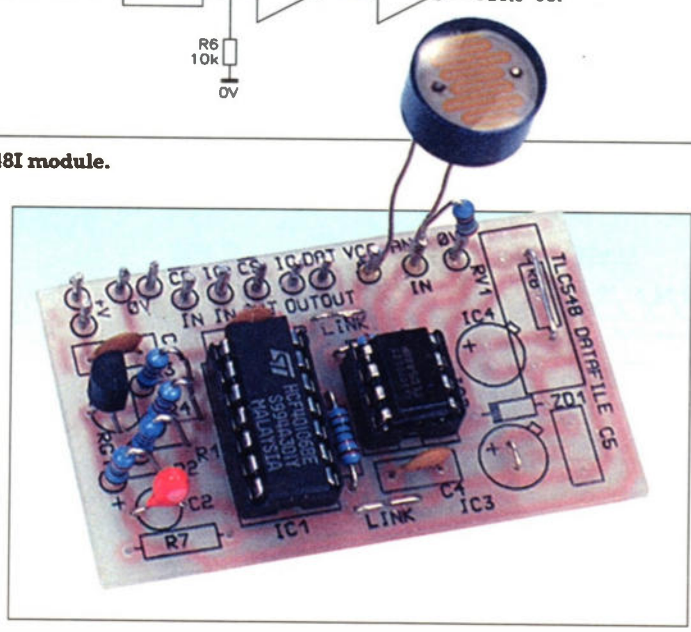
Applications

An excellent application for the TLC548I is to offer offboard remote sensing and interfacing to the PC Weather Station (LT28F) as described in *Electronics* October '93 Issue 70. The basic PC Weather Station kit provides information about just one of the elements, wind speed and wind direction. Whilst they are very important, there are of course many other factors to take into account, such as temperature, humidity, and sunlight. These are all easy enough to monitor using off the shelf instruments, but few of these give an output which is easy to decode via a computer and even less of them are compatible with each other. The answer seemed to lie with *simple* sensors giving a common output signal (e.g., thermistors or Light Dependent Resistors) which could be linked via A-to-D converters to a PC I/O card, but there are two problems to overcome:

First, any DC voltage or current related output would be degraded by excessive lead lengths and this would severely restrict the distance over which they could be mounted from the PC.

Secondly, conventional A-to-D chips tend to need fast clock speeds and a host of ancillary circuitry to enable them to work correctly, when coupled with a need for large amounts of power and possibly a 9-way plus cable for each sensor, this would mean a very large PCB to accommodate each device.

The universal PCB has been developed for the TLC548I and can easily assist in interfacing simple sensors to the PC Weather Station card. They can be individually built up for each application and mounted in slots such as provided for in an ABS box MB1 (LH20W).



Assembled TLC548I module with light sensor.

The IO and $\overline{CS}$ signals need to be produced externally for the TLC548I and these are obtained from the Weather Station card which generates them from the OSC output available on the PCs bus (B30) which is always at 14·31818MHz. This is divided down by ICs 10 & 11 for use as IO and $\overline{CS}$ signals.

As with all the signals to and from the PC these are galvanically isolated, in this case by optoisolators on the

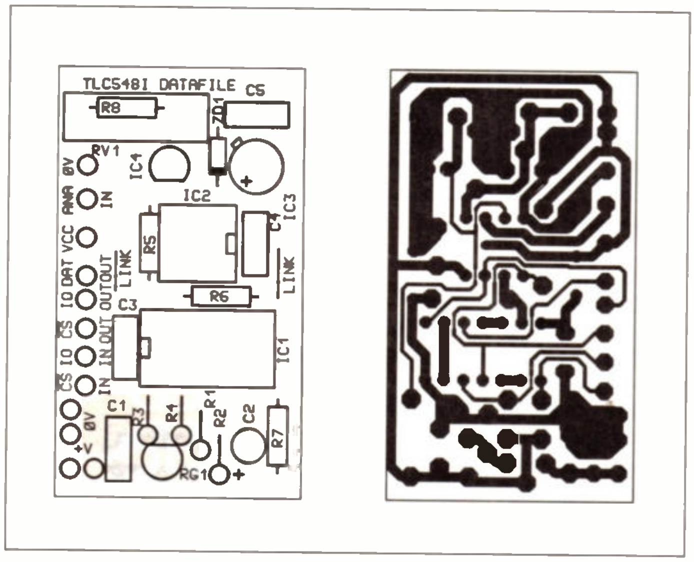
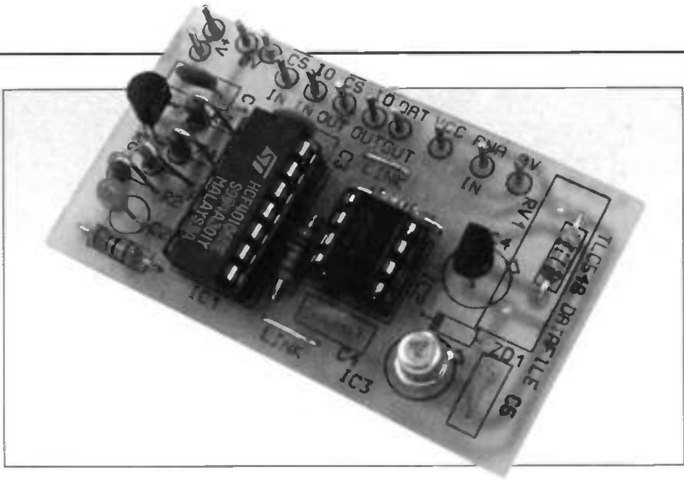


Figure 4. PCB legend and track.



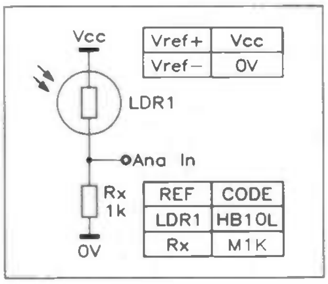


Figure 5a. Light sensor.

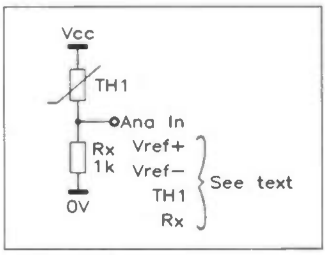


Figure 5b. Temperature sensor.

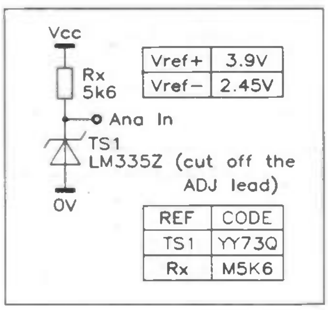


Figure 5c. Precision temperature sensor.

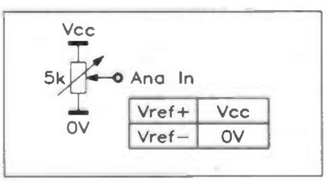


Figure 5d. Position indicator.

PC Weather Station card. At the $\overline{CS}$ IN and IO IN inputs to the TLC548I PCB these signals are 'pulled up' by R3 & R4, and then buffered and squared by 4 segments of IC1, a Schmitt inverter. An output is taken from each buffer section to enable the signals to be daisy-chained on to the next TLC548I PCB if required.

Light Sensor (LDR)

Figure 5a shows the TLC548I using a Light Dependent Resistor (LDR1) ORP12 type (HB10L) as a light sensor, where typical values of resistance on the LDR equal to 50Ω at maximum light and 1M at maximum darkness. This can be utilised with a +5V supply and a 1k resistor to provide an analogue voltage range of between 238mV and +4·76V, which is perfectly acceptable.

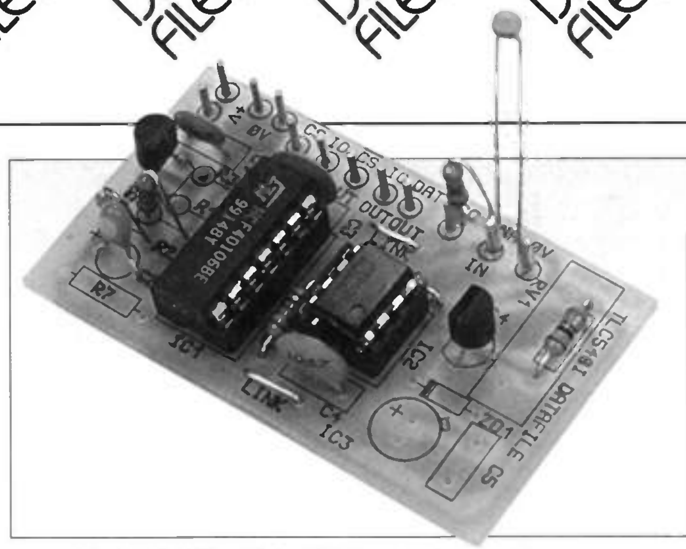
N.B. Be aware that the readings obtained in artificial light may be wrong, as the light is modulated by the AC mains at 50Hz, and produces flickering light at this frequency, which will be picked up by the LDR.

Temperature Sensor (Thermistor)

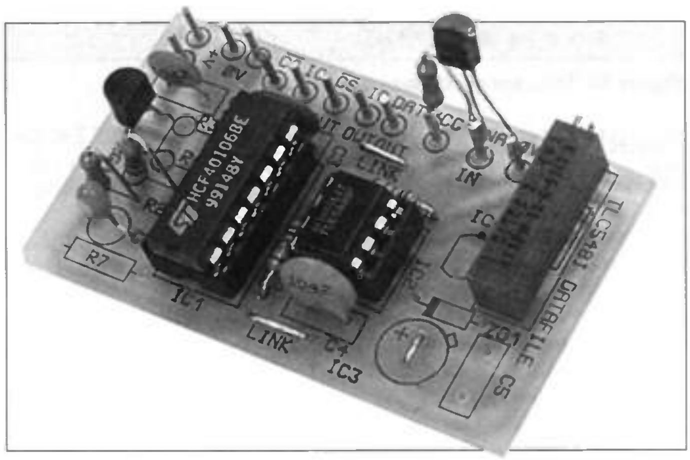
Figure 5b shows the TLC548I using a thermistor (TH1) as a temperature sensor, which is a 100k bead type (CR05F). Its range is −55°C to +155°C with a tolerance of ±2%. With the resistance range of the thermistor, a load resistor of 1k, and a +5V supply, a suitable analogue voltage can again be applied to the TLC548I, in the range of 0V to +5V.

Precision Temperature Sensor (LM335Z)

In Figure 5c this shows the TLC548I with the LM335Z (TS1), a precision temperature sensor. Its operation is similar to a Zener diode, and has a linear output equal to 10mV/°C. Uncalibrated it has a typical temperature error of only 2°C, and when calibrated the error is only 1°C.



Assembled TLC548I module with temperature sensor.



Assembled TLC548I module with precision temperature sensor.

Parameter	Min	Nom	Max	Unit
Supply Voltage V_{CC}:	3	5	6	V
Positive Reference voltage $V_{REF}+$:	2·5	V_{CC}	V_{CC}+0·1	V
Negative Reference voltage $V_{REF}-$:	−0·1	0	2·5	V
Differential reference voltage:	1	V_{CC}	V_{CC}+0·1	V
Analogue input voltage:	0		V_{CC}	V
High-level control input voltage:	2			V
Low-level control input voltage:			0·8	V
Operating supply current I_{CC} ($\overline{CS}$ at 0V):		1·8	2·5	mA

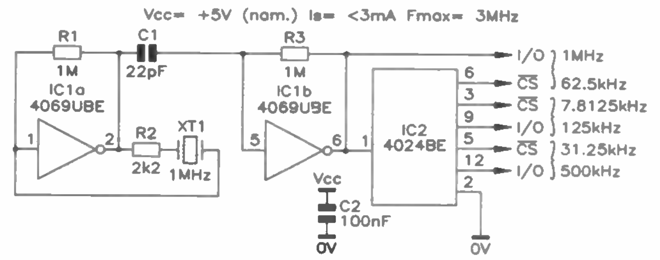
Electrical characteristics over recommended operating temperature range, V_{CC} = $V_{REF}+$ = +4·75 to +5·5V. (Unless otherwise stated.) IO IN = 2·048MHz.

Table 1a. Electrical characteristics of TLC548I IC

Parameter	Min	Max	Unit
IO Clock:	0	2·048	MHz
Duration of –CS during conversion:	17		µs
Set-up time –CS low before I/O:	1·4		µs
Operating free air temp TA:	-40	85	°C

Operating characteristics over recommended operating temperature range, V_{CC} = $V_{REF}+$ = +4·75 to +5·5V. (Unless otherwise stated) IO IN = 2·048MHz.

Table 1b. Operating characteristics of the TLC548I IC.



Ref	Description	Code	No. Off
R1,3	Min Res 1M	(M1M)	2
R2	Min Res 2k2	(M2K2)	1
C1	Ceramic 22	(WX48C)	1
C2	Minidisc 0.1uF 16V	(YR75S)	1
IC1	HCF4069UBEY	(QX25C)	1
IC2	HCF4042BEY	(QX13P)	1
XT1	MP Crystal 1MHz	(FY79L)	1
	Pin 2145	(FL24B)	1Pkt
	Strip Board 2939	(JP47B)	1

O/P frequencies using a 1MHz crystal. For other crystals, multiply by the crystal frequency in MHz (e.g. if XT1=2MHz then multiply the o/p frequencies by 2).

Figure 6a. External oscillator circuit.

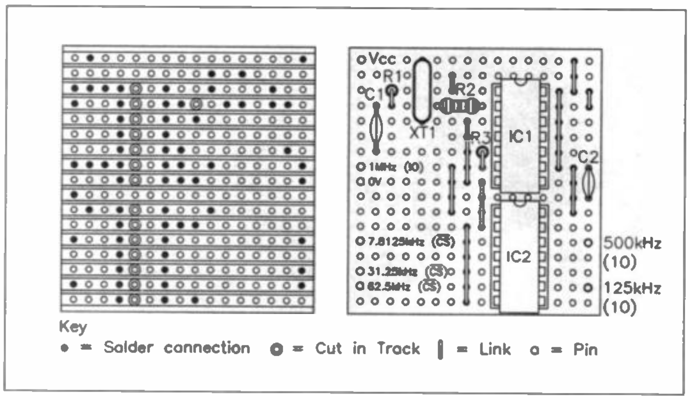


Figure 6b. Stripboard layout of oscillator.

Position Indicator (Potentiometer)

The TLC548I module may also be used to indicate the position of a window or automatic skylight as used in some greenhouses. Using a suitable potentiometer, such as the 5k linear type as shown in Figure 5d, the range of +5V and 0V can be used by the module to give a digital reading of between 0 and 255.

External Oscillator

If the TLC548I is to be used as part of a stand-alone project then refer to Figure 6a which shows a suggested external oscillator for use with the TLC548I. This uses a 1MHz crystal which along with a 4069UB Hex inverter creates 1MHz clock pulses for IO IN on the TLC548I PCB. Other clock pulses for $\overline{CS}$ IN and IO IN are derived from a 4024BE 7-stage ripple counter, and these can be used for different speeds of conversion. A suitable stripboard layout is given in Figure 6b.

Interfacing to the PC Weather Station Card

When interfacing to the PC Weather Station Card, the optoisolators having open-collector outputs only requires one card designated the 'Master', to have R3 & R4 fitted. The consequent 'Slave' units do not require them. Figure 7 shows the PC Weather Station card connected to one 'Master' TLC548I and one 'Slave' TLC548I. Up to eight TLC548I boards can be used with the project, where three ABS type boxes (MB1) would be required to house all the TLC548I boards.

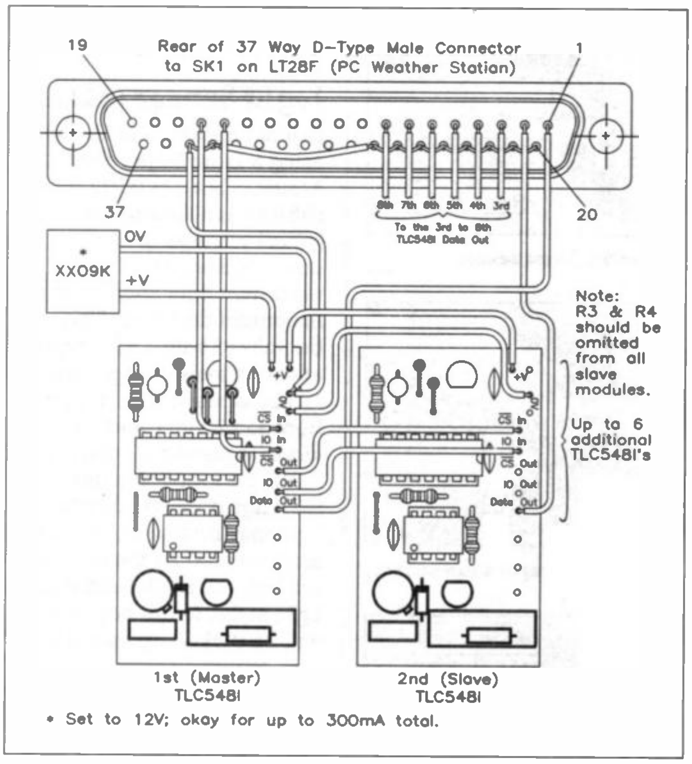


Figure 7. Wiring the TLC548I datafile to the PC Weather Station via A 37-way D-Type male connecter.

Req'd V_{REF}+	IC4 Device (Order Code)	R8 Value	RV1	ZD1 Device (Order Code)
V_{CC}	*	LINK	*	*
+2·5 to V_{CC}	*	*	5k 22T	*
+5·0V	REF50Z (DB59P)	4k7	*	*
+2·5V	REF25Z (DB58N)	1k2	*	*
+2·7 to +5·1V	*	See Note 1	*	BZY88C (QH00A-QH07H)
N.B. An asterisk (*) means Not Applicable/Not Fitted				

Table 2a. VREF + build options.

Note 1: To calculate the value of R8, take the Zener voltage and divide it by 15mA, then select the nearest standard value from the M range of 0·6W 1% resistors.
e.g., for Zener diode QH03 (3·6V) the formula is:
3·6÷0·015 = 240Ω, which would be Order Code M240R.

Req'd V_{REF}–	IC3 Device (Order Code)	R7 Value	C5
0V	LINK	*	*
+2·45V	ZN458 (DB54J/DB55K)	470Ω	100nF
+1·26V	ZN423 (DB56L)	270Ω	*
+1·2V	REF12Z (DB57M)	1k2	*
+2·0V approx. (See Note 2)	Red/Green 5mm LED (WL27E/WL28F)	360Ω	*
+1·9V approx. (See Note 2)	Orange/Yellow 5mm LED (WL29G/WL30H)	360Ω	*

Table 2b. VREF – build options.

Note 2: The voltage references shown for LEDs proved accurate during trials to within +0·1V and were stable to better than 10mV under extreme conditions (liberal applications of freezer spray and hot air guns!). They make a cheap and effective source for V_{REF}–.

```
20 REM      ***** A2D.BAS *****
30 CLS
40 PRINT "Maplin PC Weather Station project: A/D Converter input sample program."
50 PRINT "Copyright (c) Maplin Electronics PLC, 1993"
60 REM    This program reads the value transmitted by the A/D converter
70 DIM RD(8)
80 RESTORE
90 FOR N = 1 TO 8: READ RD(N): NEXT
100 K = 1
110 BASEADD% = &H300                      'Set to the required base address in Hex
120 LOCATE 10, 1: PRINT "The current value returned from A/D converter No."; K; " is:"
130 REM start
140 K$ = INKEY$: Z = VAL(K$)              'Select required A/D input
150 IF K$ = "+" OR K$ = "=" THEN Z = K + 1
160 IF K$ = "-" THEN Z = K - 1
170 IF Z > 0 AND Z < 9 THEN K = Z
180 LOCATE 10, 51: PRINT K
190 AD = RD(K)
200 OUT BASEADD%, 1 + AD                  'Enable IC3; AD=K in BCD
210 A% = INP(BASEADD%)                    'Read IC3
220 A% = A% AND 64                        'Extract bit 7 state
230 IF A% = 64 THEN GOTO 130              'If Bit 7 is high, wait
240 OUT BASEADD%, 4                       'Enable IC9
250 DTA = INP(BASEADD%)                   'Read IC9
260 DTA = 255 - DTA
270 'Check strobe                         This routine checks that the data has been
280 OUT BASEADD%, 1                       'read during the reset period only; if not,
290 A% = INP(BASEADD%)                    'then it returns the routine to the start
300 A% = A% AND 64                        'without updating the value of A
310 IF A% = 64 THEN GOTO 130
320 OUT BASEADD%, 0                       'Disable all data lines
330 LOCATE 10, 58: PRINT USING "###"; DTA
340 REM wait
350 OUT BASEADD%, 1 + AD                  'waits until the next serial data transmission
360 A% = INP(BASEADD%)                    'is complete before continuing
370 A% = A% AND 64
380 IF A% = 0 THEN GOTO 340
390 GOTO 130
400 DATA 0, 128, 64, 192, 32, 160, 96, 224
```

Listing 1. GWBasic/QBasic listing for reading data via PC Weather Station card.

Construction

First decide which configuration to build, and then refer to the required section and the relevant Parts List. Fit the resistors required in the positions on the PCB according to the selected option*. Similarly fit any links from the off-cuts obtained from the resistors. Next fit the PCB pins, using the soldering iron to push home each one and solder in place. Install the IC sockets, making sure that the orientation marker at one end aligns with the marker on the legend. Next fit capacitors C1 to C4 (C5 if required), with correct polarity observed for the bead tantalum. Fit the ICs into the sockets, and finally, fit the optional parts for the type of sensor required, and check that there are no whiskers of solder or 'shorts' on the board.

* Note that R3 & R4 are only required for a 'Master' board when used in conjunction with the PC Weather Station Card.

Basic Program Listing

Listing 1 is a GWBasic/QBasic program that can be used in conjunction with the PC Weather Station card and the TLC548I module, and reads the value transmitted by the selected TLC548I A/D converter one to eight.

TLC548I 8-BIT ANALOGUE-TO-DIGITAL CONVERTER PARTS LIST

RESISTORS: All 0·6W 1% Metal Film (Unless specified)			
R1	820Ω	1	(M820R)
R2	240Ω	1	(M240R)
R3,4	1k8	2	(M1K8)
R5,6	10k	2	(M10K)
CAPACITORS			
C1,3,4	100nF 50V Disc Ceramic	3	(BX03D)
C2	1µF 35V Tantalum Bead	1	(WW60Q)
SEMICONDUCTORS			
IC1	HCF40106BEY	1	(QW64U)
IC2	TLC548I	1	(GX06G)
RG1	LM317LZ	1	(RA87U)
MISCELLANEOUS			
	14-pin DIL Socket	1	(BL18U)
	8-pin DIL Socket	1	(BL17T)
	Single-ended PCB pin 1mm (0·4in.)	1 Pkt	(FL24B)
	PCB	1	(GH68Y)
	Instruction Leaflet	1	(XU56L)
	Constructors' Guide	1	(XH79L)

OPTIONAL (Not in Kit)			
	AC Adapter Unregulated 300mA	1	(XX09K)
	ABS Box MB1	1	(LH20W)
R7	(See text)		
R8	(See text)		
IC3	(See text)		
IC4	(See text)		
ZD1	(See text)		

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

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

Order As LT51F (TLC 5481 8-bit Analogue-to-Digital Converter) Price £7.99.

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

The following new item (which is included in the kit) is also available separately, but is not shown in the 1994 Maplin Catalogue.

TLC5481 8-bit A to D Converter PCB

Order As GH68Y Price £2.45.

CORPORATE FAX MARKET TRENDS

by Frank Booty

A great deal of controversy surrounds the emergence of a CCITT fax standard – Group IIIbis – and its expected effect on the long-established Group IV facsimile (fax) standard.

In 1980, when Group IV was first discussed, state-of-the-art fax was Group III, a 4800 bit modem with Modified Hoffman coding and a per page transmission time of about 55 seconds. In those days, the concept of a fax machine that could transmit a document in three seconds sounded marvellous, if not impossible. It is important to note that the communications industry 'experts' of the day considered the then-expensive fax to be insignificant, since few organisations were installing it (yet another 'chicken and egg' situation – Ed.).

Then, the primary mode of inter-organisation communication was the telex. The industry was betting that new automated telex products – teletex – (not to be confused with teletext, which is an entirely different TV information service) would become the medium of the future. So, as Group IV fax specifications developed, they were burdened with a requirement to be compatible with the teletex standards that were seen as the true future of data communications.

The Group IV standard was divided into three classes. Class 1 revolved around the transmission of image only, with a resolution of 200 × 200 lines per inch (lines/in. or lpi). Class 2 allowed for the transmission and reception of images at 300 × 300 lines/in., with the additional reception of teletex. Class 3 involved the sending and receiving of both image and text, in what was called 'mixed' mode; this would have sent the document as image and text, as it appeared on the same page. Class 3 also included OCR (Optical Character Recognition) capability, with resolution at this level going as high as 400 × 400 lines/in.

As the 1980s progressed, of course, teletex never came into its own as a critical standard in data communications. Instead facsimile exploded in terms of installed population, and became the standard for international corporate communications. As a result, many users and decision makers forgot the original make up of the Group IV specs, and came to think of Group IV in simpler fax-only terms.

To most users now, Group IV means high resolution (unspecified), high-speed (about three seconds per page) and plain paper printing. Interestingly enough, the use of plain (rather than thermal) paper was never one of the Group IV specs when any of the standards were set and as such, thermal Group IV machines exist in Japan.

Two of these criteria, high-speed and plain paper printing, exist today in many Group III fax machines. CCITT (Comite Consultatif International de Telegraphie et Telephonie) is working on higher resolution standards for Group III fax and a standard protocol to run Group III fax over digital data networks. When these are adopted, the final customer definition of Group IV criteria will be available on Group III machines. In addition, this should be at a very small premium over the price of today's current units. So if Group III is so good and so cost-effective, why are so many manufacturers still pushing Group IV? The answer is partly economic and partly political.

While Group III fax was proliferating, Group IV fax assumed a new significance, with installations of (or proposals to install) Integrated Services Digital Network (ISDN) lines in countries around the world. ISDN networks have been fully or partially implemented at enormous cost by large telephone carriers in Japan, Germany, France and the UK. ISDN, in the USA, exists mainly in campus test environments, and there is no widespread implementation. Why the disparity?

ISDN becomes cost-effective only when fully utilised – i.e. jammed with voice, data, image, etc. But today few terminal devices can run on ISDN, the notable exception being Group IV fax. Faced with the embarrassing prospect of publicly spending huge amounts of money to construct a super highway without any cars to run on it, the carriers turned to the fax market.

In Japan, the NTT (Japanese equivalent of European PTTs) vigorously pressurises the manufacturers to subsidise the development of Group IV fax machines for use in the home market. In Germany and France, the PTTs subsidised Group IV units. In essence, one can buy a Group IV fax below cost in all of these places.

In an effort to offset their investment in Group IV fax development, major manufacturers began to introduce them into the USA. With ISDN installation limited, however, to a few trials, most are running over customers' leased 64kbps digital networks and have been installed as hub units for their plain paper output and fast printing, but not fast transmission. Then there are the costs – Group IV machines are very expensive. And they still need special software to be downward compatible with the 12 million-plus machines on the Group III network.

There is considerable discussion about the new CCITT standard called Group III Digital, or Group IIIbis. This eliminates much of the unnecessary overhead involved in Group IV (teletex communication, etc.) and is essentially a facsimile-only standard for high-speed digital networks. It would provide all the capabilities customers expect from Group IV products, but without the need for an ISDN interface. If ISDN connection were required, Group IIIbis could connect to the network through an external interface.

Group IIIbis uses the existing T.30 (Group III) facsimile protocol standard, and therefore provides simpler communications compatibility between different manufacturers' units. The greatest benefits of Group IIIbis are ease of operation and low cost. Even the least expensive of today's Group IV machines are twice the price of the Group III machines on which they are based. New Group IIIbis machines remain as easy to operate as today's Group III machines, with the higher speeds transparent to the operator during machine set up and normal use.

Fax and E-mail – Where do you Draw the Line?

The hypothetical division between facsimile machine and electronic mail (E-mail) technologies is disappearing, by virtue of a new crop of standards, discussed at a recent CCITT Plenary Assembly. The dividing line between fax and E-mail continues to disappear in the marketplace as well, as computers and telephone equipment continue to merge.

Sellers of E-mail equipment have systems that carry fax pages as message attachments. Computer/fax vendors are finding ways to route fax images around private networks and LANs. Host computer and LAN vendors are adding fax servers and PC/fax boards to their attachment armouries. And now fax vendors are finding ways to attach text messages and binary files to fax pages.

