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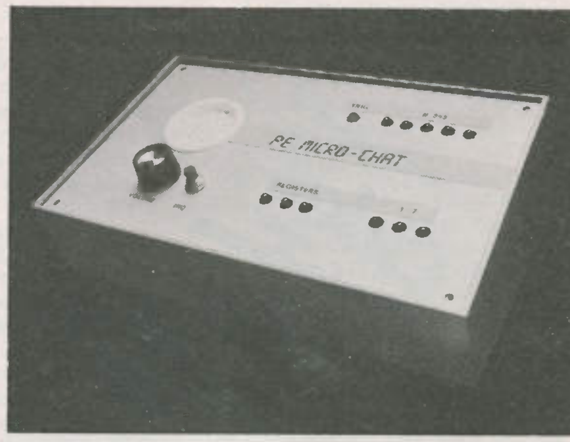
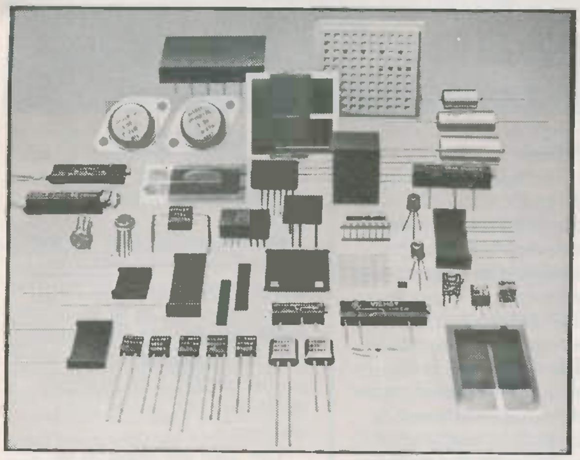
THE SCIENCE MAGAZINE FOR SERIOUS ELECTRONICS AND COMPUTER ENTHUSIASTS

PRACTICAL ELECTRONICS

PE VOL 23 NO 8 AUGUST 1987

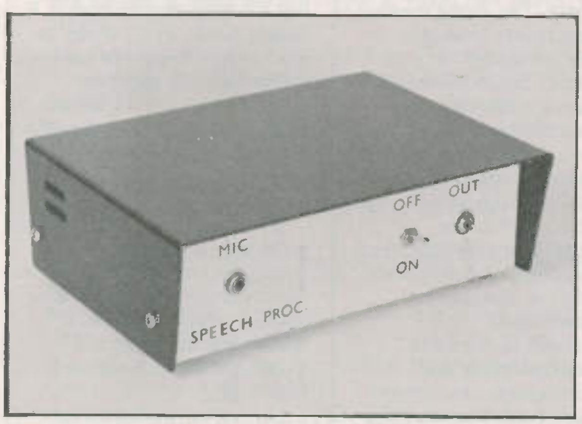
CONSTRUCTIONAL PROJECTS





SPECIAL FEATURES

REGULAR FEATURES



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THE SCIENCE MAGAZINE FOR SERIOUS ELECTRONICS ENTHUSIASTS

CATALOGUE CASEBOOK

Last month we received details of the following catalogues and literature:

British Amateur Electronics Club. April 1987 newsletter – **practically a magazine** in its own right! **B.A.E.C.,** 26 Forrest Road, Penarth, South Galmorgan.

Airwaves. The quarter journal of the IBA, Spring 1987. This issue **celebrates 30 years on ITV** for Schools. **IBA,** 70 Brompton Road, London SW3 1EY.

Bulgin. Newly released comprehensive catalogue **featuring their full range** of electrical and electromechanical components. **A.F. Bulgin & Co PLC,** Bypass Road, Barking, Essex, IG11 0AZ.

Electronic and Computer Workshop. Highly informative and understandable book describing **how to get the best from an oscilloscope. ECW,** 171 Broomfield Road, Chelmsford, Essex, CM1 1RY.

Eraser International. Comprehensive electrical and **electronics production** shortform catalogue. **Eraser International Ltd.,** Unit M, Portway Industrial Estate, Andover, SP10 3LU.

Gould. A six page colour brochure on Gould's **3000 series of real time oscilloscopes,** providing detailed technical data on the three instruments in the range. **Gould Electronics Ltd.,** Roebuck Road, Hainault, Ilford, Essex, IG6 3UE.

Hitachi. Designer's software reference manual for the HD6305 family of microprocessors. **150 pages of detailed information** for designers using this range. **Hitachi Electronic Components (UK) Ltd,** 21 Upton Road, Watford, Herts, WD1 7TP.

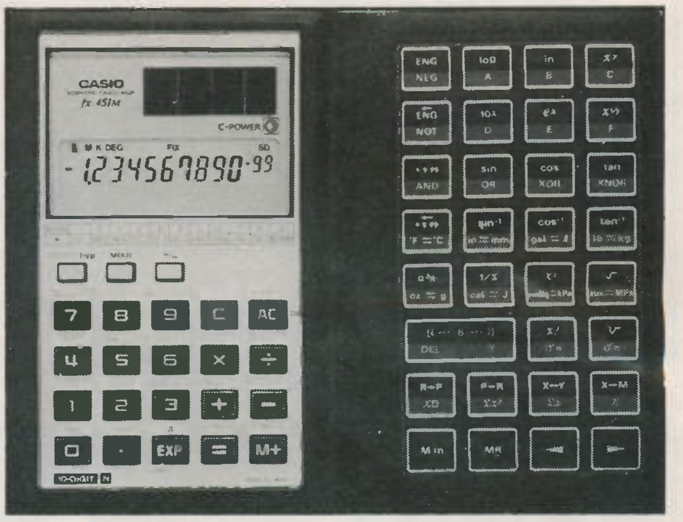
Seimens. Beautifully produced **February 1987 magazine** related to their component ranges. Also, their **liturature selector catalogue,** January 1987. **Seimens Ltd.,** Seimens House, Windmill Road, Sunbury-on-Thames, Middx, TW16 7HS.

S.E.R.T. Electronics in Measurement, Automation and Control **April 1987 magazine. S.E.R.T.** 57-61 Newington Causeway, London SE1 6BL.

Willis. 1987 catalogue of a **wide range of computer supplies,** including cleaning products for vertually every purpose with IBM 3480 drives. **Willis Computer Supplies Ltd.,** PO Box 10, South Mill Road, Bishop's Stortford, Herts, CM23 2DN.

PE

WHAT'S NEW



Solar calcs

Casio C-Power, the battery back-up for solar powered calculators that preserves data and memories when the light fails, is available in two new scientific models.

The FX451M is of the integrated-wallet format, with standard numeral and math keyboard in conventional press-button style, supplemented by the flat keypads of 'magic touch' leaf keys. Between them they afford 132 pre-programmed scientific functions, base conversions, physical constants and metric/Imperial equivalents. All calculations are to 10-digit accuracy.

In the more traditional hard case format, the FX911M boasts 79 functions and 8-digit capacity.

The recommended retail price of the Casio C-Power scientific calculator FX451M is £21.95; the FX911M is £15.95.

Hear hear!

Following complaints from the hard of hearing, a working group has been set up to study the problem of poor dialogue audibility in some television programmes. The group consists of representatives from the British Broadcasting Corporation, the Independent Broadcasting Authority, the Independent Television Companies Association, the Royal National Institute for the Deaf and the British Association of the Hard of Hearing.

People with hearing difficulties have complained that they find it hard to follow dialogue in programmes when accompanying background noises, such as music and audience response, are present at a similar level. The working party intends to organise a series of tests to investigate the way that this type of sound balance affects the intelligibility of dialogue, both for hard of hearing and normal hearing viewers.

Background sounds are used in television programmes to create atmosphere. The purpose of the tests will be to see if the sound balance can be altered, without impairing artistic effect, so that people with hearing difficulties can follow the dialogue.

The tests are likely to be complicated by the large number of factors that contribute to the problem and the manner in which hearing difficulties vary. It is hoped that the investigation will lead to a clearer understanding of the problem, and be able to suggest improvements.

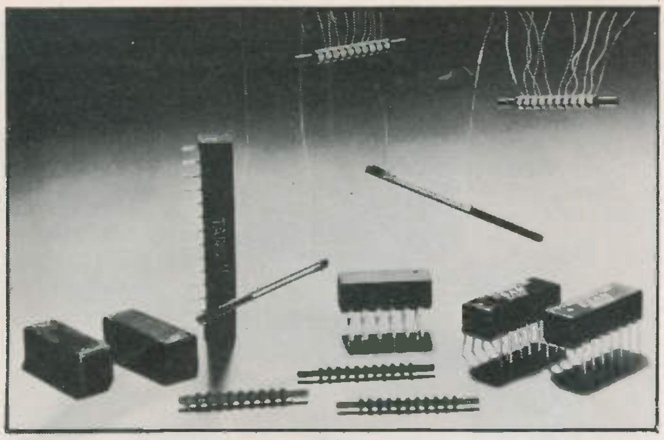
Cirkit change

Richard Bulgin has been appointed Managing Director of component suppliers Cirkit Holdings PLC, succeeding Christopher Sawyer who is leaving the company to pursue other business interests.

Richard Bulgin has spent the last fourteen months with A.F. Bulgin & Co. PLC, where as Operations Director he has been responsible for major re-structuring of the warehouse facilities and the selection and commissioning of a new computer system for the company.

No stranger to Cirkit, he was previously a member of the management team which formed the company three years ago, playing an active part in developing the Industrial Consumer and Educational Divisions.

For further information contact **Cirkit Holdings PLC, Park Lane, Broxbourne, Herts EN10 7NQ. Tel: (0992) 444111.**



Plastic Ferrite

A carbonyl iron filled diallylphalate moulding compound can be supplied by Synres-Almoco BV. This grade has specific soft magnetic properties and can be used for induction cores or coils in delay modules and delay lines. These devices generate delays and control the pulses in circuits for scientific and commercial computers.

Traditionally this kind of core is made from ferrite, but this is difficult to shape into small complex components and has low mechanical strength. Consequently, there has been a need for a suitable plastic to replace ferrite.

The thermosetting moulding compound DAP 5801 from Synres-Almoco, offers the possibility to manufacture complex, thin cores and coils with very close dimension tolerances. The carbonyl iron filler gives the material the required soft magnetic properties of permeability and coercive force at a suitable level.

According to Synres-Almoco, this product offers unique magnetic properties, particularly suited for all applications where dimensional stability and soft magnetic properties must be combined with easy processing.

Contact: Beta Public Relations B.V. P.O.Box 18, 3150 AA Hoek van Holland, The Netherlands, Tel: 01747-4342.

COUNTDOWN

If you are organising any electronic, computing, electrical, scientific or radio event, big or small, drop us a line. We shall be glad to include it here. Send details to **COUNTDOWN,** Practical Electronics, 16 Garway Road, London W2 4NH.

PLEASE NOTE: Some events listed here may be trade only, or restricted to certain categories of visitor. Also, please check dates, times and other relevant details with the organisers before setting out as we cannot guarantee information accuracy.

Periodic Hitachi Graphics User Group. 0923–46488.

Periodic The 405 Line Society – historical TV preservation. Parkstone (Dorset) 748072.

Jul 7–8. Telementry UK. Bloomsbury Crest, London. 0799-26699.

Aug 28–Sep 6. International Audio & Video Fair Berlin. 0511 529999.

Sep 1–4. International Conference on Japanese Information in Science Technology and Commerce. University of Warwick. 01-323-7924.

Sep 3–7. SIM-HI.FI-IVES European showcase of music and consumer electronics. Milan 01-4815541.

Sep 15–18. International Conference on Japanese Information in Science Technology and Commerce. University of Warwick. 01-323-7924.

Sep 15. Outdoor Sound propagation (IOA). Open University, Milton Keynes. 031-225-2143.

Sep 15–18. Design Engineering Show. National Exhibition Centre, Birmingham. 01-891 5051.

Oct 6–8. Internepcon Packaging Show. Metropole Convention Centre, Brighton. 01-891-5051.

Oct 13–15. British Laboratory Week '87. Grand Hall, Olympia, London, 0799-26699.

Three irons

Three new Weller mini soldering irons are the latest additions to Cooper Tools' product range.

The new range includes a 12 watt micro point iron and a 17 watt fine point iron for more delicate soldering jobs, and a standard point iron for medium duty work.

Manufactured at Cooper Tools' Tyne and Wear factory, the new mini irons have suggested retail prices (ex. VAT) of £6.57 for the 12 watt model, £6.75 for the 17 watt model and £6.95 for the 25 watt model. Replacement tips are available for the three irons at the outstanding price of just 60 pence each, and there is an alternative choice of an iron-plated tip for the 12 watt iron priced at £1.05.

This range made its debut at Cooper Tools' Stand at the Exclusively Tools Show (Kensington Exhibition Centre, 11-13 May). Featured also at the Show were the company's other leading brand lines including Lufkin tapes, Crescent wrenches and screwdrivers, Nicholson files and saws, Plumb hammers and wrecking bars, Wiss snips and Xcelite screwdrivers and nutdrivers.

For further information contact **Cooper Tools Ltd, Sedling Road, Wear, Washington, Tyne & Wear NE38 9BZ. Tel: (091) 416 6062.**

Two test

The Thandar Model TG401, 4MHz function generator, fully GPIB programmable, is now available from Electronic Brokers. Designed for automatic test equipment and benchtop applications, the TG401 generates sine, square, and triangle waveforms from 0.01V to 10V peak-to-peak (20V peak-to-peak in an open circuit), and d.c. output or offset from –5V to +5V into 50Ω. Waveforms can be continuous, triggered or gated.

The instrument is IEEE-488 compatible and codes and formats are according to IEEE-728. It operates as a listener and talker with extended subset capabilities.

Extended software allows clear operation with an easy to understand panel to minimise possible operator errors. The generator will automatically set a frequency or amplitude/offset to the optimal range. If data is not at full display resolution, the TG401 will allocate this, and a corresponding error message will indicate incorrect settings or syntax errors.

Other features include simultaneous frequency and level displays, the ability to store 99 complete instrument settings for fast recall; a 4-digit synthesiser accuracy, and a modify function which enables any parameter to be shifted up or down around a predetermined nominal value, simplifying electronic tests.

The TG401 also has built-in internal sweep capabilities with programmable start and stop frequency, up or down, step size and rate.

Easily portable, the TG401 function generator weighs 4kg. Options include an IEEE-488 interface, a synthesiser, a 19 inch rack mount kit, and rear panel output.

Another new piece of test equipment from Electronic Brokers is the Marconi Instruments TF2304 FM/AM battery-portable modulation meter, with high accuracy, automatic tuning and automatic level setting.

Designed primarily for the servicing and production testing of radio communications systems, the TF2304 covers carrier frequencies from 9 to 12MHz and from 18 to 1000MHz.

FM deviation is measured in eight ranges from 1.5 to 50kHz full scale, and a.m. depth is measured in two ranges of 30% and 100% full scale, with a further uncalibrated range of 10%. Accuracy for both f.m. and a.m. measurements is ±3% of full scale.

A major feature of this meter is ease and speed of use. Once connected, the instrument tunes automatically to the r.f. carrier frequency, sets the signal level, and displays the f.m. deviation or a.m. depth on the panel meter in a few seconds.

Designed with mobile radio testing in mind, the TF2304's deviation ranges have been chosen for this purpose. Extension of the carrier range down to 9MHz allows the meter to cover the standard 10.7MHz intermediate frequency.

For information on either of these items, contact **Electronic Brokers Ltd., 140–146 Camden Street, London NW1 9PB.**

CHIP COUNT!

This month's list of new component details received – mainly chips, but other items may be included.

212 series. Teledyne relays rated at 2 amps, featuring unique Telesium contacts (MC).
627 – 632 series. New ranges of surface mount thick film resistor networks (QT).
6845 ACRTC. Advanced CRT controller 'go-faster' (25%) graphics chip (HT).
701067, 701071. Improved, more stable, 0032-type high speed op-amps (TP).
HM100490. 64K×1 ECL RAM. Claimed to be the World's fastest – 7 nanoseconds (HT).
LC422 series. Very small low pass video filters for 'lower cost' digital processing. 601 compatible (MC).
NE5152. High Speed, high resolution RGB video DAC for bit-mapped graphics displays (ML).
NE5212. Transimpedance amp with improved performance and lower cost for fibre optics receivers (ML).
SE-NE5060. Low cost, precision high-speed sample and hold amplifier. (ML).
TP4950. Single mode Laser diode module for high speed, long life optical communications applications (TP).

Manufacturers, and contact telephone numbers for further details. (HT) Hitachi, 0923 46488. (MC) MCP Ltd, 01-902 1191. (ML) Mullard, 01-580 6633. (TP) Teledyne Philbrick (via MCP Ltd), 01-902 1191. (QT) Quantum (Beckman), 061-872 8121.

µP pH

There are four pH meters in a new state-of-the-art range from Channel Electronics. Top of the range is the 3100 hand held microprocessor unit, which has inbuilt buffer comparison memories, touch pad calibration and a non-volatile back up memory to retain all necessary information when the instrument is in the off mode. To facilitate ease of use and to give security of information entry there is an audible data accept signal, as well as the backup of visual error display. The 3100, which is controlled by a powerful inbuilt microcomputer, has no moving parts, as all calibrations are carried out automatically. It will also measure temperature, has automatic temperature compensation and will directly display mV for redox and ion selective measurements.

The Model 3070 is a general purpose laboratory/industrial instrument which is housed in a slim plastic case and, like the 3100, has a splashproof membrane keyboard. This unit has conventional buffer and slope calibration controls plus the added advantage of automatic temperature compensation, direct temperature measurement and the mV range for redox and ion selective measurements.

The Model 3050 is housed in the same miniature case as the other models and is also powered by the standard 9V battery, but it has been designed as a simple pH readout instrument having manual temperature compensation plus the usual hi-contrast l.c.d. readout.

All the above instruments are provided with a standard gel filled pH electrode type PCP 501 (fitted with a BNC connector) for normal liquid measuremens, but may be ordered with any of the Channel Electronics range of specialist pH electrodes.

Each instrument is supplied as standard with parts listed in the feature comparison table, and optional accessories are available. The highly compact 'stick' Model 3060 also features touch sensitive membrane switches and measures both pH and temperature with automatic compensation from 0 to 100°C. It is supplied with a replaceable combination pH electrode with integral temperature sensor plus buffers and foam lined carrying case.

For further detail contact **Channel Electronics (Sussex) Ltd., PO Box 58, Seaford, Sussex BN25 3JB.**

Vero Analogue Psus

TWO new analogue bench power supplies now available from Verospeed, including a unique quad output model. Its four independent floating outputs can be connected in any desired series or parallel combination to give up to 70V or 4A. Both supplies offer true constant current and constant voltage operation, an excellent electrical specification and high safety standards, making them ideal for both R and D and educational use.

Designated as the GPQ3020 for the quad model, and GPR3020 for the single output model, these new power supplies feature simultaneous metering of voltage and current, and can be used as constant voltage or current supplies. Individual outputs from the quad supply are two at 0-30v, 0-2A, on 5V(fixed) 1A, and one 5V (fixed) 3A. All series and parallel combinations of these outputs are available, giving a maximum of 70V or 4A as required. Series/parallel connections are accomplished internally at the press of a button, with a further push-button to control the independent or dual tracking facility. The single output supply has a voltage range of 0-30V and two current ranges variable from 0-2A.

All outputs are fully protected against overload, and short circuit. Outputs from the power supplies are fully floating, and up to 105% of output voltage is always available. Safety approvals given include BS415 and IEC 348. The power supplies come complete with all necessary leads, and an instruction manual.

Contact: Verospeed, Stansted Road, Boyatt Wood Industrial Estate, Eastleigh, Hants., SO5 4ZY. Tel: 0703 641111.

New Plastic D-Submins

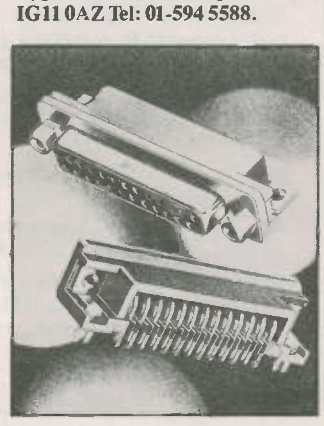
A. F. Bulgin & Company PLC have launched a new range of Beau D-subminiature connectors on the U.K market. The new 'Theta-D' series connectors are manufactured in plastic with metal shells and are designed specifically for PCB applications. they are fully compatible with all D-subminiature connectors.

Mounted at right angles to the circuit board, 'Theta-D' plugs and sockets offer a choice of 9, 15, 25 or 37 gold plated contacts. Setback configurations are 0.590in. in addition to the European 0.318in. style.

The 0.590 series offers three mounting options: holes, threaded steel standoffs for RS-232 cable assemblies and No.4-40 threaded inserts for bulkhead mounting. Inserts are factory assembled thereby eliminating the need to install jam nuts in the back of the panel.

Additionally 0.590 series provides three alternative grounding facilities: forked feedthrough ground, featuring a ground strap along the top surface and a combination ground, which has a strap.

Contact: A.F. Bulgin & Co. PLC Bypass Road, Barking, Essex IG11 0AZ Tel: 01-594 5588.



68000 trainer

The Flight Electronics 68000 microprocessor trainer (FLT-68K) can now be linked to a BBC micro so that users can learn 68000 programming and develop 68000 applications in the familiar BBC environment.

The FLT-68K's high-speed in-line assembler and efficient debugging facilities are easily accessed from the BBC micro. The computer and monitor act as a terminal and control console, connected via the serial port and a printer can also be attached.

A powerful cross-assembler package is available, enabling 68000 object code to be generated on the BBC and downloaded to the FLT-68K. The package allows high-speed assembly, using standard Motorola mnemonics throughout. The object code files may be formatted in absolute binary, or Motorola 'S' format. Files can be sent to disk or to the FLt-68K. Source code modules can be stored on disk for assembler recall, and can be included in other source code modules.

By defining labels, symbols, and variables as local to a source code module, up to 4Mbytes of source code can be assembled. Other features include user defined listing format, full range of pseudo ops, and a help facility which displays the entire 68000 instruction set.

The cross-assembler package includes a 16K eprom, two utilities diskettes, and a comprehensive instruction manual. The eprom is compatible with the BBC B and Master series machines. The BBC B also requires a terminal emulator ROM.

For further information contact **Flight Electronics Ltd., Ascupart Street, Southampton SO1 1LU. Tel: (0703) 227721.**

THE FLIGHT 68K TRAINER WAS REVIEWED IN THE JULY ISSUE OF P.E.

Graphics tablet

The A3 Graphics Tablet Mark II from Cherry Electrical Products offers several improvements over its predecessor. Users can now change from stylus to cursor puck at the flick of a switch, with none of the plug-swapping previously required. Altering configurations is also quicker, with 16 set-up DIP switches now placed in a more easily-accessible position at the rear of the tablet.

Other new features of the Mark II tablet include an LED power-on indicator, and a single industry-standard 25-pin 'D' connector that provides both parallel and serial ports. For cases where power cannot be supplied from the host computer, a new calculator-style independent power supply has also been provided. A choice of three mains connectors for the power supply is available: US 2-pin, continental 2-pin, and UK 3-pin.

Priced £550, the Cherry A3 GraphicsTablet Mark II package includes the digitising tablet itself, a 4-key, cross-hair cursor puck, a stylus, the power supply, interface cabling, a set of user-definable menu strips and marker pen, and comprehensive documentation. Computer graphics users thus have everything needed for a simple and accurate digitisation of existing drawings and creation of new ones for storage and recall with no 'optional' extras required.

The new tablet has a standard A3 working area of 384mm x 260mm which can be increased to 284mm x 290mm if the menu strip is not being used. The averaging technique ensures a stable and accurate display under all normal operating conditions and achieves a resolution of 0.1mm with an accuracy of better than ±0.5mm. Since virtually all painting or CAD software features a 'zoom' option, however, the tablet's actual accuracy can be made almost infinite.

RS232 serial, and serial or parallel TTL interfaces, all with optional handshaking are supported, with a choice of standard ASCII or packed binary formats. User-selectable baud rates of 300, 1200, 2400, 4800, 9600 and 19200 are available in point, stream or switch-stream modes. Because of this flexibility, Cherry's new tablet can be attached to practically any type of computer system. In addition it supports industry-standard SummaGraphics protocols.

For further details contact **Cherry Electrical Products Ltd., Coldharbour Lane, Harpenden, Herts AL5 4UN. 05827 63100.**

BBC CONTROLLER

CONNECT3 is an interface for the BBC model B, B+ and Master computers ideally suited to a wide range of computer control and monitoring. It plugs into the user port and printer port of any suitable computer in the BBC family. It has its own mains powered supply. Eight LEDs on the interface show the condition of the eight bits of the printer port. Two green, two yellow and four red LEDs are fitted, which help with traffic light simulation, for instance. The eight printer port bits are buffered and switch power to eight 4mm output sockets, providing up to 1 Amp at a voltage selected by a master switch. The supply voltage can be switched between 3, 4.5, 6, 9 and 12Volts. The outputs can directly drive motors, lamps, relays and buzzers.

Forward, reverse, on and off control of motors is provided by four pairs of 'motor output' sockets. Printer port bit 0 is used to switch power to the first pair, and bit 1 drives an internal changeover relay to reverse the polarity. Bits 2 and 3, 4 and 5, and 6 and 7 are similarly paired. Four motors can be controlled in this way. For example, the motors for construction kits such as LEGO, Fischer Technic and Robotix kits can be connected directly to CONNECT3.

Eight buffered input sockets give access to the eight bits of the user port. Inputs can come from anything that closes a pair of contacts or switches a transister on. Four sockets provide earth return points for inputs and outputs, and a +Vout socket provides a connection to the DC power supply. Connection to the outside world is by colour coded standard 4mm jack sockets. A range of accessories is available with stackable matching plugs.

CONNECT3 is compatible with a range of control software available to schools, including JAVELIN, BITS, CONTROL-IT, and CONTROLLER. It can also be driven from Basic programs by writing to the printer port at address &FE61 and reading from the user port at &FE60. Software control of motor speed is possible using CONTROL-IT, or timer driven assembler code. CONNECT3 costs £75.00 ex VAT.

Contact: Phobox Electronics, Holworth House, Holworth, Dorchester DT2 8NJ. Tel: (0305) 852340.

Easily strapped

Conductive wriststraps are used to drain off electrostatic charges from operators handling static sensitive components but can be an annoyance to their users and lead to them disregarding antistatic precautions. The Wristex features a flexible and skin-friendly wristband. The snap fastening can be rotated through 180 degrees and incorporates in the mould a 1MΩ protection resistor. The highly flexible coiled cord extends easily from 60cm to a full 180cm without significant force, and costs £8.50.

Cobonic Ltd., 32 Ludlow Road, Guildford, Surrey GU2 5NW. Tel: (0483) 505260.

Mobile licence

A new form for applying for a private mobile radio licence has been introduced by the Department of Trade and Industry's Radiocommunications Division.

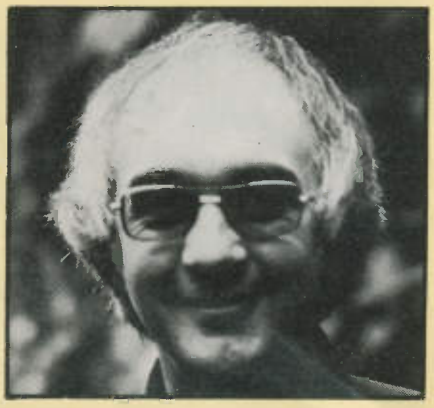
The new form (PMR1) is easier to complete and is intended to speed up the licensing process. It replaces the old CL1 form and can be used to apply for a new private mobile radio licence or to request amendments to existing systems. Copies can be obtained from the

Department of Trade and Industry, PO Box 20, London SE1 8TZ. Tel: 01 275 3200.

PE

THE LEADING EDGE

No standards



Who is this chap Seedy Rom?

BY BARRY FOX

IF you are waiting for CD ROM in your local hi fi shop, or computer store, be prepared for a long wait. Although we are continually told that CD ROM systems and discs are just round the corner, at the Which Computer Show in Birmingham earlier this year I did not see a single CD ROM on demonstration. More recently I was involved in a symposium, where two dozen people with a special interest in CD ROM locked themselves into a hotel for a weekend and exchanged views. They were all high flyers, either already making and selling CD ROM hardware and software, or planning to do so soon. I left, pretty disillusioned.

Several large publishers have identifed niches in the market where they can publish existing material on CD ROM, instead of on paper or microfiche, or instead of sending it down a telephone line as an on-line database. So they are selling the concept of CD ROM to a captive audience of existing customers. In most cases they are offering their customers an integrated system, with hardware and software tailored to a particular use. In the trade this is known as a "vertical market".

For example, book shops currently keep a paper or microfiche record of all books in print and available. This list is published by Whitaker. When a customer wants to buy a book, the staff look it up and, if necessary, fill out an order form. Now the bookshop can buy a CD ROM containing the same list of books. When a customer asks for a book the title is checked on screen and the computer automatically puts together the necessary electronic commands for an order, which is automatically sent down a telephone line when the control computer is polled during off-peak hours. The shop uses the system for this specialised purpose, with just one CD ROM disc which is regularly updated by a new pressing which arrives through the post. Another publisher, Silver Platter, sells a CD ROM disc which contains all the addresses of all the 23.5 million households in Britain, with accurate postcodes. Firms can use the disc to check customers's addresses (you would be surprised how many people still don't know, let alone use, their post code) or generate unsolicited junk mail by the sack load. The Oxford University Press sells CD ROM versions of its specialist encyclopaedias and the full works of Shakespeare in original text.

