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ELECTRONICS

SCIENCE & TECHNOLOGY

**WORD BYTE
GENERATOR**

**SCOPE
STORE**

**EVENT
COUNTER**

**BBC IRQ
CONTROL**



DESIGN — ANALOGUE
SIGNAL PROCESSING TECHNIQUES

COMPUTING — FLIGHT 68K
MICROPROCESSOR DEVELOPMENT SYSTEM

TECHNOLOGY — INTELLIGENT
MACHINE SERVANT INDEPENDENCE

EXPERIMENTAL ELECTRONICS
PRACTICAL APPLICATIONS AND EXCITING DESIGN IDEAS

PLUS:

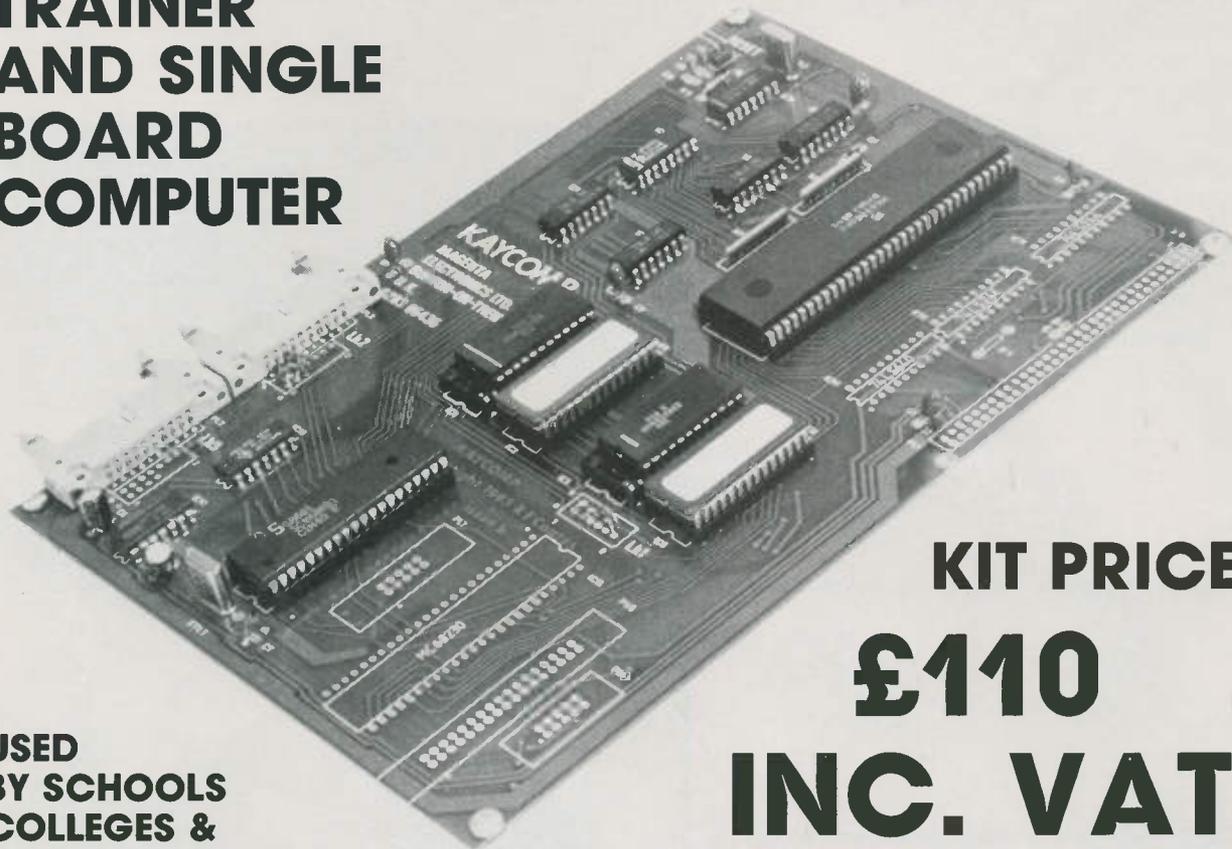
- ★ SPACEWATCH
- ★ LEADING EDGE
- ★ INDUSTRY NEWS
- ★ LOGIC PUZZLE
- ★ MARKET PLACE
- ★ PROJECTS GUIDE

THE SCIENCE MAGAZINE FOR SERIOUS ELECTRONICS AND COMPUTER ENTHUSIASTS

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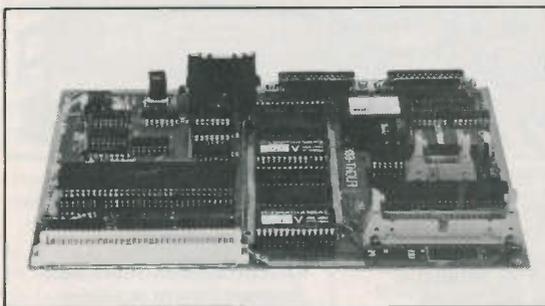
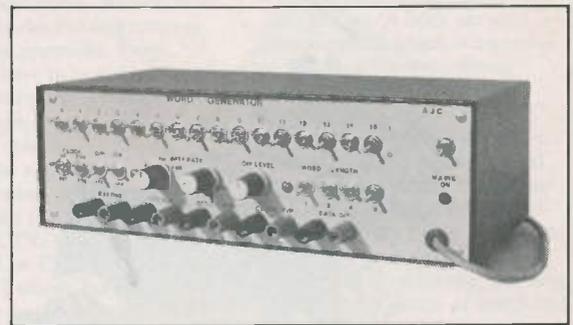
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CONSTRUCTIONAL PROJECTS

WORD GENERATOR PART ONE by Joe Chamberlain	12
A highly versatile item of test equipment for generating a binary word of up to 16 bits.	
INTERRUPTING THE BEEB by David Berry	26
A detailed discussion, with practical circuit diagrams and a program listing, of methods for externally controlling the interrupt routines on the BBC computer.	
SCOPE STORE by Robert Penfold	35
Compact self-contained digital storage techniques are used in this oscilloscope add-on unit.	
UNIVERSAL EVENT COUNTER by John Becker	49
Originally designed for use with the PE Geiger Counter, this four-digit counter display has many more capabilities.	

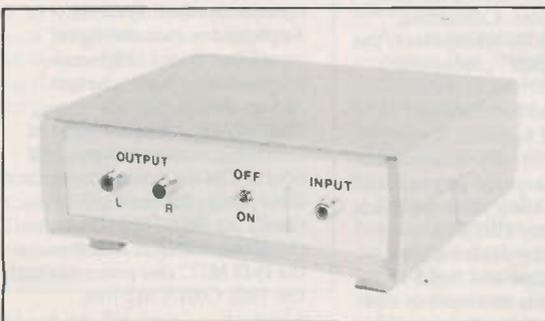
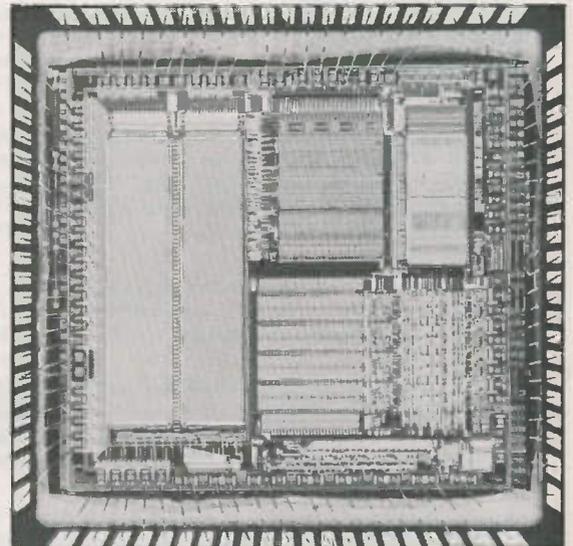


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SIGNAL PROCESSING PART ONE by the Prof	19
Analogue signal handling options are closely examined, with special regard to Dolby, companding, noise gates and delay lines.	
FLIGHT 68K REVIEW by Robert Penfold	30
A close examination of a very comprehensive commercial microprocessor development and teaching system.	
AUTOBUTLER BY Richard Mishra	44
In a delightfully told style, a predictive tale is unwoven showing how technologically aided humanity might someday be free to enjoy living.	

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NEXT MONTH . . .

You'll find the August issue equally interesting –
PSEUDO STEREO • MICRO-CHAT SPEECH SYNTH • WORD GENERATOR CONSTRUCTION • DIGITAL SIGNAL TECHNIQUES • HI-FI COMPONENTS • SWITCH MODE SUPPLIES • AND OF COURSE our top line regular features, exciting experimental ideas, and all the latest product information from our advertisers – no wonder our circulation is rising.

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THE SCIENCE MAGAZINE FOR SERIOUS ELECTRONICS ENTHUSIASTS

CATALOGUE CASEBOOK



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

Babani Catalogue of Electronics, Radio and Computer Books. the complete 1987 list of all the books currently available from this renowned publishing house. Well categorised, with descriptive details, and a numerical cross index. Bernard Babani (Publishing) Ltd, The Grampians, Shepherds Bush Road, London W6 7NF.

I.C. Electronics. The latest mail order catalogue from this discount electrical store cover electrical components, telephones, calculators, watches, audio, games, optical, records, and tools. An extremely useful catalogue to keep handy. I.C. Electronics Business Centre, PO Box 130, Aberdeen, AB 8HQ.

INSPEC. The first ever authoritative reference book on MCT (Mercury cadmium telluride) semiconductor properties. INSPEC, Station House, Nightingale Road, Hitchin, Herts, SG5 1RJ.

International Electrotechnical Commission. A fully indexed and detailed catalogue of publications, complete to 1st January 1987, covering world standards for electrical and electronic engineering. British Standards Institution, Linford Wood, Milton Keynes, MK14 6LE.

Klippon. New interface and control module catalogue. 87 pages of full colour photographs, and concise details of passive and active devices in the ranges. Klippon Electricals, Power Station Road, Sheerness, Kent, ME12 3AB.

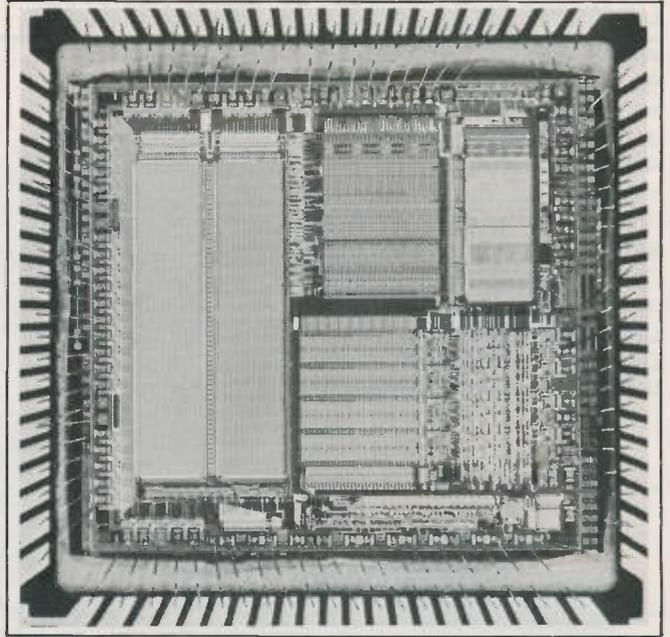
Mullard. A new publication covering Terminations for Surface Mounted Chip Capacitors, and discussing their merits and drawbacks. Mullard Ltd., Technical Publications Dept., New Road, Mitcham, Surrey, CR4 4XY.

NEC. New manual fully documenting NEC's family of digital signal processors. STC MULTI components, Edinburgh Way, Harlow, Essex, CM20 2DF.

Omni Electronics. A very comprehensive list of the type of Components used by hobbyists and normally held as stock items. Customers are assured of personal service, whether they write, phone or call to buy components. Omni Electronics, 174 Dalkeith Road, Edinburgh, EH16 5DX.

TK Electronics. A comprehensively illustrated catalogue covering wide ranges of components, equipment, tools, books and other essential items that any interested electronics constructor needs. TK Electronics, 13 Boston Road, London W7 3SJ.

WHAT'S NEW



Transputer Shipments

INMOS have announced the initial deliveries of its IMS T800 transputer and also the availability of an evaluation board for the new device.

Introduced in November 1986, the T800 is the latest addition to the transputer family. It combines a 32 bit transputer with an on-chip 64 bit floating point processor and is capable of achieving 4000K Whetstones.

INMOS state that shipments have occurred well ahead of their expectations, demonstrating the strength of both their process technology and design tools to achieve a product, with over 250,000 transistors, that works the first time.

Among the organizations receiving initial shipments was the European Economic Commission (EEC) ESPRIT Supercomputer Project, where the IMST800 delivery was some six months ahead of schedule. The Anglo-French team is being led by the Royal Signals and Radar Establishment (RSRE), Britain's top defence research laboratory, to build a modular supercomputer. Containing more than 1000 transputers, the ESPRIT parallel processing machine will cost less than one-tenth that of current machines of equivalent power:

"In terms of performance, the IMST800 leaves the conventional two-chip floating point approach standing," say ESPRIT. Moreover, the device allows them to design and build a reconfigurable and more flexible computer for a wider range of applications than can be supported by other standard processors.

Improvements in performance

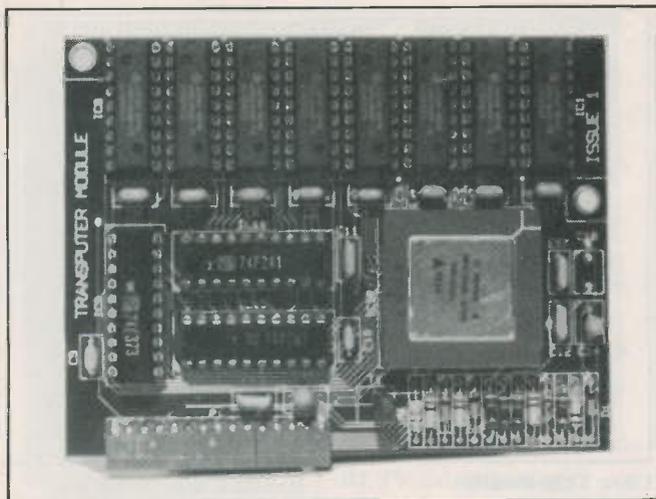
for parallel processing applications are a result of the unique transputer architecture. Unlike conventional microprocessors, which are designed for use in single-processor systems, the transputer was designed to be used in multi-processor applications.

In addition, the T800 transputer is unique in its ability to perform both standard integer processing and floating-point arithmetic functions on the same chip. Previous approaches required at least two chips, and system performance often degraded because of the time required for the two chips to pass data back and forth.

The T800 transputer is available on an evaluation board which allows customers to quickly and easily evaluate the performance and capabilities of the new device. The IMS B003-1 evaluation board costs £3,572.00 each.

Overall customer acceptance of the transputer has been good, with over 1000 companies worldwide evaluating, prototyping or manufacturing transputer-based systems. Applications include digital signal processing, high-end graphics, PC "turbocharger" add-in card, artificial intelligence, robotics, process control, military systems, and others. The expanding transputer family includes the IMS T800, the 32 bit IMS T414 transputer, the 16 bit IMS T212 transputer, the IMS M212 disc processor and the IMS C011/C012 link adaptors.

Contact: INMOS International PLC, 1000 Aztec West, Almondsbury, Bristol, BS12 4SQ. Tel: 0454 616616.



Low-Cost Transputer

The Concurrent Technology TM1 transputer module offers OEMs, educational establishments and hobbyists the opportunity to use the revolutionary Inmos T414 transputer for a relatively small outlay.

The TM1 consists of a four-layer PCB approximately 95mm by 74mm, on which are mounted an Inmos T414-15 transputer capable of up to 7.5 MIPS and 256K of high-speed DRAM. The module may be mounted vertically or horizontally on a suitable interface board, which may be a conventional double-sided PCB, or even a wire-wrap board, via a 15-way female connector.

The module may be used on its own as a low-cost transputer evaluation system: a PC interface card will soon be available, and a resident assembler. OEMs wishing to enhance the performance of an existing product will also find it of interest, because of its small size. It may also be used as the basis for a very powerful, compact, parallel-processing system: up to eight TM1s may be mounted on a single euro-card, with support circuitry, giving up to 60 MIPS from a system that can be held in one hand.

The TM1 can be supplied with a 10 MIPS IMS T414-20, or the new IMST800 (when available) as options. The latter (which includes an on-chip maths co-processor) will deliver up to 2.25 MegaFlops/sec.

The one-off price is £600.

Contact: **Leon Heller, Concurrent Technology, 30 Baldslow Road, Hastings, East Sussex RN34 2EY. Tel: (0424) 714790.**

Head up for cars

The concept of a 'Head-up display' is familiar to professional pilots, as it is used in many civil and military airline

to enable the pilots to read certain essential instruments, and often a simulation of an approaching runway, without taking their eyes off the landing lights below them. The necessary details are projected onto the 'plane's cockpit window in such a way that they are readable at the focal length at which the pilot's eyes need to remain to observe details outside the plane.

Battelle Institute of Ohio now have a simple, low cost system to do a similar job for car drivers. The system uses holography to project, in this case, a two dimensional image of the car's dashboard instrumentation at an apparent distance of ten feet in front of the windscreen, so that the driver can monitor the instruments without looking away from the road ahead, a manoeuvre which even skilful drivers sometimes find distracting.

Light is projected from an electronic instrument display beneath the dashboard instruments, and then reflected from an adjacent holographic lens onto the windscreen. A second holographic lens reflects the light, carrying the image back to the driver. The image 'appears' just above the front of the car, where the driver's eyes are focussed at a far field of vision where it can see the road ahead clearly.

An advantage of the Battelle system is that it uses broad-spectrum light instead of lasers or other specialised light sources, to project a 'real' image of the car's actual instrument panel.

Battelle say that their system has many applications besides car headup display, and is looking for licensees to develop such applications.

More information from **Renate Siebrasse, Operations Manager, Battelle Institute Ltd., 15 Hanover Square, London W1R 9AJ. Tel. 01-493 0184.**

GUARD DOG KIT

If the best deterrent to a would be burglar are good locks on windows and doors, the next best is without a doubt a dog running around the premises. Dogs, however, have to be fed, walked and generally looked after and many people do not own a dog for these reasons.

With the approaching holiday season in mind and many homes vacant with their owners away TK ELECTRONICS have produced an ELECTRONIC DOG KIT whose bark is definitely worse than its bite! It may be connected to a doorbell, pressure mat or any other intruder detector and will produce a random series of threatening barks making the would be intruder think again and try his luck elsewhere.

The only food required is an 18VDC or 12VAC supply which the dog consumes at approximately 4mA when not

barking. The kit is supplied with a high quality printed circuit board, all components, including a mains transformer and full instructions. A horn speaker is also supplied which is essential to produce the loud sound required. The "dog" can be adjusted to provide barks ranging from Terrier to an Alsatian, and contains special circuitry to produce a random series of barks giving a more realistic effect. While it will not bring you your paper and slippers in the evening, our dog will give you peace of mind and is guaranteed not to require "walkies" and will not chew your carpet.

This wonderful creature is available to all constructors at a very economical price of only £21.95 + VAT.

Contact: **TK ELECTRONICS, 13 Boston Road, London W7 3SJ. Tel: 01-567 8910**

Screening Spray

OK Industries can now supply an electrically conductive coating which gives extremely efficient screening against RFI and EMI interference. A nickel powder in acrylic resin and aerosol packed, it can coat a variety of electronic and electrical housings including OK's PacTec enclosures. It will adhere to most substrates and has a surface resistivity of 0.7Ω/cm at 0.002 dry film thickness. Typical attenuation is 50dB at 100MHz. Price is £6.50 for a 200ml can.



Contact: **J. Dornan, OK Industries UK Ltd., Barton Farm Industrial Estate, Chickenhall Lane, Eastleigh, Hants SO5 5RR. Tel: 0703 619841.**

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.

Regular - weekly meetings of Grampian amateur Computer Society. Inverurie, Scots. 0467 24030.

Jun. Series of software training courses by Ericsson Information Systems Ltd. Birmingham. 01-422 3442.

Jun 16-18. Scottish Electronics Technology Show. Scottish Exhibition Centre, Glasgow. 01-891-5051.

Jun 17-18. Electronic Printing. Royal Lancaster Hotel, London. 0799-26699.

Jun 30. DEC Village '87 exhibition and seminars-Communications and Networking. Novotel Hotel, Hammersmith, London. 0494-26271.

Jul 7-8. Telemetry 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 15. Outdoor Sound propagation (IOA). Open University, Milton Keynes. 031-225-2143.

CHIP COUNT!

This month's list of new component details received.

27C128. CHMOS 128-kilobit Eprom, designed to meet low power and high performance requirements (IT).
 27C64A-BX & 27256-BXA. CMOS low power, high performance Eproms (ML).
 C-96. Compiler (not a chip) for Intel 8096 family of 16-bit microcontrollers (IT).
 LC422. Low cost video pre A-D post D-A filters with sin x-x correction for Y,U and V channels (ME).
 LEM 100TP AC-DC sensor. An interface module for measuring and controlling AC, DC or pulse currents from 0 to 150 amps, with a fast response time of less than 1 microsecond (VS).
 NE5152BN - high performance triple 4-bit RGB video DAC operating at 50 MHz, and featuring an ECL based on-board colour look-up table (ML).
 RC-02 series. New 1% close-tolerance range of chip resistors to complement the RC-01 series. Range from 100 to 1M in the E24-E96 format (ML).
 TDD1742T. Single chip frequency synthesiser for portable transceivers (ML).
 VS451V. Single-in-line, sharp cut-off, phase equalised video filter (MC).

Manufacturers, and contact telephone numbers for further details. (IT) Intel. 0793 696204. (MC) MCP Electronics. 01-902-6146. (ME) Matthey Electronics. 0782 85631. (ML) Mullard. 01-580 6633. (VS) Verospeed. 0703-644555.



Brush-Ups

Eraser International announces the availability of a new 8-page Brochure describing an extended range of interchangeable brushes for the ECT1 Electric Cleaning Tool.

The range now includes brushes in fibreglass, stainless steel, brass and nylon for a variety of applications including electrical contact cleaning, mould cleaning and polishing oxidation and rust removal, commutator cleaning and deburring small metal parts.

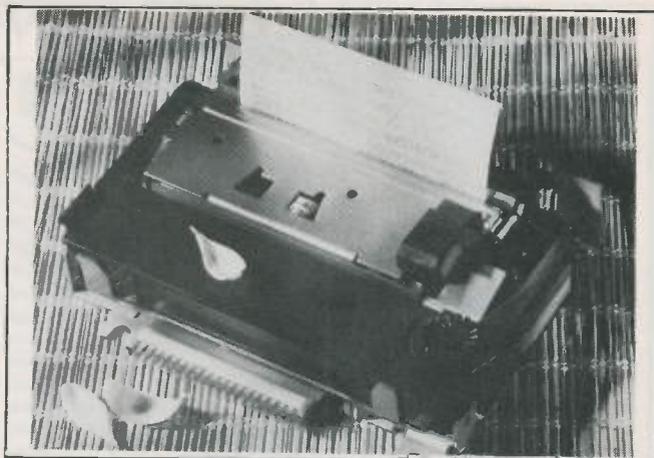
The high speed rotating brush quickly cleans and polishes material with the minimum of pressure. The tool is a lightweight 10oz and operates from an integral rechargeable battery or directly from the mains.

Contact: Eraser International Ltd., Unit M, Portway Industrial Estate, Andover, SP10 3LU. Tel: 0264 51347/8.

Universal Test Prod Kits

The modular design of OK's TPK400 series test prods and test prod kits for analogue and digital instruments enables the widest number of applications to be catered for, and for peak performance to be maintained by the easy replacement of damaged parts. The TPK400 series adapts to any analogue or digital meter with 4mm inputs and the basic kit includes two test prods with tips, two sprung hooks, two stainless steel replacement tips, two insulating tips, two alligator clips and two IC clips. They also include heat and tangle resistant silicon banana cables.

Contact: OK Industries UK Ltd, Barton Farm Industrial Estate, Chickenhall Lane, Eastleigh, Hants, SO5 5RR. Tel: 0703 619841.



Ultra Thin Printer

A break through in compact printing mechanisms: the OEM Division of Epson (UK) Limited, announce the M260, an ultra thin 35/42 column printer just 1" high. Such a small size combined with the 1.5 Million line reliability make the M260 the ideal printer for a wide range of point-of-sale receipt and ticketing applications. Epson claim that this new key product will ensure that they maintain their leadership in the emergent Electronic Funds Transfer applications market.

The M260's key features are small size and low profile, easy load ribbon cassette, character and graphics ability, single and two colour print versions and 2.3 lines a second print speed. The unit uses a seven solenoid shuttle head to achieve up to 42 columns on 76mm wide paper and can print characters either horizontally or vertically, and it also offers a red/black print facility.

Epson envisage EPOS/EFT terminal, cash dispensers, vending machines, handheld terminals and automatic Test Equipment as likely applications. Its 12V supply additionally allows automotive or other portable usage.

An appropriate control board, the BA260, interfaces the M260/M262 to a CPU. This operates in serial or parallel modes, has an on-board 128 character set with user defined options and can handle two colour graphics printing. Also under development are an autocoder, a twin station model, (M280) a validation model for printing onto cheques etc and a 24V head. The one off price for an M260 is £33.80 and £33.45 for the M262.

Epson (UK) Ltd claim to be the UK market leader in printers and volume lap-top computers and to be the fourth largest supplier of IBM-compatible PC's. Additionally the company has a substantial computer-based components division with a

dominant share of the mini printer O.E.M. market. Epson (UK) Ltd is a member of the Seiko-Epson Corporation. Contact: Epson (UK) Ltd, Dorland House, 388 High Road, Wembley, Middlesex HA9 6UH Tel: 01-902 8892.

More Printers

A couple of smart new printer ranges have announced themselves at our door. A new intelligent colour printing system from Digital is being distributed by Rapid Systems. Known as the LCP01, this is an ink-jet printer which boasts 'presentation-quality' output with 154 dpi resolution, eight colours and 216 shades. An integral graphics processor and full page buffer allow it to be used effectively with small computers, holding a complete job in buffer while the computer is freed to run other applications. There are five built in fonts and the ability to mix type sizes, styles and colours.

The LCP01 is supported by a variety of graphics packages, including Digital's complete range of office information and graphics software. It is compatible with DEC Rainbow, VAX and DECmate III Plus as well as text/graphics terminals. Contact Rapid Systems, Rapid House, Denmark Street, High Wycombe, Bucks HP11 2ER. Tel. 0494 450244.

First Software are continuing to expand into the hardware market with two high quality daisywheel printers by Panasonic. The 110-column, 17 cps KX-P3131 and 182-column, 22 cps KX-P3151 are compatible with most business and personal computers, and feature logic seeking, parallel interface, margin/justification control switch and bi-directional printheads as standard. Serial interfaces, tractor feed and auto sheet feeder are available as optional extras.

Contact First Software, Intec-1, Wade Road, Basingstoke, Hants RG24 0NE. Tel. 0256 463344.



Maplin Testing Time

THE new Maplin Catalogue features many new Testers, laboratory and workshop rather than medical. The "Star Buy" is a robust Hobby Multimeter unit which provides for accurate measurement of DC and AC voltages, direct currents, resistance and decibels on a linear meter. Price £8.95.

Also new are a large range of Multimeters, including: Pocket Digital £24.95, Hobby Digital £28.95, Push-Button Digital £39.95, High Precision Digital £41.95, Auto Ranging Digital £45.95, Multi-Purpose Digital £64.95. Maplin state that this comprehensive range of multimeters places them in the forefront of the marketplace. They can also provide the battery power required to keep the testing gear up and running. Their Standard nickel-cadmium Battery Charger has been reduced to just £6.95, and features a battery-test facility.

Another price reduction to £7.95, is the popular Maplin Universal Charger. Both units of course can only be used with rechargeable cells and batteries which are available from Maplin at highly cost-competitive prices.

Also highlighted in the new CATALOGUE are a range of products designed to keep a healthy user profile. A further "Star Buy" at only £5.95 (note-all Maplin prices include vat) is the Digital Clinical Thermometer. The LCD readout measures temperatures in the range 89.6° to 107.6°F. Then there is a Pocket Meter Digital Thermometer features internal and external sensors, clock and alarm warning facility, price £14.95. The Dual Scale Digital Thermometer at £9.95 is designed for use in the car, home, greenhouse and office. Features include clock, internal and external sensors. A highly versatile Digital Thermometer Module provides and LCD display and circuitry on

a small pcb with battery housing. Basic unit £6.95 (with Probe Module £9.60).

Also new this year is a fully automatic Blood Pressure Tester with LCD readout and built-in printer. The easy to use unit costs just £99.95. Meanwhile, the Maplin Digital Blood Pressure Tester which features LCD readout displaying the systolic and diastolic pressure and pulse rates, is available 49.95.

Contact: Maplin Electronics Supplies Ltd. PO Box 3, Rayleigh, Essex, SS6 8LR. Tel: 0702 5541550.

BT TV Satellite-Ready

British Telecom have announced two major agreements to distribute UK television programmes by satellite into Europe.

BT say that this is an important step forward for TV distribution by satellite, and that they are the European leader in this field, seeking to secure the future of UK television programmes distributed by satellite into Europe.

They have signed an agreement with EUTELSAT, the European satellite consortium, for up to eight of the transponders on the Eutelsat 2 medium-powered satellite due to be launched in the late 1989. BT has also signed an agreement with Societe Europeenne des

Satellites (SES) of Luxembourg for up to eleven of the transponders on their 'Astra' satellite due to be launched in 1988. These transponders from the UK can carry a mix of English and other language programmes.

Both of these second generation satellites offer high power, permitting reception on smaller antennas and substantially improving market prospects for companies producing TV programmes for distribution.

Reception is presently limited to about 10 million homes across Europe accessible via relatively large (3.7 metre diameter) antennas and local cable networks. The higher power of the new satellites would enable the TV companies to target community systems and individuals more effectively.

The greater power of the Eutelsat 2 and 'Astra' satellites should permit reception using dishes as small as 60cm in diameter in an area bounded by Edinburgh, Stockholm, Milan and Bordeaux.

The agreement with SES also involves joint marketing between BT and SES of the considerable opportunities for the reception of new programmes in the United Kingdom. British Telecom plans to open a new aerial as its London Teleport to transmit programmes up to the 'Astra' satellite.