The Consultative Committee for International Telegraph and Telephone (CCITT) is an agency of the International Telecommunications Union (ITU) which, in turn, is part of the United Nations. The CCITT, among other tasks, is responsible for most of the standards used by E-mail and fax systems. The X.400 series of recommendations for message handling systems was based on work done by CCITT Study Group VII. First published in 1984, it was revised in 1988 and was due for another revision in 1992's plenary assembly. The CCITT's V series of recommendations are used in fax and data modems and the T series of recommendations, most notably T.4 and T.30, form the base of the fax standards in use today.

The CCITT works in four year long cycles. Last year's study period began in 1989 and ended at the 10th Plenary Assembly, at which member nations traditionally approve all the new standards. The CCITT has been moving towards adopting a new standard for binary file transfers by Group III fax machines over existing analogue telephone lines. This has nothing to do with the coming of high-speed fax over ISDN, but is a near-term improvement of existing equipment capabilities – and one for which some already claim to have equipment.

The standard is called T.30 Annex B or the Binary File Transfer (BFT) Diagnostic Message. It is as important to fax as X.400 is to E-mail and is derived from Study Group VIII of the CCITT, which is charged with development of many fax standards. The update of the standard contains many new features, one of which is binary file transfer by half-duplex modems. Simply put, this option raises the possibility that existing fax modems could be used to transmit and receive computer files. These files could include text, spreadsheets, computer graphics, E-mail or Electronic Data Interchange (EDI) documents.

They could be the editable complement to the final form image contained on the fax page – they could, for example, even contain the computer graphics program used to generate the fax page to which it is attached. A word processor file could travel as an editable version of the fax page to which it is attached. This, however, cannot happen overnight; the worldwide installed base of 22 million fax machines is just not yet ready to receive and store computer files. Most use the CCITT Group III fax standards first adopted in 1980 and revised every four years since. But a relatively small portion of the installed base have the serial ports, disk stores and other facilities that are required for practical applications involving the transreception of binary files.

As fax machine users begin to upgrade the installed base will slowly become compatible with binary file transfer. These so-called 'memory' machines contain disk drives that can hold pages in storage for later printing, forwarding or broadcasting. They include advanced features for delayed transmission and polling that allow machine operators to schedule jobs for the middle of the night, when telephone rates are lowest. They can use a hub machine for relay broadcasting – sending the hub one copy of the document plus a distribution list of all local recipients.

Many of the latest fax machines use high resolution laser printers and thus use plain paper. Some even include large LCD screens or CRT displays on which users can look at fax pages before deciding whether to print or delete them. In other words, the newest fax machines are starting to look and behave more and more like computers.

Some years ago, the CCITT defined a modem standard called V.29 which specifies 9600 bits/s half-duplex operation over two wire dial-up lines and full duplex operation over four wire leased lines. As the CCITT moved in 1980 to define Group III, the V.29 modem standard was adopted for the fax machine's bitstream. The V.29 fax modems already support half-duplex binary file transfers at 9600 bits/s (that is the definition of a fax transmission). But the fax machines cannot make sense of the information, as they only 'read' in terms of black and white dots.

A V.29 modem could also be used to send ones and zeros that represent IA5 or ASCII characters. Indeed that use of a V.29 modem predates Group III fax. But it is up to higher level protocols to make sense of a bit stream that contains text, E-mail or EDI documents. That capability is not yet built into CCITT V.29, T.4, T.30 or Group III. But the revised T.30 will support binary file transfers by Group III fax machines.

The line between fax modems and data modems began to blur five years ago when manufacturers released their first generation of PC/fax boards. Some of these units worked to both V.29 and V.22bis standards in addition to offering Hayes compatibility. This allowed them to send and receive both faxes and 2400 bits/s data. Today, it is difficult to find a PC/fax board that does not allow dual use as a fax and data modem. In 1987 PC peripheral manufacturers started adding fax to data communications. Now it is the turn of fax machine makers to add data communications capabilities to their equipment. By adding extensions to the T.4 standard they can allow fax modems to send and receive binary files.

The Future

The potential, then, exists that such a standard for binary file transfer could pull much of the E-mail and EDI traffic into the fax domain. If present X.400 based E-mail systems were easy to use, they would be ideal. As it is, however, these systems can be very difficult. As better software and directories come into use, X.400 based E-mail systems may become as easy to use as today's Group III fax machines. They will probably also allow easy attachment of Group III fax pages to an E-mail message, as the X.400 standards envisioned as far back as 1984.

Future editions of the CCITT fax standards will also support the higher resolutions found in current laser printers – another blending of computing and faxing. Currently there are three resolutions commonly found in Group III fax machines. Standard resolution is 3·85 lines/mm, or about 100 lines/in. Fine resolution is 7·7 lines/mm, or about 200 lines/in. Superfine is 15·4 lines/mm, or about 400 lines/in. New CCITT proposals currently making the rounds for examination in 1993 will support the 300 × 300dpi resolutions of most laser printers, as well as a 400 × 400dpi mode.

Also included in the new fax standards is support for sub-addressing. In telephone systems, this means a fax 'phone number plus an extension number. In computer installations, though, a LAN/fax server 'phone number, plus mailbox codes for internal routing of fax messages to E-mail recipients, is required. The new standards will allow new Group III fax machines that support sub-addressing to send pages to a LAN/fax server, which can then route them to a specified E-mailbox.

Still contentious are the proposals to allow new Group III fax machines to send pages over the ISDN at the bearer channel rate of 64Kbits/sec, or about two seconds per page. This also should allow the interworking of Group III and Group IV fax machines over the ISDN. But there are several competing proposals, one from America, Russia and Britain, and another from Japan, Germany, Austria and France. Discussions are still proceeding.

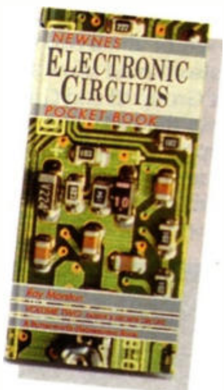
NEW BOOKS

Electronic Circuits Pocket Book – Volume 2

by Ray Marston

This volume complements the best selling volume one, and is produced in the same informative style. Covering passive electrical components, transducers and simple discrete semiconductor devices, this book has a total of 670 diagrams, tables and carefully selected practical circuits. The informative text explains the basic features and important details of modern passive components such as resistors, capacitors, inductors, switches etc., as well as relays, loudspeakers, 'phones, diodes, transistors, SCRs and TRIACs etc. These devices form the basic building blocks on which modern electronics circuits are based.

The text is non-mathematical and highly practical, and is aimed at engineers, technicians, students and experimenters who can build a design directly from a circuit diagram. Each chapter deals with a specific device and starts off by explaining the basic principles, followed by a wide range of data, tables and, where appropriate, practical applications circuits.



The first three chapters explain the important practical features of passive electrical components such as relays, meters, motors, sensors and transducers. The following two chapters discuss the design of practical attenuators, filters and 'bridge' circuits. The remaining 14 chapters deal with specific types of discrete semiconductors, and optoelectronic devices.

Copying the style of Volume 1 (WZ49D), which covers linear ICs, the emphasis is placed on practical user information and circuitry, with the added bonus that all the active devices used are modestly priced and readily available.

1993. 375 pages. 197 x 95mm, illustrated.

Order As AA25C
(Electronics Circuits2) **£12.95 NV**

Practical Electronic Timing

by Owen Bishop

This book is essentially a project book of practical electronic timing circuits, that employ several different types of specialised IC. Each group of projects has an introductory discussion highlighting the problems of timekeeping and the methods of solving such problems by using electronics.

There are projects that are suitable for beginners as well as the more experienced electronics constructor – the projects being suitably identified as either beginners, average or advanced. A wide range of different topics are covered including basic time-keeping, laboratory data recording, high-precision timing, sports and games, music and many domestic orientated applications. Each project description begins with an outline of the function of the circuit and the principles on which it operates, followed by a detailed description of how the circuit works. All the projects will operate from batteries, making them safe to build and operate – especially important for young beginners. In fact, there are several low-cost projects, that are specifically aimed at the beginner and younger enthusiast.

The circuits use common, and widely available, ICs and electronic parts. These circuits can be easily modified to meet varying individual requirements.

A well written and presented book that should have wide appeal to the beginner and the more experienced electronics enthusiast.

1993. 174 pages. 178 x 110mm, illustrated.

Order As AA28F
(Electronic Timing) **£4.95 NV**

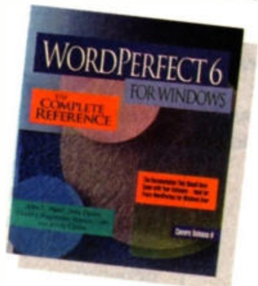
WordPerfect 6 For Windows – The Complete Reference

by Allen L. Wyatt, Steve Dyson, Daniel J. Fingerman, Stephen Cobb and Kirsty Clason

For many years, WordPerfect has been the best-selling word processor for all types of computers, but now this established program is available in a revised version for Windows. Whether you are a newcomer to WordPerfect, or an old-hand, this version – WordPerfect 6 for Windows – provides a wide range of new and improved features to enhance performance and improve productivity.

This book is much more than just a complete reference, that is an alphabetical reference list of command names and features, for it contains useful examples of common applications, with information organised according to task. Extremely helpful notes and tips are liberally placed throughout the book to help the beginner and experienced WordPerfect user understand the many features of the program. In general, each section and chapter is self-contained with references to other chapters where necessary.

The book is divided into four parts – WordPerfect basics, advanced features, a command reference and technical appendices. Advanced features include Desktop Publishing with WordPerfect for Windows, and explains how to use the graphics and font features to create documents suitable for printing. The chapter about spreadsheets and database files explains how to integrate such files into WordPerfect documents, using the linking capabilities of WordPerfect and Microsoft Windows.



This reference book will be indispensable for the novice and professional user, as it covers every WordPerfect feature, message and menu clearly, and in detail, thus providing all the information needed to master WordPerfect 6 for Windows.

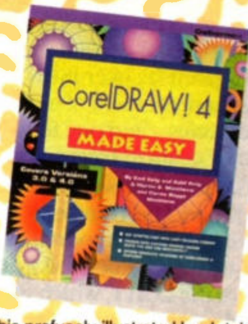
1993. 829 pages. 231 x 187mm, illustrated. American book

Order As AA29G
(W/Perfect 6 For Win) **£23.95 NV** A3

CorelDRAW! 4 Made Easy

by Emil Ihrig, Sybil Ihrig, Martin S. Matthews and Carole Boggs Matthews

CorelDraw! 4 has become one of the most widely used graphics software packages for the PC, as probably no other drawing package offers so many powerful drawing, text handling, autotracing, colour separation, and special effects facilities in one package. Version 4 adds a new range of desktop publishing features including multipage documents, text control, extensive bullets and improved colour styles with auto-trapping. There are many new artistic features including powerlines, textures and fills, artistic styles to manage complex drawings and weld capability to join the outlines of existing objects. In addition, there is a completely new technical illustrator, that includes dimensioning, clones that mirror their master, attaching data to objects and drag and drop symbol manipulation. Finally, a multimedia animation package called CorelMOVE! has been incorporated, that provides the combination of sound, graphics and two dimensional animation for use in a presentation.



This profusely illustrated book takes the reader from an elementary skill through to more complex ones. Each of the detailed chapters contains hands-on exercises to follow on your computer screen. No graphics experience is required, as the earlier exercises are designed for the beginner – it is not even necessary to have used a mouse or worked with a drawing package.

The book is primarily designed to let the reader learn skills by doing exercises, and is not dependent on passed experience, as you begin to draw straight away. As you work through the book you build on the skills you have learned in previous chapters.

A highly recommended book.

1993. 686 pages. 231 x 187mm, illustrated. American book

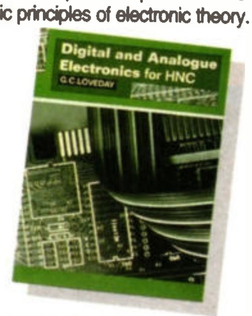
Order As AA26D
(CorelDraw 4) **£21.95 NV** A2

Digital and Analogue Electronics for HNC

By G. C. Loveday

This book primarily covers the required BTEC syllabus topics for electronic engineering at HNC/HND level, and in particular for BTEC units Analogue Electronics 13768B and Digital Electronics 13679B. Undergraduate students on electronic engineering degree courses will also find this book very useful as supplementary reading to their main course texts.

The author has adopted an engineering approach to text presentation, providing the student with many analysis and design examples, as well as exercises and solutions to consolidate the theory discussed in the text. Emphasis is placed on the basic principles of electronic theory.



The book discusses a wide range of topics including: an introduction to device and device selection, dealing with semiconductor theory, transistors, FETs and power FETs, op amps and digital logic families, theory and analysis of linear circuits, large signal amplifiers and digital circuits and signal processing.

The well qualified author has written a book that provides an integrated treatment of electronics by covering both digital and analogue elements and will be invaluable reference for those taking the courses mentioned.

1993. 238 pages. 246 x 187mm. illustrated.

Order As AA20W
(Dig & Analogue Elec) **£14.99 NV**

There is a unique fascination about being able to talk to, or listen to, radio stations from the other side of the globe. Tuning around the short wave amateur bands it is possible to hear stations from a wide variety of different places, some only a few hundred miles away, or possibly even closer. Others can be many thousands of miles away.

AMATEUR RADIO ON THE HF BANDS

by Ian Poole G3YWX

Distances

It is often the fact that signals travelling from afar bring much of the fascination to using the short wave bands. Making long distance contacts or DXing forms a major part of the hobby for a large number of people.

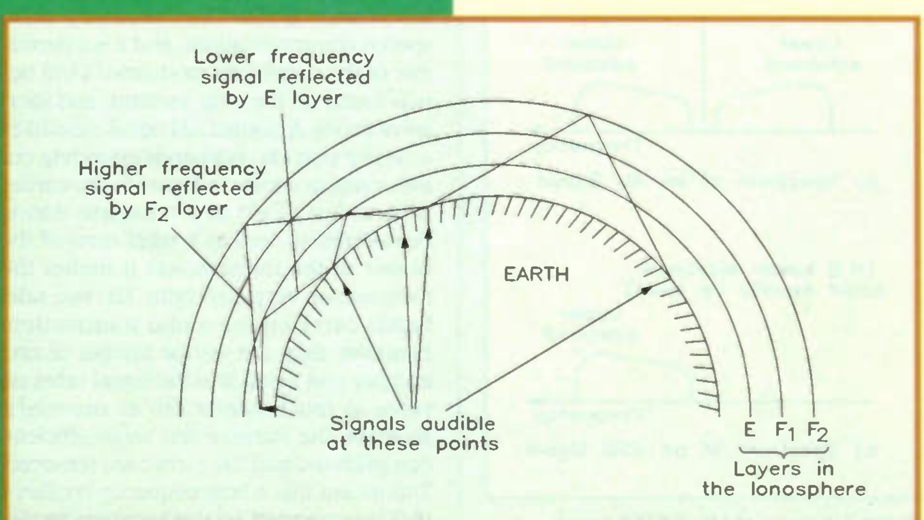
Radio waves are very similar to light, and broadly travel in straight lines. This is particularly true of signals in the microwave region of the spectrum where transmissions can only take place over paths which are virtually line of sight. To be able to travel the enormous distances covered on the short wave bands, they need some external influence. On the short wave bands the signals are reflected off various layers in the ionosphere. Sometimes several reflections may take place as shown in Figure1. A much more detailed explanation of the way in which signal propagation occurs on the short wave bands was given in *Electronics* March 1993, Issue 64.

Bands

In order to use the radio spectrum efficiently, it is split up into different bands of frequencies and these are allocated to different users. There are nine different bands allocated to radio amateurs in the short wave part of the frequency spectrum, please refer to Table 1. In view of the different propagation conditions which exist at different frequencies they all have their own characteristics. Choosing the correct band and knowing what it can reveal in the way of stations is part of the interest and skill involved in DXing. The only real way to get to know the bands is to listen to them. However, a flavour of what they are like is given here.

160 Metres

This band is also referred to as *Top Band*, being the one with the longest wavelength. It is shared with other radio users, notably with Maritime Radio communications, which are the main users. There is not a great amount of amateur radio activity here, although there are some areas in the UK that have regular users, which can provide some interesting contacts. During the day distances of 30 miles or more can be reached, but at night this figure is considerably increased. Stations over 500 miles or more are relatively common, and during the winter months especially, it is possible to make transatlantic contacts. On some occasions contacts with stations on the other side of the world can be made. However, for long distance contacts very good aerials are necessary.



Above: RSGB HQ radio room GB3RS.
Left: Figure 1. Reflections of signals via the Ionosphere.

Band	Frequency Limits (MHz)
160 Metres (Top Band)	1·81 – 2·00
80 Metres	3·50 – 3·80
40 Metres	7·00 – 7·10
30 Metres	10·10 – 10·15
20 Metres	14·00 – 14·35
17 Metres	18·068 – 18·168
15 Metres	21·00 – 21·45
12 Metres	24·89 – 24·99
10 Metres	28·00 – 29·70

Table 1. UK Amateur Bands Below 30MHz.

80 Metres

Considerably more amateur radio stations use this band than its lower frequency brother. Signals can normally be heard over distances of 200 miles or more during the day. Then at night, signals from further afield can be heard, and transatlantic contacts are not uncommon. Even contacts with Australia and New Zealand are not unusual at dawn and dusk in the spring and autumn. The main disadvantage with this band is the number of commercial stations which also use it. During the day this is not a major problem, but at night it becomes quite crowded.

40 Metres

This band is allocated purely for the use of radio amateurs, but even so it remains crowded because of its narrow bandwidth of just 100kHz. Despite this it is a very useful band to monitor. During the day stations up to distances of around 500 miles can be heard, whilst at night it opens up to reveal stations many thousands of miles away.

30 Metres

This band was only released for amateur use after the 1979 World Administrative Radio Conference (WARC). It is still used by other services and Morse is the only mode used. In view of this and some other restrictions, the band is not as widely used as some of the others. However, its low level of usage can be an advantage in terms of the lack of interference.

20 Metres

This is undoubtedly the main band for long distance communications. By day contacts can be made with stations at distances of up to 1,000 miles or more. Then at various times of the day, especially at dawn and dusk, stations much further afield can be heard. In the evening, stations from the other side of the Atlantic are plentiful, with countries from both North and South America audible. Stations can often be heard right through the night. However, in the winter and at the minimum point in the 11 year sunspot cycle the band will close for ionospheric propagation.

18 Metres

Like the 30 Metre band this allocation was also released after the radio conference in 1979. It took some while before many countries released it for amateur radio use, and as a result it is not as widely used as some others. Even so it is a very worthwhile hunting ground for DX chasers.

15 Metres

This is another very popular DX band. Higher in frequency than 20 Metres, its propagation conditions are more variable. Usually it is not open through the night, but in the afternoon and evening it can produce some very interesting long distance stations.

12 Metres

This is the third and highest in frequency of the bands released after the 1979 conference. It can produce some very good results, but being near the top of the HF portion of the spectrum it is not particularly reliable. In this respect it is very similar to 10 Metres.

10 Metres

This is the highest in frequency of the HF bands, and also the one which has the greatest amount of bandwidth – a total of 1·7MHz. In view of the amount of space available it can be used for a wide variety of modes. The more usual DX modes including SSB (single sideband) and Morse, are found below 29MHz. Above this FM (frequency modulation) is used. There are even a number of repeaters, based mainly in the USA which can be accessed when conditions are right. Some of these stations operate cross-band on to 2 Metres and it is not unknown for people at this side of the Atlantic to chat to people in the States who are just using small VHF hand-held transceivers around the house.

As the band is right at the top end of the HF part of the spectrum it is quite variable. During the low points of the sunspot cycle very few stations will be heard, except during the summer when there is the possibility of communications via sporadic E. However, the situation is exactly the opposite at the peak of the sunspot cycle. At these times the band is renowned for enabling people to make long distance contacts with low power and basic equipment. Even during these periods the band is only active during the day, normally closing after dark.

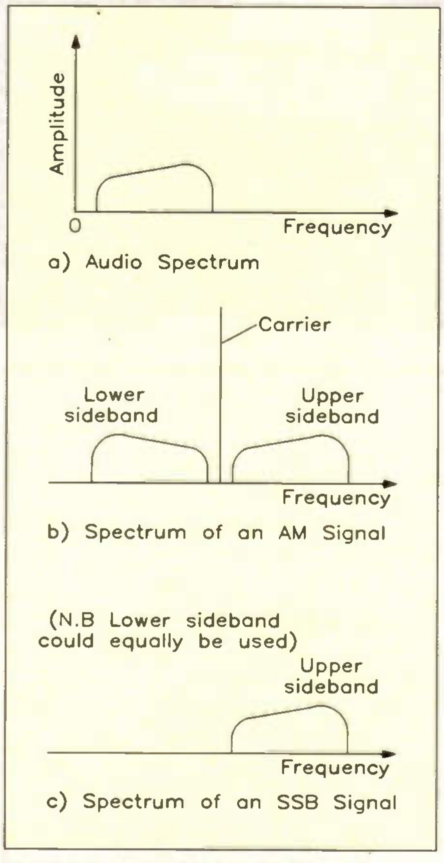


Figure 2. Spectra of AM and SSB signals.

A	·–	N	–·
B	–···	O	–––
C	–·–·	P	·––·
D	–··	Q	––·–
E	·	R	·–·
F	··–·	S	···
G	––·	T	–
H	····	U	··–
I	··	V	···–
J	·–––	W	·––
K	–·–	X	–··–
L	·–··	Y	–·––
M	––	Z	––··
1	·––––	6	–····
2	··–––	7	––···
3	···––	8	–––··
4	····–	9	––––·
5	·····	0	–––––

Punctuation	
Full Stop	·–·–·–
Comma	––··––
Question Mark (?)	··––··
Equals sign (=)	–···–
Stroke (/)	–··–·
Mistake	········

Procedural Characters

For procedural characters made up of two letters they are sent as a single letter with no break between them.

Start of Work (CT)	–·–·–
Invitation to Transmit (K)	–·–
Wait (AS)	·–···
End of Work (VA)	···–·–
End of Message (AR)	·–·–·
Invitation to a Particular Station to Transmit (KN)	–·––·

Table 2. International Morse Code.

Modes of Transmission

A variety of different modes of transmission are used. Obviously speech and Morse are used, but in addition to these types of transmission there are a number of others. Radio teletype (RTTY), and data transmissions are quite common, and for those interested in sending pictures, slow scan television (SSTV) is also used. This wide variety of different types of transmission all adds to the variety and interest of operating on these bands.

Possibly the most common form of transmission is SSB. This is used for normal speech communications, and it is a derivative of the amplitude modulated (AM) signals found on the long, medium and short wave bands. A normal AM signal consists of a carrier with two sidebands extending out either side as shown in Figure 2. The carrier is there just to act as a reference during demodulation, and as it takes most of the power of the transmission it makes the transmission very inefficient. The two sidebands carry all the audio information. However, they are mirror images of one another and mean that the signal takes up twice as much bandwidth as necessary. To make the transmission more efficient, one sideband and the carrier are removed. This means that a beat frequency oscillator (BFO) is needed in the receiver to de-

AP	Pakistan	S5	Slovenia
DJ.DK.DL	Germany	SM	Sweden
EA	Spain	T9	Bosnia Hercegovina
EI	Eire	U.UA.UW	Russia
F	France	VE.VO	Canada
G	England	VK	Australia
GD	Isle of Man	ZL	New Zealand
GI	Northern Ireland	ZS	South Africa
GM	Scotland	2D	Isle of Man (Novices)
GW	Wales		
HB	Switzerland	2E	England (Novices)
I	Italy	2I	Northern Ireland (Novices)
JA.JE.JH.JR	Japan		
K.N.W	USA	2M	Scotland (Novices)
LA	Norway	2W	Wales (Novices)
OE	Austria	4X.4Z	Israel
OH	Finland	9A	Croatia
OZ	Denmark	9H	Malta
PA	Netherlands	9J	Zambia

Table 3. Commonly heard Callsign Prefixes.

modulate the signal. Most communications receivers and many of the 'World Band' types of radio have these and are therefore able to resolve SSB. In view of its efficiency SSB is used almost invariably for speech transmissions on these bands. The only exception is the use of FM at the top end of 10 Metres. AM is very rarely used on the HF bands, but it still can be heard on *Top Band*.

Morse or CW as it is usually called is also widely used. Despite the fact that it was the first method used for carrying information over radio it still has many advantages. The secret of its success lies in its simplicity. It only needs the transmission to be turned on and off. As it is very easy for the ear to detect the simple presence or absence of a signal it means that Morse can be copied at very low strengths. In addition to this Morse occupies very little bandwidth and very narrow filters can be used to remove nearby interference. These advantages coupled to the fact that Morse transmitters can be made quite simply, means that even in today's high technology communications scene Morse is still widely used and has many advantages. The International Morse Code is given in Table 2.

Data modes are also widely used. Initially radio teletype or RTTY was the only method of transmitting data. This was characterised by the large noisy teleprinters like those seen on Grandstand giving the football results a number of years ago. Whilst RTTY is still used more people are using computers so that they can use more advanced systems like Packet and Amtor.

One of the main disadvantages of the basic RTTY system was that it was very prone to data errors. The new systems use various forms of error detection to enable the data to be resent when necessary. In addition to this they offer extra facilities to enable the system to be more flexible and convenient to use.

Where Stations are Found

There is a vast number of amateur radio stations around the globe. The USA has the largest population with around half a million. It is also hardly surprising, that Japan has a large number in view of their thriving electronics industry. Although the UK does not have nearly as many, with around 50,000 it is a sizeable amateur population.

With comparatively few exceptions, most countries allow amateur radio operation. Even the old communist bloc countries actively encouraged it, and many Russian stations are regularly heard on the bands.

However, it is not just the large established countries where there is amateur activity. Many small islands and outposts of civilisation have a disproportionate number of radio amateurs. The reason for this is simple – their radios give them a leisure activity enabling them to communicate with the outside world. As a result there are a significant number of stations in places like Antarctica, and other remote places of the world.

In addition to this, groups of radio amateurs often go to countries from where there is little activity. These 'DXpeditions' are very popular causing great interest on the band, particularly if they are in a *rare* country which normally has little radio activity. In this way most countries have at least some amateur radio activity, even if there are very few indigenous Radio Amateurs.

Callsigns

In view of the number of stations around the world some means of identifying them is necessary. In the early days of wireless, callsigns were issued to all stations, and this system has continued today. Each amateur

Abt	About	FM	Frequency Modulation	RX	Receiver
Agn	Again	FONE	Telephony	SA	Say
AM	Amplitude Modulation	GA	Good Afternoon	SIGS	Signals
Ant	Antenna	GB	Goodbye	SRI	Sorry
BCI	Broadcast Receiver Interference	GD	Good (Day)	SSB	Single Sideband
BCNU	Be Seeing You	GE	Good Evening	STN	Station
BFO	Beat Frequency Oscillator	GM	Good Morning	SWL	Short Wave Listener
BK	Break	GN	Good Night	TKS	Thanks
B4	Before	GND	Ground	TNX	Thanks
CFM	Confirm	HBREW	Homebrew (home made)	TU	Thank You
CLD	Called	HI	Laughter	TVI	Television Interference
CONDX	Conditions	HPE	Hope	TX	Transmitter
CPI	Copy	HR	Here	U	You
CQ	A general call indicating a contact is wanted	HV	Have	UR	Your, You Are
CU	See You	HW	How	VY	Very
CUAGN	See You Again	LID	Poor Operator	WID	With
CUD	Could	MOD	Modulation	WKD	Worked
CW	Continuous wave (used to denote a Morse signal)	ND	Nothing Doing	WUD	Would
DE	From	NW	Now	WX	Weather
DX	Long Distance	OB	Old Boy	XCVR	Transceiver
ERE	Here	OM	Old Man	XMTR	Transmitter
ES	And	OP	Operator	XTAL	Crystal
FB	Fine Business	OT	Old Timer	XYL	Wife
FER	For	PA	Power Amplifier	YL	Young Lady
		PSE	Please	Z	GMT – added after the time, e.g. 1600Z is 16·00 GMT
		R	Roger (OK)	73	Best Regards
		RCVD	Received	88	Love and Kisses
		RTTY	Radio Teletype		

Table 4. Commonly used Abbreviations.

radio station is given its own callsign. It consists of two parts: a prefix and the serial letters. It usually has about five or six characters. For example G3YWX is one. The prefix consisting of the part of the callsign up to the last number is important because each country has its own prefix or series of prefixes. This means that by comparing the prefix of the callsign with a list it is possible to identify the country where the station is located. G3 means the station is located in England whilst GM3 would indicate Scotland, and so forth. A list of some of the more common prefixes is given in Table 3. The serial letters following the prefix serve to identify the particular station.

Jargon

Most hobbies have a certain amount of jargon associated with them, and amateur radio is no exception. In fact, it probably has more than most. In the first instance there are all the specialised terms associated with electronics. In addition to this there are codes and abbreviations which have grown up with radio communication and amateur radio since the very early days. Some of the more commonly used ones are shown in Table 4. Most of them were introduced because of the need to communicate quickly and precisely – a very important facet when using Morse. Although the original use may have been for Morse, they are now used in everyday speech contacts as well.