The CD ROM disc for one vertical system will often not run on CD ROM hardware installed for a different vertical use. What surprised me was how little some of the publishers seemed to know or care about this. They had no apparent interest in creating a "horizontal market", where hardware is widely sold for use with a wide range of software – eg from high street shops like Dixons, Wildings and Rymans.

At the symposium one speaker, Graham Seddon of computer firm BRS, rammed home the full extent of the absurd lack of standardization which exists in the CD ROM marketplace.

The basic CD ROM standard was set by Philips and Sony in the so-called Yellow Book. This defines the physical format of the 12cm disc, just as the Red Book defines the standard for CD Audio. The Yellow Book also defines the extra error correction needed when a CD carries digital data instead of digital sound.

The Yellow Book does not define the logical format, which is the way the data is laid out on the disc, with an index of all key words so that computer software can search out selected data sections. Without agreement on a logical format, there was no hope of a standard disc for CD ROM which would play on any CD ROM system. So in October 1985 a group of worried computer people met at the High Sierra Hotel in Lake Tahoe, Nevada to try and agree a logical format. They met regularly, and came up with a proposal for a standard in June 1986.

The HSG has no official standing, but since June 1986 some of the computer industry have been using the HSG Proposal as a de facto standard. Meanwhile the National Information Standards Organisation (NISO) in America and the European Computer Manufacturing Association (ECMA) have been considering the High Sierra Group Proposal. If they can finally agree, the next step is for the HSGP to go to the International Standards Organisation (ISO) for formal ratification as a world standard by the end of this year.

All this sounds fine and dandy. But it's not. Not all CD ROM discs exactly follow the HSG Proposal for a volume directory or table of contents on the disc. And before the High Sierra Group Proposal Philips had come up with its own logical format for discs. Even assuming that all small business computers work on the IBM PC/AT standard, some use the MS DOS operating system and others use Unix/Xenix. There are three main types of CD ROM drive on the market, made by Philips, Sony and Hitachi, and all are different. There are several types of intelligent interface which can be used between the CD ROM drive and the computer, eg SCSI.

The only way to get a given CD ROM disc to work with a given drive and a given interface and a given operating system, is to use device drive software. This comes on a floppy disc and loads into the computer before use of the CD ROM disc. The range of mis-matching possibilities means that at least 24 different device drivers are needed to cover every eventuality. They don't all exist. What's more, if someone wants to use a CD ROM disc in combination with a word processing program or spread sheet, extra software will often be needed to fuse one to the other.

All this explains why firms using CD ROM for optical publishing concentrate on vertical marketing – providing an integrated package of computer hardware, computer software and CD ROM drive tailored to their own CD ROM discs. It also explains why a horizontal market for CD ROM hasn't yet emerged and why CDI or CD Interactive was created.

Encouragingly Philips and Sony have set a very rigid standard, which exactly defines the hardware and software to be used for data, text, sound and still picture storage on CD so that any CDI disc will play on any CDI system. PE

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PAPER AND CHIPS

WHEN paging through stacks of promotional leaflets, submitted texts and correspondence it is obvious that despite hi-tech communication trends, the age of paper is not yet dead. Though the Chip may be powerful, the pen and printing press are still mightier for some informative purposes.

Certainly instant source-to-recipient technology thrives healthily – modems, teletext, data satellites, electronic offices, are all viable systems. As a technophile, I applaud these and other electronic innovations, when they are practical. Yet it is an inescapable conclusion that chips without paper are still inappropriate for many textual applications. Sheet paper remains as vital to society as sliced silicon.

Take this editorial office for example. I am surrounded by word processors; indeed I am using one now, with a multi-megahertz clock following every move I make. Presently sophisticated plastic will record my digitised thoughts, during a high speed discussion between WP and disc drive. Ideally, the data could also stream down a phone line to our typesetters, or the disc could be sent by post. Fine, if there is data uniformity.

Despite increasing standardisation, compatibility can be expensive, and its price often prohibitive. Especially when typesetters serve many publishers, all of whom have a favourite system. Cost-effectively my best option is to send the typesetters a printout of this script. Naturally, they will retype it and in due course another print will return for checking. More paper; more time; more expense, but cheaper than multi-option modems.

Similarly, your computer probably can't talk to mine, so you send me letters and texts on paper. So do advertisers; and their promotional experts. This is another reason why paper is vital – presentation, and thumbing access. However good a VDU screen presentation may be, brochures still display products better. They are also quicker to thumb through than to call up as file data, despite fast CPU access times. Especially as brochures breed on an editor's desk!

Then there are Accounts, for which computers have improved interpretation dramatically. Paradoxically though, digital finance can consume far more paper than hand-written accounts books. Properly used, these form a good sequential entry, random access retrieval system. Certainly computers can be that too, but, and maybe I'm idiosyncratic, it's the paper displays that I prefer to browse thorugh, even though it means making lengthy printouts. These hardcopy backups are also immune to magnetic bugs, inspite of being fragile in other ways.

Undoubtedly chips and VDUs bring sophistication to business and domestic life, but thankfully the age of the ream continues, still allowing me to read electronics magazines on the train, without a lap-sized terminal. Although I want menu-driven chips, I prefer them to be paper-backed.

THE EDITOR

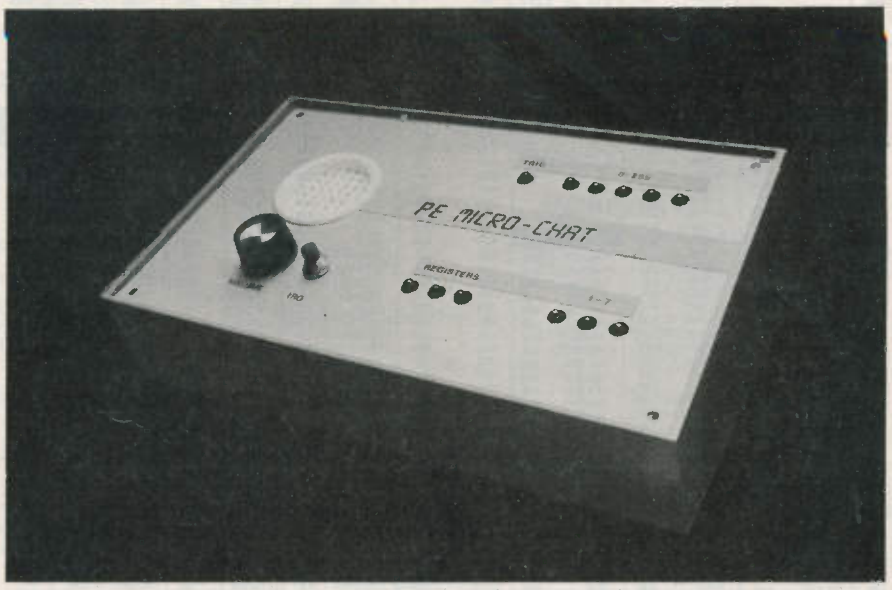
OUR SEPTEMBER 1987 ISSUE WILL BE ON SALE FRIDAY, AUGUST 7th 1987 **(see page 2)**

This speech synthesiser uses the SSI 263A speech chip with PET Basic, easily adaptable to the C64 and BBC.

PE MICRO-CHAT

PART ONE BY MALCOLM HARVEY

There's someone on the allophone



SELDOM have I had so much fun and amusement with a project as I have had with this computer controlled speech synthesiser. There is so much versatility and flexibility with the program control parameters, that it has been the cause of much laughter for myself and friends.

The control program has been written for the Commodore Pet, and with additional information for the C64 and BBC computers. The project can probably be used with other computers having an 8-bit port and two handshake lines, but it is regretted that advice cannot be given on changes for other machines. However, if you are well familiar with a different computer, you should be able to write your own program, using the Basic sections of the listing as your guide.

Speech synthesisers have been around for some time now, but it was only a few months ago that I decided to build one, selecting the synthesising chip type, the SSI 263A. Whilst it is not the cheapest chip available, it has so many controllable functions, that it really is worth the extra money.

SOUNDS AND PHONETICS

It is obvious that the written word and its spoken equivalent do not necessarily correspond to the actual spelling. Take bough, cough and rough for example, identical last four letters, but how different the pronunciation. Conversly, take rough and ruff, same pronunciation, but different spellings. And just to complicate matters further, perceived correct pronunciation may vary with locality – as a southern migrant. I now pronounce 'poem' with a long 'o' and a short 'e', yet as a Lincolnshire child, I used to say 'poym'.

Incidentally, a film editor once told me, that the BBC were supposed to have a special department to advise on pronunciation, and those concerned were reputedly known as The Annunciation Aunts!

To know the desired pronunciation for any word it is necessary to split it into separate sections, or phonemes, each representing in some form, the unmistakable sound pattern needed to speak the word correctly. Theoretically, any spoken sound can be represented using phonetic symbols and anyone familiar with the symbolism can understand the precise word pronunciation. Just as there are of course many alphabets for the normal written word, not surprisingly there are also many systems of notation for phonetic symbolisation. Probably the simplest system will be seen in a standard dictionary, where marks are put above various letters to show an approximate guide to pronunciation. It is far from comprehensive though, and it is necessary to look at a phonetic dictionary to get a better idea. Even that system though, does not appear to be totally comprehensive, and in reality the total number of phonemes required may well be uncountable. However, for an acceptable speech synthesiser system, in most instances we can get away with just a representative selection.

The phonetic system used by the SSI 263A was developed specifically for speech sysnthesis by the manufacturers, Silicon Systems. Since they are an American company, it is not surprising that some of the pronunciation phonemes are more at home on the western side of the Atlantic than on the European side. Still, I have found that I can program synthesised speech that is understandable even to a Kent commuter like myself.

ALPHABETICS

In common with other phonetic alphabets, the SSI alphabet works from the premise that sounds can be spilt into two groups, consonants and vowels. Each of these can be further subdivided, depending on the region of the mouth used to create them, and the method of vocal manipulation. Sixty four symbols are avilable, 34 representing sounds basic to the pronunciation of (American) English, (group 1). The other 30 are spilt into Allophones (group 2), and No-sounds (group 3).

The Allophone group symbols represent pronunciation variations from the basic group of 34. They are used to clarify particular sounds not specifically represented in the basic group, so also allowing a degree of manipulation for regional pronunciation differences. The No-sound symbols represent silent states that assist in more closely imitating breathing or natural pauses in normal speech, and are shown as HFC, HVC, PA.

Table 1 shows the SSI symbols, their group, allocated decimal number, and an example of usage as given by SSI (I have made no attempt to change the words to suit UK English more readily). For computational ease, and in the light of experience some codes have been changed and several additions made, as in column three.

TABLE 1: PHONETIC CODES

SSI	GRP	CPX USE	NO	SSI STATED USE
A	1	A/	8	MADE
:A	2	A3	58	MARCHEN (GERMAN)
AE	1	A AE	12	DAD
AE1	2	A1	13	AFTER
AH	1	AH	14	GOT
AH1	2	A2 AR	15	FATHER
A1	2	A1	9	CARE
AW	1	O AW	16	OFFICE
AY	2	AY	5	PLEASE
B	1	B B/	36	BAG
D	1	D D/	37	PAID
E	1	EE E/	1	MEET
E1	2	E E1	2	BENT
E2	2	E3	62	BITTE (GERMAN)
EH	1	EH	10	NEST
EH1	2	E2 AU OR	11	BELT (USA !)
ER	1	ER	28	BIRD
F	1	F F/ PH	52	FOUR
HF	1	H HF	44	HEART
HFC	3	#F	45	(HOLD FRICATIVE CLOSURE)
HN	2	#N	46	(HOLD NASAL)
HV	2	#V	42	(HOLD VOCAL)
HVC	3	#C	43	(HOLD VOCAL CLOSURE)
I	1	I I/	7	SIX
IE	2	Y IE	6	ANY
IU	2	IU	20	YOU
IU1	2	U1	21	COULD
J	1	J J/	49	MEASURE
K	1	C K K/ Q	41	KIT
KV	1	G KV	38	TAG (GLOTTAL STOP)
L	1	L L/	32	LIFT
L1	2	L1	33	PLAY
LB	2	LB	63	LUBE
LF	2	LF	34	FALL (FINAL)
M	1	M M/	55	MORE
N	1	N N/	56	NINE
NG	1	NG	57	RANG
O	1	O/ OR	17	STORE
:OH	2	OH	59	LOWE (FRENCH)
OO	1	OO	19	LOOK
OU	2	OU	18	BOAT
P	1	P P/	39	PEN
PA	3		0	(PAUSE)
R	1	R R/	29	ROOF
R1	2	R1	30	RUG
R2	2	R2	31	MUTTER (GERMAN)
S	1	S S/ X CE	48	SAME
SCH	1	SH	50	SHIP
T	1	T T/	40	TART
TH	1	TH	54	WITH
THV	1	DH	53	THERE
U	1	U/ UE	22	TUNE
U	2	U6	60	FUNF (GERMAN)
U1	2	U2	23	CARTOON
UH	1	UH	24	WONDER
:UH	2	U7	61	MENU (FRENCH)
UH1	2	U U3	25	LOVE
UH2	2	U4	26	WHAT
UH3	2	U5	27	NUT
V	1	V V/	51	VERY
W	1	W W/	35	WATER
Y	1	Y/	3	BEFORE
Y1	2	Y1	4	YEAR
Z	1	Z Z/	47	ZERO

There are several two letter codes in this column and when the computer analyses written speech, it first looks for these double codes, allocating their decimal number if found. In this way some conventional dipthongs like 'NG', 'PH' etc will be given the correct sound without recoding. However, those with the oblique alongside can be intentionally coded into written speech so that a word like TOP HAT, which would come out as TOFAT, can have the oblique following the P to separate it from the H. (Note that blank spaces are skipped by the computer as are other unrecognised characters). Using the symbols from the CPX USE column (don't use the SSI column) to replace letters or letter groupings in the written message, a pretty good and understandable spoken representation can be produced by the chip and its associated controls. Interestingly though, in many cases normally spelt words can be entered into the computer, and the synthesised results can often be roughly understandable without additional phonetic modification.

So far, the phonetic system described is probably common to other speech synthesising chips. However, this particular chip has additional parameters that can be constantly changed to create more realistic speech patterns.

PARAMETRICS

The chip has several internal registers that address the phoneme required; set its duration; define inflection target frequencies and rate of change; varying rate of speed of speech; change formant position and articulation; control sound output level; modify frequency filtering to vary voice pitch. It is not necessary to understand the precise terminology, and after using the unit for while, making various register control changes, it will soon be obvious what happens how and when. It is sufficient to say at this moment that there is not much that you cannot do with the chip – it is very versatile. For interest, its block diagram is shown in Fig 1.

PRACTICALITIES

Control of the chip requires that data is sent from the computer to select the address of the register to be accessed, and for an eight bit data block to be stored. This could of course be done using two parallel output ports from a computer, one for the data, and one for the register addresses and clocking signals. However, equivalent control signals can be generated by a single port, using an intermediate serial to parallel converter for temporary storage. In this project, the circuit requires the use of six data lines and a handshake line. A block diagram for the project is shown in Fig 2.

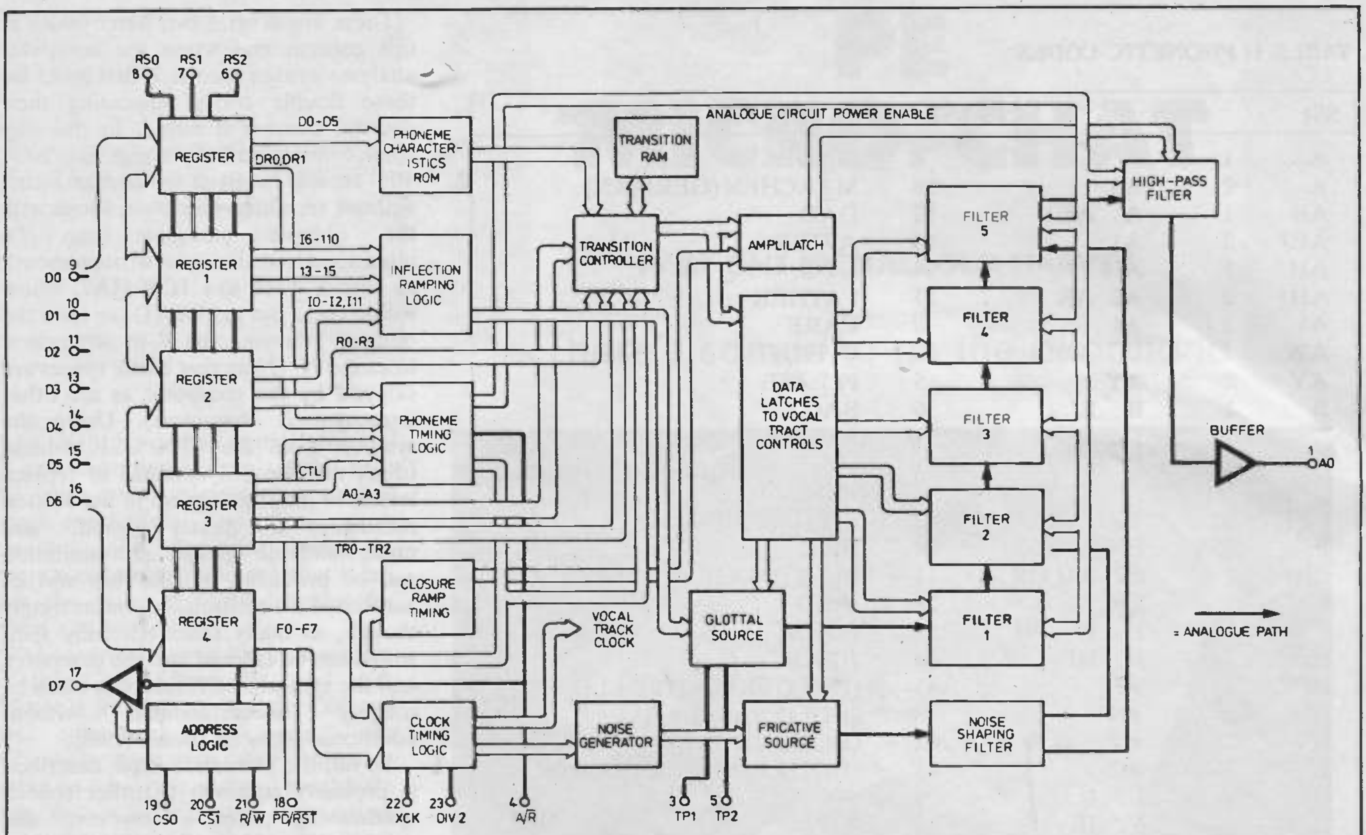


Fig.1. *Block diagram of SSI 263A Speech Synthesiser chip*

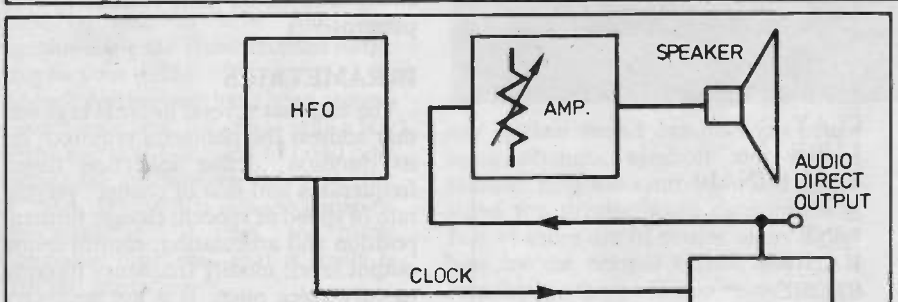


Fig.2. *Block diagram of PE Micro-Chat*

Two lines, DA0 and DA1 respectively, are used to send data and address information as streams of serial bits. These are clocked into two serial to parallel converters, one controlling the address registers, and the other sending parameter data. As each serial bit is sent, it is clocked into the relevent parallel converter by a positive transition on the clock line ATN. Upon receipt of each bit, the converter transfers the contents of eight internal registers along by one place, and stores the incoming bit. Thus at the end of eight clock cycles, the converter will have an eight bit code held within it. Each bit has its own output pin which is connected to the equivalent pin of the speech chip. The chip will take no action until DA7 is taken high, at which time the chip opens the register selected by the three address lines, and stores in it the data from the eight parameter lines.

Inside the speech chip a vast bank of digitised phoneme waveform data has been stored in the manufacturing process. An internal clock running at 1MHz, causes the data to be sent in analogue form to an audio output at rates and durations set by the control registers. In simple terms, once a particular group of phoneme data bits has been sent, the group is repeated, and will continue to be looped through until the register data is changed. In practise though, some groups will not be sent until another group has also been selected, and some groups trigger envelope routines that do not repeat.

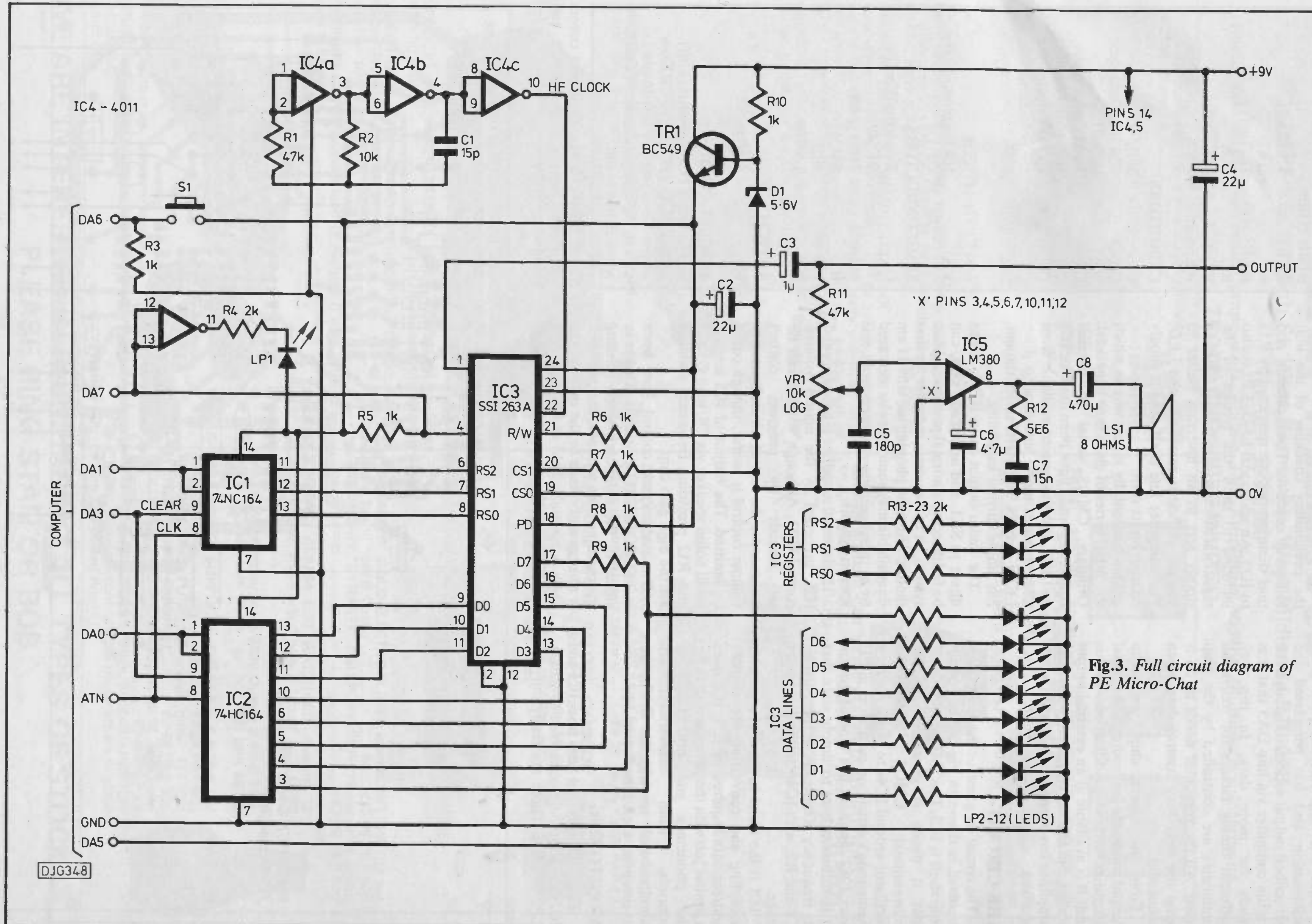


Fig.3. *Full circuit diagram of PE Micro-Chat*

Once the chip has accepted fresh information and has completed the prescribed output action, it signals back to the computer via line DA5 that it is ready for more data. In this way, different timing factors for individual phonemes are controlled by the chip itself. All the computer needs to do is send the necessary control data when requested.

From the speech chip, the audio output is suitable for feeding to a normal amplifier without modification. In this unit it is available at an external output socket, but additionally, a two watt audio amplifier has been included, with its own speaker.

THE CIRCUIT

The circuit diagram for the electronics involved is shown in Fig 3. The speech chip itself is IC3. The 1MHz clock signal that it needs is generated by the conventional CMOS Squarewave oscillator around IC4a to IC4o. Andrew Armstrong's article on oscillators in PE May 1987 discusses this type of design. It is sufficient here to simply state that its frequency is basically determined by C1 and R2, with IC4o acting as a buffer stage.

IC1 is the serial to parallel convertor accepting and converting the register address data required by IC3. IC2 does a similar job with the parameter data for the phonemes and other function controls. Both converters are simultaneously reset by line DA3 prior to receiving each set of serial bits.

MONITORING

Each of the output lines from IC1 and IC2 is additionally connected to LEDs, LP2 to LP12. These are really only for visual interest, though they also help in the preliminary checking of the unit following assembly. Their current, and thus their intensity, is restricted by R13 to R23. An additional LED, LP1 is also included to show the receipt of the register activating pulse from DA7. IC4d simply acts as an inverting buffer to provide sufficient current to the LED. The computer line itself cannot supply enough on its own.

This incidentally is one way in which the 74HC series of chips is so beneficial. Ordinary CMOS serial to parallel converters could have been used for IC1 and IC2, but the current available from CMOS is not usally sufficient to drive LEDs directly. The 74HC series though, has ample current capability.

The audio output from IC3 is taken direct to SK1, and as already said, can be fed direct to a normal power amplifier system, or to a cassette recorder for that matter. (Anyone phoning me when I am unavailable may sometimes be answered by a message tape-recorded from this speech synth!)

The internal amplifier is based around IC5, preceded by the master volume control VR1. Although volume can be set directly by program control commands, the use of an independent volume control is useful, though could be omitted. The output of IC5 feeds a small 8ohm speaker via C8, with C5, C7 and R12 providing frequency stability for the high gain chip.

One additional control has been included, the IRQ switch S1. This is to signal to the computer, when running the machine code routines, that you wish it to stop and return to the menu. Line DA6 is normally held at 0W signalling the IRQ request. PE

RESISTORS	
R1,R11	47k (2 off)
R2	10k
R3,R5-R10	1k (7 off)
R12	5E6
R13-R23	2k (13 off)
All resistors ¼w 5% Carbon film	
CAPACITORS	
C1	15p polystyrene
C2,C4	22µ 16V electrolytic (2 off)
C3	1µ 63V electrolytic
C5	180p polystyrene
C6	4µ7 63V electrolytic
C7	15n polyester
C8	470µ 25V electrolytic
POTENTIOMETER	
VR1	10k log mono rotary
SEMICONDUCTORS	
D1	5V6 400mW zener
TR1	BC549
IC1,IC2	74164 (2 off)
IC3	SSI263A
IC4	4011
IC5	LM380
SWITCH	
S1	push make
MISCELLANEOUS	
Self adhesive PCB supports (4 off), knob LEDs, (12 off), PCB276A 14-pin i.c. socket (4 off) 16-pin i.c. socket, 3.5mm jack sockets (2 off), speaker, box to suit.	

NEXT MONTH: The final part covers the Power Supply, Construction and Computer Program.