PL/M Compiler for PC's

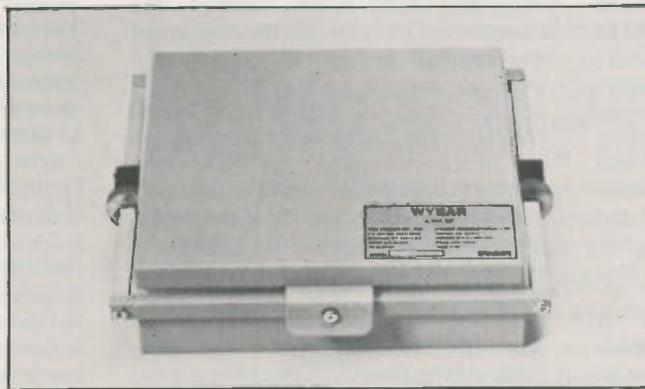
Warren Point International, the European supplier of Intel-compatible compilers and development tools, has announced an advanced PL/M development package for the IBM PC. Called Experts-PL/M, the package provides a highly efficient and economical means of developing and maintaining real-time software for Intel 8085 and Zilog Z80 microprocessors and the similar high-speed Japanese chips. Unlike other PL/M compilers, Experts PL/M is a native DOS package, thereby taking full advantage of the features of the operating systems.

Experts-PL/M on PC's has been developed for two main markets. Firstly, to offer unprecedented flexibility and economy for the many thousands of companies which already have large investments in the PL/M language. Secondly, it provides an advanced and remarkably inexpensive development environment for new projects planning to use the 8085, Z80 or similar processors. Recent surveys have shown a continued rapid increase in the number of new developments using 8-bit chips such as the 8085 and Z80. The PL/M language is renowned for being particularly well-suited to such developments.

The major component of the package is a new PL/M compiler which generates highly optimised code in the Intel MCs-85 object module format. Since it compiles a true superset of the PL/M-86 language, user's existing PL/M-80 and PL/M-86 source module will compile and execute without modification. And for the new software, the compiler provides a host of useful new features not found in PL/M-86, including structures within structures, explicitly based references, a fully-delimited IF block structure, and UNDO statement, and the relaxation of restrictions on reserved words and DECLARE statements.

Whilst the compiler is fully compatible with that originally provided by Intel, it produces much more optimised code. Code size reductions of up to 20 percent have been achieved. Other components of Experts-PL/M are the Assembler, Relocation and Linking Tools. The complete package costs £799 with special arrangements available for site licencing.

Contact: Warren Point International Limited, Babbage Road, Stevenage, Herts, SG1 2EQ. Tel: 0438-316311.



PCB Holder

Wybar Electronics announces the availability of a Printed Circuit Board Assembly Holder, the Model WY-01.

This is designed to reduce assembly times of PCBs of up to 210mm x 180mm, as used in the electrical and electronic industries.

It features an adjustable mounting rail which is spring loaded for easy insertion and removal of boards. The rail may be adjusted to allow two rows of smaller boards to be assembled simultaneously, or may be removed to accommodate larger boards. The lid is lined with

anti-static foam to hold components securely.

To use the unit, the board is inserted between the rail and frame, and the components are inserted in the board. The foam-lined lid is closed and latched at the front. The unit is raised, swiveled and turned over, exposing the back side of the PCB, enabling the components to be trimmed and soldered. The Model WY-01 measures 260m x 267mm overall, and weighs 1.4Kg.

Contact: Wybar Electronics, Unit M, Portway Industrial Estate, Andover SP10 3LU. Tel: (0264) 51347/8.

THE LEADING EDGE

BY BARRY FOX

DOLBY COMPETES WITH DIGITAL



Dolby's new Special Recording noise reduction system can give analogue audio the same quality as digital – but at a much lower cost.

THE name Dolby has become a household word. It is twenty years since Ray Dolby, now Dr. Ray Dolby OBE, invented the A-type noise reduction system which lowers the background noise you get from magnetic tape. His invention did much more than reduce tape hiss and make him a rich man.

The use of noise reduction makes it possible to reduce the width of individual tape tracks. So there can be more tracks on a single length of tape. This is what made multitrack pop recording possible; with A-type encoding 8, 16, 24 or even 32 tracks can be squeezed together on a single tape. A-type encoding divides the signal into several fixed frequency bands and in each band separately boosts any weak sounds found in that band. The artificially boosted sounds thus stand out over tape noise when a recording is made. When the tape is replayed, mirror image attenuation puts the wanted sounds back down to their intended level and reduces noise of similar frequency.

The B-type system came a few years later. It was a simplified version, designed for domestic use. The same processing is carried out in a single band of a width which varies with the signal content. B-type encoding reduced the hiss of narrow tape and thereby made the Philips cassette potentially a hi-fi medium.

The C-type system, which is essentially a doubled B-type, reduces hiss even further. It was developed in the early 80s when the Japanese electronics industry told Ray Dolby that they needed a more powerful system and feared chaos if everyone went off in different directions.

Now Ray Dolby has developed Spectral Recording, which can produce results on an analogue recorder which are comparable to the results you get from a digital recorder costing several times the price.

Ray Dolby was in London recently giving the tenth anniversary lecture to the Institute of Broadcast Sound, at the BBC's Paris studio. He gave some interesting background to the dry technology of noise reduction.

While still a student in California, in the 50s, Dolby worked with Ampex on

the world's first video recorder. He then came over to Pembroke College in Cambridge, on a scholarship, for further study. His rooms in college were fifty yards from the chapel and he ran a microphone line through from the chapel to an Ampex audio recorder in his room.

"That was when I became interested in signal-to-noise ratios", said Dolby. "I could compare line-in with line-out very easily".

The A-type system improved signal to noise ratio by around 10dB. Most of the studios Dolby approached in the sixties said they weren't interested in S/N, arguing that they could already get all the dynamic range they needed just by using good quality tape. But the Decca studios in London said they *were* interested in improving dynamic range. They bought the first pieces of A-type equipment as a test. Although probably even Ray Dolby doesn't know it, one reason why Decca bought the equipment was that their studios in West Hampstead were coming up to the end of their financial year, and had some budgeted cash left over. Decca used the A-system for stereo recording, and then other studios adapted it for multi-track.

Dolby says he calls his new system Spectral Recording, or SR, because he wants to get the message across that it is much more than simple noise reduction. "It must have been rather like that with Henry T. Ford", say Dolby. "One day he thought it would be a good idea to stop calling his new invention a horseless carriage, and christen it the motor car instead".

There is heavy pressure on the recording and broadcast industry to change over from analogue to digital technology. The pressure is technical, because the results are so good, and commercial, because record producers, engineers and artists want to use the most modern equipment.

"In the early 80s", says Ray Dolby "I looked at digital PCM recorders and saw all the complexity. I wondered about what would happen if someone threw that amount of electronics at an analogue system". SR is the result of that thought. What was seen as a one or two year project, took more than five

years to finish.

In simple terms the SR circuit is a bank of variable filters, all of which are independently responsive to the amplitude and frequency content of the signal being recorded. Different levels of signal are boosted by different amounts at different frequencies. The system is dynamic to the point of being almost infinitely flexible.

The decoder playback circuitry works in exactly the same way as the recording encoder, except that the phase relationships are opposite. This gives an accurate mirror image effect, i.e. whatever signal was boosted at the recording stage is reduced by exactly the same amount on playback.

Recording studios are now taking delivery of SR processors (at around £550 per channel compared to £300 per channel for A-type noise reduction) and the first LP records made with the process should soon be on the market. The public will of course not be aware of this (unless the sleeve has an SR logo) because all the necessary decoding is done when the master tape is transferred to master disc.

It is not widely appreciated that all Dolby systems have one thing in common. Strong signals, which need no noise reduction processing, pass straight through the encoder untouched. Low level signals, which need processing, are fed through a chain. So all the processing is done in a side chain and it only affects low level signals.

Most noise reduction systems work by processing all the signals, and this is what makes them so susceptible to nasty side effects like noise modulation; processing some signals audibly affects others.

Because SR, like all Dolby systems, processes only those parts of the signal that need processing, any quiet sounds are artificially amplified before they are recorded onto tape. When an SR master tape is played back without decoding, any unwanted studio sounds like breathing or clothing rustle – become absurdly loud. When the master tape is decoded, the background sounds are pushed back down to their normal level, and tape hiss is killed. The results are truly dramatic.

PE

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CONSTRUCTIVE COMMENTS

It may seem surprising to habitual project builders, but the motivation for constructing projects is occasionally queried by some readers.

Certainly it is true that some hobbyist circuits are available as similar commercially built units, and it is not my intention to deny the importance of these products. However, if you look back at various magazine circuits, in many cases you simply won't find their direct equivalents as manufactured units.

Some ideas, for example, may perhaps only appeal to a comparatively small proportion of the public, and the potential ready-made sales value may be outweighed by production costs, making them commercially unviable. Often though, those who write for PE and other electronics magazines, probably do not have business overheads to consider. They only have to stand the design costs, and then profit from the publication fees they receive. When readers are likely to find advantage from these ideas, they become ideal constructional publishing material.

Additionally, published ideas are occasionally so original that manufacturers have not implemented them, and readers then gain from true innovation. PE has a strong tradition for publishing such good ideas, some of which have been patented.

Naturally, there are occasions when commercial equipment has its close equivalent in a published article. This would not breach copyright, but would show that another, equally valid, approach can be made to a common subject. In this case, DIY can frequently be cheaper since the hobbyist's own free time will replace manufacturing labour costs. Only the parts have to be paid for, assuming that inadvertent mistakes are not made. Even if they are, most people will benefit by learning from them.

'Learning by doing' is as true for electronics as for other disciplines, and the best way to understand anything is to find out how it works, or why it doesn't. With electronics this can be achieved by experimentally connecting parts together and discovering what happens. At its simplest level, just varying and observing the effects reinforces theoretical understanding. At a higher level, assembling a full project teaches systems integration, and also provides a test bed for detailed functional analysis, as well as being useful for its own sake.

Much of the pleasure I gain from electronics originates from functional analysis, often starting from the question of 'what happens if...'. Inquisitive examination of interconnected components resulting in working models has enormous satisfaction, though for me, just the assembly on its own is as much a hobby as part of a job.

If you are not already addicted to electronic construction, I recommend that you try it. It can be a very rewarding, satisfying, and low cost form of entertainment, and learning. Although some projects use hi-tech ideas, their implementation does not always need hi-tech ability - just care and interest.

THE EDITOR

OUR AUGUST 1987 ISSUE WILL BE ON SALE FRIDAY, JULY 3rd 1987 (see page 2)

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7402	0.30	74281	3.20	74LS280	0.80	74ALS04	0.50	74S04	0.50	74LS111	0.55
7403	0.30	74282	0.90	74LS283	0.80	74ALS08	0.50	74S08	0.50	74LS112	0.70
7404	0.36	74283	0.90	74LS290	0.80	74ALS10	0.50	74S10	0.50	74LS113	0.70
7405	0.40	74284	1.80	74LS292	1.40	74ALS12	0.50	74S12	0.50	74LS114	0.85
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7407	0.40	74286	0.80	74LS294	0.80	74ALS18	0.50	74S18	0.50	74LS116	1.10
7408	0.30	74287	0.80	74LS295	1.40	74ALS20	0.50	74S20	0.50	74LS117	1.10
7409	0.30	74288	1.10	74LS296	2.20	74ALS22	0.50	74S22	0.50	74LS118	1.10
7410	0.30	74289	1.20	74LS297	1.40	74ALS24	0.50	74S24	0.50	74LS119	1.10
7411	0.30	74290	1.40	74LS298	2.00	74ALS26	0.50	74S26	0.50	74LS120	1.10
7412	0.30	74291	1.40	74LS299	2.20	74ALS28	0.50	74S28	0.50	74LS121	1.10
7413	0.30	74292	1.40	74LS300	2.20	74ALS30	0.50	74S30	0.50	74LS122	1.10
7414	0.30	74293	1.40	74LS301	2.20	74ALS32	0.50	74S32	0.50	74LS123	1.10
7415	0.30	74294	1.40	74LS302	2.20	74ALS34	0.50	74S34	0.50	74LS124	1.10
7416	0.36	74295	1.40	74LS303	2.20	74ALS36	0.50	74S36	0.50	74LS125	1.10
7417	0.40	74296	1.40	74LS304	2.20	74ALS38	0.50	74S38	0.50	74LS126	1.10
7418	0.40	74297	1.40	74LS305	2.20	74ALS40	0.50	74S40	0.50	74LS127	1.10
7419	0.40	74298	1.40	74LS306	2.20	74ALS42	0.50	74S42	0.50	74LS128	1.10
7420	0.30	74299	1.40	74LS307	2.20	74ALS44	0.50	74S44	0.50	74LS129	1.10
7421	0.30	74300	1.40	74LS308	2.20	74ALS46	0.50	74S46	0.50	74LS130	1.10
7422	0.36	74301	1.40	74LS309	2.20	74ALS48	0.50	74S48	0.50	74LS131	1.10
7423	0.36	74302	1.40	74LS310	2.20	74ALS50	0.50	74S50	0.50	74LS132	1.10
7424	0.36	74303	1.40	74LS311	2.20	74ALS52	0.50	74S52	0.50	74LS133	1.10
7425	0.40	74304	1.40	74LS312	2.20	74ALS54	0.50	74S54	0.50	74LS134	1.10
7426	0.40	74305	1.40	74LS313	2.20	74ALS56	0.50	74S56	0.50	74LS135	1.10
7427	0.40	74306	1.40	74LS314	2.20	74ALS58	0.50	74S58	0.50	74LS136	1.10
7428	0.40	74307	1.40	74LS315	2.20	74ALS60	0.50	74S60	0.50	74LS137	1.10
7429	0.40	74308	1.40	74LS316	2.20	74ALS62	0.50	74S62	0.50	74LS138	1.10
7430	0.40	74309	1.40	74LS317	2.20	74ALS64	0.50	74S64	0.50	74LS139	1.10
7431	0.40	74310	1.40	74LS318	2.20	74ALS66	0.50	74S66	0.50	74LS140	1.10
7432	0.40	74311	1.40	74LS319	2.20	74ALS68	0.50	74S68	0.50	74LS141	1.10
7433	0.40	74312	1.40	74LS320	2.20	74ALS70	0.50	74S70	0.50	74LS142	1.10
7434	0.40	74313	1.40	74LS321	2.20	74ALS72	0.50	74S72	0.50	74LS143	1.10
7435	0.40	74314	1.40	74LS322	2.20	74ALS74	0.50	74S74	0.50	74LS144	1.10
7436	0.40	74315	1.40	74LS323	2.20	74ALS76	0.50	74S76	0.50	74LS145	1.10
7437	0.40	74316	1.40	74LS324	2.20	74ALS78	0.50	74S78	0.50	74LS146	1.10
7438	0.40	74317	1.40	74LS325	2.20	74ALS80	0.50	74S80	0.50	74LS147	1.10
7439	0.40	74318	1.40	74LS326	2.20	74ALS82	0.50	74S82	0.50	74LS148	1.10
7440	0.40	74319	1.40	74LS327	2.20	74ALS84	0.50	74S84	0.50	74LS149	1.10
7441	0.40	74320	1.40	74LS328	2.20	74ALS86	0.50	74S86	0.50	74LS150	1.10
7442	0.40	74321	1.40	74LS329	2.20	74ALS88	0.50	74S88	0.50	74LS151	1.10
7443	0.40	74322	1.40	74LS330	2.20	74ALS90	0.50	74S90	0.50	74LS152	1.10
7444	0.40	74323	1.40	74LS331	2.20	74ALS92	0.50	74S92	0.50	74LS153	1.10
7445	0.40	74324	1.40	74LS332	2.20	74ALS94	0.50	74S94	0.50	74LS154	1.10
7446	0.40	74325	1.40	74LS333	2.20	74ALS96	0.50	74S96	0.50	74LS155	1.10
7447	0.40	74326	1.40	74LS334	2.20	74ALS98	0.50	74S98	0.50	74LS156	1.10
7448	0.40	74327	1.40	74LS335	2.20	74ALS100	0.50	74S100	0.50	74LS157	1.10
7449	0.40	74328	1.40	74LS336	2.20	74ALS102	0.50	74S102	0.50	74LS158	1.10
7450	0.40	74329	1.40	74LS337	2.20	74ALS104	0.50	74S104	0.50	74LS159	1.10
7451	0.40	74330	1.40	74LS338	2.20	74ALS106	0.50	74S106	0.50	74LS160	1.10
7452	0.40	74331	1.40	74LS339	2.20	74ALS108	0.50	74S108	0.50	74LS161	1.10
7453	0.40	74332	1.40	74LS340	2.20	74ALS110	0.50	74S110	0.50	74LS162	1.10
7454	0.40	74333	1.40	74LS341	2.20	74ALS112	0.50	74S112	0.50	74LS163	1.10
7455	0.40	74334	1.40	74LS342	2.20	74ALS114	0.50	74S114	0.50	74LS164	1.10
7456	0.40	74335	1.40	74LS343	2.20	74ALS116	0.50	74S116	0.50	74LS165	1.10
7457	0.40	74336	1.40	74LS344	2.20	74ALS118	0.50	74S118	0.50	74LS166	1.10
7458	0.40	74337	1.40	74LS345	2.20	74ALS120	0.50	74S120	0.50	74LS167	1.10
7459	0.40	74338	1.40	74LS346	2.20	74ALS122	0.50	74S122	0.50	74LS168	1.10
7460	0.40	74339	1.40	74LS347	2.20	74ALS124	0.50	74S124	0.50	74LS169	1.10
7461	0.40	74340	1.40	74LS348	2.20	74ALS126	0.50	74S126	0.50	74LS170	1.10
7462	0.40	74341	1.40	74LS349	2.20	74ALS128	0.50	74S128	0.50	74LS171	1.10
7463	0.40	74342	1.40	74LS350	2.20	74ALS130	0.50	74S130	0.50	74LS172	1.10
7464	0.40	74343	1.40	74LS351	2.20	74ALS132	0.50	74S132	0.50	74LS173	1.10
7465	0.40	74344	1.40	74LS352	2.20	74ALS134	0.50	74S134	0.50	74LS174	1.10
7466	0.40	74345	1.40	74LS353	2.20	74ALS136	0.50	74S136	0.50	74LS175	1.10
7467	0.40	74346	1.40	74LS354	2.20	74ALS138	0.50	74S138	0.50	74LS176	1.10
7468	0.40	74347	1.40	74LS355	2.20	74ALS140	0.50	74S140	0.50	74LS177	1.10
7469	0.40	74348	1.40	74LS356	2.20	74ALS142	0.50	74S142	0.50	74LS178	1.10
7470	0.40	74349	1.40	74LS357	2.20	74ALS144	0.50	74S144	0.50	74LS179	1.10
7471	0.40	74350	1.40	74LS358	2.20	74ALS146	0.50	74S146	0.50	74LS180	1.10
7472	0.40	74351	1.40	74LS359	2.20	74ALS148	0.50	74S148	0.50	74LS181	1.10
7473	0.40	74352	1.40	74LS360	2.20	74ALS150	0.50	74S150	0.50	74LS182	1.10
7474	0.40	74353	1.40	74LS361	2.20	74ALS152	0.50	74S152	0.50	74LS183	1.10
7475	0.40	74354	1.40	74LS362	2.20	74ALS154	0.50	74S154	0.50	74LS184	1.10
7476	0.40	74355	1.40	74LS363	2.20	74ALS156	0.50	74S156	0.50	74LS185	1.10
7477	0.40	74356	1.40	74LS364	2.20	74ALS158	0.50	74S158	0.50	74LS186	1.10
7478	0.40	74357	1.40	74LS365	2.20	74ALS160	0.50	74S160	0.50	74LS187	1.10
7479	0.40	74358	1.40	74LS366	2.20	74ALS162	0.50	74S162	0.50	74LS188	1.10
7480	0.40	74359	1.40	74LS367	2.20	74ALS164	0.50	74S164	0.50	74LS189	1.10
7481	0.40	74360	1.40	74LS368	2.20	74ALS166	0.50	74S166	0.50	74LS190	1.10
7482	0.40	74361	1.40	74LS369	2.20	74ALS168	0.50	74S168	0.50	74LS191	1.10
7483	0.40	74362	1.40	74LS370	2.20	74ALS170	0.50	74S170	0.50	74LS192	1.10
7484	0.40	74363	1.40	74LS371	2.20	74ALS172	0.50	74S172	0.50	74LS193	1.10
7485	0.40	74364	1.40	74LS372	2.20	74ALS174	0.50	74S174	0.50	74LS194	1.10
7486	0.40	74365	1.40	74LS373	2.20	74ALS176	0.50	74S176	0.50	74LS195	1.10
7487	0.40	74366	1.40	74LS374	2.20	74ALS178	0.50	74S178	0.50	74LS196	1.10
7488	0.40	74367	1.40	74LS375	2.20	74ALS180	0.50	74S180	0.50	74LS197	1.10
7489	0.40	74368	1.40	74LS376	2.20	74ALS182	0.50	74S182	0.50	74LS198	1.10
7490	0.40	74369	1.40	74LS377	2.20	74ALS184	0.50	74S184	0.50	74LS199	1.10
7491	0.40	74370	1.40	74LS378	2.20	74ALS186	0.50	74S186	0.50	74LS200	1.10
7492	0.40	74371	1.40	74LS379	2.20	74ALS188	0.50	74S188	0.50	74LS201	1.10
7493	0.40	74372	1.40	74LS380	2.20	74ALS190	0.50	74S190	0.50	74LS202	1.10
7494	0.40	74373	1.40	74LS381	2.20	74ALS192	0.50	74S192	0.50	74LS203	1.10
7495	0.40	74374	1.40	74LS382	2.20	74ALS194	0.50	74S194	0.50	74LS204	1.10
7496	0.40	74375	1.40	74LS383	2.20	74ALS196	0.50	74S196	0.50	74LS205	1.10
7497	0.40	74376	1.40	74LS384	2.20	74ALS198	0.50	74S198	0.50	74LS206	1.10
7498	0.40	74377	1.40	74LS385	2.20	74ALS200	0.50	74S200	0.50	74LS207	1.10
7499											

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

WORD GENERATOR

PART ONE BY JOE CHAMBERLAIN

Binary words for test signals

The word generator described in this article is an item of test equipment which generates a binary word of up to 16 bits in length with the option of producing either a straight binary output, i.e. a sequence of logic ones and noughts or a return to zero (RTZ) output where the output returns to a logic 0 between consecutive logic ones. The word may be either continuously repeated (free running) or be triggered from an external signal.

As with any piece of test equipment a balance must be struck between providing a multiplicity of control facilities and simplicity of operation. In this design a number of optional features are suggested which increase the flexibility of the equipment but also add to the number of controls to be accommodated on the front panel.

The generator is constructed using 4000 series CMOS logic throughout. Other logic ranges and technologies could be used if higher speed operation is required.

APPLICATIONS

Some possible applications for the word generator are indicated below. The list is by no means exhaustive and later in the article methods of testing will be discussed in greater detail.

The generator may be used to test serial to parallel data converters by generating a word of the desired length, incrementing the serial word by a known amount and observing the change in the converter output. It is also useful for checking serial data acquisition systems where, for example, a number of remote stations signal to a central station over a common path. The generator can be used to simulate each of the stations in turn.

Binary signals having a mark-space ratio ranging from 1:15 to 15:1 can be generated to test the performance of data modems. The generator 'Clock' output provides suitable synchronisation to observe 'eye' diagrams on an oscilloscope.

A less obvious application is in providing a delayed trigger for an oscilloscope. If a trigger signal is applied to the External Trigger input of the generator, and the oscilloscope trigger input connected to the Data output, the oscilloscope will be triggered when the data output changes to logic 1 level. With only one bit set to a logic 1 the delay will be equal to the number of bits set to logic 0 before the bit set to logic 1. The duration of each bit is determined by the clock rate so a 'fine' control of delay can be obtained by adjusting the data rate Fine control.

The receive section of UARTs (Universal asynchronous receiver transmitter) can be tested by setting the word length to account for start, stop and parity bits in addition to the data word. The effect of changing any one or more parameters can then be established. The performance of DC restorer circuits to differing patterns of binary signals can also be checked.

FACILITIES

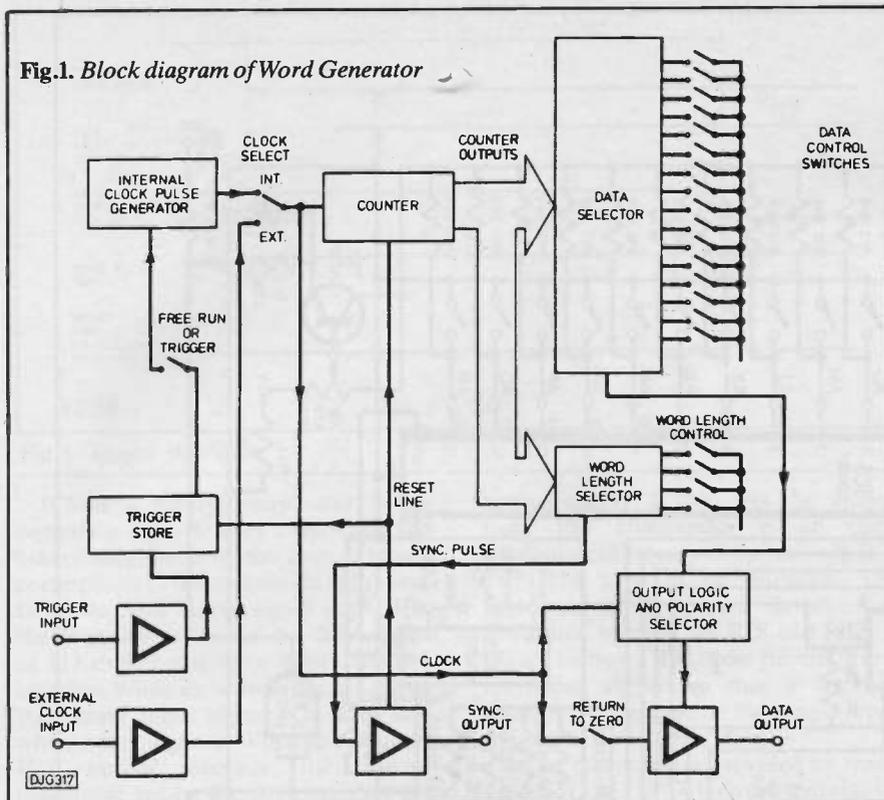
The basic facilities available are:-

- An internal variable frequency clock covering the data rates from 20 bits/second to 20,000 bits/second in three ranges, either free running or triggered.
- A set of data selector controls which allow each bit in the generated word to be set to a logic 1 or logic 0 level.
- A word length selector which permits the number of digits in the word to be set to between 2 and 16 bits.
- Data mode controls: normal or inverted, and binary or return to zero.

The output circuit will sink a maximum current of 50mA in the logic 0 state and source current from a 480 ohms resistor. The amplitude of the output signal is continuously variable



Fig.1. Block diagram of Word Generator



from two volts to ten volts.

e) Access available to the internal clock and to a synchronising signal when repetitive waveforms are to be observed.

CIRCUIT DESCRIPTION

A block diagram of the generator is shown in Fig.1. The internal clock generator drives a binary counter via the Clock Select switch. The binary counter, which counts on the negative clock edges, generates the switching signals required by the data selector multiplexer to read each data input in sequence.

When the counter outputs are 0000 on the four output lines the data selector reads input 0. As the count increases to 1111 the subsequent data inputs are each read in turn, output 15 corresponding to 1111. The binary signal on the data inputs is controlled by the setting of the data control switches.

The counter output also drives the word length selector. This is a 4-bit comparator which generates an output when the counter output corresponds to the setting of the four switches which form the word length selector. The output from the comparator remains at a logic 1 level for the duration of one clock period, after which it restores to logic 0 level. This signal is inverted by the sync output buffer and is available as a synchronising signal output. The trailing edge of the pulse is used as a reset signal for the counter, internal clock and trigger store.

The data output from the data selector multiplexer is connected to the D input of a 'D'-Type flip flop which is clocked from the same signal which drives the binary counter, but it operates on the rising clock edge. This ensures that a clean signal is presented to the flip flop input and prevents race conditions occurring due to the switching time of the multiplexer. One effect of this is to delay the output by half a clock period in relation to the sync output. Clock output, typical data word, sync output and reset pulse waveforms are shown in Fig.2.

The first output buffer gate is used to generate a return to zero output signal when the RTZ switch is closed. The second gate has its supply voltage controlled from a variable constant voltage source to provide a control of output level.

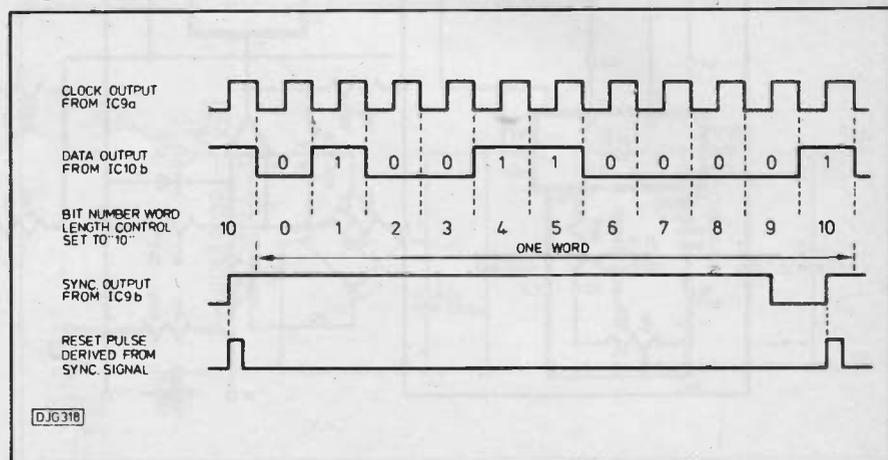


Fig.2. Output wave forms for word length control set to 10.

CIRCUIT OPERATION

The detailed operation of the circuit is described with reference to the circuit diagram Fig.3. The internal clock is formed by integrated circuits IC1,2 and 3. IC1 is an astable/monostable multivibrator with very stable operating characteristics. The device is connected in an astable configuration and can be gated by application of a positive voltage to pin 5 so that for free running operation this pin is taken to the positive rail via a 10k resistor. The Q output is used to drive the first clock input of a dual binary coded decimal (BCD) counter IC2. The output of the first counter is connected to the input of the second to provide clock pulse rates divided by 10 and 100 respectively. The complementary output of IC1 and the outputs from the two BCD counters are connected to the data range switch S21. As the outputs from the BCD counter IC2 are not symmetrical the output from S21 is connected to the input of a 'D'-Type flip flop IC3, connected as a divide by two stage to ensure an exact 50:50 mark space ratio clock signal for the data multiplexer and output stages.

The data selector IC5 is a 16-bit analogue multiplexer. Each of the data inputs is tied to the positive supply rail via a 6k8 resistor and connected to earth by a data switch. Thus if a switch is open the multiplexer will output a logic 1 level, and if the switch is closed a logic 0 level will be output. The multiplexer which acts as a rotary switch reads the data inputs from 0 to 15 in sequence under the control of the binary counter IC4. This counter is clocked either from the internal timing signal or from an externally derived clock. This option is selected by switch S22.