Some words are essentially just abbreviations and they are fairly obvious. Tx is short for transmitter, but others are not so obvious. '73' meaning best regards is one example. Its origin is not totally clear, but one story is that the early telegraph operators used to send two dashes, six dots and then another two dashes. During the course of time this was split in the middle to give the Morse characters '7' and '3'.

In addition to the abbreviations there are a number of specialised codes. The most famous of these is the 'Q' code used by professional and amateur operators. The code is very extensive, covering requirements for shipping and aircraft. However, amateur operators also use the code as well, where it is applicable. In its strict format it is used in a question and answer format as in Table 5. However, its use has widened in amateur circles. As an example a QRP transmitter refers to a low power transmitter, and people may talk about the fact that there is a lot of QRM about when there is plenty of interference.

Another code is used for giving signal reports. Called the RST code, figures are allocated for different levels of signal strength and readability as shown in Table 6. For Morse signals, a further figure is used to report on the tone of the note. Whilst most signals given these days are very good, this has not always been so and a report on the tone of the signal was very important.

Finally the phonetic alphabet is used. The use of phonetics prevents confusion between letters when they are mentioned over the air, see Table 7. It is very easy for confusion between letters like B, T, and V to occur even over telephone lines. With interference and fading over the airwaves it is even easier to mistake letters over a radio link. In view of this the phonetic alphabet is always used when spelling out names or giving callsigns for the first time.

Confirming Contacts

When contacts are made with other stations, especially those many thousands of miles away, or on some remote and interesting island, many people like to have some confirmation of the contact. To do this postcard sized cards are used. Called QSL cards, coming from the Q code meaning I confirm reception, many thousands of these cards are exchanged each year.

The first cards were exchanged back in the early 1920s shortly after the first transatlantic contacts were made. In those days long distance contacts represented a very

Various QSL cards.

QRG	What is my exact frequency? My exact frequency is ....
QRK	What is the readability of my signal? The readability of your signal is ....
QRL	Are you busy? I am busy.
QRM	Is there any (man made) interference? There is (man made) interference.
QRN	Is there any atmospheric noise? There is atmospheric noise.
QRO	Shall I increase power? Increase power.
QRP	Shall I decrease power? Decrease power.
QRQ	Shall I send faster? Send faster.
QRS	Shall I send more slowly? Send more slowly.
QRT	Shall I stop sending? Stop sending.
QRU	Do you have any messages for me? I have no messages for you.
QRV	Are you ready to receive? I am ready to receive.
QRZ	Who is calling me? You are being called by ....
QSK	Can you hear between your signals? i.e. use break in on Morse transmissions. can hear between my signals.
QSL	Can you acknowledge receipt? I can acknowledge receipt.
QSP	Can you relay a message? I can relay a message.
QSY	Shall I change to another frequency? Change to another frequency.
QTH	What is your location? My location is ....

Table 5. 'Q' Codes commonly used by Radio Amateurs

Readability	
R1	Unreadable
2	Barely readable
3	Readable with difficulty
4	Readable with little difficulty
5	Perfectly readable
Strength	
S1	Barely detectable
2	Very weak signals
3	Weak signals
4	Fair signals
5	Fairly good signals
6	Good signals
7	Moderately strong signals
8	Strong signals
9	Very strong signals
Tone	
T1	Extremely rough note
2	Very rough note
3	Rough note
4	Fairly rough note
5	Note modulated with strong ripple
6	Modulated note
7	Near DC note but with smooth ripple
8	Near DC note but with trace of ripple
9	Pure DC note

In addition to the tone figure a further letter can be added. A 'C' is used to indicate key clicks and an 'X' for a transmission which sounds crystal controlled. However, these letters are seldom used these days.

Table 6. RST code for reporting signal quality.

real achievement. Whilst today, long distance contacts are not at the forefront of technology in the same way, there is still an achievement in being able to communicate with someone in a far away country. As a result many people enjoy receiving cards, particularly from long distance stations.

Now, collecting QSL cards has become a very interesting sideline to the hobby. Many of them are very colourful, and some have pictures of the local area. Often hams decorate their shacks with them. Not only does this show the countries which have been contacted, but it also forms a very cheap and interesting form of wallpaper.

Awards

In addition to collecting cards, there are a variety of operating awards which people can work towards. These represent a challenge and give people a goal to achieve. In addition to this the certificates are usually very attractive and are well worth displaying on the wall of the shack alongside the more prestigious QSL cards.

A wide variety of awards are available. The most popular is undoubtedly one called 'DXCC' or DX Century Club. This award is issued by the American Radio Relay League (ARRL) which is the American national amateur radio society, and the award is given for having confirmed contacts with 100 different countries. As there are well in excess of 100 countries it is possible to obtain endorsements

An IARU Region 1 Award from the RSGB.

for contacting further countries. Currently there are over 300 countries which can be contacted, although this number is changing all the time with the rapidly altering political scene, especially in the former communist bloc.

DXCC is by no means the only award. The RSGB offers a variety of interesting and challenging awards. Hardly surprising, a number of them are for contacts with stations in the British Commonwealth. In addition to these awards there is the IARU (International Amateur Radio Union) Region 1 Award for contacting stations in IARU Region 1 member countries. Broadly these are stations in most European countries as well as a few in the Middle East and Africa.

For listeners, the RSGB offers the DX Listeners Century Award for confirmed short wave listener reports from stations in 100 countries.

If this was not enough there is a whole host of interesting and challenging awards issued by radio societies all over the world. Some can be gained from a few months of operation, or possibly even less, whilst others may take many years to complete.

Contests

Like any hobby or interest, there are competitions or contests held at certain times of the year. They generate a large amount of interest and activity. For the large ones the bands come alive and stations can be heard and contacted from places which would not normally have active radio amateurs. For many, the excitement of contesting is very enjoyable. This is coupled to the challenge of trying to win a section of the contest. Contests also give many stations an opportunity to make contacts into new countries. The number of stations on the air from *rare* countries and the quick contacts which are made give the lower power stations a better chance.

Contests are held throughout the year. Most of them are comparatively small with only a very small percentage of the amateur population participating. However, there are about five major contests which receive tremendous support. Of these the largest are the ARRL DX Contest, the WPX Contest and the CQ World-Wide contest and their details are shown in Table 8. For any of these contests the HF bands will be full to overflowing with stations. This naturally means that the levels of interference are high, but despite this it is still possible to make many contacts with new and interesting places.

As the aims of contests are to make as many contacts as possible, transmissions are kept very short. Normally a contact will just consist of a signal report and some form of serial number. This may be the number of contacts which have already been made, or it could be a reference number for the area or zone where the station is located. In one contest the operator's age has to be

A	Alpha
B	Bravo
C	Charlie
D	Delta
E	Echo
F	Foxtrot
G	Golf
H	Hotel
I	India
J	Juliett
K	Kilo
L	Lima
M	Mike
N	November
O	Oscar
P	Papa
Q	Quebec
R	Romeo
S	Sierra
T	Tango
U	Uniform
V	Victor
W	Whiskey
X	X-Ray
Y	Yankee
Z	Zulu

Table 7. Phonetic Alphabet.

Contest	Date	Aim of Contest
ARRL DX Contest (CW)	Third full W/E Mar	Contact stations in USA or Canada
ARRL DX Contest (SSB)	First full W/E Mar	Contact stations in USA or Canada
CQ-Worked Prefixes (WPX) (SSB)	Last full W/E Mar	Contact as many stations as possible. Extra points given for new callsign prefixes contacted
CQ-Worked Prefixes (WPX) (CW)	Last Full W/E May	Contact as many stations as possible. Extra points are given for new callsign prefixes which are contacted
All Asia (CW)	Third full W/E Jun	Contact stations in Asia
IARU HF Championship (SSB/CW)	Second full W/E Jul	Contact as many stations as possible. Extra points for new countries contacted
Worked All Europe-DX (CW)	Second full W/E Aug	Stations outside Europe contact as many European stations as possible
All Asia (SSB)	First full W/E Sep	Contact stations in Asia
Worked All Europe-DX (SSB)	Second full W/E Sep	Stations outside Europe to contact as many European stations as possible
CQ-WorldWide (SSB)	Last full W/E Oct	Contact as many stations in as many countries as possible
CQ-WorldWide (CW)	Last full W/E Nov	Contact as many stations in as many countries as possible

Table 8. Major HF contests in 1994.

given (lady operators are let off the hook and send 00)!

The number of contacts some stations manage to make is phenomenal. In just 48 hours or less for some contests, many stations manage to make well over 2,000 contacts and often more than 3,000 contacts are made. This represents about one station every minute for the whole period of the contest. Naturally these stations have several operators and often they have several sets of equipment running simultaneously on different bands.

Low Power Operation (QRP)

Anyone can enter a contest and enjoy operating in them, but the stations which stand any chance of winning the large ones are characterised by high power and the latest equipment. However, there is a growing body of people who enjoy operating with simple low power equipment. Contacts are often more difficult to make in view of the lower power levels, but there is a great sense of achievement in making them in view of the low power levels involved.

Power levels in the region 1 to 5W are commonly used and special frequencies are reserved on each band for QRP stations as detailed in Table 9. High power stations are asked to leave these spots clear to allow the low power stations to operate with the minimum of interference. With the power levels commonly used, contacts can be made all over the UK on 80 and 40 Metres. On the higher frequency bands it is possible for contacts to be made over distances of 2,000km and more. Longer distances are not uncommon, and stations have even made contact with Australia using power levels of less than 100mW. To do this very good aerials were needed. In fact any low power operation

3·560MHz	10·106MHz	21·060MHz
7·030MHz	14·060MHz	28·060MHz

All frequencies are for Morse (CW) operation.

Table 9. QRP frequencies.

demonstrates the need for a good aerial, although it is still surprising what some people manage to use.

One of the added advantages of QRP operation is that the equipment is usually simpler. Often Morse is used because it is the best mode to use when signal levels are low. This too simplifies the equipment. It means that the average home constructor can build most if not all of his equipment fairly easily. This brings the added sense of achievement that the contacts have been made on equipment they have made themselves.

Equipment

There is an enormous variety of amateur radio equipment on the market today. The equipment ranges from small ancillary items, right up to the latest state of the art microprocessor controlled transceiver, there is plenty of choice.

It is quite easy to spend a fortune on equipment and obtain a really first rate station. Fortunately the average enthusiast does not need to spend nearly as much to set up a perfectly acceptable station. There is plenty of budget price equipment available which is able to operate quite satisfactorily, but does not have all the facilities of the top of the range models. Second-hand equipment can also be considered, although if this route is adopted by a newcomer it is wise to visit a reputable dealer who will be able to advise on what is really needed and provide a warranty with the equipment.

For a anyone wanting a good all round HF receiver, the Lowe HF150 receiver has received some excellent reviews. Covering 30kHz to 30MHz and boasting dual conversion, 60 memories and synchronous detection on AM it is an ideal receiver for any listener. Alternatively it might be worth considering building some equipment. If this is to be done then there are a number of good kits which offer a very good start. These include the Maplin Ranger, a 160 Metre superheterodyne receiver, and a single band direct conversion receiver also from Maplin Electronics. This last set has a choice of any one of the nine HF amateur bands.

Finally for anyone interested in QRP operation, Maplin stock a wide range of equipment. The MFJ 9020 is a single band transceiver with semi break-in and a 4W RF output on the 20 Metre band between 14MHz and 14·075MHz. Then for those wanting to build their own Ramsey Kits there are a choice of transmitter and receiver kits for 20, 40 and 80 Metres.

Aerials

Much emphasis is rightly placed on the equipment in the radio shack itself. However, the aerials should not be forgotten. It is often the aerials that are the vital link in any amateur radio station. A poor aerial will mean that the performance of the whole station will be degraded whatever the equipment is, whilst on the other hand a good aerial will enable a station to perform to its best.

Essentially an end fed wire can be erected as shown in Figure 3. If a tree is to be used for anchoring the far end of the aerial then a pulley arrangement has to be included to take account of the movement of the tree in the wind. Normally this can

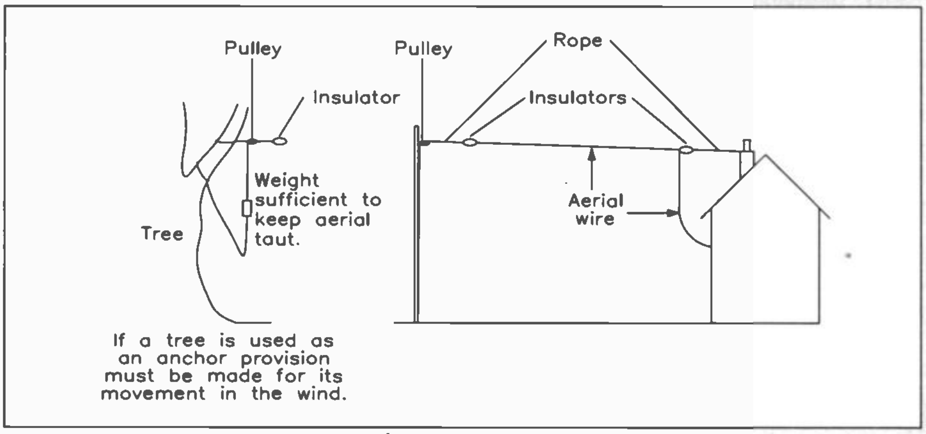


Figure 3. A simple 'end fed wire' aerial.

be accomplished quite easily as shown diagrammatically in Figure 3.

When fitting any aerial great care should be taken to ensure that it cannot cause any injury if it falls. Also the aerial should not be in a position where there is any possibility of it coming into contact with a mains supply. Obviously if the aerial came into contact with the supply then it could have disastrous consequences. People have been killed when their aerials have fallen onto high voltage lines.

For general listening the aerial should be as high and as long as reasonably feasible. It can then be matched or tuned to operate on the correct frequency by the use of an aerial tuning unit (ATU). When transmitting amateurs use end fed wires they usually cut the length so that the aerial is approximately a quarter wavelength on the most used band. Approximate lengths are shown in Table 10 for the lower frequency bands where end fed wires are more commonly used. Even with the length cut in this way an ATU is still needed.

Band	Approximate Length (feet)
160	132
80	66
40	33
30	23
20	16

Table 10. Quarter wave resonant lengths for 'end fed wires'.

Licences

Whilst no licence is required in the UK to listen to amateur transmissions, one is needed to be able to transmit. To gain one of these licences it is necessary to sit an examination, and in some cases a Morse test. Even so, the licences are not difficult to obtain if anyone is determined. In total there are four different types of licence.

The easiest to obtain are the Novice licences which were described in *Electronics* June 1993, Issue 66. These are aimed at encouraging younger members into the hobby. However, there is no age limit on them so anyone is able to apply. They offer limited access to the amateur bands and low power. Even so they are an ideal introduction to the hobby and allow a considerable amount of flexibility.

There are two sorts of Novice licence: the class A and the class B. The class B licence gives access to the bands above 30MHz and requires applicants to complete a training course and then pass an examination based on the course. This is called the Novice Radio Amateurs' Examination (NRAE). To gain access to the HF bands as well, a Morse test of 5 words per minute sending and receiving has to be passed.

To gain full access to all the bands the ordinary class A and class B licences are needed. The class B licence gives access to the full allocations above 30MHz and needs the Radio Amateurs' Examination (RAE) to be passed. The class A licence gives access to all the allocations above and below 30MHz. To obtain this it is necessary to pass both the Radio Amateurs' Examination and a Morse test of 12 words per minute sending and receiving.

For further information about licences as well as the hobby in general the Radio Society of Great Britain should be contacted at their address given below.

Conclusion

Amateur radio is a fascinating hobby which many people enjoy as a life long pastime. There is an enormous amount of variety in the hobby: from construction to operating; and experimenting with aerials to studying propagation. In addition to this many people have made very good friends over the air. All of these combine to give a hobby in which there is always something new and interesting.

Further Reading

For anyone interested in Amateur Radio on the HF bands there is a variety of books stocked by Maplin Electronics which provide excellent reading.

An Introduction to Amateur Radio
by I. D. Poole.
Order Code WS50E – price £3.50.

Setting Up An Amateur Radio Station
by I. D. Poole.
Order Code WT74R – price £3.95.

Amateur Radio Operating Manual
by R. J. Eckersley.
Order Code WS13P – price £6.95.

Practical Wire Antennas
by J. D. Heys.
Order Code WT37S – price £7.95.

HF Antennas for All Locations
by L. A. Moxon.
Order Code WS16S – price £13.50.

Address:
Radio Society of Great Britain (RSGB), Lambda House, Cranborne Road, Potters Bar, Hertfordshire EN6 3JE. Tel: (0707) 659015

AR-1 AM Airband VHF Receiver

1
PROJECT RATING

KIT AVAILABLE (CP17T)
Price £29.95

Note, Photograph shows receiver housed in optional case which is not included in the kit

FEATURES

- Easy to build
- Squelch control
- Varicap diode tuned

Specification of AR-1

DC power supply voltage:	+9V DC
Supply current min to max:	20 to 125mA
Frequency range:	118 to 135MHz
Intermediate Frequency:	10·7MHz
Reception mode:	AM
Rated loudspeaker impedance:	8Ω
Audio output power:	200mW
PCB size:	120 x 102mm

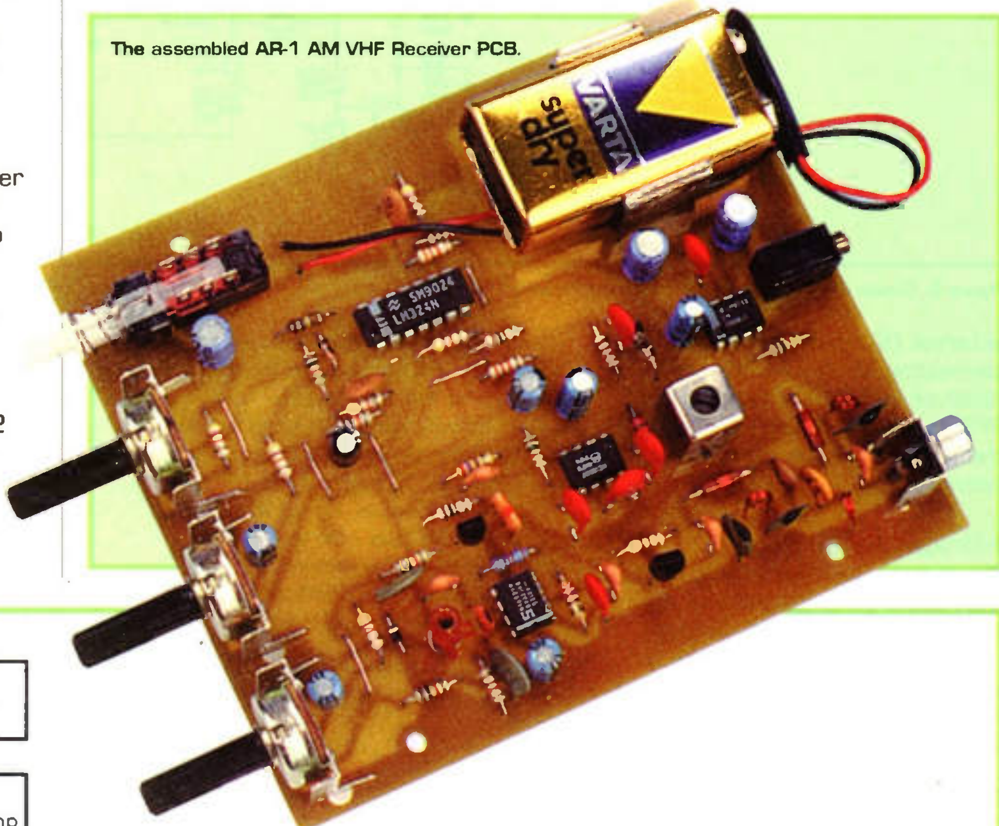
Text by Robin Hall

The reception of aircraft radio transmissions by air enthusiasts has been going on for many years, and a variety of receivers are available for this hobby. The preferred mode of transmission is amplitude modulation (AM) and all receivers and scanning type receivers intended for use on this band must be capable of AM operation. Advancement in microchip technology has made a big impact on receivers as elsewhere. There are some very sophisticated pieces of equipment available, some of which, can scan outside the band, and use other modes, such as frequency modulation (FM), or single sideband (SSB). In fact one does not require an expensive scanning receiver in order to pick-up these transmissions, and a dedicated receiver such as the AR-1 AM Airband VHF Receiver (CP17T) presented here, can be used, either by a hobbyist just starting out, or by an air enthusiast who wants to monitor a local frequency whilst keeping the scanning receiver free to scan the various channels.

Circuit Description

Figure 1 shows the block diagram for the AR-1 and Figure 2 shows the circuit diagram. These diagrams and the following circuit description will assist the reader in understanding the operation of the receiver. In the unlikely event of the receiver failing to operate as expected, this information will also assist fault-finding. The antenna connects to J1 and the RF signal passes, via C1, to a three section LC network. The RF signal is then fed, via C7, to Q1 a 2SC2498 NPN VHF transistor, where it is amplified. The RF signal now passes via C8 to U1, an NE602 mixer oscillator IC. L6 and associated components form the local oscillator, the frequency of which is set at 10·7MHz *higher* than the incoming 118MHz to 136MHz RF signal. D1 is a BB405 or BB505 varicap diode, and is tuned by the voltage taken from R1, a 10k potentiometer. The local oscillator tuning range being over 15MHz. FL1 is a 10·7MHz ceramic filter and the *difference* signal (obtained by mixing the local oscillator and incoming RF signals) passes through this filter, via C16, to Q2 2N3904 an NPN transistor, where it is amplified. The signal then passes to U2, an MC1350 IF amplifier IC; Automatic Gain Control (AGC) is also applied at this stage. L7 is a shielded 10·7MHz IF transformer, from here the signals are passed onto D2, a 1N270, which forms the AM detector. The detected signals are passed to U3, an LM324 quad Op amp IC, which deals with preamplification (U3B), AGC (U3A), squelch operation (U3D), and filtering U3C. The audio signals, after being processed by the various stages of U3, are passed onto U4, which is an LM386 audio power amplifier IC used to drive the

The assembled AR-1 AM VHF Receiver PCB.



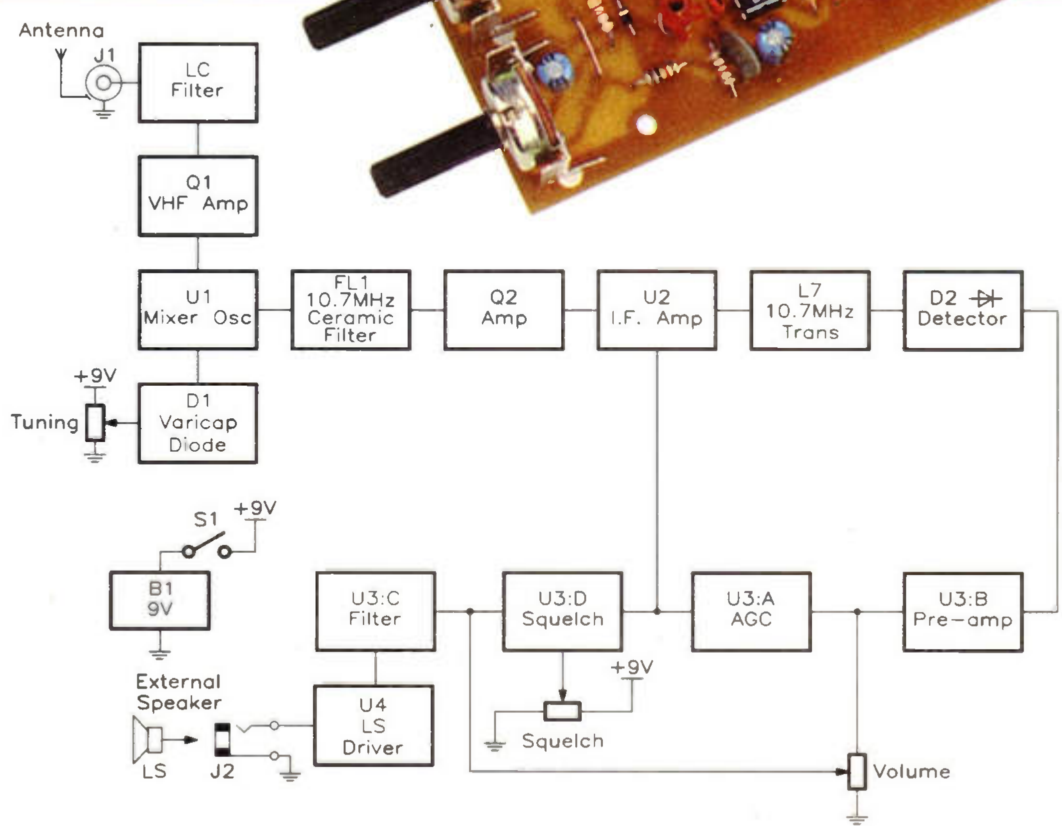


Figure 1. Block diagram of the AR-1 Airband Receiver.

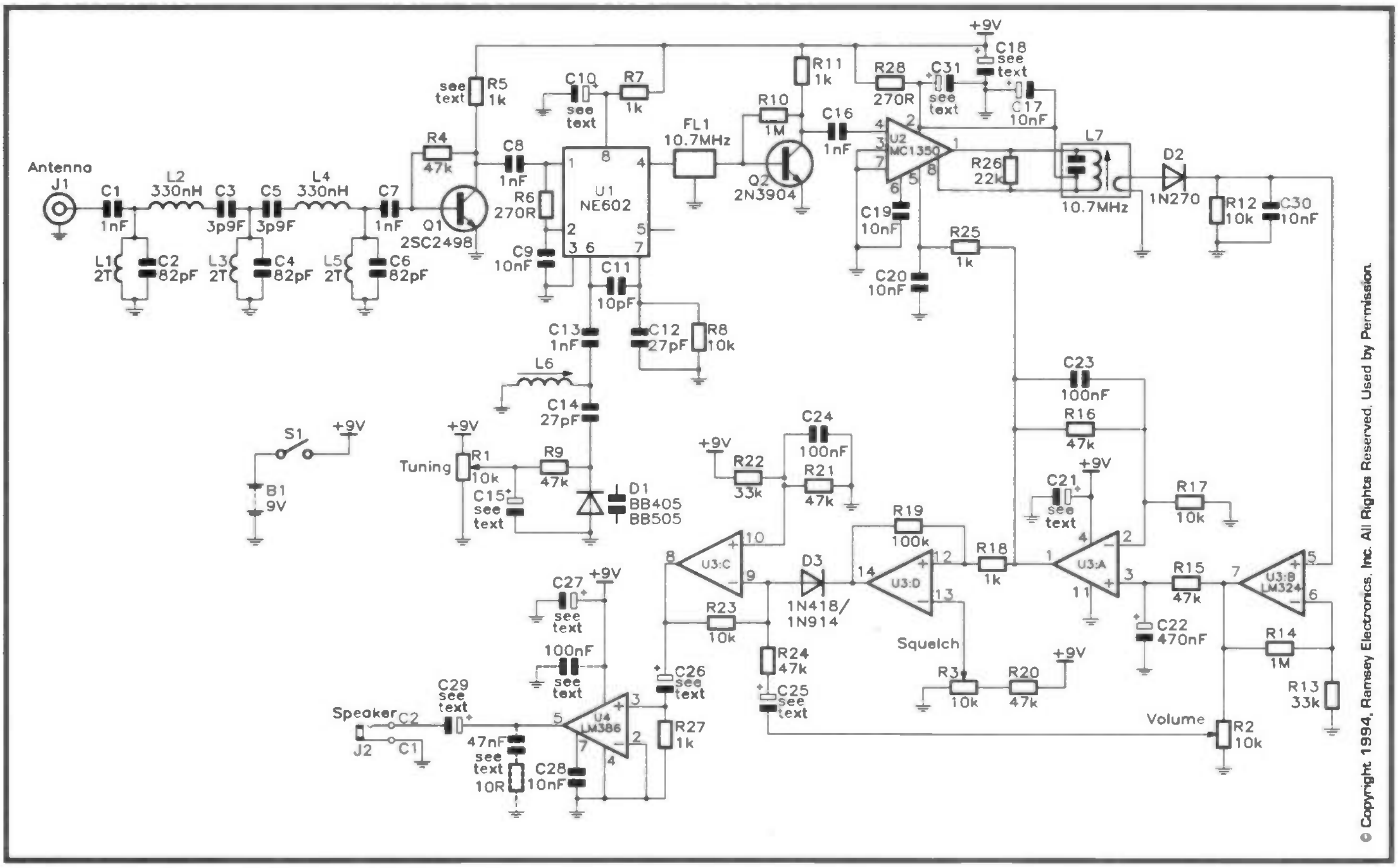


Figure 2. Circuit diagram of the AR-1 Airband Receiver.

external 8Ω loudspeaker via connector J2. Power for the receiver is supplied from a 9V PP3 type battery and is fed to the various stages via resistor networks.