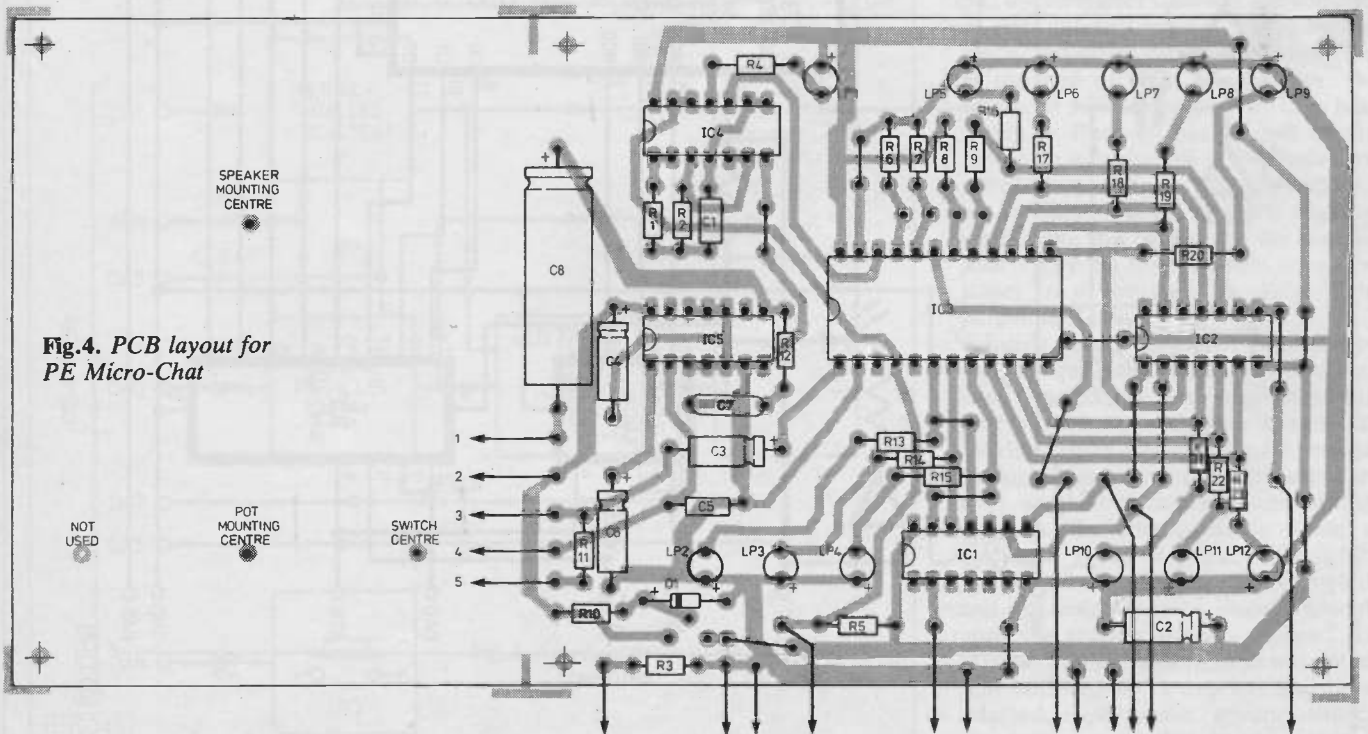


Fig.4. *PCB layout for PE Micro-Chat*

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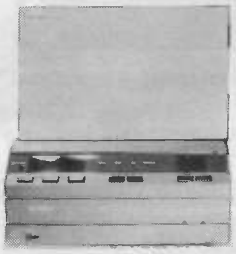

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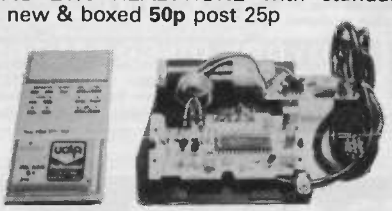

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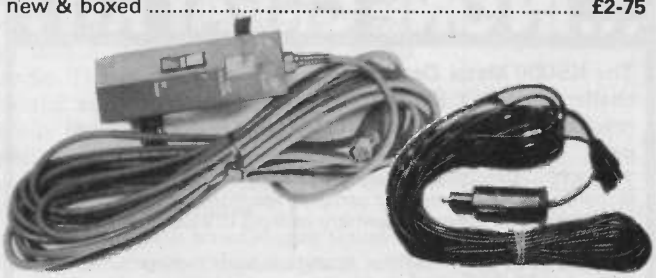

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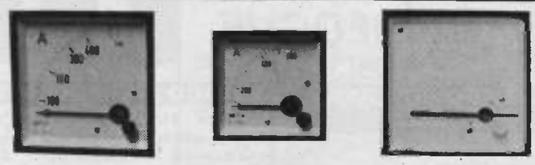

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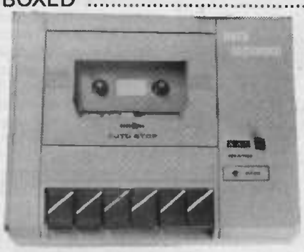

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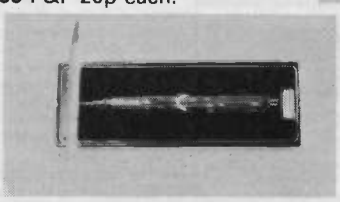

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ON THE face of it the process of converting an analogue signal to a digital one, storing it or processing it in some way, and then converting back to an analogue signal again, is doing things the hard way. Certainly most digital signal processing is far from simple, but it can produce dramatically better results than the equivalent analogue signal processing, where comparable analogue signal processing is feasible. The high level of performance provided by a compact disc player when compared to most analogue recording systems is a good example of the advantages of digital processing.

In fact, analogue systems can provide a level of performance that in some respects challenges or betters the performance of high quality digital systems, but only with the aid of noise reduction systems (as discussed in last month's article). High quality digital systems provide very high signal to noise ratios without the need for any noise reduction system at all, and do not even need the aid of pre-emphasis and de-emphasis. This clearly avoids the possible problems associated with noise reduction systems, but digital systems do have certain flaws. Digital recording equipment can provide exceptionally low levels of distortion at high levels, but they have what are usually quite high distortion levels at low levels, and it is primarily for this reason that they have not been universally acclaimed in the hi-fi world.

DIGITS OUT

Before considering the operation of today's 'state of the art' digital audio equipment it would perhaps be as well to take a look at the basics of digital audio. This perhaps has more relevance to the electronics enthusiast who can easily dabble with digital audio, but is unlikely to build a do-it-yourself compact disc player or digital tape deck in the foreseeable future.

In its raw form an analogue signal is incompatible with a digital system, and some form of analogue to digital converter is needed before digital processing or storage of the signal is possible. In its most basic form an analogue to digital converter consists of nothing more than an ordinary Schmitt Trigger. If the audio input signal is above a certain level the output signal goes to logic 1, and if the input voltage is below the threshold level the output goes to logic 0. In a recording system the output of the Schmitt Trigger would be periodically sampled and the signal levels would be stored on tape, in RAM, or whatever. With any sampling system it is essential that the sampling rate is at least double the maximum input frequency, and it should preferably be three or more times the maximum input frequency. An inadequate sampling rate gives rise to a severe form of distortion called 'aliasing' distortion.

Single bit digital systems of this type are very interesting to experiment with, but their practical applications are few and far between due to the very low standard of performance. Provided the sampling rate is adequate, the played-back signal will be a reasonably faithful reproduction of the output from the Schmitt Trigger. However, simply getting the digital signal back out of the system is not enough, as it will be a poor representation of the original audio signal with much distortion added and a lot of the signal content absent. Some form of digital to analogue converter is required in order to give a proper audio output signal, but there is no effective converter for a single bit system. The information in the digital output signal is simply not enough to reconstitute a reasonably faithful representation of the original audio signal, and although some lowpass filtering might improve the quality, it will still be extremely poor.

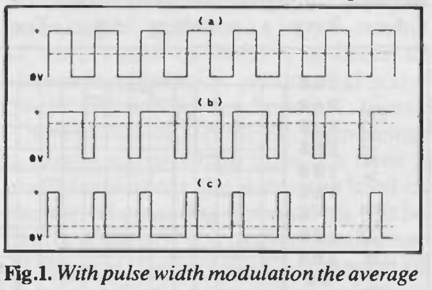


Fig.1. *With pulse width modulation the average signal level is proportional to the input voltage*

P.W.M.

It is actually possible to obtain high quality audio from a single bit system, but it requires the use of a somewhat different system called 'pulse width modulation', or 'p.w.m.'. This uses an analogue to digital converter that provides a high frequency output signal which has a pulse width that varies in sympathy with the input voltage. This operates in the manner illustrated by the waveform diagrams of Fig.1. In each case the broken line represents the input voltage, and the waveform is such that its average potential is equal to this input voltage. For example, in Fig.1(a) the input is half the supply voltage, and the waveform produced has a 1 to 1 mark-space ratio. This is actually the same process that is used in switch mode power supplies and class D amplifiers, as discussed in recent issues of PE.

The digital output signal can be sampled periodically with the sampled levels being stored in RAM, and then at playback a lowpass filter is all that is needed to restore the original audio signal. Remember that the average amplitude of the pulse width modulation signal is proportional to the input signal level. The lowpass filtering integrates the pulses to give an output which is equal to the average voltage of the pulse signal. This all sounds beautifully simple, but there is a major drawback to this system in that for good results the mark-space ratio of the digital signal must be accurately maintained through the recording and playback process. This requires the use of a sampling rate which is very many times higher than the pulse signal frequency, which is in turn two or three times the maximum audio input frequency. This gives a sampling rate which is into the megahertz range. The compression of the signal into a single bit pulse stream can only be achieved effectively if the sampling is put at a high level that gives a large number of bits per second. With any digital audio system the number of bits per second puts a definite limit on the audio output quality. Whether the bits of information are on one channel or several makes no difference.

CONVENTIONAL ADA

Pulse width modulation is used in practical audio systems, but it is mainly used in applications such as audio isolators where the signal is passed through an opto-isolator. Here the digital nature of the signal overcomes problems of non-linearity through the opto-isolator, but the pulse signal is simply filtered immediately to recover

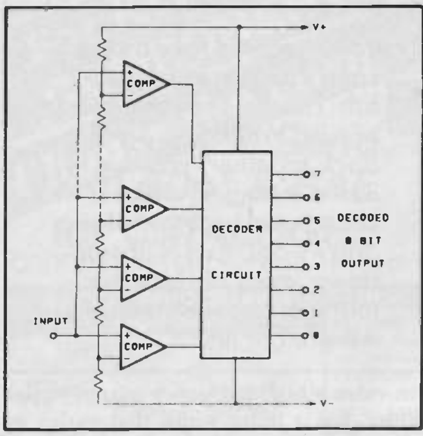


Fig.2. *For high speed digitizing a 'flash' converter is required. These are very expensive.*

the audio signal. Where digital storage and (or) some form of processing is required it is generally better to use some form of parallel system rather than a simple single digit serial data stream type.

If we start by considering an 8 bit system, the analogue to digital converter has to sample the input signal periodically and convert it to an 8 bit binary output, or in decimal terms a value of between 0 and 255. For audio digitizing a successive approximation converter such as the Ferranti ZN427E or ZN447E gives sufficient speed. These devices have been used in a number of PE projects, and their method of operation is not something that will be reiterated here. They normally have a full scale voltage of 2.55 volts, which works out at a convenient 10 millivolts (0.01 volts) per bit. For example, an input voltage of 1.2 volts would give a converted value of 120 (1.2 divided by 0.01 = 120).

For video digitizing a much higher sampling rate is required, and the speed of an ordinary successive approximation converter is inadequate. Probably the most common type of high speed analogue to digital converter is the aptly named 'flash' type. This consists of dozens of high speed voltage comparators which compare the input signal against a large number of reference voltages. There is an obvious similarity here with a bargraph display driver such as the LM3914N, which I suppose could be regarded as a very basic form of flash converter. However, for video digitizing the output signal must be in the standard binary form, and some logic circuitry is needed to convert the information from the comparators into a proper binary output signal. This gives an arrangement of the type shown in Fig.2. In fact some practical flash converters are hybrid designs which only use the flash technique to deal with the least significant bits, and have a high speed successive approximation converter to deal with the most significant bits.

The a.c. input signal is digitized in the manner shown in Fig.3. Under quiescent conditions the input of the converter is biased to about half full scale, which means an output value of 127 or 128 for an 8 bit system. The capacitively coupled input signal therefore modulates the input voltage to the converter either side of this value. As with any sampling system, for good results to be obtained it is essential that the input signal is sampled at a rate which is at least double the maximum input frequency, and preferably three or more times higher than the maximum input frequency. Obviously several samples per cycle are needed if the progress of the signal is to be tracked properly, without sections of the waveform being skipped over.

example, the ZN427E and ZN447E devices are complemented by the ZN426E and ZN428E d.a.c.s., both of which have normal full scale output voltages of 2.55 volts. In reality it does not matter a great deal if the scaling of the a.d.c. and d.a.c. circuits is not matched. If, for instance, the d.a.c. has a lower full scale voltage than the a.d.c. circuit, this simply results in a voltage gain of less than unity through the system. It does not affect linearity.

The output from the d.a.c., like the output from a bucket brigade delay line, is a stepped waveform. Fig.4 shows the reconstituted version of the input waveform of Fig.3. There is a fundamental and important difference between digital and analogue sampling

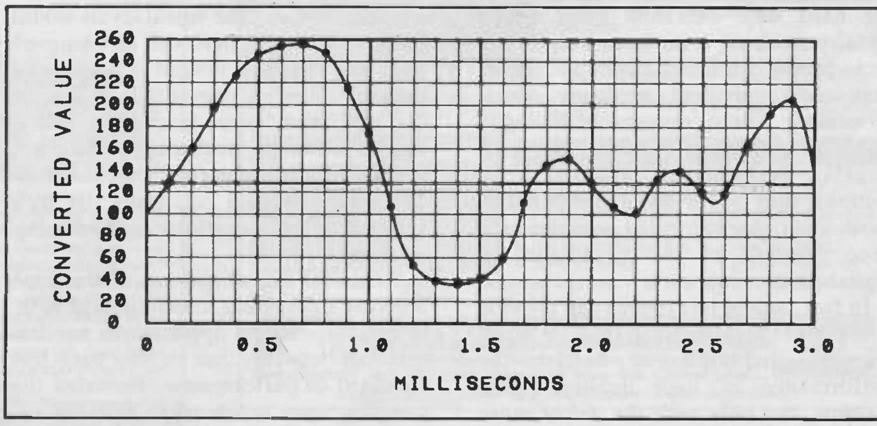


Fig.3. *The signal is digitized by sampling it at regular intervals and storing the converted values in RAM*

In this example we are assuming a sampling frequency of 10kHz (one sample every 0.1ms) which enables input frequencies up to about 5kHz to be handled. This is sufficient for speech, but would be inadequate for high quality audio applications. Compact disc players operate with a 44.1kHz sampling frequency incidentally. The series of output values (100, 127, 160, etc. in this example) are fed into RAM (or whatever) and then at some later stage are fed into a digital to analogue converter. This would normally be a type which accurately complements the analogue to digital converter, and most a.d.c.s have a matching d.a.c. For

systems, and this is the inability to remove all the stepping on the output of a digital system using lowpass filtering. An analogue system has (in theory at any rate) infinite resolution, and any voltage change from one sample to the next will always be reflected in corresponding changes in the output levels. Unless there is no change in the input voltage from one sample to the next, this gives a steppng at the output which is at a frequency equal to the sampling rate. This rate is higher than the maximum input frequency, and it can consequently be counteracted by lowpass filtering without removing any of the wanted signal.

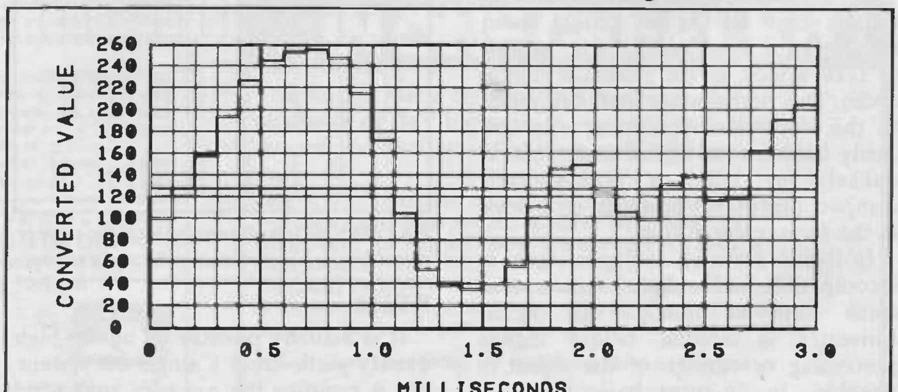


Fig.4. *The played-back signal is a stepped waveform, and lowpass filtering will not totally remove the steps*

In the waveform of Fig.4 the output voltage does in fact always change from one sample to the next, but this may not always be the case. This is due to the limited resolution of an 8 bit system. In this example the resolution (in voltage terms) is 10 millivolts, but at the time each sample is taken the input signal will not always conveniently be at some multiple of 10 millivolts. If the input was at (say) 154 millivolts at the instant it was converted, it would effectively be rounded down to 150 millivolts and converted to a value of 15. We are assuming here that the converter is a perfectly accurate type, which it might not be, and the reading could be rounded up to a value of 16. The output from the d.a.c. would therefore be either 150 or 160 millivolts, but this assumes perfect accuracy on the part of the d.a.c. It too could produce errors that would give an output closer to the correct figure of 154 millivolts, but it would be just as likely to make the error even larger.

This lack of accuracy can be minimised by using high quality converters, but this still leaves the system open to significant errors which are reflected in the form of distortion on the output signal. This is termed 'quantization noise' incidentally. The limited resolution means that with a low frequency input signal there will sometimes be no change in output level from one sample to the next, and in extreme cases there will be several identical output values in succession. This effectively reduces the sampling rate, probably bringing it down to a frequency that is within the signal frequency range. The output lowpass filtering is then ineffective at removing the stepping and the distortion products it produces on the output signal.

Another result of the limited resolution is a limited dynamic range. Staying with our example of 10 millivolts per bit, an input of around 10 millivolts peak to peak or less would have no effect on the a.d.c., and would give no change in output from the d.a.c. This gives what is a sort of built-in noise gate action, with signals at about −48dB or less being blocked. This could have its advantages, but is obviously a severe limitation in most cases.

Possibly the worst result of the poor resolution of an 8 bit system is the high level of distortion. As a general rule of thumb, the quantization noise is at −6dB per bit, or about −48dB for an 8 bit system. In percentage terms this represents less than 0.5%, which might seem to be quite reasonable. However, this ignores the fact that the absolute level of the distortion products remains constant down to the point where the input signal falls below the resolution of the system. Thus, what is 0.5% distortion with an input signal just below the clipping level becomes 5% distortion at an input level of −20dB, and 50% at −40dB. This gives what can be a very rough sounding output in practice.

OVERSAMPLING

There are ways of improving performance, with the most obvious one being to use a larger number of bits. Some sound sampling musical instruments now use a 12 bit system. This represents a much better level of performance with a 72dB dynamic range, well under 0.1% distortion at the maximum signal level, and only around 2.5% distortion at −40dB. The first high quality digital recording systems were 14 bit types, giving an impressive 84dB dynamic range, but 16 bits (as in compact disc systems) is now the order of the day, giving a 96dB dynamic range. This is more than adequate to accommodate even the most demanding pieces of music. In terms of distortion it represents only about 0.002% at the maximum signal level, or around 2% at −60dB. This second figure may seem somewhat less than hi-fi, and is the main reason that some hi-fi enthusiasts are less than enthusiastic about digital recording systems.

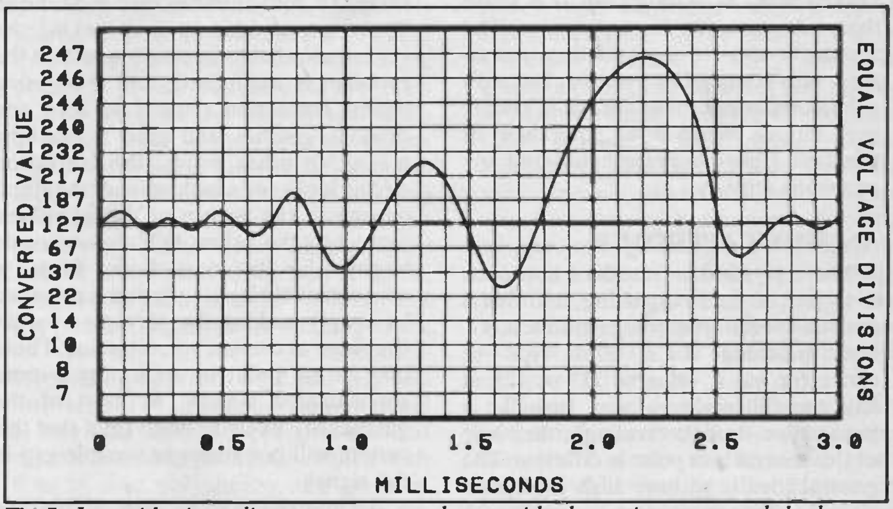


Fig.5. *Logarithmic scaling can accommodate a wide dynamic range, and the low amplitude parts of this waveform would be accurately digitized. Overall performance is something of a compromise though*

Being realistic about it though, the fundamental signal at −60dB is going to be extremely quiet, and a very keen pair of ears would be needed in order to detect the distortion products at some 34dB below the fundamental signal. There is also some difficulty in obtaining a source signal which does not have a noise level above the distortion level of the digital recording system. This will be pretty obvious if you listen to a selection of classical compact discs – with most of these the 'hiss' of the master recording is clearly the main source of noise. With really good modern (all digital) recordings the electronic background noise is insignificant, with the ambient noise in the recording hall or studio often being the only noticeable noise! No doubt technology will progress to the point where systems with 18 bits or more and a performance to match can be produced, but this may not be worthwhile, and might give little or no audible improvement.

'Oversampling' is a term which could be applied to the inhabitants of a constituency prior to a by-election, but it actually refers to a method of squeezing improved performance from a digital system. It was originally used by Philips to enable their 14 bit converter chips to give 16 bit performance when applied to compact disc players. The obvious development was to oversample with a full 16 bit system. It is impossible to playback samples that do not exist on the recording, but extra samples can be guessed at by a system of interpolation. For instance, if a value of 150 is followed by a value of 200, an extra sample of 175 could be inserted between the two. This does not necessarily give a more faithful reproduction of the original signal, but it does enable the effective sampling frequency to be increased. The normal sampling frequency of 44.1kHz is not that much higher than the maximum audio frequency of 20kHz, and very steep lowpass filtering is needed in order to give really effective suppression of clock breakthrough. This filtering can give undesirable phase shifts within the passband. Oversampling enables an equal amount of suppression to be obtained using much less sharp filtering, and it is this factor which is normally accepted as the reason for oversampling systems performing well in subjective tests.

COMPANDING LOGS

16 bit sound sampling systems are now appearing, but most systems still use 8 or 12 bits. Certainly most home-constructor designs are based on 8 bit chips which are much more affordable and readily available than 12 to 16 bit devices. This leaves a problem with poor audio quality which has to be overcome.

What is possibly the most effective method, and one which I have found to give a vast improvement in performance, is to use a compander system around the digital recording and playback system. With the aid of the NE570/571 chips (as discussed in part one of this article) the compander system need not add greatly to either the cost or complexity of the system.

Assuming that an NE570/571 style 2:1 compander is used, the effect on record is to reduce falls in the input level. So, for example, at the −40dB level the input to the a.d.c. is actually at only −20dB. At the output of the d.a.c., the signal is restored back to its correct level of −40dB. However, whereas there would normally be about 50% distortion on a −40dB signal, by compressing it to −20dB and re-expanding it, the distortion is reduced to only about 5%. The dynamic range is theoretically doubled from 48dB to 96dB. Even allowing for inefficiencies in the system, the actual signal to noise ratio is likely to be very good at around 90dB. The distortion performance is less than brilliant with about 5% at −40dB and around 50% at −80dB, but it is more than adequate for most purposes. The system is open to the problems associated with compander systems, but with a 2:1 compander these are not normally very serious. When using equipment of this type I have never encountered any problems anyway.

ANOTHER APPROACH

There is another standard approach to improved audio digitizing, and this is to use a special type of logarithmic a.d.c. and matching d.a.c. This type of converter has a value of 127 or 128 at half the full scale voltage, just like a linear type, but the scaling either side of this central bias point is different. The general idea is to have high resolution close to this quiescent bias level, with the resolution becoming more and more coarse as the input voltage moves away from this central point. Fig.5 helps to explain the way in which this system operates. If played back through a linear d.a.c. the signal would undergo severe distortion, but provided it is played back through a proper logarithmic type the distortion introduced at the a.d.c. is counterated by the distortion at the d.a.c.

The point of all this is that the higher resolution at low signal levels enables much smaller input signals to be accommodated. In fact on 8 bit system using logarithmic converters can achieve a dynamic range of over 70dB, which is adequate for most purposes. It avoids the expense and complexity of adding a compander system, and also completely circumvents any breathing effects and other problems associated with noise reduction systems. On the other hand, the increased low level performance is obtained at the expense of reduced high level performance. The action of this type of converter is to even out the high to low level performance to some extent, and in simple noise and distortion terms a linear 8 bit system plus a 2:1 compander appears to offer markedly superior performance. For the home constructor the compander method is the more practical approach as it only requires the use of readily available components – logarithmic a.d.c.s and d.a.c.s could prove to be difficult to obtain.

PROCESSING

In recording, the main advantage of a digital approach is that linearity in the recording process (or lack of it) is of no importance. The level of performance is totally dependent on the digital converters (plus any analogue processing of the input and output signals). In fact the recording medium can introduce problems in that corruption of the data is possible, and this could cause problems that would give an audio output similar to the familiar background 'crackle' that accompanies so many conventional disc recordings. These are avoided by first making the system as reliable as possible so that the problem is minimised, and then using digital correction circuits to spot any obvious glitches and give a blanking action. In other words, the correction circuit looks for a sudden and unnatural change in the stream of digital values, and alters the values that are obviously wrong. In its most basic form, a conventional blanking action is provided by simply making the corrupted values the same as the last correct value. There may be no point in opting for a more sophisticated system, as most of the glitches are likely to be so brief that this system will not give a noticeable gap in the signal.

An interesting application of this type of processing is to feed in an old recording, complete with 'crackles', 'pops' and 'hiss' type noises, and to use digital techniques to restore the recording. Perhaps restore is not the right word these days, as some systems now attempt to produce a level of fidelity that the recording never had originally, even when it was first pressed! Systems which carry out this type of processing should perhaps be called enhancers rather than restorers.

Simple blanking can be applied to the signal, but scratches on conventional disc recording produce comparatively long glitches that can give a noticable blemish during playback. Although the gap would not normally be heard as such (a gap of at least 10ms is required for this), it can give an audible glitch which sounds much like a tape dropout in a cassette tape system. With sophisticated digital processing it is possible to go beyond this basic technique.

Not all that many years ago the standard approach to restoring recording was to tape them, and then to literally cut out the sections of the recordings which contained bad scratches. Where something important was blotted out, the appropriate note from the relevant instrument could be recorded and grafted into the recording. This sounds like a very slow and highly skilled process, and it is. Few people have the skills and patience to undertake it. *(I've done it as a film editor! Ed.)*

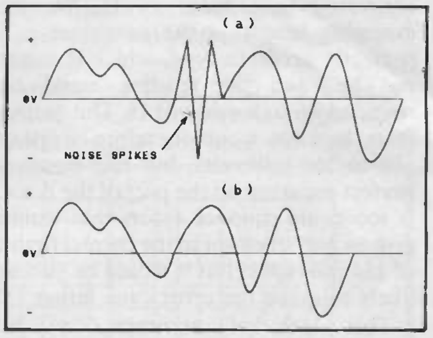


Fig.6. *This system of cutting out the noise spikes and closing of the gaps precedes the digital era*

Using a digital processor it is possible to achieve much the same result. A scratch, as in the waveform of Fig.6(a) can be eliminated by simply jumping over that section of the signal, as in Fig.6(b). This could result in a pronounced step at the point where the section of signal is cut out, but the system can be designed to produce a smooth transition so that any obvious glitch in the signal is avoided. Where there is a fairly long gap in the signal (which means a few milliseconds or so in this context) it is possible to fill in the gap. This can be done by looking at the signal immediately prior to and after the glitch, and then filling in the damaged part of the signal with a waveform that matches the rest of the signal. Fig.7 shows the general way in which this operates. The system is really doing no more than guessing at what the missing part of the signal should be like, but the chances of an accurate repair job are quite high due to the repetitive nature of audio signals. This form of processing is obviously very much in the 'look ahead' category, but with a digital system there is no problem here, as there can be a large RAM buffer between the digital source and the d.a.c., with many seconds of signal in the buffer if necessary.

Removing 'hiss' type noise is a more difficult problem than noise spikes, and it would be easy to design a complex digital system that simply smoothed out the random variations in the signal. This would be much the same as applying lowpass filtering, and would eliminate much of the wanted signal as well as the noise. It would probably be less effective than a good analogue dynamic noise limiter.

The basic method of counteracting this type of noise is to look for non-random changes in the signal. This again relies on the fact that audio signals tend to be repetitive in nature, and a mixture of random noise plus an audio signal will give a series of digitized values that are not truly random. With some number crunching a digital system can find the underlying pattern and give an output signal with vastly reduced 'hiss' level. This type of thing takes a considerable amount of computing though, and it is not the type of thing that can be achieved in real-time using something like a humble 4MHz Z80A processor. It is similar to the processing used to enhance pictures sent back from space probes, but is somewhat simpler (it takes powerful computers many hours to process these space pictures).

Digital audio processing could be taken much further than the systems described so far. Whether there is any point in producing compact disc quality from an old '78' recording is debatable. In general, the greater the enhancement, the more the processor is creating the final output signal, and so less of the original, with its subtleties and nuances, remains. This is analogous to the controversy in the art world as to how far restorers of old painting should go. Replacing discoloured varnish and repairing cracks is one thing, replacing discoloured paint with what is thought to be something closer to the original colour is more dubious. Fortunately, with audio restoration you can 'have your cake and eat it'. Any number of restored or enhanced copies can be made without damaging the original. Digitally enhanced recordings sound very impressive, but you can listen to the original if that's what you prefer.

MUSIC

Digital systems are in the process of revoltionising the recording world, but in the music world the revolution has already happened. If you go into a music shop these days it will probably be difficult to find an electronic instrument that is not at least partially digital. The earliest instruments to use audio digitizing were percussion synthesizers, and these were an obvious first step as they record and playback quite short sounds. They consequently require quite modest amounts of ROM or RAM per recorded sound. Some early systems recorded only a short burst of signal which was looped to give a continuous output signal. This was then processed by a conventional ADSR envelope shaper. With the current low cost memory circuits this type of thing is perhaps less worthwhile these days. For difficult sounds such as cymbals this technique provides much more convincing results than those obtained using conventional (analogue) synthesis.

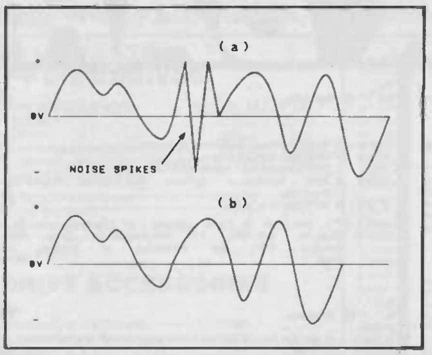


Fig.7. *There is no way of knowing for sure what has been obliterated by the noise spikes. An intelligent digital system could make a likely assumption though, as in (b)*

It is also an area where the home constructor can experiment with simple equipment that will give good results. Even a simple 8 bit linear system without any companding can give some quite realistic percussion sounds.