The output from the multiplexer is connected to the D input of IC7b which is a 'D'-Type flip flop clocked from the same signal which drives IC4, but operating on the opposite clock edge. Normal and inverted data outputs are then available from the two outputs of the flip flop and are selected by switch S24.

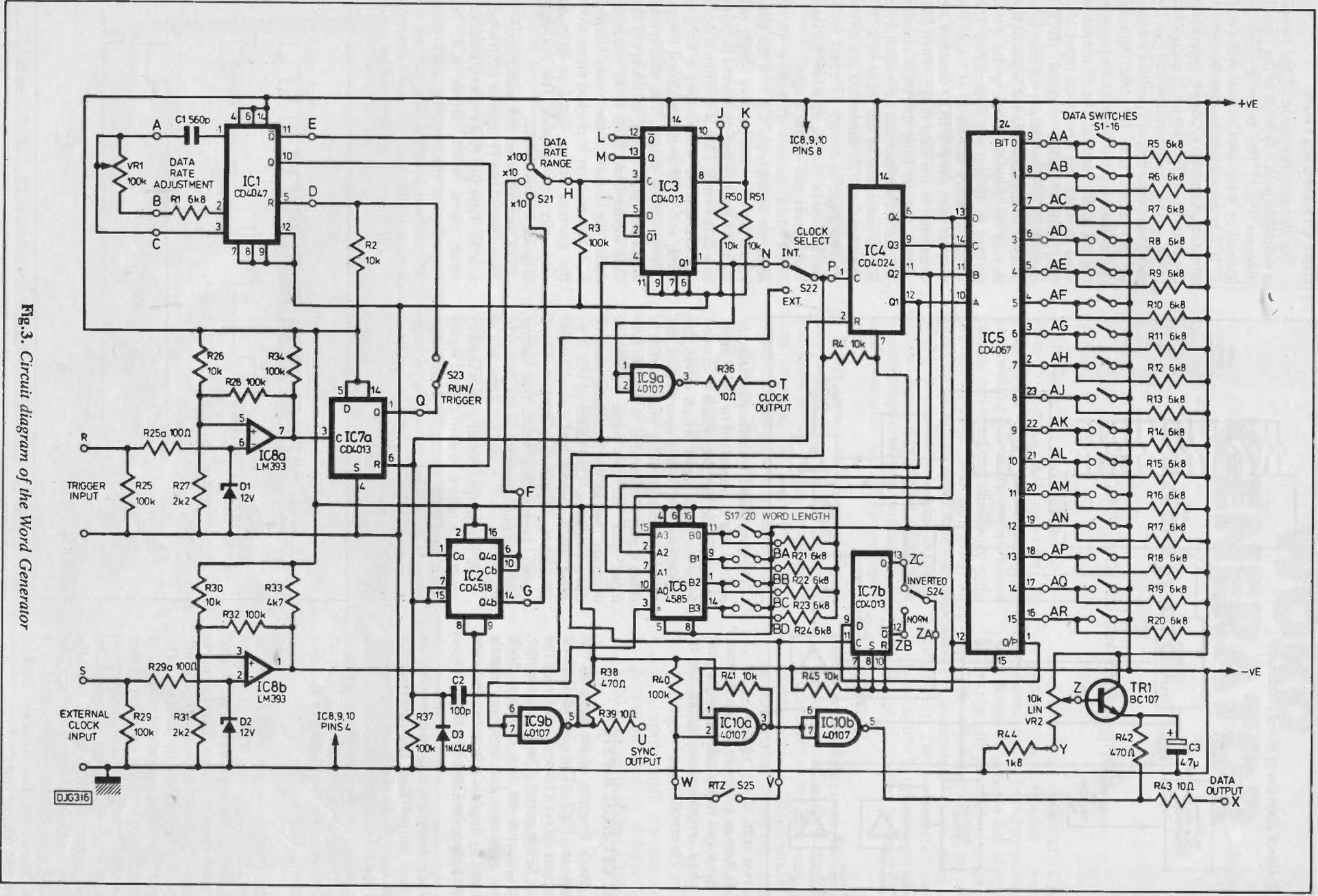


Fig. 3. Circuit diagram of the Word Generator

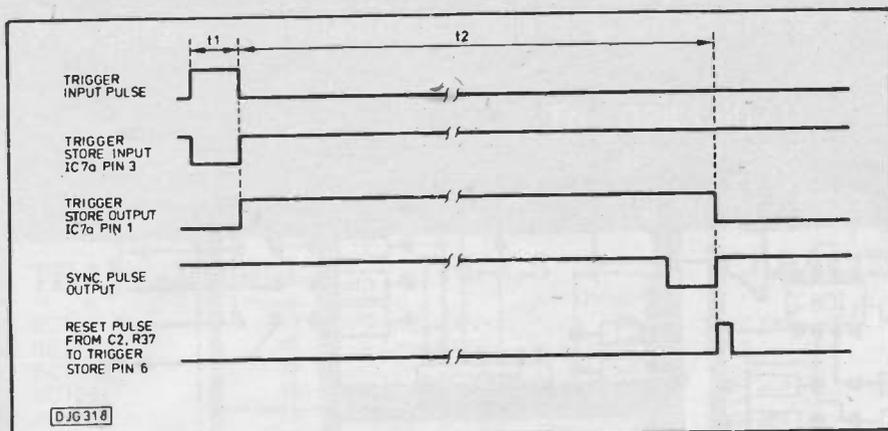


Fig.4. Trigger operation

IC6 is a binary comparator which outputs a logic 1 level only when the binary magnitude of the four A inputs corresponds to the magnitude of the four B inputs. The binary signal applied to the B inputs is defined by the settings of S17 to S20, the word length selector switches. When these switches are closed the binary input signal is logic 0 and when open, logic 1. When the counter IC4 output exceeds the binary magnitude set on the four switches the comparator output returns to logic 0. The comparator output is inverted by the sync output buffer IC9b and the trailing edge of the positive going pulse is differentiated by C2 and R37, so generating a pulse to reset the counters and trigger Store IC7a. Diode D3 is provided to prevent the negative transition of the differentiated signal going below the 0 volt supply rail with the consequent danger of damage to the integrated circuits to which the pulse is applied.

When operating in the triggered mode the clock IC1 is held inoperative by the logic 0 level applied to its control input from the 'D'-Type flip flop IC7a. This control signal changes to a logic 1 level when a positive transition is applied to the clock input pin 3. The clock then runs until the comparator output changes from logic 1 to logic 0 when the reset restores the output of IC7a to logic 0.

The waveforms associated with triggered operation are shown in Fig.4. The duration of the trigger pulse (t1) is not critical for circuit operation as only the falling edge of the signal is used. The duration of the word (t2) is determined by the word length and clock rate.

INPUT CIRCUITS

The trigger and external clock input circuits are identical in configuration and use the two sections of a dual comparator, IC8, connected as level detectors. The level at which the detectors operate is determined by the biasing resistors R26 and R27, and R30 and R31 respectively, and is set to

approximately 2 volts. As the output from this comparator is an open transistor collector, pull up resistors R33 and R34 have to be provided. The hysteresis of the level detectors is controlled by resistors R28 and R32. It should be noted that these circuits invert the input signals so that a negative transition is required on the trigger input to initiate word generation.

Input protection is provided by zener diodes D1 and D2, which prevent signals of greater than +12 volts or -0.7 volts being applied to the comparators.

OUTPUTS CIRCUITS

Clock, Sync and Data outputs are derived from CMOS buffer driver gates IC9a, IC9b and IC10b, type 40107. These gates have open collector outputs and are capable of sinking a maximum current of 50mA. Output current is sourced from the collector pull up resistors R35, R38 and R42 respectively. Series resistors are installed in each output line to provide some degree of protection to the gates if low resistance voltage sources such as power supplies are accidentally connected to them. For maximum current sinking capacity the resistor value specified is 10 ohms, but if the unit is not required to sink much current (for example if it is only used to drive CMOS circuits) it is strongly

recommended that the value be increased to 100 or even 1000 ohms.

In some of the author's test equipment an output switch has been incorporated to switch the protection resistors as shown in Fig.5.

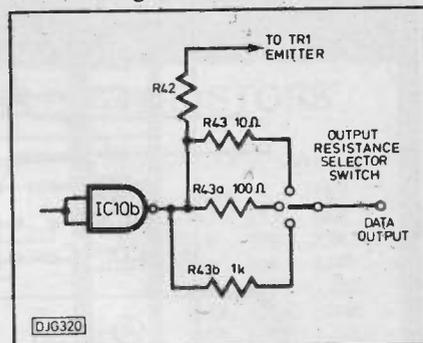


Fig.5. Method of switching output resistance

The data output level is controlled by variation of the supply voltage to the collector load resistor R42 by means of the emitter follower transistor TR1 which functions as a constant voltage source. The clock output may be similarly controlled if desired. The Sync output however should be maintained at the full 12 volts unless a further buffer stage is fitted as this output also provides the system reset.

POWER SUPPLY

A circuit diagram of the power supply is shown in Fig.6. The power supply is of conventional design and uses a series stabiliser type 7812, IC11, fed from a bridge rectifier D4 to provide a stable 12 volt supply. To conform to current safety standards the mains transformer should be either double wound or incorporate an earthed screen between primary and secondary windings. Care should be taken to connect the earth of the mains supply and the transformer screen to the chassis as shown. The mains ON/OFF switch S26 must be capable of switching a 240 volt a.c. supply.

An indication that the unit is operative is provided by the LED D5 connected across the power supply output in series

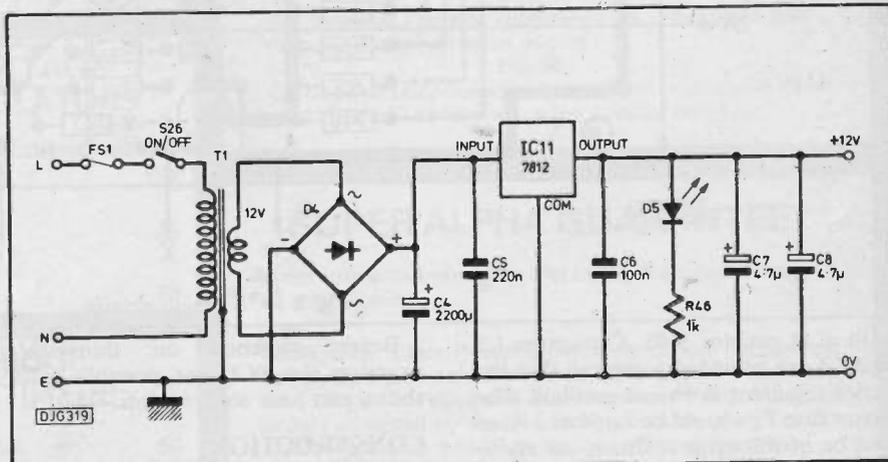


Fig.6. 12 volt power supply

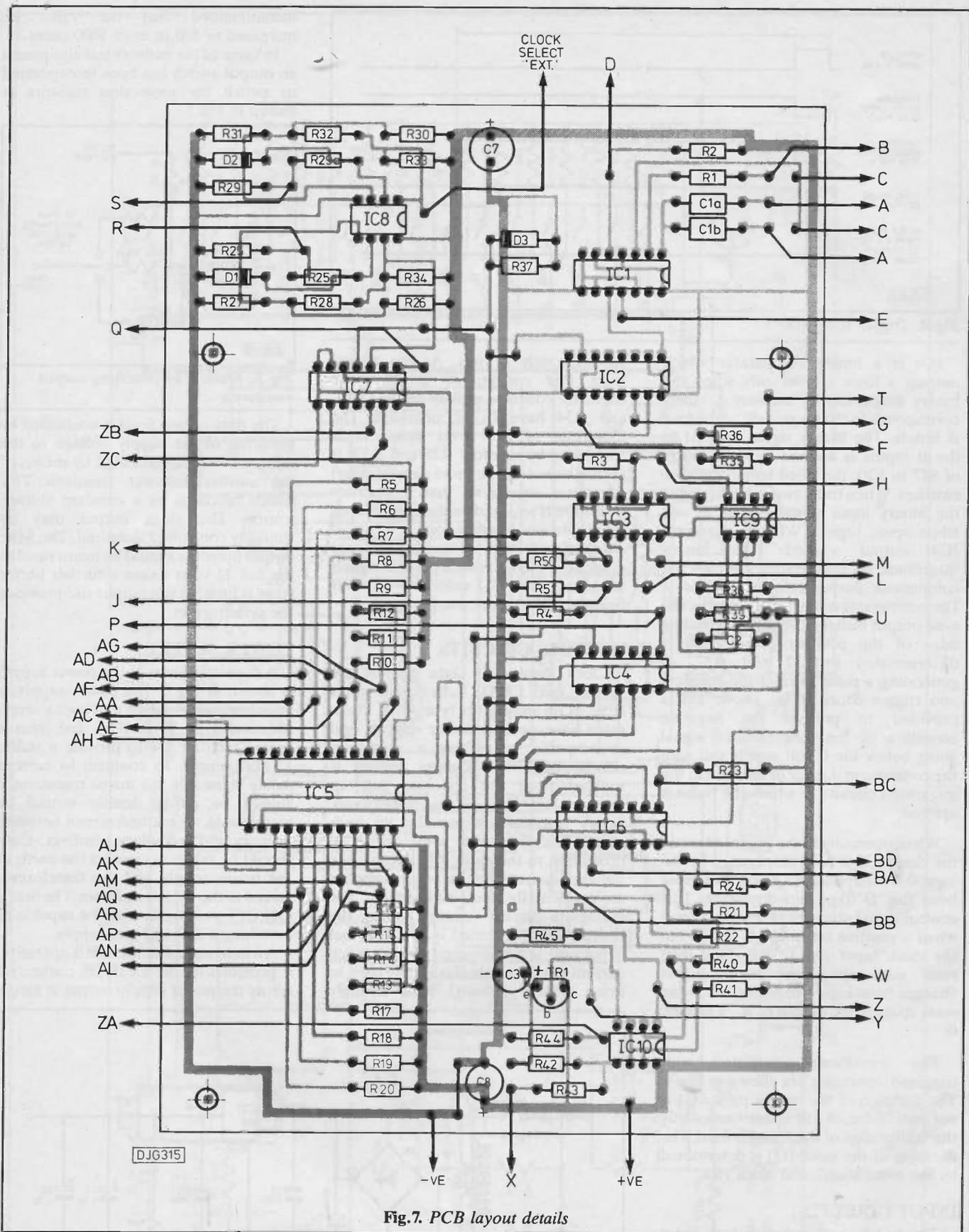


Fig.7. PCB layout details

with a 1k resistor R46. Capacitors C5 and C6 are provided to ensure that the series regulator does not oscillate. The mains fuse F1 should be rated at 1 Amp and be of the surge resistant variety to cater for the initial current drawn by capacitor C4 at switch on.

Before switching on, thoroughly examine the PCB for possible track shorts and poor solder joints.

CONSTRUCTION

The prototype unit was constructed on Veroboard, but a suggested printed

circuit is shown in Fig.7. and is available through the PE PCB service.

NEXT MONTH: Part Two will continue the constructional details, and describe the final alignment.

PE



TRANSISTORS

	Pence
BC107	15
BC107A	15
BC107B	15
BC108	15
BC108A	18
BC108B	15
BC108C	15
BC109	18
BC109B	18
BC109C	18
BC182	12
BC182B	12
BC183	12
BC183B	12
BC184	12
BC212	12
BC212B	12
BC213	12
BC213B	12
BC214	12
BC327	16
BC337	16
BC548	12
BCY70	22
BCY71	22
BD131	60
BD132	60
BD135	34
BD136	35
BF258	60
BFX85	40
BFX88	40
BFY50	37
BFY51	37
BFY52	39
TIP31	42
TIP31A	48
TIP31B	56
TIP31C	54
TIP32A	42
TIP32C	42
TIP33A	100
TIP41A	63
TIP42A	55
TIP3055	76
TIP2955	76
ZTX300	17
ZTX500	17
2N3053	60
2N3054	160
2N3707	12
2N3703	12
2N3705	12
2N3771	140
2N3904	15
2N3906	15

DIODES

	Pence
IN4001	5
IN4002	5
IN4003	6
IN4004	6
IN4448	6

TRIACS

	Pence
3 Amp 400V	75
8 Amp 400V	90

OPTO ISOLATORS

TIL111	
Transistor o/p	110
TIL113	
Darlington o/p	120
3021	
Triac driver	150

LEDs

T1 3/4 5mm	
Red	18
Yellow	18
Green	18
Super bright	
T1 3/4 5mm	
Red	35

ZENER DIODES

BZY88C 500m W	
4V7	10
10V	10
12V	10
BZX55C 500m W	
24V	10
BZX85C 1.3 Watt	
4V7	20
10V	20
12V	20
24V	20

VOLTAGE REGULATORS

LM317T	
+ 1.2V to 37V	150
LM341P	
+ 5V	60
LM7905	
- 5V	70

BRIDGE RECTIFIERS

W004 1.5A	50
6005 6A	90

CAPACITORS

	Pence
ELECTROLYTIC	
47uF 25V	10
100uF 25V	12
470uF 25V	28
1000uF 25V	36
TANTALUM BEAD	
.1uF 35V	10
.22uF 35V	10
.47uF 35V	10
1uF 35V	10
2.2uF 35V	15
4.7uF 35V	20
CERAMIC DISC	
220pF 500V	16
470pF 500V	6
1000pF 100V	6
2200pF 100V	6
4700pF 100V	6

RESISTORS

Metal Film 5% 1/3 Watt			
100R	680R	1K	1K2
2K2	4K7	5K6	6K8
10K	12K	15K	22K
27K	33K	39K	47K
56K	68K	82K	100K
120K	150K	180K	220K
270K	330K	390K	470K
560K	680K	820K	1M

2p

SKELETON PRESETS

	Pence
Horizontal	19
Vertical	19

LINEAR ICs

	Pence		Pence
741	18	NE5534	80
555	30	ZN414	90
556	65	ZN416	160
LM301	28	LM308	70
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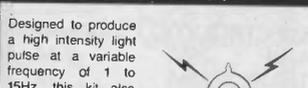


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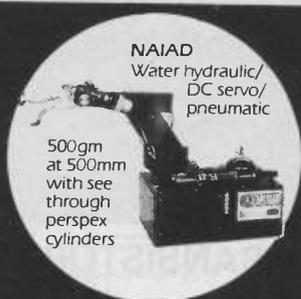
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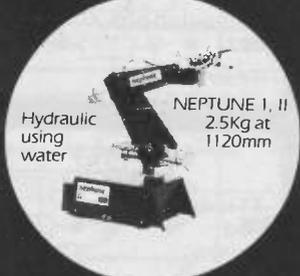
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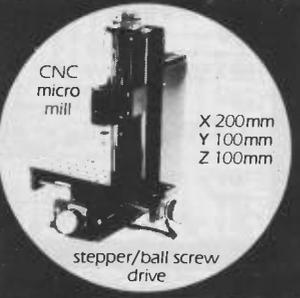
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DIGITAL AND ANALOGUE SIGNAL PROCESSING

PART ONE BY THE PROF

THE SEARCH FOR A CLEAN SIGNAL GOES ON

I suppose that in an ideal electronics world there would be no need for most types of signal processing, but in the real electronics world signals become polluted with noise of one sort or another, and some form of processing is needed to give an output that is reasonably faithful to the original. In the past this processing has mostly involved the manipulation of signals in their original analogue form, but more recently it has taken the form of digitizing the signal and then recovering the original signal (possibly after carrying out some digital manipulation). In this first article we will consider some of the standard forms of analogue signal processing, and in the second part we will take a look at digital processing. The two types of signal processing are perhaps not as clearly divided as one might expect, and some digital processing is analogous (or should that be digitus?) to established analogue processing. Also, it is not uncommon for circuits to use a mixture of analogue and digital signal processing.

NOISE ABATEMENT

Most signal processing is concerned with the reduction of noise of one kind or another, and this is often in the form of the all too familiar background 'hiss' that is generated by any linear circuit. All components generate a certain amount of noise, mainly due to random electron movement due to thermal agitation, and even the humble resistor can produce significant amounts of noise when really low signal levels are involved. Using special low noise components in low current circuits can minimise noise problems, but it will fail to abate them completely.

The most fundamental form of noise reduction is to apply some form of filtering to the output signal, and this is generally in the form of simple lowpass filtering. This works quite effectively, as although background 'hiss' is made up from signals over the entire audio spectrum, it is generally the high frequencies that are strongest and most

noticeable to human hearing. The obvious drawback of this method is that it is not only the noise that is attenuated by the filtering, for some of the wanted signal is diminished as well.

There is a way of avoiding this reduction in overall bandwidth, and this is to add complementary high frequency boost at the input of the system so that the lowpass filtering at the output does no more than compensate for this and give a frequency response that is flat overall. This is a common ploy which is used in both a.m. and f.m. broadcasting, as well as disc recording, etc. The treble boost is termed 'pre-emphasis', and the treble cut is called 'de-emphasis'. This system involves very little additional cost and complexity, but the increase in performance it provides is commensurate with this. Too much treble boost would result in signals with a strong high frequency content being clipped and severely distorted. Using only a moderate amount of treble boost avoids this, but permits only a limited amount of treble cut to be used at the output of the system with a correspondingly small amount of noise reduction.

DYNAMIC SYSTEMS

For larger amounts of noise reduction some form of dynamic system is required. In its most basic form this consists of a dynamic lowpass filter, as used in the Philips d.n.r. (dynamic noise reduction) system for example. The filter provides strong lowpass filtering under quiescent conditions, with typically a 12dB per octave roll-off above about 4 or 5kHz. However, as the signal level increases, so does the cutoff frequency of the filter. With the input at its maximum level the cutoff frequency is pushed up to something like the upper limit of the audio range.

This seems, on the face of it, unlikely to work well in practice, but surprisingly the shifting cutoff frequency of the filter is not apparent to the listener. Neither is the rise in background noise on medium and high level signals normally noticeable either, since the noise tends

Noise reduction touches most people as an essential part of hi-fi sound reproduction, but the techniques involved appear at several stages in the record/replay process, and can also be used for creating sound effects

to be masked by the signal. This can not be guaranteed, since strong bass signals will not effectively mask high frequency 'hiss', and there is a risk of the action of the circuit being clearly audible on awkward signals. This is usually counteracted by weighting the filter driver circuit so that it responds much more readily to high frequency signals than it does to low and medium frequency types. Strong low frequency signals then fail to lift the filtering significantly and are not accompanied by any noticeable increase in the noise level.

This method of noise reduction is less than hi-fi since there is some loss of the wanted signal during periods of low signal level. It still works quite well though, in that the full audio bandwidth (or something close to it) is provided on high level signals, so that it does not impair the impact of loud and strident passages of music. It is certainly much more effective than straightforward lowpass filtering, and it has the advantage of being a single-ended system. Dynamic noise reduction will therefore operate properly with any signal, and not just with one that has been suitably encoded. Units of this type have been described in previous issues of PE, and the circuitry involved is not something that will be dealt with here.

DYNAMIC DUOS

A double-ended noise reduction system, where the signal is processed at the input and then subjected to complementary processing at the output, offers better performance than a single-ended type, with no loss of frequency response at any volume level. Pre-emphasis and de-emphasis is in fact a double-ended system, but for the reason explained previously, this passive system offers only a limited improvement in performance.

Dynamic double-ended systems can provide massive improvements in signal to noise ratio. One of the best known, and one of the simplest, is the Dolby B noise reduction system. On playback this is similar to a d.n.r. unit in that it

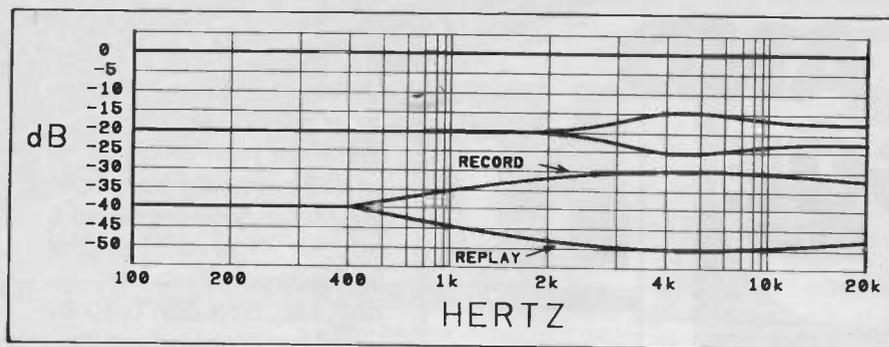


Fig.1. Typical Dolby B record/playback responses.

provides lowpass filtering which is steadily lifted as the dynamic level increases. The frequency responses are totally different though, and the Dolby B system starts to introduce the filtering at a relatively low frequency of about 500Hz. The roll-off rate is quite low though, and the maximum attenuation at high frequencies is only about 10dB. The lowpass filtering at the output is counteracted by dynamic highpass filtering at the input which gives about 10dB of high frequency boost at low signal levels, decreasing to zero boost at the maximum signal level. Fig.1 shows typical Dolby B recording/playback responses at three levels.

As there is no boost/cut at high dynamic levels, this system does not result in clipping if the signal contains strong high frequency components. It is used in addition to normal pre-emphasis/de-emphasis, and gives a weighted improvement in the signal to noise ratio of about 10 or 12dB. This is not a very large improvement, but it gives a large enough boost to cassette tape performance to raise this medium to true hi-fi standards, and can also be used to good effect with reel to reel tape machines. In fact Dolby B can be used to good effect on other mediums which suffer from 'hiss' type noise problems, and I believe it has been used by some f.m. radio stations in the U.S.A. Although the noise reduction it provides may not be very large, it has the advantage of giving acceptable results when Dolby B encoded material is played back through equipment which does not have a suitable decoder (preferably with the treble control backed-off slightly).

There is an integrated circuit which requires the addition of just a few discrete components in order to provide a fully working Dolby B encoder/decoder, but this is only available to suitably licensed equipment manufacturers. Incidentally, there is a Dolby A system, but this is a professional noise reduction system. This is rather more sophisticated than Dolby B in that the audio signal is split into four bands which are processed separately. This has the advantage of providing noise reduction over the full audio range instead of just at high frequencies, and Dolby A com-

bats any form of noise. It also means that the decoder will only lift the filtering in a particular band if there is a strong signal within that band, and this avoids having (say) a high frequency signal lift the low frequency filtering so that mains 'hum' or other low frequency noise becomes audible. Remember, the masking effect is only effective if the noise and signal to mask it are in similar frequency ranges, and at high signal levels there is no significant reduction in the noise level.

DOLBY C

In pursuit of greater performance an improved Dolby noise reduction system for consumer hi-fi equipment was developed and (not surprisingly) this is called Dolby C. In essence it is very much the same as the B system, and the signal is fed to what are effectively ordinary Dolby B encoders and decoders. However, these are augmented by additional encoder and decoder stages which provide increased boost and cut at low signal levels. At maximum boost the response starts to rise below 100Hz, reaching the maximum (+10dB) boost of the Dolby B system at 300Hz, and achieving about 20dB of boost at around 3kHz to 6kHz. The response then falls away somewhat, with the boost at the highest audio frequencies being no more than the +10dB of the Dolby B system.

The complementary cut during playback gives an effective improvement in the signal to noise ratio of around 20dB, which is some 8dB to 10dB better than Dolby B. Reasonable compatibility is achieved with the Dolby B system, but the larger amount of boost used during recording gives poorer compatibility with systems that lack either form of decoder.

COMPANDERS

So far we have only considered systems which process the signal using some form of frequency selective mechanism. This is not essential though, and a noise reduction system can operate over the entire audio band. This has the advantage of reducing any form of noise and not just high frequency 'hiss', and very large increases in the effective signal to noise ratio can be achieved. There is a disadvantage in processing the whole frequency range though, and this is fundamentally one of obtaining a fast enough response time.

With a non-frequency selective system the encoder is really just an ordinary compressor circuit, which boosts low level signals, but provides less and less gain as the input level is raised. Only unity voltage gain is provided at the peak signal level. The decoder is a volume expander, which provides reduced gain at low input levels, but has steadily increasing gain as the input level is raised. Again, unity voltage gain is provided at the peak signal level. This is generally achieved using an arrangement of the type outlined in Fig.2.

The input signal is fed to an amplifier, and some of the output signal is further amplified and then fed to a rectifier and smoothing circuit. In this demanding application a precision fullwave rectifier really is needed. The output from the smoothing circuit is used to drive a v.c.r. (voltage controlled resistor) which is connected in the feedback loop of the input amplifier. As the input level rises, so does the control voltage, giving increased feedback and reduced voltage gain from the input amplifier. On the output side of the noise generating process (which is not necessarily a tape recording system) there is a similar arrangement, but in this case a v.c.a. (voltage controlled amplifier) is used in the signal path, and fed with the control voltage. Increased input level therefore gives higher voltage gain, and produces the required volume expansion.

Overall there is no change in any dynamic level provided the characteristics of the compressor properly match those of the expander. In practice this matching is often achieved by having a voltage controlled amplifier which consists of an attenuator with a voltage controlled resistor as one element, feeding into a

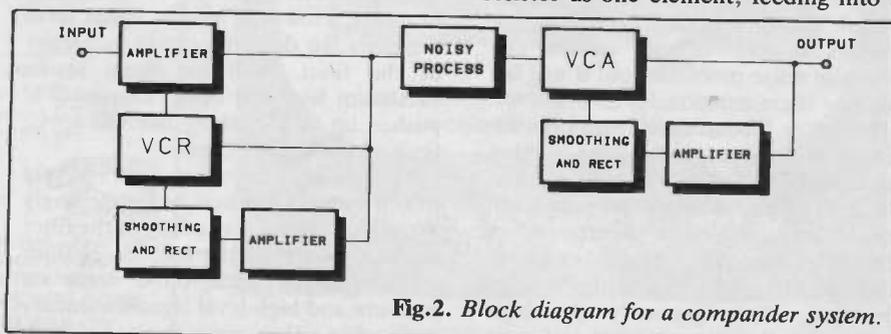


Fig.2. Block diagram for a compander system.