Hints and Tips

There are a number of suggestions that could enhance the use of the receiver preferably before completion. Using IC sockets is generally a good practice but not essential. They are not provided in the kit, and if they were to be used, would require three DIL 8-pin sockets (BL17T), and one DIL 14-pin socket (BL18U).

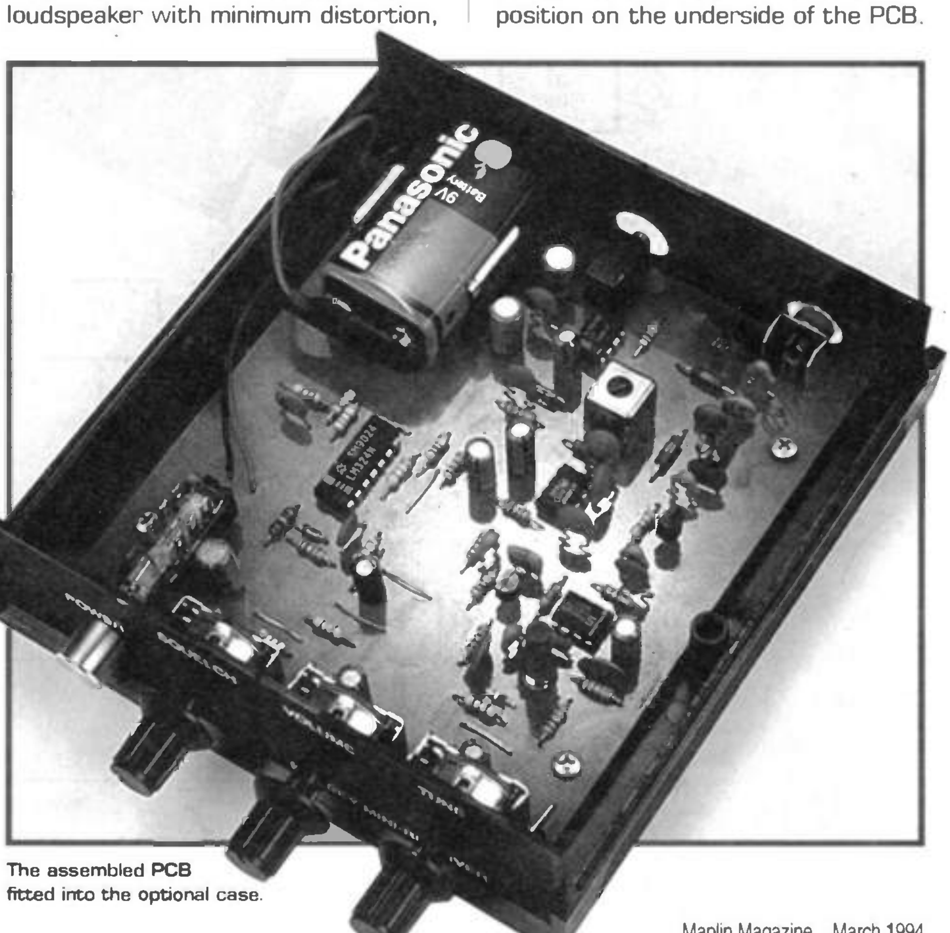
The aerial connecter although adequate for a single dedicated aerial, may not be useful if one wanted to change aerials, especially if there was another aerial available using the BNC or PL259 type of connecter. An adaptor such as the BNC Female to Phono Plug Adaptor (FE88V) would have to be used, or the UHF Female to Phono Plug Adaptor (FE89W). The receiver can operate using an indoor aerial but an outdoor aerial such as a discone aerial is to be recommended, although there are other types of wide band aerials that could be used such as the Scan King Base Aerial (RU06G).

The audio output is via a mono 2·5mm jack socket, and an external 8Ω loudspeaker or 8Ω earpiece with a 2·5mm jack plug is required. Again if one wanted to make a modification then an internal 8Ω loudspeaker could be mounted in the box, but holes would have to be made in the lid for the sound.

It may be found that a new 9V battery tends to make the receiver overload. Changing R5 (1kΩ) for a higher value, up to 4k5Ω, will minimise this effect.

To obtain a maximum audio output level of 200mW using an 8Ω loudspeaker with minimum distortion, a Zobel network comprising a 47nF miniature disc ceramic capacitor in series with a 10Ω resistor wired across the loudspeaker output will be necessary.

Another useful tip is to decouple the (+) supply to U4 with a 100nF disc ceramic capacitor soldered between pin 6 and ground. These components can be soldered in position on the underside of the PCB.



The assembled PCB fitted into the optional case.

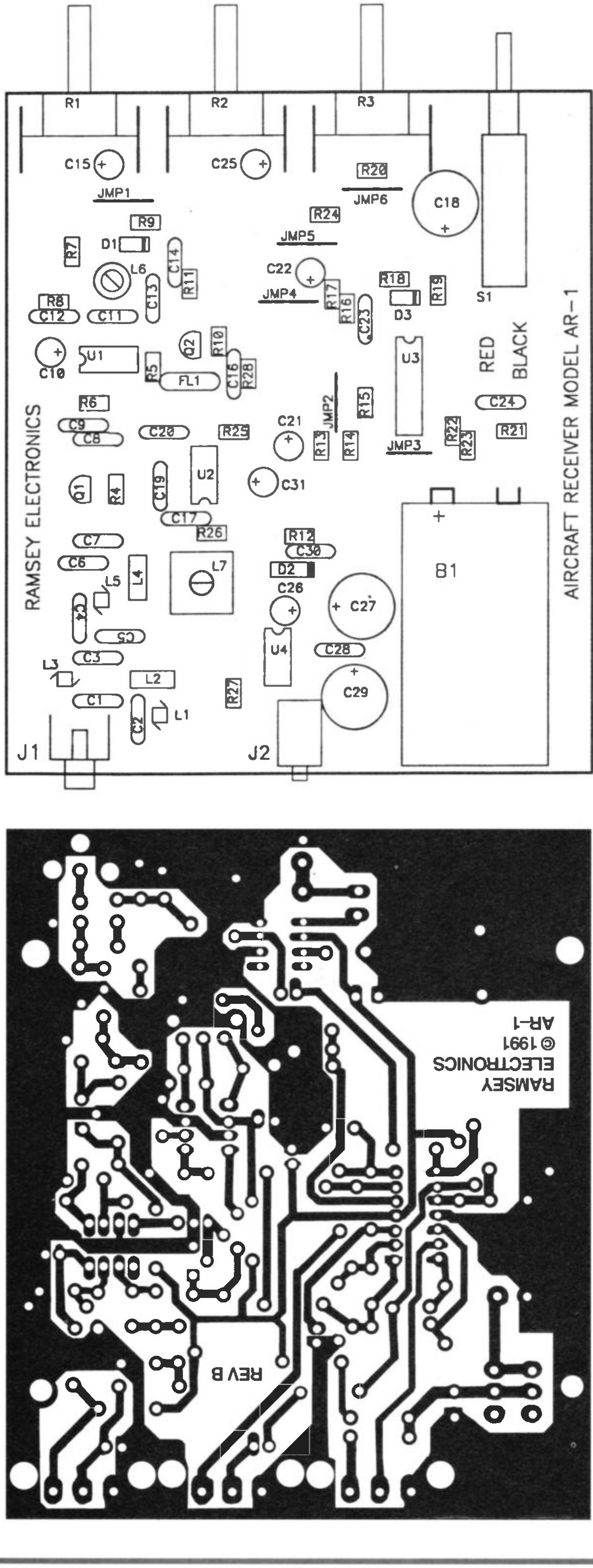


Figure 3. PCB legend and track.

To finish off, there is a case available for the kit (CP20W), which includes knobs, feet and fixing screws, and is quite easy to fit. There are a number of boxes from the Maplin Catalogue that could be made equally suitable as a case with some drilling.

Construction

The AR-1 kit includes all the components required to build the receiver PCB. It is a good idea to sort out and identify the components before soldering them in place. This way one gets to know the values and check to see if any are missing or identify the components before soldering them in position. Figure 3, which shows the PCB legend, will assist PCB assembly. It is best to start-off by fitting and soldering the *larger* components first, such as switches, jack sockets and potentiometers. Note that this is contrary to our normal recommendation and is based on Ramsey's recommended assembly sequence and check list. Next identify and fit the coils and transformers, also the ceramic filter which has three leads. Identify the different types of diodes and fit these on the board making sure that they are orientated correctly. With wire off-cuts, shape and solder in the links. Next fit the resistors, preshaping the leads before fitting and soldering them in place. Identify and fit the capacitors, starting off with the ceramic types and then the electrolytic types which are polarised; these should be correctly orientated on the board, refer to the legend. Identify the ICs and solder them in position, or if sockets are being used, solder these in place instead, making sure that the notch at the top is correctly orientated on the board. The battery clip connector should be soldered in position making sure that the red wire goes to the (+) side as shown on the PCB drawings. Finally with another off-cut of wire, solder in position the PP3 battery holder, do not use too much solder on the holder or the battery will not fit properly.

There are very good instructions supplied with the kit and they show a logical path to follow. If you are new to project building, refer to the Constructors' Guide (order separately as XH79L) for helpful practical advice on how to solder, component identification and the like.

Optional extras not included in the kit, are a pre-drilled case (CP20W), an 8Ω loudspeaker (RU73Q) and 2·5mm jack plug (JK00A), which would have to be fitted instead of the moulded 3·5mm jack plug (or alternatively an 8Ω earpiece (LB23A) with fitted 2·5mm jack plug), 9V PP3 type battery (JY60Q), a suitable aerial, such as a discone (CM09K) and 50Ω coaxial cable (XS31F), length as required, and phono plug (HQ54J).

Setting Up and Operation

Setting up the AR-1 is fairly straightforward and can be achieved with the minimum of test equipment. After making sure that all the components are in their correct positions, and that there are no shorts or whiskers of solder on the board, connect a suitable aerial to the aerial socket, an 8Ω speaker to the 2·5mm audio socket and finally a PP3 type 9V battery to the power connecter and switch on S1.

The desired tuning range is determined by L6 and adjustment must be made using a non-magnetic trimming tool – *not* a screwdriver. The tuning control R1 and the squelch control R3 should be set fully anticlockwise at this stage, and the volume control R2 set midway.

Carefully tuning L6 clockwise, there will be a point where broadcast stations will be heard. The signals may sound slightly distorted as they will be FM instead of AM. Having easily found the broadcast stations in the band 88MHz to 108MHz, L6 should now be rotated gently anticlockwise, depending on where one is located one may hear one of the aircraft beacons which are located in the band 108MHz to 117·9MHz. In the south-east the Detling Beacon (DT) can be heard on 117·3MHz. Rotate L6 further until one just loses the beacon. If all is correct then the tuning range will now be set up starting from the band edge of 118MHz.

If test equipment is available such as a signal generator, frequency counter or another VHF receiver, then the local oscillator must be set up 10·7MHz higher than the required signal, or frequency range.

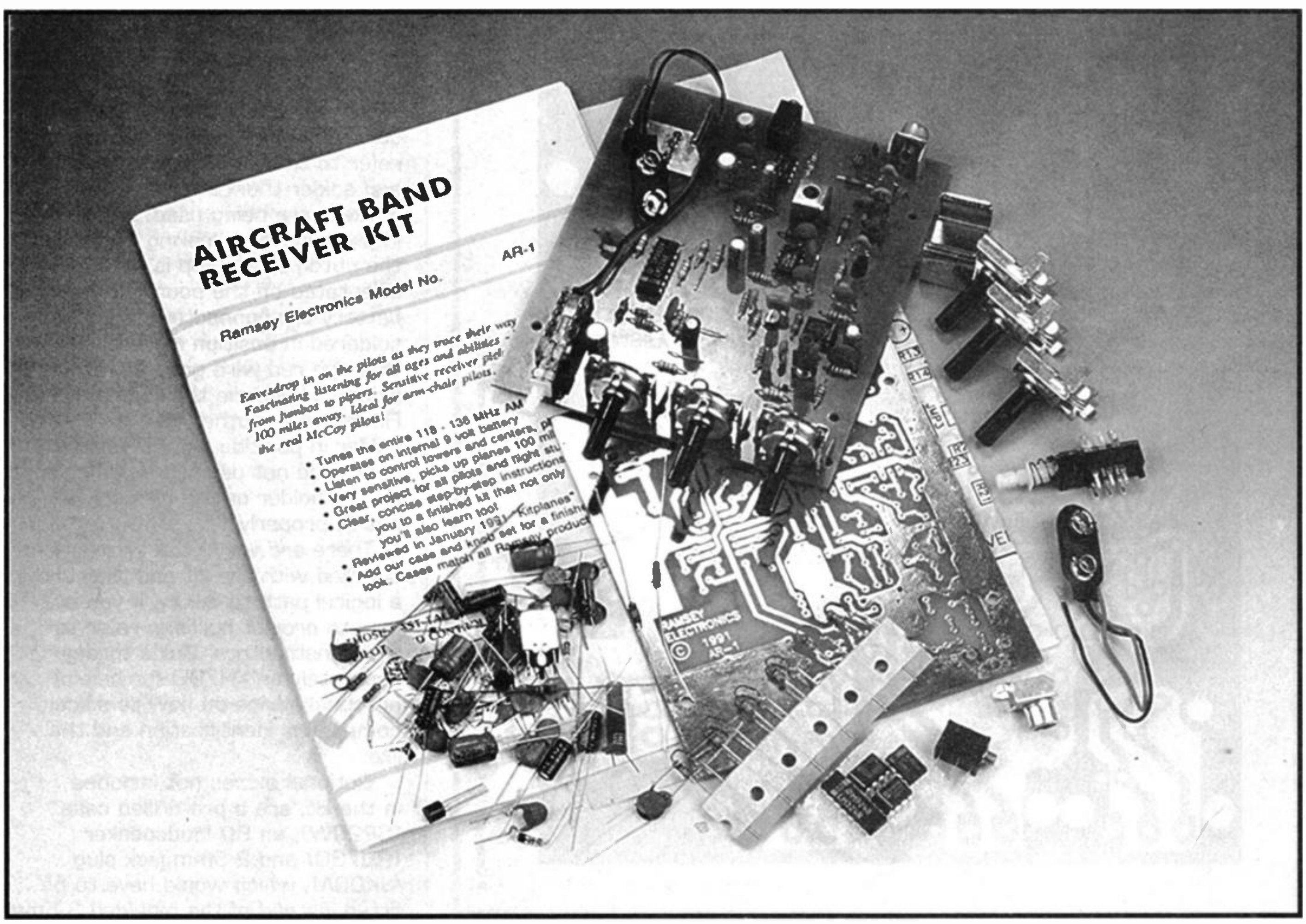
Now using the main tuning control rotate R1 over its range to see if there are any stations. Once stations are found then the IF transformer L7 can be used to peak up the signals. It is better to find a station at the centre of travel of the main tuning control, and peak up on that, rather than on the band edge. It should be noted that radio traffic on the aircraft band is kept fairly short and to the point, and it might take a number of transmissions in order to get this right.

The tuning should be over the desired frequency range of 118MHz to 136MHz. Internationally, the upper band frequency has been set to 137MHz and slight adjustment may have to be made if this is required. To assist in frequency selection one could make up a suitable logging scale and stick it in position, showing where the stations are on the dial.

Additional Information

If you are lucky enough to live near an airport then you should hear the aircraft in contact with tower and approach. Or if not, you may be under one of the many flight paths that cross our skies, and listen to the aircraft in contact with Air Traffic Control (ATC) or the Air Traffic Information Service (ATIS). Whether one can hear the ground based stations or not depends on a number of variables, such as what type of aerial is being used, its gain, the height above ground, and the location and distance from the stations concerned. The operating procedures on the band have been laid out by the International Civil Authority Organisation (ICAO) and adopted in this country by the Civil Aviation Authority (CAA). A standard English vocabulary is used and there is widespread use of phonetics and abbreviations. There are too many to list here but as an example IFR means Instrument Flight Rules, and ILS means Instrument Landing System.

To get really into the hobby, obtaining one of the air charts used by the pilots is a must. There



The kit as supplied and the assembled PCB.

are different types of charts, but generally they all show the airports and airfields plus the frequencies in use. These can be obtained from some airport shops or from flying clubs that provide charts as a service to their members. Another method is to contact directly the many companies or agencies that sell air charts. To keep the cost down a recently outdated or cancelled chart might be obtained, and in most cases a number of these are kept.

Further Reading

There are of course many books to read on civil aviation, such as aircraft recognition and identification, airport locations, runway layouts and approach routes and charts. Other books on all aspects of the hobby such as typical receivers, scanners and suitable aerials, frequency allocations and stations are available. As a start some books that could be useful for the enthusiast are the *Air Band Radio Handbook* (WT83E), *The VHF/UHF Scanning Frequency Guide* (WT70M), and *The Aviation Enthusiasts Handbook* (WT95O).

In previous issues of *Electronics* a series entitled *Electronics in Aviation*, by Chris Yates covered many aspects of aviation, these articles provide a wealth of general information, details of abbreviations in common use and guidance on how to interpret the cryptic exchanges between tower and pilot. The relevant issues of *Electronics* are: Issue 49 January '92 (XA49O), Issue 50 February '92 (XA50E), Issue 51 March '92 (now out of print – photocopies available from Customer Services, Telephone: 0702 552911), Issue 52 April '92 (XA52G), Issue 54 June '92 (XA54J) and Issue 55 July '92 (XA55K).

Contacts

Avmail (Outdated Charts),
9 Hitherwood, Cranleigh,
Surrey GU6 8BN.

British Airways (Aerad),
Customer Services, Aerad House,
P.O. Box 10, Heathrow Airport,
Hounslow, Middlesex TW6 2JA.
Telephone: (081) 562 0795.

Civil Aviation Authority, Printing and Publishing, Greville House,
37 Gratton Road, Cheltenham,
Glos. GL50 2BN.
Telephone: (0242) 35151.

Transair (UK) Ltd., (Jepperson Agents), Units 10 and 11,
The Green Business Centre,
The Causeway, Staines,
Middlesex TW18 3AL.
Telephone: (0784) 66361.

Waters & Stanton Electronics,
22 Main Road, Hockley,
Essex SS5 4JN.
Telephone: (0702) 206835
(Technical Information line).

Acknowledgment

Thanks to Waters and Stanton Electronics of Hockley for supplying the initial AR-1 AM Airband Receiver.

AR-1 AM AIRBAND VHF RECEIVER PARTS LIST

RESISTORS: All 5% Metal Film (Unless specified)		
R1-3	10k Potentiometers	3
R6,28	270Ω	2
R5,7,11,18,25,27	1k	6
R8,12,17,23	10k	4
R26	22k	1
R13,R22	33k 5% Carbon	2
R4,9,15,16,20,21,24	47k	7
R19	100k	1
R10,R14	1M	2

CAPACITORS		
C3,C5	3p9F Metallised Ceramic	2
C11	10pF Metallised Ceramic	1
C12,14	27pF Metallised Ceramic	2
C2,4,6	82pF Metallised Ceramic	3
C1,7,8,13,16	1nF Disc Ceramic	5
C9,17,19,20,28,30	10nF Disc Ceramic	6
C23,24	100nF Disc Ceramic	2
C22	470nF 16V Electrolytic	1
C10,15,21,25,26,31	4·7µF 35V Electrolytic	6*
C18,27,29	100µF 16V Electrolytic	3*

* These values may be changed, i.e. 4·7µF to 10µF and 100µF to 220µF

SEMICONDUCTORS		
Q1	2SC2498	1
Q2	2N3904	1
U1	NE602	1
U2	MC1350	1
U3	LM324	1
U4	LM386	1
D1	BB405/BB505 Varicap Diode	1
D2	1N270 Germanium Diode	1
D3	1N418/1N914 Silicon Diode	1

INDUCTORS AND FILTERS		
L1,3,5	Pre-wound 2 turn wire coils	3
L2,4	330nH Inductor	2
L6	4-turn Iron Dust Core Tuned Coil	1
L7	Shielded 10·7MHz Transformer	1
FL1	10·7MHz Ceramic Filter	1

MISCELLANEOUS		
S1	PCB Mounting Latchswitch DPDT	1
J1	PCB Mounting Phono Socket	1
J2	PCB Mounting Mono 2·5mm Jack Socket	1
	PCB	1
	PP3 Battery Clip Connector	1
	PP3 Battery Mount	1

OPTIONAL (Not in Kit)

RESISTORS:			
	10Ω (See text)	1	(M10R)
R5	4k5 (See text)	1	(M4K5)

CAPACITORS		
47nF (See text)	1	(BX02C)
100nF (See text)	1	(BX03D)

MISCELLANEOUS		
AR-1 Plastic Case (Includes Knobs, Feet and Screws)	1	(CP20W)
Discone Aerial	1	(CM09K)
50Ω Coaxial Cable	As Req.	(XS51F)
Phono Plug	1	(HQ54J)
SP-140 Mobile Speaker 8Ω	1	(RU73Q)
2·5mm Mono Jack Plug	1	(JK00A)
8Ω Magnetic Earpiece	1	(LB23A)
9V PP3 Battery	1	(JY60Q)
DIL Socket 8-pin	3	(BL17T)
DIL Socket 14-pin	1	(BL18U)
Constructors' Guide	1	(XH79L)

The Maplin 'Get-You-Working' Service is available for this project.

The above items (excluding Optional) are available in kit form only.

Order As CP17T (AR-1 AM Airband VHF Receiver) Price £29.95.

Order As CP20W (Case CRR) Price £14.95.

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

Part 2: Box Losses & Amplifier Gains

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

We left Part One in the middle of investigating why one particular system did not perform as we expected. Without tackling the problem of how to measure the actual frequency response, we could tell by comparing the measured impedance magnitude and phase with the values for the theoretical model (Figure 7 in Part One) that there was definitely something wrong.

BOX LOSSES

We can identify three causes of energy loss in the box:

1. Leakage of air through joints, etc.
2. Friction or viscous losses in the vent.
3. Absorption losses.

In his original papers, Neville Thiele gave a correct but limited analysis of box loss effects. In a later paper, Richard Small extended the analysis to consider separately, the effects of the three causes listed above, and to report the experimental result that most of the losses in conventional boxes are due to leakage. This finding was confirmed by considering the effects of the three types of loss on the electrical equivalent circuit (Figure 4 of Part One), which also led to the useful simplification that *all* the losses could be treated as leakage loss in the equivalent circuit. It is, perhaps, obvious that Figure 4 is over-simplified, because the Q of the series-resonant branch, consisting only of C_{mev} and L_{ceb}, is infinite. Leakage loss appears as a resistance R_{el} in series with this branch, as shown in Figure 8, which also shows where the absorption loss R_{eb} and the vent loss R_{ep} would appear. Since the Q of the series-resonant branch is no longer infinite, its value can indicate how much loss is occurring. This Q is the Q of the box compliance resonating with the vent mass, at the frequency f_b which is very nearly equal to f_m as defined below, and is called Q_b. We can find its value from impedance and frequency measurements on the driver in free air and in the box:

$$Q_b = \frac{h}{\alpha} \times \left(\frac{1}{Q_{es}} \times (r_m - 1) - \frac{1}{Q_{ms}} \right)$$

where:

h is the ratio of the square of the frequency f_m at which the impedance is a minimum, to the product of the frequencies f_l and f_h at which the impedance is a local maximum, i.e. $f_m^2/f_l f_h$;

α is the compliance ratio C_{as}/C_{ab}, which is calculated from

$$\alpha = \frac{(f_h^2 - f_b^2) \times (f_b^2 - f_l^2)}{f_h^2 \times f_l^2}$$

Q_{es} is the Q of the driver damped by R_E (the voice-coil resistance R_{vc} plus any external resistance R_{ex}, which we shall ignore), and is calculated from

$$Q_{es} = \frac{Q_{ms}}{r_o - 1}$$

See Part One for the definitions of Q_{ms} and r_o; r_m is the ratio of the measured impedance at f_m to R_E. Strictly speaking, we should apply some small correction factors to Q_{es} and Q_{ms}, and also check that the assumption $f_b = f_m$ is valid. The corrections are necessary because the air load mass on the driver is different from the free-air value when the driver is mounted in the box. This results in the driver resonant frequency in the box, f_{sb}, being lower than the free-air resonant frequency f_s. If the ratio $f_s/f_{sb} = k$, then the corrected values are given by $Q'_{es} = Q_{es}/k$ and $Q'_{ms} = Q_{ms}/k$. To check that f_b is nearly equal to f_m, we evaluate:

$$m = \frac{f_b}{f'_m} = \sqrt{\frac{\alpha \times Q_b^2 - h^2}{\alpha \times Q_b^2 - 1}}$$

where f'_m is the frequency near the impedance minimum at which the phase angle of the impedance is zero. This is the only case where the zero-phase frequency gives more accurate results than the frequency at which the impedance is a maximum or minimum. This ratio is usually very nearly equal to 1, but if it isn't, use mf'_m instead of f_b in the calculations. In our example, $m = 1{\cdot}013$, so no correction of f_b is necessary, but $k = 1{\cdot}03$, which means that it is just about worth correcting the Q values.

Having applied the corrections, the calculated value of Q_b for the example in Part One is 2·2, which is extremely low. It was found that several of the joints between the panels of the box were leaking because very little glue had been used. Also, the driver was mounted on a sub-baffle, and there was a great deal of leakage between this and the front panel of the enclosure. The leaks were found by driving the system at 40Hz, the box resonance frequency f_m, and applying talcum powder to the suspect joints with a small brush. You can see the talc being puffed away by the escaping air (it cleans up with a vacuum cleaner followed by a damp cloth). When these leaks were cured, the measured value of Q_b rose to 6·55, and the impedance measurements were very close to those produced by the circuit analysis program for the equivalent circuit having the same Q_b, assumed to be all due to leaks, as shown in Figure 9.

We did not think that we could get a higher Q in this box, because it was made of chipboard. The design of the panels actually made them very rigid (at the expense of some complication in the construction), and the impedance peak at f_h was not much different from the ideal case (Figure 7 in Part One), suggesting that there was very little absorption loss. But some chipboard may actually be porous, which would result in leakage quite difficult to detect. It was suggested that covering the box with self-adhesive plastic sheet would seal up any such porosity, but this was an unsuitable treatment for the application of this box. In fact, we were getting close to the limits of experimental repeatability and random error, so we stopped looking for leaks and looked at the frequency response (at last!).

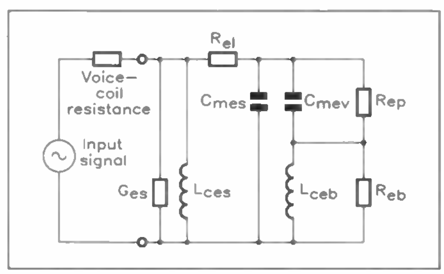


Figure 8. Electrical equivalent circuit of a vented-box system, showing loss resistance.

FREQUENCY RESPONSE MEASURED FROM THE EQUIVALENT CIRCUIT

It was shown by Richard Small that the sound pressure level produced by the system at a distant point is proportional to the time differential of the voltage across the inductor L_{ceb} which represents the box compliance (Figures 4, 6 (Part One) and 8). Now comes a really clever bit. Neville Thiele pointed out, that simply by replacing the generator in Figure 8 by a short-circuit, and introducing a

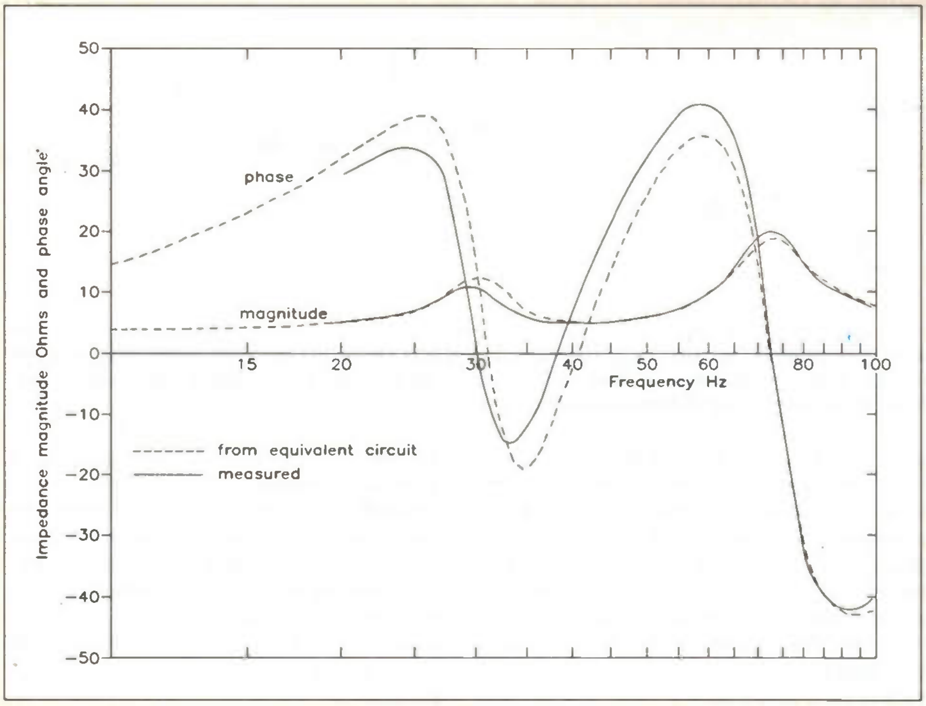


Figure 9. Impedance magnitude and phase angle as functions of frequency for the system with Q_b = 6·55.

accept somewhat less accuracy (but enough to be useful) and make something from Maplin parts for a few pounds. The starting point is the Electret Microphone Insert, Maplin Order Code FS43W (price 95p): you could use an alternative, Order Code QY62S (price £1.68), which may give a flatter high-frequency response, but the signal-to-noise ratio will not be as good. (See pages 117 to 118 of the 1994 Maplin Catalogue for more details on these items.) It is essential to use an omnidirectional microphone, and the less unnecessary material around the insert the better, hence the recommendation to use a bare insert. The FS43W has a response which is 3dB down at 100Hz, and this does not vary much between samples, because it is caused by the RC network comprising the capacitance between the diaphragm and the backplate (which is accurately fixed by the mechanical dimensions), and the bias resistor of the built-in FET head amplifier.