Sampling systems do not have to be limited to straight forward playback of the recorded sound. In fact most sound sampling instruments these days are keyboard types where the sound is played back at various speeds in order to permit a full range of notes to be obtained. Some instruments are even polyphonic (you can play several notes at once). Some of the electronic pianos (particularly some Yamaha and Technics models) demonstrate the type of thing that can be achieved with sophisticated processing. Rather than using a single sample as the basis of the output signal, samples are taken at high, medium, and low pitches, and also with the keys struck at varying degrees of hardness. Depending on which note you play and how hard it is struck, the output signal is based on the most appropriate sound sample stored in ROM. Combined with 8 to 16 note polyphoney, this gives an output quality which is far cry from the less than convincing instruments from a few years ago. By storing samples from several instruments a range of piano sounds can be produced, or in some cases brass, strings, and various other instruments are available.

DELAY LINES

The other main use of digitized audio in electronic music is in delay lines, and the various effects that are based on the use of these (echo, flanging, chorus, reverberation, etc.). The delay is achieved by storing samples in a block of RAM, and then going back to the beginning and overwriting the original samples with fresh ones. This is repeated indefinitely. The delayed signal is obtained by outputting each sample to the d.a.c. prior to overwriting it. The output is therefore delayed by the amount of time it takes to do one complete write cycle of the RAM block.

(As the PE Polywhatsit demonstrates in the June issue, pitch changing, and track reversal can also be achieved. Ed.)

Even with a system based on a 8k by 8 static RAM costing a few pounds it is possible to obtain reasonable audio quality and a delay of around 200ms or more. With a few hundred kilobytes of RAM no longer costing hundreds of pounds it is possible to obtain delays of several seconds with the full 20kHz audio bandwidth at quite reasonable cost.

CONCLUSION

It has only been possible here to look at the basic digitizing techniques and to breiefly consider some of the processing that can be applied to the signals in their digital form. Digital signal processing seems likely to play an ever bigger role in practically every aspect of electronics, including amateur electronics. There have been a number of digital audio projects in PE in the past, and these are probably just the forerunners of many to follow. Digital techniques can also be applied to test equipment (as in the storage 'scope add-on project' in the July issue), and numerous other fields of electronics. The clever tricks used by television stations are now so commonplace that probably few people even notice them. They are all produced using complex high speed digital equipment. This type of thing has been very expensive up to now, with it being cheaper to buy a large house than to buy equipment to generate some of the more difficult effects. However, perhaps before too long prices will fall to the type of figure where the dedicated home video enthusiast can start to use some of these techniques.

Digital television sets already exist, and can do clever tricks such as having the picture of one station as the main display while having the picture of another station as a miniature inset on the screen. So far the impact of digital television receivers has been such that most potential customers probably do not even realise that they exist! However, with improved performance and lower costs things could change dramatically. There are special digital chips for applications such as speech recognition, speech compression and as seen in this issue, speech synthesis. The future impact of digital signal processing may depend on the supply of such chips to make complex processing something that can be used routinely by circuit designers. PE

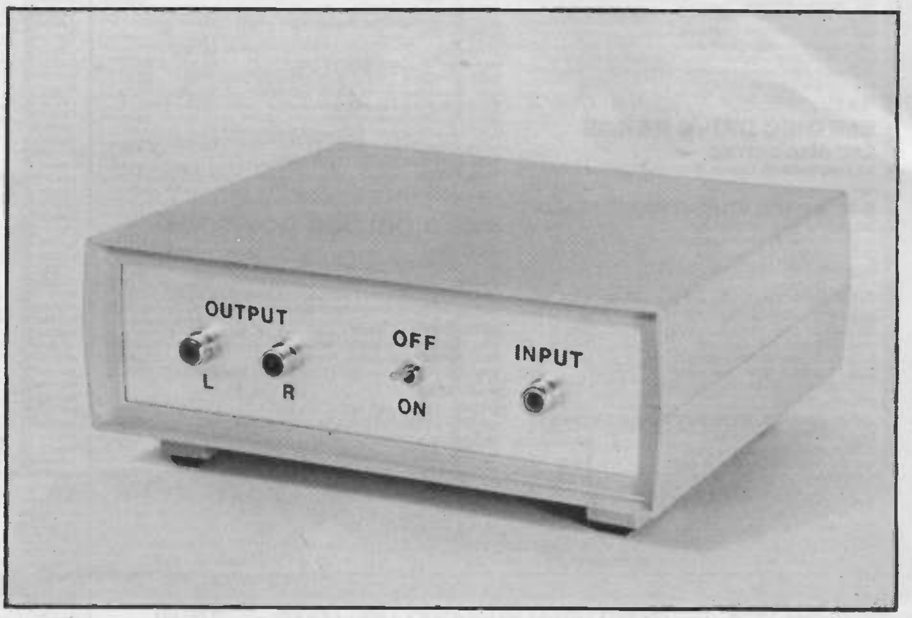
NEXT MONTH: The Prof takes a look at another Signal Processing aspect and describes a Constructional Project for improving speech signals.

The Prof is determined to get less mono for his money, and is ready to try several ways of doing it—even if it means a hole in the head.

PSEUDO STEREO

BY THE PROF

You'll never believe your ears!



ATTEMPTS to produce a reasonable stereo effect from a monophonic signal source probably date back to the earliest days of stereo sound. Although stereo sound systems have been commonplace for many years, pseudo stereo is probably more in evidence now than ever before. In particular it is used in some up-market television receivers as part of their superior sound systems. No doubt real stereo television will come along in due course, but it is likely to be some time before it is available to the vast majority of users, and until then pseuso stereo will be the only alternative to monophonic sound for most of us. Pseudo stereo is not confined to television applications, and it is also used by people who live in poor reception areas for f.m. stereo radio, where the options are noisy stereo reception, low noise monophonic reception, or low noise pseudo stereo reception derived from a monophonic signal. Of course, pseudo stereo is also used on old recordings as part of the audio processing used to rejuvenate them. Although some musical puritans frown on any tampering of this type, even simple audio processings can make a surprising improvement to many old recordings.

HUM AND HISS

The basic method of stereo recording is to use two microphones, one aimed at each side of the sound stage. When replayed through two loudspeakers placed some distance apart, the effect is to reproduce the original (relative) positioning of the sounds, including those from the centre of the sound stage which are reproduced through both the loudspeakers. In fact results with this basic set up are often not very good, with the so called 'hole in the middle' effect tending to give a poor central stereo image. The usual way of improving things is to have three microphones positioned 'left', 'right', and 'centre', with the 'centre' microphone feeding equally into both stereo channels. The signal from this microphone appears in-phase in the two channels, and it is this factor which gives a strong central stereo image from such a set up.

Playing a monophonic signal into a stereo system simply by coupling the signal to both channels gives what is effectively the same effect as the signal from the 'centre' microphone. In other words, the entire signal seems to emanate from half way between the two speakers. Many listeners prefer this to single speaker monophonic reproduction, but to others it can often sound as though the performance is being heard from the wrong end of a tunnel. Room acoustics as well as the aural systems of the listeners probably play a big part in exactly how a given signal actually sounds, but it is unlikely to be anything like a real stereo signal.

However clever the processing, it is unlikely that a monophonic source can ever produce a real stereo effect. I suppose that with the ultimate digital processing equipment it might be possible to largely isolate the sound of individual instruments and then remix these into a stereo signal of sorts. Whether this would give sufficiently good results to be worth the effort is another matter, and with the current technology it certainly goes well beyond the scope of a do-it-yourself project.

There are some simple types of processor which will not give a genuine mono-to-stereo conversion, but which will give a reasonably effective pseudo stereo effect. What we are really talking about here are systems that spread the sound between the two loudspeakers giving a more natural effect than monophonic reproduction. If possible the system should also position various instruments at particular positions between the loudspeakers, but this is not something that all systems actually attempt to do, and any positioning that is obtained is likely to be totally arbitrary. We will consider a variety of methods here, some of which are much more effective than others.

Probably the best known form of pseudo stereo circuit is the simple frequency splitter type. This operates by feeding the input signal to both a highpass filter and a lowpass type. The -3dB points of the filters should be at the same frequency, and at about the middle of the audio frequency range. The outputs of the filters constitute the pseudo stereo output signals, and the general idea is for high frequency signals to be directed to one side of the sound stage, with the bass frequencies directed to the other side. Middle frequencies are produced at similar levels from both loudspeakers, and consequently appear at around the middle of the sound stage. Rather like the cross-over system in a two way loudspeaker, the filters do not introduce any significant variations in the overall frequency response of the system, with the two frequency responses accurately complementing one another.

This all sounds fine in theory, but in practice the results using a system of this type can be very disappointing. The first problem is that the frequency splitting technique tends to send most of the inevitable 'hiss' type noise to one loudspeaker, and any mains 'hum' to the other. Instead of 'left' and 'right' hand

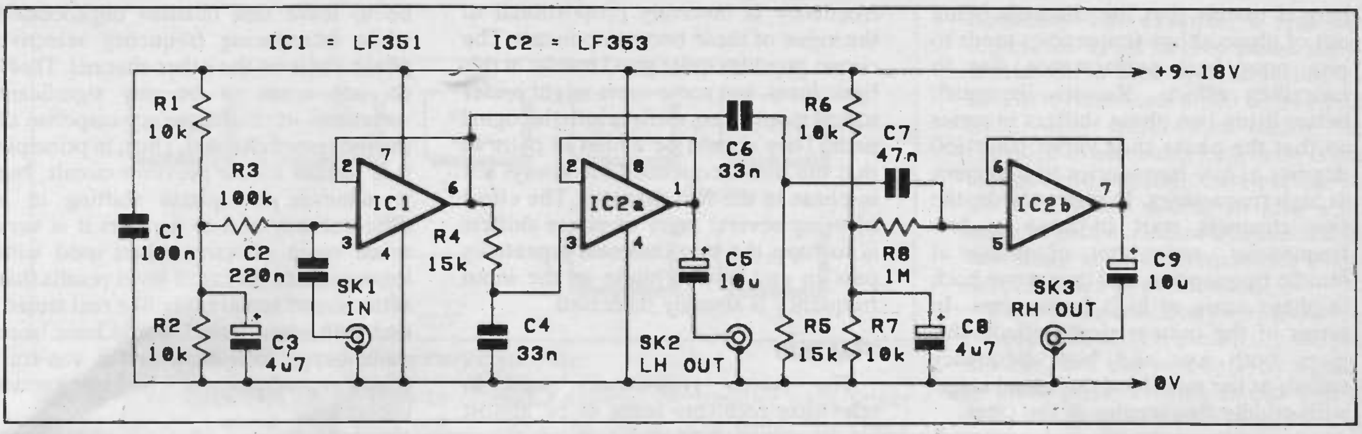


Fig.1. *A frequency selective stereo synthesiser circuit*

channels they could more appropriately be called 'hum' and 'hiss'. This lop-sided noise tends to be much more noticeable than it would be when produced monophonically, and can be something of a distraction from the music. Of course, just how serious this problem happens to be is very much dependent on the quality of the source signal. It can work well with a high quality f.m. radio source, but is likely to be less effective if used with an old '78' record.

Even assuming that the source signal is perfect, this system still has its drawbacks. One of these is merely that it can sometimes be a bit obvious in operation, and certainly lacks subtlety. Perhaps rather surprisingly, the systems of this type that I have heard have tended to have an apparent lack of channel separation. At most frequencies, even using 6dB per octave filters, the actual channel separation is quite high, bearing in mind that a separation of only a few dB is sufficient to place a sound well over towards one side of the sound stage. Possibly the problem is due to the fact that the majority of the signal tends to be at the middle frequencies close to the cross-over frequency. Higher slope filters can improve separation, but this exacerbates the problem of the system being obvious in operation.

Where systems of this type are probably at their best is when used with headphones and a reasonably noise-free source signal. The effect can then be extremely good with something that is perhaps closer to a real stereo effect than any other simple pseudo stereo system. Such a set up works especially well with classical orchestral music where the standard arrangement is to have the violins at the left of the sound stage, the violas and cellos towards the centre, and the basses on the right. Feeding the high frequencies to the left hand channel and the low frequencies to the right hand channel gives placing of these dominant instruments which closely adhere to this standard arrangement.

To my ears at any rate, this form of pseudo stereo unit does not work well with loudspeaker operation or with anything other than a fairly high quality source signal, and it is not one that I could whole-heartedly recommend. It is a system that is interesting to try out though, and it does not require anything very elaborate. In fact it can be implemented using passive filters to process the signal fed to the headphones or loudspeakers, but results with any form of passive filter tend to be unpredictable. Some form of active filter is better as it can be designed to render the source and load impedances unimportant so that results are much more predictable. Fig. 1 shows the circuit diagram for an active pseudo stereo unit of this type.

This circuit is very simple in operation, and it has IC1 as an input buffer stage which provides an input impedance of about 100k and a low enough output impedance to reliably drive the two filters. The latter are basic single stage C–R types with R4 and C4 acting as the lowpass filter, and C6 plus R5 acting as the highpass type. The cutoff frequencies must be matched, and the frequency used is also quite important. The filters must provide good channel balance without having to significantly boost the gain of one channel or the other, as this would give a far from flat frequency response. The cutoff frequency used here is at around 750Hz, and this figure was reached after some experimentation and listening tests. It is about what one would expect to give the best results though, as it is a frequency at more or less the middle of the audio frequency range. What might be a worthwhile modification would be to use a dual gang potentiometer to provide the two filter resistances. This would enable the cutoff frequency to be varied, and could be adjusted to give good channel balancing. With filters having a roll-off rate of more than 6dB per octave an adjustable cutoff frequency would almost certainly be necessary in order to obtain good results.

A unity gain buffer stage is used after each filter to ensure that it feeds into a suitably high input impedance. The circuit is designed for connection between the output of tuner, tape deck, or some other high level signal source, and the input of a stereo power amplifier. It will work quite well when fed from the infra-red headphone receiver unit described in the June issue, and gives quite a good effect in this context. No bypass switching is shown in Fig. 1, but this could obviously be added without difficulty.

PASSING PHASE

Producing anomalies in the frequency responses is one standard approach to stereo synthesis, and the use of phase anomalies is the other. As explained previously, for a good central stereo image a signal that is in-phase is required in the two stereo channels. The most simple type of phase reliant stereo synthesis technique is simply to invert one channel so that the monophonic signal is reproduced out of phase in the two stereo channels. This does not even require any additional electronics, and it can be tried simply by reversing the connections to one of the loudspeakers. It works about as well as one would expect from such a simple set up.

This system has the effect of spreading out the sound across the sound stage, but the lack of any in-phase signals gives a severe 'hole in the middle' effect, with what is likely to be no apparent sound stage at all in the area between the loudspeakers. A better method is to use a straight-through signal for one channel, and a variable phase shift on the other. This gives in-phase signals at some frequencies and a strong central stereo image, and out of phase signals at other frequencies to spread the sound across the sound stage.

In its most basic form a circuit of this type consists of a single phase shifter circuit which gives a level of phase shift that varies from 180 degrees at low frequencies to 0 degrees at high frequencies. This gives high frequency signals at the middle of the sound stage with lower frequencies spreading out to the sides.

In practice this system is rather too basic for good results, and the problem here is merely that the channels being out of phase at low frequencies tends to give poor bass performance due to cancelling effects. Results are much better using two phase shifters in series so that the phase shift varies from 360 degrees at low frequencies to 0 degrees at high frequencies. In other words, the two channels start in-phase at low frequencies, move out of phase at middle frequencies, and then move back in-phase again at high frequencies. In terms of the pseudo stereo effect, this gives both low and high frequency signals at the middle of the sound stage, with middle frequencies at the sides.

frequency is inversely proportional to the value of these two components. The circuit provides quite good results in this basic form, but some users might prefer to add more phase shifters into the signal path. They should be added in pairs so that the bass frequencies are always left in-phase in the two channels. The effect of using several pairs of phase shifters is to have the two channels repeatedly pass in and out of phase as the input frequency is steadily increased.

TDA3810

The stereo synthesisers used in television receivers seem to be almost

be to leave one channel unprocessed while introducing frequency selective phase shifts on the other channel. There do not seem to be any significant variations in the frequency response of the processed channel. Thus, in principle it is similar to the previous circuit, but it achieves the phase shifting in a different way and to my ears it is very much more effective when used with loudspeakers. In fact it gives results that often sound remarkably like real stereo, and with some tests I would have been quite happy to believe that it was true stereo reproduction if I had not known otherwise.

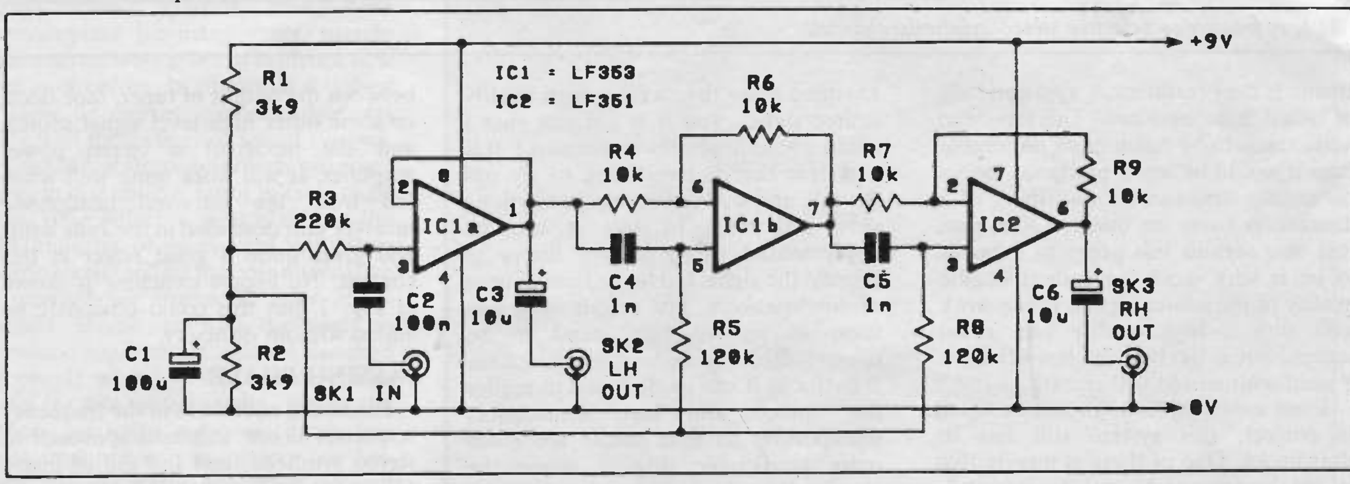


Fig.2. *A simple phase type stereo synthesiser*

Fig.2 shows the circuit diagram for a two stage phase shifter circuit. This is just an input buffer amplifier followed by two standard operational amplifer phase shifter circuits. The straight-through signal is taken from the output of buffer amplifier IC1a. The circuit provides a 180 degree phase shift at a frequency of around 1.2kHz, but this can be altered by changing the values of R5 and R8. The 180 degree phase shift

invariably based on a special pseudo stereo integrated circuit, the TDA3810. This is used in a circuit of the type shown in Fig.3.

The TDA3810 itself is basically just a set of buffer amplifiers, differential amplifiers, and control logic circuits. The discrete components must provide phase shifting, filtering, or whatever, in order to give the pseudo stereo effect. The effect of the standard circuit seems to

The story is a very different one when the unit is tried with headphones though. With a mono signal reproduced through headphones the sound seems to emanate from half way between the two earphones, or in the middle of the listeners head, to put it another way. Anything of this type is very subjective in nature, but to me the effect of this pseudo stereo circuit with headphones is to focus the sound more tightly half

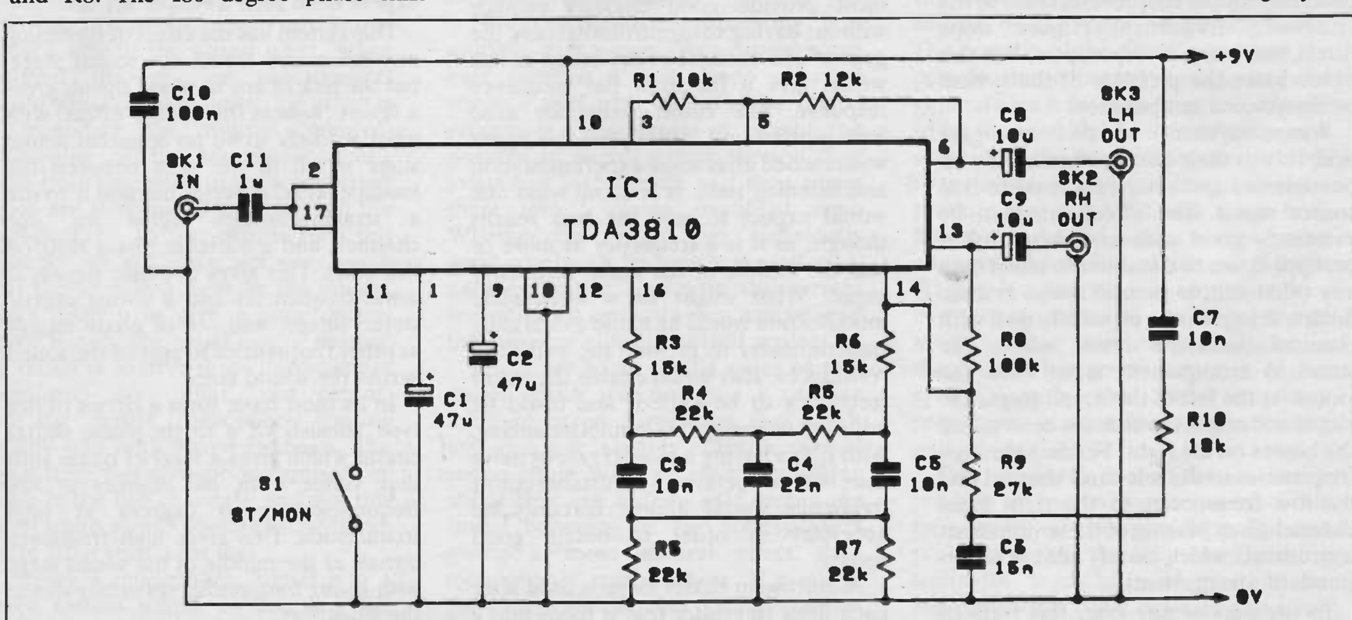


Fig.3. *A stereo synthesiser based on the TDA3810 chip*

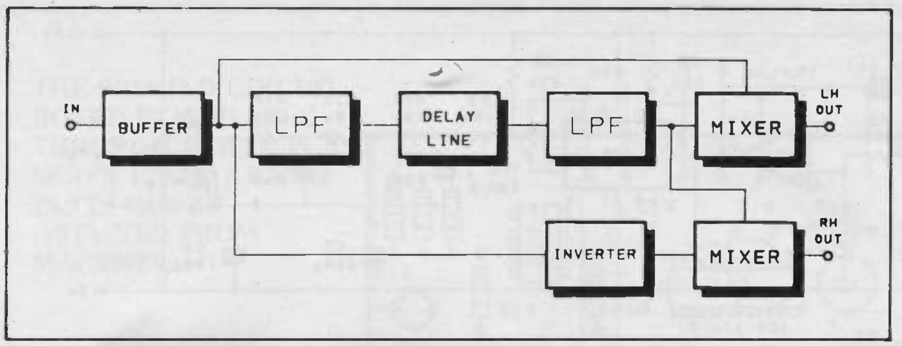


Fig.4. *Block diagram for the complementary comb filter*

way between ones ears rather than to spread out the sound. This does not produce very pleasant results, and mono listening (S1 closed) is preferable.

COMB FILTER

I have occasionally come across references to comb filters and their use in stereo synthesis, but I have never actually seen a practical circuit for a unit of this type. Continuing the policy of this series and boldly going where no technical writer has gone before, I developed a reasonably simple unit of this type. The block diagram of Fig.4 shows the general make up of the unit.

For those who are unfamiliar with the term 'comb' filter, it should be explained that this is a filter which has a response that alternates between peaks of moderate gain and troughs of high attenuation, giving a frequency response chart something along the lines of Fig.5(a). The 'comb' filter name is probably derived from the fact that the frequency response graph has a slightly comb-like appearance, although there is the other possibility that it is derived from the sound that results if a swept audio tone is processed by this type of filter. The effect can be something like that produced by running ones finger along the teeth of a comb. In either event, a comb filter on its own is of little use as a pseudo stereo unit.

What is needed in this application is two comb filters with the second one having a complementary response, as in Fig.5(b). This is essentially the same idea as that used in the frequency selective stereo synthesiser unit described at the beginning of this article, but with the audio range split up into lots of narrow bands that are fed predominantly to one channel or the other, rather than just having a two way split.

In this design the first comb filter response is produced with the aid of a delay line. This is a standard analogue 'bucket brigade' type having the usual input and output lowpass filters to avoid aliasing distortion and other problems associated with this type of delay line. An input buffer stage provides the circuit with a fairly high input impedance and gives a low enough output impedance to drive the subsequent circuits properly. A mixer stage is included at the output of the unit, and this combines the delayed and non-delayed signals. The delay produces a phase shift, but the degree of the phase shift varies with frequency. For example, a 5ms delay represents a 180 degree phase shift at 100Hz where each cycle lasts 10ms. At 200Hz it represents a 360 degree phase shift, with each cycle lasting 5ms. Provided a reasonably long delay is used, the mixing gives the desired result with the two signals adding to give a 6dB boost in gain at certain frequencies, and cancelling at other frequencies to give deep notches of attenuation.

The complementary response is produced in what is essentially the same manner, but the non-delayed signal is inverted prior to being mixed with the delayed signal in a second mixer stage. Therefore, at frequencies where the two signals were previously in-phase they are now out of phase, and at frequencies where they were out of phase they are now in-phase. This gives a response that is an accurate complement of the original and requires a minimal amount of additional circuitry.

Fig.6 shows the main circuit for the complementary comb filter, but the circuit for the mixer and inverter stages is shown separately in Fig.7.

Starting with the main circuit, IC1a acts as the basis of the input buffer stage and VR1 is used to optimise biasing. The circuit is largely d.c. coupled, and VR1 controls the biasing for much of the unit, including the delay line. IC1b is used in a standard third order (18dB per octave) lowpass filter having a cutoff frequency at about 20kHz. The output filter is a fourth order (24dB per octave) type based on IC3 and again having a cutoff frequency at about 20kHz. The unit therefore achieves the full audio bandwidth. IC2 is the delay line itself, and this is a TDA1097 1536 stage type. VR2 is used to mix the outputs of the last two stages of the delay line, and it is adjusted to minimise clock glitches on the output. In the absence of an oscilloscope to aid the setting up of VR1 and VR2, VR1 can just be given any setting that gives a good quality output at high signal levels. Results will be perfectly acceptable if VR2 is simply set at a roughly mid-setting.

The delay time is controlled by a two phase clock oscillator, and this is a simple astable circuit based on two CMOS gates (IC4a and IC4b) with IC4c acting as a buffer and IC4c acting as an inverter to provide the anti-phase clock signal. The clock operates at a frequency of about 100kHz, and the delay time is equal to the number of stages in the delay line divided by double the clock frequency (in Hertz). In this case this gives 1536 divided by 200000, which equates with a delay of just under 0.0077 seconds (7.7 milliseconds). This produces quite a good comb filter response, but if desired R13 could be replaced with a fixed resistor and a variable resistor in series so that the delay time could be varied to give what is subjectively deemed to be the best effect.