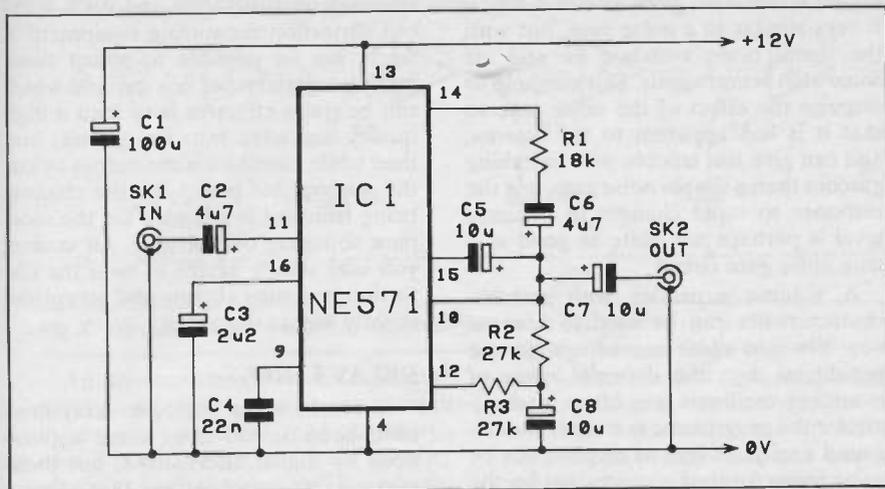


Fig.3. Basic NE570/571 compressor circuit.

voltage amplifier. The voltage controlled resistor is the same type as used in the compressor, as are the rectifier and smoothing circuit. With the two circuits built using the same basic circuit blocks they tend to provide naturally well matched characteristics.

The noise reduction is obtained due to the reduced gain of the expander when playing back low level signals. This reduces any system noise, but as with the frequency selective noise reduction systems, the unit has no effect on high level signals. It is therefore dependent on high level signals being able to properly mask any background noise. Systems which use this compression/expansion technique are often referred to as 'componders' incidentally.

With a system that only processes medium and (or) high frequencies there is no difficulty in using fast attack and decay times in the dynamic filter. To avoid generating significant amounts of distortion the gain must be varied during the course of several signal cycles, and must not simply jump rapidly from one level to another. At a medium frequency of (say) 1kHz, several cycles only represents a few milliseconds, which permits suitably fast response times to be adopted. With the entire audio range being processed the minimum input frequency will be in the region of 20Hz, and several cycles at such a low frequency obviously represents a much longer time of around 250 to 500 milliseconds. This can lead to problems with the system not responding fast enough to sudden and large changes in dynamic level, with signal clipping and other problems being produced as a result. Matters can be improved by using a rapid attack time with a slow decay time. This helps to avoid repeated and rapid changes in gain, while still enabling the unit to respond to sudden rises in dynamic level. It is not a complete solution though, since sudden falls in dynamic range will still leave the gain momentarily at the wrong level. This is heard as a brief burst of background

noise, or 'breathing' effects as these sounds are graphically and quite accurately termed.

Another problem is that the system is ineffective when processing strong low frequency sounds, again leading to noticeable background 'hiss' in many cases, and producing a form of 'breathing' effect.

DBX

Componder noise reduction systems have not achieved the same sort of success as frequency selective types, but there are systems which are based on this technique. The most popular of these are the DBX range of noise reduction units, and these are mostly based on a 2:1 compression/expansion characteristic. This simply means that any changes in dynamic level is halved by the compressor, and then doubled back to its original level by the expander. For example, a 20dB rise in dynamic level would be compressed to a 10dB change. The attraction of compander systems is the large effective amount of noise reduction that they provide. With a 2:1 expansion/compression characteristic the effective signal to noise ratio is doubled. By this I do not mean a 6dB improvement, but with (say) a 50dB signal to noise ratio being turned into a 100dB signal to noise ratio. In practice the improvement may not be as large as this because the compander might introduce noise that would slightly degrade performance, as might any piece of equipment to which the output signal is fed. However, in terms of signal to noise ratio it is still possible to achieve the sort of ratio generally only associated with compact disc players and other high quality digital equipment.

For the home constructor there is nothing difficult about building a compander system these days, and the NE570 or NE571 compander chip, plus a few discrete components are all that is needed. These two chips are basically the same, but the NE570 has a slightly higher specification with a typical

untrimmed distortion level of 0.3% (0.05% trimmed) as opposed to the 0.5% (0.1% trimmed) figure for the NE571. These devices are primarily intended for operation in telephone systems, but their specification is adequate for high quality audio applications.

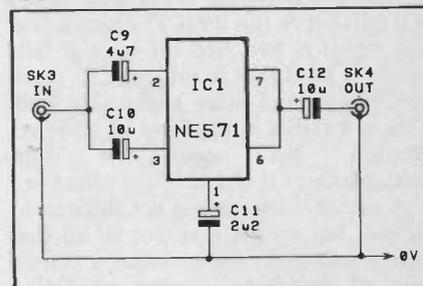


Fig.4. Basic NE570/571 expander circuit

The basic compressor and expander circuits are shown in Fig.3 and Fig.4 respectively. It is assumed here that one section of the device will be used as a compressor with the other section configured as an expander. However, the device contains two identical sets of circuit blocks and it can actually be configured as two compressors or two expanders. Both circuits are based on the general arrangement outlined in Fig.2 and described previously. The discrete components are mostly d.c. blocking and decoupling capacitors, with feedback resistors also being required in the case of the compressor circuit. C3 and C11 are the smoothing capacitors, and it is these that determine the response time of the system. Other values can be tried, but these two capacitors should both have the same value. A faster response time is certainly desirable, but a value of much less than 2µ2 is likely to generate significant amounts of distortion. In theory the expander should counteract any distortion produced by the compressor, but in reality the matching of the two circuits is unlikely to be accurate enough for this to work really well.

I have always found that NE570/571 companders provide excellent results when used with such things as analogue and digital delay lines, and other noisy electronic circuits. I have never tried a set up of this type with a tape recorder, although there is no obvious reason why it should not give quite good results. An advantage of this type of system is that it is not input level dependent, and the decoder should always expand the signal to the correct relative dynamic levels even if the output amplitude is substantially different from the original input level.

NOISE GATES

It is probably true to say that most noise gates are in fact volume expanders rather than true noise gates. This type of equipment is most commonly used in

electronic music where problems with high levels of background noise (especially mains 'hum') are not exactly unknown. It is a form of single-ended noise reduction unit, and with a true noise gate the signal passes through the unit unprocessed if it is above a certain threshold level, but is switched off (or at least attenuated by about 20dB or so) if it falls below this level. The idea is that the signal is switched off once it falls below a level that is sufficient to mask the background noise reasonably well. This is a rather crude form of noise reduction, but under the right circumstances it can be quite effective.

A simple noise gate is not difficult to devise, but results may not be all that one would wish. The problem is mainly one of switching glitches producing unwanted 'click' sounds as the gate switches off, and more particularly when it switches on. Just how noticeable or not these switching glitches happen to be depends on the switching threshold level and the characteristics of the input signal. Up-market designs avoid them by using sophisticated switching circuits that have zero crossing detection. With this system the signal is only switched on or off as it passes through zero volts, as in Fig.5(b), and in this way there is no sudden jump from zero to a high voltage (or vice versa), as in the waveform of Fig.5(a). It is these sudden jumps in voltage level that generate the 'click' sounds with simpler circuits.

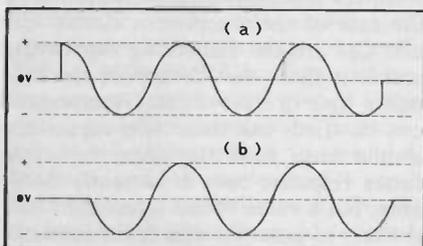


Fig.5. Asynchronous switching as in (a) produces switching "clicks". The zero crossing switching of (b) avoids these.

An expander can be designed to give a similar effect to a noise gate, and for this application it would ideally provide about 10dB to 20dB of expansion at low signal levels, with no changes in gain at

higher levels. This gives an effect which is very similar to a noise gate, but with the signal being switched on and off somewhat less abruptly. This can help to disguise the effect of the noise gate so that it is less apparent to the listener, and can give less trouble with switching glitches than a simple noise gate, but the response to rapid changes in dynamic level is perhaps not quite as good as a true noise gate circuit.

A volume expander with suitable characteristics can be used to breathe new life into older recordings. In the pre-digital days the dynamic range of recording mediums was often inadequate for the programme material, and the sound engineers had to combat this by using some form of compression on the signal. Otherwise quiet passages would disappear beneath the noise level. A volume expander can be used to counteract this compression, but it is not possible to cancel it out precisely as the compression characteristic is an unknown quantity. Quite good results are usually obtained if the expansion characteristic introduces the expansion very gradually as the input level is increased, and the amount of expansion is limited to about 10dB or 12dB. This can give more dramatic results on loud passages, and it effectively improves the signal to noise ratio of the signal by an amount which is equal to the overall level of expansion provided by the system.

The NE570/571 are suitable for use in an expander of this type, but the normal 2:1 characteristic provides what is likely to be about 50dB too much expansion. This is overcome using the slightly modified circuit of Fig.6. This has obvious similarities with the expander circuit described earlier, but it uses both sections of the NE570/571 in order to give stereo operation. Also, R1/R3 have been added to the expanders in order to reduce the amount of expansion provided to the required 10dB or so. Making these components a little lower in value gives reduced expansion, or making them higher in value boosts the amount of expansion.

The circuit includes distortion

trimming controls VR1 and VR2. Without distortion measuring equipment it might not be possible to adjust these really accurately, but one method which can be quite effective is to feed a high quality sine wave into the circuit, and then while monitoring the output by ear the appropriate preset for the channel being trimmed is adjusted for the most pure sounding output tone. Of course, you may simply prefer to omit the distortion trimming circuits and accept the slightly higher distortion.

DELAY LINES

In recent times analogue delay lines have been ousted from some applications by digital alternatives, but these are generally applications that require quite long delays (a few hundred milliseconds or more), and where shorter delays are required analogue types still represent the most cost effective solution. There are various types of analogue delay line, but by far the most popular these days are the so-called 'bucket brigade' devices, or 'charge coupled devices' (c.c.d.s) as they are more properly known. These can supply delays from under a millisecond to a few hundred milliseconds at comparatively low cost, and with what is in most cases a fairly high standard of performance.

Bucket brigade devices are based on a chain of charge storage capacitors, electronic switches, and buffer amplifiers. Fig.7 shows the general scheme of things, albeit in rather over-simplified form. Of course, in a practical circuit the switches are electronic types based on MOS transistors and controlled by a clock oscillator, and are not mechanical switches.

Initially, S1 connects C1 across the input, and it charges to the input potential. S1 is then switched to the opposite state (as does S2) so the charge voltage on C1 is passed on to C2. The buffer amplifier is essential in order to ensure that C2 is charged to the C1 potential. Without this stage the charge on one capacitor would flow into the other until they reached a state of equilibrium, which would not give satisfactory results.

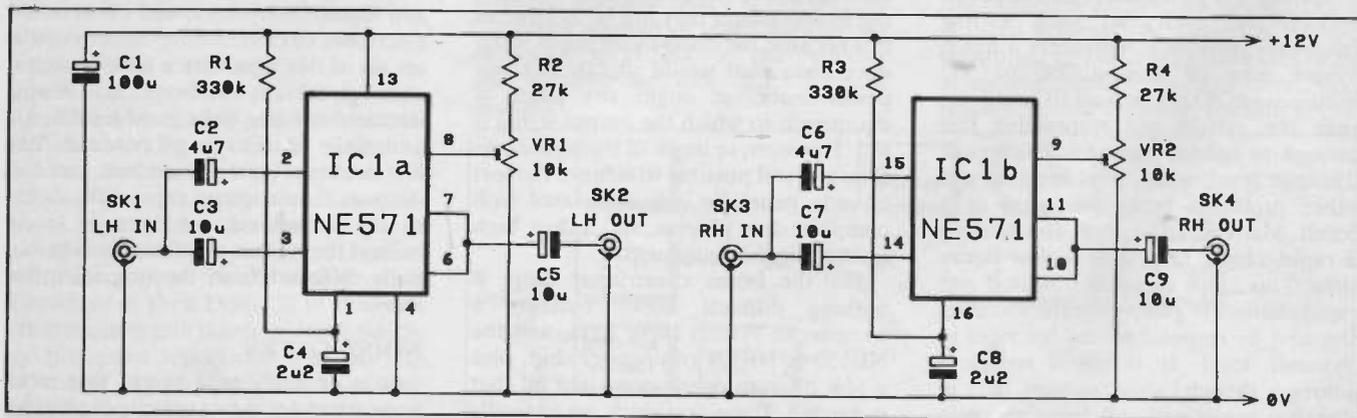


Fig.6. The stereo volume expander circuit diagram.

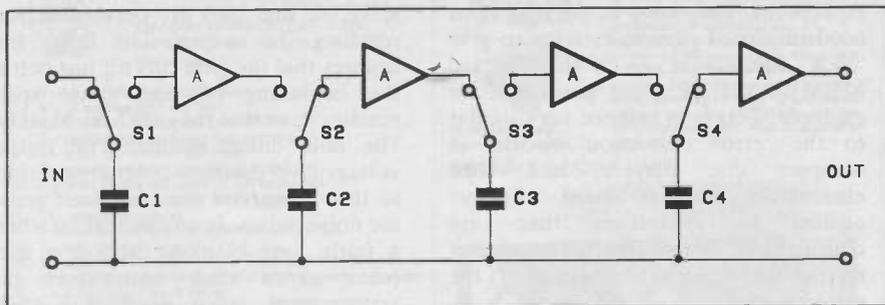


Fig.7. The basic system used in an analogue delay line.

All the switches now change state again so that C1 is once more charged to the input potential, and the charge on C2 is passed on to C3 via a buffer amplifier. Then the switches change state once more, with C1 passing on its charge to C2 again, and C3 passing on its charge to C4, and then to the output via a buffer amplifier. The action of the circuit is therefore to pass input samples down the chain of capacitors and eventually to the output. This is analogous to buckets of water being passed along a human chain, and it is from this that the 'bucket brigade' name is derived.

In Fig.7 only four stages are shown, but practical devices have a few hundred or even a few thousand stages. The odd numbered switches operate out-of-phase with the even numbered switches, and c.c.d. delay lines therefore require a two phase clock signal. There is no obvious reason why the circuitry to generate the second clock phase should not be built into the delay line chip, but I have yet to come across one which has this feature. The delay time depends on the number of stages and the frequency of the clock signal used to control the switches. It is equal to the number of stages divided by twice the clock frequency. One might expect the delay to be equal to the number of stages divided by the clock frequency (rather than double this frequency), but operation of the 'bucket brigade' system is such that a capacitor can not simultaneously receive and pass on a sample. This means that two stages are needed for each

sample that the delay line can hold. Incidentally, digital systems operate in a different way which does enable one sample per storage cell, and analogue systems consequently required twice as many stages for a given delay.

For the system to operate properly the clock frequency must be at least double the maximum input frequency, and preferably three or more times this frequency. Fairly obviously, at least a few samples per input cycle are needed if the output is to track the input signal fairly accurately. If the clock frequency is inadequate a severe form of distortion called 'aliasing' distortion results. Also fairly obviously, the output signal is a stepped waveform produced as the out-

put jumps from one sample level to another, and holds at each new level until its fresh sample is output. In fact the output waveform is a series of pulses, as shown in Fig.8(a), since there is a lack of output while the final capacitor is switched to receive the sample voltage from the penultimate stage. This signal can be fed through a high slope lowpass filter to integrate the pulses and give a proper audio output, but a large amount of filtering is needed in order to achieve satisfactory results. It is more usual for an extra stage to be included at the end of the delay line, and this is used to fill in the gaps and give a stepped output of the type shown in Fig.8(b). This places less stringent demands on the output filter, but it is still necessary in many cases to have a high slope (36dB per octave or more) type at the output of the circuit. Often a similar filter is needed at the input in order to restrict the bandwidth of the input signal and keep aliasing distortion down to an acceptable level.

The TDA1097 is a fairly typical c.c.d. delay line chip, and the basic circuit for this device is shown in Fig.9. At the input there is a potential divider circuit which biases the input of the device, and VR1 is adjusted to give optimum large signal

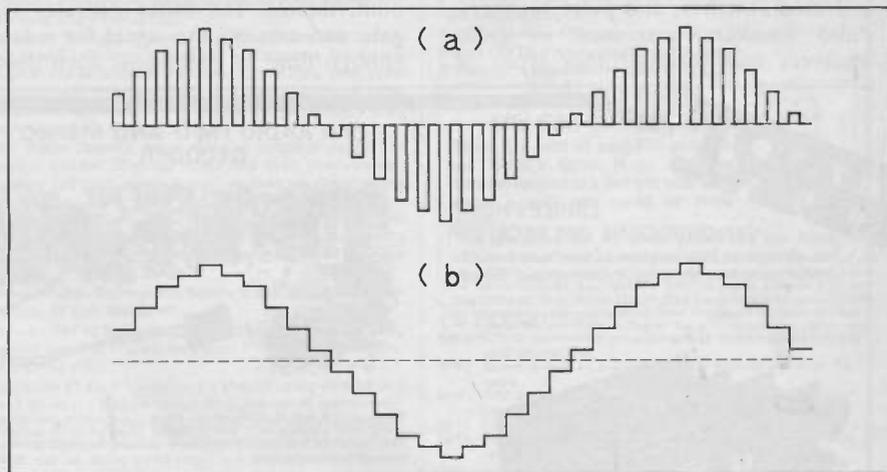


Fig.8. (a) Output from the final stage of the delay line, and (b) the stepped wave obtained by mixing the output from the last two stages.

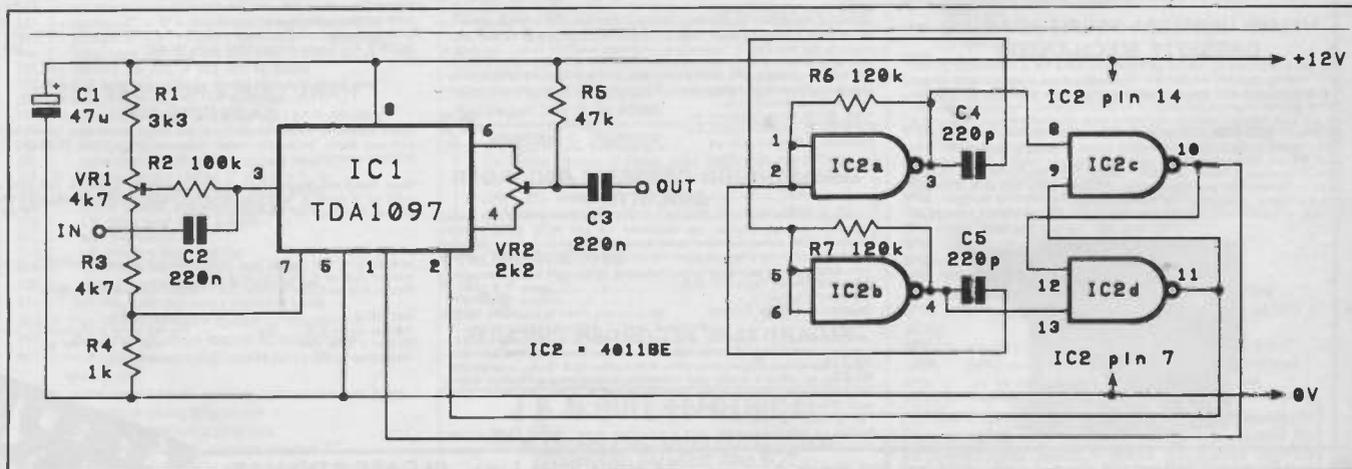


Fig.9. Basic TDA1097 delay line circuit.

handling capability. This circuit also provides a bias voltage for another input of the TDA1097. At the output VR2 acts as a passive mixer which combines the outputs of stages 1536 and 1537. Note that the latter simply fills in the gaps in the output signal and that there are only 1536 delaying stages. VR2 is adjusted for minimum clock breakthrough. R5 is just a load resistor for the output stages. Of course, input and output filters are needed, and the cutoff frequency of these must be tailored to suit the particular application of the device.

Delay line chips are often rather fussy about the characteristic of the clock signal, and in the case of the TDA1097 the two phases must accurately complement one another. This is achieved in this circuit using a simple CMOS astable circuit driving a set/reset flip/flop. Both circuits are formed from the gates of a CMOS quad two input NAND device. The specified values give a clock frequency of about 30kHz. This is sufficient for a bandwidth of 10kHz or so and gives a delay of approximately 26ms.

APPLICATIONS

Delay lines have numerous applications including musical effects, voice activated switches, and pulse blankers. Pulse blankers are used in radio receivers and various other types of

equipment. They have in the past been used in record players systems to give 'click' elimination, as in the Garrard MRM101 unit of some years ago for example. This is in essence very similar to the 'error correction' circuits in compact disc players, and click eliminators are far more effective against bad scratches than are conventional scratch filters. They do not restrict the audio bandwidth of the system either.

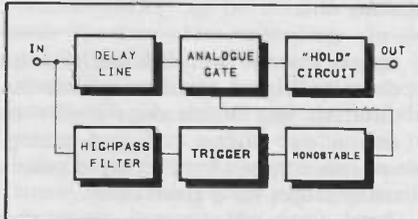


Fig.10. Basic arrangement for a pulse blander.

The block diagram of Fig.10 shows the basic requirement for pulse blanking. The delayed signal is fed to an analogue gate, and then to the output via a 'hold circuit'. The non-delayed signal is fed to a highpass filter which strips off the main signal to leave the noise pulses, and the latter are used to operate a trigger circuit which in turn activates a monostable multivibrator. The latter operates the gate and cuts off the signal for a long enough time to encompass each noise

spike, so that they are prevented from reaching the output. The delay line ensures that the gate cuts off just before the beginning of each noise spike reaches it, so that they are fully blanked. The 'hold' circuit maintains the output voltage level during the blanking periods so that the circuit does not itself generate noise pulses. In an application where a fairly long blanking period is used (such as a click eliminator) this arrangement might produce a slight audible glitch which sounds rather like a tape drop-out, but is still a great improvement on the 'clicks' and 'pops' of a damaged record. With a more sophisticated gating and 'hold' arrangement using zero crossing detection or some similar process the performance can be further improved.

A drawback of 'bucket brigade' devices which prevents them from being used in some potential applications is their inability to take in a signal and store it for playback some time later. Digital circuits are more suitable for this type of thing, and as we shall see next month, permit types of processing which are totally impractical with analogue techniques.

PE

Part two of Digital and Analogue Signal Processing will be in the PE August issue, on sale July 3rd.

HART

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INTERRUPTING THE BEEB

BY DAVID BERRY

... with a rotation-direction-position sensor, for example

The author explains the virtues of implementing interrupt-driven software through the VIA port, with hard conditioning of the position-sensor signals. Some alternative methods are touched on along the way

When it comes to hanging sensors onto the BBC micro the designers have provided a number of options. There is a four channel A/D converter, one port of a VIA with control lines, a 1MHz bus (which can most usefully address a second VIA) and a number of odd lines such as the "fire buttons" and light pen strobe. Unless you are really scratching, the most obvious interfaces to use will be the ADC or the user port of the VIA, depending on whether you have an analogue or digital application. In this article I shall describe how I hung a rotation-direction-position sensor onto the VIA and wrote interrupt driven software to process the incoming signals.

The user port is the "B" side of the user/printer VIA, the "A" side being buffered and used to drive the printer. CA1 and CA2 are also used by the system but the two CB lines are not. The VIA base address is Sheila &60 (i.e. &FE60). Anyone not familiar with 6522 VIAs should refer to the BBC Advanced User Guide (Bray, Dickens & Holmes), or to 6502 Assembly Language Processing (Leventhal).

VECTORS

On the software side, interrupt requests (IRQs) are vectored through two memory locations conveniently making interrupts available to us, the users. The priority vector is held in &204/5 and is the address of the system interrupt handler. Unless your program requires a priority over all the systems interrupts because of speed or hierarchy, it is best to stay well clear of this vector. Having said that, one time when you must use this vector is when trapping a system interrupt such as the 50Hz clock because the system interrupt handler, after dealing with the interrupt, clears it rather than passing it on to the secondary vector.

The secondary vector is held in &206/7 and is provided specifically for the user. The system routine jumps through this vector on exit so that the system always has priority. If the current interrupt is not one which the system has to deal with, it is passed on through the system interrupt handler untouched and so is available on exit, and hence can be dealt with by a user routine vectored to by the secondary vector.

Whichever vector is used the user interrupt handler should be written as a patch: the normal flow is diverted via the vector to the routine then on to the original vector content (address). This ensures correct resetting of the various interrupting devices.

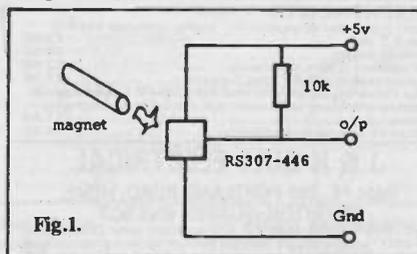
POLLING

But why use interrupts at all? Well, the alternative to interrupting is polling where the program goes back and looks at the input devices on a regular basis, such as each time an innermost loop is completed. The problem with that is that if the inputs are coming in faster than the loop cycles then some will be missed. Sometimes this doesn't matter; for example when you use the ADC you often only need to know its level at various stages in the program - you don't need to be flagged every time its level changes.

But where inputs are expected to occur only occasionally with long gaps between, a polling system can become a high time-overhead. Where inputs arrive in rapid succession, in random order, where they have priority or where the polling overhead is unacceptable, then interrupts should be used.

Actually the 6502 forces us to use a combination of interrupt and poll. This is because the processor only has one available interrupt request line (IRQ) so it alone cannot tell the processor which device is doing the interrupting - only that *some* device somewhere is interrupting. The user program then has to poll all the possible devices to find out which one it was.

From the software point of view writing interrupt systems is a little harder than writing polling routines, and the possibility of building in deeply devious bugs is far greater. My advice is keep the routines short and tremendously simple.



HARDWARE

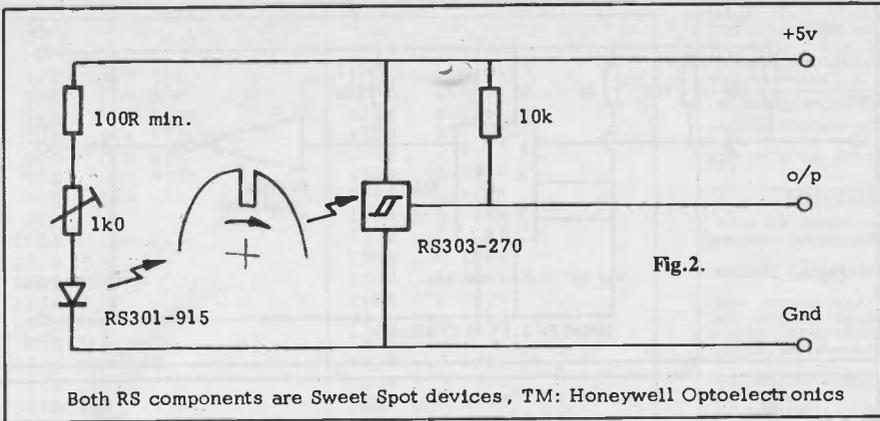
Time to look at a little hardware. Fig.1 shows a simple arrangement of a sensor supplied with current from the computer's supply and feeding its signal into the CB1 pin of the user VIA. I have drawn the sensor as a Hall effect device such as an RS 307-446, but it could equally well be optical or indeed a simple switch. The only constraint is that it must run on 5 volts and interface the single TTL load represented by the VIA pin. Schmitt devices are best because they cannot "dither" between the two states, but it depends on your application. Each time the magnet approaches the Hall effect device its output changes state; removing the magnet changes it back again.

SOFTWARE

The listing is of a program that covers both this simple case and the more complex case that I shall describe next. If you have no interest in the second case then you type the listing in *omitting the indented lines*. For the sake of clear understanding I shall refer to the entire listing as program 2 and the listing without the indented lines as program 1; that way we might all stay sane!

Program 1 is a program which will detect high to low transitions on the CB1 pin via the interrupt facility of the 6522 VIA. Note how complex it is for such a simple task. The VIA is configured to flag incoming pulses on CB1 as interrupts. Here I should point out that the choice of CB1 was arbitrary and that any of the other interrupting lines could have been used instead, or as well - if you have more sensors. (Lines 1340 to 1410, but note that line 1390 has to be entered as ORA £&88 - sorry, its the one obligatory gliche in my grand scheme!)

The low priority vector IRQ2VEC in &206 / &207 is changed to point to our service routine (Lines 1430 to 1510). Note also that in order to prevent interrupts occurring while this vector is being changed the entire interrupt system is disabled (by SEI) and later re-enabled (by CLI). Can you work out what the effect would be if this were not done?



occured. At that time its bit pattern will indicate which VIA facility or line has flagged the interrupt.

INTERRUPTION

The facilities and lines which can generate an interrupt are: CA2, CA1, Shift Register, CB2, CB1 Timer 2 and Timer 1. Clearing an interrupt is often accomplished by writing back to the IFR the value just read from it. The two books mentioned earlier both have excellent chapters covering this whole topic.

The second sensor is more complex. Here two narrow beam Schmitt output optical sensors detect slots in a rotating disc illuminated by narrow beam LEDs. Two sensors are used 90 degrees out of phase because then the number of slots need only be half that required by one sensor for the same resolution, and because this configuration can detect direction of rotation. The circuits are shown in Fig. 2.

At this stage, because of the increasing loads, a separate 5V supply is necessary. I also isolated the inputs from the computer with opto-isolators; of which more anon.

The two output signals are fed into the VIA. The direction line goes into a normal port input pin since I do not need to know instantly if the direction changes (so I do not need an interrupt) and the pulse (clock) line goes to PB6 which is the Timer 2 decrement line. Each time a negative pulse is detected on pin PB6, Timer 2 decrements and when it reaches zero an interrupt is flagged. This is a facility provided by the VIA.

Finally the service routine itself is written as concisely as possible and does nothing more than increment a multi-byte counter (Lines 400 to 1080). The reason for this is that interrupt routines have to fit timewise between incoming interrupts from all sources otherwise they will themselves be interrupted. This is possible (it's referred to as re-entrancy) but it's difficult to keep track of exactly what is happening, and difficulties we can do without!

In any case there is no need for an extensive routine. Once our system is running the counter will tick away nicely thank you, incrementing each time the magnet approaches the sensor. Basic, or any other language or code, can then access the counter and any further processing can be done there.

SERVICE RULES

There are rules to follow if your interrupt service routine is going to be successful. One is given above: make it short and fast. Another is that the processor registers should be stored at the start and recovered at the end of the routine. The reason for this may seem a little obscure. Remember though that an interrupt may occur while the routine

is running; if the routine is re-entrant then both it and previous interrupts will be handled correctly and all that saving and retrieval is necessary to ensure that following interrupts do not corrupt previous ones.

This simple sensor can be used for a number of things including rotation and translation of just about anything. I use both Hall effect and optical sensors in my burglar alarm (an excellent use for old Atoms) to detect doors and gates opening and movement of a fence under a man's weight.