But to measure our sub-woofer, we need a generator in series with C_{mes}, the circuit itself provides the differentiation! The results, from the circuit analysis program, are shown in Figure 10, for the ideal case where there is no loss in the box at all, and for Q_b = 6·55. The finite value of Q causes a loss of response level, with the largest effect occurring around the box resonance frequency f_m. A rather visible characteristic of this defect is the 'flat' which appears on the response curve between about 45Hz and 75Hz.

The fact that effectively the *same* equivalent circuit can predict the impedance (which we can check with electrical measurements) and the frequency response (which we can't) means that we don't really need to tackle the difficult problem of measuring the frequency response at all. However, to dispense with it entirely requires a lot of confidence, especially as there are at least three ways of doing it which are not so difficult as is often imagined.

MEASURING THE FREQUENCY RESPONSE FOR REAL!

Top-class loudspeaker manufacturers spend a great deal of money on an anechoic room (or something even larger, such as an empty room 8m in each direction, which can be used to measure frequency response by digital methods). An anechoic room is a room whose walls have been lined with sound absorbing material, so that there are no reflections (anechoic means no echo). The absorbing material has to cover all six inside surfaces, so some form of grid floor is necessary, and the lining (usually of wedge-shaped foam or mineral fibre slabs, but it is also possible to use strings of cubes) has to be at least 1m thick, so a very large shell gives quite a small working space, and is very costly.

Luckily, it is possible to do useful measurements without such an expensive toy. What is essential is a microphone whose frequency response is flat, or at least known and correctable. You could pay most of £1,000 for a measurement microphone and then more for its necessary amplifier, or you can

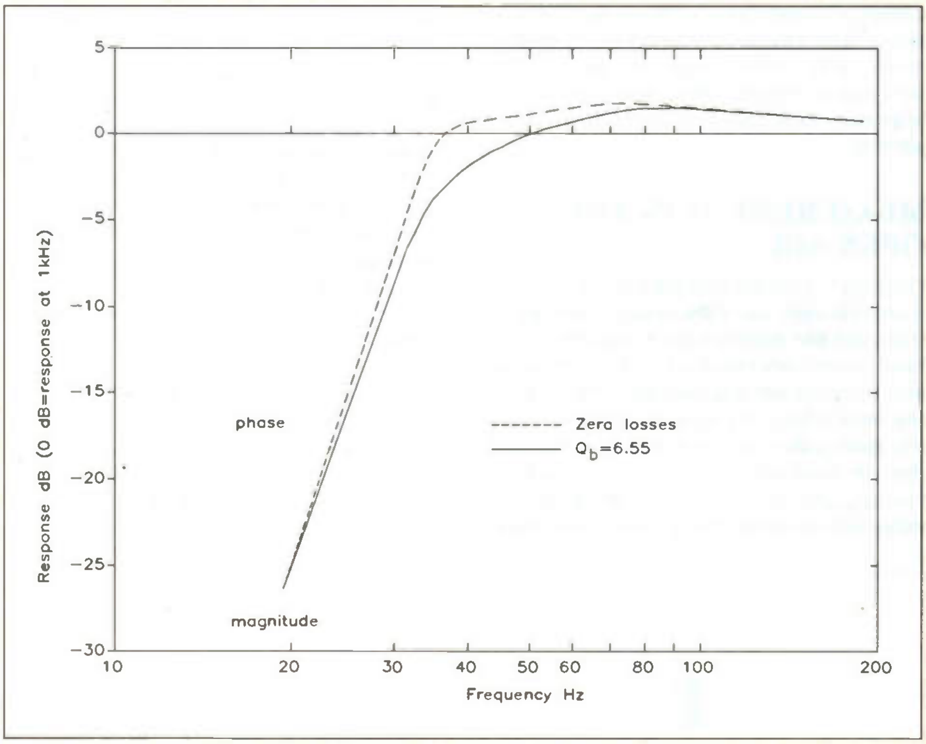


Figure 10. Frequency responses of the equivalent circuits for zero box loss and for Q_b = 6·55.

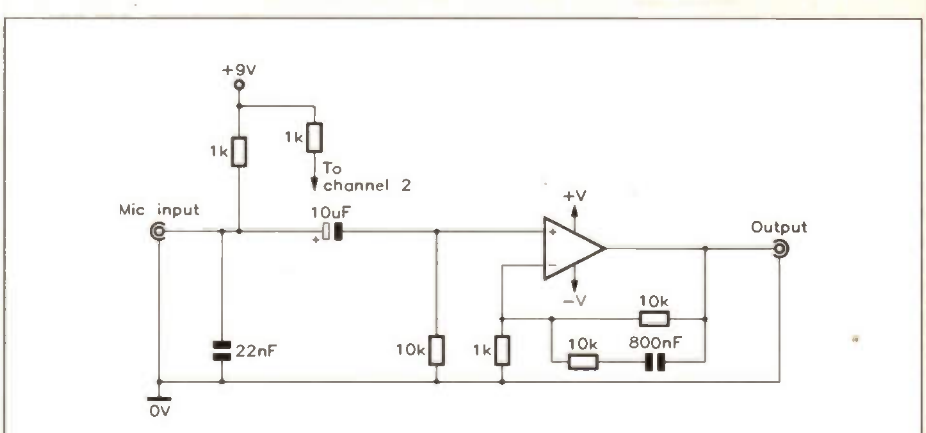


Figure 11. Electret microphone energiser and equaliser. Notes: Op amps can be TL081 or the dual TL082 or equivalent. The supply voltage should be at least ±9V. The 800nF capacitor can be made up from 470nF and 330nF in parallel. The 22nF is present to combat RF interference.

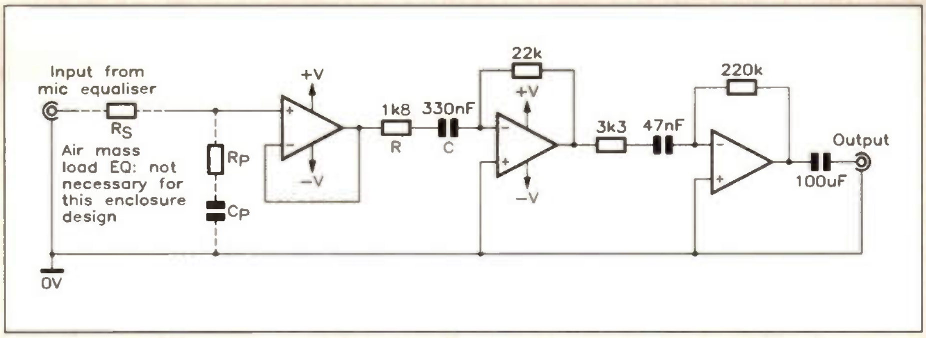


Figure 13. Equaliser for measuring frequency response by Small's method. Notes: The op amps can be TL081 or equivalent. If there is no need for air mass load equalisation, then only R and C need be adjusted for different designs: $CR = \frac{1}{2\pi f_m Q_b}$

response no more than 3dB down at 20Hz. We can quite easily achieve accurate equalisation with a suitable RC network in the microphone amplifier. This amplifier does not need very much gain - because the microphone inserts are sensitive and the sound pressure levels will be quite high (very high in one of the methods we shall be looking at) - if only to overcome background noise, and it can also conveniently provide the supply voltage for the microphone. Because the sound pressure levels will be high, we need a high supply voltage to prevent the FET being driven into clipping overload. The circuit of a suitable amplifier, including the low-frequency equaliser, is shown in Figure 11. You may notice that it has two identical channels, and this is because one of the methods of measuring frequency response requires two microphones when used to measure a vented system. For those who haven't read my articles before, the circuits and text should give enough information for experienced constructors, but do not give full constructional details. The microphone inserts have a peak in the frequency response in the 3kHz to 5kHz range. For the present, we need do nothing about this, because the response of the driver collapses above 2kHz anyway.

MEASUREMENT IN THE OPEN AIR

Contrary to popular rumour, it *is* occasionally warm enough, and calm enough (any wind will ruin the microphone's signal-to-noise ratio), to measure out of doors. You need a flat area with no large obstructions within at least 5m, with a firm, dry surface. If we mounted the loudspeaker and microphone in the way they are shown in photographs of anechoic rooms, about 1m above the ground, reflections from the ground would introduce large errors in the measurements. So we put both the loudspeaker and the microphone *on* the ground, about 1m apart and with the loudspeaker box arranged so that the driver is as close to the ground surface as possible, as shown in Figure 12. Ground reflections then simply create an 'image' driver below the ground level, increasing the measured sound pressure level, but *not* disturbing the frequency response (at the frequencies we are interested in at present). The effect of reflections from obstructions (including you!) can be reduced if you use a function generator to provide the input signal for the amplifier and set it to produce a narrow-band frequency-modulated sine-wave ('warble tone'). A modulation frequency of 10Hz and a deviation of ±5% are suitable. Unless you are prepared to invest quite a bit in test equipment, you will have to do point-by-point measurements, at every one-third octave (see Table 1). This logarithmic spacing gives the best accuracy for the minimum number of measuring frequencies.

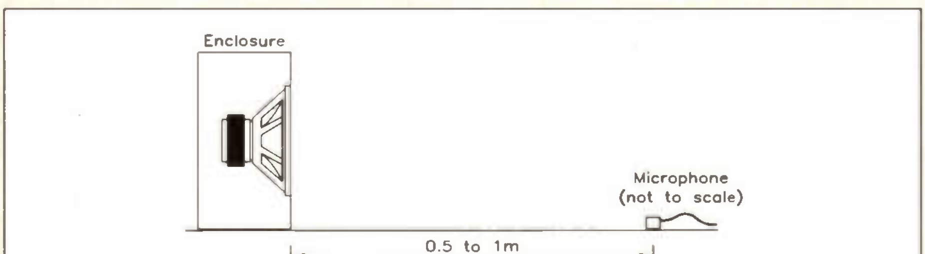


Figure 12. Arrangement for measuring frequency response outdoors. Notes: The enclosure is shown cut away to indicate that the driver should be as close to the surface as possible. The microphone should also rest on the surface. The microphone lead must be screened.

Although outdoor measurements are not usually very convenient and depend very much on having suitable weather conditions, they are the only reasonably reliable way for the home constructor to measure at frequencies above about 200Hz (and for goodness sake, if you intend carrying all this out on the patio, tell the neighbours what to expect). Measuring a full 20Hz to 20kHz range requires a total of 31 measurements, at every ⅓ octave, and this spacing is too wide to get a realistic approximation to the 'sweep frequency' response which the driver manufacturer may publish. It is obviously possible, but time-consuming and perhaps boring, to make more measurements at closely-spaced frequencies, but most people would probably begin to consider some form of automatic measurement.

Numerous special-purpose digital test instruments are now available that will do sweep frequency measurements as well as many other things, but they are costly (like £3,000+!). The cheapest way of doing automatic measurements is probably to use a function generator with a sweep-frequency facility as the signal source, and a computer with an analogue-to-digital voltage converter at the output of the microphone amplifier as the data recorder, although you will have to solve the synchronisation problem in order to know what frequency each sample represents!

20	63
25	80
31·5	100
40	125
50	160

Table 1. Standard ⅓-octave centre frequencies (ISO R266 and BS6840-1). Multiply or divide by powers of 10 for frequencies outside the range shown.

SMALL'S METHOD

Richard Small pointed out in an AES paper that it is possible to derive the frequency response of the free-air sound pressure level of a loudspeaker system from the frequency response of the sound-pressure level *inside* the box. The microphone preamplifier described previously can be used as is for the outdoor measurements, but for internal measurements, the measured values have to be subjected to a three-stage equalisation process. Two of these stages have a response proportional to frequency (differentiators); the first has a time-constant determined by f_b or f_m and Q_b, while the other is simply chosen to prevent the measuring system being swamped by high frequency noise. The second time-constant can conveniently be made 150µs, while the first is given by $1/2\pi f_m Q_b$), and is 608µs in our case.

The third process is a shelf attenuator, like the electret microphone equaliser. This is necessary to account for the fact that, at very low frequencies, air in the immediate vicinity of the driver cone compresses and expands, and thus is part of the box compliance, but at higher frequencies (above about 50Hz in many cases) it moves as a whole and thus acts as a mass load. The overall effect is a reduction in the effective box compliance at higher frequencies. Unfortunately, it is not easy to deduce precisely what this shelf attenuator should do, either in terms of amplitude or frequency. The volume of air which acts in this perverse way is approximately $2{\cdot}2r_d^3$, where r_d is the piston radius of the cone (see Part One), 65mm in our case, and so is 0·61 (litres). This is 2% of the box volume, and gives us the height of the amplitude step. Since it is only 0·2dB, we are likely to be able to ignore the effect! If we did need to allow for it, the step (say it needed to be 3dB) should be in full effect at the frequency where this air mass resonates with the rest of the box compliance, which is approximately $100\sqrt{r_d/V_b}$ *Hz*. (This equation is dimensionally incongruent, so it only works for metric units.) In our case, this frequency is 161Hz. We would make the frequency at which the step is half effective (i.e. 1·5dB down from the response at very low frequencies indeed) at 161/3 = 54Hz approximately.

A circuit for the necessary equalisation to be applied to the output signal from the microphone amplifier is shown in Figure 13. The microphone should be positioned inside the box near its geometrical centre. Because of interactions from the tunnel and the loudspeaker metalwork, it may be necessary to move it to find a position where there are no 'glitches' in the measured response. It is highly desirable to monitor the output waveform from the microphone amplifier on an oscilloscope while using Small's method, because the sound pressure levels can be very high indeed, even with only 1V or so applied to the driver. If any clipping occurs, the input signal voltage to the driver must be reduced. The microphone lead should be brought out through the port, so as to avoid yet another hole in the box as a source of unwanted leakage. An example of the frequency response measured in this way is shown in Figure 14. The method is clearly only useful from about 30Hz (with the microphone equalised to be -3dB at 20Hz) up to about 200Hz, but this is the range in which almost all anechoic rooms are defective. It is, of course, quite possible to equalise the microphone down to lower frequencies, but wind noise becomes an increasing problem (even indoors there are draughts!). It is preferable to use a more complex equaliser, for example a third-order network which is only 0·5dB down at 20Hz but has an 18dB/octave rate of cut-off.

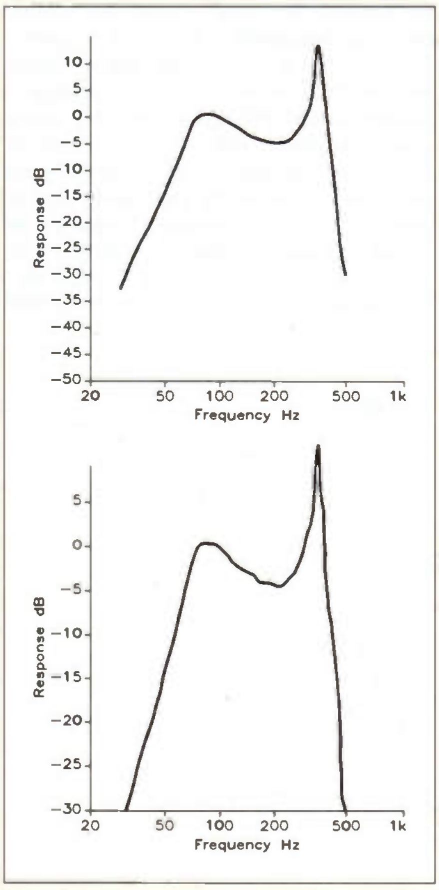


Figure 14. Frequency response of an early version of the sub-woofer measured by Small's method. This box was leaking badly, and the tunnel was too long.

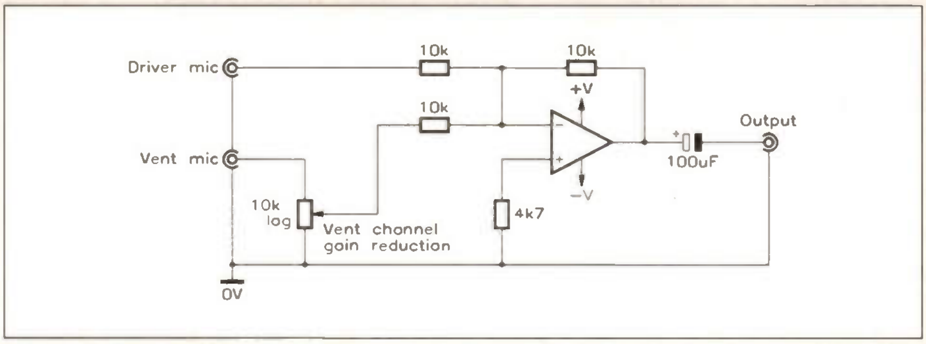


Figure 15. Simple 2-channel mixer for using Keele's method of measuring frequency response of a vented box. Notes: The op amp can be a TL081 or equivalent. This circuit is connected to the outputs of the circuit shown in Figure 11.

KEELE'S METHOD

This method was almost certainly not first used by D. B. (Don) Keele, but he put it on a sound theoretical footing in an AES paper. It has advantages over Small's method in that it does not require a special equaliser, nor a microphone to be put inside the box, and it works up to slightly higher frequencies before the apparent response degenerates into a forest of dips and peaks (Small's method sometimes fails rather below 200Hz, whereas Keele's method often works to somewhat above 200Hz). However, for vented boxes it has the disadvantage that it needs one microphone for the driver and one for the vent (in fact one for *each* vent if you indulge in multiple vents). All it means for us is that we now need the two-channel microphone amplifier which we met in Figure 11, plus the add-on shown in Figure 15, which is a simple two-channel mixer, one of whose inputs has a gain adjustment.

What Don Keele did was to show that, up to a certain frequency, the sound pressure level at a point distant from the driver is proportional to the sound pressure level very close to the cone. This is by no means as obvious as it first appears. For a vented box, the vent acts as a second driver over a limited frequency range, and to allow for the different areas of the driver and the port, we have to reduce the gain of the 'port' microphone channel by:

$$\delta G = 20 \log \frac{d_d}{d_p}$$

where d_d is the effective diameter of the driver and is equal to $2r_d$ (see Part One), or 130mm in our case, and d_p is the port diameter, 69mm for the troublesome box. The calculation gives δG = 5·6dB for this example. To set this, we put both microphones very close together, close in front of the driver, to which we apply a 100Hz signal. With the 'port' mic disconnected, we measure the output from the mixer due to the 'driver' mic. We then disconnect the 'driver' mic, connect the 'port' mic and set the gain control so that the output due to this mic is 5·6dB below (or 0·52 times) the first value. We then transfer the 'port' mic to be just at the port opening, while the 'driver' mic is close to, but not touching, the driver cone. Then, of course, we apply signals at the frequencies listed in Table 1 to the driver, making sure that the applied voltage is the same for each frequency (preferably 1V for 4Ω drivers or 2V for 8Ω units). The output voltage of the mixer circuit represents the frequency response of the loudspeaker system. An example of the response measured in this way is given in Figure 16.

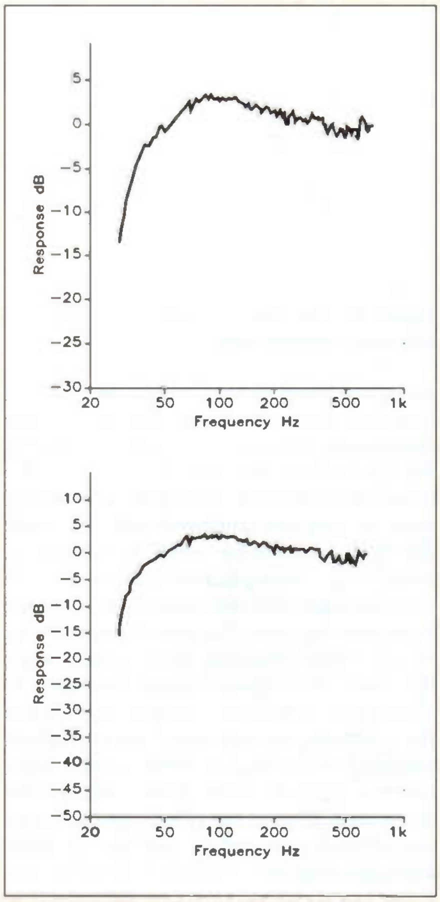


Figure 16. Frequency response of a much later version of the sub-woofer, measured by Keele's method.

CROSSOVERS FOR SUB-WOOFERS

We saw in Part One that crossovers are another sort of filter, and we have all sorts of filters to choose from. However, we run into practical limitations in several ways, as we shall immediately see.

If you are going to use either one or two completed units to cover the sub-woofer frequency range, in conjunction with two main loudspeakers for stereo, the crossover frequency should be in the range 150Hz to 250Hz. For these examples, we shall take the middle value of 200Hz. Because the response of the sub-woofer is well-maintained up to 2kHz, we must 'turn it off' above 200Hz otherwise it would compromise the stereo image produced by the main loudspeakers. We want the signals below 200Hz not to go to the main units, where they will tend to cause distortion, and certainly won't be properly reproduced. The simplest way to do this would appear to be to connect an inductor in series with the sub-woofer and a

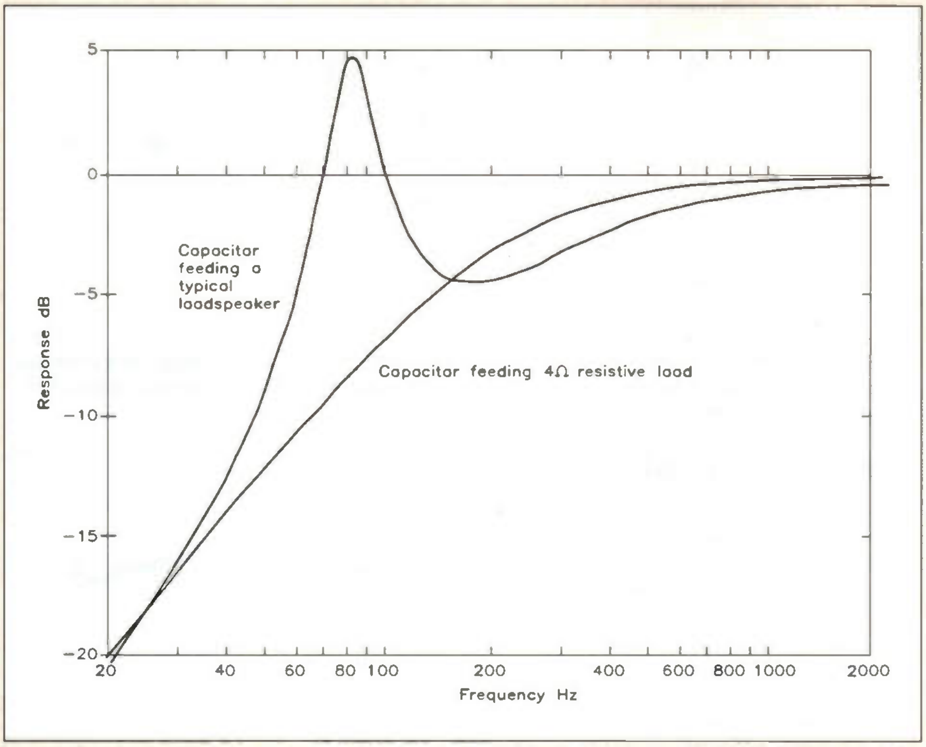


Figure 17. The disastrous effect of trying to use a simple passive crossover capacitor with a full-range loudspeaker.

capacitor in series with the main unit, but this does not work at all, and anyway the component values required are very difficult for the home-constructor. In our case, the inductor has to be 3·4mH, and its resistance must be very low compared with 4Ω, while the capacitor must be 185µF. At this level of precision, non-polarised electrolytic capacitors are right out, because of their wide tolerances on value. But even if you put a lot of effort into obtaining these components, the result will be disappointing, and Figure 17 shows why. At the bass resonant frequency of the main unit, its impedance rises to a peak, assumed to be 44Ω at 100Hz in this case, quite a typical value. This destroys the attenuating effect of the 185µF capacitor in no uncertain terms, and in fact the capacitor resonates with the resultant inductance due to the loudspeaker compliance and mass (L_{ces} and C_{mes} in Figure 4, Part One) to produce a peak of 5dB at 80Hz! Compare this with the smooth attenuation (Figure 17) we would expect if the loudspeaker had a purely resistive impedance. The input impedance of the capacitor and loudspeaker series circuit also leaps about at low frequencies, and this is unkind to the amplifier.

It is much more sensible to use separate amplifiers for the sub-woofer and the stereo pair, and this also makes it much easier, not only to combine the low bass of the stereo signals into a single signal if you are satisfied with only one sub-woofer system, but also to adjust the relative gains of the amplifiers so that the sound levels from the systems balance properly. Without this facility, you can only balance the levels by choosing driver units of matching sensitivities before you begin the whole design process, which can be quite difficult. Once we decide to use separate amplifiers, the crossover circuits can be made with op-amps, with capacitors and resistors of values that are easy to come by, and much more sophisticated crossover filters become practicable.

SUB-WOOFERS AS LOUDSPEAKER STANDS

If you make one sub-woofer for each channel, and make the enclosures rather tall and narrow, they can act as excellent stands for the main loudspeakers. This opens up an interesting possibility, if the main loudspeakers are good down to 100Hz. In this case (ONLY!), one can use very simple complementary first-order (R/C and C/R) filters for the crossover. These networks have every desirable characteristic of an ideal crossover except one: their 6dB/octave rate of cut-off is normally much too low. It requires both of the systems to work well for at least an octave into the cut-off range. But that is exactly the case we have here: the sub-woofers are certainly OK up to 400Hz. Also, because the sub-woofers are close to the main loudspeakers, their radiation above 200Hz does not damage the stereo image. A suitable circuit is shown in Figure 18. By splitting the frequency range between amplifiers, the individual power ratings can be quite modest, and the 20W GE13P (PCB only) or even 15W YQ43W (complete kit) will give impressive sound levels.

SINGLE-BOX SUB-WOOFER WITH TWO DRIVERS

In this case, you put the two 25 litre boxes together to make one enclosure (as in the original 'Range Rover' design mentioned in Part One). Such an enclosure can be disguised as a (fully-functional) seat in the home, as well as in a dual-purpose vehicle. However, it is not permissible for the sub-woofers to radiate significantly above 200Hz, or perhaps 150Hz, because of the resultant confusion of the stereo image. We need a faster rate of cut-off in the crossover networks, and the third-order Butterworth filter is often used. Butterworth filters are 'maximally flat', i.e. the frequency response has a flat section and a sloping section; there are no peaks. You could get a higher initial rate of cut-off by using Chebyshev filters with, say 0·5dB of 'ripple' (frequency response waviness) in the pass-band, but it probably isn't worthwhile. Circuits for a 200Hz crossover frequency are shown in Figure 19. The component values come from a handbook on filter design; they are not very easy to calculate from first

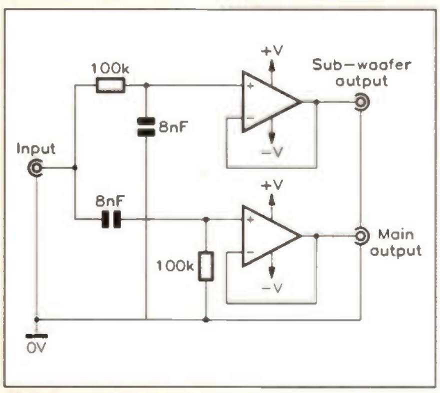


Figure 18. Active crossover with sub-woofers acting as loudspeaker stands for the main stereo pair.

