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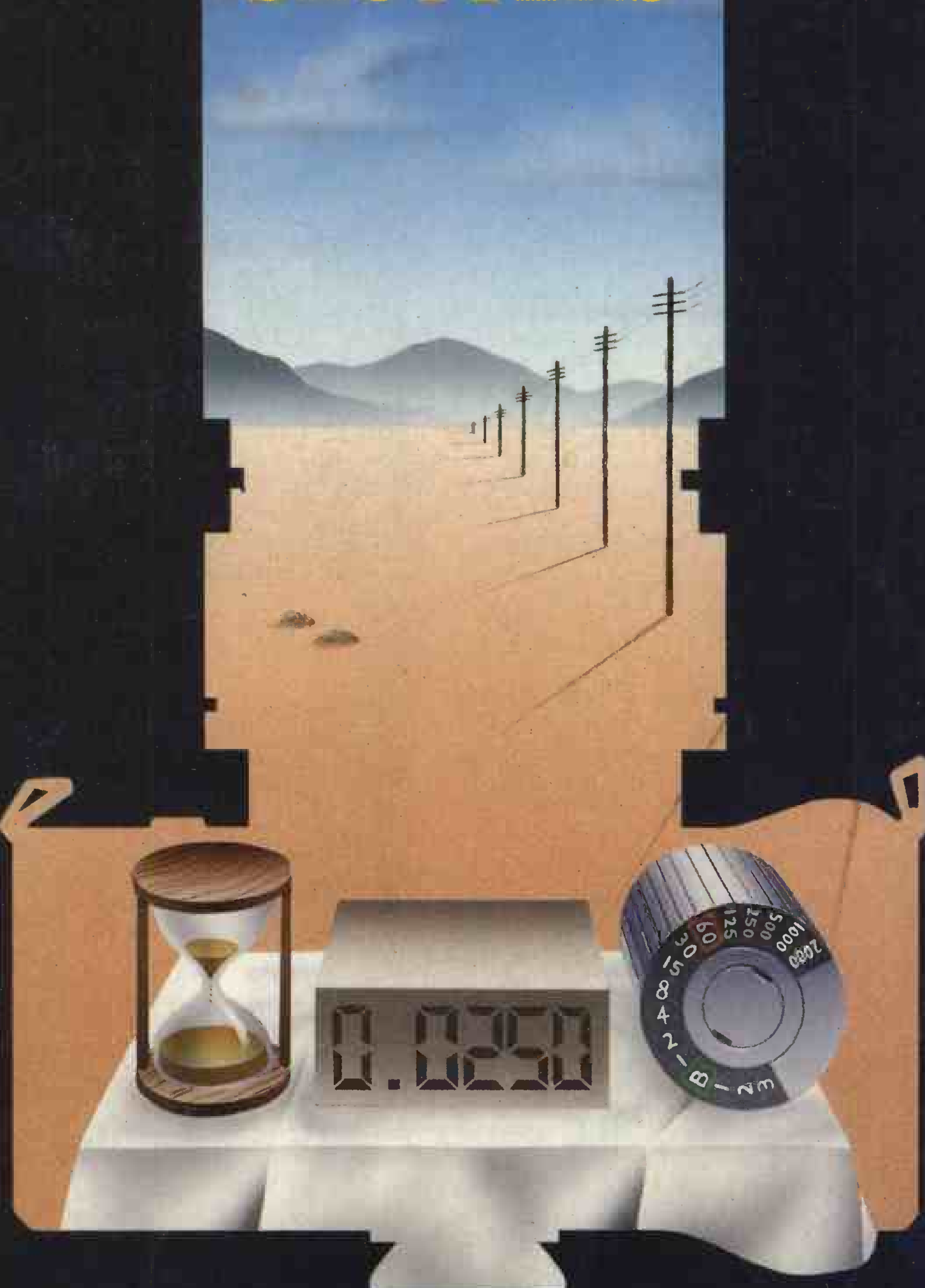
SCIENCE & TECHNOLOGY

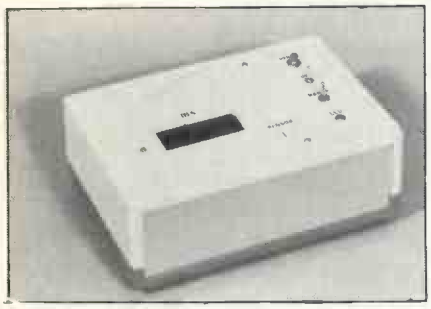
TIMING CAMERA SHUTTERS



AUTOGUIDE - THE HI-TECH ROUTE TO TRAVEL

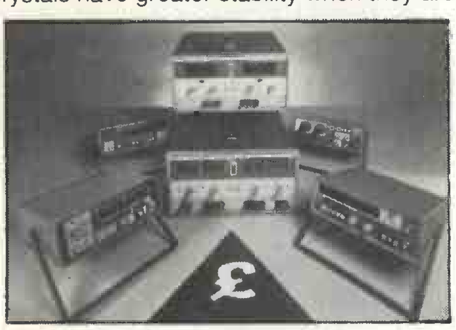
PRACTICAL ELECTRONICS

PE VOL 25 NO 3 MARCH 1989

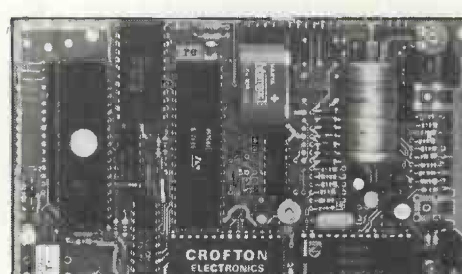


CONSTRUCTIONAL PROJECTS

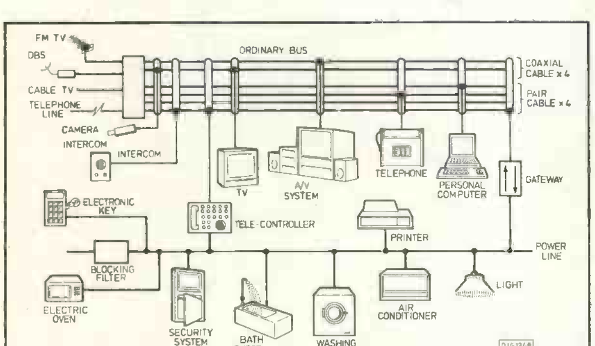
SPECIAL FEATURES



REGULAR FEATURES



PRODUCT FEATURES



NEXT MONTH . . .

WE'RE BRINGING YOU THE FIRST PARTS OF TWO MAJOR NEW FEATURES –
☆ YOUR EDITOR REPORTS ON THE ADVANCING STATE OF HOME AUTOMATION ☆ TOM IVALL TURNS HIS EYES SPACEWARD TO TAKE A TECHNICAL LOOK AT SATELLITES ☆ AND OF COURSE WE'LL HAVE OUR PAGES FILLED WITH OTHER TOP FEATURES ☆

**THE APRIL 1989 ISSUE IS FAR TOO IMPORTANT TO MISS
IT'S ON SALE FROM FRIDAY MARCH 3RD
FROM ALL THE BEST NEWSAGENTS**

THE SCIENCE MAGAZINE FOR SERIOUS ELECTRONICS ENTHUSIASTS

We have recently received the following literature:

The British Electronics Club has issued the latest quarterly news letter – 26 pages of it, covering a **wealth of ideas and information** concerning electronics. If you want to join this **excellent club,** write to the **Chairman, Mr. C. Bogod, BAEC,** 26 Forrest Road, Penarth, South Glamorgan, and enclose a stamped addressed envelope.

The Electronic Organ Constructors Society has sent its latest magazine. The magazine and the EOCS itself are of **vital importance** to any diyer interested in **electronic keyboard circuits and technology.** Anyone interested in joining the club should write to John Long, Hon Membership Secretary, **EOCS,** 5 Gander Close, Hartcliffe, Bristol, BS13 9PN.

Heinemann have sent their complete list of books, including many new ones. As well as covering electronic and electrical engineering, **their range covers many subjects,** from business management to travel. **Heinemann Professional Publishing,** 22 Bedford Square, London, WC1B 3HH. Tel: 01-637 3311

West Hyde have published a new 96 page catalogue of electronic enclosures that will be **of interest to those in the trade** looking for a broad range of **excellent enclosurers. West Hyde Developments Ltd,** 9-10 Part Street Industrial Estate, Aylesbury, Bucks, HP20 1ET. 0296 20441.

Instrumex have produced a new six-page colour leaflet detailing new products in a range of **text and measurement instruments from leading manufacturers** such as Tektronix, Stag, Marconi, Thurlby and many others. **Instrumex,** Dorcan House, Meadfield Road, Langley, Berks, SL3 8AL. 0753 44878.

STC Instrument Services have produced their first full-colour catalogue which, in 320 pages, features **a vast selection of products** from over 65 leading manufacturers. **STC Instrument Services,** Dewar House, Central Road, Harlow, Essex, CM20 2DF. 0279 641641.

VSI have sent a short form catalogue on their **semi-custom products.** Being mainly concerned with gate arrays, it will be of interest to our professional and more advanced readers. **VSI Electronics (UK) Ltd,** Roydonbury Industrial Park, Horsecroft Road, Harlow, Essex, CM19 5BY. 0279 29666.

Bonex have issued a 136 page A4 illustrated catalogue of **components and hardware,** ranging from battery holders and boxes, through passives and semiconductors to wire strippers and zif sockets. Of particular interest are their **kits and modules** for transceiving applications, including **weather satellite systems.** An extremely useful catalogue for your reference bookshelf. **Bonex,** 12 Elder Way, Langley Business Park, Slough, Berks, SL3 6EP. 0752 49502.

SRS have advised us of their new fully illustrated 4-page brochure on their entire range of **19 inch Style 70 sub-racks,** accessories and components. **SRS,** 19 Mead Industrial Park, Riverway, Harlow, Essex, CM20 2SE. 0279 418401.

WHAT'S NEW

Downing Tools

Intent on maintaining reputation for high performance test and measurement instruments at low prices, Flight Electronics have cut the price of eight of popular pieces of equipment.

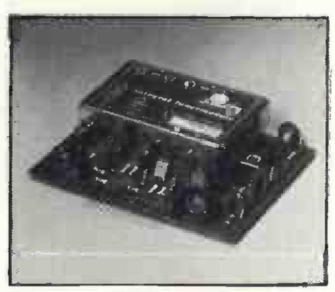
The cuts have produced a particularly cost-effective range of high-quality high-specification instruments. Significant among the reduced items is the GPD 3020D, a digital dual-output bench power supply unit with 0 to 30VDC, 0 to 2A outputs – now retailing at £290. A 120MHz digital frequency meter, the GFC 8010F, has been reduced to just £99.50 from £155.

Prices have also been reduced on universal, intelligent and digital frequency counters, a quad-output analog bench PSU, a 2MHz function generator and a pulse generator with logic probes and pulser.

Applications exist for the instruments in all electrical and electronics based industries, in R and D, service and production environments. They are also ideal for educational use.

The other new prices are: GPQ 1850 quad analog psu – £325, GFG 8015F function generator – £149, GFC 8010F digital frequency counter – £99.50, GFC 8100G intelligent counter – £325, GUC 2010 universal counter – £215. Discounts are available on large orders.

CONTACT: Suzanne Kittow, Flight Electronics, Ascupart Street, Southampton, SO1 1LU. Tel: 0703 227721.



Tuning Cirkit

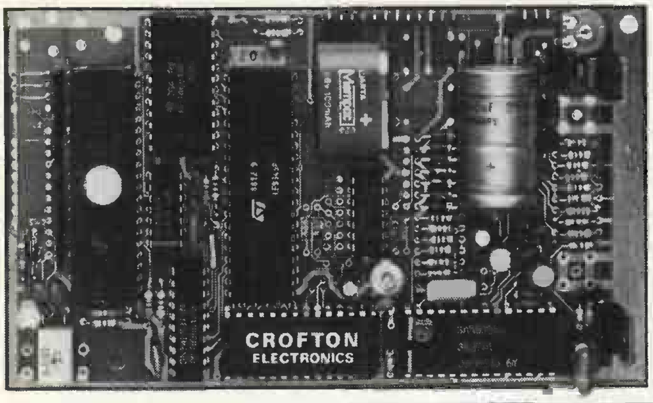
A new Larsholt range of fm-receiver tuner sets, in stereo and mono versions, and featuring an on-board audio amplifier is now available through the Danish company's exclusive UK distributor, Cirkit Distribution.

Especially suitable for applications in sound distribution systems, the three models all feature TDA1062-based front end, which combines good sensitivity with excellent large signal handling, a frequency range of 87.5-108MHz, am suppression of 50dB and image rejection of 70dB. Other advanced features include varicap tuning, afc amplification and control, tuning and signal level meter, noise and deviation muting and oscillator output. The 7256 is supplied in stereo or mono versions with the 7260 having an on-board audio amplifier, capable of delivering up to 6W in to 4Ohms with a signal-to-noise ratio of greater than 90dB. The unit only requires the addition of a few external components and a loudspeaker to make a complete fm receiver.

Diode-tuned and equipped with oscillator tap to make pll synthesis the digital display possible, the 7256 and 7260 are only half Euro=card size, with dimensions of 100mm x 80mm and a maximum height of 25mm. Connection is via a 15-pin edge connector with 2.5mm space pins.

Larsholt plan to extend the series in the near future with the addition of a stereo version with audio amplifier and a control unit for pll-synthesis.

CONTACT: Cirkit Distribution Ltd. Park Lane, Broxbourne, Hertfordshire, EN10 7NQ. Tel: 0992 444111.



Picturing Crofton

Crofton have been involved in the video field now for some twenty years. Their small cctv camera design was shown, and demonstrated, on Tomorrow's World back in 1969. That little camera was actually hooked up to the transmitter and produced live pictures over the air, and although there was some trepidation at the time, everything went smoothly. It was probably the first time ever that the BBC had allowed a non standard video source to be connected to the transmitter and used to produce live off-air pictures.

Crofton are currently able to offer an extensive range of standard cctv security and computer products, as well as miniaturised ccd cameras, am and fm video transmitters, with, or without, sound for normal and cover surveillance applications. The size and weight of this equipment make it ideal for portable use.

Now, two more new products have been released from the same stable. The first is a miniature ccd solid state tv camera known as the Model CCD2. It is the smallest video camera presently available on the market and is bound to create a very broad spectrum of interest in many diverse fields. The resolution capabilities are far better than the average Vidicon camera, and its sensitivity goes down to -3 Lux. As it requires no tube change, and has no user replacement parts it can literally be installed and forgotten, thus making it the obvious choice for many applications. The price is also attractive, and compares favourably with all of the currently available more conventional ccd cameras on the market.

The second product is a time//date and message generator. Known as the TDMS1 this generator is an all British designed and manufactured video overlay unit. It also incorporates a stop watch available in two basic forms: Either as a basic pcb which allows manufacturers to build it into their own equipment, or as a boxed, free standing unit complete with mains transformer, input and output BNC sockets, and setting push buttons.

This unit has been designed and produced so as to seriously compete with similar Far Eastern designs and has a far wider and more flexible specification.

Applications for this product are extremely wide and diverse, and range from a simple time/date insert generator for video signal chains, to use as an event timer, a message generator for airport/hotel or other public place applications, as well as for use as a video editing ident signal, to name but just a few. The price has been kept to an absolute minimum and good quantity discounts are available.

CONTACT: Crofton Electronics, "Kingshill", Nextend, Lyonshall, Herefordshire, HR5 3HZ. Tel: 05448 557.

Low Distortion Sig Gen

Masterswitch Ltd, who manufacture the Linstead range of instruments have introduced a low distortion, low cost, battery powered audio signal generator. The Model G3 has sinusoidal, square and triangular outputs, and yet it is not a function generator.

The sinewave output is pure with a maximum distortion of less than 0.04% over its range of 20Hz to 20kHz, and the instrument is ideal for testing and checking distortion levels on Hifi equipment. The G3 is also a very useful general purpose audio signal generator, having switched and continuously variable attenuators with a maximum output of 6 volts p-p from a 50ohm source.

Very compact and weighing only 400grms with batteries this Sig Gen will make an excellent service tool.

CONTACT: Masterswitch Ltd, 8 Dorset Road, Tottenham, London, N15 5AJ. Tel: 01-802 1423.

COUNTDOWN

If you are organising any event to do with electronics, big or small, drop us a line – we shall be glad to include it here.

Please note: Some events listed here may be trade or restricted category only. Also, we cannot guarantee information accuracy, so check details with the organisers before setting out.

Feb. 7-9. Smartex – Surface Mounting Technology Exhibition. Wembley Exhibition Hall. 01-302 8585.

Feb. 22-23. Instrumentation Harrowgate. Harrowgate Exhibition Centre. 0822 614671.

Mar. 14-16. EPOS North 89. Seminar and exhibition of retail information systems. Armitage Centre, Manchester. RMDP. 0273 722687.

Mar. 21-22. Instrumentation Bristol. Crest Hotel, Filton, Bristol. 0822 614671.

Mar. 21-23. Corporate Electronic Publishing Systems. Exhibition and conference. Olympia 2, London. 01-891 5051.

Apr. 5-6. Laboratory Science and Technology Show, Kelsey Kerridge, Cambridge. 0799 26699.

Apr. 11-13 Portable Computing and Data Capture 89. Conference and exhibition. Rivermead, Reading. RMDP. 0273 722687.

Apr. 25-27. British Electronics Week. Olympia. 0799 26699.

May 8-10. Eurobus 89 – German Conference. Munich Sheraton Hotel, Munich. 01-940 4625.

Jun. 5-9. Lasers, Optoelectronics, Microwaves. 9th International Trade Fair and Congress. Munich Fair Centre. 01-948 5166.

Jun. 14-15. Instrumentation Scotland. The Forum, Livingstone. 0822 614671.

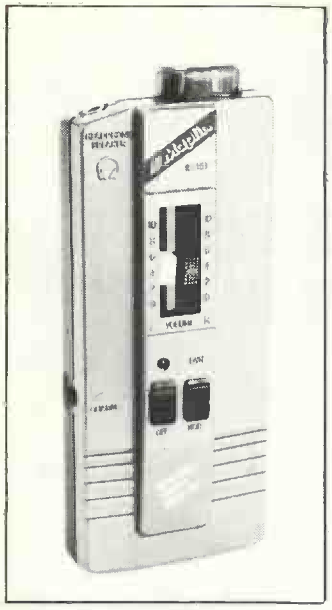
Jul. 10-13. EWEC '89. European wind energy conference and exhibition. Scottish Conference and Exhibition Centre, Glasgow. No reference tel. known.

Aug. 25-Sep 3. International Audio and Video Fair. Berlin.

Sep. 4-6. Eurobus 89 – UK Conference. Novotel Hotel, London. 01-940 4625.

Sep. 12-15. EPOS 89. The World's largest exhibition of retail information systems. Alexandra Palace, London. RMDP. 0273 722687.

BTEC CONTINUING EDUCATION CERTIFICATE COURSES. Starting dates Jan11 and Apr 26 – each course 2 days per week Wed/Fri for 13 weeks. London Electronics College, 20 Penywern Road, London SW5 9SU. 01-373 8721.



Stereo Wireless

Providing you stay in sight of the transmitter unit – normally up to 30 feet or more away, the new Maplin stereo infra-red cordless system allows you to live in peace with your hifi (or tv set).

Headphones are plugged into the highly compact receiver which allows the adjustment of volume and balance from the comfort of your armchair anywhere within range. The system eliminates the need for long trailing cable from your hifi or tv to headphones. The receiver has been designed to be clipped onto shirts, pockets or belts, giving full (in range) mobility.

Apart from left/right volume control, the receiver features a dynamic switch that expands the frequency range and increases sensitivity by 10dB to accommodate high quality equipment such as cds and laser disc video players.

The system comprises an infra-red transmitter, connected to the headphone jack of any audio equipment and an infra-red receiver into which any stereo headphone (8 to 100n) can be plugged. The transmitter has 12 infra-red leds which give a 110° signal field and is powered by a 12V dc 500mA ac adaptor. The receiver meanwhile is powered by 3AAA dry cells or equivalent nicad rechargeable batteries. The nicad batteries can be recharged in the receiver by simply plugging in the ac adaptor supplied.

The YP63T i-r stereophone costs £39.95 including VAT, but excluding batteries, and is available from Maplins' nationwide shops.

Transputer Training

The world's first fully integrated transputer training package has been launched by leading microprocessor-trainer specialist, Flight Electronics. The system allows a high level of transputer literacy to be achieved in a very short space of time and at low cost.

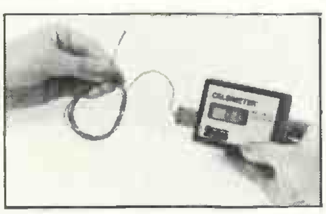
Used in conjunction with a host IBM-PC, the trainer offers a complete educational introduction to the Inmos T414 transputer chip. The package costs £995 and comprises a transputer module, IBM-PC interface card and all necessary development software, including TDS 1 OCCAM from Inmos. Being external from the IBM-PC, the transputer is easily accessed by the student.

The package includes everything needed to gain a good level of hardware and software knowledge of the powerful parallel processing transputer, and use it to implement real-time control tasks. Comprehensive 'self-teach' tutorial documentation and a wealth of example-program software is included in the package.

Flight also offers comprehensive three-day transputer training courses. Purchasers of the transputer trainer qualify to take advantage of the course for £200, half the usual cost.

Southampton University's world leading Transputer Support Centre at Chilworth, supported by SERC, developed the system in conjunction with Flight's training system specialists.

For further information contact Suzanne Kittow, Flight Electronics, Ascupart Street, Southampton, SO1 1LU. Tel: 0703 227721.



Hot Stuff

The Celsimeter Mini K is a new small electronic temperature meter. A variety of thermo element sensor probes are available for it and can be used for practically all temperature measuring problems between -50°C and +800°C.