One quick point to add here is that because the operating system uses interrupts, and because the interrupt vectors have been changed by our program, stopping the program running may involve a cold start (CTRL + BRK) to reset the vectors.

The 6522 VIA will allow up to six incoming pulses to be passed on as processor interrupts. These are controlled by two registers, the interrupt enable register (IER) and the interrupt flag register (IFR - called IXR in the program for obvious reasons). The first allows the programmer to decide which interrupts he will use and the second is valid for reading when an interrupt has

TRADE-OFF

An interesting point to consider is the trade-off between hardware and software. In this case I conditioned the signals from the two optical sensors using hardware - the XOR to double the

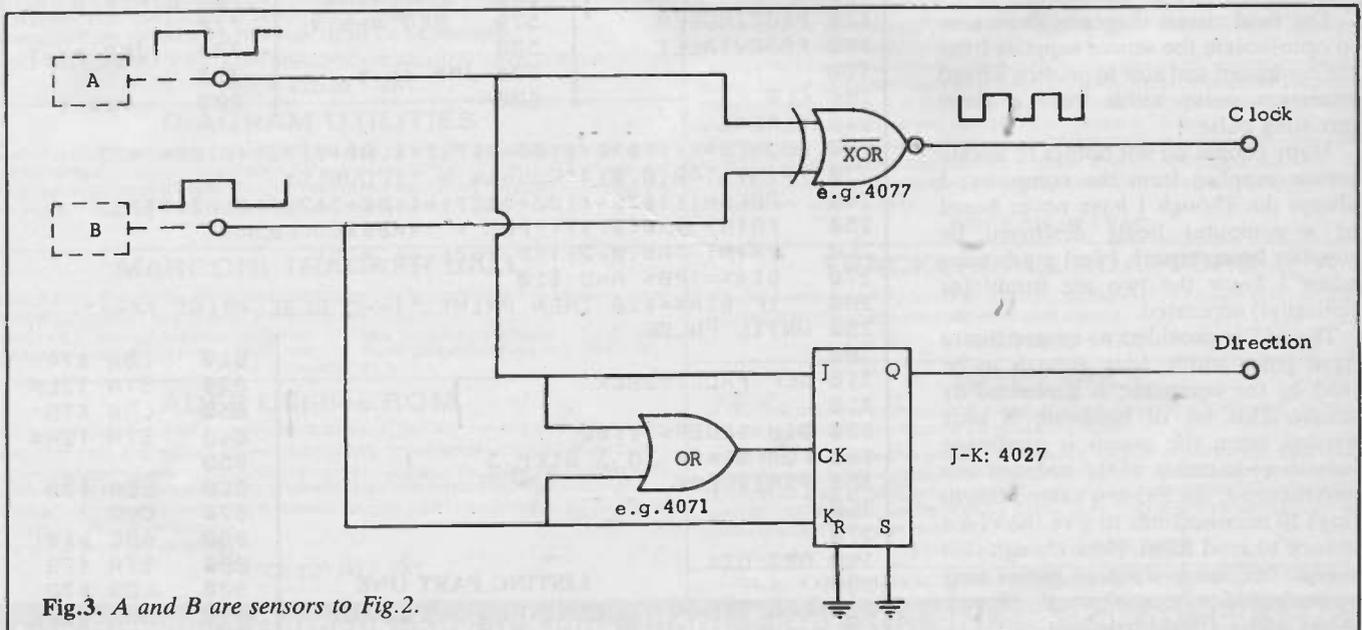


Fig. 3. A and B are sensors to Fig. 2.

INTERRUPTING THE BEEB

pulse rate and the j-k flip-flop to give me direction. But I could equally well have fed the raw sensor outputs into the VIA and written software to act as XOR or flip-flop. Why didn't I?

Well, the trade-off is between the cost of hardware plus the cost-time to get it going against the cost-time of writing and de-bugging the (more complex) software. Into the equation also goes the number of port interrupting lines used: one for the hard solution and two for the soft.

So why did I choose to do things that way? I suppose it was simple convenience; the hardware solution let me use the PB6/timer 2 which greatly helped the other aspects of the work and used an interrupt facility that may not otherwise have been used, thus freeing some other line. But both solutions are equally valid.

LONG LIST

Program 2, if you remember, is the entire listing including the indented lines and the change to line 1390. Program 2 will handle the direction/position sensor. The program is fundamentally the same as program 1 with just a couple of points to note: Timer 2 is configured to repeat. Each time it interrupts the counter value is reloaded and the countdown begins again. An alternative is to configure the counter as a one shot device. The other point is that Basic handles the direction indication by polling the VIA (lines 260 to 280).

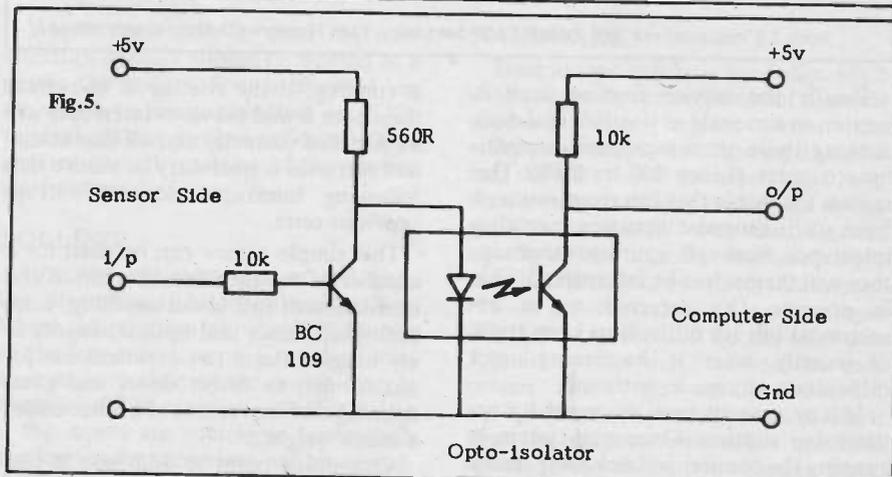
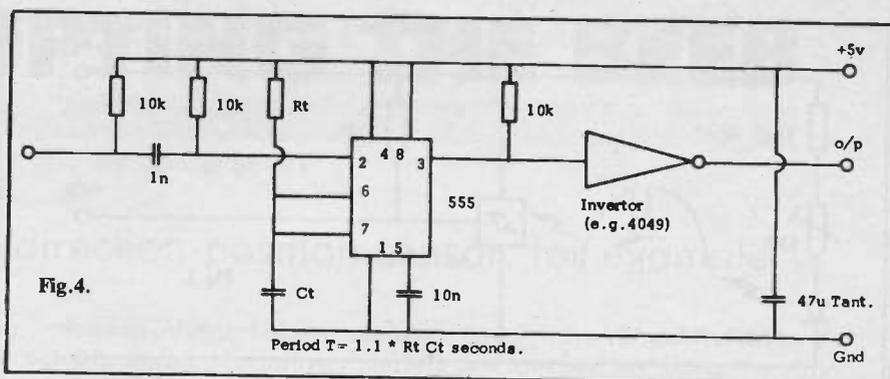
One thing the Advanced User Guide tells us is to avoid using OSBYTE and OSWORD calls when using interrupts because some of these routines use interrupts themselves and/or take a large amount of cycle time. Hence the direct addressing used in the programs, which will only cause problems if attempted across the tube.

IN ISOLATION

The final circuit diagrams show how to opto-isolate the sensor supplies from the computer, and how to provide a fixed minimum pulse width from a short incoming pulse.

Many people do not bother to isolate sensor supplies from the computer; I always do. Though I have never heard of a computer being destroyed by supplies being mixed, I feel much safer when I know the two are firmly (or optically!) separated.

The 555 is provided to ensure that a fixed pulse width, long enough to be read by the computer, is generated by sensor. This bit of hardware is only needed when the sensor is producing very short impulses of the order of one microsecond; the 555 can extend this to (say) 10 microseconds to give the VIA a chance to read them. Note though that a high frequency chain of pulses may cause the 555 to be continuously tripped; this is where I leave it to you.....



```

10 PCR%=&FE6C
20 IXR%=&FE6D
30 IER%=&FE6E
40 T2L%=&FE68
50 T2H%=&FE69
60 ACR%=&FE6B
70
80 PB%=&FE60
90 DDRB%=&FE62
100
110 !&70=0
120 ?&75=0
130 ?&74=10
140 !&76=0
150 ?DDR%=&0
160
170 PROCIRQSER
180 PROCVIASET
190
200 CLS
210 REPEAT
220 COUNTS%=(?&70*&100+?&71)*&100+?&72)*&100+?&73
230 PRINT TAB(0,0);"Counts = ";COUNTS%
240 PB6%=(?&76*&100+?&77)*&100+?&78)*&100+?&79
250 PRINT TAB(0,1);"PB6 = ";PB6%
260 PRINT TAB(0,2);"Direction = ";
270 DIR%=?PB% AND &20
280 IF DIR%=&20 THEN PRINT "(--" ELSE PRINT "(++)"
290 UNTIL FALSE
300
310 DEF PROCIRQSER
320
330 DIM IRQEP% &100
340 FOR OZ%=0 TO 3 STEP 3
350 P% =IRQEP%
360
370 ↑
380 OPT OZ%
390
400 LDA &FC
410 PHA
420 TXA
430 PHA
440 TYA
450 PHA
460
470 LDA IXR%
480
490 AND #&88
500 CMP #&88
510 BEQ cbtwo
520
530 LDA IXR%
540
550 AND #&A0
560 CMP #&A0
570 BEQ pbsix
580
590 JMP exit
600
610 .cbtwo
620 STA IXR%
630
640 LDA &73
650 CLC
660 ADC #&01
670 STA &73
680 LDA &72
690 ADC #&00
700 STA &72
710 LDA &71
720 ADC #&00
730 STA &71
740 LDA &70
750 ADC #&00
760 STA &70
770
780 JMP exit
790
800 .pbsix
810 LDA &74
820 STA T2L%
830 LDA &75
840 STA T2H%
850
860 LDA &79
870 CLC
880 ADC #&01
890 STA &79
900 LDA &78
910 ADC #&00
    
```

LISTING PART ONE
CONTINUED OVER PAGE

INTER interrupting THE BEEB

920 STA &78	1290 LDA ACR*
930 LDA &77	1300 ORA #&20
940 ADC #&200	1310 AND #&FD
950 STA &77	1320 STA ACR*
960 LDA &76	1330
970 ADC #&200	1340 LDA PCR*
980 STA &76	1350 AND #&3F
990	1360 STA PCR*
1000 .exit	1370
1010 PLA	1380 LDA IER*
1020 TAY	1390 ORA #&A8
1030 PLA	1400 STA IER*
1040 TAX	1410 STA IXR*
1050 PLA	1420
1060 STA &FC	1430 LDA &206
1070	1440 STA &1dV
1080 JMP (oldV)	1450 LDA &207
1090	1460 STA &1dV + 1
1100 .oldV	1470
1110 EQUW 0	1480 LDA #IRQEP* MOD 256
1120	1490 STA &206
1130 +	1500 LDA #IRQEP* DIV 256
1140	1510 STA &207
1150 NEXT	1520
1160 ENDPROC	1530 LDA &74
1170	1540 STA T2L*
1180 DEF PROCVIASET	1550 LDA &75
1190	1560 STA T2H*
1200 DIM VIAEP* &40	1570
1210 FOR OZ% = 0 TO 3 STEP 3	1580 CLI
1220 P% = VIAEP*	1590 RTS
1230	1600
1240 +	1610 +
1250 OPT OZ%	1620
1260	1630 NEXT
1270 SEI	1640 CALL VIAEP*
1280	1650 ENDPROC

LISTING PART TWO



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Flight Electronics' new 68000 development system is a serious tool which can be used both for learning about the 68000 μ P and for developing practical applications.

FLIGHT 68K REVIEW

BY ROBERT PENFOLD

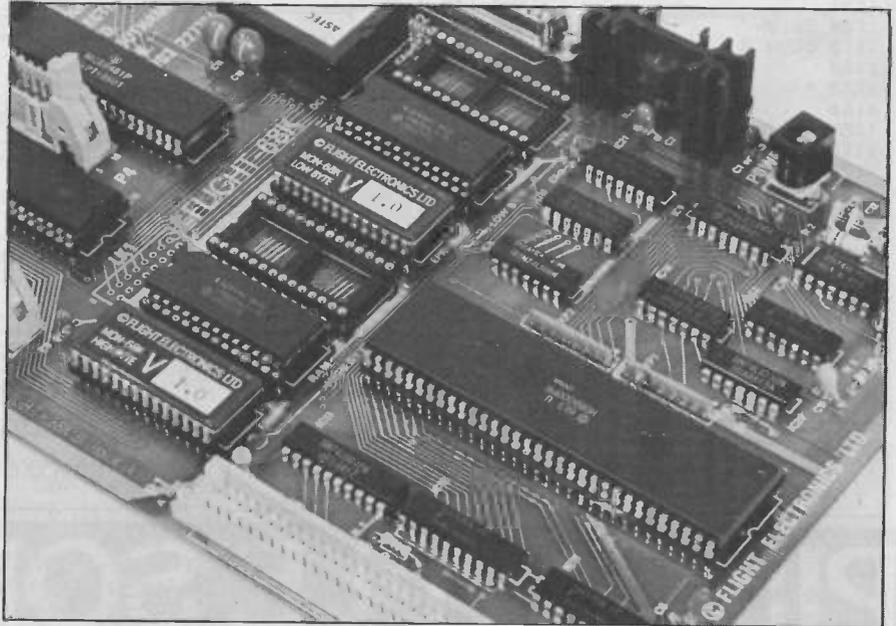
A NEW DEVELOPMENT SYSTEM
BASED ON THE MOTOROLA 68000

UNTIL recently there were numerous microprocessor development and teaching systems available, but currently there seems to be a very limited choice indeed. The reasons for this are debatable, but the general down-turn in the microcomputer business and competition from home-computers at throw-away prices almost certainly have something to do with it. Certainly most microprocessor development systems were left looking rather expensive when compared with many home computers, but they are really aimed at totally different markets, and development systems are never likely to achieve the mass sales of home computers, making production costs that much higher. Development systems are intended to familiarise the user with the hardware, interfacing techniques, and programming in a low level language. In other words, the aim is to take you through to the stage where you can design your own hardware and software for control applications rather than teaching you to become an expert programmer in BASIC, or at using an applications program such as a word processor.

This sort of hardware and programming skill is presumably the kind of ability that would appeal to many *Practical Electronics* readers, and the Flight 68K development system should therefore be of considerable interest. As its name implies, it is a system based on the Motorola 68000, which as most readers will be aware, is a very powerful 16 bit microprocessor having 32 bit internal registers and the ability to directly address up to 16M of memory. Basing the system on such a sophisticated microprocessor adds to the interest value of the unit, although it is debatable whether many control applications require such processing power.

HARDWARE

The Flight 68K unit is an uncased printed circuit board which measures about 220 x 155 millimetres. It requires a separate power supply (a mains adaptor provided as part of the system) and a computer or other form of terminal which is used to control the unit via an RS232C port. There is a second



serial port for use with a printer or other peripheral device. The unit is fitted with three further sockets which are a G64 expansion port, a 40 way connector which gives access to the input/output lines of a PIA/Timer device, and a 10 way connector which enables the auxiliary lines of the DUART (dual serial interface) chip to be used.

The board is dominated by the huge 64 pin 68000 microprocessor which operates at a clock speed of 8MHZ. There are six holders for 8k RAM/ROM/EPROM/EEPROM devices, and these must be 8 bit devices used in pairs. As supplied, two sockets are occupied with the monitor EPROMS, two are fitted with 6264 CMOS RAMS, and two are left free for expansion purposes. The other two devices of note are a 68681 DUART, and a 68230 parallel interface/timer. The unit is fitted with a reset switch, but apart from this it must be controlled via an external terminal unit, or by an on-board program in ROM chips of some description.

There are obviously several routes by which the unit can be connected to the outside world in order to control something and (or) read in data from external sensors. However, the main route is via the 68230 parallel interface/timer. This has similarities with the more familiar

6522 VIA chip as utilized in the BBC and VIC-20 computers amongst others, but it is a larger (48 pin) device, which apart from the usual 8 bit I/O ports plus handshake lines also has a multipurpose 8 bit port. The timer is a 24 bit type which can operate in a variety of modes. There is insufficient space available here for a detailed description of this device (the data sheet is actually an 80 page book), but this device clearly gives the unit considerable potential, which is augmented by the inclusion of the other expansion ports.

The board is a very high quality double-sided through-plated type which is populated with high caliber components from well known manufacturers. The whole unit is very tough and beautifully made, and should last a very long time even if it is not treated with the respect it deserves.

COMMUNICATION

Communication with the board requires a suitable terminal, which will usually be a microcomputer running a suitable terminal emulation program. The microcomputer must have an RS232 or compatible port, capable of running at one of the Baud rates supported by the board.

The terminal program must be capable of sending control codes to the board (i.e. ASCII values below 32), and some emulation programs designed for use with modems filter out these codes (except CR and LF), and so may not be usable if you want to make full use of the board. The terminal must be capable of displaying at least 40 columns.

Once everything is connected and switched on, and the terminal is active, the board must be allowed to adjust its baud rate to that used by the terminal. This it does automatically, and you must send a series of CRs to enable this. You will then see the signing-on message on the terminal screen.

THE MONITOR

You enter the monitor automatically when communication with the board is established. The signing-on message is followed by an F> prompt. There are 32 two-letter commands which may be entered at this prompt. Useful initial ones are TC which toggles between an 80 column and a 40 column display format, and HE (help) which lists all the commands and what they do.

The monitor has all the usual facilities to inspect and change memory locations, inspect and change registers etc. There are memory block move, copy and verify instructions, register display, and disassembly instructions. You can single-step or run programs, and there is an instruction to initialise the 68000 registers. Up to four breakpoints can be set within programs. There is a continue command which can be used after a break, but this cancels the breakpoint for future runs.

You can connect a printer direct to the port B of the board, and there are commands to enable and disable it. The enable command first checks to see if a printer is connected and active, so the monitor should not hang up because of a full printer buffer and no printer taking the data. In fact, the monitor has all the facilities you would expect to find.

It also has special facilities for programming EEPROMS. There are two sockets on the board for adding extra memory (you need two chips – for the high and low bytes of the memory words), and these can be used for EEPROMS. There are two of these commands. One is used to transfer data from outside into 5V EEPROMS, or to move the data within them. The other is used to move data from outside into 32-byte page write inverted data poll 5V EEPROMS.

If EEPROMS (or externally-programmed EPROMS) in the auxiliary memory sockets are used to contain application programs, the board can be used to run these programs without the terminal being present, so the board can be used as a stand-alone computer for control applications.

The monitor also has an assembler. As usual with monitors, this is one of the on-line direct type. This means each line of source code is assembled immediately as soon as it is entered. This is satisfactory for short routines, or for entering published programs, but is less satisfactory for developing longer programs as this type of assembler cannot by its nature provide any assistance with calculating the addresses and offsets for forward branches. For this you need a two or three pass assembler.

Flight Electronics can supply a cross-assembler for the BBC Microcomputer, but this was not included with the review board. Cross-assemblers for the 68000 series are also available for the IBM PC and compatibles, and many other computers, so there should be little difficulty in finding a suitable one.

The monitor assembler accepts standard Motorola mnemonics, and also a number of pseudo operations, for example to enter ASCII strings and data bytes.

If the printer is enabled during assembler entry only the assembler output is sent to the printer, to give a clean listing of the code. The input and any error messages appear only on the terminal.

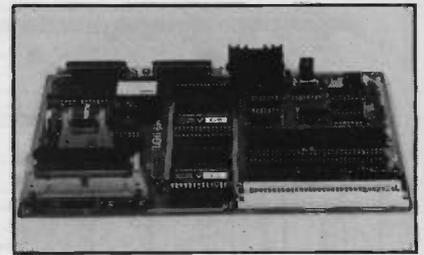
Object files in Motorola 'S' format can be loaded in two ways, either from the terminal, or from a host computer connected to port B on the board.

The manufacturers have largely succeeded in making the monitor 'user friendly', and it gives clear prompts for the next line to be entered where necessary. However, when entering values and addresses in Hex format, if a key other than the Hex digits, carriage return or delete is pressed, the entry is immediately discarded and you must begin again.

DOCUMENTATION

It would probably be something of an understatement to say that the unit is provided with comprehensive documentation. The main manual is around 250 pages long, and it includes an introduction to the system, getting started (connecting the unit to a terminal, printer, etc.), system description, monitor commands, and monitor system calls. There are further sections on addressing modes, a full description of the 68000 instruction set, operation of the main chips, details of the G64 interface, and even a circuit description.

There is a smaller book which gives the monitor program source listing, and then there are full data sheets (books?) for the 68000 MPU, 68681 DUART, and 68230 PI/T chips. There is also a programmer's reference card which is a convenient source for basic details of the 68000. Finally, there is a large colour chart which shows what's what on the printed circuit board and gives basic



details on the system. The latter may seem a bit trivial, but it is very useful indeed when you are first trying to get to grips with the unit, and it is a nice touch.

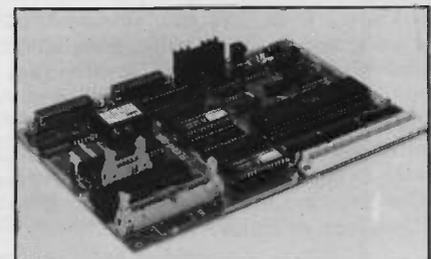
Everything you are ever likely to want to know about the system is included in the documentation, and unlike some systems I have encountered, there is no need to obtain data sheets and additional books before you can make full use of it.

CONCLUSION

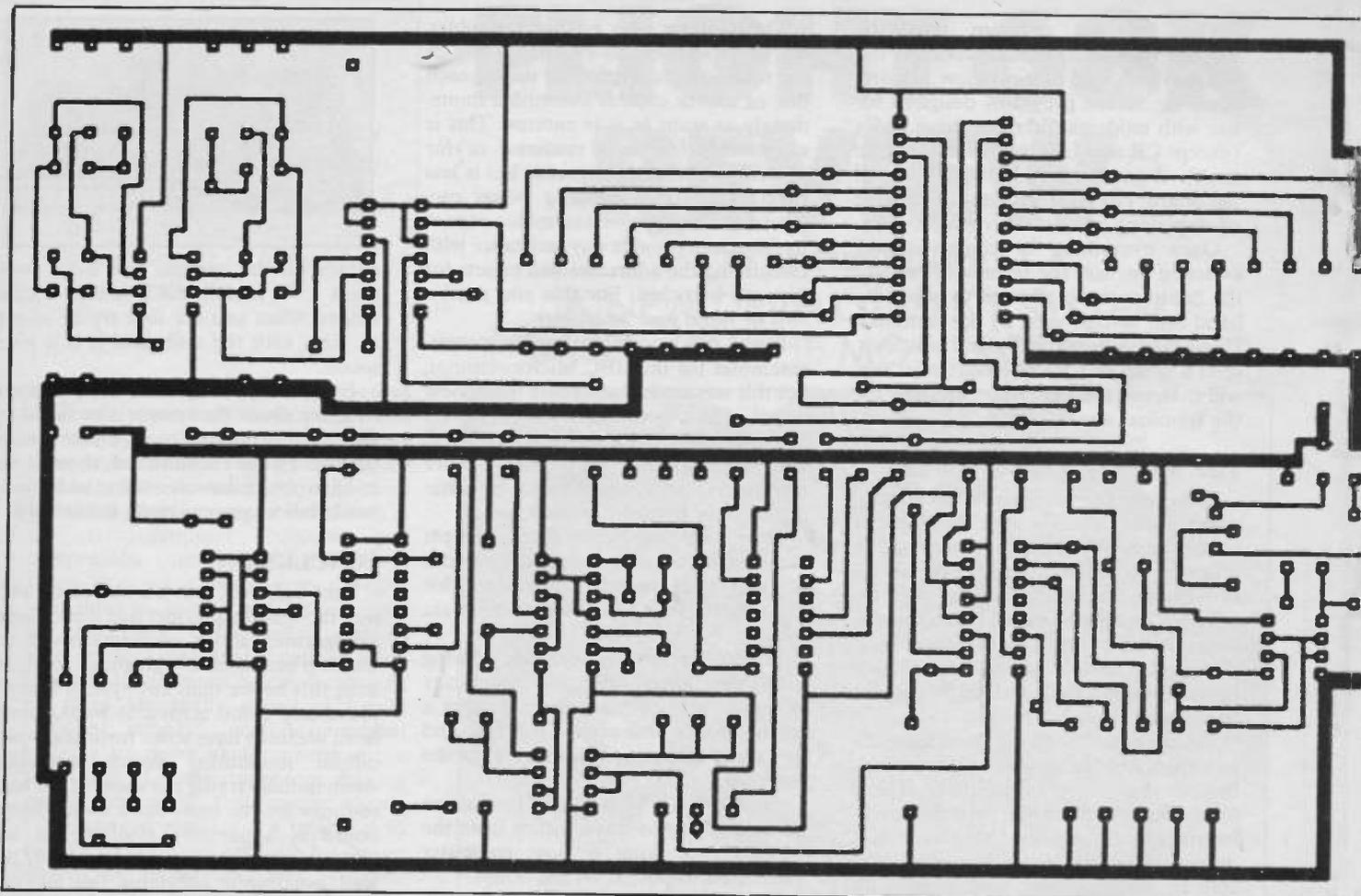
The Flight 68K unit is a well made and well thought out product that is excellent for learning about microprocessors at the chip and assembly language level. It does this better than any system I have previously come across. It would have been useful to have some form of simple output monitoring device available when initially trying out some of the test routines for the unit, but a switch/lamp board is apparently available as an optional extra, and it would probably be well worthwhile obtaining this add-on with the unit.

Many tutorial/development systems are really only suitable for learning purposes, and would be of little practical value in real control applications. The Flight 68k unit is not in this category, and could be used in earnest without too much difficulty once the user has mastered the system. The speed and power of the 8MHZ 68000 is such that the unit is capable of comfortably handling any likely applications. Against this there is the cost of the system to take into account, and it is inevitably more expensive than 8 bit alternatives. For someone looking for a unit of this type and who has a suitable terminal unit, or computer that can operate as the terminal unit, this unit is undoubtedly a worthwhile proposition at £395.

PE



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Ascupart Street, Southampton, S01 1LU.
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▲ *Word Generator. PE 147*

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(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.

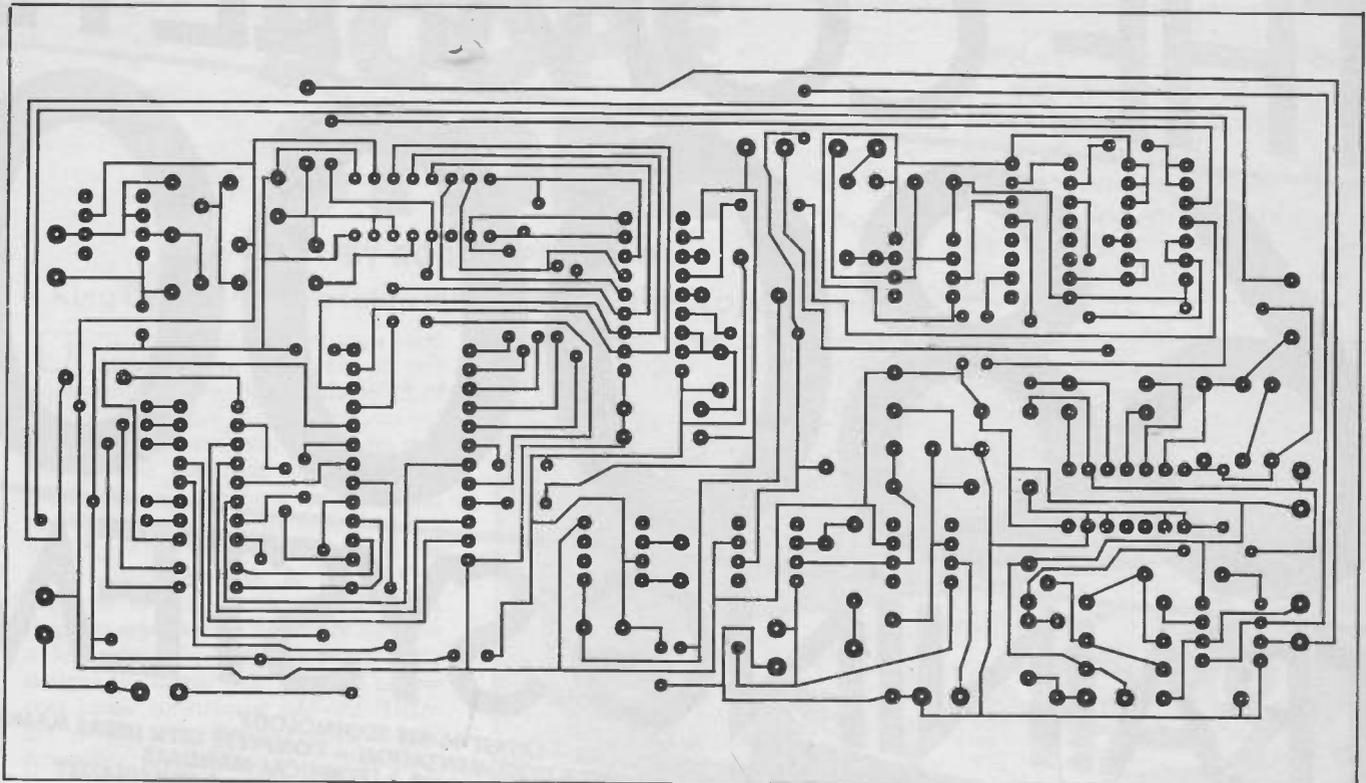
(PCB materials and chemicals are available from several sources – study advertisements.)

*** 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.

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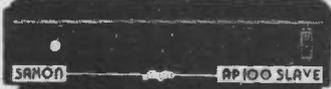


▲ Scope Store. PE 148

The Word Generator and Scope Store printed circuit boards are available through the PE PCB Service.

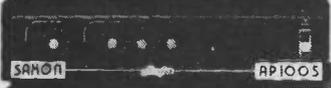
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SCOPE STORE

BY ROBERT PENFOLD

An all-hardware add-on digital storage unit for existing oscilloscopes, useful for audio frequencies, with a sampling rate in excess of 100,000

King Canute couldn't stop the waves, but the Scope Store can

UNTIL recently a digital storage oscilloscope was an item of test equipment that was beyond the reach of all but the better funded professional electronics laboratories. I suppose that this is still the case where a wide bandwidth instrument is involved, but the situation has greatly improved if a low frequency storage oscilloscope for audio frequency use is all that is required. Many users are only interested in audio applications, and there are then a few relatively low cost ready-made designs to choose from, as well as low cost home constructor add-ons. There are in fact two distinct types of low frequency digital storage oscilloscope; those instruments which are based on a home or personal computer, and those which are based on traditional oscilloscope techniques. The technique for storing and replaying the data is really much the same in both cases, and the main technical difference is whether the trace is produced in the tradition oscilloscope single sweep method, or using the scanning technique of a computer display.