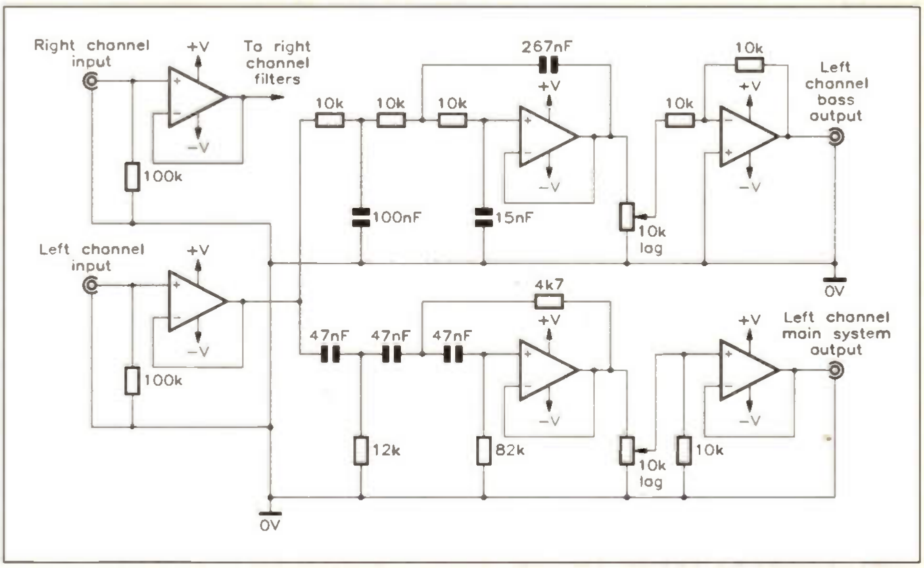


Figure 19. Third order crossover filter pair for 200Hz crossover frequency. The 267nF capacitor can be made from 220nF and 47nF in parallel. The op amps can be NE5532 or similar (but not TL082 or equivalent).

principles. For a 150Hz crossover frequency, the resistor values in the low-pass filter, and the capacitor values in the high-pass filter, are all divided by 150/200 = 0·75. Note that the signal polarity delivered to the sub-woofer is *inverted*. This is because the third-order crossover introduces rather a lot of phase-difference between its outputs, which is minimised if one output is inverted, thus subtracting 180° from the phase difference.

SINGLE-BOX SUB-WOOFER WITH ONE DRIVER

This arrangement is similar to the two-driver case, in that the third-order crossover network is essential, but it also requires the simple

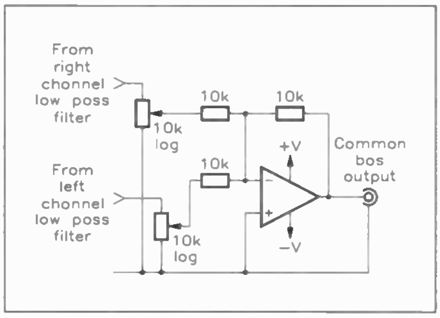


Figure 20. Simple mixer for deriving a common bass signal for a sub-woofer containing a single driver. This circuit replaces the inverting stage at the top right of Figure 19.

mixer circuit shown in Figure 20 to derive the common bass channel from the two stereo signals. For classical and MOR music, this system gives no surprises, but some current recordings have artificially different bass sounds in the two channels. This is easy to achieve with DI (Direct Inject) boxes or by multi-tracking, but would not (or should not) occur on an undoctored live recording. So some records may sound different through this system, but they will certainly have stronger and more accurate bass than without the sub-woofer.

NEXT TIME

The response of the Maplin XP25C driver is quite extended, and it is quite small. These properties are ideal for a two-way full-range system, and we shall see in Part Three how this can be done, with either passive or active crossover networks.

What's On?

VHF Convention

Last year's Radio Society of Great Britain (RSGB) National VHF Convention at Sandown Park in Surrey, attracted over 2,500 visitors. This year they hope for even more.

Featuring specialist RSGB groups, trade stands and an extensive afternoon lecture programme, the show will have appeal to all VHF enthusiasts from bargain hunters to serious trackers. Gear on offer will range from small components for simple projects, through antennas and low-loss feeder systems for ambitious systems, to expensive transceivers.

The value of events such as the RSGB VHF Convention lies not only in the wide array organised displays, but also in the opportunity for like minded devotees to meet and share ideas. This can be particularly appealing if you are a relative newcomer to the field.

Of course another way to learn is by attending the lecture programme. This year's lectures include; 'An Update on the New Amateur Radio Satellites' by Ron Broadbent (G3AAJ); 'Spread Spectrum Techniques' by James Vincent (G1PVZ); '10GHz Come of Age' by Mike Walters (G3JVL) as well as various discussions on Microwave.

The one day exhibition and lecture programme, will take place on 20th February, and is open to all.

Opening Times: 10.30am to 5.30pm. *Prices:* Adults £3.00, over 65 £1.50, under 18 £1.00, under 14 Free. *Venue:* Sandown Exhibition Centre, Esher, Surrey. Contact: Geoff Stone (G3FZL) Tel: (081) 699 6940.

Freezing Point

Responding to worldwide concern about ozone depletion by Chlorofluorocarbons (CFCs) in the 1980s, ICI have developed a suitable replacement which does not damage the ozone layer. The development of the production technology for the new chemical won the 1993 MacRobert Award (a leading national engineering prize for technological innovation) and features in a special display at the Science Museum until March.

Although ozone benign KLEA 134a had been identified in the 1970s as a potential CFC replacement in refrigeration and air-conditioning, no commercial manufacturing process was available.

In 1987 ICI assembled a team of engineers and chemists to develop commercial production for the refrigerant. In 1990 the world's first commercial plant for HFC 134a was opened in Runcorn, Cheshire, followed in 1992 by a plant in the USA and a further plant in Japan last year. In the exhibition, visitors can operate a display that illustrates the construction of these commercial plants.

MacRobert Award winners have been displayed at the Science Museum since 1988. Previous winners displays include BP's hydraulic fracturing techniques, the Quantel Paintbox, the SERC James Clerk Maxwell telescope, the new Rover Metro, and Nightbird, an airborne infra-red night vision system from the Defence Research Agency.

Opening Times: 10.00am to 6.00pm Monday to Saturday, 11.00am to 6.00pm Sunday *Prices:* Adults £4.00, Children and Concessions £2.10. *Time Required:* A full day to see all exhibitions. Contact: The Science Museum, Tel: (071) 938 8000.

Electronic Renewal

Recycling '94 is set to build on its reputation as Europe's premier showcase for recycling equipment, technologies and services.

Exhibitors from around the world, will be displaying a range of recycling solutions from electronics, metals and textiles to plastics, paper and chemical, reflecting the needs of local authorities, waste management companies, processors, manufacturers and retailers.

The UK's response to the increasing importance of recycling in the electronics industry is the establishment of the Industry Council for Electronic Recycling (ICER), with founder members including Boots, IBM and ICL.

'Designing for Recycling' is now being incorporated into the development of personal computers such as the recently launched Virgin 'Green' machine and the ICL D4/25, both constructed from recyclable materials.

Recycling '94 runs from 27th February to 1st March, at the National Exhibition Centre in Birmingham. Contact: Recycling '94 Tel: (081) 660 8008.

DIARY DATES

Every possible effort has been made to ensure that information presented here is correct prior to publication. To avoid disappointment due to late changes or amendments please contact event organisations to confirm details.

29 January to 2 February. British International Toy & Hobby Fair, Earl's Court 2. Contact: (071) 701 7127.

30 January to 2 February. European Lightshow, Earl's Court, London. Contact: (0952) 290905.

1 February. Maplin Shop Sale Starts. Contact: (0702) 552911 for details of your nearest shop.

8 to 10 February. Integrated Communications '94 – The ISDN User Show, Wembley, London. Contact: (0733) 394304.

9 to 10 February. Instrumentation, Crest Hotel, Bristol. Contact: (0822) 614671.

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

15 to 17 February. Smart Card '94, Wembley, London. Contact: (0733) 394304.

16 February. High Definition Television Conference, Financial Times Conference Organisation, London. Contact: (071) 251 9321.

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

22 to 25 February. The Windows Show 1994, Olympia Grand Hall & Conference Centre. Contact: (0256) 381456.

1 March. Hardware, Sudbury and District Radio Amateurs, Wells Hall Old School, Great Cornard. Contact: (0787) 313212.

1 to 3 March. Enterprise Computing 1994, Earls Court 2. Contact: (081) 742 2828.

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

8 to 10 March. CADCAM, National Exhibition Centre, Birmingham. Contact: (071) 404 4884.

9 to 10 March. Instrumentation, Exhibition Centre, Harrogate. Contact: (0822) 614671.

21 to 24 March. Control '94 Conference, Institution of Electrical Engineers, University of Warwick, Warwick. Contact: (071) 240 1871.

22 to 24 March. Nepcon Electronics, National Exhibition Centre, Birmingham. Contact: (081) 948 9900.

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

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

Part 5

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

POWER ELECTRONICS IN THEORY & PRACTICE

The previous article in this series concentrated on the basic principles of relaxation oscillators using the unijunction transistor (UJT) and the programmable unijunction transistor (PUT). Some idea of the design procedure was also given. In this article, we shall look at a few of the great variety of circuits that can be devised using the above devices. Some circuits I have tested, some I haven't. Either way, they offer scope to the experimenter to investigate and modify where appropriate. Some of the devices used may need to be replaced by more modern or more readily accessible types. Provided that the basic operation of each circuit is clearly understood, this should provide nothing more frustrating than a satisfying challenge and the ultimate reward of a functioning circuit at the end.

To start this brief review of UJT and PUT applications we revert to the basic PUT oscillator whose circuit and brief description were given in the previous article. The circuit diagram is repeated here in Figure 1a.

THE BASIC PUT OSCILLATOR

The circuit is essentially very simple. In addition to the PUT itself, two components are used for timing (R1 & C1), two are used to determine the intrinsic stand-off ratio $\acute{\eta}$ (R3 & R4) and one component (R2) is used as the load. The circuit actually comes from a Texas Application Report (CA 169) dated 1972, entitled succinctly *The Programmable Unijunction Transistor*. Not unreasonably, this report concentrates upon the devices then available from Texas Instruments Ltd, although no actual PUT type was specified for this particular circuit, even though component values were given. In all probability either the A7T6027 or A7T6028 was intended. The matter is academic; we have to use what we can readily lay our hands on, namely the BRY39. The crux of the matter is that this circuit won't work without modification using the latter device.

With such a simple circuit there isn't much to modify. The timing components R1 & C2 determine the repetition frequency. The load resistor R2, together with capacitor C1, determine the duration of the output pulse. That only leaves the divider resistors R3 & R4 as the remaining components on which we can ring the changes. As stated above, they determine the value of $\acute{\eta}$ which, with the equal values given (both 100k), has a value of 0·5. It can't really be their *relative* values that are the problem; it must therefore be their *absolute* values. The fact that they are each 100k is more likely to mean their values must be reduced rather than increased. On this note of wisdom I made a tenfold reduction in their values to 10k and, *voila*, the circuit sprang into life. This was with the design supply voltage of +2V. Increasing the supply voltage was only possible up to about +3·5V, when the circuit stopped oscillating, although the oscillations were perfectly stable up to this point. Obviously the PUT circuit is quite voltage-sensitive. Bear in mind that the circuit is not driving a load as yet, which may have a further bearing on circuit behaviour.

The output of the circuit, seen across load resistor R2, consists of a train of short, sharp positive pulses with an amplitude of about 0·6V. Expanded up on a faster setting of the time base, each pulse is seen to have an almost vertical leading edge (where the PUT switches regenerate extremely quickly) followed by an exponential tail, where

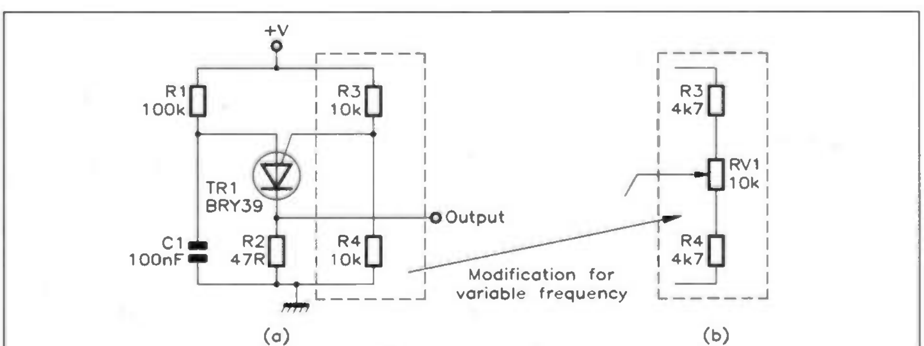


Figure 1. (a) The basic PUT oscillator; (b) modification for variable frequency.

the timing capacitor C1 discharges through the anode-cathode resistance in series with the load resistor R2.

The frequency of the pulses is given by the formula which appeared in Part 4, Issue 74 and is repeated here as follows, with the appropriate component references inserted.

$$\frac{1}{f} = T = R_1C_1 2{\cdot}3\log_{10}\left(\frac{R3+R4}{R4}\right)$$

Inserting the component values from the circuit leads to:

$$T = 10^5 \times 10^{-7} \times 2{\cdot}3\log_{10}2$$

From which:

$$T = 6{\cdot}92 \times 10^{-3}$$

And:

$$f = \frac{1}{6{\cdot}92 \times 10^{-3}}$$

$$= 144{\cdot}5\text{Hz}$$

The actual frequency obtained from a working circuit was 109Hz, thus showing a substantial error even allowing for component tolerances. This need not be viewed with any great alarm. Had we wished to design a PUT oscillator with a repetition frequency of 144Hz, this design would have put us close enough for us to be able to say, 'reducing the value of R1 to, say, 82k from its initial value of 100k will adjust the frequency much closer to the desired value'. By proportion, the new frequency will be equal to 109 x 100÷ 82, which is 133Hz. The obvious way of getting nearer to the required frequency is to make part of R1 variable. In this case, a 68k fixed resistor in series with a 22k preset will permit the frequency to be set precisely and easily.

It is also possible to vary the intrinsic stand-off ratio and this affects performance in two ways. It causes variation in frequency to occur and the amplitude of the output pulses is also affected. This can be done as shown in Figure 1b by using a variable resistor with equal padding resistors at each end. The variable section was chosen at 10k with padding resistors of 4·7k on either side. The total resistance is virtually the same as the original sum of R3 & R4. A useful frequency variation of rather more than 10:1 is obtainable in this way. With the wiper at the top end of its travel, the frequency was 27Hz. Turning the wiper down to the other end gave a frequency of 294Hz only a few degrees before the end of travel, after which the circuit stopped oscillating. There was a 2:1 change in pulse amplitude between the top and bottom ends of the potentiometer. One further effect was noticed. With the wiper at the top end of the potentiometer, the supply voltage could be increased to +5V before oscillations stopped. Obviously not only do the absolute values of the divider resistors control the voltage sensitivity of the circuit but their relative values do also.

A PUT OSCILLATOR CIRCUIT APPLICATION

A version of the PUT circuit shown in Figure 2 also appeared in the last article. This has been modified to give it a more specific function which some readers might find useful. Essentially the circuit has a timing function in which an SCR is triggered by the output of the PUT after a specific time interval has elapsed. Power is then applied to the load, whatever the nature of that is. What I have chosen to do here is to make the load a relay coil, one set of contacts of the latter then latching the circuit in the ON state. Other contact sets on the same relay can then be used for switching a variety of required functions after the timed interval has elapsed. The specified PUT is the Texas type A7T6028 so some development will almost certainly be needed in order to utilise the BRY39 instead.

Circuit operation is initiated by holding down the normally open push-button switch S1. This must be held down until the circuit times out and the relay pulls in. At this time, the push-button contacts are bridged by a relay set and the push-button can be released. Once the SCR has been triggered into the conduction state, it can only revert to a non-conducting condition if its anode current is momentarily reduced below the holding value. The easiest way of doing this manually is to insert a second, normally closed, push-button switch S2 in series with the SCR cathode circuit. The delay time equals the time taken for the capacitor C1 to charge up to the peak point voltage V_P. The time constant of this particular circuit is (2µF x 10M), which equals 20 seconds. Shorter or longer times may conveniently be obtained by reducing or increasing the value of C1.

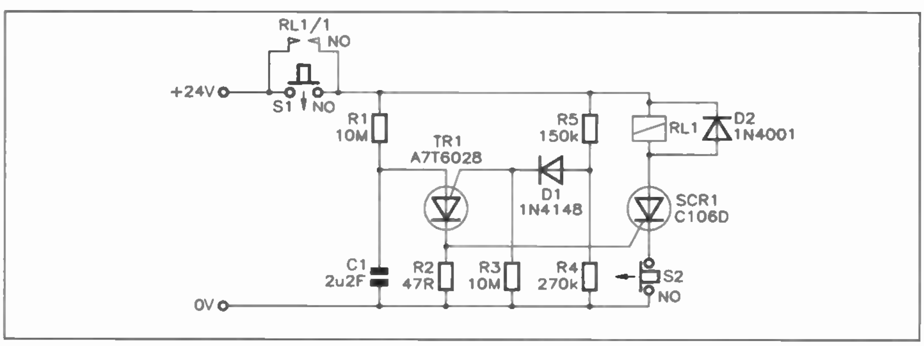


Figure 2. Time delay circuit to operate a relay.

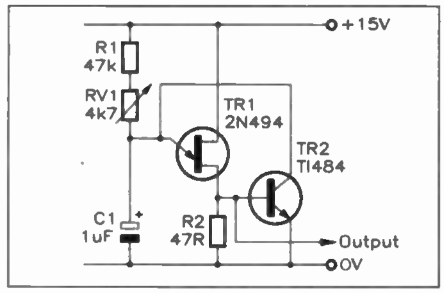


Figure 3. Modification to speed up discharge of timing capacitor.

UJT CIRCUITS

Before we look at some UJT applications, it is worth having a look at Figure 3 which shows a way of improving the performance of the UJT as a generator of fast pulses. It may be remembered that, in connection with the previous PUT oscillator, the output pulses were described as having a very steep front but a long tail following it. It was also explained how the latter was derived from the time constant of the timing capacitor and the total resistance of the discharge path, consisting of the internal resistance of the device plus the series resistance of the load resistor. Because the long fall time of the waveform limits the frequency of operation, it is worth knowing how to reduce it.

The circuit works as follows. The capacitor C1 charges towards the supply voltage through R1 & RV1. When the firing point for TR1 is reached, the capacitor starts to discharge through TR1. There is then a volt drop across the load resistor R2, sufficient to cause TR2 to become conducting. This offers an alternative, parallel discharge path for C1, through the low collector-emitter resistance of TR2, with the result that C1 discharges considerably faster than it otherwise would have.

A UJT TRIANGULAR WAVE GENERATOR

The waveform at the emitter of a UJT is an exponential one, arising from the charging of the timing capacitor through its associated timing resistor. To turn this into a triangular wave, two things need to be done. In the first instance, the wave needs to be linearised; in the second instance, the discharge time must be made the same

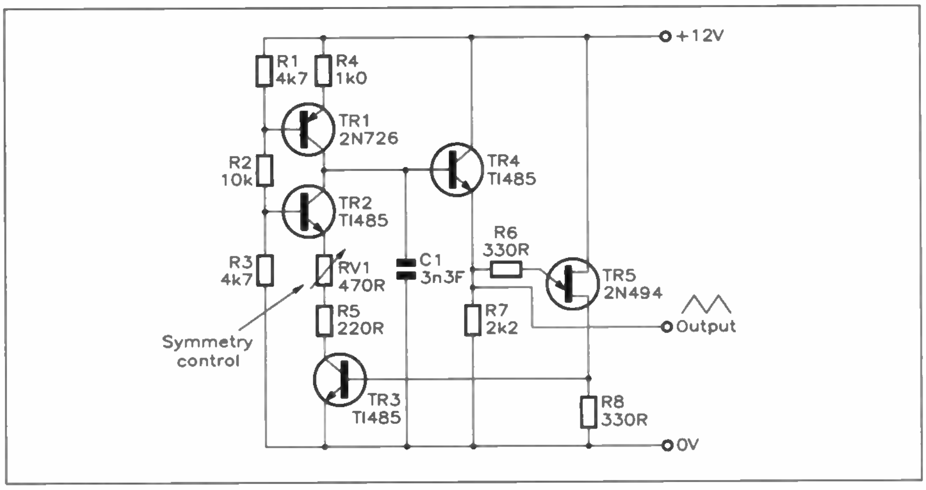


Figure 4. A triangular wave generator.

as the charge time. The circuit of Figure 4 does just this.

Transistor TR1 is a PNP type and its purpose is to supply constant current to the timing capacitor C1. Initially, while TR1 is conducting, the two NPN transistors, TR2 & TR3, are cut off because the base drive for TR3 is derived from the output of the unijunction TR5 which is, of course, at this time, non-conducting. The fourth transistor TR4 is an emitter follower, the rising output of which (following the linear voltage rise of C1) will eventually trigger the UJT into conduction. When it does so, TR2 & TR3 are forced into conduction, so providing a discharge path for C1. The total resistance of this path can be pre-set by varying RV1, thus allowing the charge and discharge time constants to be made equal. The discharge of C1 will also be linear since the current flow out of C1 constitutes the collector currents of TR2 & TR3, these being constant current devices, of course. As a result, a linear triangular wave should be produced at the output of the emitter follower TR4.

The transistors specified are again fairly old Texas types and substitutions will need to be made and resistor values modified. It would probably be a good idea to choose devices with only low to moderate gain values in order to minimise too extensive a redesign of the circuit. However, since the basic circuit principles are, I hope it is agreed, quite straightforward, this should make an interesting project for anyone to whom it appeals. I intend to redesign the circuit myself using currently available components and will then publish it in a later instalment of this series.

A SIMPLE PULSE GENERATOR

The UJT relaxation oscillator can be used as the basis of a pulse generator, provided that the pulse shape is cleaned up somewhat. This can be done by using the pulse to overdrive a BJT amplifier. The trigger pulse with its exponential tail, straight out of Base 1 of the UJT becomes much more rectangular as a result. The circuit shown in Figure 5 does just this. The 2N2646 UJT generates a wide range of pulse frequencies, according to the timing capacitor selected and the setting of the potentiometer RV1; the output of the BC182 amplifier swings between +11V and 0V, generating a pulse that is nearly rectangular, the waveshape being maintained over a range of frequencies from about 1Hz to a little over 60kHz.

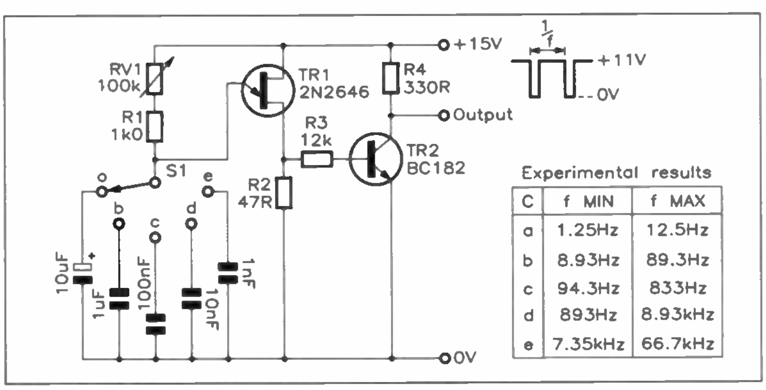
The figures given in the table were obtained experimentally using capacitors of nominal value straight from the box. This accounts for the fact that the figures don't exactly line up for all ranges. Nonetheless, they give a good guide to the selection of components should anyone decide to take the basic design any further. The pulses out of the BJT are negative-going but could be inverted by using a further unity- or low-gain common emitter stage.

The pulse width depends upon the range selected, since it derives from the time constant of the capacitor and the discharge path through the emitter to ground. Naturally, the pulse length becomes shorter at the higher frequencies. For example, on the lowest frequency range, with 10µF selected, the pulse length is 14ms. By contrast, the pulse width is a mere 8µs on the highest range, where the timing capacitor is 1nF. This is not unreasonable and while it might otherwise be possible to have very much shorter pulses at the low frequencies, it becomes a matter of practical impossibility to have long pulses at high frequencies.

A LOW POWER DC FLASHER UNIT

Figure 6 shows a working design for a flasher unit using a UJT trigger circuit and a pair of SCRs. SCR2 is the main SCR which drives the lamp load; SCR1 is a commutating SCR whose function is to turn the lamp off. The manner in which it works is as follows.

The UJT oscillator sends a constant train of trigger pulses to the gates of both SCRs. Assume that at this moment SCR2 is the one energised and the lamp is on. When the next trigger pulse arrives it triggers SCR1 on and as its anode drops in potential by about 10V, this negative-going change is coupled to the anode of SCR2 by the non-polar capacitor C3. This forces SCR2 to become non-conducting and the lamp goes out. Since the commutation pulses are longer than the trigger pulses, it is impossible for SCR2 to be triggered on again inadvertently. While SCR2 is conducting, it will eventually discharge C3. After this time it is



Experimental results

C	f MIN	f MAX
a	1.25Hz	12.5Hz
b	8.93Hz	89.3Hz
c	94.3Hz	833Hz
d	893Hz	8.93kHz
e	7.35kHz	66.7kHz

Figure 5. Simple pulse generator circuit.

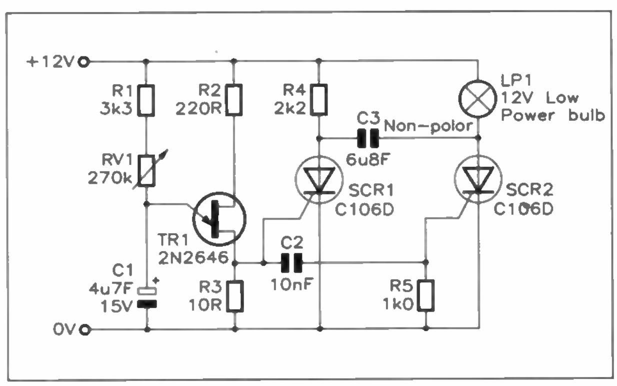


Figure 6. Low power DC flasher circuit.

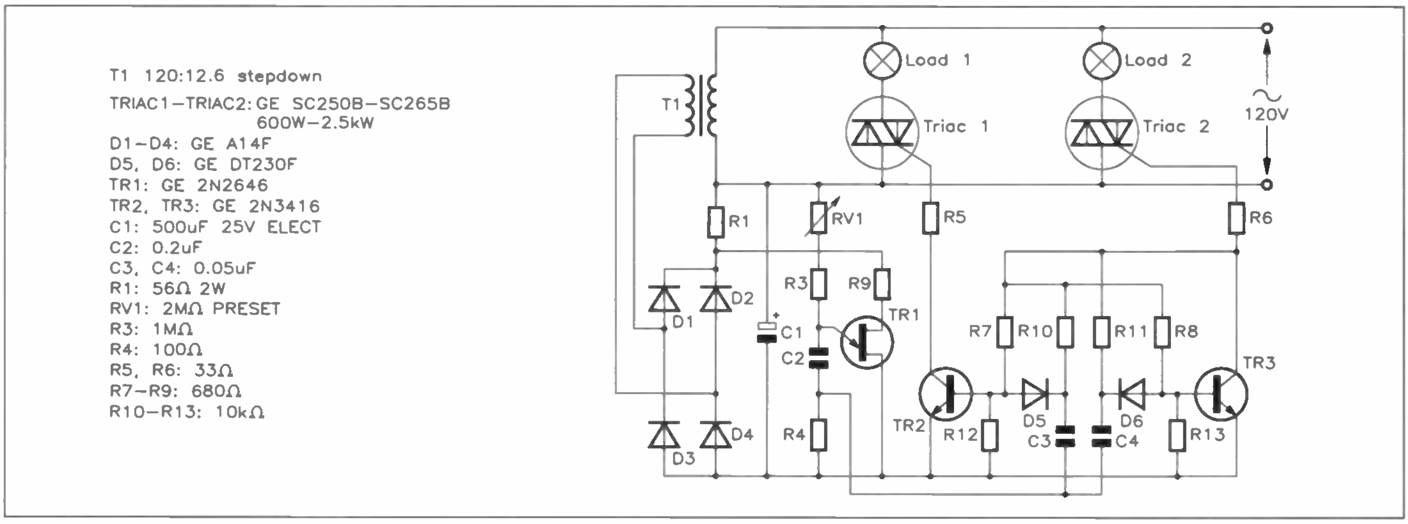


Figure 7. Circuit for high power AC flasher, capable of driving 2·5kW loads.

possible for SCR2 to be triggered on again. Thus, the two SCRs alternate in their roles as conducting devices. It is impossible for both SCRs to be on together since SCR1 is operated in what is termed a *starved* mode. This simply means that its anode resistor, R4, is sufficiently large so that it is unable to remain on except for the time it takes to discharge C3. During the time that SCR1 is off and SCR2 is on, the commutating capacitor C3 receives a charge such that its left-hand plate is at +12V and its right-hand plate is at about +2V. This is the commutating voltage that is used, as described earlier, to drive SCR2 into the off state at the appropriate time.