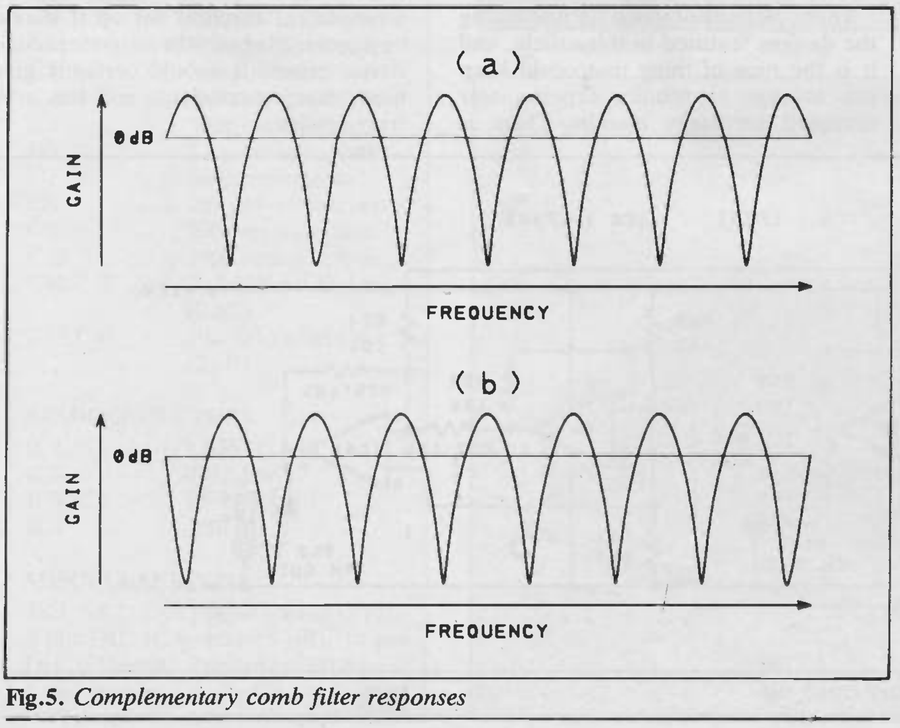


Fig.5. *Complementary comb filter responses*

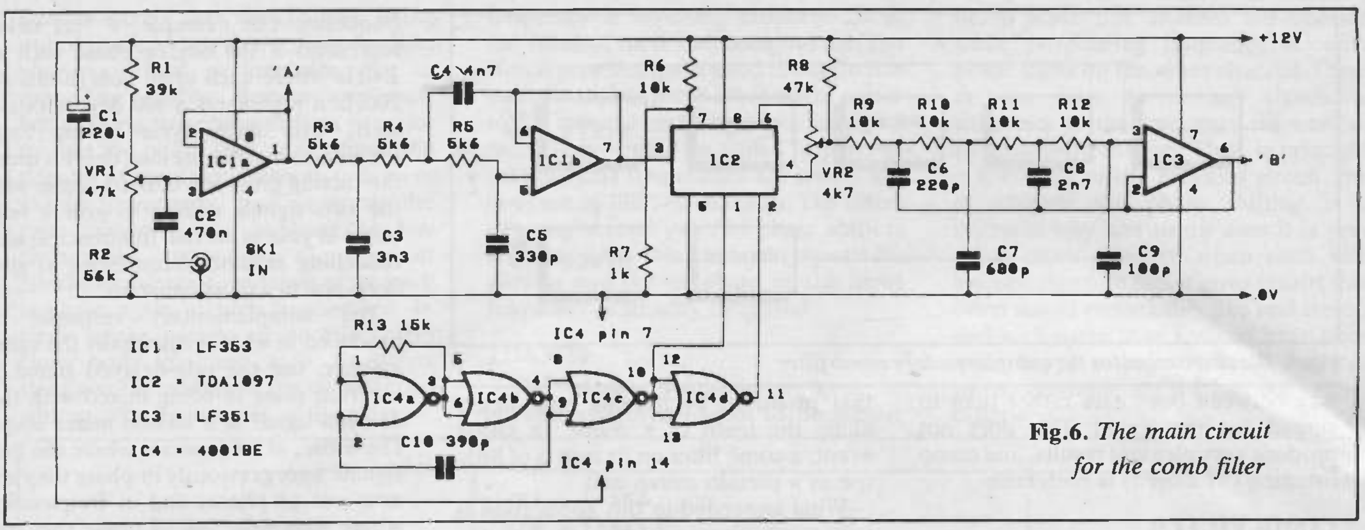


Fig.6. *The main circuit for the comb filter*

Turning to Fig.7 now, IC5 is a standard summing mode mixer which combines the delayed and non-delayed signals. IC6 provides the inverter and second mixer stage. In all the stereo synthesiser circuits included in this article one output is shown as the right hand channel with the other shown as the left hand channel. Obviously with synthesised stereo there are no true left and right hand channels, and the effect is much the same if they are reversed.

Results with the complementary comb filter are quite interesting, with a sound stage that seems to have almost three dimensional qualities. The sound seems rather more reverberant than from the unprocessed signal, which could be due to the delay-line based system of filtering. The outputs from the two channels are never in-phase, being 180 degrees out of phase at a peak/trough in the response, and shifted by 90 degrees when the two channels are at unity voltage gain. I expected this to give a pronounced 'hole in the middle' effect unless one of the channels was inverted, but the sound seems well spread across the sound stage, and inverting one of the output signals did not seem to greatly affect results. If anything, there seems to be a less strong central image with the inverter added, but this is perhaps not very surprising in that there is little point in bringing the channels in-phase when one channel is totally dominant and the sound is right at one side of the sound stage. The unit certainly produces a useful pseudo stereo effect whether it is used with loudspeakers or with headphones, and is excellent for use with a monophonic electric or electronic instrument when a pseudo stereo output is required.

It is a very interesting unit for experimentation purposes, and for those who would like to construct it the printed circuit design of Fig.8 has been provided. Construction of the unit is not difficult and offers little that is out of the ordinary, but bear in mind that IC2 and IC4 are MOS devices, and that the normal anti-static handling precautions should be taken when dealing with these devices.

FURTHER DEVELOPMENT

There is plenty of scope for fine tuning the designs featured in this article, and it is the type of thing that could keep the average electronics experimenter occupied for many months. There is probably a limit to the improvement that tweaking of these designs could provide, and if I was determined to produce the ultimate stereo synthesiser I think that I would try a system based on a graphic equalizer. In fact a stereo graphic equalizer with separate controls for each channel could be used to produce complementary peaks and troughs in the frequency response of the two output channels without the need for any modifications. However, this would be a relatively cumbersome way of doing things in the current context, and it would be difficult to get the adjustments just right so as to avoid any irregularities in the overall frequency response of the system. What would be better and much simpler would be a graphic equalizer plus an inverter and mixer stage to provide the complementary response, as in the comb filter unit. Complementary boost and cut could then easily be added at the required bands in order to give what was subjectively deemed to be the most realistic results. With such an arrangement carefully set up it should be possible to obtain the ultimate pseudo stereo effect. It should certainly give much more controllable and less arbitrary results.

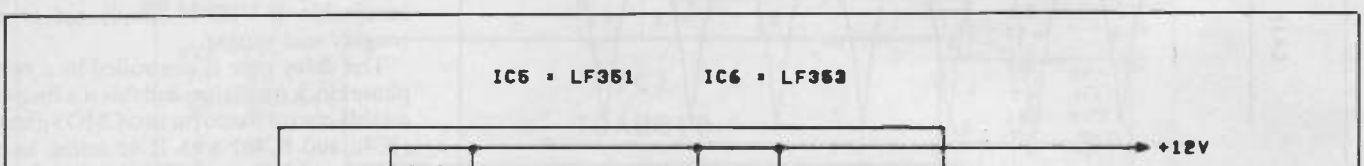


Fig.7. *The output stages of the complementary comb filter*

THE PRINTED CIRCUIT BOARD IS AVAILABLE THROUGH THE PE PCB SERVICE, AND A KIT OF PARTS CAN BE OBTAINED FROM MAGENTA.

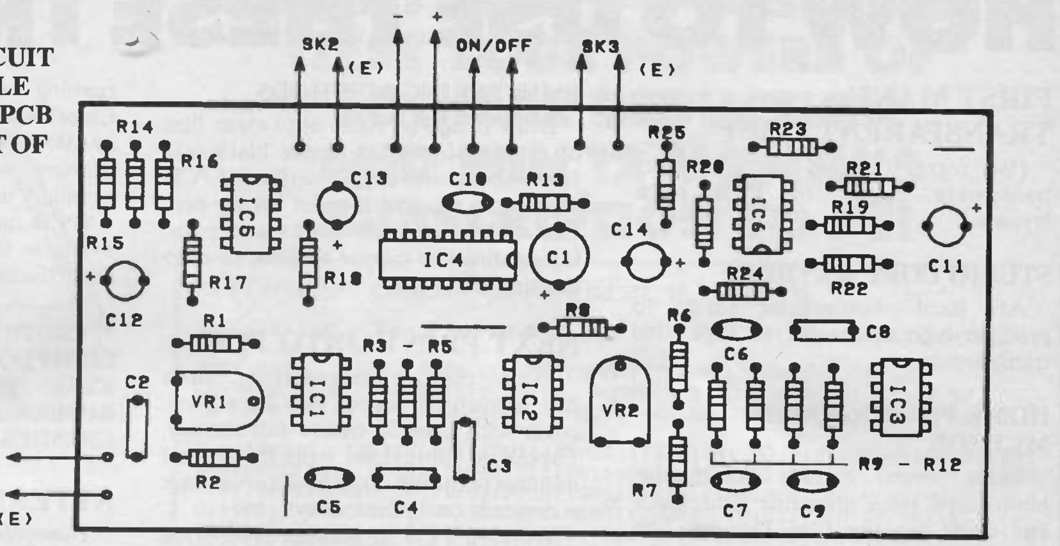


Fig.8.
The comb filter component layout

COMPONENTS . . .

RESISTORS

R1	39k
R2	56k
R3,R4,R5	5k6 (3 off)
R6,R9,R10,R11, R12,R14,R15,R18, R19,R22,R23,R24, R25	10k (13 off)
R7	1k
R8	47k
R13	15k
R16,R17,R20,R21	4k7 (4 off)

POTENTIOMETERS

VR1	47k sub-min hor preset
VR2	4k7 sub-min hor preset

CAPACITORS

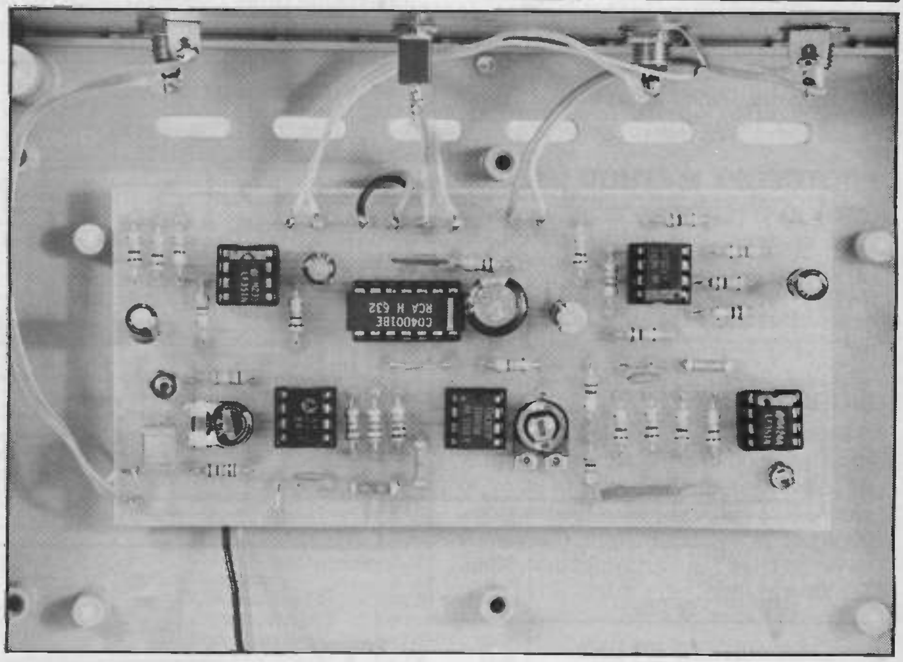
C1	22μ 16V radial elect
C2	470n polyester layer
C3	3n3 polyester layer
C4	4n7 polyester layer
C5	330p ceramic plate
C6	220p ceramic plate
C7	680p ceramic plate
C8	2n7 polyester layer
C9	100p ceramic plate
C10	390p ceramic plate
C11,C12	2μ2 63V radial elect (2 off)
C13,C14	10μ 25V radial elect (2 off)

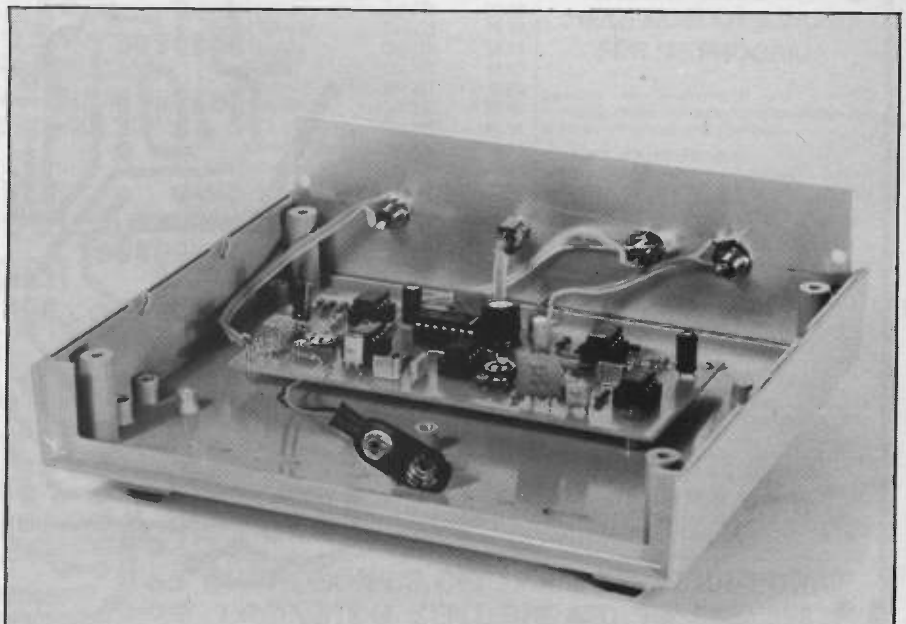
SEMICONDUCTORS

IC1,IC6	LF353 (2 off)
IC2	TDA1097
IC3,IC5	LF351 (2 off)
IC4	4001BE

MISCELLANEOUS

SK1, SK2, SK3 Phono socket (3 off); 8 pin DIL IC holder (5 off); 14 pin DIL IC holder; Printed circuit board; Case, wire etc. PE





HOW TO USE THESE TRACKS

FIRST MAKE TRANSPARENT COPY

(We regret that we cannot supply transparent copies of PCB track layouts.)

STUDIO COPY METHOD

Ask local photographic studio to produce high contrast 1 to 1 positive transparency.

HOME PHOTOGRAPHY METHOD

Using even, bright illumination, photograph track onto fine grain black and white negative film. Develop film for high contrast. Photographically enlarge image up to lifesize, and print onto high contrast lithographic cut film, such as Agfa Copyline HDU 3P Type 2. Develop in Agfa Litex G90T litho developer, or similar.

PHOTOCOPY METHOD

Ask local photocopy shop to make a good contrast copy onto acetate film. (Some copiers are better than others – shop around.) Then touch up tracks with dense black ink, or photographic opaque ink.

ISODRAFT METHOD

Have a normal photocopy made, ensuring good dense black image. Spray ISOdraft Transparentiser onto copy in accordance with supplied instructions. **ISOdraft** is available from **Cannon & Wrin,** 68 High Street, Chislehurst, Kent. Tel: 01-476 0935.

PAINSTAKING METHODS

Draw image by hand onto clear film or drafting film using dense black ink. Draw direct onto copper surface of PCB fibreglass, using etch-resist inking pen. Use etch resist PCB tracks and pads, taping direct to copper surface, or onto drafting film.

NEXT PRINT ONTO PCB

Place positive transparency onto photosensitised copper clad fibre glass, cover with glass to ensure full contact. Expose to Ultraviolet light for several minutes (experiment to find correct time – depends on UV intensity).

Develop PCB in Sodium Hydroxide (available from chemists) until clean track image is seen, wash in warm running water. Etch in hot Ferric Chloride, frequently withdrawing PCB to allow exposure to air. Wash PCB in running water, dry, and drill holes, normally using a 1mm drill bit.

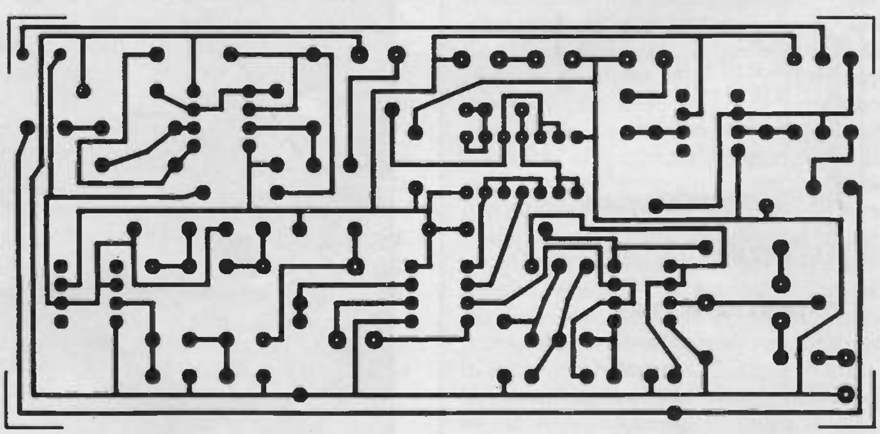
(PCB materials and chemicals are available from several sources – study advertisements.)

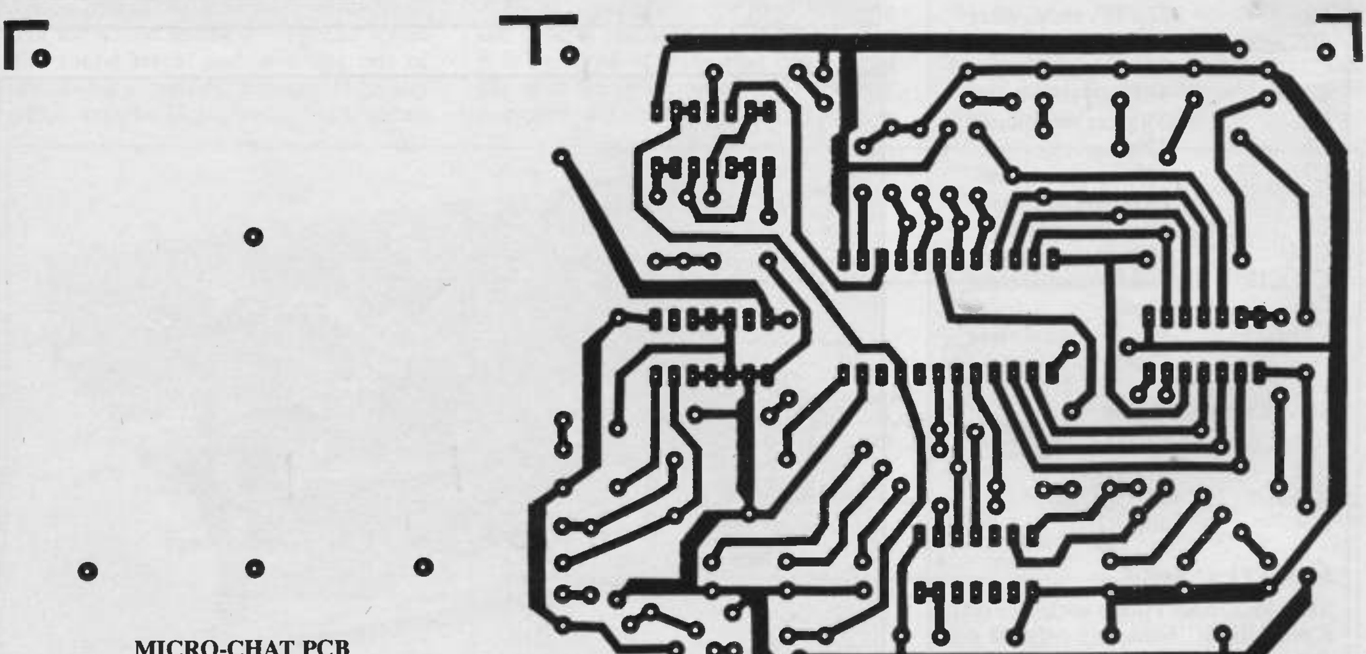
*** CAUTION – ENSURE THAT UV LIGHT DOES NOT SHINE INTO YOUR EYES. PROTECT HANDS WITH RUBBER GLOVES WHEN USING CHEMICALS.**

ALTERNATIVE METHOD

Buy your PCB ready made through the PE PCB SERVICE, most are usually available – see page 60. PE

PSEUDO STEREO PCB





MICRO-CHAT PCB

BINARY CHOP – PUZZLE NO 5 TEST YOUR POWERS OF LOGICAL DEDUCTION AND WIN 12 MONTH'S SUBSCRIPTION TO PE!

BINARY CHOP – PUZZLE NO 5

DECODE THIS 249 CHARACTER MESSAGE

THE SERIAL BINARY DATA CONVERTER OMITTED ALL LEADING ZEROS!
LETTERS A TO Z = ASCII 1 TO 26. NUMBERS 0 TO 9 = ASCII 48 TO 57.
COMMA = ASCII 44, FULL-STOP = ASCII 46. NO OTHER CODES ARE USED.

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ANSWER TO BINARY CHOP PUZZLE 3

WITH PUZZLE 2 LAST MONTH, THE METHOD FOR PUZZLE 1 APPLIES FIRST. THEN FIND ALL FULL STOPS, EXTRACT THE OBVIOUS SINGLE LETTERS. FINALLY BY DEDUCTION WORK OUT THE DOUBLE AND TRIPLE LETTER COMBINATIONS. IT WAS PROBABLY NOT AS HARD AS IT LOOKED INITIALLY. HAVE FUN WITH THE NEXT ONE.

Send your answer to The Editor to arrive before 1st August 1987.

12 month's subscription to Practical Electronics will be awarded for the first three correct answers opened. The Editor's decision is final.

Answer in the October 1987 issue.

Look out for another mental challenge next month!

Winners!
Congratulations to the winners of Binary Chop No 3:

Chris Archer of Beeston.
John Phillips of Kings Heath.
Steve Markie of Towcester.

The winners of the program competition will be announced next month once I've had the chance to study them all in more detail – some remarkable entries!

SWITCHED MODE REGULATOR

Switched mode power supplies come in many shapes, sizes, and configurations. The different types are suitable for different applications. Here we look at some generic types, and go through the design of a flyback converter.

BY ANDREW ARMSTRONG

Fly back to an established principle

MANY commercial switched mode power supplies are offline switchers. That means that the mains is rectified and switched into the primary of a double wound, high frequency power transformer, and the output is taken from the secondary. Control circuitry is run from the secondary output, and control signals are fed back to the primary side by means of opto-isolators or pulse transformers. In this way, the switched mode inductor provides isolation from the mains as well as being the energy storage element in the regulator. This technique provides a compact lightweight power supply – for example a power unit just a bit larger than a domestic economy size box of matches may provide a well regulated 5V at 5A, using a switching inductor wound on an RM10 pot core.

Unfortunately this circuit configuration needs an inductor which is tricky to design and build. Adequate insulation to isolate the output from the mains must be fitted on to a small transformer. Any deficiency in this area can seriously compromise the safety of the unit, so it is not really practical for most home constructors. In addition to the safety problems, leakage reactance can be a right pain with this type of inductor. The substantial insulation between primary and secondary windings reduces the coupling between them so that a significant fraction of the magnetic flux round one winding does not link with the other. To see why this causes problems, we will take a brief look at some of the different switchmode configurations.

BUCK REGULATOR

The most obvious type of regulator is the series or "buck" regulator. The basic configuration is shown in Fig 1, and waveform diagrams are shown in Fig 2. The switching element used here may be a bipolar transistor or an f.e.t., but whatever type of device is used it must switch on and off hard and quickly. The

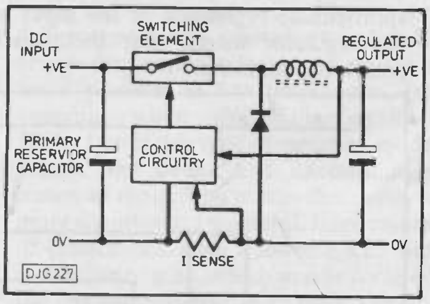


Fig.1. *Series regulator*

only time it dissipates significant power is when it is halfway on or off.

This type of regulator is efficient and economical. As the waveform diagram shows, the peak current in the inductor and the switching element is not too far above the average load current, so that the ratings of these components need not be too high. The main reason for this is that whether the inductor is charging or discharging the current always flows to the load. The waveform diagram illustrates an extra reason. The inductor current never declines to zero, which raises the average and the peak currents by equal amounts rather than equal percentages. The peak current is thus less than double the average current. Because output current flows continuously, while input current is only required intermittently, the available output current is greater than the input current pro rata with the voltage step down (neglecting losses).

The disadvantage of this particular technique is that the switching frequency is higher, so that carrying this idea too far can be counterproductive. A

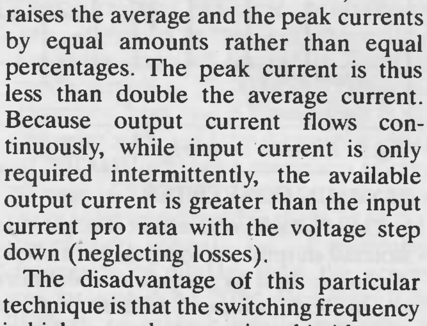


Fig.2. *Series regulator waveforms*

limitation of the circuit configuration is that it can only provide an output voltage lower than the input voltage, and it is only convenient to provide one output per regulator circuit.

BOOST REGULATOR

A regulator design which looks similar to the buck regulator, but which works in a complementary fashion, is the boost regulator. The principle of this is shown in Fig 3. This type of regulator has as much in common with the flyback converter (described later) as with the buck regulator, in fact.

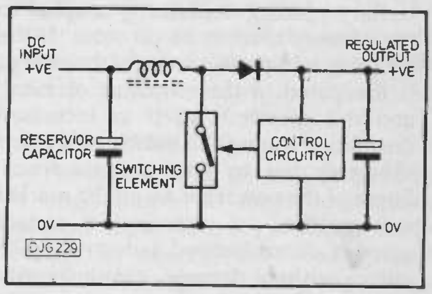


Fig.3. *Boost regulator*

The buck regulator can only provide an output voltage below or equal to the input voltage, the boost regulator can only provide an output above or equal to the input.

The inductor is charged when the switching device is on, and it charges out the output capacitor up above the input voltage while the switching device is off. As input current flows continuously, while current is supplied to the output intermittently, the output current is less than the input current pro rata with the voltage increase.

FORWARD CONVERTER

The forward converter uses a separate winding for the output. This allows the output to be isolated from the input, but raises the problem of leakage reactance, that is to say imperfect coupling between the two windings. Fig 4 illustrates the configuration. When the switching element is on, the current in the primary

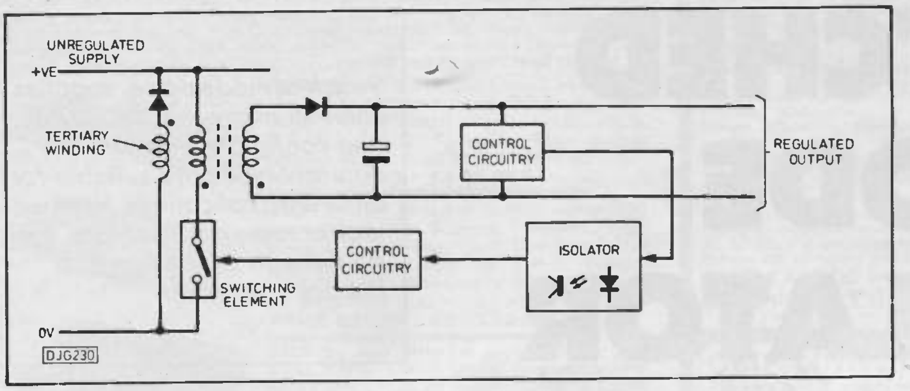


Fig.4. *Forward converter*

increases, and this induces current to flow in the secondary. The current in the secondary sets up a magnetic field tending to cancel that due to the primary, but the coupling between the windings is not perfect so an increasing net field results. If allowed to continue this would cause the core to saturate, so the primary current is switched off at the preset level.

When the current has risen to the required level, the switch element is turned off and the primary current ceases. As we know, current in an inductor cannot stop or start instantaneously – the energy stored in the magnetic field would be transferred, probably destructively, to any switching device which tried. The third winding is there to transfer this energy back to the main smoothing capacitor, and if this tertiary winding is perfectly coupled to the primary there is no problem. If the coupling is imperfect some of the energy is dissipated in the switching element, and this manifests itself as increased dissipation during the switch off (which obviously has to take a finite time). Some of the power f.e.t.s on the market are specified to withstand a certain amount of unclamped inductive spike energy without damage, obviously with this effect in mind.

A well designed forward converter will spend longer transferring energy from primary to secondary than ridding the core of unwanted magnetic field, but nevertheless the output current is not continuous, and as a result the peak rating of the components must be higher for any given output than with a buck regulator. The control circuitry is also rather more complicated than for the buck regulator.

The forward converter can provide more than one supply rail, however, and if the main output rail is regulated then the others will have a reasonable regulation so long as all the secondary windings are closely coupled. A range of supply voltages can be provided, some above and some below the input voltage is required. All the different outputs can be isolated from each other if necessary.

Regulating one output will regulate the others to some extent, but if accurate regulation of several outputs is needed then the usual technique is to regulate the highest current output with the switchmode control circuitry, and to use linear regulators on the other outputs. This is still more efficient than the use of linear regulators alone because the approximate regulation of the input to the regulator means that their dissipation is minimised.

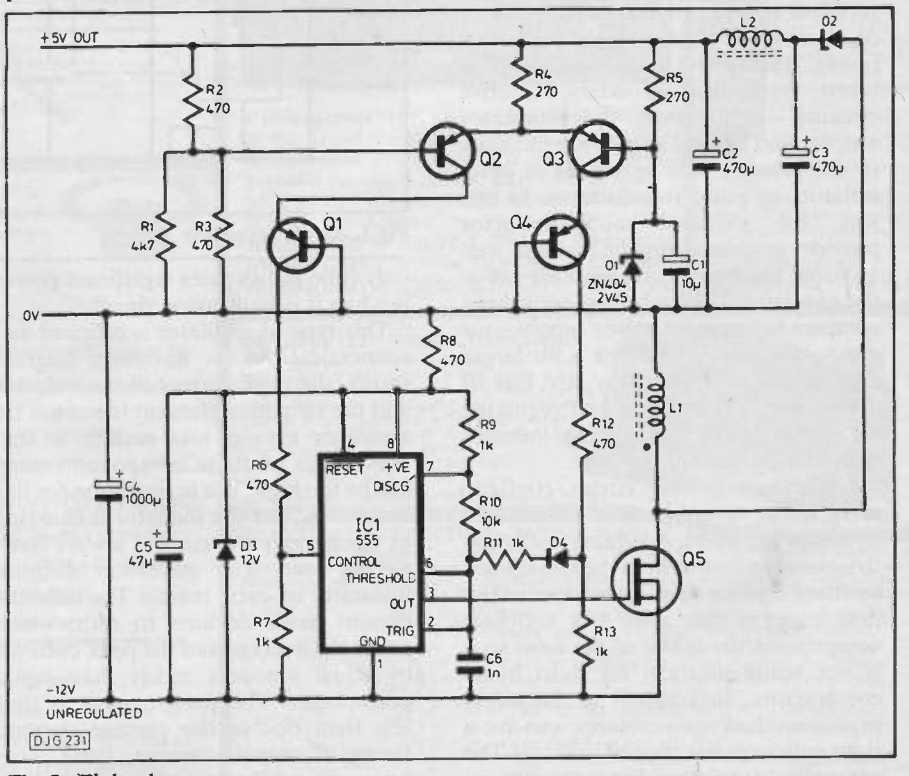


Fig.5. *Flyback converter*

FLYBACK CONVERTER

The flyback converter can provide isolated outputs if required, but instead it can be used to provide one or more non-isolated outputs without leakage reactance causing significant problems. This is the configuration used in this project. It is also the principle used in television e.h.t. generators – the line transformer is a flyback converter inductor.