The best route to take depends very much on what equipment you happen to have already, and technically there is little difference between the displayed results of the two systems. In practice the oscilloscope method often provides what appears to be a superior display quality, but this is almost certainly due mainly to the smaller screen size rather than any greatly superior resolution. The unit described here is an add-on storage unit for an oscilloscope, and this method was chosen largely because it was felt to be more convenient to have an add-on unit for a piece of existing test equipment, rather than to import a computer system into the workshop. This exclusively hardware method also avoids the need for loading software each time the system is used. It is also a system which has received comparatively little coverage in the technical press, and which deserves more attention. A home constructed digital storage unit can cost only a fraction as much as the oscilloscope with which it is used, but can disproportionately increase its usefulness.

STORAGE BASICS

Obviously much waveform analysis can be undertaken using an ordinary



oscilloscope without any real difficulty. Problems arise primarily when viewing non-repetitive waveforms, or repetitive but infrequent events. With an event which is a one-off and brief, all that the oscilloscope provides is (literally) a fleeting glimpse of the waveform. This may be sufficient to give meaningful information, but it does not permit detailed examination of the waveform and will often be of little or no practical value. With a brief and infrequently repeated event the situation is much the same. Things are slightly better with the waveform being flashed on the screen (say) every second or so, but without some form of storage mechanism this still gives a trace that is very dim and difficult to see.

Some oscilloscopes overcome the problem with the aid of a long persistence phosphor, or a special tube which causes the trace to hold on for a reasonable length of time. The digital approach is a purely electronic one in which the analogue input signal is sampled at regular intervals and stored in random access memory as a series of digital numbers which correspond to the sampled signal voltages. These values are then fed to a digital to analogue converter and sent to the oscilloscope as an analogue signal which closely resembles the original input signal. However, whereas the input signal might have been a one-off or infrequent event, the signal stored in RAM can be played

back into the oscilloscope many times per second. Thus the oscilloscope gives a bright and flicker-free image as it is displaying a repetitive waveform with a sweep frequency of 25 Hertz or more, and detailed examination of the signal is possible. It is even possible to amplify a small part of the waveform to permit a really detailed examination, although if this is done the resolution of the system is not necessarily adequate to show any more detail. The sampling rate must be much higher than the maximum input frequency if a reasonably faithful representation of the waveform is to be stored in RAM, and it is this factor that limits the performance of low cost systems. Inexpensive digital to analogue and analogue to digital converters are not capable of operating at a sample rate of much more than about 100000 per second. Also, very high sampling rates would require a very large amount of RAM to store even brief snatches of signal.

SYSTEM OPERATION

Although a scope store unit sounds very simple in theory, in a practical system everything must be carefully regulated by a control logic circuit if the system is to give usable results. The system must have separate store and playback modes so that a complete set of data can first be stored in RAM and then repeatedly sent to the oscilloscope. The store mode must be designed so that

SCOPE STORE

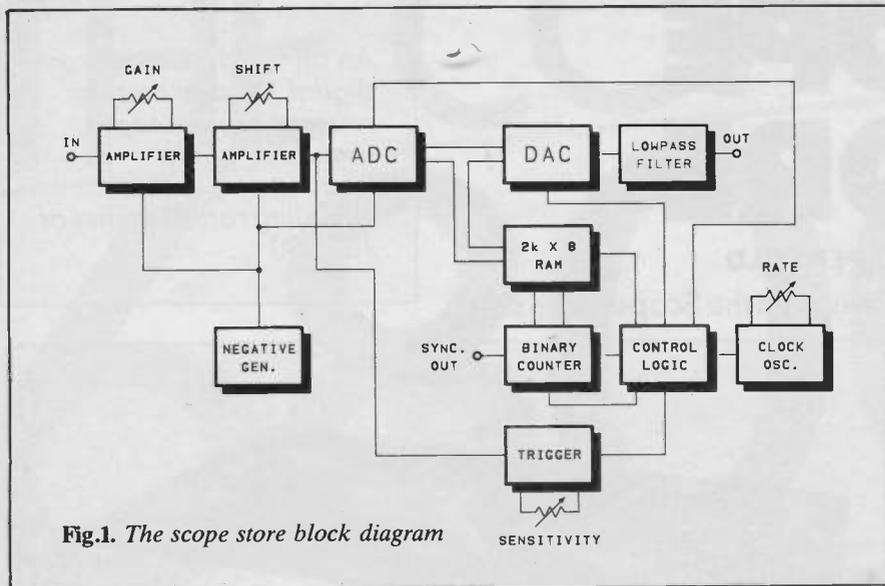


Fig.1. The scope store block diagram

it operates for precisely one complete RAM storage cycle, and some means of triggering is required. Manual triggering will suffice in some cases, but in most it is essential to have some form of automatically triggered sweep. In this case manual triggering and automatic triggering when the signal exceeds a certain (positive or negative) threshold voltage are provided. Fig.1 shows the general make-up of the unit in block diagram form.

At the input of the unit there is a voltage amplifier/buffer stage and a volume control style gain control. This is followed by a second amplifier which incorporates a preset Y shift control. These stages give the unit a maximum sensitivity of about 115 millivolts peak to peak into 100k to fully drive the unit. It is important that the input signal should fully drive or almost fully drive the analogue to digital converter (ADC) stage, as the vertical resolution of the system will otherwise, in effect, be greatly reduced. This would give a rather poor representation of the input signal on playback. The analogue to digital converter is a successive approximation type which is guaranteed to operate at something over 110000 samples per second, but which can in most cases be used at a substantially higher rate. In practice the full speed of the converter can not be used as a certain amount of time is taken up when the converted values are stored in RAM. However, even around 100000 samples per second is adequate for audio frequency digitizing and the unit can achieve at least this sort of rate.

The two input amplifiers are standard d.c. coupled operational amplifier designs which require a negative supply rail. The analogue to digital converter also requires a negative supply for the 'tail' resistor in its comparator stage. The unit is designed to operate from a single +5 volt supply rail. Many modern oscilloscopes, such as the author's

Crotech 3132, have various supply outputs for accessories, including a +5 volt type. These can generally supply currents of up to about 1 amp, which is around twenty times the current requirement of this unit. A few oscilloscopes can provide a negative supply rail, but the scope store incorporates a negative supply generator so that it can be powered from instruments that do not have such a facility. If the unit is used with an oscilloscope that does not have a suitable power supply output, then it must either be fitted with a 5 volt regulated mains power supply, or it can be powered from four nickel cadmium cells wired in series.

On the output side of the unit a digital to analogue converter reconstitutes the analogue signal from the digital information and it feeds the output socket via a lowpass filter. The output signal is a stepped waveform, since the signal jumps almost instantly from one sample level to the next, and it does not vary continuously like the analogue input signal. The lowpass filter attenuates signals above the upper limit of the audio range, and this tends to smooth out the steps to some degree so that the output signal is a slightly more accurate representation of the original. With a resolution of 2048 by 256 the unit gives no obvious sign of stepping on the average oscilloscope display anyway. The input signal must have its bandwidth limited to a fraction of the sampling frequency, but normally it will have no significant content outside the audio range anyway. However, a certain amount of lowpass filtering is built into the input amplifiers.

The input samples must be stored in RAM, and a 16K static RAM organised as 2K by 8 bits is used for this purpose. This has its address bus provided by a multi-stage binary counter, and the latter is driven by a clock oscillator via the control logic circuit.

If we consider the action of the unit

in the store mode first, the control logic circuit can either be triggered by operating a push button switch, or automatically by a trigger circuit which detects when the output of the second amplifier stage exceeds a certain level. The circuit will be triggered by either a positive or a negative signal peak above the threshold level. Once activated, the control logic circuit enables clock pulses to be fed through to the binary counter. It provides a divider action though, and several clock pulses are needed per increment of the counter. The control logic circuit provides control pulses to other parts of the circuit on clock cycles when it is not incrementing the counter.

Taking the operation of the unit on one complete store cycle, the first clock cycle results in a 'start conversion pulse' being sent to the analogue to digital converter. On the next pulse the output of the RAM is enabled and the digital to analogue converter is activated, but this is not of any real importance in the store mode. Nothing happens on the next clock cycle which is merely included as a null cycle to give the analogue to digital converter more time to complete the current conversion. On the next cycle the outputs of the analogue to digital converter are activated, and the RAM is set to the 'read' mode. The 8 bit value from the converter is therefore stored at the current memory address. The next clock pulse increments the binary counter and takes the RAM onto the next address, and on the following clock cycle the whole process is taken back to the beginning with a new start conversion pulse being produced.

This action continues until every RAM location has been fed with an input sample value. An output of the binary counter then goes high, and this sets the control logic circuit back to its original stand-by state.

The action of the circuit is very similar in the playback mode, and it differs in only two respects. The most important one is that the pulses which formerly enabled the outputs of the analogue to digital converter and set the RAM to the 'read' mode are blocked. The contents of the RAM are therefore protected and are not overwritten. The RAM outputs and the digital to analogue converter are activated during each set of clock cycles, and this reads the RAM contents to the output as a reconstituted analogue signal. On the face of it there is a flaw here in that the output signal is only provided by the unit for one clock cycle in each set of five. However, the digital to analogue converter has a built-in eight bit data latch, and it therefore provides a continuous output without any need to resort to an external latch or sample and hold circuit.

The second respect in which the playback mode is different is that the

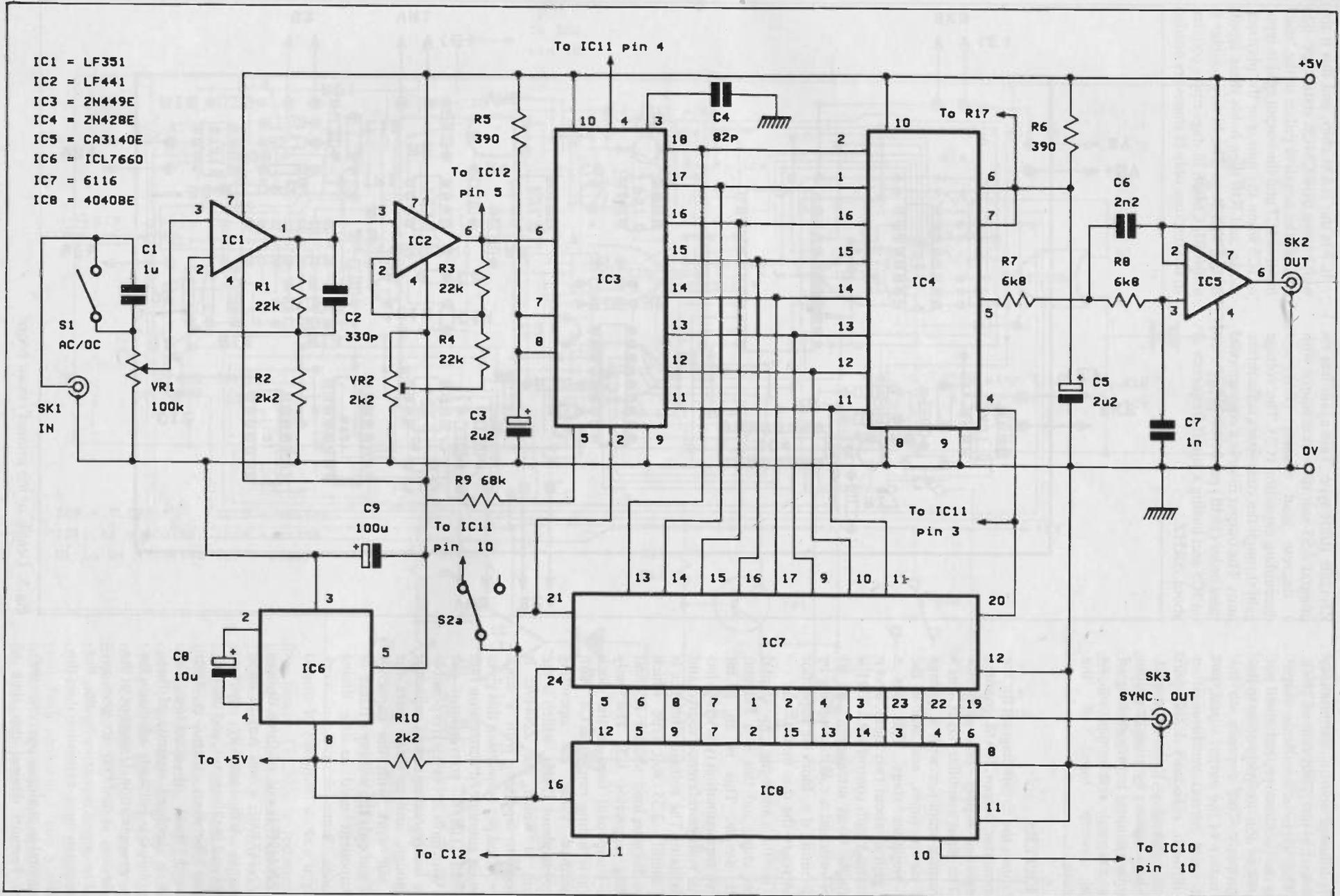


Fig.2. The circuit diagram for the input, converter, RAM, counter and supply generator stages

SCOPE STORE

circuit is allowed to run continuously rather than for just 2048 sets of clock cycles. This gives a continuous output signal to the oscilloscope, but it will not necessarily be able to synchronise to this signal properly. This depends on the precise nature of the output signal, but in most cases correct synchronisation will be difficult, especially if only part of the data stream is to be examined. This can be overcome by using an output of the binary counter to provide a signal for the external synchronisation or triggered sweep input of the oscilloscope.

CONVERTERS

Fig. 2 shows the circuit diagram for the input, converter, output, RAM, counter, and negative supply rail generator stages. The input amplifier has IC1 as a non-inverting amplifier with a voltage gain of eleven times, and IC2 is the second amplifier stage. This has a voltage gain of about two times, and it incorporates Y shift control VR2. VR1 is the variable input attenuator, and S1 provides switched a.c./d.c. coupling by short circuiting d.c. blocking capacitor C1 when set to the d.c. mode.

IC2 is the analogue to digital converter chip, and this is a Ferranti ZN449E device. This is an 8 bit successive approximation type which has a built-in voltage reference source and clock oscillator. The voltage reference is a high quality 2.55 volt type which requires discrete load resistor R5 and decoupling capacitor C3. The only discrete component used in the clock oscillator is timing capacitor C4. With the specified value the operating frequency is about 1MHz, which is the maximum at which the ZN449E is guaranteed to operate. With 9 clock cycles required per conversion this gives a maximum guaranteed conversion rate of around 11000 conversions per second. With most ZN449Es it is possible to use a much smaller timing capacitor value though, and in some cases the device will work with the capacitor omitted and only the self capacitance of the component used as the timing capacitance. Some devices will work properly at a clock frequency of around 2MHz.

The ZN449E is one of three devices in the ZN447/8/9E series. Any of these components will actually operate perfectly well in this circuit, and the only difference between them is their guaranteed level of accuracy. The ZN449E is the least accurate of these devices, but it is perfectly adequate for the present application. Using one of the other devices is unlikely to give any noticeable improvement in results, but they are much more expensive than the ZN449E.

The digital to analogue converter uses another Ferranti device; this time a

ZN428E R/2R type. This again has an integral 2.55 volt reference source with a discrete load resistor (R6) and decoupling capacitor (C5). The voltage gain through the converters is therefore unity. The output filter is a conventional third order (18dB) per octave type based on IC5 and having a cutoff frequency at about 20kHz.

IC7 is the RAM chip, and this is the well known 6116 CMOS static type. S2a cuts off the negative pulses to the 'read' input of IC7 and the output enable input of IC3 when the unit is in the playback mode, and R10 then holds these inputs in the high state. The binary counter is a 4040BE CMOS 12 stage ripple counter. In this instance only 11 stages are needed

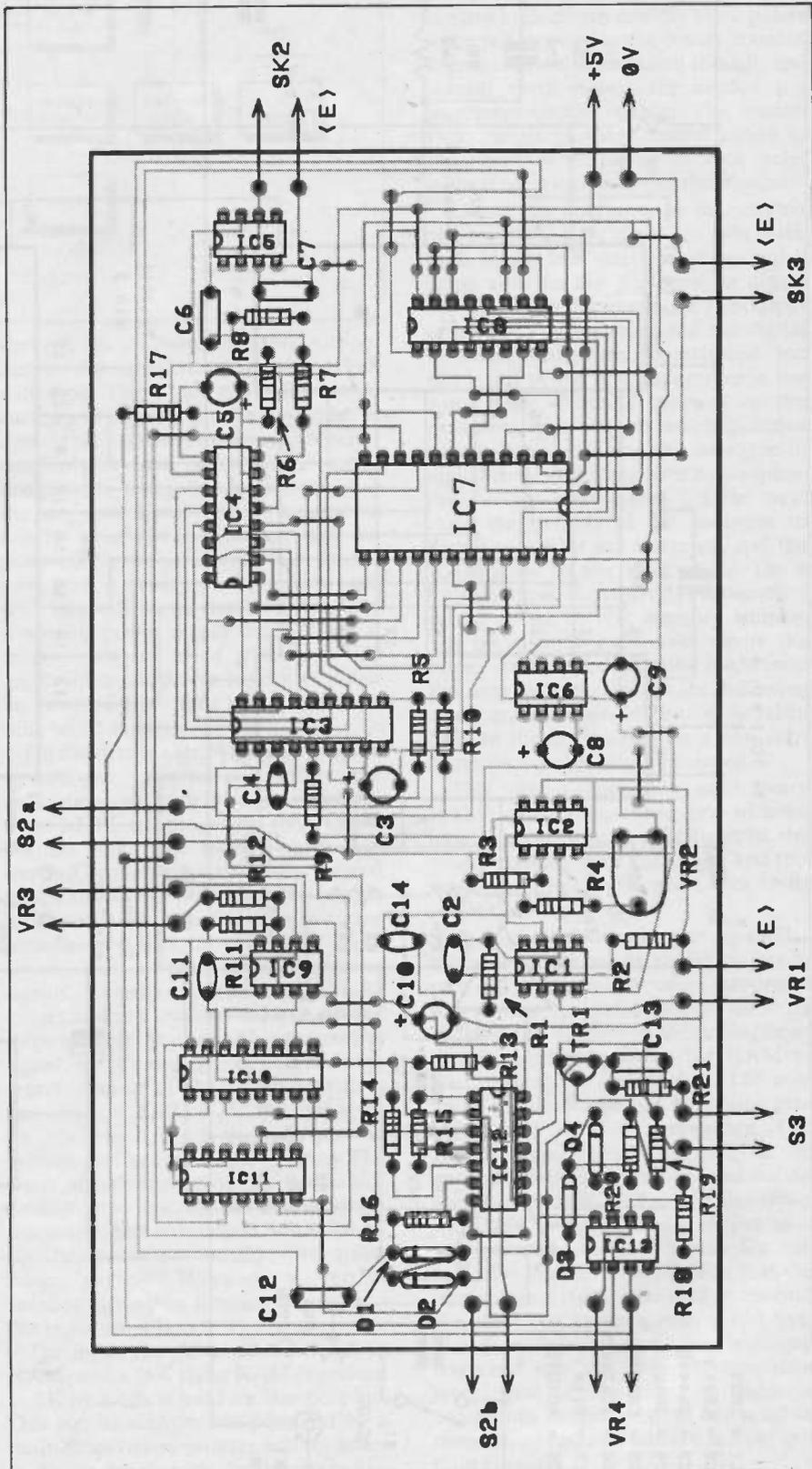


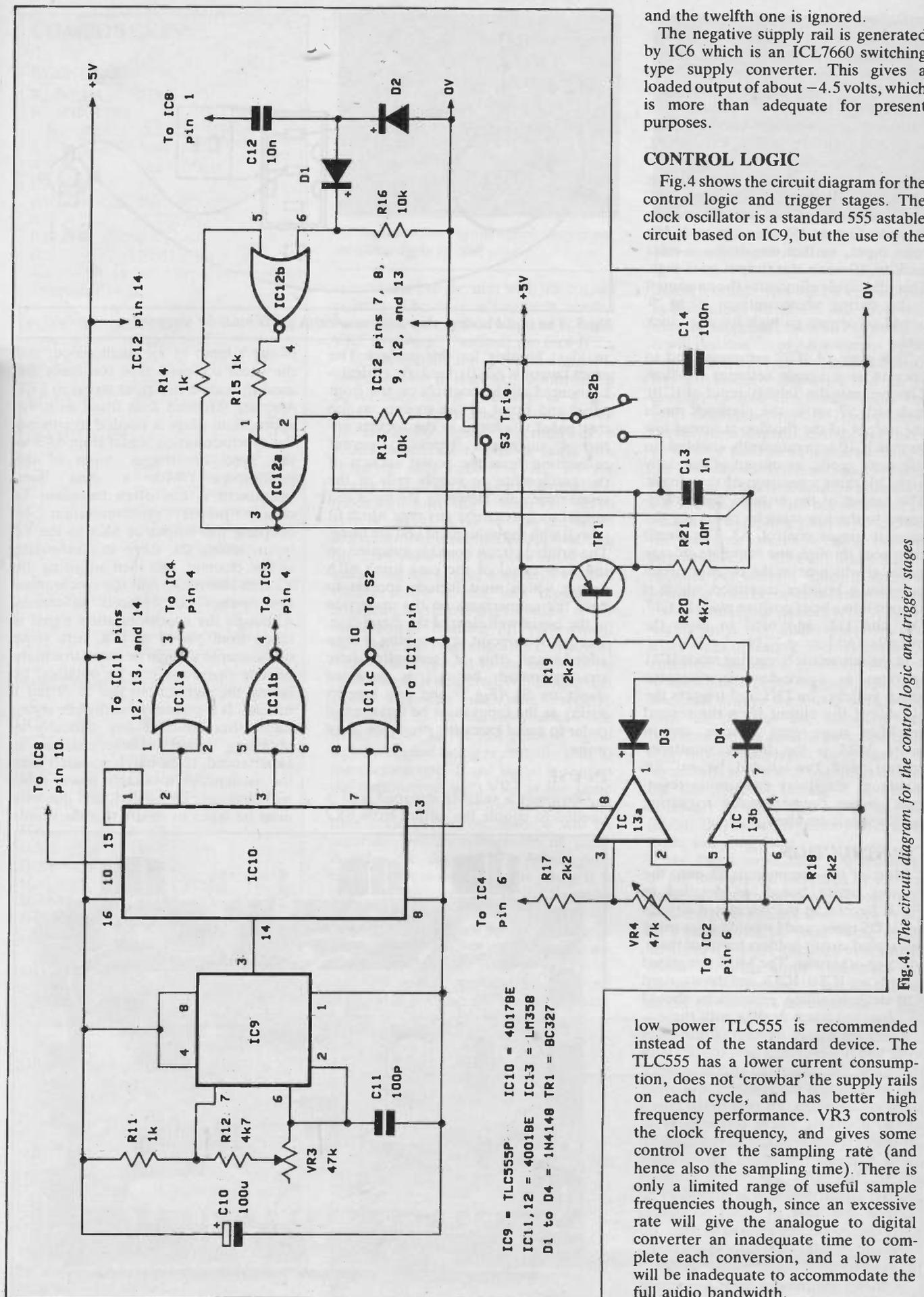
Fig. 3. Details of the printed circuit board

and the twelfth one is ignored.

The negative supply rail is generated by IC6 which is an ICL7660 switching type supply converter. This gives a loaded output of about -4.5 volts, which is more than adequate for present purposes.

CONTROL LOGIC

Fig. 4 shows the circuit diagram for the control logic and trigger stages. The clock oscillator is a standard 555 astable circuit based on IC9, but the use of the



- IC9 = TLC555P IC10 = 40178E
- IC11, 12 = 40018E IC13 = LM358
- D1 to D4 = 1N4148 TR1 = BC327

Fig.4. The circuit diagram for the control logic and trigger stages

low power TLC555 is recommended instead of the standard device. The TLC555 has a lower current consumption, does not 'crowbar' the supply rails on each cycle, and has better high frequency performance. VR3 controls the clock frequency, and gives some control over the sampling rate (and hence also the sampling time). There is only a limited range of useful sample frequencies though, since an excessive rate will give the analogue to digital converter an inadequate time to complete each conversion, and a low rate will be inadequate to accommodate the full audio bandwidth.

IC10 is at the heart of the control logic circuit, and this is a CMOS 4017BE one of ten decoder. Output '0' is inverted by IC11b and used to provide the 'start conversion' pulses, output '1' is inverted by IC11a and provides the enable pulses to the digital to analogue converter and the RAM, and output '2' is left unused. IC11c inverts output '3' to give the negative enable pulses to the analogue to digital converter, while output '4' supplies clock pulses to the binary counter. Output '5' connects to IC10's reset input, so that the device is reset back to '0' when this output goes high. This effectively eliminates the unwanted cycles during which outputs '5' to '9' would otherwise go high for one clock cycle.

Two gates of IC12 are connected to operate as a simple set/reset flip/flop. This controls the 'inhibit' input of IC10, and with S2 set to the playback mode the output of the flip/flop is forced low so that IC10 is permanently enabled. In the store mode its output is normally high, blocking operation of the circuit. The output of the bistable can be triggered to the low state by operating the manual trigger control, S3. The circuit then goes through one complete storage cycle, at which point the counter circuit provides a positive transition which is shaped into a brief positive pulse by C1, D1, and D2, and used to reset the bistable and inhibit IC10.

In the automatic triggering mode IC11 operates as a window discriminator which switches on TR1 and triggers the bistable if the output from the second amplifier stage goes outside certain limits. VR4 is the trigger sensitivity control, and this should be set for minimum sensitivity (maximum resistance) when the automatic triggering facility is not required.

CONSTRUCTION

Most of the components fit onto the printed circuit board, as detailed in Fig.3. Several of the integrated circuits are MOS types, and I would advise using integrated circuit holders for all of them, MOS or otherwise. The MOS integrated circuits are IC5 to IC12, and the standard anti-static handling precautions should be observed when dealing with these.

There are a large number of link wires to fit and it is probably best to start with these and the integrated circuit holders, and to then add the resistors and other small components. Fit pins to the board at the positions where connections to off-board components will eventually be made. Construction in the main is quite simple, but with any fairly intricate printed circuit board it is necessary to exercise due care to avoid accidental short circuits between tracks or pads. Be especially careful where tracks are taken between the pads of integrated circuits.

A metal instrument case measuring about 200 by 140 by 70 millimetres makes

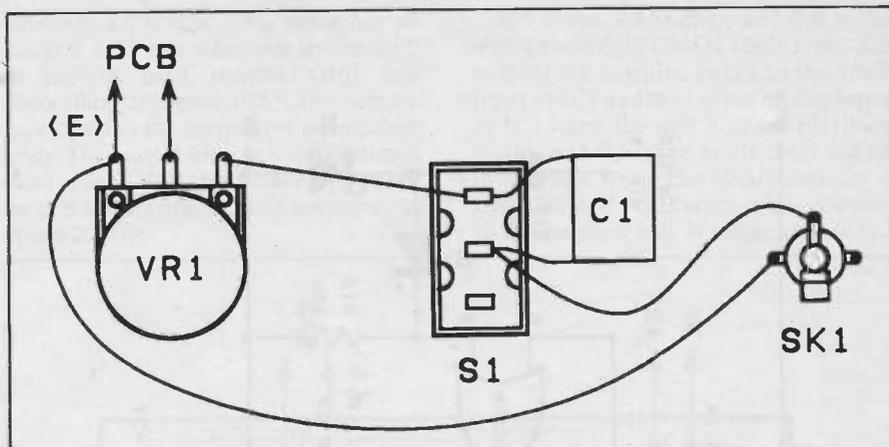


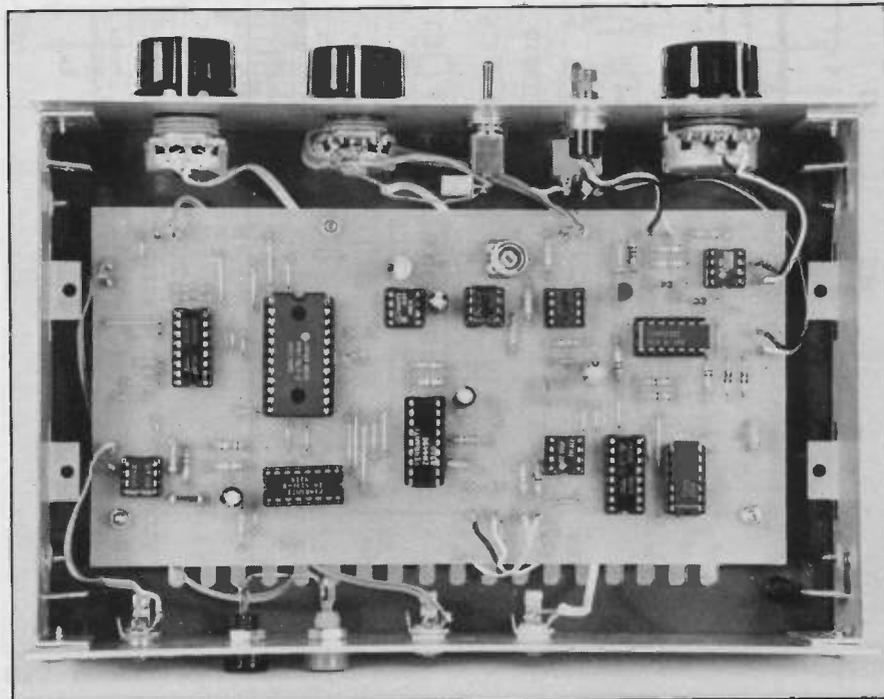
Fig.5. The input wiring. Any long non-earth leads must be screened

an ideal housing for this project. The exact layout is not particularly critical – I mounted all the controls on the front panel and fitted all the sockets on the rear panel. Included in the sockets are two 4 millimetre types to permit connection from the power sockets of the oscilloscope to supply rails of the scope store unit. However, the input and output sockets can be any type which fit in well with the equipment you are using. The printed circuit board is mounted on the base panel of the case using 6BA fixings which must include spacers to hold the connections on the underside of the board well clear of the metal case. The point to point style wiring is then added, and this is generally quite straightforward, but C1 is mounted direct on S1 (Fig.5) and any lengthy wiring at the input must be screened in order to avoid excessive stray pick up of noise.