I have deliberately specified a low power lamp for this particular circuit because one of the limitations of the circuit is that commutation is only effective if the commutating capacitor is able to store enough charge to turn SCR2 off. The more current that SCR2 has to deliver to its lamp load, the larger must be the commutating capacitor. The 6·8μF capacitor used in this design was the largest non-polar electrolytic type available at the time the circuit was built and tested. It is definitely not large enough to switch auto bulbs of, say, 6W or more rating but should be able to handle smaller bulbs such as panel indicators. A non-polar capacitor is essential because of the regular polarity reversals encountered. The answer could be to make up a bank of parallel connected capacitors for switching higher power loads.

A HIGH POWER AC FLASHER CIRCUIT

As we have just seen, one of the disadvantages of the DC flasher circuit is its need for a large commutating capacitor when high power loads have to be switched. A possible answer is seen in the AC circuit of Figure 7. This circuit is able to handle two independent loads of up to 2·5kW each. A DC supply is developed by transformer T1, diodes D1-D4, resistor R1 and capacitor C1, which powers the UJT oscillator TR1 and the BJT bistable circuit comprising TR2 & TR3. The interbase voltage for TR1 is taken directly from the bridge rectifier and so is pulsating; this forces the UJT to run synchronously with the supply frequency. Negative-going pulses appear across the resistor R4 and these are *steered* alternately to the bases of TR2 & TR3, by the diode steering circuits shown. Since TR2 drives the gate of TRIAC 1 and TR3 drives the gate of TRIAC 2, these devices turn on alternately driving their loads as they do so. The flashing rate is determined by the time constant of RV1, R3 & C2.

It may be noted that the AC supply is specified as being 120V. This is really irrelevant and occurs only because of the origin of the circuit. Any AC supply could be used, with the appropriate choice of mains transformer giving 12·6V rms at the secondary winding. This is only a low power transformer since it is only needed to meet the requirements of the UJT oscillator and the flip-flop circuit.

PRECISE LONG TIME DELAY CIRCUITS

There are a number of circuits using UJTs that allow very long and extremely precise time intervals to be generated. Precision may, however, also be obtained at very short time intervals, and it is possible to generate predictable intervals as short as a fraction of a millisecond. Figure 8 shows one such circuit for generating precise delay times in the range 0·3ms up to in excess of three minutes. The actual delay obtained depends upon the value of R1 that is chosen. Values up to hundreds of megohms are possible.

The secret of success lies in the use of a low leakage mylar capacitor C1 for the capacitive timing element instead of a large value electrolytic capacitor. The peak point current of the UJT is effectively reduced so that a very large emitter timing resistor R1 may be used. The peak point requirement of TR1 is reduced by up to 1,000 times by pulsing its Base 2 with a negative-going pulse derived from the free-running oscillator TR2, via C2. This pulse momentarily drops the peak point voltage of TR1, allowing peak point current to be supplied from C1 rather than from R1. The pulse rate of TR2 is not critical provided that its periodic time is less than 0·02 seconds.

Next month's article in this series will be the first of two exploring circuits that make use of SCRs.

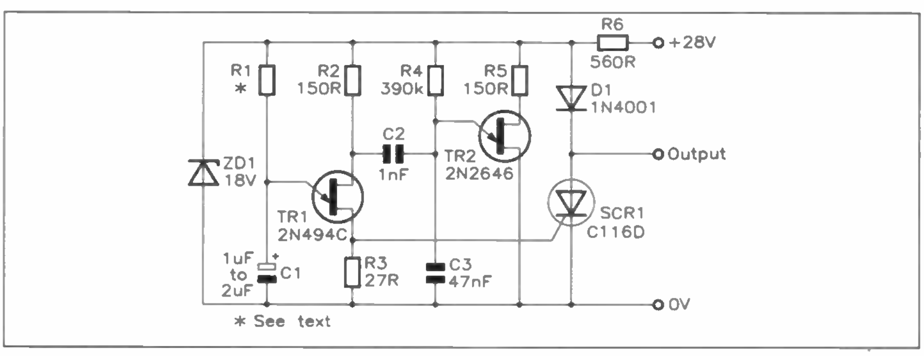
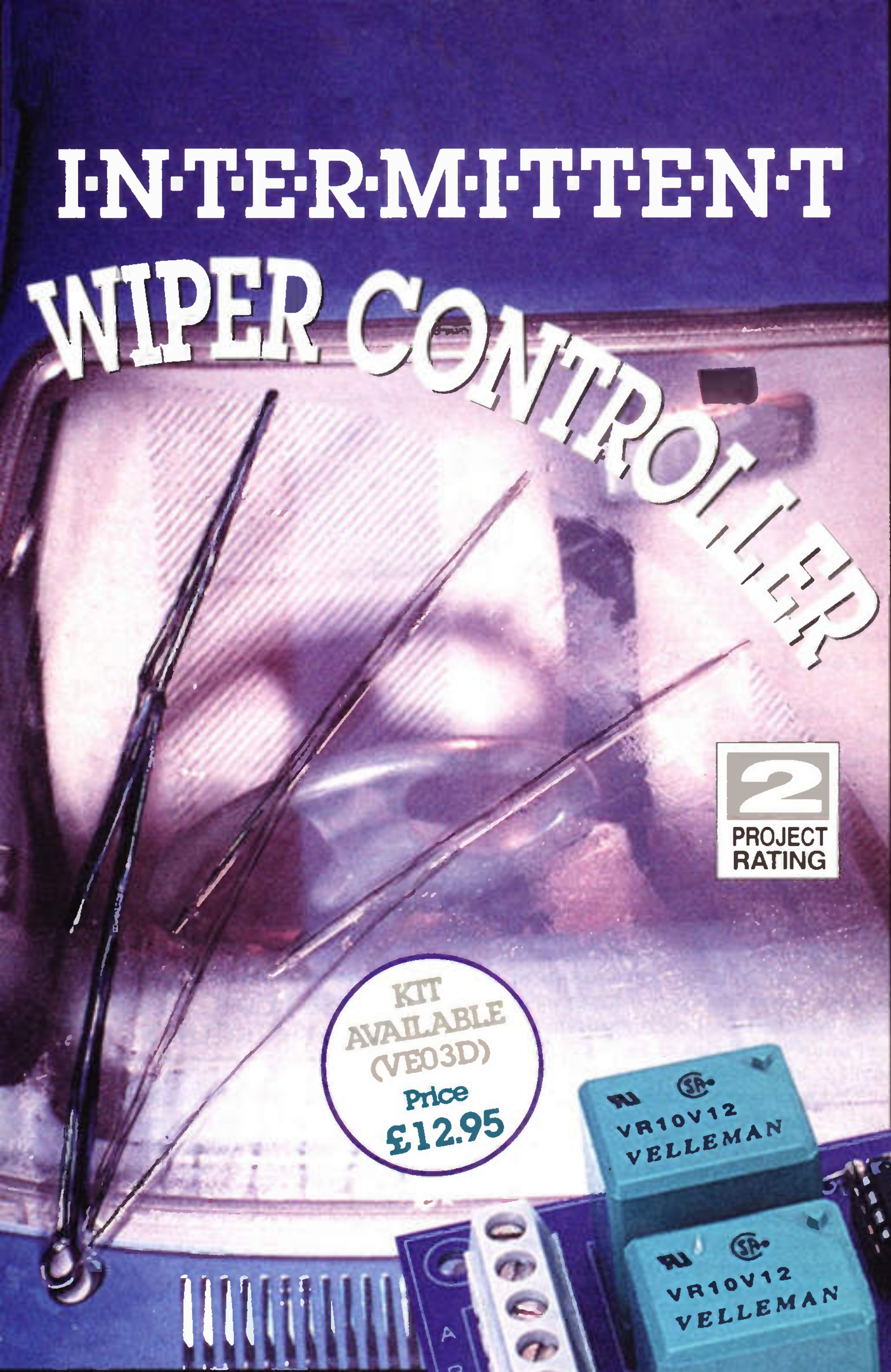


Figure 8. A precise long delay timer circuit.

I·N·T·E·R·M·I·T·T·E·N·T WIPER CONTROLLER



2 PROJECT RATING

KIT AVAILABLE (VE03D) Price £12.95

"Rain, rain go away come again another day." Most of you out there with older cars will appreciate this saying. Most modern cars come with wind screen wipers that operate at a range of speeds, including intermittent wipe for that misty kind of rain. Their counterparts found on earlier cars were not so good, sometimes with only one setting, i.e. on or off, or two speeds if you were lucky.

This project is ideal for those of you that have the old system fitted to your car. You now have the chance of updating the wiper system by adding an intermittent setting, featuring three different time intervals of 5, 10, and 15 seconds, which can be selected to match weather conditions. The advantages of having intermittent wiping are many fold, not least that lives of wiper blades are extended, and that the mechanical wear of the motor and gearbox is lessened.

Close-up of the assembled controller ready for installation.

Text by Robin Hall and Alan Williamson

FEATURES

- Timer intervals 5, 10 and 15 seconds
- Relay output: 2 x 5A single-pole changeover contacts
- LED indicator

Important Safety Warning

Since a car battery is capable of delivering extremely high currents, it is imperative that every possible precaution is taken to prevent accidental short circuits occurring. Remove all items of metal jewellery, watches, etc. Before connecting the module to the car electrics, disconnect the battery. Helpful hint - Remove ground connection first, to prevent accidental shorting of the (+) terminal to the bodywork or engine. It is essential to use a suitably rated fuse in the supply to module. The wire used for the connections should also be rated to pass safely the current required.

Circuit Description

Figure 1 shows the block diagram for the Intermittent Wiper Controller.

Referring to Figure 2, this shows the selection of three delay speeds as well as 'ON' & 'OFF', by the rotary switch (SW), which is used in this design as a 2 pole 4 way type, although the two poles are connected together on the PCB.

Pole 'C' is used to switch the unit 'ON' & 'OFF', where 'OFF' is position 9 and 'ON', positions 10, 11 & 12. The other pole used on SW is pole 'A', which is used to select the resistor for the required time interval. The timer circuit comprises the ever popular 555 timer IC. Capacitor C2 and resistor R4 combine with the selected resistors R1, 2 or 3 via the switch (SW), to set the interval lengths.

D1 is in parallel with relays RY1 & RY2 and is there to protect the 555 IC from the induced emf produced by the relays when they de-energise. R5 is the current limiting resistor for the light emitting diode LD, which is lit when the relays are not active. Capacitor C1 is required to decouple any high-frequency noise present on the power supply rail as cars are a notoriously electrically noisy environment.

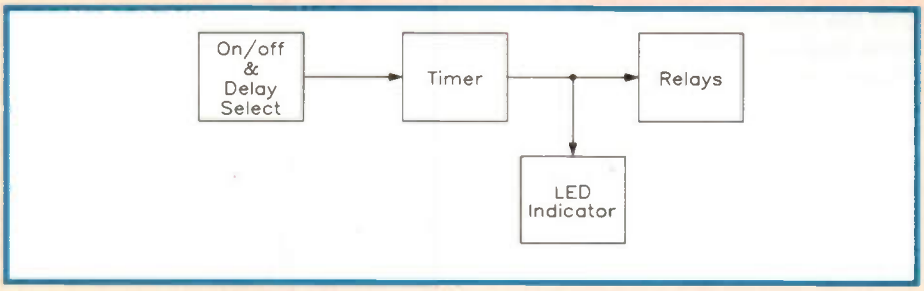


Figure 1. Block diagram of the Intermittent Wiper Controller.

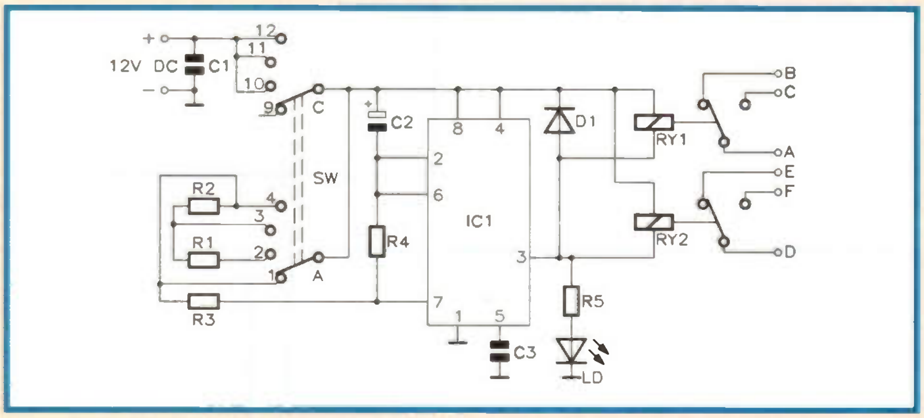


Figure 2. Circuit diagram of the Intermittent Wiper Controller.

Construction

Refer to the circuit diagram in Figure 2 and the Parts List.

Start by fitting D1, which is a small signal diode either 1N4148 or 1N914 type, making sure that the band on the cathode matches that of the PCB legend. Next identify and fit the resistors referring to the Parts List. Orientate the 8-pin DIL IC socket so that the notch at the top of the socket matches the mark on the PCB. Next fit C1 and C3 the two 100nF capacitors, C2 is an electrolytic capacitor which is polarised; it is important to fit the leads correctly. Solder the positive lead, which is slightly longer, towards the top of the PCB, and the negative lead, shown by a series of arrows, towards the bottom. The terminal blocks are next, making sure that the holes point outwards in each case. Next fit relays RY1 and RY2, note that these fit one way round only. The light emitting diode (LD) has a flat surface on one side and this should match the legend on the PCB, see Figure 3. The rotary switch used in the kit is a three pole four way type, although only two poles are used. If the switch does not rotate through four positions it may need to be re-configured. If this is so, unscrew the lock-nut and remove the shake-proof washer, inside is a ring with a locator on it and this must be in position '4'. If not take the ring out, making sure that the switch is fully *anticlockwise* and put the ring back with the locator in this position, and refit the shakeproof washer and locknut. At this point decide whether the rotary switch is to be soldered directly onto the PCB or whether ribbon cable will be used so that the switch can be mounted remotely. Refer, again to Figure 3, which shows the connections for either option. If the rotary switch is to be soldered directly to the PCB then nothing further needs to be noted; but if ribbon cable is to be used then make sure that the connections match those in Figure 3. The drawing shows poles 'A' & 'C' are common, and also that position '12, 11 and 10' are joined. Last but not least insert IC1 (555) into the 8-pin DIL IC socket, making sure that the notch matches that on the socket.

No particular box is recommended for the kit; the choice is left entirely to the constructor.

Testing

Testing the circuit is a very simple task; all that is required is a +12V DC power supply. Check first that the rotary switch SW is set to 'OFF' by rotating the spindle anticlockwise to its leftmost position. Connect a +12V DC supply referring to Figure 3, making sure that the polarity is correct. Switch on the supply and LD should illuminate. Next turn the rotary switch clockwise to the second position. The relays will activate for an instant and LD will extinguish. The relays deactivate, and LD will illuminate again. This cycle will repeat approximately every 15 seconds. The third and fourth positions are for the 10 and 5 seconds interval respectively. If you want longer or shorter interval lengths than provided, then replace C2 with either a larger or smaller value capacitor.

Preliminary Checks

On most modern cars the electrical connections are numbered as shown in Figure 4a. In some other cases they may be colour coded instead. These will have to be checked for their equivalent connections, and tested with either a multimeter or test lamp. Connect the (–) lead of a multimeter or lead of a test lamp to ground (31) and the (+) lead or other lead of a test lamp onto the connection of the wiper motor.

Specification

Power supply:	12 to 15V DC
Supply current:	Output off – 25mA
	Output on – 100mA
Interval lengths:	5, 10, and 15 seconds
PCB dimensions:	82 x 52 x 40mm

With the wiper switch in the 'LOW' speed position terminal (53) will become live. The next connection to check is for 'HIGH' speed, and this is terminal (53B). The third terminal to check is terminal (31B), this will be live as long as switch (SA/SB) is in position 1 or 2. When SA/SB is switched off, the wipers will not be in their parked position and so power will be applied until they return. Switch 'P' is mechanically linked to the motor and when the wipers are about to reach the parked position, will switch from position 1 to 0, thus short circuiting the motor to make it stop quickly. It may be found in some cars that the wiper switch is connected between the motor and the ground. The principle remains the same, but

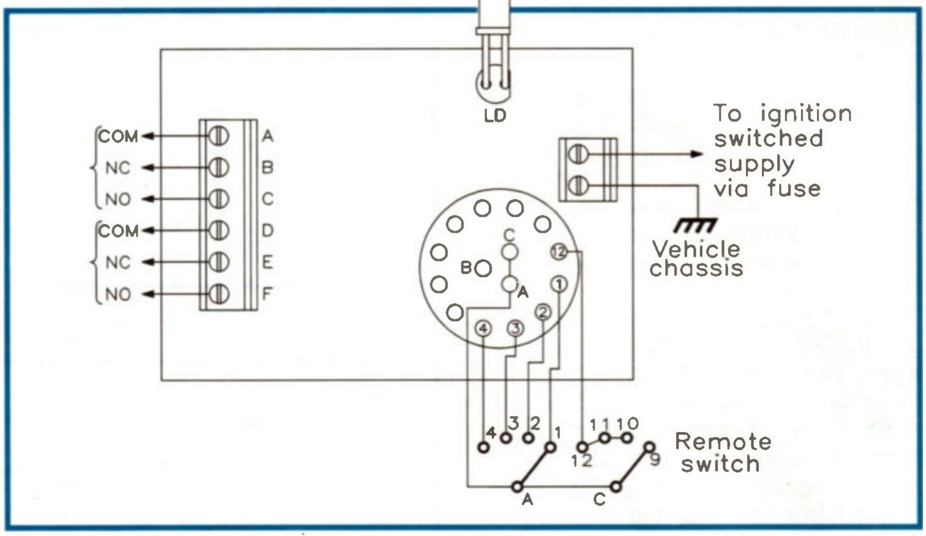


Figure 3. Remote wiring of switch and LED.

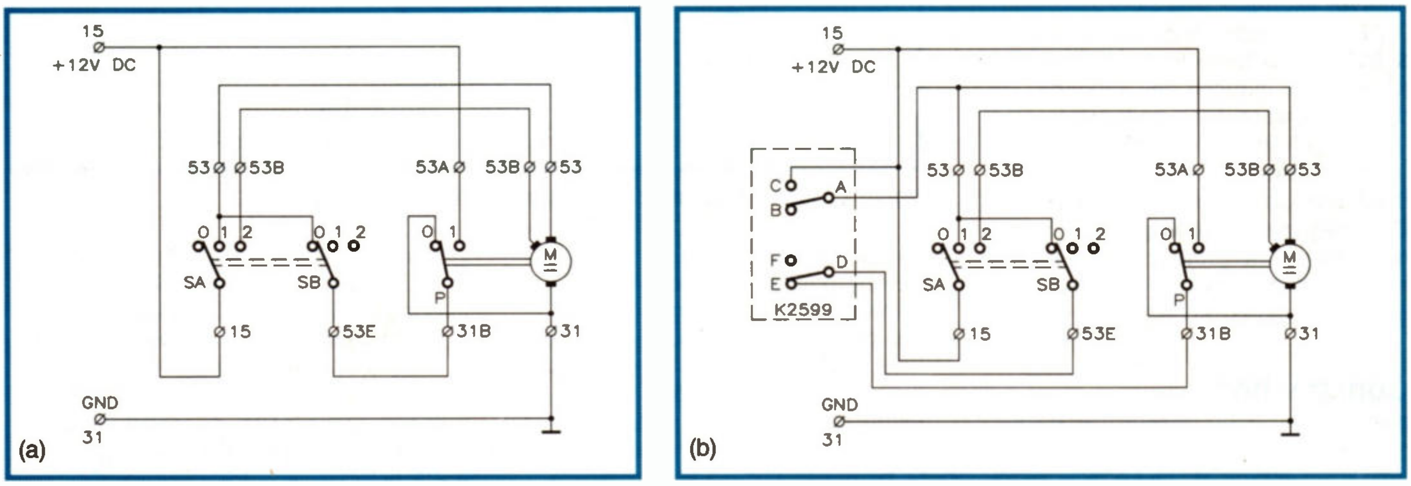


Figure 4. (a) Wiring of a typical 5 wire front wiper motor; (b) With the Intermittent Wiper Controller connected.

electrical connections will have to be changed as appropriate.

Note that the original wiper switch still has priority over the module.

Installation

Remember to disconnect the battery before commencing work.

With the relevant information on the electrical connections, refer now between Figures 3 and 4b. First disconnect the link between terminals 53E and 31B. Connect terminal 53E to position D and terminal 31B to position E on the six position terminal connecter. Next connect a lead from terminal 15 to position C, and connect a lead from terminal 53 to position A. Note that there should be nothing connected on either positions B or F. Power for the module should be from a fused ignition switched supply, and this should be connected to the top connection of the two position terminal connecter as shown in Figure 3, and the ground connection should be made from the vehicle's chassis to the lower connection.

Double-check all wiring before reconnecting the battery.

If everything has been connected correctly, the module should function as described. If problems are encountered, recheck the wiring and use a multimeter to check that correct voltages are present on the relevant cables. If this fails to reveal the problem, remove the module and repeat the test procedure. If this still fails to resolve the problem, contact an automotive electrician, who should be able to help.

INTERMITTENT WIPER CONTROLLER PARTS LIST

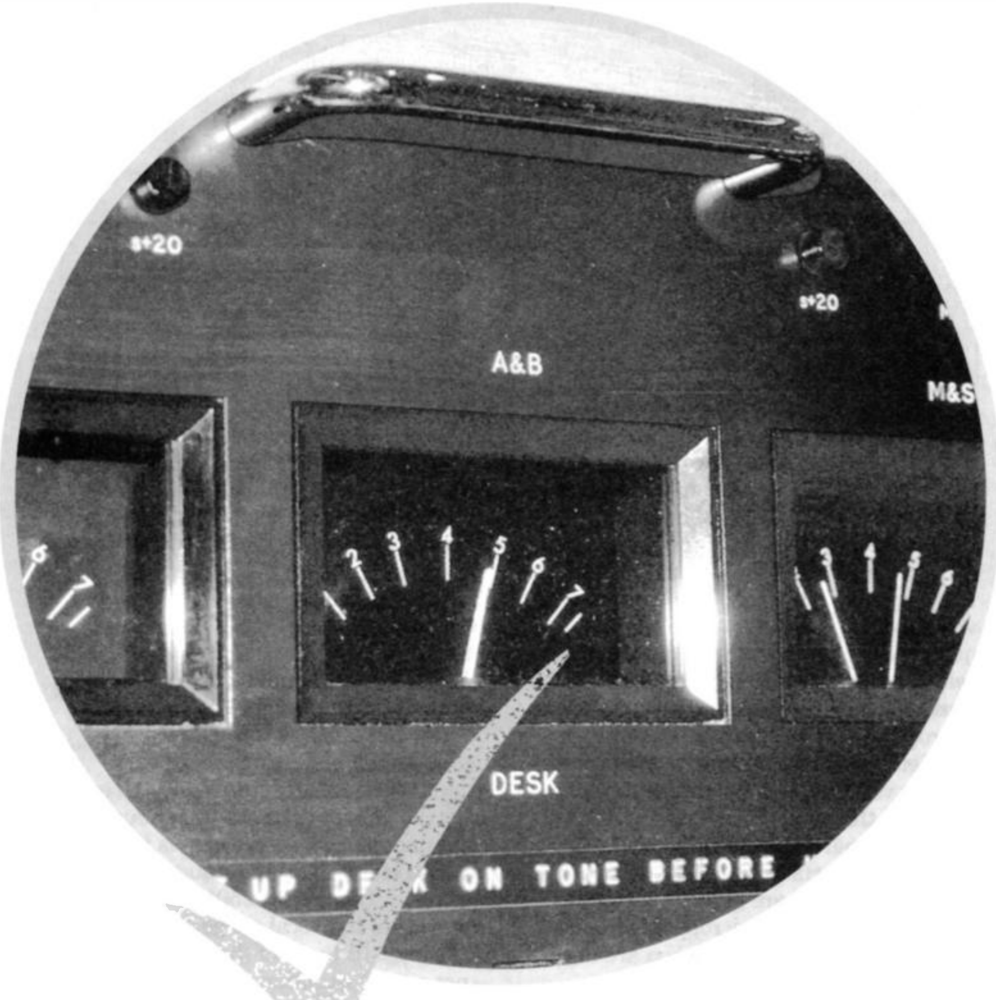
RESISTORS: All 0·6W 1% Metal Film		
R1,2	150k	2
R3	120k	1
R4	22k	1
R5	560Ω	1
CAPACITORS		
C1,3	100nF	2
C2	47μF Electrolytic	1
SEMICONDUCTORS		
IC1	555	1
D1	1N4148/1N914	1
LD	LED	1
MISCELLANEOUS		
SW	3-pole 4-way Rotary switch	1
	8-pin DIL Socket	1
RY1,2	12V Relay Single Pole 2-way	2
	2 Terminal Screw Connecter	1
	6 Terminal Screw Connecter	1
	PCB	1
OPTIONAL (Not in Kit)		
	Ribbon Cable 10-way	As Req. (XR06G)

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

The above items (excluding Optional) are available in kit form only.

Order As VE03D (Intermittent Wiper Controller) £12.95.

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



A GUIDE TO PROFESSIONAL AUDIO PART TWELVE

by T. A. Wilkinson

Last month saw the end of sound recording techniques, culminating in digital recording equipment. We now look at signal processing, beginning with equalisation, or tone control.

EQUALISERS for audio use have, over the years, become one of the most debated types of signal processing equipment. Furthermore, they have seen an enormous amount of development work and research by all manufacturers. It is most likely that any EQ (equalisation) work done to an audio signal will have been performed using an EQ section that forms an integral part of a mixing desk, and these EQ sections are now seen as great marketing tools. Even very diminutive mixers such as the Soundcraft Spirit Folio have quite comprehensive EQ facilities. Typically, these days, '3 band' EQ controls (a sort of refined bass, middle and treble arrangement) seem to be the starting point. From here EQ gets more and more complex in terms of both its design and implementation, and I suppose its use is really only limited by the imagination of the user!

Interestingly, the home Hi-Fi scene has over the last decade or so, seen a definite departure away from EQ or 'tone' controls of any sort on amplifiers, whilst the use of EQ in recording situations has veered in exactly the opposite direction! The Hi-Fi purists maintain that they obtain a better quality sound without these 'nasty' filters in the signal path, in an attempt to claw back some of the 'quality loss' introduced by the recording process itself. Some would also prefer an amplifier without source selector switches for much the same reasons. I leave you to draw your own conclusions here, except to say that much of this is driven by trend, market forces and the need to keep up with the Joneses!

So, is it always necessary to have such complex means available in order to produce the desired result? Whilst many users would say yes, possibly as a result of hype in some recording orientated magazines, or perhaps in order to justify their immense expenditure on a new mixer, there are very many others who would disagree and prefer minimum EQ if any at all!

For example, a competent person recording say a female voice in a reasonable environment, with reasonable equipment correctly set up and with due consideration to microphone placement, should not need too much in the way of equalisation at all. But this assumes most things being near perfect, and of course life just isn't like that, and it's better to be equipped with at least some EQ system even if it's rarely used.

Equalisation as a Form of Correction

The term 'equalisation' is used to describe the way in which we use certain pieces of circuitry to change the frequency response or shape of an audio signal by 'cutting' (attenuating) or 'boosting' (amplifying) certain points of the audio band, but rarely do we use equalisation in the way the term implies. The dictionary definition for the word equalisation is 'to make or become equal', but in terms of what we do with the EQ controls of a mixer, the word is not a very accurate description. To 'equalise' would in fact imply correcting the frequency response of a signal which has in some way changed from its original form.

For example, in radio we often use equalisers to flatten the sometimes 'lumpy' frequency response of the analogue BT music circuit line. Typically, this smooths out any uneven frequency peaks and dips, and on occasions when the use of such a line is considered to be critical, for example in music applications, great efforts would be made to produce a flat as possible frequency response from that line. After all, there is a limit to just how much audio you can force down what is basically a long pair of twisted solid core wires, and BT do their best to provide the best quality route available. We would certainly not add more bass or treble simply because we like the sound! This kind of application is perhaps where the true meaning of the term equalisation can be applied. However, equalisation has now been generally excepted as having a much broader but less accurate meaning, which is best described as 'changing' the frequency response of some part of the spectrum of an audio signal.