A particularly interesting application is the monitoring of tip temperatures of soldering irons. A lot of problems and soldering iron tip wear can directly result from defective thermostats in soldering irons. For the best results the selected soldering tip temperature must be correct.

Apart from this there are numerous temperature measuring problems not only at work but also in the home. A small investment will solve all these problems.

Also available from the same source is an irreversible, and cost effective temperature measuring and registering paint called Celsilack is available in more than 100 values between +40°C and 1200°C. The paint is applied by brush onto the test area and in a few minutes dries into a measuring spot with good ahesion.

The predetermined temperature, when exceeded, is not indicated by a colour change but by means of a remelting process. After cooling the re-crystallised measuring spot gives a clear optical indication if the melting temperature has ever been reached.

Further information on Celsilack and Celsimeters contact: Cobonic Ltd., 32 Ludlow Road, Guildford, Surrey, GU2 5NW. Tel: 0483 505260.

Filtered Sockets

Microcomputers, electronic office machines and hi-fi apparatus are typical examples of a wide range of equipment which can now be cost-effectively protected from mainsborne transients using the new filter socket from Briticent.

Excellent radio frequency interference protection is provided by the new four-socket unit. Several pieces of sensitive electronic equipment can be conveniently connected at the same point which ensures 'clean' power. In addition to RFI protection, high-voltage static discharge (spike) suppresssion is provided. Overcurrent protection is via a replacable fuse link.

Isolation switching is omitted so that the risk of accidental switch-off of equipment is minimised. An integral neon shows when the unit is live. The socket may be supplied alone, alternatively an assembly is offered with two metres of cable and a BS1363 13A plug.

Contact Briticent International Ltd, Crow Arch Lane, Ringwood, Hampshire, BH24 1NZ. Tel: 0425 474617.

New Iron Age

Antex have launched their first in-handle temperature control soldering irons, the TCS 24 and TCS 240. These provide low-cost temperature control in a light-weight compact design. Simple to use, they offer temperature control (tc) flexibility without the need for a tc station. The temperature can be easily set at any point in the range 200-450°C, using a small screwdriver.

The advanced ceramic heating element provides rapid recovery of tip temperature even with heavy soldering demands, and fast warm-up from cold (60 seconds to 350°C).

Electronic control is one of the important features of this advanced iron. Unlike magnetic or mechanical switches, the electronic proportional voltage control is both highly accurate and reliable. This facility anticipates reaching the prescribed temperature and adjusts the power input accordingly. The result is an iron which very closely keeps to the specified temperature, eg within 1% in use, within 2°C idling.

By exploting surface mount technology, TCS soldering irons are small and light, giving operators positive, precise soldering control.

For full information on their whole range of soldering irons and equipment, contact: Antex (Electronics) Ltd., Mayflower House, Armada Way, Plymouth, Devon, PL1 1JX. Tel: 0752 667377.

Packing Power

A holder for four AA (R6) size cells is a new extension to Bulgin's range of panel mounting holders. The BX0027 has a removable, latching, loading magazine and 2.8mm series tabs/solder tags. Four tabs/tags can be wired in series or in two pairs. Polarity is clearly marked.

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

Discerning DVM

CERN is exploiting the precision measurement capability of Schlumberger Instruments' 7081 8 1/2 -digit multimeter in colliding beam physics experiments. Twelve units have been delivered to CERN for very accurate measurement on the LEP accelerator, the electron/positron storage ring developed for the experiments.

The accelerator is installed in a circular underground tunnel of 27km circumference constructed on the Swiss/French border. The first phase of construction, to be completed by the middle of 1989, includes the complete magnet and vacuum system, with the radio-frequency equipment required to store electron/positron beams up to an energy of 50GeV.

The role of the 7081 dvms is to measure the currents generated by power converters to energise the LEP magnets. The instruments are required to guarantee the final precision demanded of these power converters by checking individual elements such as a-d and d-a converters and dc current transformers. DVM performance must therefore be superior to that of each element.

The twelve voltmeters have now operated reliably and with unwavering precision for almost two years. A regular check in the LEP calibration room, using calibrators and standard cells which are themselves checked at the Swiss metrology centre at Bern, shows that the instruments have remained perfectly within specification during this time.

CONTACT: Schlumberger Instruments, Victoria Road, Farnborough, Hants, GU14 7PW. Tel: 0252 544433.

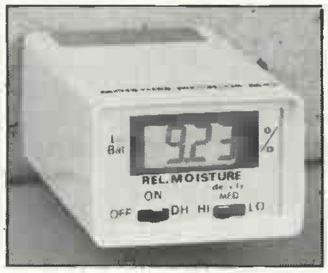
Rising Damp?

Electronic Temperature Instruments have announced the addition of the M49 digital moisture meter to their range of digital instrumentation.

The M49 is priced at £170 and represents a complete breakthrough in the measurement of free moisture. It is entirely electronic and utilises the latest silicon chip technology to measure the quantity of water within its electro-magnetic field, penetrating deep into the material under investigation. Calibrated up to 20% by weight it is suitable for the determination of water content in cement, building materials, wood, paper, foodstuffs, fibres, etc.

The unit is supplied complete and requires no probes or other accessories for its operation. The results of the measurements are displayed in large, clear digits with a resolution of one hundredth of one percent.

CONTACT: Electronic Temperature Instruments Ltd, P.O. Box 81, Worthing, West Sussex, BN13 3PW. Tel: 0903 202151.



Counting time

A new fully programmable, low-cost counter/timer has become available from Global Specialities.

The 6010 gives optimum resolution throughout a frequency range of between 0.1Hz to 125MHz, and utilises both conventional and reciprocal techniques. Using three independent channels and nine full size leds, thirteen different measuring functions can be provided including time interval averaging, rise/fall time, and peak voltage.

Also featured in the counter/timer are internally pre-selected intervals or external intervals ranging from 100s to 1000s.

CONTACT: Global Specialities, 2-10 St. Johns Street, Bedford, MK42 0DH. Tel: 0234 217856.

CHIP COUNT!

This month we highlight more recently received information on transputers:

MORE COLOURFUL

Two more new products, have also been announced, the IMS G178 Colour Look Up Table and the IMS B409+408 distributed graphics system, adding to INMOS' expanding portfolio of high-performance graphics products. This already includes the G171 Colour Look Up Table, the industry standard component used in the IBM PS/2 and many IBM compatible personal computers.

The IMS G178 is a high performance graphics device which integrates the functions of a 16 million colour palette, digital to analog converters and a bi-directional microprocessor interface into a single 32 pin package.

The high resolution B409+408 distributed graphics system is the latest addition to the INMOS line of transputer modules (TRAMs) and motherboards, and is made up of one IMS B409 display module and as many B408 modules as necessary to provide the desired drawing performance, up to a maximum of 12.

The IMS B408 implements the drawing and image storage functions of a medium to high performance graphics system. When connected to an IMS B409 via the INMOS pixel bus and a suitable monitor, a complete drawing and display system is formed. The integrated graphics system can be used for numerous applications including animation, flight training, medical imaging, and high quality video.

Ray Oliver, Sales and Marketing Director for INMOS, said, "The IMS G178 announcement signals the beginning of the next generation of colour graphics devices. We will continue to integrate more graphics functions on-chip as well as provide the added performance and features requested by our customers."

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

WORLD RECORD TRAM

Systems West has released the first of its series of trams. TRAMs are board-level transputers with a simple, standardised interface. They integrate a processor, memory and peripheral functions, allowing powerful, flexible, transputer-based systems to be produced with minimal design effort.

The TM8011 is a 1.05" x 3.66" 16-pin dual in-line package carrying eight pieces of dram and an Inmos 32-bit transputer. Fitted with a 20 MHz T800, the TM8011 packs one megabyte of memory and 10 mips (million instructions per second) of throughput into roughly 1.5 cubic inches. This is the highest MB*MIPS density yet achieved by any manufacturer in the world.

The module complies with published tram specifications and is compatible with tram motherboards from Inmos, Systems West, Levco, and other manufacturers. Up to ten can be installed on a Systems West TBX10 motherboard (or equivalent Inmos B008), putting 100 MIPS and 10 megabytes into one XT/AT slot.

The TRAM is available in two variants. The TM8011 carries a 20 MHz T800-20, with integral floating point unit. The TM4011 has a 20 MHz T414, without a floating point unit. Both have 10 MIPS throughput, but the integral floating point unit gives the TM8011 a floating point throughput of 1.5 MegaFLOPS (million floating point operations per second).

The TM8011 tram lists for £1095, the TM4011 at £950. Trade, OEM, and educational discounts are available.

Contact: Systems West, Whitefriars Southgate, Lewins Mead, Bristol, BS1 2NT. Tel: 0272 273990.

SQL TO SEARCH AND SERVE

BY BARRY FOX
Winner of the UK Technology Press Award

MANY A STITCH, BUT NO PATTERN

Database software has developed from simple path-based searches to the ability to compose sets of data – but is it any advance on the knitting-needle.

The computer industry has two shot feet. It keeps coming up with new ideas which are incompatible with whatever has gone before – and the people coming up with the new ideas are incapable of explaining them.

So it is often a matter of pure chance whether one piece of hardware or software works with another. And the unfortunate user finds out only after buying the product.

The latest buzz phrase is SQL, short for Structured Query Language and pronounced "sequel". In the same breath as talking about SQL, people also talk about relational databases. This is because SQL is supposed to be the standard language for relational databases. Of course it's nowhere near that simple, even when you know what relational databases are.

Computer company Oracle recognises the confusion which cripples its industry and organises occasional briefing seminars. These are intended to help journalists understand what they are writing about, and people turn up because Oracle makes a point of not plugging any brand products. The latest was on SQL and relational databases. Some useful background information emerged.

A database is a collection of information like an address list, through which search software can hunt for entries that fit a specified requirement eg, names beginning with "S" and ending with "Y", and born since 1960.

The information in the database is stored, retrieved and modified under the control of a DataBase Management System, or DBMS. The earliest DBMS programs were called "hierarchical". The data had to be structured like a family tree, which is very restrictive. Then came "network" DBMS software, which lets different lines in the family tree cross-interconnect.

Around 1970 an IBM researcher called Ted Codd came up with the idea that databases should be "relational", which in plain English means that they should be organised like two dimensional tables, ie as on paper. Whereas in hierarchical and network systems there are fixed paths between different entries, in a relational database the search software matches entries from one table with entries in another.

On the face of things, it sounds far more sensible to build up a database in this way, from tables, instead of pathed trees. The computer industry did it the hard way first time round because it is quicker and easier to search along pre-determined paths then hunt through lengthy tables. But now hardware and software technology has made the commonsense approach practicable.

Think of it this way. A pathed database is very efficient at doing some things, but very inefficient at doing others because it relies on roundabout search routes. A relational database is flexible, and is equally inefficient at doing everything, so early systems were painfully slow. Modern technology provides the speed.

SQL is a computer language, developed by IBM in 1974, which tells relational database management systems what to do. It bridges the gap between desk top PCs, minis and mainframe computers, using different database management systems. It lets a central database search out and "serve" selected pieces of data, when called up by different work stations in a computer network.

To work really efficiently, the calling computers should be running under an operating system which allows multitasking, ie handle several different jobs at the same time. The current standard operating system, Microsoft's MS-DOS, does not allow multitasking. It can only do one thing at a time.

Bell Labs in America developed an operating system called UNIX, which allows multitasking and there is a version, called XENIX, which is suitable for use on PC.

But XENIX is incompatible with many networking systems and the computer industry pins its faith on OS/2, a multitasking operating system which Microsoft developed as a long term replacement for MS-DOS. So far the world is still waiting for a finished, bug-free, version of OS/2. But with IBM backing the system for its PS/2 new range of computers, you can be sure that OS/2 will eventually happen. That's when SQL and relational databases will really take off. And this explains why so many computer software companies are now claiming that their databases are relational and run under SQL. If only it were all that simple.

No-one seems quite sure how to define what exactly makes a database relational. The concepts are too esoteric to grasp. Ted Codd left IBM, became the guru of relational databases and drafted twelve rules which were supposed to settle the argument once and for all. Many people find the rules muddled, so Codd is reputedly working on a new set, which will run to around two hundred. Whether this simplifies the already confused argument over concepts, remains to be seen.

There are another twelve rules, written by another ex-IBM researcher, Chris Date, which define the difference between a database which serves whole files (a file server) and selected information (a database server) to network stations in a "distributed database". Codd and Date have now teamed up to offer a consultancy service for people who are thoroughly confused by their rules.

Oracle claims to have produced the first commercially available SQL-based relational system, in 1979. Others, including IBM, followed. SQL is now accepted as the industry standard. But the computer industry does not treat standards like any other industry. There are what the industry tactfully describes as different "dialects" of SQL. Different software houses have made different enhancements to SQL, which means that there is no guaranteed compatibility between different databases.

A rock solid SQL standard is at least two years away. And even a rock solid SQL standard won't solve all the problems, because programmes will seldom run on all computers, eg dBase IV won't run on a VAX, and there is physical incompatibility between different networking systems.

The best we can hope for is that there will be reasonable compatibility in the future between systems running on MS-DOS and OS/2.

Continued on page 47

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SILVER JUBILEE YEAR PE 25 1964-1989

INTEGRATING VACUUMS

When was the last time you saw a vacuum valve? Chances are that of recent years you've probably seen very few and, with the rare exception, seldom seen circuits using them published in the hobbyist electronics press. Heated vacuum valves have been largely ousted by solid state devices. Valves are now used in only a handful of specialist applications, such as in high power radio transmitters, electron microscopes, as display tubes for tvs and scopes, and, of course, for pleasing those audio enthusiasts who believe that valve amplifiers can produce a far more pleasing sound.

It may surprise you, then, to learn that valves may well make a come back and soon compete with solid state devices. A number of scientists in groups around the world are actively researching into a new concept in the field of valve technology. For example, there is one such team at GEC's main research laboratory in London. Led by Dr Rosemary Lee, this team is taking advantage of the recent rapid developments in silicon processing techniques to produce valves that are comparable in size to semiconductors. Indeed, GEC's team believe that it is quite feasible to expect the introduction of devices having one million valves on a single square centimetre of silicon.

Normal thermionic valves have three main elements – cathode, anode and a heater, all enclosed in an evacuated glass envelope. The new generation of valves will differ greatly. Whereas thermionic valves only emit electrons when the cathode is heated, the new valves work on the field emission principle. In other words, they are cold cathode devices from which electrons can be literally dragged from the cathode surface by a suitable electrical potential. One advantage is that there is no warm-up time; another is that the devices can yield much greater current densities, so allowing higher operating frequencies and faster switching.

Currently, GEC's experimental devices are fabricated onto a 16-pin dil package and then, for experimental purposes, installed in a large vacuum chamber. This comprises a large stainless steel sphere with observation ports and a variety of probes connecting the chip to an external control panel. In commercial production, numerous elements will fabricated and evacuated together within their device package.

One problem GEC are attempting to resolve is that of surface contamination which affects the field's emission characteristics. With the test device in the vacuum chamber a scanning electron microscope is used to examine the cathode surface. This enables visual records to be made of any breakdown in the electrodes and to relate the results against known timing factors.

There is much more research to be carried out before the new valves will become commercially available, but it is expected that they will ultimately find many applications. They could perhaps replace almost any hot-cathode electron source for which thermionic valves are normally used. They could also have great potential for use as flat tv displays, and since they are capable of operating in high temperature environments, they could even be used for monitoring conditions within jet engines.

They appear to be yet another revolutionary device that will have an impact on the 1990's.

THE EDITOR

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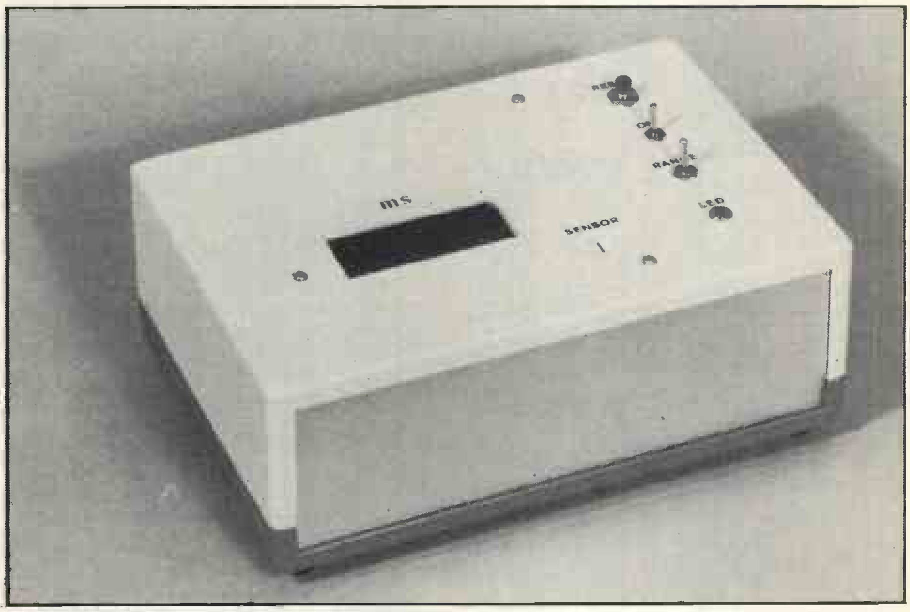
SHUTTER TIMER

BY ROBERT PENFOLD

TIMELY EXPOSURE

Any serious photographer knows that for given film speeds and lighting conditions, correct exposures can only result from the precise setting of the relationship between shutter speed and aperture. The latter can be finely adjusted, but only if you know the exact speed of the shutter.



There have been countless articles describing items of electronic test equipment, but the vast majority of these have been for equipment to test electronic components or circuits. In industry electronic test gear is used to check just about anything and everything, and it is not restricted to such instruments as multimeters, oscilloscopes, capacitance meters, and other devices for purely electronic testing. Many of these specialised types of test equipment are so specialised as to be of no practical interest whatever to the home constructor. However, there are a few devices in this field which make interesting and useful projects. This includes the unit featured here, which is a shutter timer that can be used to check the timing accuracy of camera shutters.

The unit has a three digit led display with an overflow indicator. It has two measuring ranges of 0 to 99.9ms and 0 to 999ms. Most cameras have shutter times from about 1/15th to 1/500th of a second, and are fully catered for by these ranges. Some upmarket cameras have a very wide range of shutter speeds, and the unit might not cater for all of these. In particular, a few cameras now have very long maximum manual speeds – some four seconds in the case of my Pentax LX cameras for instance. Obviously the unit will enable most of the speeds to be checked on cameras of this type, and even the slow speeds can be checked quite well by counting off the whole seconds and then using the "overflowed" timer to indicate the fraction of a second to the nearest millisecond.

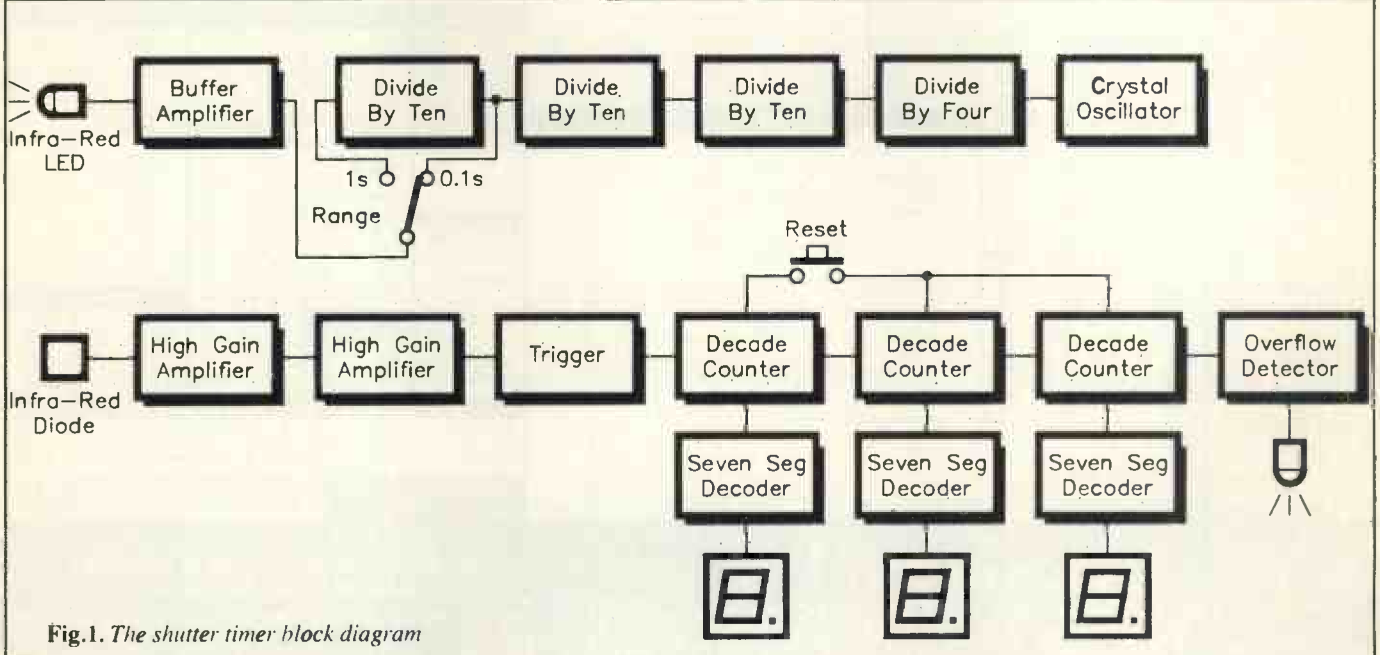


Fig.1. *The shutter timer block diagram*

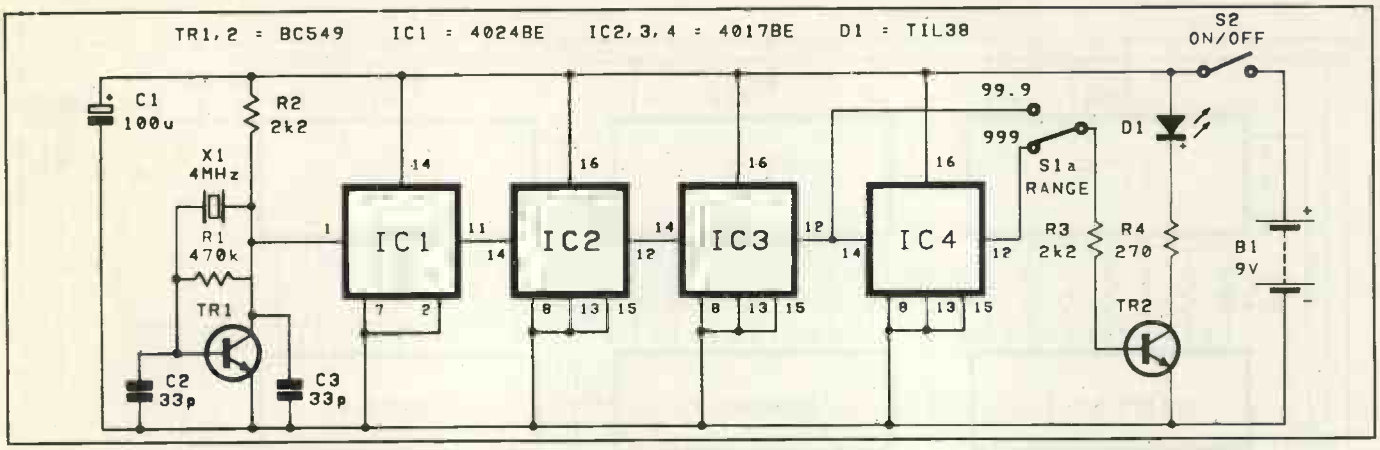


Fig.2. *The pulse generator circuit diagram*

SYSTEM OPERATION

There are various ways of obtaining the desired action from a unit of this type, but they boil down to what are really just two basic approaches. Either the shutter can be used to produce a gate signal for a conventional digital timer circuit, or the shutter can operate directly as the gate circuit of a conventional timer. No doubt either method can be made to work well, but the second method is the more simple, and is the one adopted for this unit. The block diagram of Fig. 1 shows the general arrangement used in the shutter timer project.