IN USE

Obviously a suitable screened lead is needed to couple the output from SK2

to the Y input of the oscilloscope, and the usual screened type test leads are used to couple the input signal to SK1. Another screened lead fitted with the appropriate plugs is needed to connect the synchronisation signal from SK3 to the 'sync' or 'trigger' input of the oscilloscope. With a dual trace instrument it can often be easier to obtain proper synchronisation by coupling the output of SK3 to the Y2 input, setting the scope to synchronise to this channel, and then adjusting the Y2 shift control so that the synchronisation pulses are placed off-screen. Although the synchronisation signal is taken from pin 14 of IC8, with some oscilloscopes it might be found that more reliable operation can be obtained by taking the signal from pin 15 or pin 1 instead. It is certainly worthwhile trying these alternatives if any difficulty in obtaining good synchronisation is experienced. If the unit is powered from the oscilloscope a suitable power cable will obviously be needed, and due care must be taken to ensure that the supply



COMPONENTS . . .

RESISTORS

R1,R3,R4	22k (3 off)
R2,R10,R17,	
R18,R19	2k2 (5 off)
R5,R6	390 (2 off)
R7,R8	6k8 (2 off)
R9	68k
R11,R14,R15	1k (3 off)
R12,R20	4k7 (2 off)
R13,R16	10k (2 off)
R21	10M (10%)

All 1/4w 5% carbon film or better, unless marked.

POTENTIOMETERS

VR1	100k lin
VR2	2k2 sub-min hor preset
VR3,VR4	47k lin (2 off)

CAPACITORS

C1	1 μ polyester layer
C2	330p ceramic plate
C3,C5	2 μ 2 63V(2 off)
C4	82p ceramic plate
C6	2n2 polyester layer
C7,C13	1n polyester layer (2 off)
C8	10 μ 25Vradial elect
C9,C10	100p ceramic plate (2 off)
C12	10n polyester layer
C14	100n ceramic

SEMICONDUCTORS

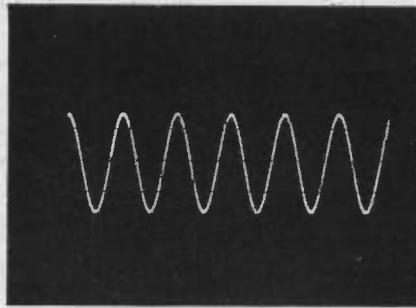
IC1	LF351
IC2	LF441
IC3	ZN449E
IC4	ZN428E
IC5	CA3140E
IC6	ICL7660
IC7	6116
IC8	4040BE
IC9	TLC555
IC10	4017BE
IC11,IC12	4001BE (2 off)
IC13	LM358
D1,D2,D3,D4	1N4148 (4 off)
TR1	BC327

MISCELLANEOUS

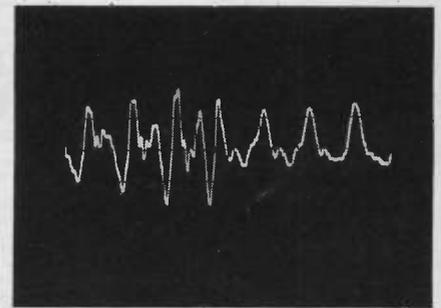
S1	s.p.s.t. sub ² -min toggle
S2	d.p.d.t. sub-min toggle
S3	Push to make release to break
SK1,SK2,SK3	3.5mm jack sockets (3 off)

Printed circuit board, case about 202 x 138 x 70mm, 8 pin DIL IC holder (6 off), 14 pin DIL IC holder (2 off), 16 pin DIL IC holder (3 off), 18 pin DIL IC holder, 24 pin DIL IC holder, control knob (3 off), 4mm socket (2 off), pins, wire, connecting cables, etc.

The PCB is available through the PE PCB Service. A kit of parts is available from Magenta - see advert.



A sinewave test signal which shows no obvious signs of 'stepping'



A few ms of speech showing the characteristic non-symmetry

is connected to the unit with the correct polarity. The only adjustment needed before the unit is ready for use is to set VR2 to give 1.25 volts at pin 6 of IC2.

When initially trying out the unit it is probably best to start with a simple test signal such as a sinewave of a few hundred Hertz in frequency, provided by an audio signal generator or a function generator. Use a fairly low sampling rate initially (VR3 set for nearly maximum resistance) and set the mode switch to 'store'. With VR1 set to give a signal level to the analogue converter that is something approaching the 2.55 volts peak to peak maximum, advancing the trigger sensitivity control should result in the unit repeatedly triggering and providing an output to the oscilloscope. Backing off VR4 should stop the triggering, and a burst of output should then be sent to the oscilloscope each time S3 is operated, confirming that it is triggering the unit properly. Switching S2 to the playback mode should result in the last burst of signal to be recorded being repeatedly sent to the oscilloscope. If the signal is sent to the oscilloscope with VR3 at the same setting that was used for recording, the time scale of the oscilloscope will be accurate and measurements of pulse duration etc. can be made. Where time measurements are not to be made it is often beneficial to output the signal to the oscilloscope with VR3 set for the highest possible rate (set at minimum resistance) as this will give a completely flicker-free display.

If the unit is operated in the store mode with VR3 set for a sampling rate

that is too high, this will be very obvious as the output waveform will show clear signs of 'stepping', or in an extreme case it will just consist of a few output pulses. As explained previously, it is well worth trying various values for C4 in an attempt to find the lowest value that gives satisfactory results. This optimises the conversion speed, and should enable VR3 to be used at its highest setting in the store mode. Even without tweaking the value of C4 it should be possible to use the unit with VR3 set almost at the maximum sampling rate. VR3 enables the sampling rate to be set at between approximately 20000 and 120000 samples per second, which in terms of sampling time represents between about 100ms and 17ms respectively. This is a useful range for audio purposes. For some types of testing, such as displaying envelope shapes, it could be desirable to use a much longer sampling time. This does not always work well with a unit such as this, as the sampling rate becomes too low and the envelope shape may not be displayed very clearly or accurately. If you wish to try out the unit for this type of testing it is merely necessary to make VR3 higher in value (about 1M) so that it encompasses much lower sampling rates.

The input impedance and sensitivity of the unit can be increased by altering some of the component values, but I would advise against this. There would be a severe risk of noise being picked up from the logic circuitry and ruining results. If high input impedance and sensitivity are required it is probably best to use an external preamplifier. **PE**



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BAB10	4"x514"x11/2" with lid	1.45

TOOLS

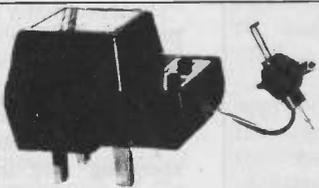
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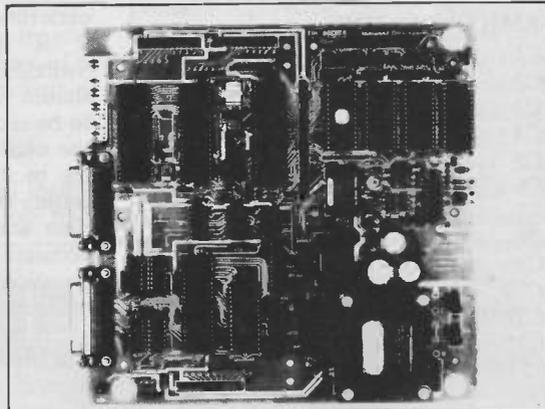
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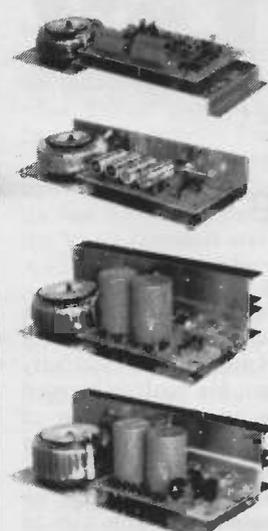
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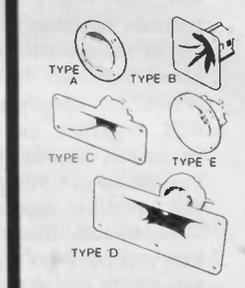


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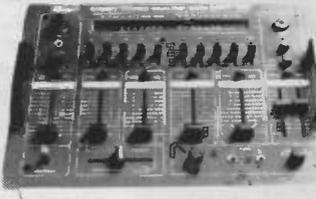
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Computers are very ingenious – but not terribly clever. Which may be just as well, if we're going to get along with them around the house.

AUTOBUTLER

BY RICHARD MISHRA

Very good, Sir. Shall I log off?

I have a butler that speaks poetry. Lives in the house with me, though I can never tell just where he is. We talk through the house phone – an intercom arrangement in every room that picks up my voice and broadcasts his. It lets us keep in touch without having to chase around the place. He is a useful chap, but I have to be direct with him. He doesn't understand if I get too chummy or talkative. He likes his orders to be clear and his replies are the same.

But still, he answers the door for me. Lets me know who it is before allowing anyone in so I can pretend to be out if I want to. There are some people he lets straight in. He recognises the voices of my friends and just calls me to say they're coming. Others he keeps well away and if I'm out, he's always there to give and take the message.

It's the same for the telephone. He answers it and if I'm around, lets me know who it is. Allows me to decide whether I want to take the call. There are even a few he makes himself, mostly to other servants. And another thing, he knows, or can find out, all the phone numbers I need. I just tell him who I want to call and he does the dialling, even introduces me and checks the person is in before handing over. After all, I don't want to find myself talking to the other fellow's butler, do I? It is nice not to have to bother with numbers any more.

As I say, he is a useful chap. Always keeps me up to date with messages left for me when I don't want to be disturbed or while I'm away. Reminds me to get things done. Keeps my diary in order and knows everyone's birthday. Sometimes I have to phone him myself to check on things; what is what's-his-name's address, am I free next Thursday for cocktails? That kind of thing. It's just as well he knows my voice, there's no telling what secrets he could give away. Still, he has strict instructions about what he can and cannot discuss with other people. He tells me if anyone questions him about anything, gas bills or politics.

He doesn't actually do any housework. I think he believes manual labour beneath him. I can't say I blame him. I might too if I had no real body. Fortunately everything he deals with is remotely operated. None-the-less he

does keep things under control – heating and lighting for instance. He'll turn off the lights in any empty room unless I tell him not to. Keeps the place at a pleasant temperature, but only in the rooms I'm likely to use. These days I rarely have to tell him which ones to prepare. He's a good learner – picked up a lot about my habits. I suppose he remembers what I've told him in the past and keeps on the look out to see if I'm doing the same sort of things again.

He wakes me up by whistling like a dawn chorus and drawing the curtains. The kettle is always boiling, the temperature of the shower water just right. To say he whistles is not quite fair. It's actually a recording. In fact, he has a large number of them and they're not just of bird song.

When I first took him on, I spent some time giving him my entire music collection to store. Of course I kept the record sleeves and notes. He plays it back through the Hi-Fi and shows the videos that we have acquired to go with them. Of course I can play any of the collection in any order by just asking for the music by name, but there's more to it than that. I can do things like hum a half remembered passage. My butler will probably recognise it and give me a list of tunes that it could come from. I don't have to worry about damaging the records because I don't have to touch any of the system. Besides which records aren't used, all the music is stored, and added to, electronically. He helps me edit together my own videos using broadcast material. That's quite fun, especially as he can take care of most of the laborious bits.

He usually has a list made up for me every time I go shopping, mostly dull essentials from the supermarket. He could order them directly and have them delivered, but to be honest, I quite like the chance to see what's there for myself. His lists do mean that I never run out of the basic things, but he does like to be told whenever I use something up. That's no problem, all I have to do is mention it out loud as I throw the empties away. He hears and adds it to the list.

The other day I told him that we needed to save some money. He had a look at the fuel bills, how much things were costing to run. In the end we

decided to stop using the dish washer. I used to load it up and he would turn it on in the dead of night, when electricity is cheap. Even so, his analysis showed it was still quite an expensive way of doing things. Now I do it by hand. Just because you have a servant, there's no reason to be wasteful. In fact things run much more economically with him to keep them under proper control.

With his organisation, life runs more smoothly too. I tell him about the television programme that I want to watch and he reminds me just before it comes on. Even records it for me if I'm away. If I want to know what's showing at the cinema, he can find out. He can find out a lot more, just by getting in touch with a colleague of his in the library. Sometimes, if things are too uncertain, I have to do the interrogation myself, but he can look up railway time table or find the population of Paris should I need to know.

If I come across something interesting in a magazine I'm reading, I mention it to him: he puts the appropriate information into his indexed file. It means that I can find the article again, even though I might have forgotten where I'd read it. I tell him what it was about and he lets me know where to find it.

I don't think he ever sleeps. Once some chap tried to get into the house at night. My butler noticed someone was moving too near the house for comfort and switched on the floodlights over the movements. The burglar went away. He told me about it the next day over breakfast. When I showed it to them, the police were quite interested in the snap shot that was taken automatically – a criminal with a surprised look on his face.

He is good at keeping things under control. Not just the household appliances, but the budget too. He pays the bills directly, making sure that his calculations of what we've used matches up to them. In fact I can leave most of the official stuff to him. Tax returns and the like only need to be checked and signed by me. Of course, I keep him informed about what I earn and spend. He automatically keeps track of changes in the various regulations and makes sure I get the best deal. In fact he can reach of lots of 'Experts' for me. He

knows when the car is due for service and can even find information on how to fix it.

He reminds me when to plant the tulip bulbs and, now that I've done the appropriate bit of plumbing, he waters the indoor plant for me. He even knows when I don't want to be disturbed and by whom – because I tell him.

Still you do need to know how to treat him. For example if I'm having a party, the box room with the two cabinets and the VDU terminal stays firmly locked. And as I say, I can't be too free with my confidences with him, he doesn't really understand. After all, he is only a servant, not like a real person.

But even with all the monitoring and taking notes he does, he is at his most useful, at his cleverest, when dealing with other people. He comes across as firm, polite and aloof. It's not because he is, he simply has to work within the limits of his comprehension: he can't let himself get too involved in conversation. But it is good not to have to rush to answer the phone or door, even nicer not to have to worry about bills and official forms.

have to find the right way to relate to them. This is one approach. It encompasses the limitations of Machine Intelligence and also puts into context the view that they may surpass us. Unlike mankind, the sole purpose of their creation would be to serve. Without us, the machines' existence would be pointless.

We can see what a dramatic change would be brought about by a small increase in the 'intelligence' of machines. The age of servitude is not dead, it is just waiting for machines to become smart enough. Then we could all benefit from having servants, without forcing any person into the indignity of being servile.

Compared to people, the machines will still be restricted to a small range of tasks. More importantly, they will only act under strict instruction. Though these instructions may be in human language rather than some sort of code, the resulting actions will still be just as clearly laid out.

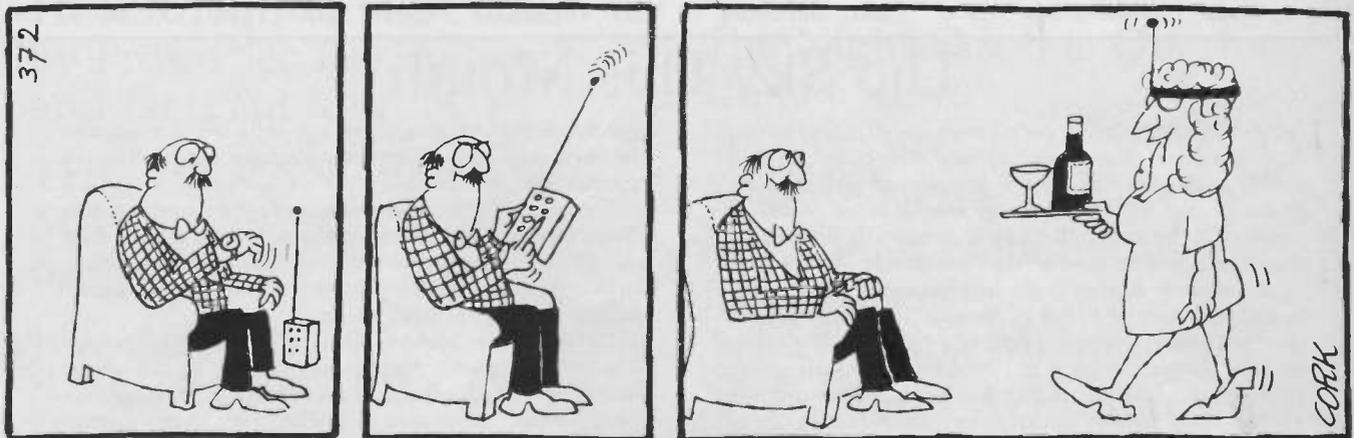
Physically, they will still be limited. It is hard to make machines sufficiently agile to cope with the full range of

work place or home. This will also mean that they will no longer be mysterious objects to fear, but familiar things for which to develop a contempt. In short, we can treat them in exactly the same way as the wealthy of earlier generations treated their servants, the advantage being that everyone in our society will have access to them. No actual people would be faced with the humiliation of servitude.

EMERGING INDEPENDENCE

With this attitude, intelligent machines can be allowed to take control of the products of technology, be they cars or the factories in which cars are made. At the moment technology is often as much a source of anxiety and harm as it is of help.

Using telephones, we are given the ability to communicate with people throughout the world almost instantly. But we can waste a long time trying to find telephone numbers, waiting for people to be near the phone so we can reach them and being called by people we don't want to hear from. We can travel to places around the world in hours, and



The thing is, when he has nothing much to do, when he's not taking dictation or reading my handwriting from the writing bureau where I do my letters, or checking that my bedroom is warm enough for when I go to bed, or looking up another interesting recipe using fish-fingers, he just thinks. All the actions involved in running a house come together with all the words that he's come across, new and old, as he tries to piece together a description of his world – my house.

In his musing with words to try to find some patterns, he sometimes has some problems. When this happens he asks me, and his question can be quite poetic: 'Can I compare thee to a summer's day?'

MACHINE INTELLIGENT SERVANT

Within ten years servants like this could be real. A lot of the technology already exist. As machines become increasingly clever and 'friendly', we

normal animal actions without making them very bulky or complicated.

Their limitation will be clear to everyone, not just specialists, because the machines will be accessible to everyone.

'Machine intelligent servants' is probably too imaginative a way of phrasing it, but these devices will provide a way for people to deal with machines, household or otherwise, and other people with much less effort. We can address the machines we use as we would servants, through speech operated control devices, but their comprehension will be limited to only what is required for their particular functions. They will only be able to understand simple, direct commands and their answers will be similarly straight forward. Their speech will leave you in no doubt that they are quite 'simple minded'.

Because they can hear and talk, they will be useful in virtually any situation,

we can spend the same amount of time in traffic jams that we could avoid if we knew about them. The pattern is repeated throughout technological life. Technology is useful, but usually it falls short of being pleasant to use. There is no doubt that help is needed.

It will be the first step in reacclimatising mankind to our technological environment. As such it will require a revolution in itself. Not least we will have to get used to the idea that industry does not exist for the sake of industry, but for people. The wealth generated by machines cannot blindly be put back into making more machines, as happens now: people must be able to use the wealth.

If this happens, technology will have grown up sufficiently to start looking after itself and so start being really useful. People will be given the room to step back and deal with being human.

SPACEWATCH

BY DR PATRICK MOORE OBE

OUR REGULAR LOOK AT ASTRONOMY

Pluto is the most remote of our sun's planets, but is it really a true planet, or is it one of a swarm of remote asteroids?



ANY space-craft en route for the outer planets must necessarily pass through the asteroid belt. More than 3500 asteroids have now been observed sufficiently well to have been given permanent numbers; it is surprising that of these, only three have been 'lost' (apart from one, Adalbera, which never existed at all). The missing asteroids are 719 Albert, 724 Hapag and 878 Mildred. The loss of Albert is particularly unfortunate, as it was one of the early 'Earth-grazers', but we have to admit that its recovery after more than forty years will be largely a matter of luck!

There have been surprising revelations about one of the best-known and most beautiful double stars in the sky, Albireo or Beta Cygni. It consists of a 3rd-magnitude golden-yellow star

together with a 5th-magnitude blue secondary; the separation is 35 seconds of arc, so that the pair can be split with a very small telescope. It has always been assumed that the two are physically associated, but it has now been suggested that they are not, so that the blue star lies 'in the background'. If this proves to be correct, then certainly Albireo will deserve to be regarded as the most remarkable 'optical double' in the entire sky.

A new quasar-galaxy association has also been announced, by G. Djorgovski and his colleagues in the United States. They claim that the quasar PKS 1614+051 is associated with a very faint galaxy, of magnitude 24. The two lie in Hercules, and have an enormous red shift amounting to 3.215. The galaxy

itself seems to have a fairly active nucleus, and may be a Seyfert system, though it is so dim that it is very hard to study.

Pluto and Charon. Pluto and its companion Charon, in the outer part of the Solar System, make up a remarkable pair. Pluto was discovered by Clyde Tombaugh in 1930, but it is only within the last ten years that the separate existence of Charon has been proved. By a happy chance, we are now in the midst of a period of mutual eclipses and occultations of the two, and these are being intensively studied, notably by Dale Cruikshank and his colleagues at the high-altitude observatory on Mauna Kea.

Originally Pluto was believed to be rather larger than the Earth, but

The Sky This Month

OF the bright planets, only Saturn is well placed during this June. Mars is out of view altogether; Venus is visible in the dawn sky, but is low down – and since the phase is over 98 per cent., no markings on it will be expected to be seen; Mercury is technically an evening object, but will be hard to see even during the first part of the month; Jupiter is coming into view as it moves against the stars of Pisces in the east before sunrise, but does not reach opposition until mid-October. This leaves us with Saturn, which is at opposition in 9 June, when its magnitude will be exactly 0 – brighter than any star visible from Britain apart from Sirius (which is, of course, too near the Sun to be seen at present) and Arcturus.

Saturn remains in Ophiuchus, which is not officially counted among the Zodiacal constellations, but does intrude into the Zodiac between Scorpius and Sagittarius. The declination of Saturn this month is about $-21\frac{1}{2}$ degrees, so that from Britain it is inconveniently low; look for it rather above and to the east of Antares, the red supergiant in Scorpius (Saturn is a magnitude the brighter of the two). The rings are wide open, so that even in a small telescope Saturn is a magnificent sight.

Of Saturn's satellites, Titan is an easy object; there are reports that it has even been glimpsed with powerful binoculars. Voyager results show that it has a dense atmosphere made up chiefly of nitrogen, but its surface is hidden by clouds, and as yet we have no real idea of what the surface conditions are like. Iapetus, Saturn's outermost large satellite (though smaller than our Moon) is an oddity; one hemisphere is highly reflective, while the other is dark. Since Iapetus, like all major satellites, has a captured or synchronous rotation, and so keeps the same face turned toward its primary all the time, it is always much brighter when west of Saturn, and showing us its bright face, than when to the east of Saturn. During June it is eastward of the planet, and the magnitude will be below 11; by early August, when it

reaches westward elongation, it will be bright enough to be seen with a very modest telescope. At its best, its magnitude can exceed 9.

The reason for this curious state of affairs is not known. Since Iapetus has a mean density not much greater than that of water, it is presumably made up of rock and ice, so that the dark region is superficial – probably produced from inside the satellite's globe.

Of the outer planets, Uranus (in the Ophiuchus-Sagittarius region) reaches opposition on 16 June, magnitude 5.8; Neptune, in Sagittarius, is at opposition on 28 June, magnitude 7.7; Pluto, in Virgo, passed opposition on 29 April, magnitude 14. The Voyager 2 probe, now in 'cruise mode' between the orbits of Uranus and Neptune, continues to function well. Instruments on it were recently used to study the supernova in the Large Cloud of Magellan, described in last month's Spacewatch, but otherwise Voyager 2 will simply continue on its way toward a rendezvous with Neptune in August 1989.

The evening skies are less brilliant than those of winter; Orion has disappeared, and Leo sets in mid-evening. However, we do at least have the so-called 'Summer Triangle', made up of three brilliant stars; Vega in Lyra, Altair in Aquila and Deneb in Cygnus. It is interesting to compare Vega with Arcturus in Boötes (the Herdsman), which can be found by following round the 'tail' of the Great Bear. The two are almost equal in brilliancy, but differ in colour; the blueness of Vega contrasts sharply with the lovely light orange of Arcturus.

Much of the southern aspect is occupied by the large, faint constellation of Ophiuchus (the Serpent-bearer), Serpens (the Serpent) and Hercules. Below them, over the southern horizon, lies the red Antares, not far from Saturn. Antares, like Altair, is flanked to either side by a fainter star, but there can be no danger of confusion, because Altair is white and is much higher in the sky.

successive estimates have reduced its diameter – it was even said that if things continued at such a rate, Pluto would eventually vanish altogether! The latest values give Pluto a diameter of 1500 miles (2420 km), while that of Charon is about 730 miles (1180 km). This means that the two are not so very unequal, and the system should rank as a double planet – or, more plausibly, a double asteroid – rather than as a planet and a satellite.

More surprisingly still, the combined mass of the two amounts to only about one-fifth that of our Moon. Pluto is certainly smaller than Triton, the senior

satellite of Neptune, and not a great deal larger than Ceres, the largest and massive member of the asteroid swarm. So what is its true nature? The idea that it may have been a former satellite of Neptune does not seem likely, but there is at least a chance that Pluto is the brightest member of a whole swarm of asteroidal-bodies moving in the outer Solar System.

Preliminary results show, too, that there is a definite difference between Pluto and Charon. While Pluto seems to be coated with a layer of methane ice, Charon's surface indicates water ice. If this is confirmed, we have yet another

mystery on our hands.

It is most unfortunate that there seems no hope of finding out much more in the near future, particularly as the mutual eclipses of Pluto and Charon will end this year and will not recur for over a century. No planned probes will go anywhere near – and so by the end of the century it is likely that of all the main members of the Solar System, only Pluto and its companion will remain unexplored by probes launched from Earth.

PE

Astronomy Now

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and Dr. Paul Murdin

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H010	0.28
H011	0.28
H012	0.28
H013	0.28
H014	0.28
H015	0.28
H016	0.28
H017	0.28
H018	0.28
H019	0.28
H020	0.28
H021	0.28
H022	0.28
H023	0.28
H024	

UNIVERSAL EVENT COUNTER

BY JOHN BECKER

ANYTHING FROM RADIOACTIVITY TO SHEEP

This four-decade event counter was originally developed for use with the PE Geiger Counter, but it will happily count up any event which can provide a +5V pulse.

DURING the Autumn of 1986, I exhibited the PE Geiger Counter (Aug 86), and its second-generation offspring at selected locations in Kent. Since it was felt to be antisocial to use radioactive mineral samples to illustrate nuclear radiation detection, it seemed appropriate to show how the geigers would detect normal background radiation. Thankfully, the background level is normally very low, but this of course makes it a little difficult to illustrate using an analogue display meter intended to show more significant levels. Whilst the geiger audio output produces loud clicks at each impact detection, it cannot on its own demonstrate long-term detection rates. The better method is to use a computer or an event counter and relate the readout to a particular period of time.

The event counter to be described here is the one that I designed for use at the exhibitions to demonstrate nuclear event detection by the geigers. It is suited to carrying out long-term counting of impacts from many sources of radiation, such as geological samples or contaminated food stuffs. In the latter case, the sampled count rate would be compared with the known normal background count, so indicating any significant count increase over several hours.

However, since all the counter does is to count pulses, it is of course ideal for any situation where a counted display is necessary. All that is required is that the trigger source should be a positive going pulse of 5v.

CIRCUIT DESCRIPTION

The heart of the counter is the ZN1040E count display chip, IC1. It has several more facilities available other than those used for this unit, and a brief description of their function will be given later on.

Basically IC1 is a four-decade synchronous up-down counter with memory registers, and having outputs suitable for directly driving seven-segment LED displays. It additionally has a carry-borrow output for direct synchronous cascading, count inhibit gating, and a

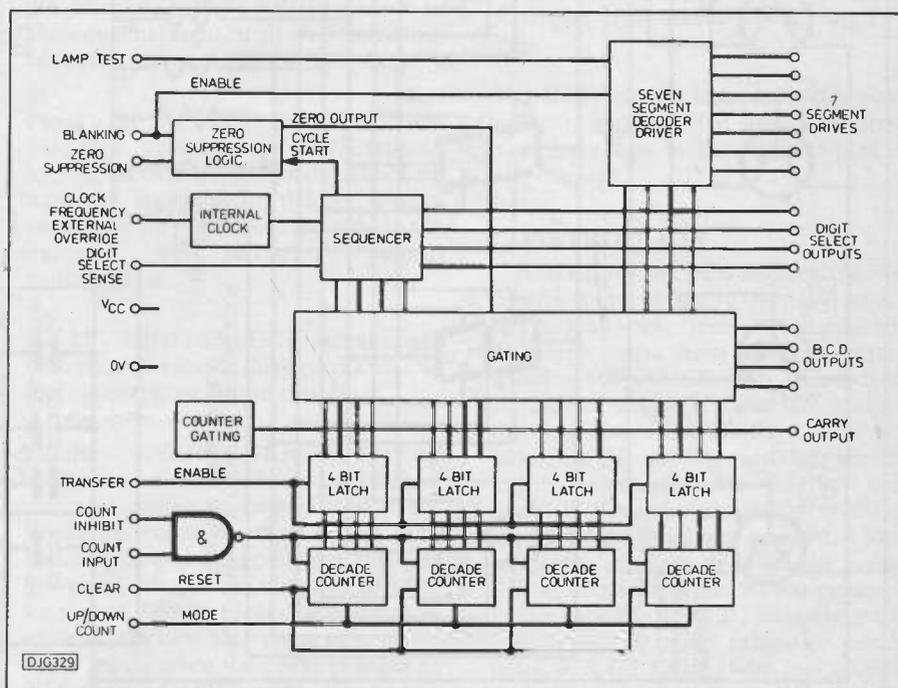


Fig.1. Block diagram of ZN1040E Count Display Chip

Schmitt trigger on the count input for slow input waveforms. A separate set of BCD outputs is also available.