Equalisation comes in many forms,

from the very basic but adequate, to very complex and mind blowing (read 'budget blowing') arrangements. Simpler types offer upper, mid and lower frequency cut and boost centred around respective fixed operating points; these will often be sufficient for many types of audio work, but invariably there will be occasions when the fixed operating point will not be the frequency at which you need to make the corrections.

Decibels and Octaves

Whenever there's talk of equalisers, filters, tone controls or whatever, one term crops up again and again – 'dB/octave' (decibels per octave). The term 'dB/octave' is a very simple and extremely useful way of representing the effect a particular filtering device will have on a signal. Put quite simply, for every octave (doubling or halving of frequency) from a certain point in the audio spectrum (determined by the filter's centre operating point), there will be 'n' dB (determined by the filter's characteristic) of attenuation or amplification at that frequency.

Figure 1 shows the performance curve of a fairly typical LF cut device with a fairly mild attenuation characteristic of 6dB/octave. The point at which the signal begins to be affected by this device, the roll off point, is around 500Hz. In the graph of Figure 1, for each octave (doubling or halving of frequency) from 500Hz downward, there is 6dB of attenuation (a halving of signal amplitude) of the audio signal. The first –6dB point is at 250Hz, and at around the 63Hz mark, the signal is attenuated by about 18dB. A LF boost device with similar characteristics would achieve 18dB of amplification at 63Hz.

On a modern mixing desk – even a relatively inexpensive type – a 4 band EQ would not be uncommon. Slightly better types also include roll off filters with variable frequency operating points at the extremes of the audio band. Roll off filters generally have specific (fixed) attenuation characteristics, with steeply shelving response curves typically giving 12 to 18dB per octave of signal attenuation at the selected operating point.

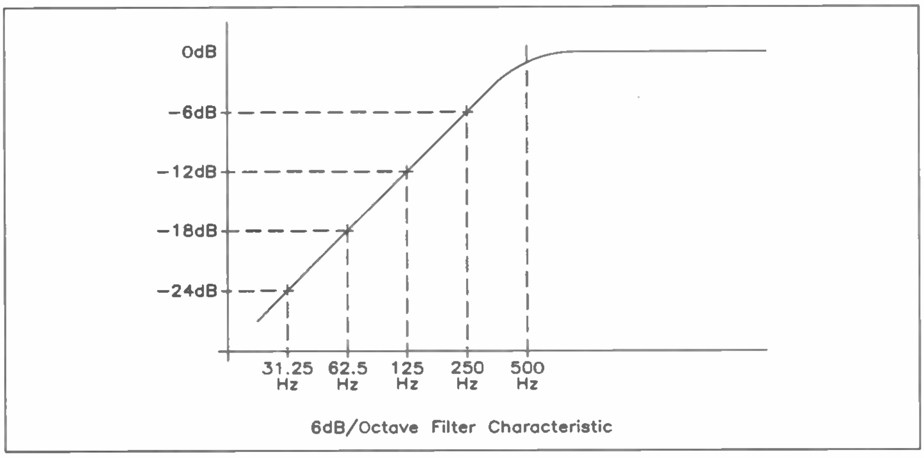


Figure 2. Roll off filters have steeply shelving response curves.

Now let's look at a nasty but not unimaginable situation. You have a vocalist on stage and a whole load of quality audio gear, but with a long, complex run of cables terminated some distance away from the stage microphones at your mixing desk input. A quiet but noticeable hum is present on that vocalist's channel of the desk, although the microphone itself and the mixer channel have proved to be clean, thus the cable run is to blame. Now the PA company, who are supplying you with the feed of this microphone, assure you it's "OK leaving them". You are now left with two options: 1, Remove the offending cable and re-route it away from the hostilities that are making your life hell (this is without doubt the best option), or 2, try and filter out the 50Hz hum using a suitable bit of signal processing gear, i.e., the EQ section of your desk.

With a conventional 6dB/octave bass cut device with a roll off frequency of 500Hz, you could be in real trouble as you would be lucky to get 20dB attenuation at 50Hz (see Figure 1), even with the bass cut flat out (maximum attenuation). But even worse is the adverse effect on other frequencies in this band. Because at 250Hz, which is well within the vocal range, you would be losing 6dB (half) of the 250Hz signal – not a good situation, resulting in a vocal sound which is 'bass light'. Clearly this solution is far from satisfactory and does more harm than good.

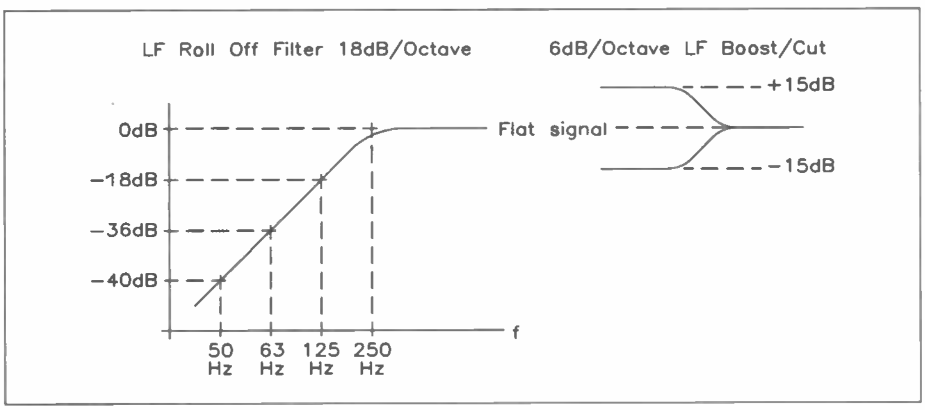


Figure 3. A steep HF roll off filter.

The only way to reduce the 50Hz hum by any significant amount is to use a filter with a very steeply shelving roll off slope. Enter the desk's roll off filters (assuming of course it has them!) and you could be well on your way to solving the problem. Clearly Figure 2 shows a much better solution. Even with a roll off point at around 250Hz, we get about 40dB attenuation at 50Hz. Of course, the *best* solution to our mains hum problem has got to be to move the cable!

LF roll off filters can prove to be invaluable tools, but, as with any form of signal processing, they should be used to solve a problem and *not* simply as a matter of course because they are there!

LF roll off filters can be used to good effect where the following conditions (but not exclusively) present problems:

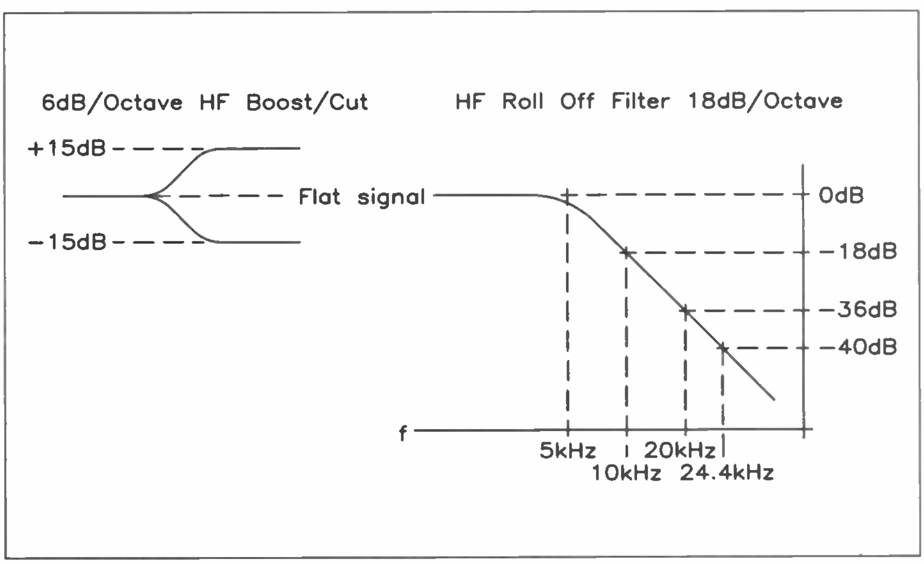


Figure 1. Performance curve of a typical 6dB/octave LF cut filter.

Low frequency traffic rumble
Vocal blasting/popping
Low frequency howl around components (LF positive feedback)
Reducing air-conditioning rumble

At the other end of the scale, but usually paired with LF roll off devices, are the HF (high frequency) roll off filters, see Figure 3. Again these have 12 or 18dB of attenuation at a frequency roll off point determined by the user. Typical uses for HF roll off filters include:

Reducing HF vocal sibilance
HF noise, etc.
Reducing air-conditioning whistles
Reducing TV line timebase whistle

So far we have dealt with the extremes of the audio frequency spectrum, and in reality the roll off devices described act to limit the audio bandwidth to some extent. Having eliminated any possible problems at the extremes of the spectrum, we are left with a pass band for our audio signal, which might resemble that of Figure 4, with some moderate roll off at 40Hz and 18kHz.

Easy Do es It

With the remaining EQ controls at our disposal, there is much we can do to change the frequency response of this band. One immediately obvious possibility is to do nothing at all, leaving the remaining EQ controls to give an overall flat response, and why not? After all, is our job not to capture the moment of a performance as it happens, and with a high degree of faithfulness to the original performance (Hi-Fi?). Of course it is! The minimalist approach to equalisers is just that! Minimal! There is a very strong argument for leaving the EQ controls alone and allowing the artist and the recording process to produce as natural a sound as possible. Certainly some classical recordings are made in as pure a way as possible. It could of course be argued that any recording process is not really very natural anyway, as it is a whole series of destructive compromises, but that's another story!

We should not treat the EQ section of a mixer or desk as something that must be used on all occasions, simply because it exists. The problem is that, precisely because it *does* exist, it means that there will always be great temptation to exercise our 'creative talents' and use it.

Certainly there *are* individuals who can create something a little bit special with EQ, and then there are those who *think* they can create something special in this way, but who actually create something that is not only a poor representation of the original, but also lacks anything in terms of merit! Generally though, the EQ can be used in a sensible way to emphasise or highlight certain aspects of the signal.

Conventionally, and perhaps conveniently, the pass band we are left with is split into several frequency EQ bands. On any fairly recent mixer, even on a modest unit, there is likely to be at least three EQ bands, with half a dozen or more on a more hi-tech model.

These arrangements of the EQ bands generally fall into three categories, being:

1. Fixed Frequency Type

Having three or four EQ bands set at specific and non-variable frequency points. A fairly straightforward system, giving perhaps up to 10 or 15dB of cut or boost of the fixed frequency points. Generally found on modest/inexpensive mixers with typical adjustment points at around 80 to 150Hz for the LF band, around 3kHz (or say 2·8 and 5·6kHz for a 4 band type) for the MF band and around 10 to 12kHz for the HF band.

The big drawback with this type of EQ is that the fixed frequency points at which the cut/boost operates are invariably not the frequencies you want to tweak! This is not a fault of the design, merely a cruel fact of life!

2. Variable/Swept Mid Band

The next group of EQ systems are those which allow some control over the frequency points at which at least some of the controls operate. It is usual to find fixed LF and HF operating points, with the added convenience of control over the mid section. There are at least three possibilities here with either a single swept mid control, variable between say 300Hz and 7kHz, or switchable MF operating points at typically 300Hz, 2kHz, 5·6kHz, 7·5kHz or a pair of overlapping, swept mid controls with a range of say 100Hz to 1kHz, and 350Hz to 8kHz.

The best of this group is the latter, as it allows a much greater degree of control of the mid frequency band of signals.

3. Fully Variable Parametric

This group of EQ systems is to be found on top flight, and hence expensive, mixing desks, where several EQ bands have adjustable operating points, each band with its own cut/boost control. True parametrics also have a 'Q' control which allows the frequency width ('Q') to be set from very narrow to quite wide. The width of 'Q' is measured as the area in that frequency band between the lower and upper 3dB points, i.e., where the LF and HF signals of a band have been reduced by 3dB respectively, see Figure 5. These systems can be quite complex to operate and can alter sound quite severely, but with carefully considered operation they have the ability to be very useful tools. Parametric EQ often has a bewildering number of knobs offering incredible and very precise control and adjustment of the mid frequency band, a veritable knob twiddlers paradise! The danger here is that you can spend more time twiddling EQ knobs than actually listening to what you are supposed to be recording, not a recommended way of operating!

Equaliser Usage

Any of these last two groups are a vast improvement over the basic 3-band fixed EQ. Great emphasis is now placed on variable mid frequency EQ systems, and these are now the norm rather than the exception even on very modest but 'serious' recording and live stage/PA mixing desks.

But why all the fuss about MF equalisation? Well, logically there is an awful lot of signal information in this area of the audio spectrum coupled with the fact that the mid band seems to get progressively wider with every new mixer brought onto the market.

Vocal work is a prime candidate for using mid EQ, a boost in response at around 3kHz is said to add 'presence' to a vocalist, an effect which highlights important vocal tones and brings the vocalist 'up front' which makes them appear to be much closer to the listener.

Drum kits are often heavily EQ'd, and, in common with other musicians, many drummers (and producers) have a

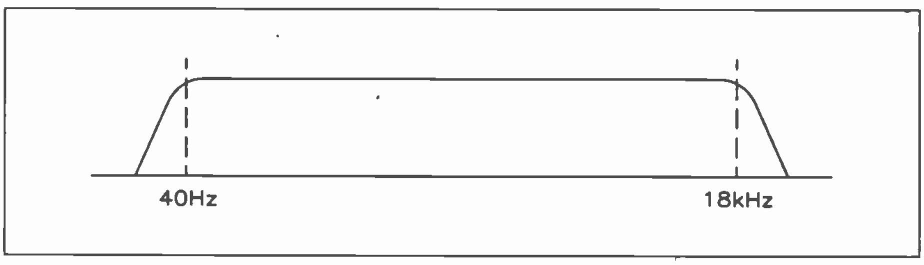


Figure 4. Audiosignal pass band with 'extremes' remo ved by filtering.

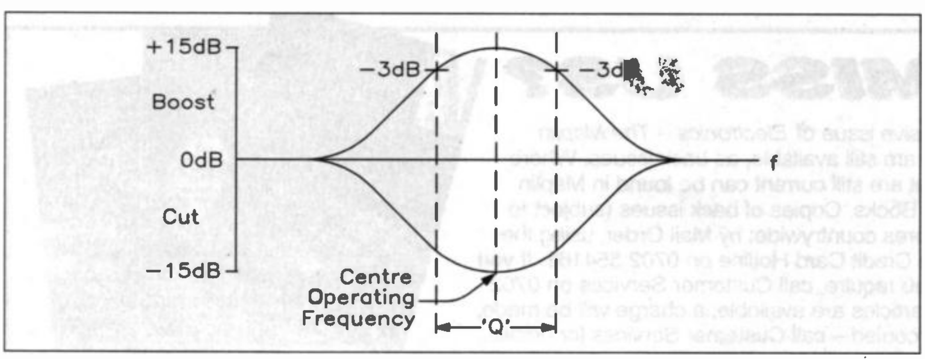


Figure 5. The 'Q' bandwidth of a variable parametric equaliser.

particular sound for their kit that adds individuality. Typically this might involve rolling off some MF and HF from the kick drum leaving a very deep powerful drum sound. Snare drums would be quite different, with the LF rolled off for a punchy airy sound, it all depends. But I have probably seen as much EQ work done with drum kits as anything else; there are individuals who have very clear ideas of how they want a kit to sound and will 'preset' the EQ controls on the drum channels of a desk to about the right position before even hearing a note, with very little fine tuning done subsequently!

Whilst rummaging through some old notes during the research for this series, I came across a very useful piece of information relating to the use and abuse of equalisation. I have included that info in this feature with one or two amendments to it, see Table 1.

Finally, perhaps the important part of any EQ system is the bypass or 'flat' switch. As its name suggests, when operated this vital accessory bypasses all of the equalisation controls and produces a non-equalised flat signal. The main purpose of this is to provide an instantly available source of flat signal, the user can then compare the equalised (or 'fiddled with') signal with the pure untouched flat signal.

It is quite easy to keep adding and changing the equalisation in a mixer channel, but unless we have a flat signal with which to compare this with things can very easily get out of hand, resulting in very nasty un-natural sounds.
At least with an EQ bypass switch comparisons can be made very easily, and if you get in a real mess it can always be left on flat!

Octave	Frequency	Quality added to spectrum	Effect if Over-emphasised
1st	16-32Hz	Large pipe organ lower bass frequencies.	Watch those speaker cones go past your ears!!
2nd	32-64Hz	Bass fundamentals. Main bass frequencies of organ, double bass, tuba, etc.	Boominess, highlights mains hum problems.
3rd	64-128Hz	Gives warmth and body to sound.	Muddiness. Danger – 1st harmonic of mains hum!
4th	128-256Hz	Fundamentals of male voices, cello, viola, clarinet, horn and trumpet. Gives richness to the sound.	'Boxiness', cardboard quality.
5th	256-512Hz	Fundamentals of female voices, oboe, and flute. 'Power' giving way to intelligibility.	'Roof of mouth' quality.
6th	512Hz-1kHz	The 'telephone region' giving most intelligibility to music and speech.	6th – 'hollow, megaphone' quality. 7th – 'tinny' quality.
7th	1-2kHz	The easiest frequencies to hear and reproduce.	6th + 7th – causes listener fatigue.
8th	2-4kHz	'Brilliance and articulation' – adds 'presence' to instruments (3·6kHz) and voices (2·8kHz) moderate boost (3dB) at 2·8 – 3·2kHz adds 'clarity' to choirs. Main area of 'needle scratch'!	'Peaks' here give a 'nasal' quality.
9th	4-8kHz	Important overtones that give quality to musical instruments. Accurate 'sibilance' if response here is correct.	'Peaks' here give rise to 'stridencies' (harsh tones).
10th	8-16kHz	Overtones of reeds, brass, cymbals etc. Gives lively, sparkling character and 'transients' to sound.	Peaks here give a 'comb and paper' effect to some strings. Over emphasis gives 'chromium plated' effect.
11th	16-32kHz	Adds further overtones. Much of this area out of conventional audio spectrum.	See those dogs come running!!

Table 1. Audiospectrum summary.

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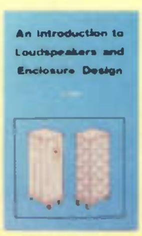

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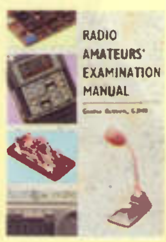

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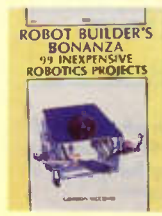

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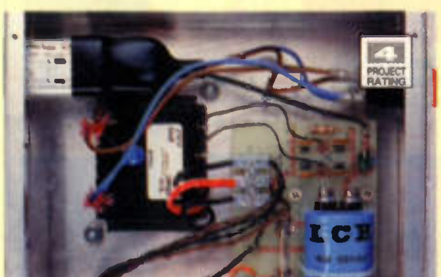
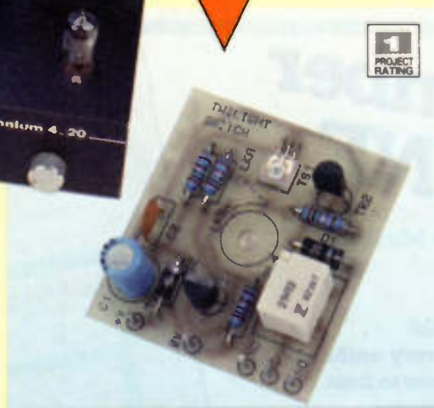


MILLENNIUM VALVE AMPLIFIER PSU

A Power Supply kit for the Millennium 20W Valve Power Amplifier. The supply is capable of powering up to two amplifier modules for a stereo system, or alternatively you could use two PSU kits and two amplifier modules to produce a pair of 'monobloc' amplifiers.
Order as: LT44X, **Price £49.95** C6. Details in *Electronics* No. 73 (XA73Q).



TWILIGHT SWITCH

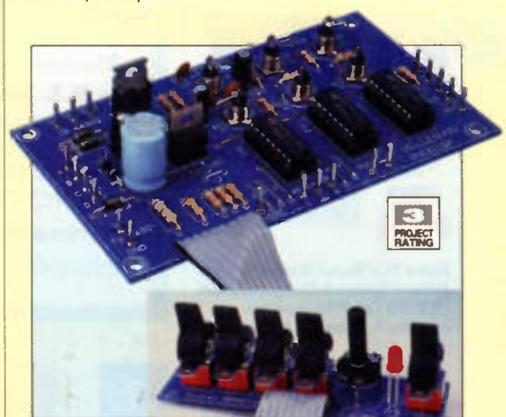
Using the ULN3390T opto-electronic switch, this versatile project senses the ambient light level and operates the built-in relay at dawn and dusk. Typical applications are automatic control of lighting, night-time security or anywhere that daylight related switching is required.
Order as: LT47B, **Price £5.95**. Details in *Electronics* No. 73 (XA73Q).

EXTRA LARGE LED DISPLAY

A choice of two 20cm (7 1/2in.) 7-segment LED displays, catering for open-collector and open-anode circuits. Ideal for educational equipment, public displays, exhibitions, demonstrations, clocks etc. Connects to existing 7-segment display drivers. Operating voltage: 22 to 26V DC, maximum supply current: 400mA.
Order as: VF01B, Common Cathode Version, **Price £32.95,** or: VE63T, Common Anode Version, **Price £32.95**. Details in *Electronics* No. 74 (XA74R).

MODULAR GRAPHIC EQUALISER FRONT PANEL

A pre-drilled front panel and pre-printed foil to give a professional look to your completed equaliser project. The panel is suitable for a standard 19in. housing having a height of 2 units (2U).
Order as: VE41U, **Price £32.95** A1. Details in *Electronics* No. 74 (XA74R).



GRAPHIC EQUALISER PSU & SWITCHING UNIT

Part of the Modular Graphic Equaliser System. This project provides a regulated power supply for various of the other units in the system, a front panel mounted line input sensitivity control and also provides all of the necessary switching functions.
Order as: VE45Y, **Price £32.95**. Details in *Electronics* No. 73 (XA73Q).

AUTOMATIC REAR WIPER CONTROL UNIT

At last! Comprehensive control for rear window wipers, tied into the operation of the front windscreen wipers and gearbox. Facilities include: Single shot (when front wipers turned on), Intermittent operation (when front wipers on), and Auto wipe (Reverse gear selected and front wipers on).
Order as: LT46A, **Price £9.95.** Details in *Electronics* No. 74 (XA74R).

These descriptions are necessarily short. Ensure that you know exactly what the kit is and what it comprises before ordering, by checking the issue of *Electronics* referred to in the list.
The referenced back-numbers of *Electronics* can be obtained, subject to availability, at £1.95 per copy.
Carriage Codes – Add; A: £1.45, B: £2.10, C: £2.65, D: £3.15, E: £3.70, F: £4.25, G: £5.10, H: £5.70.

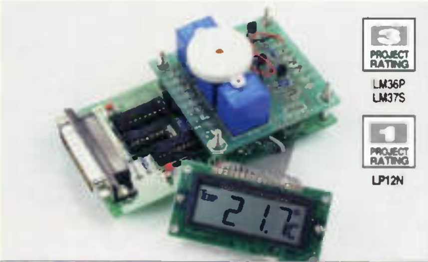
DID YOU MISS THESE PROJECTS?

The Maplin "Get-You-Working" Service is available on ALL of these projects.

To order Project Kits or Back-numbers of *Electronics*, 'phone Credit Card Sales on (0702) 554161. Alternatively, send off the Order Form in this issue, or visit your local Maplin Store.
See base of this page for locations of Maplin Stores.

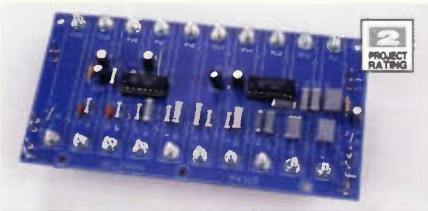
Maplin: The Positive Force In Electronics

All items subject to availability. Prices include VAT.



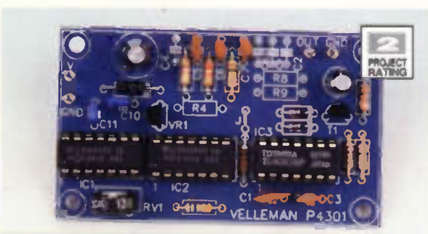
USING TEMPERATURE MODULES

This very practical *Electronics* article details the use of the following projects which, when used in conjunction with the range of temperature modules available from Maplin, can provide some extremely versatile environmental control functions.
Order as: LM37S (Relay Interface Card Kit), **Price £12.45**; LM36P (Serial/Parallel Converter Kit), **Price £14.95**; LP12N (24-line PC I/O Card), **Price £21.95**. Details in *Electronics* No. 71 (XA71N).



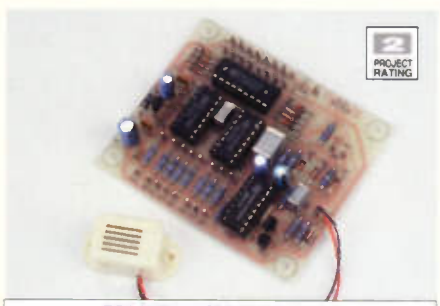
10-BAND GRAPHIC EQUALISER MODULE

This easy to build equaliser project has ten frequency bands that allow you to adjust audio response to your particular preference.
Order as: VE44X, **Price £34.95**. Details in *Electronics* No. 71 (XA71N).



PINK NOISE GENERATOR

This easy to build pink noise generator employs a pseudo-random digital noise source and can be easily adapted to produce white noise if required.
Order as: VE43W, **Price £11.95**. Details in *Electronics* No. 72 (XA72P).

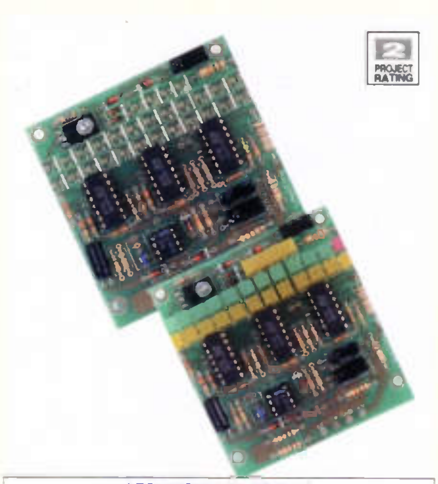


PRIORITY QUIZ BUZZER

No more arguments about who got the answer first! This versatile system allows up to eight contestants to battle it out without altercation, and can be expanded in blocks of eight by simply adding more units. Order as: LT41U, **Price £9.95**. Details in *Electronics* No. 72 (XA72P).

DIGITAL MODEL TRAIN CONTROLLER

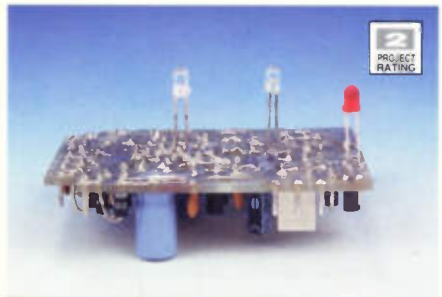
This versatile project allows you to control up to fourteen locomotives on a single layout, with up to four locomotives being active at any one time. The basis of the system is a Common/PSU board, to which one controller is added for each active locomotive. All locomotives require a receiver. To complete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



LED POWER METER

A pair of LED power meters for the Velleman Stereo MOSFET Amplifier, VF17T. The meters can be used in either stereo or mono configuration. Order as: VF18U, **Price £34.95**. Details in *Electronics* No. 72 (XA72P).

Visit our stores in: Birmingham, Brighton, Bristol, Cardiff, Chatham, Coventry, **Edinburgh**, **Glasgow**, Ilford, Leeds, Leicester, London (Edgware, Forest Hill and Hammersmith), Manchester (Oxford Road and Cheetham Hill), Middlesbrough, Milton Keynes, Newcastle-upon-Tyne (The Metro Centre, Gateshead), Northampton, Nottingham, Portsmouth, Reading, Sheffield, Slough, Southampton, Southend-on-Sea, Stockport, plus NEW stores opening soon in Stoke and Dudley. Ring 0702 552911 for further details.



INFRA-RED SWITCH

Look, no hands! This versatile remote control switch can operate a multitude of electrical or electronic equipment without you even touching it.
Order as: LT38R, **Price £9.95**. Details in *Electronics* No. 71 (XA71N).

STEREO MOSFET AMPLIFIER

A superb high power stereo amplifier that sounds as good as it looks. Bridged configuration transforms the unit into a 600W (music power) mono amplifier.
Order as: VF17T, **Price £299.95** H29. Details in *Electronics* No. 71 (XA71N).

TWINKLING CHRISTMAS CANDLE

This simple to build, high tech electronic candle has a realistic pseudo-random flicker, but won't burn a hole in your pocket – or anything else for that matter. Ideal for decorations or plays, as there is no danger of fire, or of the flame being blown out. The kit includes constructional details of a suitable cardboard lantern for the festive season. Order as: LT40T, **Price £6.95**. Details in *Electronics* No. 72 (XA72P).