The unit really consists of two separate circuits: one to generate infra-red pulses and one to count them. The pulse generator circuit is based on a 4MHz crystal oscillator, and this feeds into a divider chain. A divide by four circuit followed by three divide by ten stages gives an overall division rate of 4000, and a final output frequency of 1kHz. This provides the 0 to 999ms range, but by omitting the last divider stage a 10kHz signal and a 0 to 99.9ms range are obtained. A range switch is used to select the appropriate output. The pulses are used to drive an infra-red led by way of a buffer amplifier.

It would be possible to omit the last two divider stages in order to obtain a 100kHz pulse signal and a 0 to 9.99ms range. One problem in doing this is that the photo-cells in the circuit do not operate well at such a high frequency, though a few experiments with the prototype equipment tended to suggest that they may sometimes be usable at this frequency. Another problem is simply that it is difficult to arrange things so that the extra theoretical resolution would actually be realised. The problems involved with measuring fast shutter speeds are discussed later.

The other section of the unit is a circuit that picks up the infra-red pulses and counts them. The weak output from an infra-red detector diode is fed to a two stage high gain amplifier and then to a trigger circuit. This gives a squared signal at logic levels which can be used to drive the counter circuit. The latter is a simple three stage type consisting of three decade counters, seven segment decoders, and led displays. The last stage drives a simple overflow detector circuit, which is basically just a set/reset flop/flop driving a led indicator. The counter is automatically reset to zero at switch-on, and there is also a manual reset control.

In use the output from the infra-red led is directed at the photo-diode through the camera's shutter. Assuming that the unit is set to the 0 to 999ms range, and that the pulses are at a frequency of 1kHz, one pulse will be received and counted for each millisecond that the shutter is open, and the required timing action is required. With the pulse frequency at 10kHz there is one pulse received and counted every 0.1ms, reducing the maximum count to 99.9ms but giving ten times the timing resolution.

OPEN AND SHUT

As pointed out previously, there can be problems in obtaining accurate results at fast shutter speeds, and these need to be understood if this unit is to be used to good effect. In order to understand these problems you need to be familiar with the basic manner in which camera shutters function. These days few cameras have "leaf" shutters, which are actually in the lens and are a form of iris mechanism. These usually have a top speed of 1/500th of a second, or as little as 1/125th of a second for the large shutters (as used on "long" 5 x 4 camera lenses etc). Accurately measuring the faster speeds on this type of shutter is not usually difficult.

Most modern, small cameras, plus a few larger types, have focal plane shutters. As the name implies, these are at the plane of focus, or to be more precise, just in front of it (just in front of the film in other words). This type of shutter utilizes a twin curtain arrangement. When the shutter is activated, the first curtain is drawn across and opens the shutter. After the appropriate time has elapsed the second curtain moves across and closes the shutter. The two curtains are then drawn back across to their original positions when the shutter is cocked.

This explanation of a focal plane shutter is idealised in that the curtains take a relatively long time to fully open and close the shutter. As a result of this, at fast shutter speeds the second curtain starts to close the shutter before the first one has fully opened it. In effect, a narrow opening is moved across in front of the film, and the faster the shutter speed, the narrower the slit is made. At very fast shutter speeds the slit might be no more than a few millimeters across. This may seem to be a rather crude way of doing things, but it seems to be the best modern technology can offer at a reasonable price, and for most purposes it works well enough. The maximum flash synchronisation speeds of most cameras are quite low, at typically about 1/30th of a second to 1/125th of a second. The reason for this is that at higher speeds the shutter is never fully open, and only part of the film will be exposed when the flash fires. You can judge from these low flash synchronis-ation speeds just how narrow the slit needs to be at a shutter speed of around 1/100th of a second.

This may all seem to be of academic importance when testing shutter speeds, but it is in fact a crucial factor. If the led used as the source of the infra-red pulses is a standard type, and the infra-red detector device has a similar diameter, this means that the effective width of the infra-red beam might not be very much different to the width of the slit provided by the shutter at its fastest speeds. Take an extreme example where the width of the beam is equal to the 36 millimetre width of the frame. The system can be set up so that the counter only functions when the shutter is fully opened, or it can be set up so that the slit obtained on high shutter speeds lets through sufficient infra-red to activate the system. Either way the results are invalid. With the first method the shutter is never fully open on high shutter speeds, and so the counter would not operate at all on these speeds. With the second method the counter would operate for the time taken for the slit to travel from one side of its run to the other. This would give measured times that were greatly elongated.

It is this second method that has to be adopted, but the narrower beam provided by the led helps to minimise the "smearing" of the gated signal. Even so, the error on

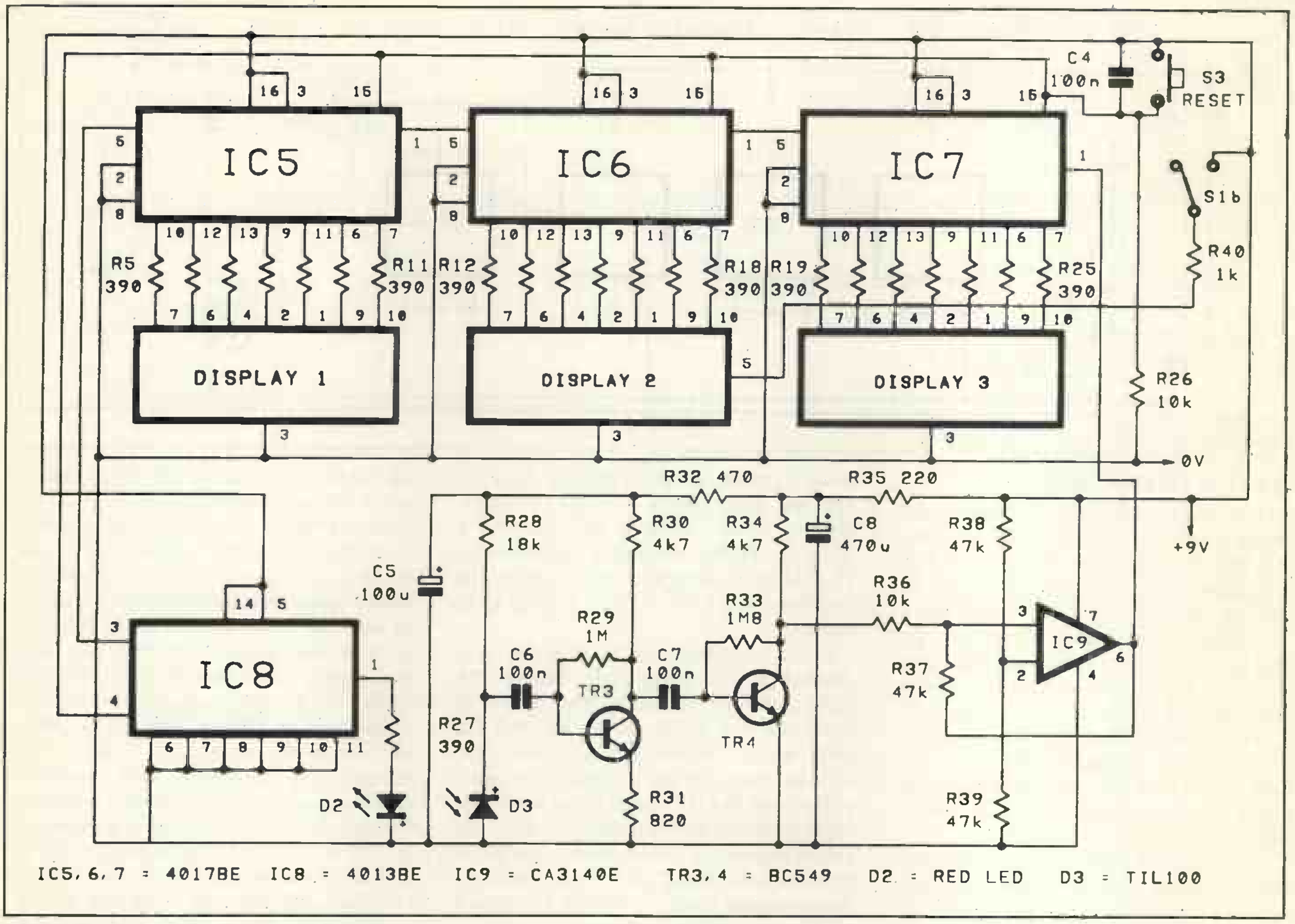


Fig.3. *The counter circuit diagram.*

shutter speeds of around 1/1000th of a second can be something approaching 100%! Ideally the infra-red beam would be infinitely narrow, but this is obviously not achievable in practice. However, the system has been made far more sensitive than the minimum requirement, and this makes it possible to mask the photo-diode down to the point where the beam is effectively just a very narrow slit, only about a millimetre wide. This gives greatly improved accuracy on the higher shutter speeds.

CIRCUIT OPERATION

The circuit diagram for the pulse generator section of the unit appears in Fig. 2 – the counter circuit is shown separately in Fig. 3.

TR1 operates as a conventional crystal oscillator. There is no means of trimming the operating frequency of the circuit to precisely 4MHz, but the error should be so small as to be of no significance on a three digit instrument. IC1 is the divide by four circuit, and this is a seven stage binary counter. In this circuit only the first two stages are utilised. IC2 to IC4 are the divide by ten stages, and these are identical. They are based on 4017BE one-of-ten decoders, but in this case only the "carry" outputs are used, and the other ten outputs of each device are simply ignored. S1a selects the 1kHz or 10kHz signal, as required, and couples it through to the input of the buffer amplifier. This is a simple common emitter switch based on TR2. R4 sets the led current at about 20 to 25 milliamps, but as the led is switched off for 50% of the time the average led current is only about 11 or 12 milliamps. D1 is the infra-red led, and it is a standard device as used in remote control applications. Although leds of this type are usually operated at currents of around 50 to 100 milliamps, long range is obviously not important in the current application, and a much lower led current is perfectly adequate.

D3 is the infra-red detector diode, and it operates in the reverse biased mode with R28 as its load resistor. The output from D3 is likely to be quite low in amplitude, and two stages of amplification provided by TR3 and TR4 boost the signal to a level where it can drive the trigger circuit reliably. The trigger circuit is a standard operational amplifier non-inverting type with a substantial amount of hysteresis provided by R37.

The counter has three identical stages based on IC5 to IC7. These are cmos 4026BE decade counters which have built-in seven segment decoders and led drivers. The displays are driven via current limiting resistors R5 to R25. Any reasonably efficient seven segment led displays should be suitable, except that they must be common cathode types (not common anode displays). C4 and R26 provide a reset pulse at switch-on, and S3 can be used to manually reset the counter. S1b switches on the decimal point of display 2 when the unit is set to the 99.9ms range. Overflow indication is provided by IC8, which is a dual "D" type flip/flop. In this circuit only one section of this device is used, and it is wired as a basic set/reset flip/flop. It is activated from the "carry" output of the most significant counter (IC5) and it is reset when S3 is operated. On the prototype I used the decimal point of the most significant display (display 1) as overflow indicator led D2, but obviously a panel led could easily be wired in here if preferred.

The current consumption of the unit is inevitably quite high due to the use of the led display. The exact consumption is largely dependent on the number of display segments that are switched on, but it is unlikely to be much under 100 milliamps on average. The unit must be powered from a high capacity 9 volt battery such as a PP9 type or six HP7 size cells in a plastic holder.

CONSTRUCTION

With the only exceptions of the battery, infra-red led D1, and the controls, all the components fit onto the printed circuit board. Details of the board are provided in Fig. 4.

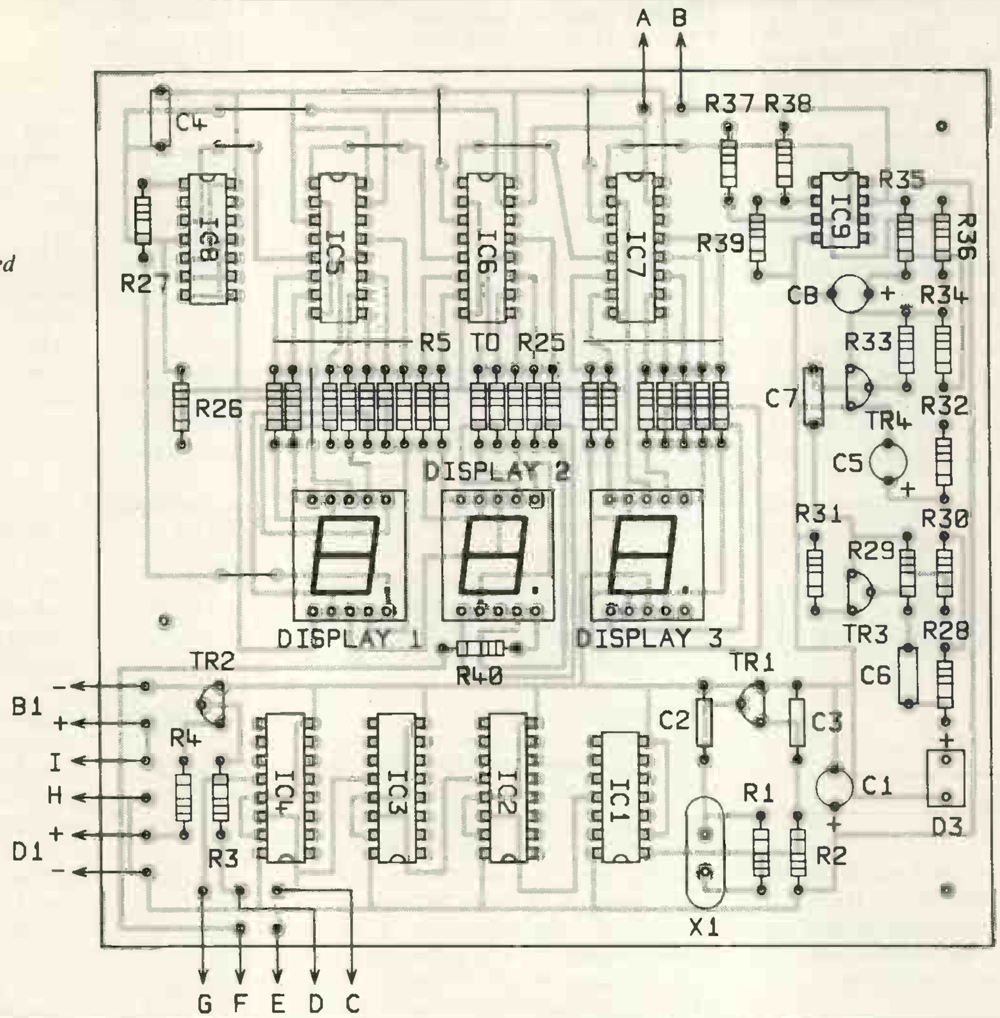


Fig.4. *The printed circuit board component layout*

The first point to note is that all nine integrated circuits are mos input types, and that they consequently require the standard anti-static handling precautions to be observed. In particular, they should all be fitted in sockets, and should not be fitted into the sockets until construction of the unit is in all other respects finished. When fitting the integrated circuits handle them as little as possible (especially their pins) and keep away from any obvious sources for static electricity. Note that the two rows of integrated circuits have the opposite orientation to one another.

I would also recommend that the three displays should be fitted in sockets. Suitable sockets do not seem to be available, but it should not be too difficult to improvise something. Soldercon pins offer one possible solution to the problem. The alternative method I use is to cut a 14 pin dil ic holder into two seven way sil strips, and to then remove the end pins of each strip. This gives two 5 pin sil holders which will readily fit onto the board, and into which a display will plug without difficulty. Apart from the fact that some leds are easily damaged by heat when soldering, the use of holders helps to raise the displays so that they are clear of all the other components on the board. This is important, as it will otherwise be impossible to mount the board in such a way that the displays are immediately behind the display window cut in the front panel of the case. The printed circuit board is suitable for standard 0.5 and 0.56 inch common cathode led displays, but other sizes might be unsuitable. In particular, the standard 0.3 inch displays have a totally different pinout arrangement and are unusable with this board design.

There should be no difficulty in fitting the crystal onto the board provided it is a miniature wire-ended type. I would advise against the use of any other type. Similarly, the three polyester capacitors should fit into place easily provided they are miniature (7.5 millimetre pitch) printed circuit mounting types, and the use of alternatives is not recommended. D3 is mounted with its sensitive surface (the large surface opposite the one which carries the type number and other markings) facing towards the nearby edge of the board. It is then bent over at right angles so that the sensitive surface is facing upwards. D1 is mounted off-board, and is connected to the board via a twin cable about half a metre or so in length. One way of doing this is to simply drill a small entrance hole for this cable in the front panel, thread the cable through the hole, and then connect it to the board. It is probably worth the small additional expense of making these connections via (say) a 3.5 millimetre jack plug and a matching socket mounted on the front panel. Be careful not to get the connections to D1 swopped over somewhere along the line. It is unlikely that this would result in any damage to the components, but obviously the unit would fail to work until the error was rectified.

Be careful not to overlook any of the link wires. There are eight of them (seven above the counter chips and one just to the left of display 1). At this stage printed circuit pins are fitted to the board at the points where connections to the off-board components will eventually be made.

A case about 205 by 140 by 75 millimetres was used for the prototype, but this is somewhat larger than is absolutely necessary. The printed circuit board is bolted in place behind the front panel, or fitted on stand-offs. Either way it must be spaced off the front panel by a sufficient amount to hold the displays just clear of the front panel. A rectangular display window must be cut in the front panel at the appropriate position, and this can be done using a fret-saw or coping saw. A piece of red window material is glued in place behind the cutout, taking care not to smear any of the adhesive over the window material. A narrow slit must be cut in the front panel just in front of D3. Rather than cutting a narrow slit in the panel, it might be easier to drill a large hole and then mask this off on the rear side of the panel using pieces of thin opaque material (card, plastic, etc.). Using a temporary adhesive (such as Bostick or Blue-Tack) you can then experiment with various apertures in an attempt to find one that gives a good compromise between sensitivity and accuracy. Having found the optimum width the two pieces of opaque material can then be permanently glued in position.

The three controls are mounted at any convenient places on the front panel, and then they are wired to the printed circuit board. This wiring is shown in Fig. 5, which should be used in conjunction with Fig. 4.

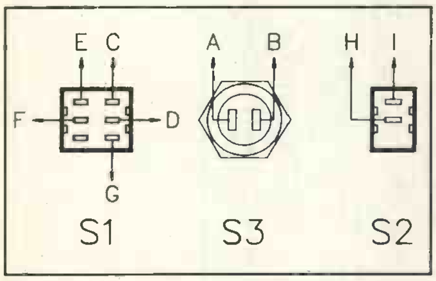


Fig.5. *Control wiring.*

IN USE

When the unit is switched on the display should read "000", and aiming D1 at D3 should result in the counter operating at the appropriate rate. If the counter fails to operate properly, switch off at once and recheck the wiring.

Assuming all is well, aim D1 away from D3 and reset the counter using S3. Setting up the system with the camera and D1 in the right position will probably take a little ingenuity. With cameras that have removable lenses it is generally easier if the lens is removed. There is then no need to bother about adjusting the setup to avoid any dispersion of the infra-red beam that could prevent the unit from functioning properly. If the unit must be used with the lens in place, use it on maximum aperture and make sure D3 is reasonably close to the film plane. There should then be no difficulty in obtaining good results with any

Marked Speed (s)	Equivalent Time (ms)
1	1000
1/2	500
1/4	250
1/8	125
1/15	66.6
1/30	33.3
1/60	16.6
1/125	8
1/250	4
1/500	2
1/1000	1

Equivalent shutter speeds.

reasonably short focal length lens fitted to the camera. If the camera has a removable back it is a good idea to unclip this as well. With any camera try to avoid touching any part of the shutter mechanism, which is almost certain to be very delicate. Seriously damaging the shutter of some cameras can result in a repair bill for an amount greater than the value of the camera!