The basic circuit to provide one regulated output is shown in Fig 5, the waveform diagram is shown in Fig 6. This non-isolated design provides a positive 5V output from a negative input, though an isolated design could of course provide either polarity.

The principle of the flyback converter is that a current is made to flow in an inductor, and then diverted into the load. When the switching element, in this circuit Q5, is turned on, the current in the inductor starts to rise. After a preset time, Q5 is switched off and the current in the inductor flows to the output via D2. There is no leakage reactance here because there is only one winding. There can be no high voltage overshoot spike applied to the drain of Q5 because as soon as D2 switches on the drain voltage is prevented from rising further, and all the stored energy is transferred to C3.

HOW IT WORKS

The 555 timer is wired as an astable oscillator, with a frequency calculated to allow the inductor to charge and discharge fully at the input and output voltages to be used. The output of the 555 drives Q5 directly, as its current rating is sufficient to charge and discharge the gate capacitance rapidly. The use of a f.e.t. as the switching element reduces the average drive current requirements because current only flows when the gate capacitance is being charged or discharged. Because of this low power consumption, it is

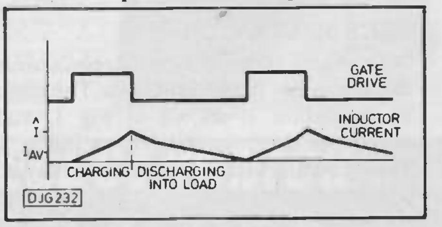


Fig.6. *Flayback waveforms*

practical to zenner stablilise the power supply to the 555. This permits the circuit to work with higher input voltages without damaging the i.c.

The mark to space ratio, and hence the charging time per cycle, is set by control circuitry powered from the regulated 5V output. If the control circuitry is not operating, as for example at switch on, the charge time is set to a low value by the potential divider action of R7 and the internal resistors in the 555. In this way the switch-on surge is limited, as is the short circuit current.

Q2 and Q3 form a long tailed pair which compares the output voltage with a reference voltage. The addition of R1 to the comparison chair compensates for the fact that the reference is only 2.45V, and therefore the output would only be 4.9V without R1. The addition of R1 raises the nominal output voltage to 5.15V, a little over 5V to take account of wiring resistance between power supply and load.

At high output currents, the charge time of the inductor must be increased, which requires current to be supplied to R7. At full output a current of about 6mA may be needed. If the long tailed pair transistors had the full input voltage applied to them when operating at this current, enough heat would be generated to alter the Vbe of the devices thus causing the regulated output voltage to drift. To prevent this from happening, cascode transistors Q1 and Q4 are used. Variation in the junction temperature of these transistors will not affect the output voltage.

At very low output currents, the basic mark:space ratio of the 555 oscillator may still provide too much power. For this reason, the control circuit can cut the charge time of the inductor still further by injecting current into the time constant capacitor. The combination of the two control methods enables the power supply to provide a regulated output over a range of load currents from 0 to the maximum available from the core and frequency in use.

The output filtering is of interest. The value of C2 an C3 is higher than you would expect simply to give a low ripple at the frequency in use. The reason for this is that electrolytic capacitors are not perfect (to say the least) and they have unwanted inductance and resistance as well as capacitance. The e.s.r. (equivalent series resistance) and e.s.l. (equivalent series inductance) are not a usual problem at low frequencies, for example when smoothing rectified 50Hz, but in this type of switched mode supply, the peaky and discontinuous nature of the current makes these effects more significant. In general, large values of capacitance have a lower e.s.r., and a distributed e.s.l. which makes some of the capacitance appear to have a lower e.s.l. In addition, the large value of smoothing capacitance improves the transient performance of the supply, and relaxes the requirements on the control circuitry. The 4.7µH inductor prevents fast switching spikes from reaching the load.

COMPONENTS . . .

RESISTORS

R1	4k7
R2,3,6,8,12	470R
R4,5	270R
R7,9,11,13	1k
R10	10k

All resistors 1/4W 5%

CAPACITORS

C1	10µ 16V radial elect
C2,3	470µ 10V axial elect (2off)
C4	1000µ 25V axial elect
C5	47µ 16V radial elect
C6	1n ceramic

SEMICONDUCTORS

D1	ZN4 4 voltage reference (Ferranti)
D2	5A Schottky diode e.g. 50SQ30 or VSK530
D3	12V 400mW zenner
D4	1N4148
Q1,2,3,4	BC212B or equivalent
Q5	BUZ10, BUZ11, IRFZ30 or similar
IC1	555 timer

MISCELLANEOUS

Veroboard, wire, small heatsink, RM10-250 pot core, 4.7µH 3A choke.

INDUCTOR DESIGN

For the purpose of this design, let us assume that a single out of +5V at a load current of 2A is required. This is just enough so that most linear regulator circuits would be fairly inefficient.

The core itself sets the maximum energy transfer per cycle. A maximum value of energy storage is often specified for cores intended for use in switched mode supplies. To take a couple of examples from the RS range, an RM7 pot core with a A1 (inductance factor) of 250 nH/Turn2 has a maximum energy storage of 0.406 mJ. If this much energy were to be transferred to the load 50,000 times per second, i.e. a switching frequency of 50kHz, then the power output would be 20W. However, it is difficult to achieve this in practice. A look at the waveform diagram for this type of power supply shows that the peak current in the inductor is about three times the average output current for this particular choice of input and output voltages. At a peak current of 9A the losses rise alarmingly, and as the f.e.t. and the core heat up due to the losses the efficiency decreases further.

Therefore it is more practical to use the next size of core, an RM10 with an A1 of 250 and a maximum energy storage of 1.731 mJ. It is practical to run this in a mode where the current does not decline to zero with each cycle, so that the peak current is lower for any given average. To achieve this, a higher inductance will be used, which increases the magnetic flux in the core. The inductance can be raised considerably above the level which would fully discharge every cycle without the larger core saturating. A value of 100µH is suitable, which coincidentally uses a nice round number of turns, to whit 20.

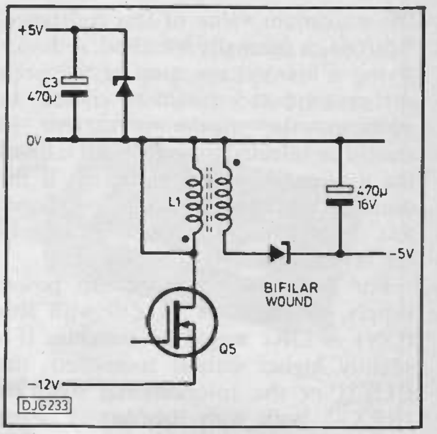


Fig.7. *Method of producing a —5v supply*

With this value of inductance, and the 69kHz nominal switching frequency given by the timing components round the 555, the current in the inductor never reaches zero at higher load levels. The waveform of current in the inductor is similar to the inductor current waveform in Fig 2.

BIFILAR WINDING

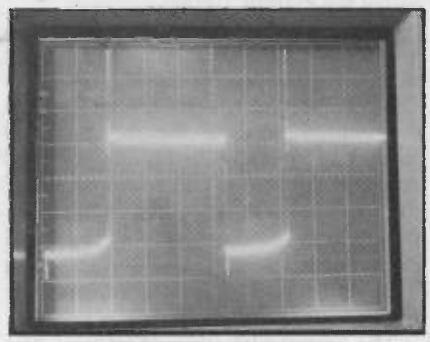
The design so far has only referred to a single output. If more outputs are needed these can be provided fairly simply, by adding extra windings and extra diodes and smoothing capacitors. The extra rails thus provided will be more or less regulated relative to the main 5V output. The closer the coupling between the extra windings and the primary the better will be the regulation of the extra outputs.

If, for example, a −5V supply is to be provided, two lengths of wire can be twisted together and the two windings wound together. This is called bifilar winding, and it gives the closest possible coupling between the windings. In principle, if any multiple of 5V is required for the extra output, more strands of wire may be twisted together to do the winding, and connected in series to provide the output. In practice, it gets difficult to wind with more than about four strands. Fig. 7.

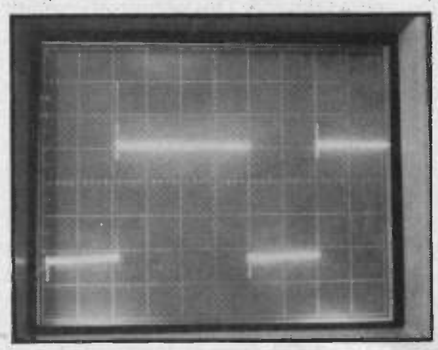
FET CHARACTERISTICS

For this design to work properly, the correct type of power fet must be used. Unlike bipolar transistors, fets in saturation act like a low value resistance.

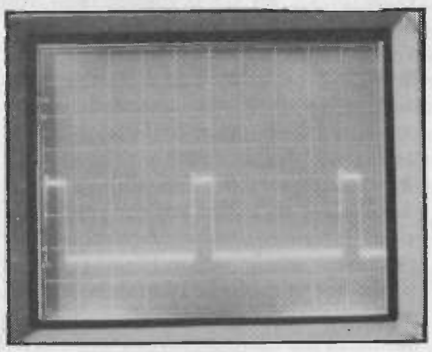
All oscilloscope picture 5v/div, OV middle line



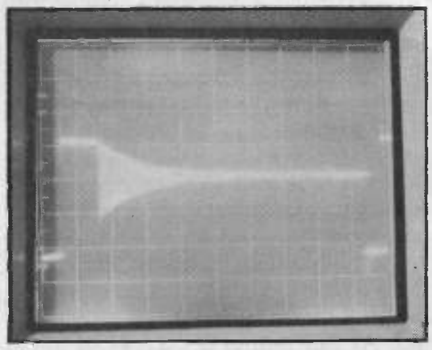
Core saturation using RM7



Full load using RM10 core



Output of 555



Observe ringing on light load

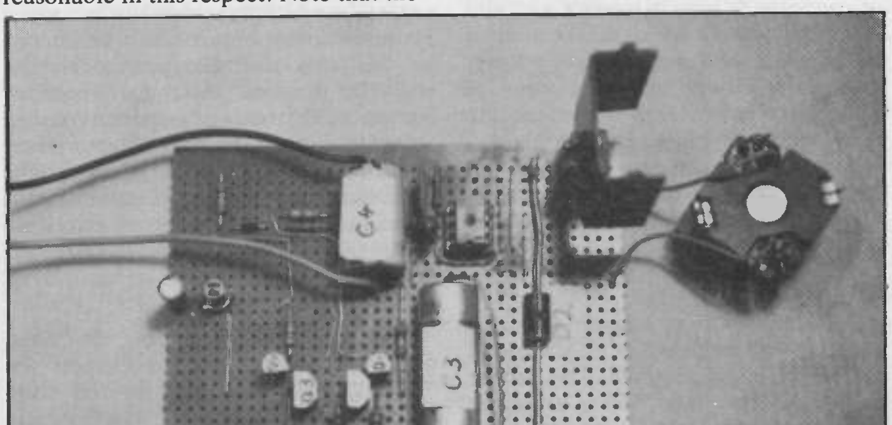
The maximum value of this resistance, Rds(on), is normally specified. A device giving a low voltage drop at the peak current expected should be chosen. In addition, the maximum current Id should be selected to be at least 1½ times the maximum current expected. If the drain current approaches the maximum too closely, the effective resistance of the fet increases.

For the design load of this power supply, the Mullard BUZ10 with Rds (ON) of OR1 would be suitable. If a slightly higher output is needed, the BUZ11 or the International Rectifier IRFZ30, both with Rds(on) of about 0.05R are suitable.

CONSTRUCTION

Because high peak currents flow in this power supply, the physical layout is of some importance. In particular, the OV connections should be short and thick, and the paths between C4, Q5, and L1, and D2, C3, and L1 should be short. The heavy peak currents flow in these loops. The arrangement of components on the veroboard model shown in the photograph is quite reasonable in this respect. Note that the veroboard prototype does not include L2 and C2, but these components are recommended for applications in which power supply noise is a problem.

A more compact layout than that used for the prototype would be useful for most applications – it is up to the constructor to decide what is most suitable. Assembly should present no serious problems, though some care should be taken not to zap the power f.e.t. with static. Before the f.e.t. is connected, it is a good idea to check that the 555 oscillator is providing the right sort of waveform – as shown in the photograph. Then connect the f.e.t. and run the supply first at no load, and then at full load, while measuring output voltage and checking that the f.e.t. does not get hot.



Photograph of Veroboard Prototype layout

CONSTRUCTORS NOTE: The author advises that RS pot cores can be obtained from Electromail, and the power FETs from Farnell (but phone them first!) PE

POINTS ARISING

30 + 30 AMPLIFIER (MAR 87) Page 49

Fig.1: "Right – VE from C35" should read "Right – VE from C36". Also, "Left + VE from C36" should read "Left + VE from C35".

VIDEO FADER (JAN 87) Page 24

Fig.5. The polarity of C2 should be reversed.

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BAB8	4"x4"x1½" with lid	1.35
BAB9	4"x2¾"x1½" with lid	1.10
BAB10	4"x5¼"x1½" with lid	1.45
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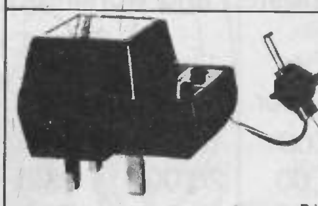

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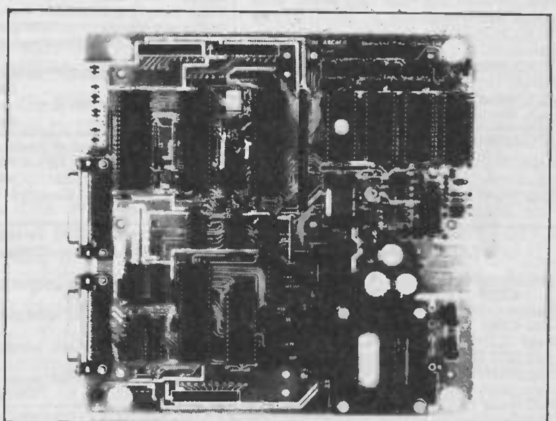

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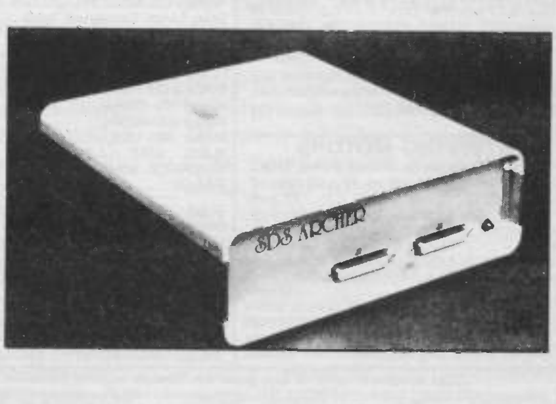

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MORE ABOUT WOODPECKER

BY RON A. ADAMS

The most powerful transmitter in the world

Russian pulser now on the very low frequency band (VLF) 100kHz.

THE Russian pulsers were first heard during the winter of 1976-77. Because this winter was a very severe one in most of the United States, it was speculated that the Russians were possibly interfering with the weather using very high power radio transmissions. This theory was widely circulated through the American media creating more paranoia about secret scientific experiments behind the Iron Curtain. However, no feasible scientific evidence has ever been amassed to support this hypothesis.

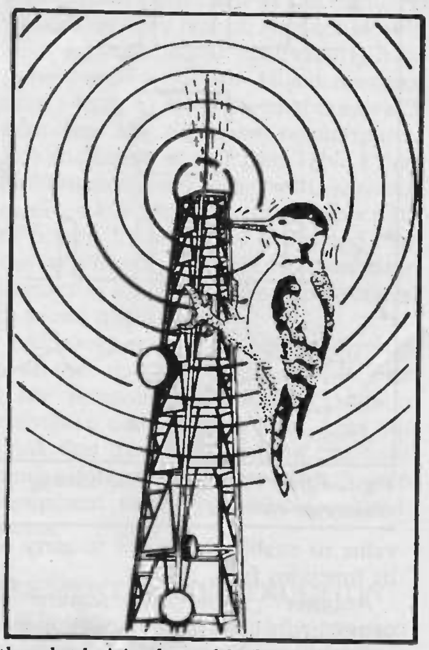
Woodpecker is a wideband signal that consists of pulses spread out over a range of more than 100kHz. The amount of these pulses can vary, but using an oscilloscope shows that ten per second is a common number. The characteristic sound akin to a woodpecker rapping on wood resulted in the adoption of the obvious nickname. Woodpecker was commonly heard on the following frequencies:

3261kHz	6880kHz	12446kHz
3357kHz	7750kHz	13359kHz
4484kHz	8010kHz	13572kHz
4775kHz	8626kHz	14774kHz
5071kHz	9482kHz	15595kHz
5865kHz	11488kHz	15814kHz
6461kHz	12095kHz	17540kHz

However, this enigmatic signal seems to have ceased operation on the above frequencies and is now sitting on the VLF band at 100kHz. Not many people would be aware of this, since the lowest frequency that domestic or communication receivers operate on is 150kHz. I stumbled on it by accident while doing some VLF reception experiments. Woodpecker appeared on VLF a few months ago, and the phenomenal signal strength indicates transmitted power of millions of watts.

This utilisation of VLF and very high transmitted power seems to back up the popular theory that the Russians are researching, and using, the theories of Nicola Tesla. He believed that it was possible to transmit electrical power without intervening wires. Indeed, Tesla built a transmitter at Long Island, sixty miles from New York City, and claims to have transmitted power across the world.

The theory that the Russians have carried on his researches gained momentum when it was discovered that



they had visited an elderly gentleman in Canada, who had worked closely with Tesla in the early part of this century. Are then the Russians engaged in transmitted power experiments? Possibly, but another more sinister hypothesis is periodically put forward, that Woodpecker is being used for mind control. Many dismiss this as an absurd notion, but an interesting book was published in 1962 by Leningrad State University on Instruction from the Editorial Council of the University of Leningrad.

It was translated into English in 1963 under the title "Experiments in Distant Influence. Discoveries by Russia's Foremost Para-psychologist – Professor L.L. Vasiliev". This book describes, and gives the results of, experiments done with telepathy and the triggering of conditioned reflexes by high voltage, low/high frequency transmitted electromagnetic fields. On page 29 of this fascinating book, the following significant statements are made; "low frequency fields produce a highly excitory effect on isolated nerves and nerve centres when in vivo in their natural setting in the organism". Also; "it is of the utmost importance to note that low-frequency electromagnetic fields can apparently affect the human cerebral cortex, and hence higher nervous activity".

Reference (21) on page 230 further states, as an addition to the above, "sub-sensory or sub-threshold reactions: Those responses to the stimulation of receptor organs which reach the cerebral cortex but are not consciously noted owing to insufficient intensity of the stimuli. It is however, possible to establish conditioned reflexes to such unnoticed responses".

Researches in parapsychology have pointed to the fact that 24-75% of all humans exhibit psychophysiological sensitivity to magnetic and electrical fields in the VLF range corresponding to brain wave spectra. These fields can supposedly produce erratic behaviour in humans, and presumably animals.

Despite this, Woodpecker is likely to be nothing more sinister than over-the-horizon or low-level radar. It is common knowledge that both the United States and the Soviet Union are working flat out on such systems. Low-level radar is given top priority, because of gaps in defence systems. Conventional radar is limited in range, and spy satellites are slow in providing information. Conventional radar systems are in the microwave range, using low power and giving sharp reflections from approaching aircraft. Unfortunately, microwaves cannot pro-pagate beyond the horizon, being 'line of sight' frequencies.

However, conventional short wave frequencies can propagate beyond the horizon. The obvious drawback to using conventional short wave frequencies is the massive transmitting power and gigantic receiving installations required. For example, an experimental low-level radar installation in Maine USA, had a transmitting aerial 2276 feet wide and 135 feet high. It was fed by 21 transmitters, each with 100 kilowatts output. Obviously, VLF low-level radar installations would require much larger transmitting and receiving installations. In fact we are talking about hundreds of square miles for an efficient VLF aerial. Hardly an installation that can be kept secret is it?

In conclusion, I leave the enigma of Woodpecker suspended and open to further conjecture, and in all probability we can accept the low-level radar theory. The chilling thought remains though that a powerful transmitter like Woodpecker could perhaps produce unforseen mental side effects. PE

Individual components used in hifi are often not up to spec., or have some structural disadvantage. The solution is to upgrade selectively with more stable parts.

COMPONENT TECHNOLOGY

PART ONE BY GRAHAM NALTY

Changing components with military precision – a sound decision

If you read carefully through any specialist HiFi magazine you will notice that more and more attention is being paid to the quality of components used inside amplifiers, tuners, tape decks and compact disc players. The reason is that every resistor, capacitor, diode, transistor, valve, switch, potentiometer, cable and connector influence (= changes = distorts) the sound quality. This does not only apply to those parts which actually handle the audio signal voltage, but also applies to parts used in power supplies. If all the electronics parts we used behaved *exactly* as their description implied there would be no problem.

Electronic parts are not the physical realisation of perfect or ideal components. If you look at their detailed specifications, you will see that resistors vary in value with temperature; capacitors suffer from dielectric loss and dielectric absorption; the voltage across a diode varies with current; the gain of a transistor varies with changes in any one of several parameters; anode current in a valve varies with temperature and so on. Good design can reduce the effects of changes in the components, but can not eliminate them.

PARAMETERS

If we accept the argument that changes in a component parameter can affect the sound quality of a signal passing through the component, then it is reasonable to assume that a component which has a lower change in that same parameter will distort the signal less. So the goal is to obtain, and use in our hifi amplifiers, components with the most stable performance. The audio industry is just starting to look at component quality in detail. The instrumentation and military electronics industries have always had component quality as the foremost design requirement to their purpose. An instrument manufacturer requires his product to measure accurately and to keep on measuring accurately. Most electronic instrument are used at local ambient temperatures in various parts of the world, so they have to remain accurate over a range of temperatures. Military equipment may be used anywhere in the world and the components used must be not only able to withstand wide temperature variations, but remain sufficiently stable in

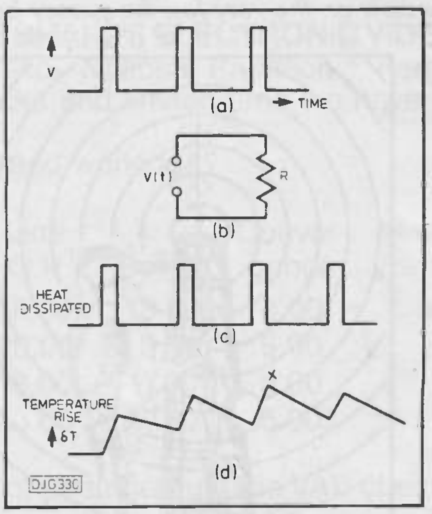


Fig.1. *Effect of pulse signal heating resistance element*

value to enable the circuit to carry out its functions fully.

Another important feature of components used in military equipment which also applies to components in civil aircraft and railway signalling is reliability. The component must not fail. At worst the failure of a component in some situations can cause loss of life. In other situations the failure of a component can have very expensive results if a train is halted, an aircraft is grounded or an industrial process using very expensive machinery is halted. All these industries require components of a higher 'quality' that are more expensive to manufacture than we have been used to using in audio electronics.

Experience shows that when we substitute a higher grade component in an audio circuit, the sound quality is judged to be improved. It is not within the scope of this article to suggest whether such an improvement means that the sound is more pleasant to listen to, or that it sounds closer to the sound of the live instrument or voice that was recorded. The overall commercial viewpoint is that most people who are sufficiently interested will pay more of their hard earned cash to enjoy the sound of their hifi system using the higher grade component.

It is not enough to simply substitute a more expensive component and expect the sound quality to be improved. We would simply be going on an upwards cost spiral which bore little value in relation to the cost. For example about 10 years ago you could walk into a hifi shop and buy a very expensive hifi amplifier that sounded hardly any better than one at a third of the price. Of course you got more power – and also more useless knobs and switches. If you want to use better quality components in your hifi system, you need to understand why such components sound better and choose your components for the right reasons.

RESISTORS

I will start with resistors because on the surface these are the simplest components. If you were to have asked any good audio engineer five years ago about resistors, you could have been told simply that metal film types are best because they have the lowest noise and that it is better to use close tolerance types such as metal film or metal oxide to avoid gain imbalance between channels of a stereo amplifier. This is only a very small part of the story. Let us start with metal film resistors because they are so easily and so cheaply available today – a 1% ¼watt metal film resistor costs typically 5p through regular suppliers advertising in the magazine. If you are still using 5% carbon resistors in your hifi, we have already overtaken you. Readers who have followed my articles on the PE 30 + 30 will be aware that I have recommended the use of Holco H8 resistors in certain critical positions. I have done so with good reason because I have found by my own listening experience that Holco resistors *do* improve the sound when they are used in place of standard lower cost metal film types. That is observation. What are the *plausible* causes of differences in two types of metal film resistors?

a) Changes in resistor value due to temperature changes.

b) Changes in resistance due to humidity.

c) 'Dissimilar metal' effects at the connection between the resistor and its lead.

d) Inductive and capacitive effects in metal film.

Temperature effects will be examined first. The easiest way to illustrate this point is to consider the effect of a resistor which is subjected to voltage pulses at intervals. Fig.1a shows the voltage applied to the resistor. Fig.1b shows the circuit. Fig.1c shows the relationship between heat dissipated in the resistor with time, which is equal to the power applied to the resistor, V_2/R. As the resistor element heats up, it will lose heat by conduction:

Heat conducted away from resistor = k $(T_1 - T_2)$
where
T_1 = temperature of resistor element
T_2 = temperature of insulating material
and K is a constant.

The faster that the heat is conducted away from the resistor element, the lower the temperature rise at any point in time. In Fig.1d, we see the temperature rise in the resistor element. As the pulse is applied, the resistor heats up rapidly. If the pulse duration is short we can assume that the temperature rises uniformly with time. In practice the temperature rise will slow down slightly as heat is conducted away. At the end of the pulse, no power is applied to the resistor; no further heat energy is applied. There is a temperature difference between the resistor element and the ambient temperature so heat is conducted away via the insulating material. Thus the lower the thermal resistance of the resistor body, the faster that heat is taken away from the resistor element and the lower its mean temperature. A second pulse will raise the temperature further, but the heat will conduct away faster due to the higher temperature difference. At some point, shown by X on the diagram, the average heat dissipation will equal the average heat from the pulse, and some form of equilibrium is reached.

Imagine that the pulses are replaced by bangs on a big bass drum and we wish to superimpose the sound of a female singer. The variations in resistance will modulate the voice and change in its level. If we take a typical resistor of 50ppm/°C of 100K ohm and assume that the variations in temperature due to the bass drum is 10°C we can work out the change in resistance during the cycle.

$$\frac{1}{\delta T} \times \frac{\delta R}{R} = 50 \times 10^{-6}/°C$$

$R = 10^5, T = 10°C$
Change in resistance
$= 50 \times 10^{-6} \times R \times \delta T$
$= 50 \times 10^{-6} \times 10^5 \times 10$
= 50 ohms or 1 part in 2000

If we use a carbon resistor with a temperature of 1000 ppm/°C, we would get a change in resistance of 1 part in 100!

Under such circumstances, the sound of a drum will modulate the sound level of a vocalist, and of course the singer will modulate the sound of the drum. The two factors which will affect the distortion caused by temperature variations are:

a) Temperature coefficient of resistor.
b) Thermal conductivity of the resistor body.

HOLCO TYPE	BSE 9111-N001			COMMERCIAL	
	STYLE	WATTAGE @ 70°C	TEMPERATURE RISE	WATTAGE @ 70°C	TEMPERATURE RISE
H10	H	0.063	14°C	0.1	20°C
H8	J	0.125	28°C	0.25	40°C
H4	K	0.25	32°C	0.5	55°C
H2	L	0.5	43°C	1.0	65°C

Table 1. *Ratings of Holco resistors*

As the Holco resistor which I have tested had the same specified temperature coefficient as the ordinary metal films they replace (but could well have a better actual coefficient), it is quite possible that the Holco resistors have a body of lower thermal resistance than their less expensive counterparts. It is interesting to note from Table 1 that Holco resistors of a higher wattage rating exhibit a lower temperature rise per watt of power. I have heard it claimed that the substitution of an H2 Holco resistor in place of an H8 gives an improvement in sound quality.

Although resistors exhibit changes in resistance due to humidity, and 'higher grade' resistors have a lower change in resistance due to damp heat, I do not think that this factor in itself can have much effect on the performance of audio equipment used in domestic environments.