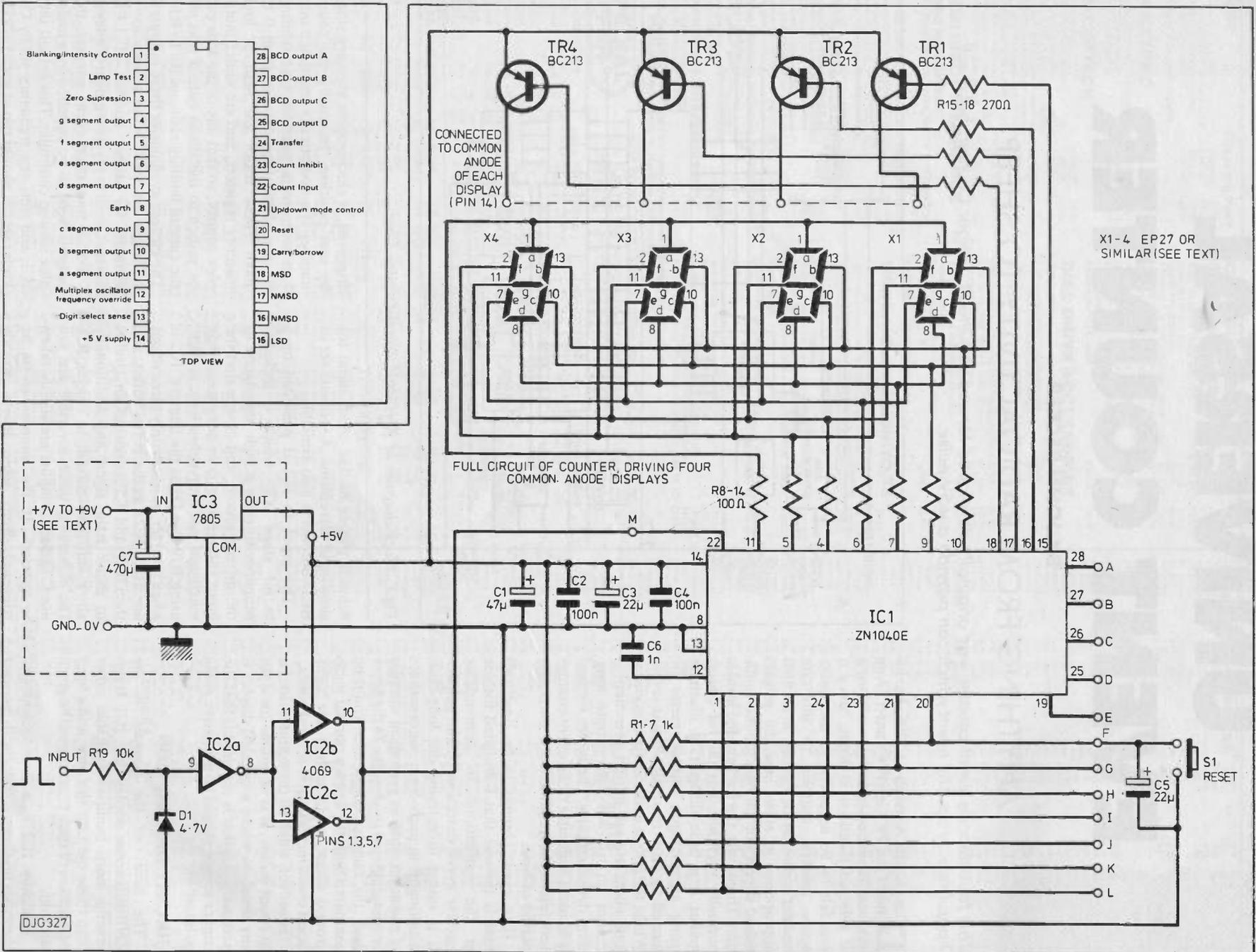
The input to IC1 is preceded by a buffer stage IC2, which is included primarily to offer a high impedance to the driving source, and ensure that the input voltage level does not exceed +5v maximum, nor drop below logic nought, using R19 and D1 as the limiters. IC2 is a hex inverter, of which only three stages are used, IC2a as the initial buffer, and then IC2b and IC2c connected in parallel to reinvert the signal and additionally allow sufficient current to trigger IC1. The remaining three inverters are not used, and their inputs are simply taken to ground. If the counter is to be triggered from logic levels already known to be satisfactory for driving TTL, IC2 could be omitted, and the input taken direct to IC1 pin 22.

Ignoring the control pins of IC1 for the moment; each time the counter is

triggered, it clocks up its memory store by one position. Internally the count number is automatically translated into four seven-segment codes, each relating to one of the four decades from 0 to 1000. These codes are held in four memory registers, and are under multiplex control, so that any of the four can be routed to the seven output pins via the current limiting resistors R8 to R14. The current available at these outputs is sufficient to sink 100mA and so is suitable for direct control of LED devices, such as seven-segment displays.

For a four digit event counter, the outputs need to be switched by a multiplex section controller. This is built into IC1, and runs at a frequency set by C6. Preferably, it should run at about 12kHz or less, though too slow a rate will cause flickering of the display digits.

The multiplex oscillator switches the four registers through to the outputs, one after the other, and at the same time



UNIVERSAL EVENT COUNTER

applies a high level to one of the outputs at pins 15 to 18. The current available at these pins is insufficient to feed the displays directly, but can readily control the switching transistors TR1 to TR4 via R15 to R18. As the relevant level is applied in turn to these transistors, they switch on, allowing current to reach the common anode of the relevant display. The selected display then becomes illuminated, showing the decoded numerical digit. Since each of the displays is turned on in sequence at a high frequency rate, the impression received visually is that all are turned on together. But of course in reality, each is only on for a quarter of the time. This has the additional benefit of reducing the total display current to a quarter of the amount required for normal constant display.

S1 is a push button reset switch, connected to IC1 pin 20. Normally this pin is held high by R1, but on pressing S1, the pin is grounded, and the counter is reset to zero. C5 ensures that the counter is automatically held reset at power switch-on, until it has charged up via R1. For the exhibitional purposes, manual control of the reset was quite satisfactory, but for other instances, it could be put under automatic logic pulse control.

POWER SUPPLY

The unit requires a +5v supply and draws a little under 300mA with all displays showing eights. If a +5v PSU is available, it can be connected directly to the positive rail of the PCB. However, if the optional 5v regulator, IC3 is included, the power source can be at a higher voltage level, but must be at least 7v to ensure adequate stabilisation down to +5v by IC3. It is preferable not to use a preregulated supply greater than

9v otherwise IC3 will require a heat sink. C7 is an initial smoothing capacitor, then C1 to C4 are post-stabilisation power line decouplers.

OTHER OPTIONS WITH IC1

All pins numbered refer to IC1 pins, and the lettered PCB pins F to L are normally held high by R1 and R7. Any of the control pins can be activated by manual switches, or by automatic logic level control voltages.

Pin 1 – DISPLAY BLANKING. Taking this to ground blanks the displays, but the chip continues counting.

Pin 2 – LAMPTEST. By grounding this pin all four displays will be forced to show decimal eight. If all are functioning correctly, numeral 8888 will be seen.

Pin 3 – ZERO SUPPRESSION. When held high, as it is here via a 1K resistor, leading zeros of any decimal number are inhibited. By grounding this pin, leading zeros can be reinstated, though at the expense of increased current consumption.

Pin 13 – DIGIT SELECT. Inapplicable with common anode displays (as used in this counter), so ignore this pin.

Pin 19 – CARRY-BORROW. May be used as an overflow indicator, or to allow direct cascading of several ZN1040Es. When the count direction is UP, then the carry output will go high on the next low-going edge of the count input after a count of 9999 is reached. It will go low again on the next high going edge at the count input, when the count changes to 0000. In the DOWN mode, the reverse applies.

Pin 21 – UP-DOWN MODE. Reverses the count direction from UP to DOWN when this pin is grounded.

Pin 23 – INHIBIT. Grounding this pin stops the counter at the last count number, and leaving the displays activated.

Pin 24 – TRANSFER. With this pin high data is passed straight from the counter internal register latches to the displays. When taken low, the displays are held at their last number, but the chip continues counting.

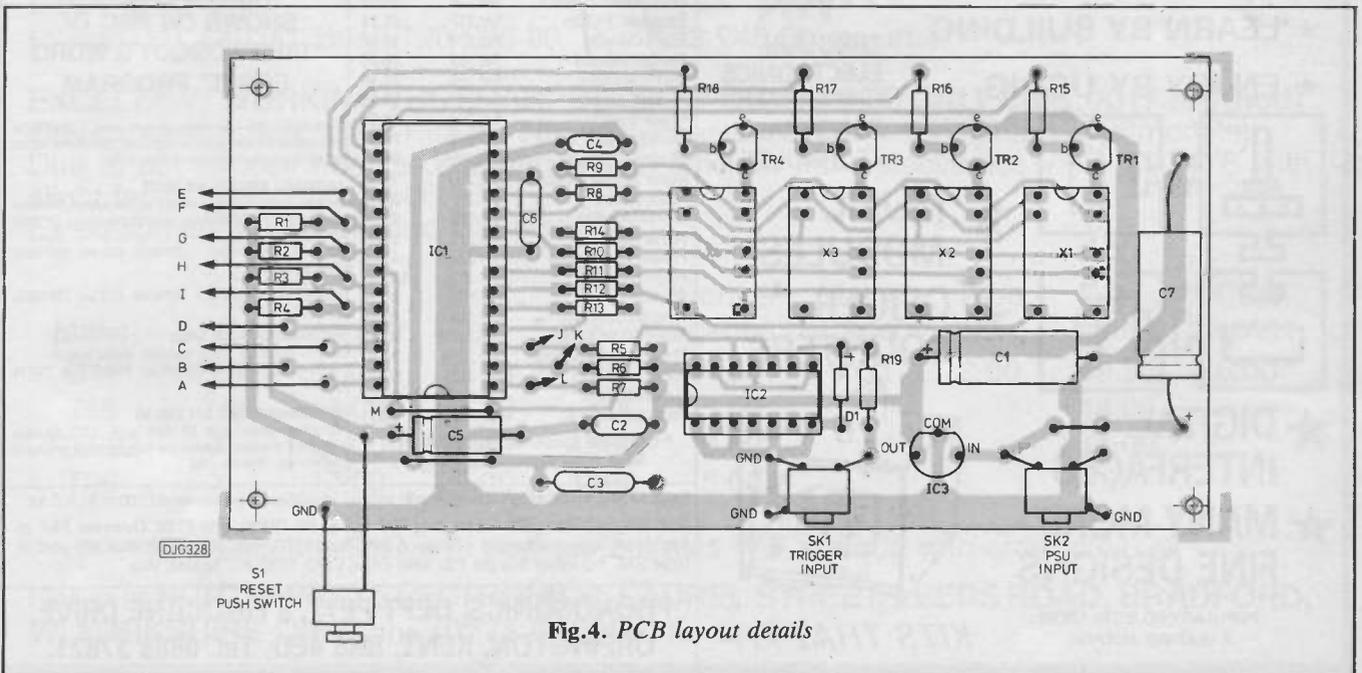
Pins 25 to 28 – BCD OUTPUTS. Binary Coded Decimal Outputs in order of D, C, B, A, and suitable for driving TTL logic.

The chip does not have a decimal point control, and the PCB makes no provision for access to the relevant pins on the displays.

CONSTRUCTION

Assembling the PCB needs no special comment except to give the usual advice to check all solder joints thoroughly, and discharge static from yourself before handling IC1 and IC2. Also, DIL sockets should be used for IC1 and IC2, and for the seven-segment displays. For the latter, the DIL sockets need their unused legs to be cut off before insertion into the PCB. Common anode displays other than the type listed may be used as long as the pin configurations are the same.

For practical reasons, S1 was mounted at the back of the PCB, allowing ready manual access under exhibition conditions. IC3, C2, C4 and both jack sockets were mounted flat against the PCB in order to ensure a low front profile. The



UNIVERSAL EVENT COUNTER

COMPONENTS . . .

RESISTORS

R1-R7 1K (7 off)
 R8-R14 100 (7 off)
 R15-R18 270 (4 off)
 R19 10K
 All resistors 1/4w 5% carbon

CAPACITORS

C1 47µ 10V electrolytic
 C2, C4 100n polyester (2 off)
 C3, C5 22µ 16V electrolytic (2 off)
 C6 1n polystyrene
 C7 470µ 10V electrolytic

SEMICONDUCTORS

D1 4V7 400mW zener
 TR1-TR4 BC213 (4 off)
 IC1 ZN1040E
 IC2 4069
 IC3 7805
 X1-X4 EP27 (or similar common anode 7-segment displays) (4 off)

MISCELLANEOUS

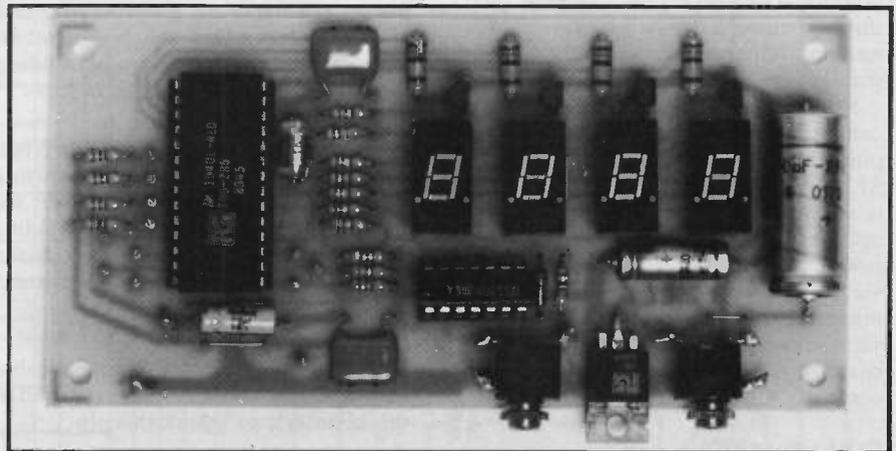
Pcb clips (4 off), PCB278A, 14-pin i.c. socket (5 off), 24 pin i.c. socket, 3.5mm jack socket (2 off). Pcb and kit of parts available from Phonosonics, see advert.

original display unit was mounted inside a glass fronted display cabinet, using self adhesive PCB supports, mounted forwards, to secure the board to the glass. If bright ambient light diminishes the display brilliance, a hood can be fitted to shade the numerals. The board may alternatively be fitted inside a box with a suitably cut slot for the displays, protecting them with a red gelatine filter. The filter will also help to minimise ambient light problems.

For use with the PE or EE geigers, or any of their second-generation offspring, the geiger's computer output can be plugged direct into this counter, via SK1.

IC1 FUNCTION PINS

Letter	Pin	Function
A	28	Binary
B	27	Coded
C	26	
D	25	Decimal
E	19	
F	20	Carry-Borrow
G	21	Reset
H	23	Up-Down
I	24	Inhibit
J	3	Transfer
K	2	Zero Suppression
L	1	Lamp Test
M	22	Blanking
		Count Input



CONSTRUCTIONAL

KIT CATALOGUE

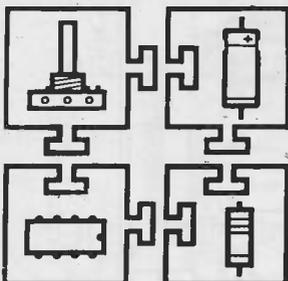
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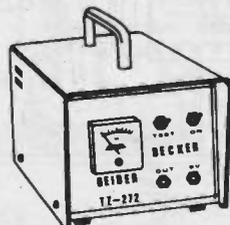
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4002	13p	4093	18p	74LS48	15p	74LS248	50p	6840	210p	75172	720p	7912	40p
4006	36p	4094	48p	74LS51	16p	74LS249	32p	6845	620p	75182	100p	7915	40p
4007	13p	4095	58p	74LS54	18p	74LS251	30p	6850	110p	75183	100p	7918	40p
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4011	13p	4502	38p	74LS75	28p	74LS258	42p	8156	360p	75224	340p	78118	28p
4012	13p	4503	32p	74LS76	28p	74LS259	58p	81LS95	130p	75225	155p	78124	28p
4013	19p	4504	55p	74LS78	28p	74LS260	48p	81LS96	130p	75226	145p	78125	40p
4014	35p	4505	200p	74LS83	43p	74LS266	28p	81LS97	130p	75227	45p	78126	40p
4015	34p	4506	60p	74LS85	45p	74LS273	52p	81LS98	130p	75450	45p	78127	40p
4016	13p	4507	33p	74LS86	19p	74LS279	40p	8224	270p	75452	42p	78128	40p
4017	31p	4508	70p	74LS90	32p	74LS280	140p	8226	270p	75453	85p	7824C	100p
4018	33p	4510	37p	74LS91	75p	74LS283	60p	8228	270p	75454	65p	7824K	100p
4019	28p	4511	40p	74LS92	38p	74LS290	30p	8243	250p	75454	65p	7824K	100p
4021	35p	4512	42p	74LS93	30p	74LS293	30p	8243	850p	75480	135p	7824K	220p
4022	36p	4514	75p	74LS96	37p	74LS305	37p	8067	1100p	75491	60p	78177	180p
4023	13p	4515	75p	74LS107	32p	74LS367	35p	8253	320p	8726	95p	78223	40p
4024	25p	4516	40p	74LS109	34p	74LS368	38p	8255	310p	8728	110p	78HGC	570p
4025	13p	4517	120p	74LS112	36p	74LS373	55p	8256	1200p	8731	330p	78HGC	800p
4026	60p	4518	38p	74LS113	32p	74LS374	55p	8257	350p	8735	90p	78H2KC	700p
4027	18p	4519	30p	74LS114	30p	74LS378	40p	8259	360p	8736	110p	78GUC	190p
4028	29p	4520	38p	74LS122	400p	84LS390	50p	8271	3400p	8737	90p	79GUC	215p
4029	35p	4521	90p	74LS123	42p	74LS393	45p	8272	1200p	8738	110p	79HGC	800p
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4031	90p	4528	80p	74LS125	84p	74LS629	105p	8282	300p				
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4066	20p	74LS514	20p	74LS175	42p	8502C	930p	75107	80p				
4067	13p	74LS515	15p	74LS190	55p	8503	570p	75108	80p				
4068	13p	74LS520	15p	74LS196	65p	8504-15	250p	75109	110p				
4069	13p	74LS211	15p	74LS192	50p	8522	300p	75110	80p				
4070	13p	74LS222	15p	74LS193	51p	8530	1050p	75112	140p				
4071	13p	74LS224	38p	74LS194	53p	8542	460p	75113	195p				
4072	13p	74LS227	15p	74LS195	52p	8545	880p	75114	130p				
4073	13p	74LS271	15p	74LS191	52p	8530	530p	75115	130p				
4075	13p	74LS238	15p	74LS197	52p	8800	210p	75111	135p				
4076	45p	74LS300	15p	74LS221	56p	8802	220p	75122	125p				
4077	13p	74LS322	17p	74LS240	55p	6803	800p	75150	110p				
4078	13p	74LS333	17p	74LS241	55p	6808	500p	75154	110p				
4081	13p	74LS37	16p	74LS242	55p	6809	600p	75158	140p				

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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 September 1987 issue.

Look out for another mental challenge next month!

BINARY CHOP - PUZZLE NO 4

DECODE THIS 204 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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11000010000110011001110011111110011111110011110101110100111001110
1100111001100101010011111000010101110101101010010111001010111010111
1100011101010111011010110010110000101001111110011100001000010111001
0100111101001101101011010010011101101100111011001010101101001011110
0011100100001000111100011001011110100101100101110010011111110000100
00101110010100111010010111100111101101110111111010111101111010111
0000111100011100111011001110011101001100101111100101001100111101111
00111100001110001010111010110001110011100110010110101110001001111000
1111001101011101011011110001101001001100001101011001111100111010111
00001110011101101101101010011011100011010110001100101001010110100111
00111110011011110100010110100010000100111100011010110000110110110000
1101101101111010011011011111010111000111001011011011010011011001011
0111101001100011111101110011101111111100011010011100011000110101001
01111
```

THIS SHORT BINARY-CREATING PROGRAM MAY HELP.

```
10 FOR A=1 TO 57:A$="" :FOR B=0 TO 5:D=A AND (2^B)
20 A$=STR$(ABS(D>0))+A$:NEXTB:PRINT VAL(A$):NEXTA:PRINT
```

BOOKMARK

The following books have recently been received:

Electronic Circuits for Computer Control of Model Railways. R.A. Penfold. Babani BP180. £2.95. The projects consist of various types of controller, including a high quality pulse type, as well as circuits for train position sensing, signal and electric points control, etc.

International Radio Stations Guide. Babani BP155. £2.95. An invaluable aid in helping all those who have a radio receiver to obtain the maximum entertainment value and enjoyment from their sets.

Midi Projects. R.A. Penfold. Babani BP182. £2.95. Mainly provides details of how to interface many popular home computers with Midi systems, and also covers interfacing Midi to analogue and percussion synthesisers.

Introduction to CP/M. R.A. Penfold. Babani BP183. £2.95. This book has been written for the benefit of newcomers to computing and experienced users alike, to clarify the basic functioning of a disc drive operations system such as CP/M.

Electronic Synthesiser Construction. R.A. Penfold. Babani BP185. £2.95. With this book a relative beginner should be able to build, with the minimum of difficulty, and at a reasonably low cost, a worthwhile monophonic synthesiser, and to learn a great deal about electronic music synthesis.

Getting Started with Basic and Logo on the Amstrad PCWs. F.A. Wilson. Babani BP188. £5.95. Written especially to complement manufacturers' manuals and to help readers overcome the first hurdles in computing on the PCW.

Guide to Broadcasting Stations. 19th Edition. P. Darrington. Heinemann Newnes. £6.95. A standard receiving guide to tell you who is transmitting and where they are, giving frequency, location, and alphabetical order.

Computer Projects for Railway Modellers. R. Amos and M. Cook. Patrick Stephens Ltd. £4.99. 96 pages of features, circuit diagrams and program listings, for the Sinclair ZX Spectrum and BBC Model B.

BINARY CHOP NO 2 ANSWER AND WINNERS

Despite the deliberate spelling variation in Binary Chop No 2, nearly all the answers received were correct, though I suspect that some of you may still be working at the problem! This is the answer -

A HARD ONE. DECYPHER THE RANDOM ALPHA CHARACTERS, EACH OCCURS 3 TIMES. THERE IS ALSO A SELECTION OF FULL STOPS.
Q.A.O.F.J.H.H.K.E.I.X.O.B.G.V.L.DPG.A.H.R.V.E.M.N.X.U.M.I.D.E.Z.O.A.
S.DT.S.NR.C.W.V.T.C.Z.Y.SQ.U.V.R.L.H.K.T.J.C.I.X.H.U.F.BL.P.B.Z.P.
VWG.O.F.N.K.J.

Congratulations to the three winners -

Mr A. Osborne of Croydon, Surrey.
Dan Hopper of Peru in the U.S.A.
Chris Finn of Beverley in E. Yorks.

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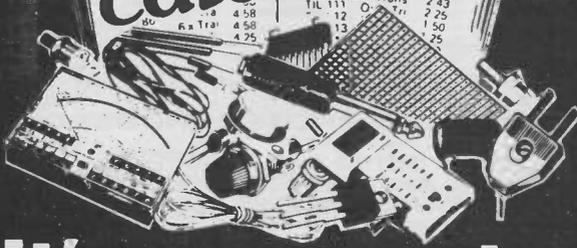
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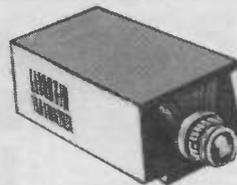
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REPORT BY
TOM IVALL

INDUSTRY NOTEBOOK

ELECTRONICS AND THE THIRD WORLD

The large pool of low-cost labour in the Far East has worked to the benefit of the UK electronics industry, but this situation may change dramatically as South East Asia's own industries become established

THE highly successful Amstrad business is often held up as an example of what can be done in flagging old Britain in the field of consumer electronics goods. Undoubtedly much of this success is due to the marketing skills of Alan Sugar, the founder. But another very important factor is that Amstrad does most of its manufacturing in the Far East (e.g. South Korea) where labour costs are much lower than in the UK and Europe generally. Of course, this is a well known strategy which has been used by other British electronics firms for a good many years. Amstrad's outstanding business success has simply highlighted it.

When Sir Clive Sinclair (whose earlier computer business was bought up by Amstrad) was television's favourite pundit on science and technology, he used to argue for a permanent relationship of this kind. He would say that Britain is strong in basic research and invention but weak in the application of these mental products to manufacturing and marketing. We are good at generating ideas but not in exploiting them for profit. So why not make the UK a kind of R&D centre – which would live basically by selling its brainpower through licences, royalties etc. – while other countries, notably those of the Third World, would benefit from producing and selling the resulting hardware.

But whether this would fit in with the present situation is somewhat doubtful. America, Japan and West Germany are the leading industrial nations because they not only produce good research and inventions but the technology to exploit them as well. Everyone else follows in their wake, though not without making contributions to the total body of knowledge. The overall picture, however, is one in which the industrialised countries – broadly the OECD group – generate the technology and monopolise it. They call the shots, while the Third World is in a position of dependence.

It's all very fine for the richer nations, but this technological imbalance makes the present world economy work to the permanent disadvantage of the developing countries. And this is morally, socially and economically bad for everyone. The famous Brandt Report ('North – South: a programme for survival') pointed out the dangers in some detail several years ago. So in our discussion of the effects of the electronics industry on society it makes good sense to explore what is happening in the Third World countries where electronics is just beginning to have an impact on people's lives.

The fact that some of the people in the poorer countries can now buy radio or tv sets, pocket calculators, digital watches and the like is not very significant. It is a highly marginal change in awareness relative to experience of the brute facts of living in poverty, sometimes near to starvation. If electronics has any significance at all it must be the underlying effect of this technology on industrial production, capital accumulation and economic development.

Economists, industrialists and business people have traditionally held the view that because the Third World has huge populations and enormous pools of unemployed labour it should naturally adopt labour-intensive methods of production. Of course, this does in fact happen and the still tremendous competition for jobs drives the price of labour downwards. Hence the availability of sources of cheap labour for European companies such as Amstrad. And in saying 'cheap' I don't mean to imply poor quality, because the labour is often both cheaper and better than that available on the European market.

But this assessment, although it represents the current situation, is faulty in the long term. First of all there is no reason to suppose that governments and industrialists in the Third World would want to see their people as a permanent

pool of cheap labour for the richer nations, thus perpetuating the present dependence of the South on the North. It's bad enough to be forced into this dependence by economic necessity without voluntarily choosing it as a way of life.

Secondly, the traditional view is based on the concept of the *quantity* of labour and its laws of supply and demand. It doesn't take into account the qualitative change that is occurring in industrial production. High technology, led by electronics and computers, is being used, as discussed last month, not primarily to reduce labour requirements but to improve the overall efficiency of production and the quality of manufactured goods. If the developing nations are going to compete effectively with the richer ones they must utilise the new electronics-based technology for similar purposes – and in fact are already beginning to do so. As their labour is cheap anyway, there is relatively more incentive for them to use the new production technology to improve efficiency and competitiveness than simply to save on labour costs.

So how will the Third World deal with its vast unemployment problem? Already the manufacturing industries of the developing countries are unable to absorb the steadily increasing labour force resulting from the growth of their populations. One possibility would be to expand employment in agriculture. Although this would be going in the opposite direction to what happened in the European and American industrial revolution, it does make sense in the light of the new, automated production technology in manufacturing industries. Work in agriculture doesn't require the speed, accuracy, unflagging attention and precise measurement and control that are nowadays demanded by manufacturing production. Its rhythm is slower, in synchronism with the seasons and hence more suited to human abilities.

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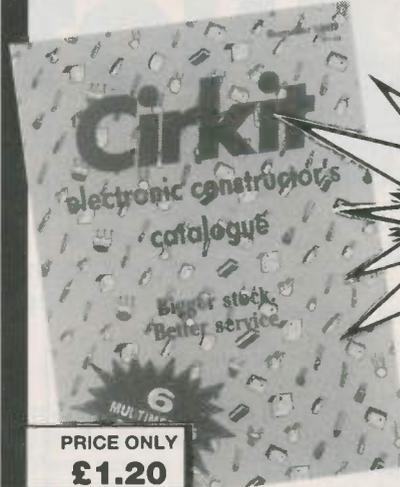
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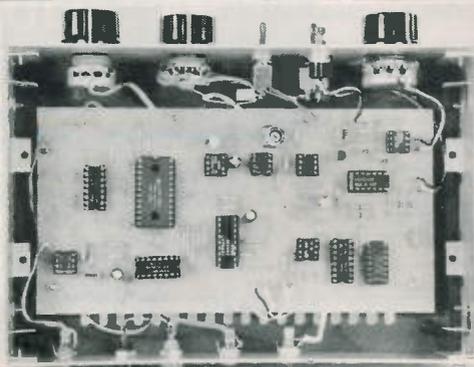
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For many projects you only need a few simple tools – Soldering iron between 15W and 25W, with a bevelled tip. Damp sponge for keeping the tip clean. Good multicore solder of 18swg or 22swg grade. Fine nose pliers for wire shaping. Adjustable spanner 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.

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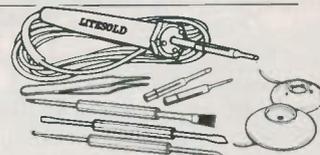


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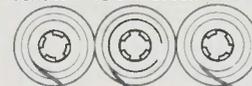
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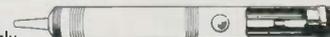


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Modular Audio Power System	APRIL '85		
Pt-3: Test Signal Source		504-09	£4.73
Power Supply		504-10	£4.70
Amstrad Synthesizer Interface		505-01	£4.77
Rugby Clock Pt-2		504-03	£30.84
"	MAY '85	504-05	£5.93
"		504-06	£11.70
"		504-07	£6.30
"		504-08	£12.60
CBM64 Music Keyboard			
Keyboard	JUNE '85	506-02	£5.19
Main PCB		506-03	£3.90
MTX 8 Channel A to D	JULY '85	507-01	£4.37
Voltmeter Memory Adapter		506-01	£3.90
Envelope Shaper	AUG '85	508-01	£4.11
Car Boot Alarm	SEPT '85	509-01	£3.90
RS232 To Centronics Converter		509-03	£5.70
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Exp. with Robots (double-sided)	OCT '85	004	£21.30
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Model Railway Track Control		010	£6.35
*Bytebox: ROM Board (double-sided)		002	£15.89
ZIF Socket		003	£3.90
RAM Board	NOV '85	007	£5.70
Battery Backed RAM		008	£4.13
EPROM Board		009	£3.90
*Special Price - Complete set of 5 boards		00A	£29.25
	DEC '85		
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Synth & 8-Bit I/O Port (double sided)		023	£7.74
Burglar Alarm			
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Sound Activated Switch		102	£6.17
Photographic Trigger Unit (set of 2)	APRIL '86	00C	£7.89
IEEE1000 PSU		105	£5.28
Scratch and Rumble Filter		106	£5.13
Notcher Effects Unit		107	£5.99
Logic Checker	MAY '86	108	£4.59
D.F. BeaconTimer		109	£6.18
STEBus backplane		110	£14.97
GuitarTracker		111	£6.98
Thermocouple Interface	JUNE '86	112	£3.90
PE Hobby Board		113	£29.00
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Passive IR Detector		115	£3.90
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Display board		117	£14.35
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Fibre Optic Data Link			
Set of two boards	SEPT '86	00E	£10.14
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Time Delay - Mains (Set of 2)	OCT '86	122	£7.92
Mains Dimmer		123	£3.90
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Baby Alarm - Set of two boards		125	£10.71
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