The camera might need to be placed on something in order to bring it to a suitable height so that its shutter is immediately in front of D3. A few magazines or a book should suffice. D1 can be held in position manually, but it is much easier if it can be clipped in place. It would probably not be too difficult to make up a simple mechanical arm to hold it in place, but I just used a "helping hands" tool which was to hand. Everything must be set up so that the counter operates reliably when the camera's shutter is open, and the "T" or "B" setting of the camera can be very useful when initially setting things up.

When everything is ready, reset the counter using S3, and operate the camera's shutter. Where possible the 99.9ms range should be used as this provides much better resolution and accuracy than the 999ms range. Camera shutters do not seem to be metricated, and still have speeds that are normally in the form of fractions of a second. The table of marked speeds versus equivalent times in milliseconds should be helpful when using the unit.

COMPONENTS

RESISTORS

R1	470k
R2,R3	2k2 (2 off)
R4	270R
R5-R25,R27	390R (22 off)
R26,R36	10k (2 off)
R28	18k
R29	1M
R30,R34	4k7 (2 off)
R31	820R
R32	470R
R33	1M8
R35	220R
R37-R39	47k (3 off)
R40	1k

All resistors 1/4W 5%.

CAPACITORS

C1,C5	100µ 10V radial elect (2 off)
C2,C3	33p polyester (2 off)
C4,C6,C7	100n polyester 7.5mm pitch (3 off)
C8	470µ 10V radial elect

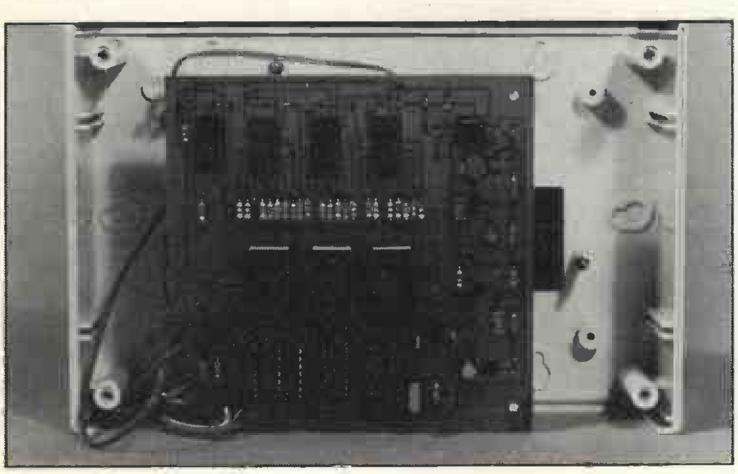
SEMICONDUCTORS

IC1	4024BE
IC2-IC4	4017BE (3 off)
IC5-IC7	4026BE (3 off)
IC8	4013BE
IC9	CA3140E
TR1-TR4	BC549 (4 off)
D1	TIL38
D2	red led (see text)
D3	TIL100
Display 1,2,3	0.5 or 0.56 inch common cathode led (3 off)

MISCELLANEOUS

S1	dpdt miniature toggle
S2	spst miniature toggle
S3	push to make, release to break
B1	9 volt (ie, 6 x HP7 in plastic holder)
X1	4MHz HC-49/U crystal

Printed circuit board, 8-pin dil ic holder, 14-pin dil ic holder (5 off), 16-pin dil ic holder (6 off), red display window material, case about 205 x 140 x 75mm, printed circuit pins, wire, solder, etc.



Interior of unit showing PCB in position

Quite large margins of error are not necessarily indicative of a faulty shutter. Most shutters are not designed for a very high degree of accuracy, and do not have to be. A 10 to 20% error will not have a very large effect on the exposure, bearing in mind that an increase of one stop requires the shutter time to be increased by 100%. A common problem with purely mechanical shutters is a slowing up with age (I know how they feel). The shutter timer should clearly show up any fault of this type. Another problem which is common on badly worn shutters is inconsistent timing. Taking a number of timings at each shutter speed should again show up any problem of this type. PE

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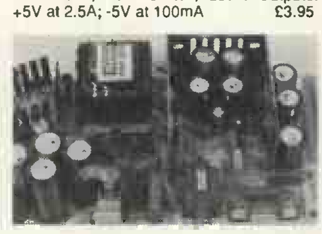

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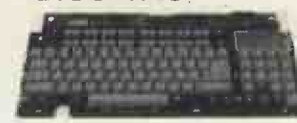

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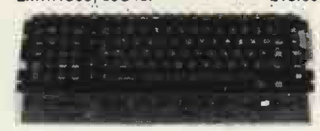

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SEMICONDUCTORS

BY ANDREW ARMSTRONG

PART 14 – Audio Circuits

The most obvious opamp circuit is not always the best. Here are some straightforward applications, and some which are obvious only after you have seen them.

One important aspect of an opamp's specification is whether or not it is unity gain stable. Unity gain stable means that the opamp will not oscillate when 100% negative feedback is applied, ie when the inverting input is connected directly to the output. Some opamps are only rated to be stable with a certain minimum gain, and if they are used at a lower gain, they will oscillate at a frequency determined by the internal phase shifts of the device.

These phase shifts are caused by stray capacitance in each of the stages of the opamp. A major cause is the collector/base capacitance of transistors providing voltage gain. If only one stage had caused significant phase shift, then there would be no problem, but the phase shifts of several stages can add to give sufficient phase shift to cause oscillation (180° when using negative feedback).

Obviously gain rolloffs are associated with the phase shifts. If the phase shifts with their corresponding gain reductions take effect at different frequencies, then oscillation is unlikely. Therefore, a means of preventing oscillation which is often employed to make opamps unity gain stable, is to impose a deliberate rolloff at a frequency below that at which the unintended phase shifts become serious. This lowers the overall gain of the device at the higher frequencies at which oscillation could otherwise take place, and it is this deliberate rolloff which gives rise to the almost constant 90° phase shift which most opamps exhibit over a significant frequency range.

FEEDBACK PHASE

It is not immediately intuitively obvious how it is that the output of an opamp used with negative feedback is apparently in phase with the input signal, rather than lagging by 90° as the phase/gain plot might suggest. To understand the reason for this, we must remember that the gain of the opamp is finite and that the output voltage is equal to the voltage between inverting and non-inverting input terminals multiplied by the gain and phase response of the device. All that would be necessary to make the output waveform in phase with the input waveform, if the amplifier had 90° phase shift at the frequency in question, would be a very small resultant quadrature signal between the inverting and non-inverting inputs.

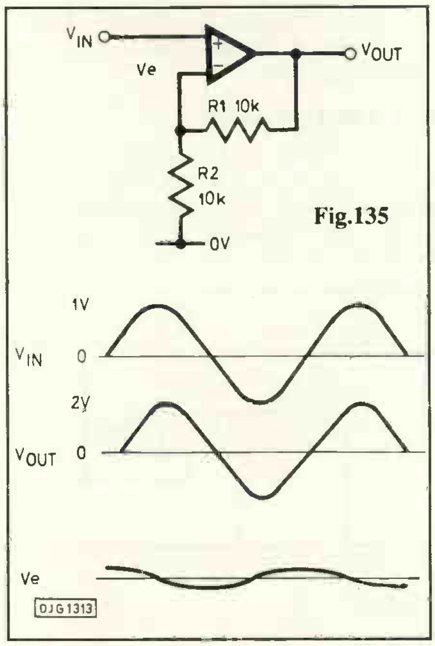


Fig.135

In practice, because of the finite gain, the output waveform lags the input by a small amount. This phase lag is normally insignificant, but in some applications it can cause problems. And yes, the error signal really is more or less in quadrature. This effect is illustrated in Fig. 135.

Another effect associated with phase shift in opamps is the time delay between input and output signals. Time delay is distinct from phase shift, though it manifests itself as a specific phase shift at any specific frequency. The way to measure time delay would be to apply a square wave to the input of the opamp and measure the time between edges on the input and the output.

TONE SHAPING

Not all audio circuits require that the opamp should be unity gain stable, but the circuit of Fig. 136 would oscillate at certain settings if the opamp were not unity gain stable. This is a fairly conventional Baxandal tone control circuit. This circuit is so widely used, and so well known, that I don't think I have seen its operation described.

The circuit can be considered as two halves. At high frequencies the impedance of C2 and C3 is very low, so that VR2 is effectively shorted out, and its position does not matter. VR1, on the other hand, is not shorted out, and is connected to the opamp via C1, whose impedance is relatively low at frequencies in excess of 10kHz. At such high frequencies, the effective circuit works like the simple gain controlled circuit shown in the inset.

At medium frequencies the impedance of C1 is much higher than that of R3, so that the position of VR1 has little effect. VR2, however, is still effectively shorted out because the values of C2 and C3 are much higher than that of C1, so VR2 doesn't do very much either. At mid frequencies the circuit works as a unity gain inverter.

At low frequencies VR1 is still unable to affect anything, while the increased impedance of C2 and C3 below, say 300Hz allows VR2 to affect the gain. At low

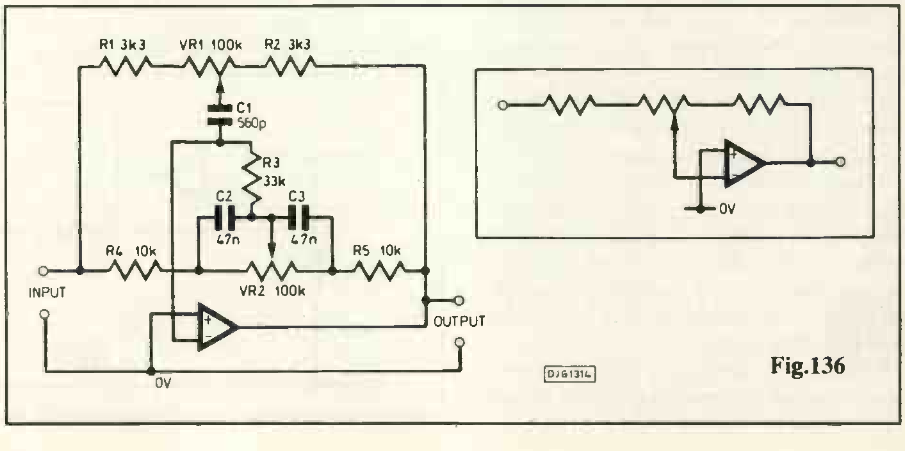


Fig.136

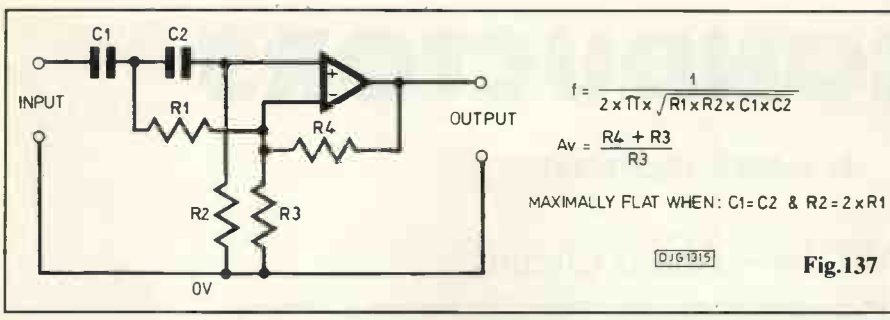


Fig.137

frequencies, the circuits works once again like the circuit shown in the inset.

Another useful audio frequency shaping circuit is the high pass or low pass filter.

There are many configurations available, but one of the most common ones is shown in Fig. 137. This circuit is for a vcvs (voltage controlled voltage source), high pass filter. If C1 = C2 and R2 = 2 x R1, then the response is as sharp as it can be with this configuration, without actually having an overshoot. This would be described as maximum flat. Raising the value of R2 relative to R1 would introduce a peak at the turnover frequency.

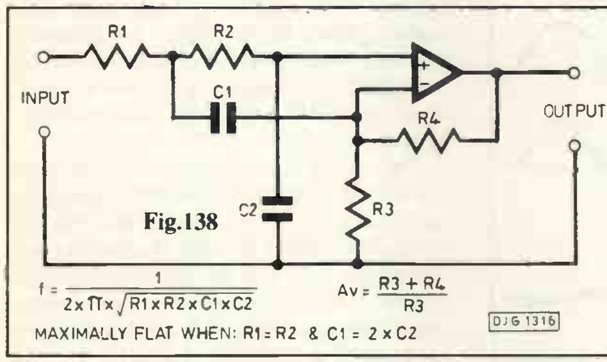


Fig.138

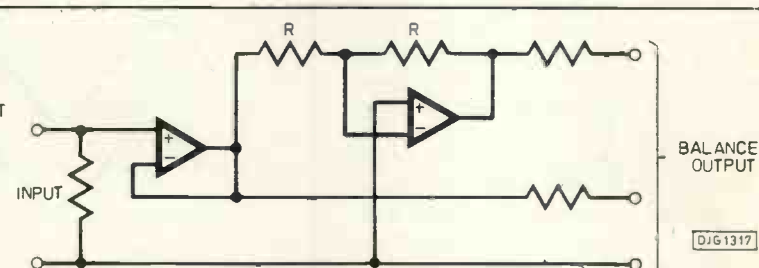


Fig.139

The circuit shown here has a voltage gain, and as far as this aspect of the circuit is concerned, it is just the same as Fig. 135. All that is required to make the circuit work is a unity voltage gain at a low impedance to drive the right hand end of R1. Therefore, if the circuit is required to provide voltage gain, the value of R3 in parallel with R4 should be much less than the value of R1. In many applications, voltage gain is not required, in which case R3 would be omitted and R4 replaced by a direct connection.

This circuit as it stands can be used for frequency response shaping, communications, or to filter out rumble or subsonics when using a conventional pickup and turntable.

The low pass equivalent of this filter is shown in Fig. 138. In this circuit, capacitive reactance has been replaced by capacitive reactance. Therefore, to obtain the maximally flat response, C1 = 2 x C2, because doubling the value of a capacitor halves its reactance. The gain is of course given by the same formula, and interestingly enough the formula for frequency response is the same for either circuit.

A simple way to obtain a slightly sharper cutoff in either of these circuits is to design the active filter to produce a slight peak in the response, at the cutoff frequency, and to precede the active filter with an r/c passive filter chosen to just cancel the peak. The rolloff will then be somewhat sharper, and this can be valuable in filtering out subsonic noise from a record turntable without spoiling the music.

BALANCING ACT

In professional audio applications, when signals have to be sent over long distance, balanced rather than single-ended line drivers and receivers are used. The advantage of this is that any interference picked up is likely to be common mode, while the signal is differential mode. If the circuitry at the receiving end is designed to respond to differential mode signals, but to reject common mode ones, then interference can be rejected. Done properly, this can reduce both mains hum and the awful buzzing noise generated by triac controlled lights.

A simple circuit to generate a balanced output is shown in Fig. 139. This employs an input buffer, followed by a unity gain inverter, to provide the differential drive. Output resistors are included to give approximate matching to the line. This circuit is quite acceptable in many applications, but in some cases the extra time delay imposed by the inverter will lower the effectiveness of the system. Fig. 140 shows a circuit which gets around this problem, by using an extra opamp as a non-inverting buffer to equalise the time delays.

Receivers are almost always more difficult to design than transmitters, and line receivers are no exception to this rule. The obvious design is a circuit like that of Fig. 141, but with equal resistors throughout. A moment's thought shows that this is not good enough, because the input impedance to the non-inverting input is R3+R4, while the input impedance to the inverting input is apparently R1.

The next most obvious idea is to make R1 and R2 twice the value of R3 and R4. This is nearer to giving equal impedance on both inputs, but it is not correct if equal and opposite signals are applied to the two inputs, A and B. Following the reasoning through, the signal amplitude at point C is half that at point B. The action of the opamp with its negative feedback is to make the inverting input track the non-inverting input, so that the waveform at point D is similar to that at point C.

The effective input impedance under these conditions is the impedance to the point on the input resistor at which the signal amplitude is zero. This is illustrated in Fig. 141 by the way that R1 is drawn in two parts. At point E, the junction of the two resistors, the signal from point D and the input signal from point A cancel. Under these conditions point E is effectively at earth potential, and the input impedance seen at point A is the same as if the right hand end of the 24k resistor were connected to 0V. This circuit exhibits a 48k input impedance across the lines, *but only when the signals on points A and B are equal in amplitude and opposite in phase.* Input B always has an input impedance of 24k, but

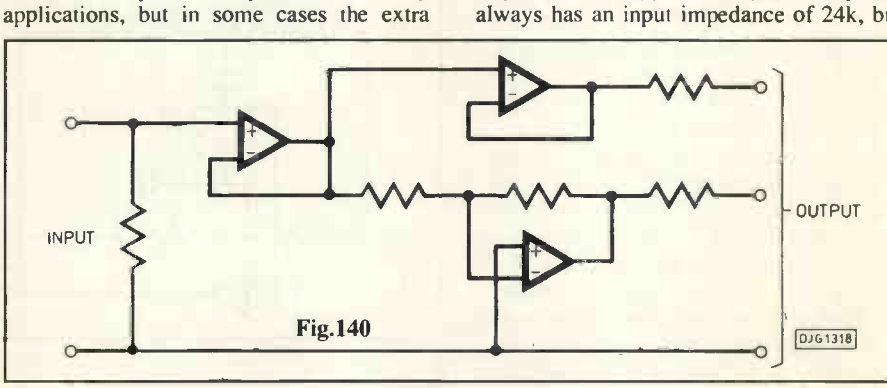


Fig.140

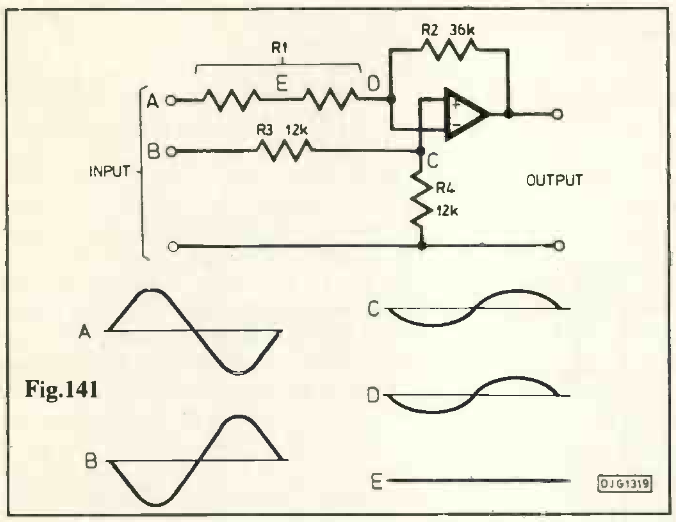


Fig.141

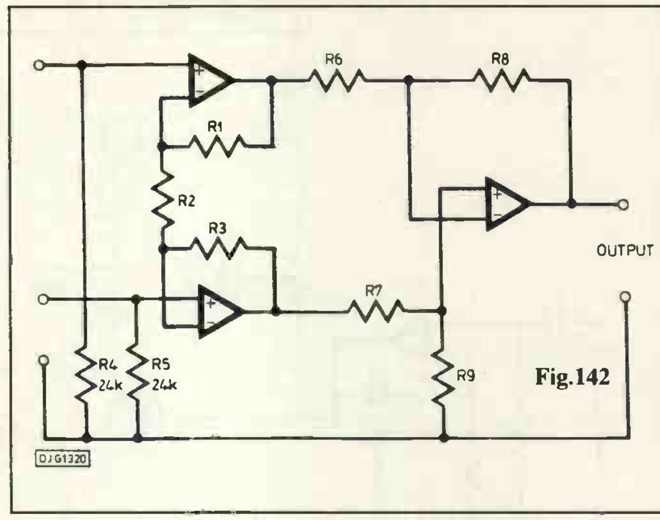


Fig.142

input A has an effective impedance of 24k if the circuit is used in true differential mode, and 36k if no signal is applied to input B.

There is another aspect of the performance of this circuit which is not ideal. Though, in theory, it rejects all common mode signals, two things reduce the effectiveness of this function of the circuit. First of all, the effective input impedance of input A to a common mode signal is quite different from the impedance of input B. Secondly and more seriously, common mode signals are only rejected to the extent to which the gains of the two inputs are matched.

If we assume for a moment that the line is of negligible impedance, so that the total resistance in series with the inputs of the opamp is that shown on the circuit diagram, then the gains from each input are as follows:

From input A, gain = R4/(R4+R3)x(R1+R2)/R1

From input B, gain = -R2/R1.

If the ratios of R 1 to R2 and R3 to R4 are not identical, then the gain from each input is different. This means that common mode input signals do not cancel, and there is a common mode gain equal to the difference in the two gain figures. The common mode rejection is equal to this net figure divided by the differential mode gain. Using practical resistor tolerances, such a circuit may achieve a low frequency common mode rejection of -30dB, though the figure quoted for the opamp itself may be around 100dB. At higher frequencies stray capacitances and imperfections in the opamp will reduce the rejection still further.

The circuit of Fig. 142 gets around this slightly insanitary situation by buffering each input in a circuit which may have a high differential gain, but only has a common mode gain of 1. Thus, if an input differential gain of 10 is used, the overall common mode rejection of the circuit is improved by approximately 10dB. The matching of R1 and R3 is not critical to achieving the common mode rejection, though the differential gain relative to each input will be slightly different if the resistor values are different.

In addition, the input impedance on each input is set by the input resistors R4 and R5. Also because the differential amplifier is buffered from the lines, its matching is likely to be better, and this can be improved further at high frequencies by adding trimming capacitors in parallel with R8 and R9.