ELEMENTAL CONSTRUCTION

It is quite possible that the connection between the resistor lead and the resistor element has some sonic effect similar to a switch or plug-socket connection. A more expensive product can have a higher grade connection. In the Holco resistor range 'the ends . . . are gold plated to ensure good electrical contact with the end caps'. The source of this information is the Holco specification leaflet. This is a typical example of how a 'better quality' component might exhibit sonic improvements that might not be obvious from its published specifications.

Metal film resistors are wound in a spiral and so exhibit inductive effects. This is a point that is not generally realised amongst audio designers. There are some instances in which audio designers have used very high grade carbon resistors (i.e. military spec components which would never get near any audio constructors catalogues) to achieve better sonic performance at high frequencies, but I do not have any information on the exact types used, or any opinions on their comparative sound quality with metal films. It is interesting to note that special non-spiralled resistors can be manufactured from the Holco range, but only up to 1k resistance and at a higher price. Single turn spirals are available for values up to 2k. It is obvious that the type of spiral could affect sound quality, but it is not easy to predict exactly how, except through listening tests, and only resistor manufacturers are equipped to do any research in this area. This is another possible instance in which quality of manufacture can affect sonic performance without any evidence being available in the specifications.

If metal film resistors exhibit characteristics which are not absolutely ideal, then bulk metal foil resistors have some of the answers:

a) Extremely low temperature coefficients as a result of controlling two opposing physical phenomena. The coefficients of thermal expansion of the resistive alloy and the substrate are different. This creates a compressive stress on the resistive alloy for a rise in temperature. The change in resistance due to the compressive stress is equal and opposite to the increase of resistance with temperature (Fig.2).

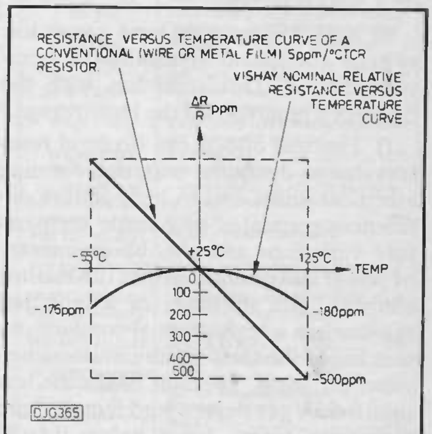


Fig.2. *Comparison between the Vishay resistance versus temperature (TCR) behaviour with a conventional 5ppm/°C TCR precision wire or precision metal film behaviour*

b) Very tight resistance tolerance is achieved by trimming various adjusting points that have been designed into the photoetched pattern of the resistive element. Trimming the pattern at one of these points will force the current to seek a longer path, thereby raising the resistance value by a specific percentage (Fig.3).

c) Inductive effects are self cancelling because no two resistance paths carry current in the same direction. Capacitive effects are minimised by developing the lumped capacitance in series. The result is that bulk foil resistors perform extremely well under high frequency and pulsed signal conditions. Inductance is below $1\mu H$ and capacitance below 1pF.

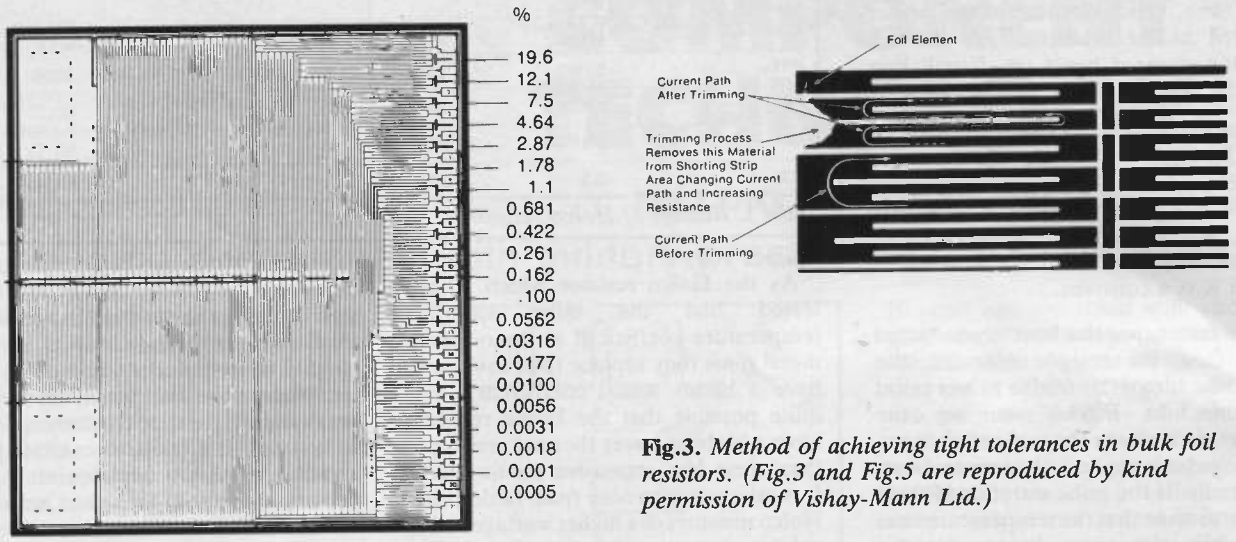


Fig.3. *Method of achieving tight tolerances in bulk foil resistors. (Fig.3 and Fig.5 are reproduced by kind permission of Vishay-Mann Ltd.)*

d) Two factors contribute to the extremely low noise of bulk foil resistors. The resistive alloy is a solid metal and its molecular structure is unaltered by processing. Secondly, due to the photo-etched pattern, the current paths are smooth and uniform. There are thus no variations in the width which will produce current variations and which would be a source of noise.

e) Bulk foil resistors have a very low voltage coefficient, typically 0.1 ppm/volt applied. This compares with the figure of 5 ppm/volt for the Holco range.

f) Thermal effects can occur in resistors due to dissimilar materials forming electrical joints and to temperature differences generated by outside temperature variations and also by asymmetry of power distribution within the resistor element. The substrate of a bulk foil resistor has a high thermal conductivity that keeps the temperature uniform between the leads. Thermal EMFs are less than $0.5\mu V$ per degree lead temperature difference (some types below $0.1\mu V$/degree) and less than $4\mu V$ per watt of power dissipated in the resistor.

BULK FOIL

In sonic terms the performance of bulk foil resistors is excellent and a big step closer to the real thing. But they are expensive, costing several pounds each. Few people will wish to afford the cost of using only bulk foil resistors in their amplifier, so it is useful to give some guidelines on the places where they will achieve the most significant sonic improvements.

Fig.4a shows a power amplifier and the first place to fit a bulk foil resistor is the main output to input resistor R1. The gain of the amplifier is a function of R1 and R2 and as R1 handles a much larger voltage than R2 this is the more critical. In a low distortion high feedback amplifier, it might prove an interesting exercise to compare the harmonic distortion figures between amplifiers identical except for carbon resistors in the feedback circuit of one, and bulk foil resistors in the other.

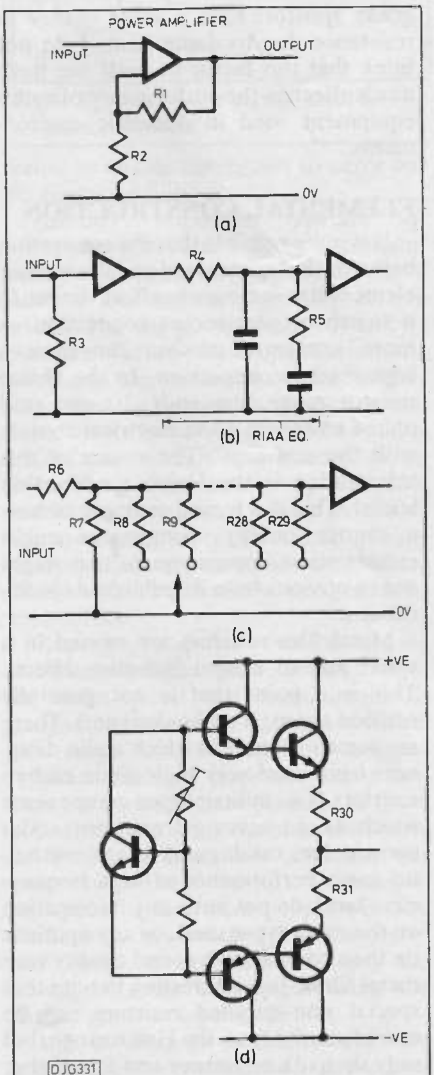


Fig.4. *Circuit locations where higher quality resistors are most profitably used.*

Another location for the profitable use of bulk foil resistors is the cartridge loading resistor, though I do not claim to understand fully the effects. However, it is well known amongst hifi dealers that the sound of a cartridge can be greatly changed by change of resistor value. My own observation is that the sound of a cartridge can be significantly changed by a higher quality resistor of the same value.

It would also appear that the 'quality' of resistor may affect the tracking ability of a cartridge. The only explanation which I can offer is that noise in the resistor is fed back into the mechanical parts of the cartridge as vibration. Or perhaps temperature effects of resistance caused by the output from the cartridge.

If you are spending over £50 on your cartridge, can you honestly justify spending under £1 on a pair of Holco resistors for loading it? It is an interesting argument to suggest that a cartridge costing over £50 should be loaded by bulk foil resistors costing almost £10. It would be an interesting exercise to take two cartridges by the same manufacturer priced about £10 apart, loading the more expensive one with metal film resistors, and the lower priced model with bulk foil resistors.

The next profitable application of bulk foil resistors is in the RIAA equalisation circuits. In the passive circuit of Fig.4c, R4 would be the most critical. The final application for bulk foil resistors is in a switched volume control. Both carbon and conductive plastic potentiometers have a high temperature coefficient, much higher than metal film resistors. Even in an amplifier using standard metal film resistors a 'high quality' potentiometer is the weak link and a 23 position switch coupled with the same number of bulk foil resistors is the ideal but very expensive solution. The cost can be cut to a fraction if only R7 and those two or three resistors switched at normal listening levels are bulk foils.

The final location for bulk foil resistors lies in the emitter resistors of the main power transistors. I myself have observed significant sonic improvements from replacing either wirewound, or low cost metal film resistors, with a number of 1W Holco resistors in parallel. Bulk foil power resistors are available in T0-3 (Vishay) and H pack (Alpha) which have a power rating of 10 watts when fixed to a heat sink and would seem to be ideal for this application.

NEXT MONTH: Part Two looks at capacitors in detail, and takes a brief glance at semiconductors.

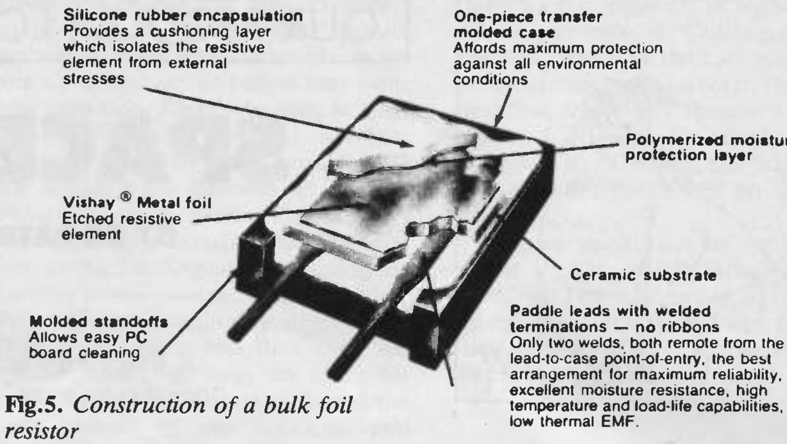


Fig.5. *Construction of a bulk foil resistor*

OUR REGULAR LOOK AT ASTRONOMY

SPACEWATCH

BY DR PATRICK MOORE OBE

A black hole is born, and Pioneer 9, one of our "eyes" on the sun, finally dies

BIRTH of a Black Hole? The Supernova in the Large Cloud of Magellan has continued to provide astronomers with a great deal of information. It has not behaved in the way which had been expected; for one thing it appears to be underluminous by Supernova standards. However, we now know definitely that it is of Type II, and marks the collapse of a massive star which has run out of available 'fuel'. The progenitor star has been positively identified.

Two bursts of neutrinos were recorded, arriving at different times, and it now seems that these bursts marked two stages in the story of the Supernova – first, collapse into a neutron star; second, collapse into a black hole. If this is confirmed, then for the first time we have been able to watch the birth of a black hole, and to find out exactly when it was formed. Astronomers have always been anxious to study a supernova and its results from close range; if we cannot be privileged to see one in our Galaxy, then a supernova in the Large Cloud is the next best thing. The distance of the Cloud is given by observers at the Royal Greenwich Observatory as 155,000 light-years, though other estimates prefer 170,000 to 180,000 light-years.

The James Clerk Maxwell Telescope, on Mauna Kea, has been offically opened by the Duke of Edinburgh. It is not an optical instrument, but is designed to study radiations in the submillimetre region of the electromagnetic spectrum (1 to 0.1 mm).

A New Infra-red Camera. The James Clerk Maxwell telescope is only one of several on Mauna Kea, and more are planned; the altitude – around 14,000 feet – is a clear advantage. There is, for example, UKIRT, the United Kingdom Infra-red Telescope, the largest of its kind in the world.

A new development takes the form of a highly sensitive infra-red camera, IRCAM, developed by Dr. Ian McLean and his colleagues from the Royal Observatory Edinburgh. IRCAM has recently been installed on UKIRT, and seems set to spark off a true revolution. It allows astronomers to "see" the sky as it would appear if our eyes were heat-sensitive – something which has never before been possible. At the heart of IRCAM is a small solid-state detector array containing almost 4,000

The Sky This Month

THE summer of 1987 remains rather a poor time for planetary observers. Mercury reaches inferior conjunction on July 4, and observers will be lucky to see it at all this month, though it may just possibly be glimpsed low in the east before sunrise during the last week. Venus is a morning object, but rises only very shortly before the Sun. Mars is out of view altogether. However, both the giant planets can be seen; Jupiter as a morning object, and Saturn, just past opposition, for much of the period of darkness, though it is well south of the celestial equator in the constellation of Ophiuchus (which is not officially ranked as a Zodiacal group, but which does intrude into the Zodiac between Scorpius and Sagittarius). Saturn's rings are wide open, so that the planet is a glorious sight in even a small telescope.

The Earth, incidentally, is at aphelion (furthest distance from the Sun) on July 4, at 152,000,000 kilometres. The Moon is full on July 11, and new on the 25th. There are no eclipses this month, and no bright comets are due, though one of the most famous of the periodical comets, Encke's, reaches perihelion on the 17th. Encke's Comet is an old friend; it has the shortest period of any known comet (3.3 years), and modern instruments can follow it all round its orbit. Near perihelion, however, it is too near the Sun in the sky to be seen, and even when it emerges from the Sun's glow the magnitude will hardly exceed 16 – well beyond the range of average amateur-sized telescopes.

Various minor meteor showers are active during July; the Delta Aquarids may have a ZHR as high as 20. (The ZHR, or Zenithal Hourly Rate, is the number of meteors which would be visible to a naked-eye observer per hour under ideal conditions, with the shower radiant at the zenith – conditions which, needless to say, are never fulfilled!) But during the last week of the month we start to see the advance guard of the Perseid shower, the most reliable of the year. Maximum will be reached on the night of August 12-13.

Obviously summer is not the best time for observing the stars, but there is plenty to see when the Moon is not too obtrusive. Almost overhead the brilliant blue star Vega is dominant; this is one of the few stars found by IRAS, the Infra-red Astronomical Satellite, to be associated with cool material which may indicate either a planetary system or else a planetary system in the process of formation. Vega makes up a large triangle with Altair in Aquila (the Eagle) and Deneb in Cygnus (the Swan); of the three Deneb is much the faintest, but is in fact extremely powerful and remote, with a luminosity perhaps 70,000 times that of the Sun. Ursa Major, the Great Bear or Plough, is in the north-west, the W of Cassiopeia rising in the north-east; also in the north-west you can find the orange Arcturus, in Boötes (the Herdsman), which is actually the brightest star in the northern hemisphere of the sky. Very low in the south, look for the glorious star-clouds of Sagittarius, which indicate the direction of the centre of the Galaxy. The Square of Pegasus is coming into view in the east, but will be much better placed later in the year.

independent infra-red sensors operating together.

DEATH OF A PIONEER

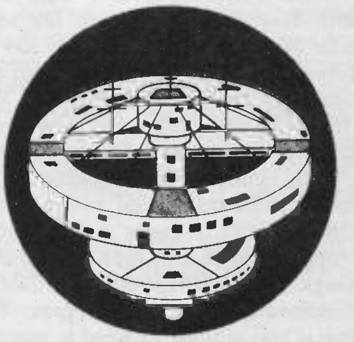
The passing of a pioneer is always a sad event, though in this case we are dealing with the demise not of a human being, but of a probe. Pioneer was launched on 8 November 1968, and was put into an orbit round the Sun, so that its distance ranged between 113 million and 145 million kilometres – keeping it just inside the path of the Earth. Its revolution period was 297 days.

It had many tasks. Of special importance were its studies of the solar wind, which was originally believed to be gentle and steady. Pioneer showed otherwise. There are regions of great turbulence, with fast-moving streams interacting with slower ones and producing shock-waves. Cosmic rays were also investigated – these are not rays at all, but high-velocity atomic nuclei. Cosmic rays are affected by the eleven-year solar cycle, and Pioneer 9, which functioned for more than a full cycle, proved to be highly informative.

Solar activity is also of vital importance in manned space-flight; solar protons can be harmful. When positioned behind the Sun, Pioneer 9 could help to predict solar storms, because it could monitor events on the Sun up to two weeks before they came into view from Earth – bearing in mind that the Sun takes almost a month to complete one rotation on its axis. During the Apollo lunar missions, in 1969-72, Pioneer 9 and its sisters (Pioneers 6, 7 and 8) provided hourly reports of solar activity. And in August 1972, during the greatest solar storm ever recorded, Pioneer 9 was fortuitously aligned with Pioneer 10, which was then over 200 million kilometres away en route for Jupiter. The two Pioneers measured the same masses of gas upstream and downstream, providing important data for solar physicists. They found that the gases lost half their velocity but increased markedly in temperature, so that the solar wind seems to convert much of its motion energy into thermal energy. Incidentally, during this investigation Pioneer 9 measured the highest solar windspeeds ever recorded.

Pioneer 9 lasted as an active probe for far longer than had been planned. It went on transmitting until 18 May 1983, but then 'went silent', probably because of an electrical short-circuit. Finally, in March 1987, engineers at NASA's Ames Research Centre in California used all the equipment at their disposal to see whether they could revive it. They failed; and now, reluctantly, Pioneer 9 has been declared 'dead'. No doubt it will continue to orbit the Sun indefinitely, but signals from it can no longer be picked up.

But we should not be too unhappy about it. This gallant space-craft has performed its tasks nobly. To quote one of the scientists involved with it in all its aspects: "We're sorry to lose Pioneer 9, but it has its day in the Sun!" PE

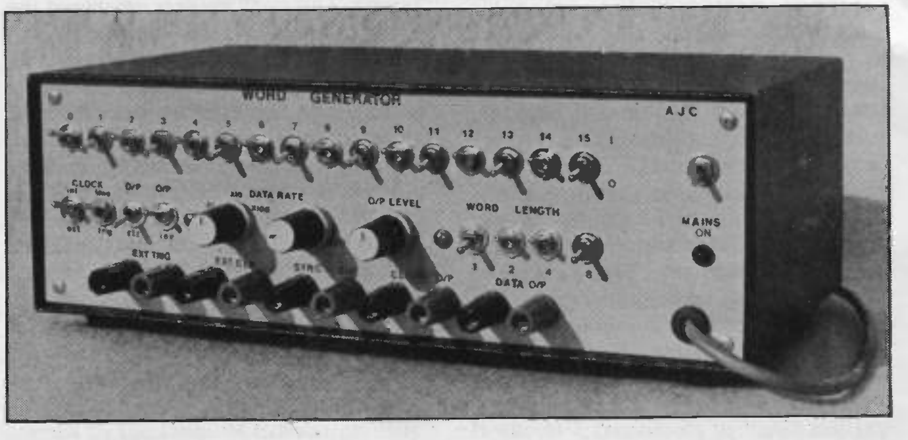


Useful for a wide range of test applications, this CMOS project can generate binary words from 2 to 16 bits, free running or triggered, with straight or return-to-zero output. This final part completes the construction and testing.

WORD GENERATOR

PART TWO BY JOE CHAMBERLAIN

Binary words for test signals



The unit was housed in a metal case 305mm wide, 100mm high and 170mm deep. The front panel layout is seen in the photograph. The top row of switches starts 25mm down, and they are at 15mm intervals starting from the left, the final one being preceded by a 45mm space. Line two starts at 55mm from the top, with similar switch spacings. The three controls are spaced equidistantly at 35mm. The third line is at 80mm from the top, 40mm in and then with 20mm spacings. Hole sizes should be drilled to suit individual component types. The wiring is too simple to need a specific diagram, and all the information is contained in the circuit diagram. Note that the single pole switches are open circuit with the toggle up, the generator producing logic 1 in this position. The mains power supply should be wired in accordance with standard safety practice.

The layout of the suggested PCB in Fig.7 is not too critical, but care should be taken to keep both power and interconnecting leads reasonably short. Remember that although the data rates involved are fairly slow, the switching rate of 4000 series CMOS logic can be around 20nS, so to keep cross talk problems to a minimum the impedance of the connecting paths must be low. Similarly, it is not advisable to tie connecting leads to the front panel in neat, tight forms. In the prototype the unit was built on two circuit boards mounted back to back with a third board housing the power supply components.

If any problems are experienced with noise on the power rails 2.2nF capacitors can be connected across each integrated circuit although this was not necessary in the prototype. The 4.7μF capacitors shown on the power unit circuit diagram Fig.6 were mounted on the individual logic boards.

If it is desired to include any or all the extra control functions indicated in the following section a slightly larger front panel will be desirable.

ALIGNMENT

The only alignment that has to be undertaken is to correct the time constant of the master clock IC1 to compensate for variations in production tolerances of the integrated circuit. Although the circuit is stable in operation, timing can vary by up to 20% between chip samples.

Set the clock speed to the maximum range (maximum resistance) and monitor the frequency at the Clock Output terminals. With the generator set to the free running mode adjust the timing capacitor C1 on IC1 to produce frequency of about 1.95kHz.

Then set the fine control to the opposite end of its range and again check the output frequency, which should be slightly greater than 20kHz. The fixed resistor R1 in series with the fine control may need some adjustment if the 'high' frequency is not within the required range.

To check the operation of the divider chain set the frequency on the x100 range to a convenient value and change to the x10 range when the output frequency should be divided by 10, and then to the x1, range when a further division by 10 should be seen. This completes the alignment of the unit.

TESTING

Assuming that the alignment of the clock was satisfactory the clock and division circuits have already been tested. Should any problems arise first check the output from IC1 on pin 10. The frequency at this point should be twice that expected at the clock output and should still cover a 10:1 frequency range. Also check that the generator is in the free running mode.

Still with the generator in the free running mode set the word length to 15, that is, all four switches S17 to S20 open, and check the Sync output to see that a pulse occurs every 16 clock pulses and that its duration is one clock cycle. Connect an oscilloscope to the data output of the data multiplexer IC5 pin 1. It should be possible to see each data bit change state as the corresponding data switch is operated.

Now decrease the word length by 1 by closing switch S17. Bit 15 should now be inoperative and the time between successive sync pulses should decrease by one bit. If a bit other than bit 15 is inoperative, or the bits varied do not correspond to the switch operated the switches are probably wired incorrectly.

With the oscilloscope still triggered from the sync pulse examine the Data Output. With the word length set to maximum (15) set the data bits to alternate ones and noughts, note the width of the pulses and then operate the RTZ switch S25. The pulse width should now change to half its original value and the leading edge of the pulses should not change in time. If the Normal/Inverted switch S24 is set to Normal the data output should be in the inverse phase to the data coming from the multiplexer IC5 and be delayed by half a clock period. Operate switch S24 and check that the data output is inverted.

To check the external clock and trigger input circuits, connect a variable amplitude signal source to the External Clock input and examine the output from IC8b on pin 1. With the input signal set to greater than 2 volts amplitude the signal at pin 1 should be switching between binary 0 (0V) and binary 1 (12V). With the input reduced below 2 volts the output should be at a permanent logic 1 level. A similar check may now be performed on the trigger input with the generator still in the free running mode.

With the input signal to the External trigger input running at a lower rate than the sync pulse rate, check that the output from the trigger store IC7a on pin 1 changes to a logic 1 level when the trigger input falls to logic 0, and returns to a logic 0 level when the end of the sync pulse occurs. During the period when the output from IC7a is high, the clock IC1 should run. If the trigger store IC7a fails to reset at the end of the sync pulse check the amplitude of the sync pulse (12V) and the reset line from capacitor C2 to the reset input of IC7a pin 6.

This completes the testing of the generator. If problems are experienced in obtaining correct operation the circuit board should be rechecked first to ensure there are no solder whiskers between tracks and that no tracks are cracked. The wiring between the circuit board and the various controls should then be checked. Checking for errors in the word generator construction is one of the many tasks for which a word generator is well suited! It can simulate the action of various parts of the circuit in turn and allow known timing sequences to be injected at various points.

OPERATION

In the introduction some examples of the type of equipment that can be tested was indicated and the paragraph on testing the word generator itself gives some idea of its usefulness. In this section methods of testing and setting up the generator will be discussed.

Its has already been said that in the free running mode the end of the sync pulse occurs half a bit before the first transmitted digit (or, if you prefer, half a bit before the end of the previous word). This ensures that the start of the first bit can be observed on an oscilloscope. A similar delay occurs in the trigger mode, in this case the start of the word is delayed after the falling edge of the trigger pulse, on the maximum data rate range by half a bit, and on the other two ranges, until the first rising edge of the divide by ten counter output is reached.

Typically, in testing any circuit it is possible to predict the correct waveform at any specific point. If the circuit is broken at this point and the predicted waveform is simulated by the generator, the performance of the following circuits can be evaluated. By changing the injected waveform the response of the circuits can be observed and any error in the original circuit determined by simulation.

When testing modems (MOdulator/DEModulator) it is useful to determine the practical performance of the filter circuits by injecting known waveforms and observing the output signal response.

The generator can also be used as a simple square wave generator, the repetition rate being varied by a combination of the settings of the data bits and the clock rate. If for example, a given square wave rate is required to be doubled or halved, a 16-bit word may be set to 1111 0000 1111 0000, then, to exactly double the rate, set the generator to 11 00 11 00 11 00 11 00; to halve the rate set it to 11111111 00000000.

The labelling of the word length switches needs some explanation. A 16-bit word starts at bit 0 and finishes at bit 15 and the values associated with the switches reflect this terminology. When a word is set to a length '11' for example digit 11 is the last bit in the word. As the word starts at bit 0 the word length is actually 12 bits.

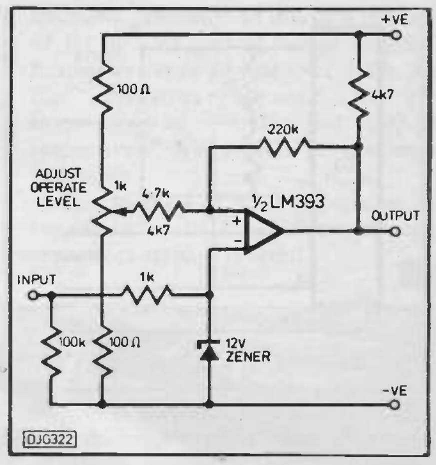


Fig.9. *Alternative adjustable trigger level circuit for clock and/or trigger inputs.*

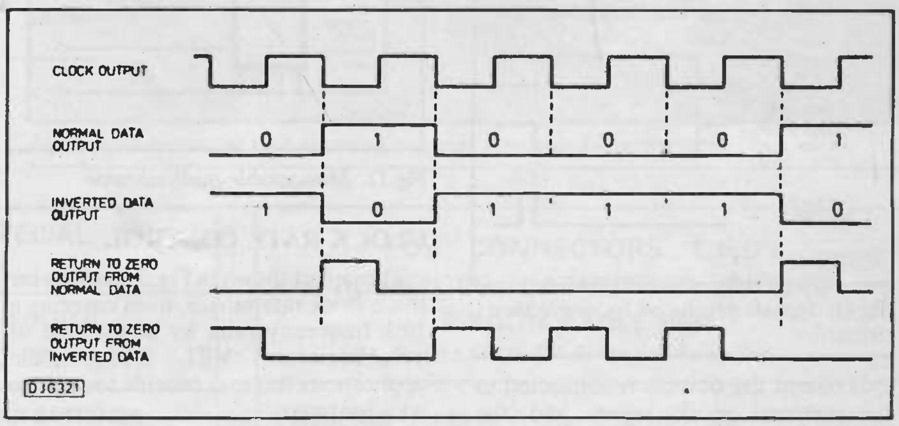


Fig.8. *Normal, inverted and return to zero waveforms.*

In Fig.8 the relationship between the clock, normal and inverted data is shown together with the corresponding return to zero (RTZ) waveforms. From this diagram it will be seen that although the inverted data output is the complement of the normal data, the RTZ signal is not.

The RTZ signal returns positive signals (logic 1) to zero but has no effect on negative signals (logic 0). Thus, where RTZ signals are used to lock a decoding clock at the receiver of an asynchronous transmission system, clock information is lacking during long strings of logic 0s. The generator can be used to check the performance of a clock recovery system using this form of transmission.