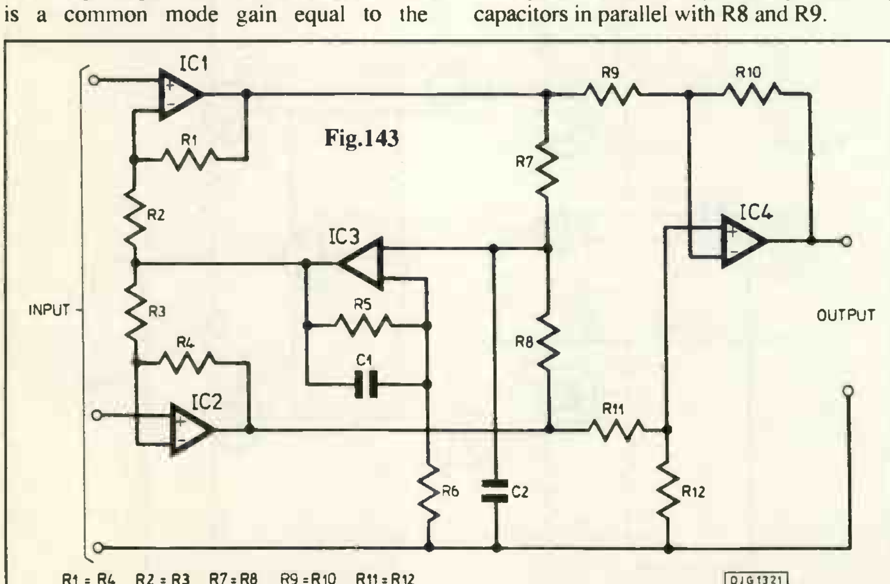


Fig.143

An elaboration of this principle which I have seen suggested recently uses an extra opamp to give a common mode gain of less than 1 in the input stage Fig.143. Common mode signals on the output are amplified and fed back to the inverting inputs of the input amplifiers to cancel the common mode signal. The extent to which this is possible is determined by the gain of IC3, set by R5 and R6.

Almost perfect cancellation could be achieved if R5 were omitted, and the inverting input of IC3 grounded, but it is possible that the imposition of this gain in the feedback loop could cause oscillation. C1 and C2 are included to reduce this likelihood and to trim the high frequency performance. This is a circuit which may be worth experimenting with in situations where the best possible common mode rejection is needed.

AMPLIFIERS

One common application of opamps is in audio amplifiers. In some designs an opamp is used inside the main feedback loop of an amplifier to give a lot of the voltage gain, and to reduce dc offsets on the output of the amplifier. This can be a very effective technique, but unless care and discretion is applied in choosing and using the opamp, the results can be less than hifi.

One of the problems is illustrated in Fig.144. An opamp which may perhaps be unity gain stable is used in a circuit with extra gain and phase shift in the loop. If too much negative feedback is applied then the opamp may, in effect, be being asked to be not just unity gain stable, but negative gain plus extra phase shift stable. It can't be, of course, and oscillates under these

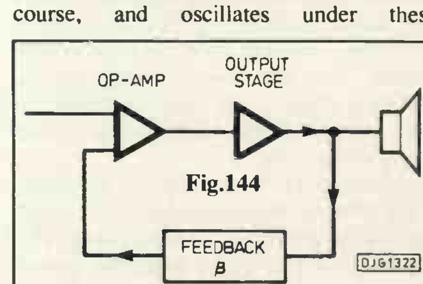


Fig.144

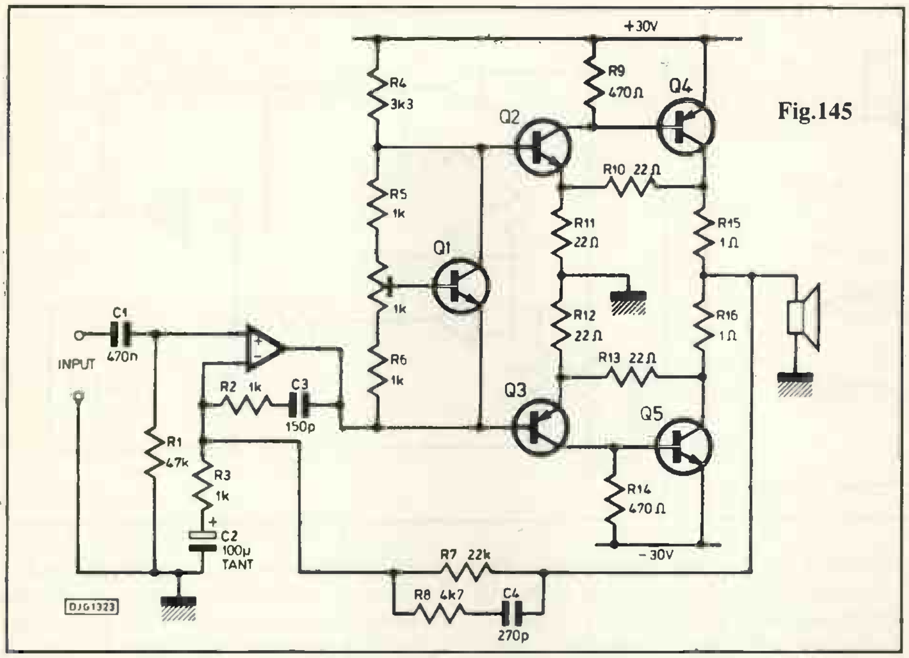


Fig.145

circumstances. To keep the circuit stable, the feedback attenuation must more than counteract the output stage gain. In addition, phase compensation may be needed to keep it to the straight and narrow.

An example of an opamp based power amplifier is shown in Fig.145. The gain of the output stage is set by the feedback resistors R10, R11, R12, and R13. The voltage gain, set by the ratio of these pairs of resistors, is approximately 2. Clearly the value of these feedback resistors must be chosen so that the current through the feedback resistor is a significant proportion of the total feedback in the chain. Or, to put it another way, the emitter currents of Q2 and Q3 must not be the major component of the current in R11 and R12 respectively.

The overall negative feedback in this circuit is frequency dependent. There is 100% feedback at dc, courtesy of C2. At medium frequencies, the feedback is set by the ratio of R3 and R7, while at ultrasonic frequencies the impedance of C4 becomes low enough that the overall negative feedback is increased. At higher frequencies still, C3 has the effect of reducing the local gain at the opamp. The values shown here may not be exactly what experiment would show was required, but they are along the right lines to keep the amplifier stable. Note also that the limited voltage gain in the output stage not only keeps the loop gain under control, but also minimises phase shift in the output stage. This circuit would probably not work exactly as drawn, and in any event it has no output overload protection. It would however form a very suitable first step towards designing an amplifier which could provide twice as much voltage swing on its output as the opamp can provide.

A rather different technique is illustrated in Fig. 146. In this design the output is not taken from the output of the opamp. The output is in fact taken from the power supply pins via Q1 and Q2. The major advantage of this technique is that, once again, one can derive much more output than the opamp is capable of providing. As can be seen, the opamp is run at a constant power supply voltage of ±14.3V. Its quiescent current is more or less constant, and is used to bias Q3 and Q4. The select on test resistors must be chosen for the individual opamp, in order to set the correct quiescent current.

When a signal is applied to the opamp, a current flows in the resistor from the opamp output to OV. This current is supplied by one or other of the power supplied via Q1 or Q2 and results in increased current through Q3 or Q4 respectively. The output current is further boosted by Q5 and Q6 to feed the loudspeaker.

Once again, it is unlikely that this circuit would work exactly as drawn, but the principle definitely does work, and can be highly effective. With a little care in choosing the select on test resistors, the circuit as far as Q3 and Q4 can be made very linear. The principles illustrated here form a good starting point for the intrepid amplifier designer.

If you need a large output swing directly from the opamp rather than via some extra transistors, you don't necessarily have to buy a super high voltage opamp. The circuit of Fig. 147 allows the opamp to give an output swing greater than its power supply rating permits. The power supply rails that the amplifier actually receives are regulated relative to its output voltage at any given moment, so it can climb up and down its own power supply rails. This circuit can be invaluable in certain specialised applications, where the interpolation of extra active stages would degrade the signal intolerably.

It is probable that the circuit as drawn would work, but that it would not perform well at higher frequencies. It is extremely difficult to make this type of circuit work up to the full frequency and slew rate capabilities of the opamp, which fact you could probably have deduced from the law of the conservation of misery. The performance can be improved over that of the circuit as shown, if speed-up capacitors were added in parallel with the zener diodes, or perhaps if some sort of cascode arrangement were used to supply the opamp.

AUDIO QUALITY

Because it is tricky to design this type of circuit for top performances, it is only to be recommended in situations where nothing else will do. It is not normally to be recommended for audio applications, because really low distortion audio amplification demands circuits which are spot-on.

This comment leads on to a consideration of the basic characteristics needed in

Fig.146

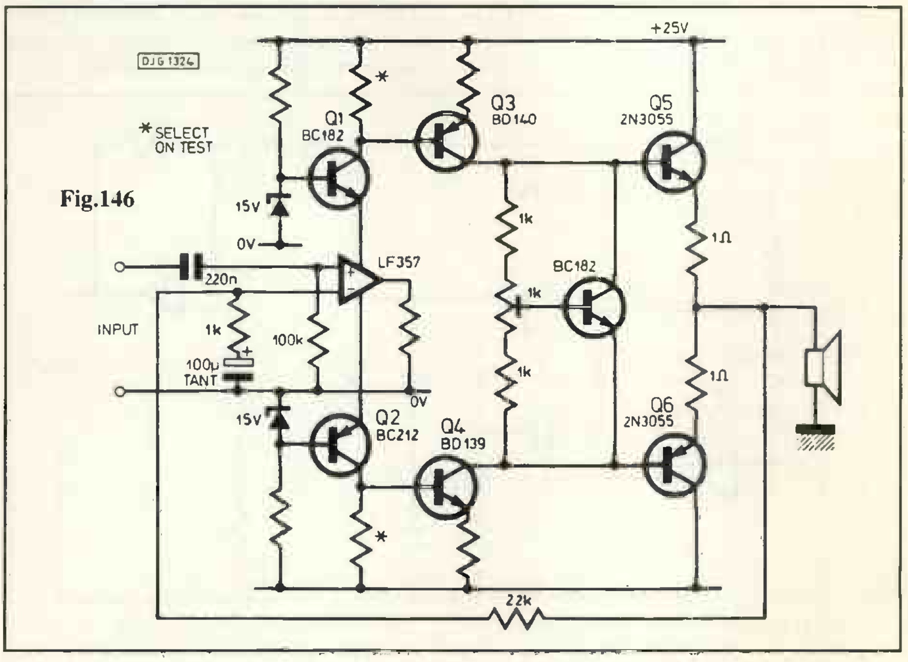
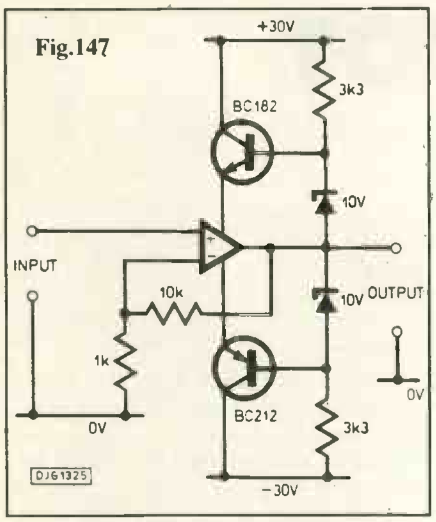


Fig.147



opamps which are to be used for high quality audio. The most obvious requirement is that the frequency response and slew rate should be adequate for full performance of the circuit over the full audio bandwidth. Additionally, the noise figure of an opamp is important in most audio applications.

Though it is less immediately obvious, the inherent linearity of an opamp matters as well. While a circuit may employ enough negative feedback to force the opamp to work linearly, any abrupt discontinuities in its transfer function may manifest themselves as subtle distortion on tricky waveforms. This is one of the many reasons why audio designers are not enamoured of the 741: many implementations of it did not apply any bias at all to overcome crossover distortion in the output stage. This alone is enough to render the device unsuitable for top quality hifi.

Real hifi equipment is of course always operated with plenty of overload margin, and never comes near to clipping. It is nevertheless worthwhile considering what a circuit does if it should be fed with too large a signal. Probably a majority of the opamps which would otherwise be suitable for audio use react very nastily if their common mode input range is exceeded. A common problem is phase reversal in which the tips of a waveform are suddenly inverted instead of being cleanly clipped off. The sound this makes is much more unpleasant than ordinary clipping.

One device which seems to fulfill the requirements for audio use is the dual NE5532 and its single version, the NE5534. Its noise level is low, its slew rate and frequency response reasonable, it is inherently not too non-linear, and it does not suffer phase reversal. For this reason, it crops up in a number of audio designs.

The next and possibly final part in this long running series is intended to cover the use of opamps in other circuits such as oscillators and various types of signal conditioning. Can anyone guess what figure number we shall finally reach? **PE**

SOLAR CAMEL POWER

Reading an extract from a patent report about constant temperature containers, I was reminded of a recent tv sequence in which camels were shown having large solar panels strapped to their backs. Puzzled as to why the "ship of the desert" might be having its hump-stored water supply solar heated, I turned up the sound.

The true fact of the situation was ingeniously interesting. In order to keep medicines and vaccines cool while being transported to oasis settlements they are placed inside huge refrigerated carrier bags strapped to the camel. The power to drive the fridges comes from the solar panels. This keeps them at the constant temperature necessary to maintain the vaccine's efficacy. It has been estimated that, due to damaging temperature changes, normally about 50% of all vaccines are destroyed en route before they reach their intended recipients in developing countries.

I wonder if the camels' tempers are also kept solar cool -have you ever encountered them at close quarters?!

Ed.

THE THOR SPOT

BY WAYNE GREEN

UPDATING THE OPTICALS

The Thor may be setting in for the spring of recordable optical discs, but icy patches still mar the landscape. Inconsistency in drive rates and access times raises rundamental questions when it comes to high speed database storage.

The Radio Shack promise of a $500 recordable optical disc system sure got things stirred up. CD fans, put off by the cost of dat recorders, instantly began to salivate. Wow! We're going to have a way to make digital compact disc copies! The computer tweeks got all excited over a new data storage medium, one which promises around 550 megabytes...and is erasable.

The announcement of the NeXT system by Chairman Jobs, complete with an erasable optical disc drive, made the Thor system seem even more real. Well, we'll see how much of the Thor is vapour and how much reality – in a year or so. But let's put this whole cd-rom business into some perspective.

CD ROMPS ON?

The cd-rom has had a great press reception, with nay-sayers being shushed. The compact disc, with its storage of about 600 megabytes looked like a great technical development for computers. Sure, it was designed for digital sound data storage, but just look at the incredible storage capacity! And with the cost of the equipment brought down by the economies of scale of about five million cd players being sold per year, it looked like a big winner.

It didn't take very long before some flies began to come to the surface in the ointment. The first problem was that the firms which rushed into putting their data bases on cd-rom discs found that the data quickly became dated. This led to a faster and faster turn-around of discs. Many firms had to go to weekly update discs shipped overnight. Obviously the whole system wasn't as good as hoped. Some sort of updatable data base medium was needed.

Most of the cd-rom products (only about 200 so far) are just copies of data already available from on-line services. How many users are there? Less than 60,000 drives have been sold. So far, cd-rom has been more hype than substance. Now, if an updatable disc could be developed...?

One group has been working on re-writable optical discs. Another on combining the cd-rom optical data (read only) with a magnetic layer for updates. Well, that wasn't a very elegant solution. That meant that what was a modified cd player now had to also have a floppy disc drive system built in too. Since it was obvious that a better system would have to be developed, little enthusiasm ensued for this hybrid approach.

Dr Wayne Green is the renowned US author, publisher and founder of over 50 computer and technology magazines, including Byte and Microcomputing.

ANOTHER THORN

Now, problem number two – an even worse misery – and one which will, I expect, substantially reduce interest in the Tandy Thor approach. This one stems from the basic system used by compact discs. It was designed to store digitised sound data. Engineers needed to be able to handle 150K bytes per second for high quality sound, so that's the transfer rate of a cd...and a cd-rom. That's awfully slow for today's computers.

Worse, in order to keep the data flow constant, the disc has to rotate at a different speed on every revolution, going from about 600 rpm at the start to about 200 by the time the end of the spiral is reached. This doesn't bother a cd player handling music data, where the gradual change in disc speed isn't a big deal. But with computer data, which are often hopping from one part of the disc to another, the disc mechanism will have to be able to speed from 200 up to 600 rpm and back constantly. CD players aren't designed for that kind of abuse, nor to be able to provide the instant speed changes fast data access demands.

Computer discs spin at a constant speed with the data stored in concentric rings instead of one long spiral track. Each ring has the same amount of data. This means that the outside rings waste a lot of space and the inside densely packed rings are a real bear to read accurately. It's been fun watching the computer industry get rid of the easy-to-read disc areas by making them ever smaller.

Now, if the erasable cd technologies insist on being compatible with audio cds and cd-roms, they're going to have the limitation of both the slow transfer rate and the continuously variable speed drive for the disc. It doesn't make good sense to me. How long will it be before someone invents an erasable data storage system which does what computers need? And has it already been invented with the digital tape technology (dat)?

RAMIFICATIONS

One digital tape will hold about six times as much data as a cd-rom (or Thor disc). The read transfer rate can be boosted to around 400 times that of a cd. I haven't seen data on the limits of the write transfer rate. The tape speed is constant, simplifying the motors and control system. The transfer rate can be changed by changing the tape speed gearing.

Neither the cd-rom nor the dat technology are going to be of much value when we need to do a fast search of a large data base for several interrelated data. For instance, suppose we want to look through a complete US telephone list for the Johnsons who live on Smith Street and who have a five in their phone number. A computer searching its ram data can sort that out before you can grab your coffee cup. Looking for that combo on a cd-rom would give you time for a leisurely lunch. DAT would be faster, due to its ability to read data at the fast-forward or rewind speeds, taking less than a minute to search the whole tape.

But you don't want to be thrashing tape around like that, so it's likely that dat-oriented storage systems will lean toward large ram memories and tend to offload megabytes of data into ram before it is massaged. Since most data bases tend to be in the single or double figure megabyte range, this may be a practical way to keep from wearing out tapes. One tape could then store many fairly large data bases and each would be downloaded into ram for actual use. The updated data would then be rewritten over the old base – or written elsewhere on the tape if the old data is needed for archival purposes. With three or four thousand megabytes of storage room on each tiny dat you may not have to throw things away very often.

Engineers in UK have a decided advantage over their American counterparts in that dat systems are much more easily available. The Japanese Trade Ministry has put thumbs down on any official exports of dat recorders to the US, so what few are available are from importers of gray market products.

TOSHIBAN BOOMBOX

The MITI ban on dat is less in response to the threats of legal action by the Record Industry Association (RIAA) than from concerns over possible congressional action. The Japanese are still very worried over possible retaliation by congress for the Toshiba disaster, where a secret manufacturing process was sold to the USSR which enabled them to render the American submarine detection system useless.

Congress got mad. The Japanese won't soon forget the congresswoman bashing a Toshiba boombox with an axe in front of the Capitol on the evening news. Congress wanted to outlaw all Toshiba products for five years. Within hours they were getting panic phone calls from their military suppliers explaining that if they wanted continued delivery of tanks, planes, rockets and other beloved items of hardware made in their states, they'd better not prevent the use of Toshiba supplied parts for which there were no alternative sources.

RETYREMENT BENEFIT

That reminds me of a WWII story. An uncle of mine in Pennsylvania made tyre flaps. When the war came along there was an instant rubber shortage, an official of the War Production Board figured trucks could get along without flaps, so he cancelled the rubber allotment for the Rex Hide company. My uncle said great, locked up his factory and went on a fishing trip to Canada.

About two weeks later the truck production lines in Detroit ground to a halt. No tyre flaps. It turned out that tyre flaps weren't those splash guards which hang behind the tyres. They were an inner wrap between the tyre and the inner tube. No tyre flaps, no trucks.

It took the WPB another week to find my uncle in Canada and convince him to come back and unlock the factory. I suppose that's also a parable for the problems the USSR had over their sixty-year disaster with their government management of business.

MITIGATING CIRCUMSTANCES

One might think that the repeated assurances from congress that they will not legislate against dat unless there is positive proof that it actually has caused losses to the music industry might break the MITI ban. But no, MITI has held firm and no Japanese firm has defied them so far. Well, this is tough for the US and bonanza for the UK and Europe. Here's an opportunity to get a major step ahead of the US with a new and exciting technology.

In the meanwhile I think I'd be a little cautious about investing in cd-rom based enterprises and perhaps be more inclined to favour dat-based systems.

One parting swipe. I mentioned the much-ballyhoo'd NeXT computer from Steve Jobs. The media loves Jobs, but the industry just sniffed in derision. The NeXT system isn't price advantageous over its competitors. Neither does it offer any real technical advantages. NeXT looks like a BuST and may be the LaST from JoBS.

PE

CANNED WORMS

IFPI, the International Federation of Phonogram and Videogram Producers, has reacted vigorously to the reported development of CD-R (referred to in some quarters as WORMS - write once read many times) and CD-E (erasable) compact disc systems. They fear that if these systems are introduced without accompanying protection for copyright, the recent recovery of the recording industry will be undermined.

New developments in technology are welcomed by IFPI but they say that "those which threaten the creativity of artists, performers and producers must be opposed". Ed.

HDTV – THE GREAT SYSTEMS BATTLE

PART TWO BY TOM IVALL

SAMPLED DEFINITIONS

Eureka! – Sampled pidgeon holes compress the band, but though there's a shuffling into line, the standards are still uncertain

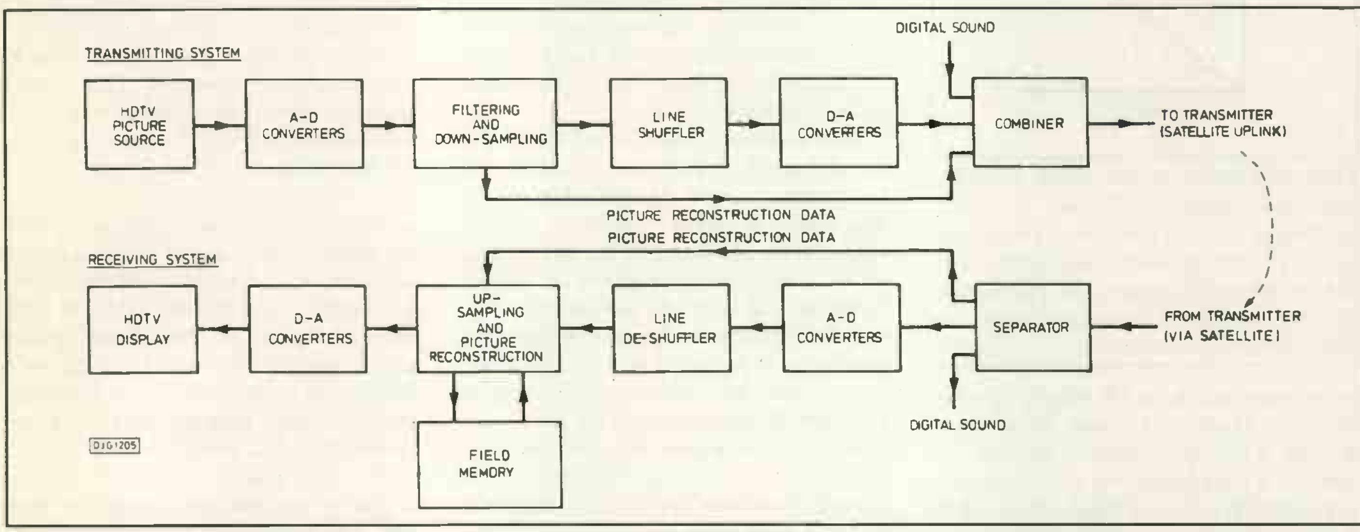


Fig.4. *Main processes in hdtv transmission and reception. The transmitting and receiving chains shown here are expansions of the corresponding chains in the very simplified Fig.2 diagram in part one.*

To describe the digital signal processing in a bit more detail, Fig.4 is an expansion of what takes place in the two heavy-line boxes of Fig.2 in part one. At the transmitting end (upper part of diagram) the signals from the hdtv picture source - which could be a camera, vtr or film scanner - are first converted into digital form. This is done by analogue-to-digital converters, one for each of the three components in the colour tv picture signal. Some readers may know already how an a-d converter works. For those who don't Fig.5 shows the basic principle.

SAMPLING

Essentially the incoming analogue voltage waveform is 'sampled' at regular instants of time. At each sampling instant, the amplitude of the voltage waveform is measured and a decision is made on which one of many voltage 'pigeon-holes' it falls into. Each pigeon-hole is a small range of voltage called a quantum and the whole process of sorting out the voltage measurements into these quanta is called quantisation. In one hdtv system the voltage measurements are sorted into 256 quanta. One can think of them as 256 distinct levels on the maximum amplitude of the analogue voltage waveform.

When a voltage measurement falls into a particular quantum the a-d converter generates a binary number corresponding to the quantum. As there are 256 possible quanta or levels, the binary numbers generated must be 8-bit numbers in order to provide enough combinations of 1 and 0 to represent all of them.

BANDWIDTH COMPRESSION

Thus, referring back to Fig.4, the outputs of the a-d converters consist of streams of 8-bit numbers. Once the vision signals have been digitised in this way they undergo bandwidth compression. The first part of this is to filter out of the digitised signals any image components which, as spatial patterns on the tv screen, are not perceivable by the viewer. For example, the eye-brain physiology

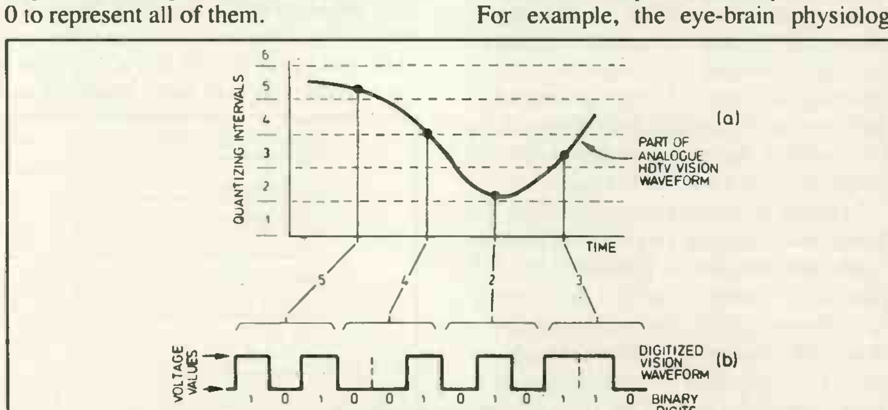


Fig.5. *Basic principle of analogue-to-digital converters as used in hdtv system (see Fig.4). For simplicity the digitised vision waveform is shown here as a data stream of 3-bit numbers, but actual hdtv system use very much finer quantization of the analogue waveform (eg 256 levels) and so generate longer data words (eg 8-bit).*

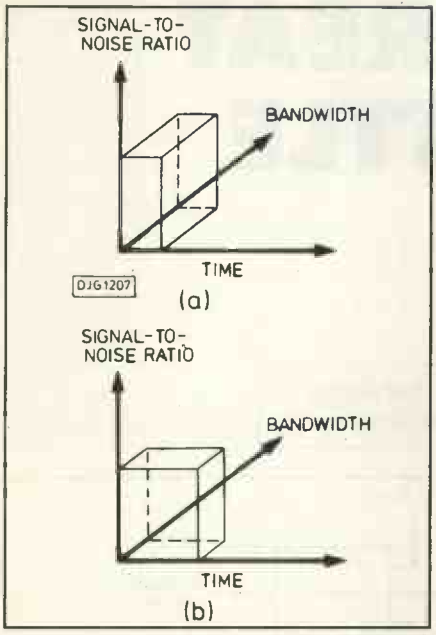


Fig.6. *Bandwidth compression. Showing how bandwidth and time can be exchanged when sending a given amount of vision information (volume of box). In (b) the bandwidth required is less than in (a) because more time is taken to transmit the information.*

cannot see fine detail on rapidly moving objects. Unnecessary visual information of this kind is removed, because to transmit it would require a certain amount of bandwidth - wasted bandwidth - when the great need is to reduce bandwidth.

The fundamental principle of bandwidth compression is to slow down the rate at which signal information is transmitted. Bandwidth is the total range of sine-wave frequency components needed to synthesize a particular waveform. This range is measured in hertz (Hz). If the waveform contains rapid transitions - like the edges of square pulses - it requires a wider bandwidth than that of a waveform containing only slow transitions. So the bandwidth normally needed to synthesize a particular transition can be reduced by taking a longer time to send that transition through a system - in other words, by reducing its rate of rise or fall. The information transmitted (the amount of the transition) is the same but the process of transmission is extended in time.

In practical communication systems this means that a 'trading' or exchange between bandwidth and time is possible. One such practical system, used for visual surveillance and also by radio amateurs is slow-scan television. This principle of trading is illustrated in a general way in Fig.6. In both (a) and (b) the volume of the box is proportional to a given amount of information to be transmitted (measurable digitally in bits). The amount of information is the same in (a) and (b) - the boxes have equal volumes. But in (b) the system takes a longer time to send the information than is required in (a). As a result the bandwidth in (b) can be smaller than in (a) in order to keep the amount of information transmitted (box volume) the same as in (a). This exchange assumes a constant signal-to-noise ratio in the trans-mission system.

Applying this general principle to the hdtv system means taking some of the visual information from each tv field and spreading it out over the longer time occupied by several fields - actually four fields in both the NHK and the Eureka systems. The visual information for which this process gives the best results is static information - for example, a shot consisting of a stationary (non panning) view of a house, or a shot in which the background is stationary though there may be movement in the foreground.

This technique takes advantage of the fact that much of the visual information in tv pictures - as in cinematography - is redundant. In other words, it doesn't change from one frame to the next. But of course it has to be repeated at the normal frame rate (25 or 30 per second in tv, 24/s with film) purely for the sake of depicting movement in a smooth manner. So in the hdtv system this inherent redundancy is exploited. If certain areas of the picture are stationary over at least the time taken by four successive fields (80 milliseconds in Europe) the system can afford to take four fields to send these areas from the transmitting end without impairing the final picture as seen by the viewer.

Of course, in practice, many areas of many picture sequences remain static for longer than 80 ms. But the extra time given by four fields instead of one is enough to achieve the substantial bandwidth compression of 4 : 1 in the final baseband signal.

In the Fig.4 system this extension of time is obtained by the digital process of down-sampling. This means re-sampling the samples already taken and digitised by the a-d converter at a lower rate than used in the a-d converter - in fact at a quarter of the original rate. Thus in the Eureka system the original a-d sampling is done on the luminance signal component at a rate of 54 million samples per second (54 MHz), and the re-sampling of the resulting digital data is done at 13.5 million samples per second (13.5 MHz). These particular rates have been chosen to fit in with the CCIR digital coding standard mentioned earlier.

MOVEMENT PROBLEM

Unfortunately there is a snag. The bandwidth compression works well on stationary areas but results in blurring on moving objects. The 4-field repetition rate is too slow to analyse the rapidly changing visual information in sufficient detail to given an accurate rendition of the moving object. So the system has to use a highly complex algorithm for dealing with the moving objects separately. This involves breaking down the total picture digital information into small areas and distinguishing when movement occurs in any of these small areas. The algorithm responds automatically to what comes along from the picture source and so is called 'motion adaptive'. A final stage in this procedure is to measure the speed and direction of the moving objects. In physics any quantity which requires direction in space to be specified in order to define it is known as a vector. so these measurements in the hdtv system are called motion vectors.

All this analysis and measurement results in a continuous output of digital data which specifies the structure of the picture from moment of moment. It is needed at the receiving end to reconstruct the picture accurately, according to the analysis performed at the transmitting end. The digital data is therefore organised into a stream and transmitted to the receiver as a separate digital reconstruction signal, as shown in Fig.4.

LINE SHUFFLING

At this point the bandwidth-reduced signals are still in a high-definition line format (1125 lines for NHK, 1250 for Eureka). They must therefore be converted into a 625-line format which can be accepted by existing tv sets, as shown

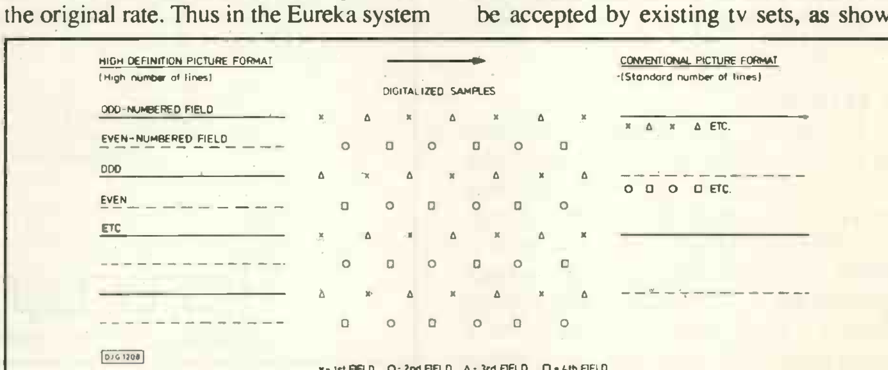


Fig.7. *Line shuffling principle for re-arranging digitised samples from an hdtv picture (eg 1250 lines) into a standard picture format (eg 625 lines) to achieve a compatible broadcasting system.*

by Fig.2, but in such a way as to retain and transmit the additional visual information needed by the hdtv receiver to show high-definition pictures. This is done by a process called line shuffling.

All the digitised samples from the 1250-line or 1125-line structure are rearranged into a 625-line or 525-line structure as shown in Fig.7. In a four-field sequence the line shuffler rearranges samples from two successive lines in each field of the originated picture into one line of a standard picture. For instance, samples from odd-numbered original 1250-line fields are transferred into one 625-line field, while samples from the even-numbered original fields go into the next, interlaced, 625-line field.

Next, the 8-bit samples of the digitised vision signals are changed back into analogue signals by a digital-to-analogue converter. This operates on the reverse principle to that illustrated in Fig.5. The resulting analogue vision signals are then combined with digital sound data from the hdtv studio and with the picture reconstruction data mentioned above, to produce the final hdtv baseband signal for modulating the satellite uplink transmitter.

In the combiner, or multiplexer, both NHK and Eureka use a system which keeps the vision luminance and colour components separate by transmitting them at different times in a regular sequence (time-division multiplexing). In the Eureka scheme this is derived from the MAC (multiplexed analogue components) transmission system. MAC was devised in the UK by the IBA and is to be used for Britain's first dbs broadcasts from the BSB satellite in 1989. The MAC waveform is shown in Fig.3, compared with the established PAL signal used in European terrestrial tv broadcasting.

The main point about the MAC signal, relative to PAL, is that it gives better quality pictures. Keeping the luminance and colour components separate in time means that they cannot interfere with each other. The resulting pictures are therefore free from the spurious cross-colour patterning effects which occur with PAL because PAL uses a subcarrier to frequency-interleave the colour components with the luminance component (frequency-division multiplexing). This improvement given by time-sequential transmission is a benefit for satellite broadcasting generally but is particularly important for hdtv, where any likely sources of picture impairment must be avoided to attain the highest possible quality.

In the ordinary MAC signal the luminance and colour components have to be compressed in time, as shown in Fig.3, in order to fit them into the normal 625-lie signal format. In hdtv, however, extra picture information is generated with the wider, 16:9 aspect ratio relative to the existing 4:3 aspect ratio (Fig.1). To accommodate this in the MAC signal used for hdtv, the analogue vision signals have to be time-compressed even further. As a result the bandwidth of the hdtv baseband signal is increased from about 8.4 MHz (ordinary MAC) to about 10.5 MHz.

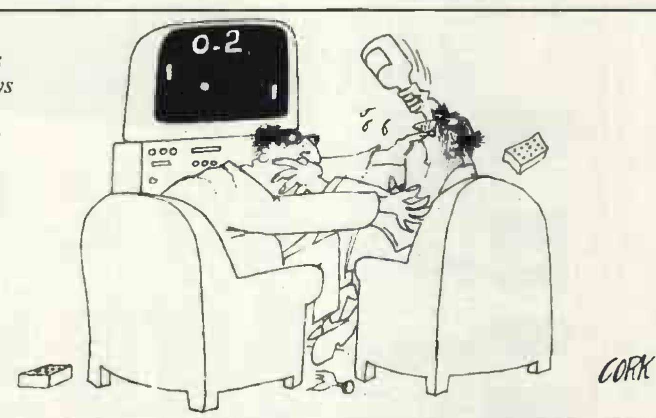
Fig.4 shows that the hdtv receiver includes signal processing which is basically the reverse of that used at the transmitting end - analogue-to-digital conversions as against digital-to-analogue, up-sampling as against down-sampling, and so on. An important part of the bandwidth restoration system (reversing the bandwidth compression) is a digital field memory constructed from semiconductor vlsi chips. This is necessary for reconstructing pictures from 8-bit samples over the period of four fields mentioned above. As each field is received the digitised samples it carries must be held in the memory to be combined with further samples arriving with the following fields.

UNCERTAIN FUTURE

While the general principles of digital signal processing in the NHK and Eureka hdtv system are very similar - because r&d engineers naturally tend to use the most advanced technology available - the chosen standards remain different. At the time of writing it's difficult to see what the outcome will be of the continuing attempt to decide on a single world-wide production standard.

After its September 1988 demonstration at Brighton the Eureka team has to develop its system further - particularly to obtain adequate fine detail on movement - and it will be staging another demonstration in late 1989. A final decision on a world-wide hdtv production standard could well be reached at the 1990 meeting of the CCIR if international agreement is achieved, but this is not absolutely certain. PE

Some TV definitions may always result in systematic battles



ELECTROVALUE

*Distributors of **high quality** components since 1965*

POLYESTER CAPACITORS 5mm PCM 63v 10%

4.7nF	0.06
6.8nF	0.06
10nF	0.06
15nF	0.07
22nF	0.07
33nF	0.07
47nF	0.07
68nF	0.08
100nF	0.08
150nF	0.12
220nF	0.10
330nF	0.17
470nF	0.22
680nF	0.22
1µF	0.32
1.5µF	0.40

100V 10%

100nF	0.08
150nF	0.09
220nF	0.10
330nF	0.13
470nF	0.17

7.5mm PCM 400V 10%

1nF	0.06
1.5nF	0.06
2.2nF	0.06
3.3nF	0.06
4.7nF	0.06
6.8nF	0.06
10nF	0.06

250V 10%

15nF	0.06
22nF	0.06
33nF	0.06
47nF	0.07

100V 10%

68nF	0.07
100nF	0.07
150nF	0.08
220nF	0.09
330nF	0.11

CERAMIC PLATE

Short leads

100V 2%

1.8pF to 330pF	0.08
470pF to 1000pF	0.08

CERAMIC MULTILAYER COG 100v 5%

10pF	0.05
22pF	0.05
47pF	0.05
68pF	0.05
100pF	0.05
220pF	0.06
470pF	0.06
1nF	0.07

COG 63v 5%

2.2nF	0.08
4.7nF	0.12

X7R 63V 10%

4700pF	0.06
6800pF	0.05
10nF	0.05
22nF	0.06
47nF	0.06
100nF	0.07
220nF	0.13
470nF	0.23

Z5U 63V 20%

100nF	0.05
220nF	0.11
470nF	0.13
1µF	0.21
2.2µF	0.48

HI-K CERAMIC

µF 63v +50-20%

0.01	0.06
0.022	0.06
0.033	0.06
0.047	0.06
0.068	0.07
0.1	0.08

CERAMIC DISC 330V ac

1nF	0.10
10nF	0.16

ELECTROLYTIC RADIAL

µF	V	
1	100	0.05
2.2	63	0.05
4.7	63	0.06
10	63	0.07
22	63	0.08
47	16	0.06
47	40	0.08
100	16	0.07
100	25	0.08
100	63	0.12
220	16	0.08
220	25	0.10
220	63	0.16
470	6	0.08
470	16	0.12
470	25	0.16
470	40	0.30
1000	16	0.16
1000	25	0.33

TANT BEADS

µF	V	
0.1	35	0.10
0.22	35	0.10
0.47	35	0.10
1.0	35	0.10
2.2	16	0.10
2.2	35	0.13
3.3	35	0.15
4.7	16	0.13
4.7	35	0.16
6.8	16	0.15
6.8	25	0.16
10	6	0.13
10	16	0.15
10	25	0.20
22	6	0.16
22	16	0.26
22	25	0.42
33	6	0.14
33	10	0.26
33	16	0.38
47	6	0.26
100	3	0.15
100	10	0.64

ELECTROLYTIC AXIAL

µF	V	
1.0	63	0.12
2.2	63	0.13
4.7	63	0.12
4.7	100	0.17
6.8	40	0.11
10	25	0.11
10	40	0.12
10	63	0.17
10	100	0.19
10	350	0.45
22	10	0.09
22	25	0.13
22	40	0.17
22	63	0.19
22	100	0.21
22	350	0.57
47	10	0.15
47	25	0.17
47	40	0.19
47	63	0.21
47	100	0.24
47	350	1.03
100	10	0.17
100	16	0.19
100	25	0.19
100	40	0.22
100	63	0.23
100	100	0.34
100	160	0.93
220	10	0.19
220	16	0.20
220	25	0.22
220	40	0.23
220	63	0.32
220	100	0.64
470	10	0.22
470	16	0.23
470	25	0.31
470	40	0.32
470	63	0.50
470	100	1.06
1000	10	0.29
1000	16	0.31
1000	25	0.38
1000	40	0.50
1000	63	1.00
2200	16	0.49
2200	25	0.67
2200	40	1.01
2200	63	1.25
4700	16	0.94
4700	25	1.18
10000	10	1.31

REVERSIBLE ELECTROLYTIC 50V peak 20v

2µF	0.29
4µF	0.32
6µF	0.35
8µF	0.37
10µF	0.40
16µF	0.44
25µF	0.51
40µF	0.63
50µF	0.69
60µF	0.72
100µF	0.94
150µF	1.30
300µF	2.39

ELECTROLYTIC CANS

µF	V	
100	350	1.65
220	350	2.21
220	385	2.47
470	100	2.01
1000	63	1.98
2200	40	1.70
2200	63	2.05
2200	100	4.01
4700	40	2.11
4700	63	4.05
4700	100	6.78
10000	16	2.02
10000	25	2.61
10000	40	3.69
10000	63	6.57
22000	16	3.36
22000	25	5.48

COMPUTER GRADE

µF	V	
3300	350	35.58
4700	40	3.90
10000	16	3.65
10000	40	6.25
22000	16	6.18
22000	40	10.93
22000	63	15.76
47000	16	8.38
47000	40	16.55
100K	16	15.34

VARIABLE AIR SPACED Jackson C804

5pF	3.25
10pF	3.25
15pF	3.25
20pF	3.25
25pF	3.42
30pF	3.95
50pF	3.42
60pF	3.95
75pF	3.95
100pF	3.95
150pF	4.90

SOLID DIELECTRIC

100pF	2.36
200pF	3.45
300pF	4.40
500pF	4.85

STANDARD single

365pF	5.19

Twin

365+ 365pF	7.45

MINIATURE TWIN-GANG

350+ 350pF	1.50

TRIMMER Polyester

2-10pF	0.24
2-22pF	0.30
5.5-65pF	0.43

CHOKES miniature RF

0.1µH	0.11
0.15µH	0.11
0.22µH	0.11
0.33µH	0.11
0.47µH	0.11
0.68µH	0.11
1.0µH	0.12
1.5µH	0.12
2.2µH	0.12
3.3µH	0.12
4.7µH	0.12
6.8µH	0.12
10µH	0.12
15µH	0.12
22µH	0.12
33µH	0.12
47µH	0.12
68µH	0.12
100µH	0.12
150µH	0.13
180µH	0.13
220µH	0.13
330µH	0.13
470µH	0.13
680µH	0.13
1000µH	0.14
1500µH	0.14
2200µH	0.14
3300µH	0.14
4700µH	0.14