ALTERNATIVE INPUT CIRCUITS

The trigger and clock input circuits shown in Fig.3 operate when the applied signal exceeds 2 volts. Particularly when the input signals are noisy or of underfined shape, it can be an advantage to be able to select a particular part of the waveform. The circuit shown in Fig.9 incorporates a sampling level shift control to permit the operating voltage of the input signal to be selected. The range of control is from +1 volt to +11 volts.

The hysteresis of the level detector is mainly controlled by the ratio between the 220k resistor connected between the output and the positive input of the comparator and the 4k7 resistor between the positive input and the 1k bias control potentiometer. A 1k current limiting resistor is connected in series with the input to protect the voltage limiting zener diode.

SINGLE SHOT FACILITY

The facilities so far described allow the generator to either free run or be triggered on a single word basis from an external source. Particularly when checking the operation of some stepping circuits, it is useful to be able to control the data one bit at a time. To do this a single pulse external clock signal has to be provided. One half of IC3 (a dual 'D'-Type flip flop) is unused in the basic design and this spare circuit can be utilised to provide a contact bounce eliminator as shown in Fig.10. The device is connected as an RS bistable by grounding the clock and D inputs and pulling the set and reset inputs to the 0v

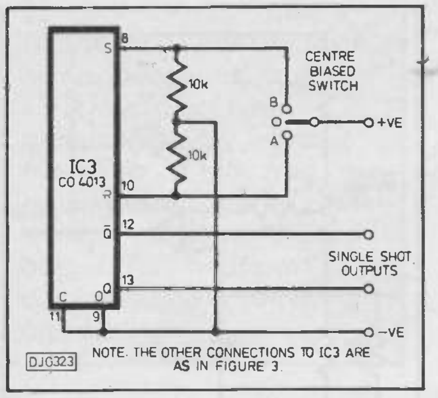


Fig.10. *Modification to IC3 to provide internal contact bounce eliminator for single shot clock or trigger.*

rail be means of 10k resistors. A centre biased switch is then connected to the positive rail as shown. Momentary operation of the switch then produces a stable output level which will not change until the switch is thrown in the opposite direction. The associated waveforms are shown in Fig.11.

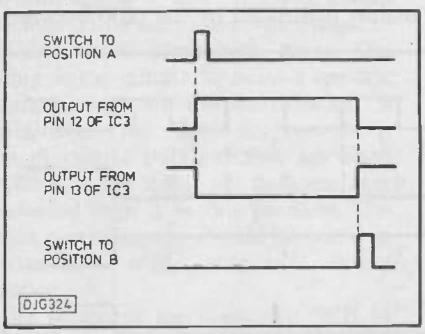


Fig.11. *Signals produced by single shot circuit.*

If one of the outputs is connected to the external clock input, and the external clock input selected by means of switch S22 the data output will step by one bit each time the circuit is cycled. It should be noted that both a positive and a negative edge have to be applied to the clock input since the input buffer inverts the clock signal, and although the positive input edge causes the counter IC4 to select the next digit, the negative edge is required to load the data into the output circuit.

The same control signals can be used to provide an internal single word trigger. In this case it is only the negative going edge that provides the word trigger.

An alternative method of providing a single shot facility is to use a monostable multivibrator such as that shown in Fig.12.

The time constant of the circuit should be longer than 20mS to cover any contact bounce in the switch.

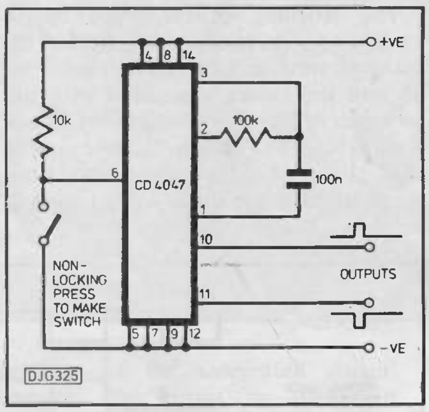


Fig.12. *Monostable multivibrator*

CLOCK RATE CONTROL

The circuit shown in Fig.3 provides for three clock rate ranges, each covering a 10:1 frequency ratio by adjustment of potentiometer VR1. In some applications this may provide too coarse an adjustment.

For fixed data rates, an external clock signal derived from a crystal controlled baud rate generator is ideal (see PE September 1985), but where a

COMPONENTS MAIN UNIT

RESISTORS

R1	6k8 (see text) 2%
R2,R4,R26,R30, R41,R45	10K (6 off)
R3,R25,R28,R29, R32,R37,R40	100K (7 off)
R5-R24	6k8 (20 off)
R27,R31	2k2 (2 off)
R33,R34	4k7 (2 off)
R35,R38,R42	470 (3 off)
R36,R39,R43	10 (3 off)
R44	1k8

All resistors ¼w 10% except R1

CAPACITORS

C1	560pF Polystyrene (*see text)
C2	100pF Polystyrene
C3	4.7µF 25v Electrolytic

SEMICONDUCTORS

D1,D2	12v ZENER 450mW
D3	1N4148
TR1	BC107
IC1	4047
IC2	4518
IC3,IC7	4013 (2 off)
IC4	4824
IC5	4067
IC6	4585
IC8	LM 393
IC9,IC10	40107 (2 off)

POTENTIOMETERS

VR1	100k log Rotary
VR2	10k lin Rotary

SWITCHES

S1-S20,S22,S23, S25	s.p.s.t. min (23 off)
S21	1P3 way rotary
S24	d.p.s.t. min

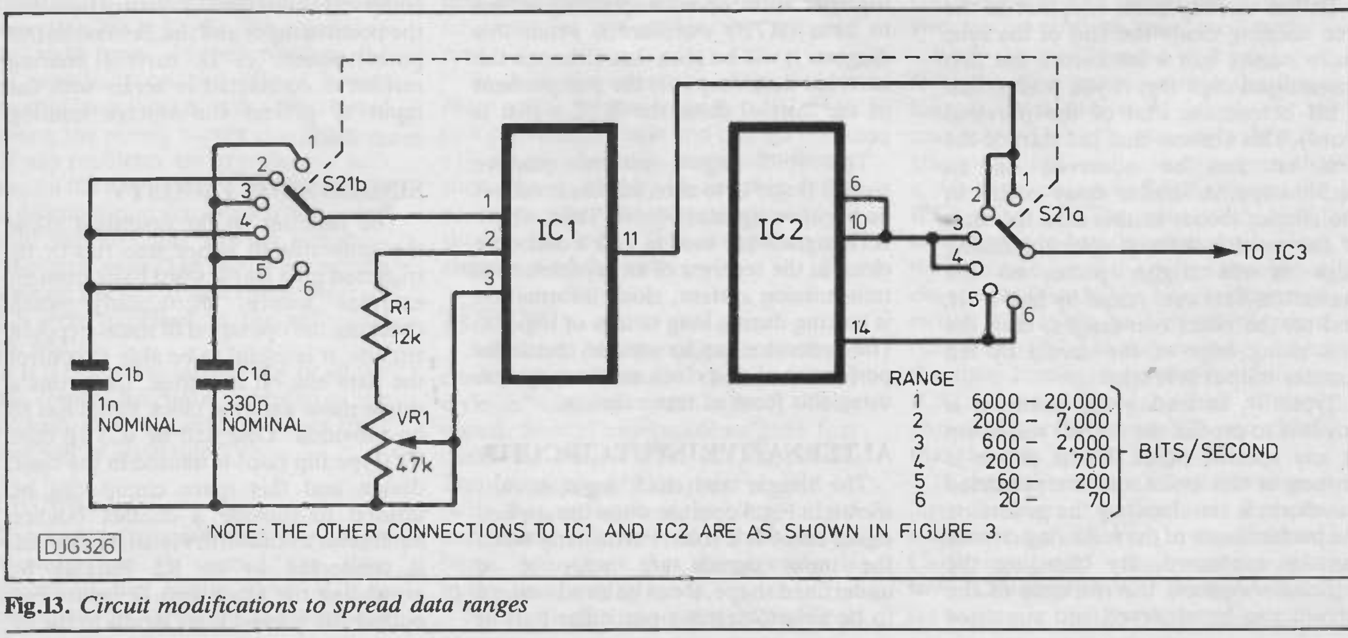


Fig.13. *Circuit modifications to spread data ranges*

COMPONENTS POWER SUPPLY

RESISTORS

R46	1K (½w 10%)

CAPACITORS

C4	2200μF25v elect.
C5	220nF
C6	100nF100v
C7,C8	4.7μF25v elect.

SEMICONDUCTORS

D4	1.5A Bridge Rect.
D5	LED and clip
IC11	7812

SWITCH

S26	mains s.p.s.t

TRANSFORMERS

T1	15v sec 12VA.

MISCELLANEOUS

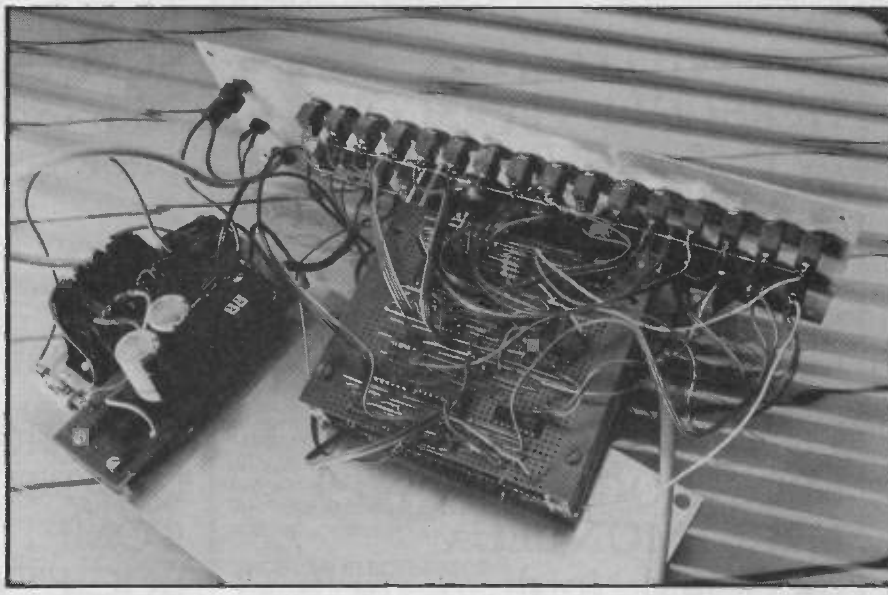
Fuseholder and 1 amp slow blow fuse, printed circuit board, grommet. Terminals (10 off, to suit), knobs (3 off), nuts and bolts, metal case, connecting wire, etc.

continuously variable data rate is required, the control of the internal clock can be improved by switching the timing capacitor C1 associated with IC1, to provide six ranges, each covering a ratio of about 3.5:1. The circuit modifications to do this are shown in Fig.13.

The method of alignment of the various ranges is similar to that described in the paragraph on aligning the basic generator. In this case the ratio of R1 to VR1 should be set to give a frequency range of just over 3.5:1, and the capacitors adjusted to give frequencies of 6000 Hz and 2000 Hz respectively with VR1 at maximum resistance.

This method of scale expansion can be expanded to cover three or more capacitors steps if desired.

PE



Interior of prototype unit showing original veroboard construction.

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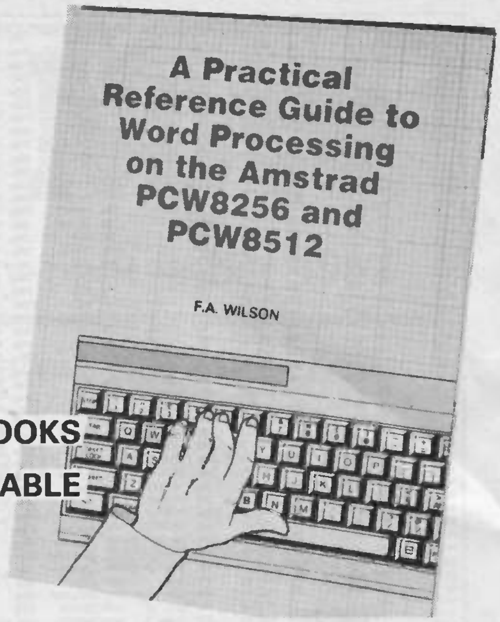

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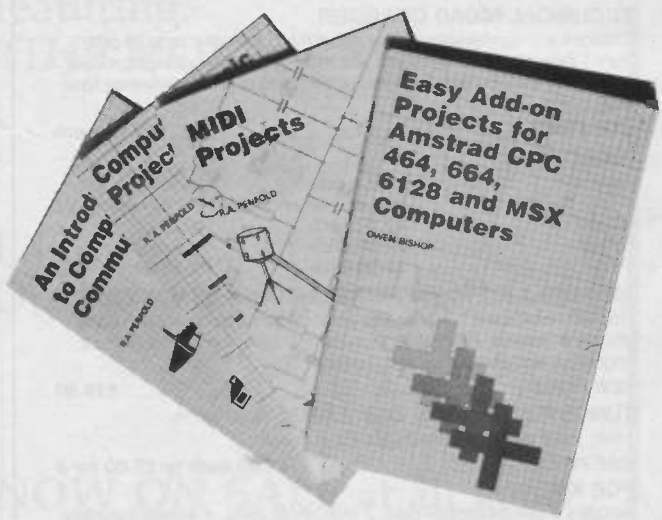

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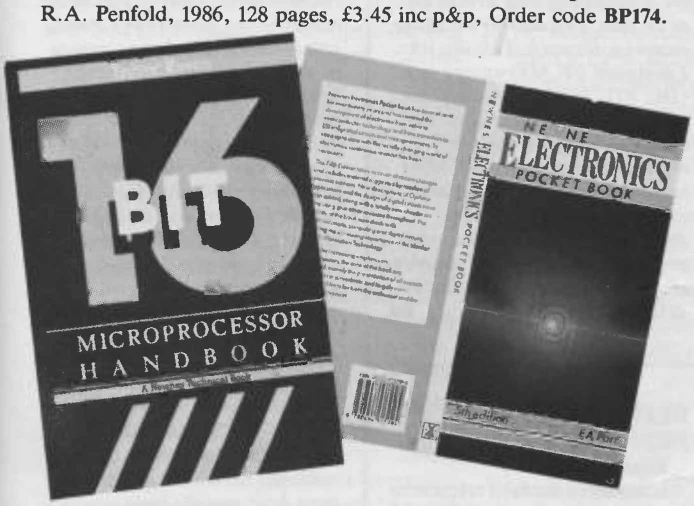

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READERS' LETTERS

In the interests of conciseness and clarity, we reserve the right to edit letters before quotation.

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(Name and address supplied.)

Whilst we expect our advertisers to keep a reasonable stock of the goods advertised, naturally there will be times when an unusually high demand is made on a supplier for a particular product. This is expecially true when the product is new and demand exceeds expectation. Under such circumstances supply will sometimes fall below demand, and a delay may well be experienced. If this time is likely to be over 21 days I would expect a supplier to advise of this situation, but not necessarily otherwise – it is after all, accepted practise for mail order companies to quote 28 days for delivery. I should also point out that some time can elapse between advert submission and publication date, during which time stock situations can vary.

It should additionally be borne in mind that companies have to allow time for cheque clearance, and this is subject to Bank routines and procedures. Sadly, cheque fraud is not unknown, and even putting cheque card numbers on a cheque does not guarantee that a mail order transaction will receive cheque clearance; it is possible that the number quoted may be incorrect, or the amount exceed the card value limit. As general advice I would suggest that if you are in urgent need of goods, that you check the delivery situation prior to ordering. However, where an advert actually quotes despatch by return, then I would expect this statement to be honoured.

In addition to these comments, I also confirm that, as required by law, PE only accepts advertisements on the express understanding that the advertiser warrants that the advert does not contravene any Act of Parliament. We also require that the advertiser does not contravene any of the guide lines set out by the Advertising Standards Authority. However, should any reader feel that any advertisement contravenes the guide lines, the matter should be brought to our attention, and to that of the ASA, Brook House, Torrington Place, London WC1E 5HN. **Ed.**

EXPORT COVER

Dear Editor,

Why does PE no longer quote the overseas prices of the magazine on the front cover? I am concerned that my newsagent may overcharge me.

I.B. Hassan, Malaysia.

We no longer quote overseas currency prices on PE since International exchange rates are fluctuating too unpredictably for our distributors to accept the limitations. It is unlikely that unreasonable prices will be charged by overseas suppliers, but should you have direct proof that they are, please let me know and I will pursue the matter further. **Ed.**

IF YOU HAVE ANY COMMENTS, CRITICISMS OR SUGGESTIONS, WRITE AND LET US KNOW. WE ARE INTERESTED IN WHAT YOU THINK AND SAY.

NO SCOPE?

Dear Sir,

I buy PE every month and find it very interesting and educative. Why though do you not show amateurs how to build a very simple Oscilloscope? I am sure that many readers would benefit from the design.

S. Oleghe. London Sw18.

I would love to publish an oscilloscope constructional article, and indeed some time ago looked into the possibility of designing one myself. However, I concluded that although the electronics side can very readily be presented, the availability of the cathode ray tube required could present difficulties, arising from realistic pricing for the CRT, the assurance of long term stocks of the tube, and also the breakage factor on despatch. This was why I designed PE Microscope unit, (Dec 85), in which a computer could be used for the read out display. Though it does not replicate a scope exactly, it offers reasonable facilities for many situations. Should another designer offer me a true scope project in which the CRT problem could be overcome I should be delighted to publish it. **Ed.**

REFERENCES PREFERRED

Dear PE,

It would be useful if references for further reading could be given at the end of articles, so helping those who wish to design their own circuits. I should also like to see a few more articles on electronics in medical applications.

N. Gharebeigui. London W4.

An interesting comment to which I have several times given a lot of thought. References would be helpful, though there is a practical problem in that many designers who write for PE are so familiar with their subject matter that they probably may not recall the sources from which it was learned. Having said that though, should authors quote references to me I shall be pleased to include them.

Medical applications is certainly an area that I should be pleased to see covered periodically – is there a doctor reading this who knows how to write? **Ed.**

JOKING ASIDE

Dear Editor,

I note that PE is the science magazine for serious electronics and computer enthusiasts. I am dismayed to find though, that a flippant approach is used in caption and side-header writing. This is not humourous, but just silly and misleading, causing your image to suffer among intelligent and literate readers. There is also another practical disadvantage experienced when thumbing through back issues for particular articles. Captions provide a useful guide, but only when they are factual and sensible.

J. Duffill, Glos.

Point taken on the latter aspect, though I personally find that when going through back issues looking for a particular subject, I refer first to the index page and look at the titles, which are a good guide to the subject field.

On your first criticism though, I cannot agree. Perceived humour relates to the interpreter's mental attitude and outlook, and cannot be defined against intelligence factors. Seriousness is certainly an aspect of electronics, but a light hearted approach carefully applied does not damage the benefits of the technology. Most people find humour in double-meaning quips, and we at PE, together with some of our authors, frequently have a chuckle at some of them. After all, we enjoy producing this magazine, and wish the majority of our readers to share in the implied humour of coincidental word relationships. Historically, and as Shakespeare fans will confirm, double entendres and puns have usually been considered jocular, even when they are 'bad puns'. For example, three other possible word-play captions to your letter which we find droll are: Pundits Prohibited; Index-linked Rule of Thumb; Unclear Exclusion Zone.

I would also comment that the ability to see the inter-relationships, whether with words, actions, concepts or knowledge, is an essential attribute for anyone intent on scientific, technological, or computing investigation, even if the talent is occasionally put to mis-use in jest. (What one might call the WACKER Factor – I'm not going to spell it out; re-read the sentence to find it!)

Rest assured though that we have no intention of extending humour by replacing text with cartoon characters blowing bubble comments; that certainly would lead to animated animosity. **Ed.**

PE

INDUSTRY NOTEBOOK

Electronics and finance capital

REPORT BY TOM IVALL

High technology in the finance industry is big news. But what will the pay off be? Prosperity or greed?

At about the same time as Ferranti was arranging to borrow £100 million from its bankers to finance further work, commercial law firms in London were reporting that so many individuals and companies were under investigation by the DTI that they were unable to handle the demand for legal representation. Not long afterwards, experts in the City were saying that the new electronic technology introduced by the Stock Exchange at the time of 'Big Bang' was making the stock market excessively volatile. And in the same month British Telecom was declaring its continued support for the national introduction in 1988 of EFTPOS (electronics funds transfer at the point of sale).

None of these events has any direct connection with each other. But they were all current manifestations of a single phenomenon – the increasing prominence of finance capital in industry and commerce. The electronics industry is involved in two ways. First, it needs money to finance its activities. In this respect it is no different from other industries, but because the electronics business is expanding as a result of rapid technological development the companies need increasing amounts of finance from outside sources to stay in this highly competitive race. Secondly, the industry is producing new electronic systems which are making great changes in the methods of trading, both in material goods and in quanta of economic value such as stocks and shares.

In these respects electronics as a business is certainly benefitting from the rise of finance capital. Whether this is a good thing for society in general I am not at all sure. There is a danger that we are losing sight of the true value of this technology and its industry because our motives are becoming distorted. Instead of exploiting the technology to make useful things and earn a living thereby, we are beginning to exploit it to acquire money as an end in itself, leaving the usefulness or otherwise of the things made as a secondary consideration, a mere means to an end. It's rather like the 'selfish gene' theory in biology. Instead of the chicken laying an egg to reproduce itself through its genes, the genes (finance capital) are using chicken (industry) simply as a convenient machine to ensure their own continuance.

Finance capital – as distinct from capital in the more general sense of land, buildings, machinery etc. – is a comparatively modern phenomenon. Although money has been used as a medium of exchange and measure of exchange value for thousands of years, banks have only been performing the investment functions we know today for a few centuries. At the beginning of the Industrial Revolution banks were small-scale affairs and the early entrepreneurs financed themselves mainly from their own resources without having to pay interest on loans. As for pension funds, unit trusts, finance corporations, insurance companies and other such institutions, these are only a few decades old as sources of finance capital for industry.

THE LARGE HAVE FORCED THE SMALL OUT OF BUSINESS

These organizations have now become extremely large in terms of the funds they control and hence extremely powerful as institutional shareholders. What has made them large has also made them relatively few in number: competition. In the incessant fight for market share the large have forced the small out of business or taken them over. Consequently there is now an oligopoly in finance capital. A small number of very powerful institutions decide where capital shall be invested – not only in what companies but in what kind of activities. They can decide to invest in a productive activity like manufacturing industry or in a completely non-productive one like currency speculation.

Yet there is no sinister plot in all this. Your pension fund, for example, is only doing what is right and proper: maximising its investment returns to ensure the best possible pension for you. It is simply that this whole financial system is bringing about a distortion of economic and to some extent human life. Exchange value is beginning to dominate use value. Adam Smith, in his famous *Wealth of Nations*, was one of the first to point out that 'value' had two different meanings: "value in use" and "value in exchange". Things like banknotes or share certificates have exchange value because they can be possessed but no intrinsic use value. A certain volume of air, on the other hand, has considerable use value (e.g. for breathing and thus staying alive) but no exchange value because it cannot be owned. Between these extremes an object like an oscilloscope, say, has degrees of both use and value and exchange value.

How did exchange value become so important? Initially, after barter of goods was replaced by money purchasing, the producers of goods exchanged their own goods for money simply to buy other goods for their own consumption. But the independent existence of money, or exchange value, made possible the new job of middle-man or merchant. The producers were happy to sell to him and buy from him because his activity encouraged the flow of goods and thus trading volume. But the merchant neither produced nor consumed the goods he handled: he only bought in order to sell again, at a profit, thus using exchange value (in building) to acquire more exchange value (in selling). So exchange value took on a life of its own and became an object of desire because of its purchasing power.

What goes on in the City of London and other such centres is officially called providing services (though to judge from some of the inflated salaries and illegal share dealings now coming to light, 'financial self-services' might be an equally valid description). In so far as electronics is improving the efficiency of transactions like transfers of money and trading in shares it is doing a useful and worthy job. But to the extent that electronics is helping to secure the dominance of exchange value over use value, making the pursuit of the former an end in itself, it is not adding real wealth to society by merely promoting greed as a desirable way of life. PE

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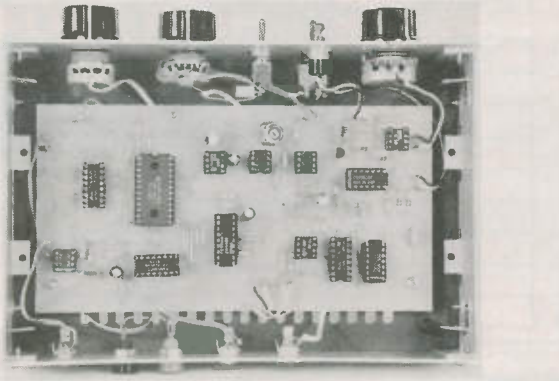

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Component identities are usually clearly marked on them. Even if they are colour coded, like some resistors and capacitors, their values are easily worked out from component colour code charts. From time to time we publish these charts, but if you don't already have one, send a 9in x 4in stamped and self-addressed envelope to the Editorial office asking for one.

TOOLS

For many projects you only need a few simple tools – Soldering iron between 15W and 25W, with a bevelled tip. Damp sponge for keeping the tip clean. Good multicore solder of 18swg or 22swg grade. Fine nose pliers for wire shaping. Adjustable spanner or heavy pliers for tightening nuts. Miniature screwdriver for adjusting preset controls. Small wire cutters for trimming component leads. Drill and selection of bits for drilling holes in boxes. Strong magnifying glass for checking joins in close up. It's also preferable to have a multimeter for setting and checking voltages. There are some very good low cost ones available through many of our advertisers, but get one that is rated at a minimum of 20,000 ohms per volt. Many projects do not require you to have a meter, but if you are serious about electronics, you really should have one.

ASSEMBLING THE PCB

Authors will sometimes offer their own advice on the order of assembly, but as a general guide, it is usually easier to assemble parts in order of size. Start though with the integrated circuit sockets. Please use them where possible, they make life much easier than if you solder the ICs themselves – with sockets you can just lift out an IC if you want.

Then insert and solder in order of resistors, diodes, presets, small capacitors, other capacitors, and finally transistors. Clip off the excess component leads after you have soldered them. Now use a magnifying glass, ideally one that you can hold to your eye, and take a good look at the joins, checking that they are satisfactorily soldered, and that no solder has spread between the PCB tracks and other joins. Be really thorough with visual checking since errors like this are the most likely reason for a circuit not working first time.

SOLDERING

Bring the tip of the iron into contact with the component lead and the PCB solder pad, then bring the end of the solder into contact with all three, feeding it in as it melts. Once sufficient solder has melted to fully surround the pad and the lead, remove the solder, and then the iron. Now allow the join to cool before touching it, otherwise the solder may set unsatisfactorily. If it does move, just reheat the join once more.

WIRING

Connecting the PCB to the various panel controls is the final assembly stage. Do this just as methodically, following the published wiring diagram. You can connect the wires to the PCB in one of three ways. The best is to insert terminal pins into the connecting holes on the PCB, and then solder wires direct to them. Or, pass the end of the wire through the PCB hole, soldering it on the other side. Alternatively, the wire can be carefully soldered direct to the PCB tracking. In all cases first strip the plastic covering off the wire, twist the strands together, and apply solder to them to keep them secure.

TESTING

Now you are ready to test and use the project as described by the author. Components can occasionally fail, but these days it is extremely uncommon, and if you have followed the instructions, been careful with your joins, and bought the parts from a good supplier, you will have the enormous satisfaction of having built an interesting and working unit. It really can be easy if you do it with care.

CHOOSE ONE NOW!

The PE PCB Service list shows all the PCBs directly available through PE (though some designers sell their own PCBs for their PE projects – see kit suppliers adverts). Look down the list and see which title takes your fancy – there must be at least one that will interest you! You will probably already have the relevant issue of PE, but even if you don't we can still help you.

BACK ISSUES

We can usually supply copies of back issues of PE up to three years old. These are £1.50 each including postage (£2.00 for overseas readers). If we no longer have the issue needed, we will be pleased to send a photocopy of the article for the project that you want to build. These are £1.00 each per issue, including postage (£1.50 to overseas readers).

OBTAINING PARTS

Some projects are available from advertising suppliers as complete kits. Where this is so, the source often will have been stated in the project text. If no supplier is quoted, contact the normal kit suppliers anyway – they might well have introduced a kit after publication. Otherwise, all the components listed in the text will be available from suppliers who specialise in individual components.

Occasionally a specific part may only be available from a particular supplier, if so the source will be given in the parts list. Otherwise there should be no difficulty in buying the parts. We have many good suppliers advertising in PE so have a look through their adverts – that's why they're there! Even though a part may not be listed in the adverts, a phone call or two should find a supplier who will be pleased to help. Like us, they too are in the business of encouraging you to enjoy electronics! PE

P.C. BOARDS

Printed circuit boards for certain PE constructional projects are available from the PE PCB Service, see list. They are fully drilled and roller tinned. All prices include VAT and postage and packing. Add £2 per board for overseas airmail. Remittances should be sent to: **PE PCB Service, Practical Electronics, 16 Garway Road, London W2 4NH.** Cheques should be crossed and made payable to **Intra Press.**

Please note that when ordering it is important to give project title, order code and the quantity. Please print name and address in Block Capitals. Do not send any other correspondence with your order.

Readers are advised to check with prices appearing in the current issue before ordering.

NOTE: Please allow 28 days for delivery. We can only supply boards listed here. You may send a photocopy of the Order Form.

TELEPHONE ORDERS (OPEN 24 HOURS)

You can now order your printed circuit boards by telephone, quoting your Access credit number. The number to ring is: 0268 289923. In stock items will be despatched within 24 hours of receipt of order. If you ring out of office hours please state your order, credit card number and address **clearly,** as the order is recorded on an answering machine.

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