CONNECTORS DIN, AUDIO SOCKETS

2-way	0.06
3-way	0.18
4-way	0.20
5-way 180°	0.20
5-way 240°	0.20
5-way 360°	0.20
6-way	0.20
7-way	0.22
8-way	0.26

Plugs

2-way	0.09
3-way	0.14
4-way	0.16
5-way 180°	0.20
5-way 240°	0.16
5-way 360°	0.20
6-way	0.22
7-way	0.22
8-way	0.26

JACKS AUDIO 2.5mm

Socket	0.12
Plug	0.10
Line skt.	0.24

3.5mm

Socket	0.19
Plug	0.25
Line skt.	0.28

6.3mm 0.25"

Socket	0.19
Plug	0.44
Line skt.	0.58

D-SERIES Plugs

9-way	0.38
15-way	0.51
25-way	0.73
37-way	1.05
50-way	1.32

Sockets

9-way	0.50
15-way	0.77
25-way	1.06
37-way	1.66
50-way	2.02

Hoods

9-way	0.45
15-way	0.45
25-way	0.50
37-way	1.15
50-way	1.28

DIN 41612 Straight

Plug 64p	3.05
Skt 64p	1.96
Plug 96p	3.93
Skt 96p	2.73

Rt angled

Plug 64p	1.43
Skt 64p	4.86
Plug 96p	1.93
Skt 96p	3.93

DIODES

1N914	0.03
1N914B	0.10
1N916	0.11
1N4007	0.05
1N4148	0.03
1N5408	0.15
AA113	0.17
AA118	0.18
BA127D	0.11
BA138	0.15
BAL74	0.11
BAR12-1	2.78
BAR16-1	1.53
BAR74	0.11
BAS40-04	1.36
BAS70-04	1.43
BAV20	0.20
BAV70	0.09
BAV99	0.09
BAW56	0.09
BB105G	0.36
BB112	2.38
BB204B	0.73
BB204G	0.73
BB304	0.84
BB409	0.62
BB505B	0.44
BB609A	0.64
BB801	1.05
BY350	1.62
BY360	0.65
BYS21-45	0.83
BYS21-90	0.92
BYS26-45	1.77
BYS26-90	2.49
OA47	0.25
OA91	0.14
OA202	0.16

BRIDGES 250V ac

1A W04	0.20
3A BR34	0.60
6A BR64	0.75
25A FB2506	1.65
35A FB3506	2.50

THYRISTORS 400V

0.8A MCR100	0.36
3A B0226	0.33
4A C106D1	0.72
5A TIC106D	0.58
12A TIC126D	0.66

TRIACS

4A TIC206D	0.67
8A TIC226D	0.80
16A TIC246	1.20
25A T2513NK	8.20

DIACS 32V

A9903	0.36
D0201YR	0.22

TRANSISTORS

2N697	0.37
2N706	0.25
2N930	0.40
2N1613	0.34
2N1711	0.34
2N1893	0.45
2N2218A	0.36
2N2219A	0.40
2N2222A	0.30
2N2369A	0.30
2N2484	0.30
2N2646	0.60
2N2905A	0.36
2N3053	0.40
2N3054	0.55
2N3055 (RCA)	0.66
2N3702	0.18
2N3703	0.18
2N3704	0.18
2N3705	0.18
2N3706	0.18
2N3707	0.18
2N3708	0.18
2N3710	0.18
2N3711	0.18
2N3771	1.85
2N3772	1.85
2N3773	1.85
2N3819	0.55
2N3820	0.90
2N3823	1.00
2N3904	0.18
2N3906	0.18
2N4036	0.70
2N4058	0.18
2N4062	0.18
2N4124	0.25
2N4126	0.25
2N4303	0.48
2N4991	0.64
2N5163	0.42
2N5192	1.59
2N5195	1.40
2N5457	0.60
2N5459	0.60
2N6050	3.38
2N6057	3.38
AC128	0.30
AC126	0.33
AC153K	0.16
AC176	0.35
AD133	3.90
AD136	1.30
AD149	1.40
AD161	0.30
AD162	0.80
AF124	0.56
AF126	0.58
AF127	0.56
AF200	0.09
AF279	0.25
BC107A	0.24
BC107B	0.24
BC108B	0.21
BC108C	0.19
BC109B	0.25
BC109C	0.25
BC121	0.20
BC125	0.40
BC126	0.40

BC141	0.40
BC147	0.18
BC149C	0.18
BC159	0.15
BC160	0.35
BC161	0.40
BC167A	0.21
BC167B	0.17
BC168C	0.21
BC169C	0.27
BC177B	0.21
BC179B	0.21
BC182	0.17
BC182L	0.17
BC183	0.17
BC183L	0.17
BC184	0.17
BC184L	0.17
BC212	0.17
BC212L	0.17
BC213	0.17
BC213L	0.17
BC214	0.17
BC214L	0.17
BC237A	0.13
BC237B	0.14
BC238C	0.13
BC239C	0.15
BC257A	0.20
BC258B	0.17
BC267	0.25
BC300	0.40
BC301	0.35
BC303	0.40
BC307B	0.18
BC327	0.20
BC328	0.20
BC337	0.20
BC338	0.20
BC413	0.17
BC414	0.27

BF244B	0.40
BF254	0.17
BF255	0.17
BF420	0.30

BU407	1.05
BUX26	3.78
BUX82	2.00
BUX85	1.30

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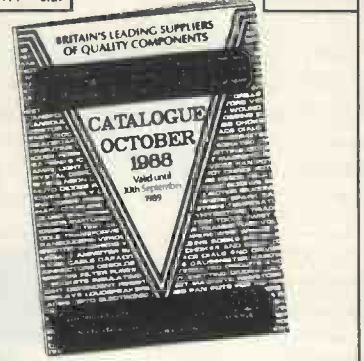

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CFY19-18	17.61
CFY19-27	6.27
MJ2955	0.90
MJE340	0.48
MJE2955	0.95
MJE3055	0.70
MPS6531	0.40
MPS6534	0.42
MPSA12	0.23
MPSA63	0.47
TIP31A	0.36
TIP32A	0.36
TIP41A	0.45
TIP41C	0.60
TIP42A	0.45
TIP42C	0.60
TIP122	0.45
TIP127	0.68
TIP150	1.41
TIP2955	0.66
TIP3055	0.66
VN10KM	0.78
VN46AF	1.50
VN66AF	1.95
VN88AF	2.20
ZTX107	0.18
ZTX108	0.18
ZTX109	0.19
ZTX300	0.18
ZTX301	0.18
ZTX302	0.18
ZTX304	0.18
ZTX331	0.19
ZTX500	0.18
ZTX501	0.18
ZTX502	0.18
ZTX503	0.19
ZTX504	0.19
ZTX531	0.20

7491	0.65
7492	0.55
7493	0.55
7494	0.70
7495	0.85
7496	0.75
74100	2.00
74104	0.65
74107	0.40
74121	0.45
74123	0.75
74125	0.65
74126	0.75
74141	0.75
74151	0.55
74154	0.85
75155	0.55
74156	0.55
74157	0.60
74190	1.00
74191	1.00
74192	1.00
74193	1.00
74393	1.20

74LS SERIES

LS00	0.24
LS02	0.24
LS03	0.24
LS04	0.24
LS05	0.24
LS08	0.24
LS10	0.24
LS11	0.24
LS13	0.24
LS14	0.40
LS20	0.22
LS21	0.22
LS22	0.22
LS27	0.24
LS30	0.24
LS32	0.24
LS37	0.24
LS38	0.24
LS40	0.24
LS42	0.40
LS47	0.75
LS51	0.22
LS54	0.24
LS73	0.24
LS74	0.30
LS75	0.40
LS76	0.29
LS83	0.40
LS85	0.40
LS86	0.29
LS90	0.45
LS92	0.35
LS93	0.54
LS96	0.95
LS107	0.35
LS109	0.40
LS112	0.35
LS122	0.55
LS123	0.75
LS125	0.35
LS126	0.50
LS132	0.60
LS136	0.35
LS138	0.55
LS139	0.50
LS145	0.80
LS148	1.05
LS151	0.35
LS153	0.36
LS154	0.95
LS155	0.45
LS156	0.45
LS157	0.45
LS158	0.55
LS160	0.55
LS161	0.55
LS163	0.55
LS164	0.55
LS165	0.56
LS168	0.55
LS169	0.96
LS173	0.75
LS174	0.55
LS175	0.85
LS181	1.30
LS191	0.55
LS192	0.55
LS193	0.55
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LS195	0.55
LS196	0.80
LS197	0.80
LS221	0.80
LS240	0.80
LS241	0.80
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LS247	0.80
LS251	0.65
LS253	0.60
LS256	0.80
LS257	0.45

BC548B	0.13
BC547B	0.14
BC548B	0.13
BC549C	0.14
BC557B	0.15
BC558C	0.15
BC559C	0.15
BC560C	0.20
BC639	0.25
BC640	0.26
BC807	0.16
BC817	0.16
BC847B	0.16
BC857B	0.13
BC877	0.56
BC879	0.59
BC880	0.61
BCV46	0.28
BCV47	0.28
BCW66G	0.21
BCW68G	0.21
BCX41	0.42
BCX42	0.42
BCX70K	0.13
BCX71K	0.13
BCX79	0.30
BCY58	0.30
BCY59	0.39
BCY70	0.25
BCY71	0.25
BCY72	0.25
BD131	0.60
BD132	0.60
BD135	0.31
BD136	0.33
BD139	0.36
BD140	0.36
BDX33C	0.65
BF115	0.48
BF167	0.48
BF178	0.35

BF421	0.32
BF457	0.21
BF459	0.25
BF597	0.18
BF989	1.78
BFQ69	2.61
BFQ71	6.91
BFR15A	5.48
BFR34A	1.73
BFR35AP	1.64
BFR92P	1.31
BFT65	1.64
BFT66	4.97
BFT92	3.32
BFT93	3.60
BFX29	0.40
BFX84	0.40
BFX85	0.40
BFX87	0.36
BFX88	0.35
BFY50	0.40
BFY51	0.40
BFY52	0.40
BFY90	2.28
BRY39	0.95
BSS84	0.90
BSS87	1.45
BSS89	0.81
BSS91	0.77
BSS92	0.91
BSS96	0.88
BSS97	0.96
BSS100	0.51
BSS101	0.54
BSS110	0.56
BSS123	0.82
BSS125E	1.38
BSS129	0.97
BSX20	0.30
BU205	1.50
BU208A	1.05

BUZ10	1.35
BUZ10A	1.40
BUZ11	2.16
BUZ11A	1.84
BUZ15	6.40
BUZ20	1.22
BUZ21	2.02
BUZ23	3.69
BUZ24	6.47
BUZ30	1.60
BUZ31	2.00
BUZ32	1.25
BUZ35	4.11
BUZ36	6.56
BUZ41A	1.47
BUZ44A	2.56
BUZ45	7.00
BUZ46	4.80
BUZ50A	3.69
BUZ54	12.29
BUZ54A	11.47
BUZ63	6.79
BUZ64	6.56
BUZ71	0.72
BUZ71A	0.71
BUZ71L	1.04
BUZ73	0.82
BUZ73A	0.79
BUZ74	0.97
BUZ74A	0.95
BUZ76	0.97
BUZ76A	0.95
BUZ80	3.12
BUZ80A	3.40
BUZ83	5.51
BUZ83A	5.89
BUZ171	1.05
BUZ353	6.81
CFY17	22.85
CFY18-23	35.79

IC'S 7400 SERIES

7400	0.30
7401	0.30
7402	0.30
7403	0.30
7404	0.30
7405	0.30
7406	0.40
7407	0.40
7408	0.25
7409	0.30
7410	0.30
7413	0.35
7414	0.70
7420	0.30
7430	0.30
7440	0.30
7442	0.65
7443	0.70
7444	0.80
7447	1.85
7448	1.00
7450	0.30
7451	0.25
7453	0.25
7454	0.30
7460	0.45
7470	0.40
7472	0.35
7473	0.55
7474	0.45
7475	0.60
7476	0.55
7480	0.80
7483	0.85
7485	0.85
7486	0.40
7489	1.90
7490	0.55

LS259	0.80
LS266	0.50
LS273	0.80
LS279	0.55
LS280	1.10
LS283	0.70
LS290	0.60
LS293	0.70
LS295	0.80
LS298	0.80
LS299	1.60
LS366	0.60
LS367	0.45
LS368	0.50
LS373	0.60
LS374	0.60
LS375	0.60
LS378	0.80
LS390	0.55
LS393	0.70
LS398	1.00
LS541	1.05
LS639	1.75
LS668	1.05
LS669	1.10
LS670	1.50

4000 Series

4000	0.15
4001	0.20
4002	0.18
4006	0.36
4007	0.15
4008	0.36
4009	0.24
4010	0.24
4011	0.18
4012	0.22
4013	0.24
4014	0.36
4015	0.36
4016	0.28
4017	0.40
4018	0.36
4019	0.24
4020	0.35
4021	0.36
4022	0.36
4023	0.15
4024	0.30
4025	0.18
4026	0.70
4027	0.30
4028	0.36
4029	0.40
4030	0.25
4035	0.45
4040	0.45
4041	0.50
4042	0.30
4043	0.40
4044	0.36
4046	0.50
4047	0.50
4049	0.30
4050	0.25
4052	0.45
4053	0.45
4060	0.45
4066	0.30
4069	0.22
4070	0.20
4071	0.20
4072	0.16
4075	0.16
4076	0.55
4077	0.18
4081	0.20
4082	0.15
4093	0.27
40106	0.60
4501	0.55
4502	0.50
4503	0.50
4510	0.55
4511	0.50
4514	0.85
4516	0.45
4518	0.42
4519	0.45
4520	0.40
4522	0.50
4526	0.40
4528	0.36
4538	0.65
4541	0.65
4543	0.65
4555	0.35
4584	0.35
4585	0.46

REGULATORS

7805	0.40
7806	0.45
7808	0.45
7812	0.40
7815	0.40
7818	0.40
7824	0.40
78L05	0.25
78L12	0.25
78L15	0.25
78L24	0.36
7905	0.52
7906	0.52
7908	0.52
7912	0.52
7915	0.52
7918	0.52
7924	0.52
79L05	0.30
79L12	0.30
79L15	0.30
79L24	0.50

Variable

LM317K	2.40
LM317T	0.55
LM337T	1.80
723-T05	1.07
723-dip14	0.55

ANALOGUE

S041P	2.33
S042P	2.57
TL071CP	0.35
TL072CP	0.40
TL074CN	0.55
TBA120T	1.37
TBA120U	1.37
UAA170	2.92
UAA180	2.92
LM301AN	0.26
LM308N	0.60
LM324N	0.35
TCA325A	1.29
TCA335A	1.29
LM339N	0.30
LM348N	0.73
TCA365	5.37
LM380N	1.20
LM380N-8	1.05
LM382N	2.40
ZN414Z	1.30
ZN424P	1.09
ZN425E	4.90
TCA440	3.04
TL497	1.70
555	0.22
556	0.40
NE567N	1.26
S576B	2.58
SAS580	4.21
SAS590	4.21
SAB0600	4.34
SAB0601	4.34
SAB0602	4.34
709-T05	1.33
709-14DIP	0.44
LM710N	1.20
741-T05	2.01
741-8DIP	0.20
741-14DIP	0.47
TCA765A	1.29
TCA785	4.96
TBA800	0.48
TBA810S	0.75
TBA820	0.48
TBA820M	1.06
TCA965	3.21
TDA1037	2.58
1458	0.91
1488	0.48
1489	0.48
TUA2000-4	3.13
TDA2002	1.10
TDA2003	0.90
TDA2030	1.30
CA3046	0.65
CA3080E	0.75
SG3524	1.80
LM3900	0.77
LM3914	3.50
LM3915	2.90
TDA4050B	2.37
TDA4290-2	3.58
TDA4292	7.06
TDA4600-2	3.40
TDA4601	3.35
TDA4601D	3.18
TDA4714A	5.47
TDA4716A	6.66
TDA4718A	7.37
TLE4903F	3.25
TDA4920	2.78
TDA4930	4.12
TDA4935	5.20
TDA4941	7.08
TDA5850	2.41
7107	7.75
7555	0.55
7556	1.20

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Position sensor

KSY10	5.03
KSY13	4.73

I.C. analogue

SAS231W	3.12

I C threshold

TLE4903F	3.25

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FP17L200E	9.70
FP17D500E	7.83
FP100L100	3.00
FP101L100	4.00
FP110L10	7.23
FP111L100	11.17

LOUD SPEAKERS

Type	dia mm		
3612	38	8Ω	0.85
FE201	58	8Ω	0.75
CS28	65	8Ω	0.60
CS264	65	64Ω	0.85
TP26G	71	80Ω	1.40
FE300	76	8Ω	0.80

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30PM1	50uA	2.95
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MU100U	100uA	5.00
MU500U	500uA	5.00
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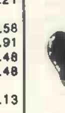
MU1A	1A	5.00
MU5A	5A	5.00
MU10A	10A	5.00



OPTO ELECTRONICS L E D's 3mm round

RL3	red	0.09
YL3	yellow	0.12
GL3	green	0.09

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RL5	red	0.09
YL5	yellow	0.12
GL5	green	0.09

5mm rectangular

red	0.19
yellow	0.14
green	0.19

Surface mounting

red	0.25
yellow	0.25
green	0.25

Red/green

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5mm	0.29
3mm	0.45

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30mm dia 80mm fl	0.46

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4N35	0.47
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ILQ30	2.80
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12v dc coil		3.85
240v ac coil		4.30

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SMR12v ~ 320Ω	1.49

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MR63 6v coil	0.62
MR123 12v coil	0.52

MIN PCB

10A 24vdc	
MR610 6v coil	1.56
MR1210 12v coil	1.56

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SR-2P	6W	0.40
SR-3P	4W	0.40
SR-4P	3W	0.40

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TSW33 DPDT	0.49

Miniature

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3201 DPDT	0.64

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SSP10 momentary	0.95
SSP11 alternate	0.81

Miniature

PB113 black	0.28
PB113 red	0.28
8225 dpdt	1.48

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EVS08 8way	0.72

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DPDT std	0.18
DPDT c/off	0.18

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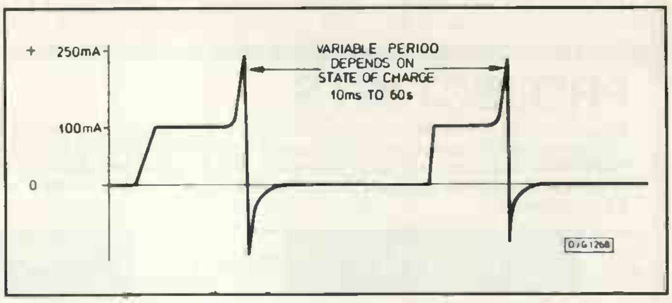
READERS' LETTERS



RMS v AVERAGE

Dear Sir,

I spring to the defence of your correspondent, John Goatcher, ("More letters", Sept. 88, p.34), who wrote you a well-reasoned and technically correct letter, explaining why currents being used for battery-charging purposes should be measured as average and not rms values.

Rod Cooper's reply skated round the point, with remarks about damping and 'snag-free measurements'. The point is that the two modes of measurement are each used for certain purposes, and neither is generally an appropriate substitute for the other. The rms method is correct for the measurement of power, since the power dissipated in a load of resistance R is equal to I^2R. RMS (root mean square) current is the equivalent of the square root of the mean of many instantaneous values of current, each squared.

However, when it comes to measuring charging current, we are interested, not in power, but in the rate of transfer of charge. The unit of charge, or quantity of electricity, is the coulomb, and one ampere = one coulomb per second (NB – not a power of two in sight!). Hence the appropriate measurement here is average, and not rms, even if the latter is a 'snag-free measurement'.

Consider two battery chargers, A and B, the first delivering a steady dc, the other delivering a pulsed current having a 50% duty cycle. Each charges a cell via a two ohm resistor, for a period of 10 seconds. For case A, the mean current is 3 amps, and so is the rms current. The charge transferred is equal to 3x10 amp-sec or coulombs. The power dissipated in the resistor is I^2R, or 3x3x2=18 watts. For case B, the mean current is also 3 amps, but the rms current is equal to SQR (02=62)/2), (6x1x5), as before, but the power in the resistor is now 4.24x4.24x2 or 36 watts.

Chris Finn, C.Eng; M.Inst E, Beverley.

Dear Sir,

I find much to criticise in Mr. Finn's letter. Firstly, I am sure I did not attack Mr. Goatcher, either his reasoning or technical correctness, so Mr. Finn cannot spring to his defence on this score. What I did was to cast doubt on the method of using a moving coil meter to measure currents in pulsed waveforms, and to say that average currents are not much use in making calculations. If you want to calculate circuit component ratings, then the rms value is the most useful, a point confirmed in Mr. Finn's resistor calculation. The rms value is also useful for battery charging calculations as I shall shortly demonstrate in my forthcoming article.

Secondly, and most important, Mr. Finn's counter-argument would be more acceptable if he has included a quick, cheap, practical method of making an average current reading in real life. How, for example, would he arrive at an average reading for the current waveform shown?

I have been designing pulse-type battery chargers for some time (see *Wireless World* June to Sept 85) and there has always existed a problem with complex waveforms. At first I used the coulomb method, watching the waveform on a scope and counting the squares enclosed by the waveform by superimposing a grid, subtracting and averaging and converting to amps. But I made very few measurements like this because it was not only time-consuming but also very dull work. What made it tedious in the extreme was mis-counting and having to start all over again. To make things simpler and quicker, I took an old Simpson mc meter with a five inch scale and recalibrated it with an accurate square wave to read average current. However, the results with this meter were at odds with the scope results when used with the pcr waveform. Moreover, the results repeated with a small Japanese mc meter with a one inch scale were different again. I assumed that the difference were due to meter ballistics, but I suppose there may have been differences in inductance and resistance of the coils despite the fact that they had the same dc rating for fsd I did not bother to investigate but gave up this attempt at getting average current readings.

Such were the snags I spoke of in my letter!

I then borrowed some thermocouple instruments, calibrated rms (but with non-linear scales) and found that *if used correctly* I would get quick, accurate results. I also discovered that true-rms reading instruments were much more useful than I imagined for a lot of other applications in electronics generally, so when I had to hand them back I decided to make my own thermal-conversion instruments for general purpose use, but with a more linear scale (much more readable than a non-linear) and with an output for a chart-recorder. The latter I found was an absolute boon, because the battery charger could be left to itself, and I could get on with something else without being bothered by periodic readings, and is recommended to anyone seriously interested in battery chargers. These instruments are the subject of the forthcoming article.

Regarding the rest of Mr. Finn's letter, I do not think I skated round any point. I was certainly short on words – a letters column is no place for a free-of-charge treatise – but I did mention a forthcoming article and I suspect most readers will have taken the hint that more information was on its way.

May I suggest that other readers do not jump the gun but wait for the appearance of the article before commenting?

Rod Cooper.

Rod Cooper's article is nearing the top of the schedule but a publishing date has not yet been fixed.

Ed.

HOROSCOPE

Dear Ed

I've often wondered how I could check the accuracy of crystal oscillators between several clocks. Your informative scope article has shown me how easily it can be done. I look forward to completing it at school next term and never being late again!

M.J.S. Allenthorpe, Bristol.

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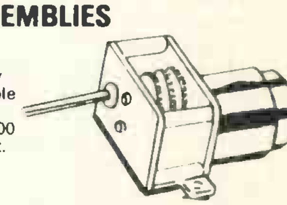

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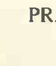

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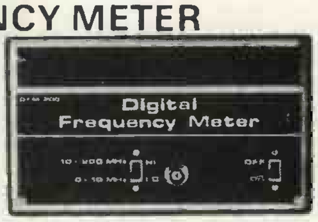

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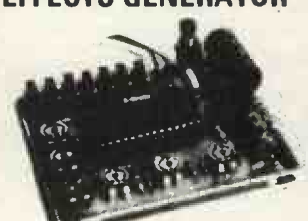

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DIGITAL ELECTRONICS

BY OWEN BISHOP

PART 6A – CONTINUING THE CONVERSION

In part six last month we took a look at some of the basic principles of digital to analogue, and analogue to digital converters. We follow on now with other conversion techniques and a practical approach to try out.

ANOTHER A/D CONVERTER

Many of the popular a/d converter ics rely on the principle of successive approximation. The device makes a series of 'guesses' at what its output should be and gradually gets nearer and nearer to the correct answer. That is not to say that the ic makes wild guesses; the approach is strictly a systematic one known as a binary search. The main sections of the circuit are shown in Fig. 13.

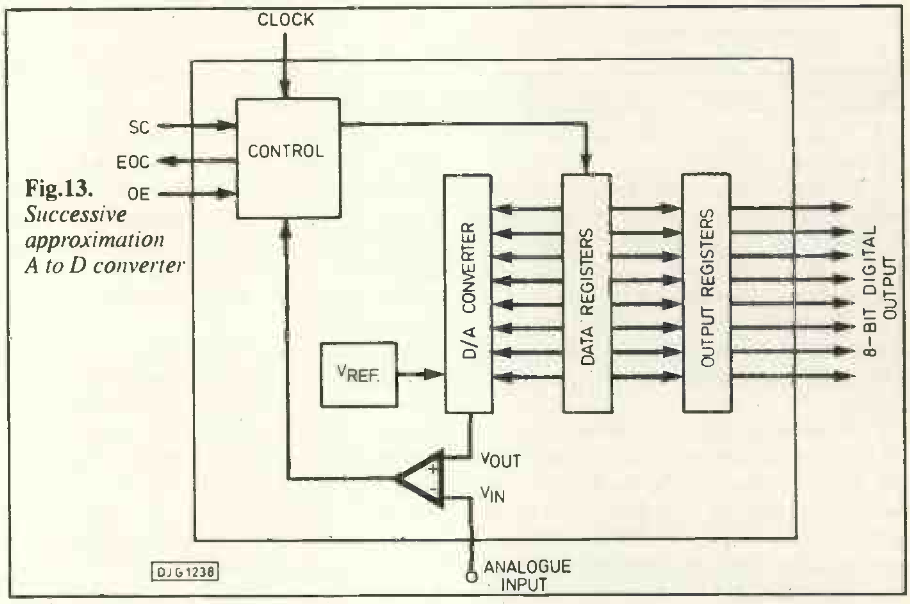


Fig.13. *Successive approximation A to D converter*

The circuit is programmed to run through a series of operations. It requires an external clock to provide the pulses to initiate each operation. The sequence is as follows:

1. When the start conversion (SC) input goes low, the control section sets all bits in the data register to zero (00000000). However, the state of the registers does not appear at the output terminals yet.

2. The most significant bit is set to '1', making the register hold 10000000.

3. The register is connected to a d/a converter on the a/d chip. The value held in the register is converted to an analogue voltage. Since the register holds 10000000, V_{out} is half of V_{ref} of the d/a converter.

4. A comparator, also on the a/d chip, compares V_{out} with V_{in}, the analogue input to the converter:

* If V_{in} is equal to or greater than V_{out}, then the converter continues with step 5.

* If V_{in} is less than V_{out}, the converter continues with step 6.

5. The 'guess' is correct – since the input voltage is half or more than half the reference voltage, the most significant bit should be '1'. The circuit leaves the bit set at 1 and makes the next most significant bit a '1'; the register now holds 11000000.

6. The 'guess' is incorrect – since the input voltage is less than half the reference, the most significant bit should be '0'. The circuit resets the bit to 0. Then it sets the next most significant bit to '1'; the register now holds 01000000.

7. After stage 5 or 6 the converter repeats steps 4 and 5, to find if the second bit should be '0' or '1'. It works its way along the digits, setting each in turn and testing the result, until all eight bits have been tested and correctly set or reset.

8. Conversion is now complete and the end of conversion (EOC) output goes high. This tells external logic that the result is now ready to be read. In the circuit of Fig. 13, the EOC output is connected to the output enable (OE) input. When EOC goes high, output is enabled. The contacts of the data register are transferred to the output register. The results of the conversion appear on the output terminals.

9. A new conversion begins as soon as SC is made low again. The results of the previous conversion remain on the output register until the next conversion is complete.

The practical circuit of Fig. 14 shows the converter being driven by an astable made from a Schmitt trigger gate. Conversion takes eight cycles of the clock. The faster the clock runs, the faster the conversion, except that allowance must be made for the internal d/a converter to settle and for the comparator to operate at each stage. The total conversion time can be 1µs or more, so this type of converter is appreciably slower than the 'flash' converter we described previously. However, the successive approximation converter is usually fast enough. It is accurate and is considerably less expensive then the 'flash' type.

Trial 5

Successive approximation a/d converter

In Fig. 14 we test the action of the converter by taking the analogue input from a variable resistor VR1. The voltage is the analogue of the angular position of the control knob. The further the knob is turned clockwise, the higher the voltage. The voltage can be varied from 0V to 2.5V. Since V_{ref} on the on-chip d/a converter is 2.5V (as in the ZN428E ic) we are covering the complete input range of the converter. Note that this ic requires a -5V supply. Although it is specified to operate on ±5V, to make it compatible with TTL, it works well enough for this demonstration on ±6V, as provided by two batteries (see Fig. 14 inset).

1. Set up the circuit as in Fig. 15. You can read the output from the converter in one of several ways:

* use a voltmeter, sampling each output (pins 11-18) in turn.

* use an led or logic probe, connected to each output in turn.

* best of all, connect eight leds to the outputs. Use eight separate leds, on a second breadboard, or two of Module 2 (PE Sept. 1988).

2. Turn VR1 anti-clockwise so that V_{in} is 0V.

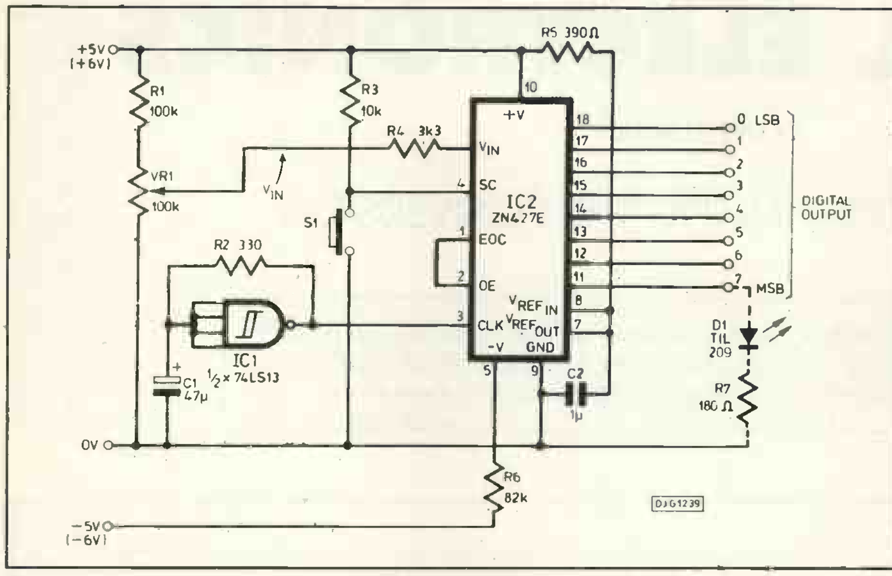


Fig.14. *Demonstration of analogue to digital converter IC.*

3. Press S1. This grounds the SC input and starts conversion.

4. A fraction of a second later, the digital output appears. If you have eight leds, one or two of the least significant ones may light. This corresponds to a near-zero reading such as 00000001 or 00000010.

5. Gradually turn VR1 clockwise, to increase V_{in} a little at a time. Press S1 occasionally and watch the digital output increase.

6. Repeated pressing S1 without turning VR1 should give the same output. However you may find that, on the borderline, and output may be, say, 01000000 on some occasions and 00111111. These two look very different when displayed as a row of illuminated leds, but the difference between them is only 1!

7. If you turn VR1 fully clockwise, V_{in} becomes 2.5V. The leds should all be lit.

8. As an exercise in design, remove R1 from the board and replace it with an ldr or a thermistor. You may need to replace VR1 with a resistor of another value. The output from the converter will then be the digital equivalent of the amount of light falling on the ldr or the temperature of the thermistor. If you are using a thermistor, you could try to calibrate it. Draw out a conversion table, so that the binary output can be read as temperature in degrees Celsius.

OTHER CONVERTERS

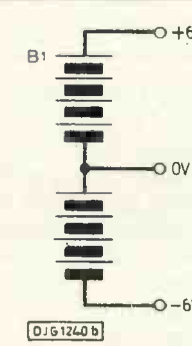
This is yet another approach to a/d conversion. A v/f (voltage-to-frequency) ic accepts an analogue input (a voltage) and generates a digital output, a series of pulses. The pulses are all the same length but their frequency depends on the input voltage (Fig. 16). The ics for performing this operation are cheap and give a reasonably accurate conversion. An example of a voltage-to-frequency converter is the 4151.

This converter has a single output terminal. It gives a series of pulses – not a number of parallel bits on separate output lines. If you need to send data over a single line, a series of pulses sent over one line is more useful and less expensive than having to have eight parallel lines for eight individual bits. At the end of the line, the pulses can be fed to a counting circuit that registers the number of pulses received in a given time. This number can be used to drive a display to give digital readout of the analogue input.

This converter is also useful for feeding data to the serial input of a microcomputer. The microcomputer is programmed to measure the frequency of the serial input, and then calculate the original voltage (or whatever other quantity, such as light intensity or temperature) of which the voltage is an analogue.

There is another advantage in transmitting data in this way. If we attempt to send a varying voltage over a line, we run into problems with the resistance of the line. If the line is long, the voltage at the receiving end is certain to be lower than that at the sending end. But, if we send a series of pulses instead, the number of pulses reaching the receiving end in a given time is certain to equal the number being sent. Even if the pulses are slightly distorted on the way, we are not likely to lose or gain one whole pulse (*but beware of Murphy's Law! Ed.*) At the receiving end, we re-convert the pulse train to an analogue voltage, using a frequency-to-voltage converter, such as the LM2917.

The 507C is another converter that produces a series of digital pulses. This is a voltage-to-time converter. It differs from the v/f converter in that the signal from the converter is of constant frequency, but the length of time for which the signal is high depends upon the input voltage (Fig. 17). Like the 4151 described above, this is a low-cost converter useful for sending analogue data along a line or to the serial



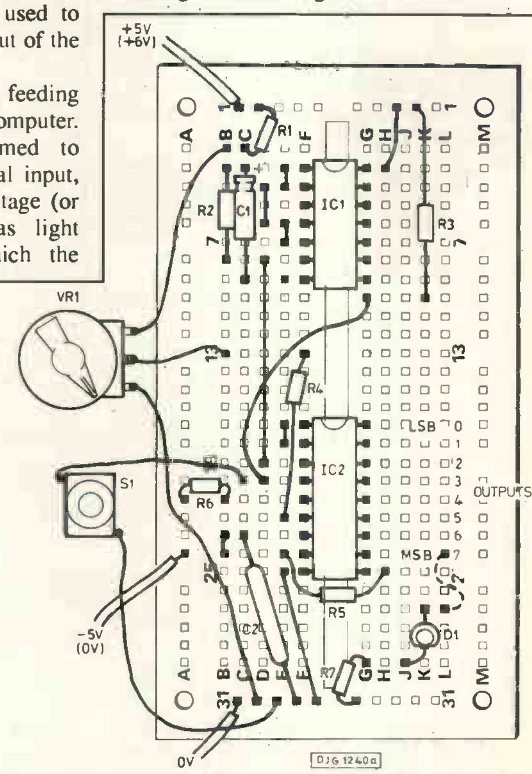


Fig.15. *Breadboard version of Fig.13. The inset shows the battery power supply*

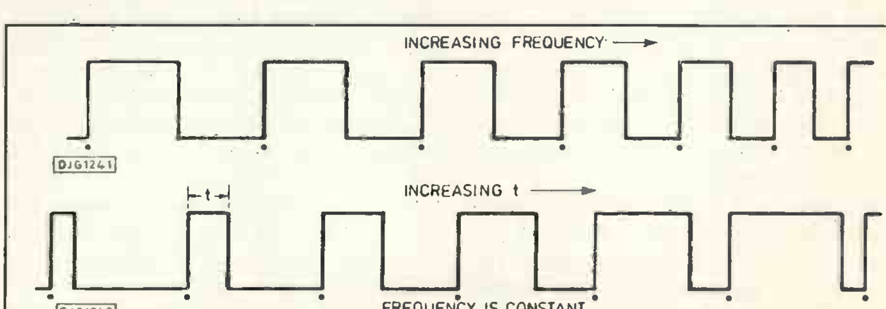


Fig.16. *(top) Output of a V-F converter, as Vin rises.*
Fig.17. *(bottom) Output of a voltage-time converter, as Vin rises.*

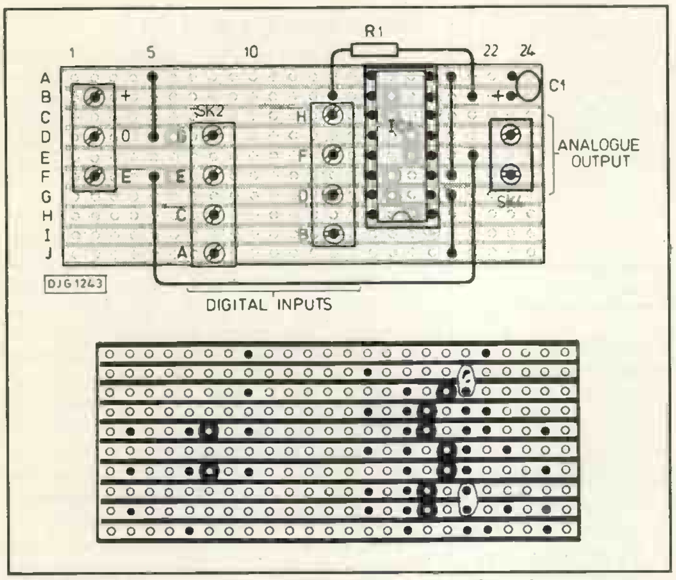


Fig.18. *Digital to analogue converter layout and track view.*

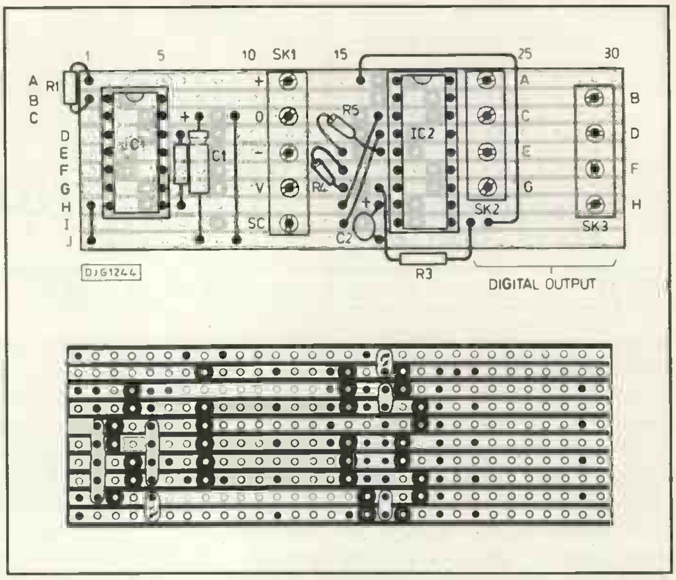


Fig.19. *Analogue to digital converter and track view*

input of a microcomputer. The signal can be converted to a count by suitable logic.

MODULES OF THE MONTH

9. Digital-to-analogue converter

This module (Fig. 18) is based on the circuit of Fig. 8 in part six. It operates on a 5V supply. The ENABLE input (E) is made low to enable conversion. This is brought low by external logic, or more simply wired directly to the 0V (0) input. It accepts 8-bit input (where H is the msd and A is the lsd). Output V is in the range 0V to 2.5V. The module requires 25mA. Note that the ic is not mounted the usual way round on the board.

Parts required.

R1 390 ohm, 0.25W
C1 1μF tantalum
IC1 ZN428E d/a converter
SKT1 pc terminal 3-way
SKT2, SKT3 pc terminal 4-way (2 off)
SKT4, pc terminal 2-way
14-pin dil socket
Stripboard Vero 14345

10. Analogue-to-digital converter

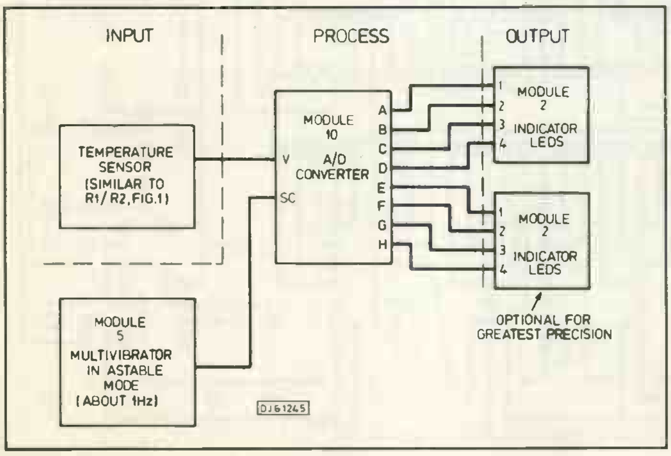
The module (Fig. 19) is based on the circuit of Fig. 14. It requires a power supply of ±5V, but appears to work reliably on ±6V too. Analogue voltage in the range 0-2.5V is fed to terminal V. The START CONVERSION (SC) input is normally held high but is made low when conversion is to begin. You can do this from a logic output, or by using a resistor and push-button, as in Fig. 8 in part six. The 8-bit digital output appears on the two sockets at the right of the board. H is the msd and A is the lsd. The module requires 25mA on the positive rail, and only a few microamps on the negative rail.

Parts required

R1 1k (all resistors 0.25W)
R2 330 ohm
R3 390 ohm
R4 3k9
R5 82k
C1 47μF electrolytic
C2 1μF, tantalum
IC1 74LS13 dual 4-input Schmitt trigger NAND
IC2 ZN427E a/d converter
SKT1 pc terminal 3-way plus pc terminal 2-way
SKT2, SKT3, pc terminal 4-way (2 off)
14-pin dil socket
18-pin dil socket
Stripboard 30 holes by 10 strips

SYSTEMS OF THE MONTH

Fig. 20 is the system diagram of a digital thermometer. V_{in} increases as temperature increases over a given range. Select resistor values so that Vin does not exceed 2.5V. The astable 'clocks' the START CONVERSION input, to convert the input once a second. Output is in the range 0 to 255. You could work out a table for converting reading in binary to temperatures in degrees (see Trial 5, step 8). Unfortunately, it is not easy to make the binary output correspond neatly with the temperature in degrees or Kelvin. If the thermometer is being used in some kind of process control, and you don't need a digital readout, design logic to switch on (or off) the heaters, lamps, sirens etc when the digital output reaches certain levels. The 7485 4-bit magnitude comparator (not the same type of device as the analogue comparators of Fig. 1 in part six) is an ic used for detecting when the digital output of the converter reaches a given binary value. It accepts two four-bit numbers and its 'A=B' output goes high when they match exactly. Fig. 21 shows how a logic gate is used to detect when none of the four most significant bits is high, ie the temperature is less than 00001000 (whatever the equivalent in degrees Celsius may be). Supposing that 00001000 is equivalent to about 2°C, the output from the NOR gate triggers a bistable, sounding a 'frost alarm'. Other logic may be connected to the same



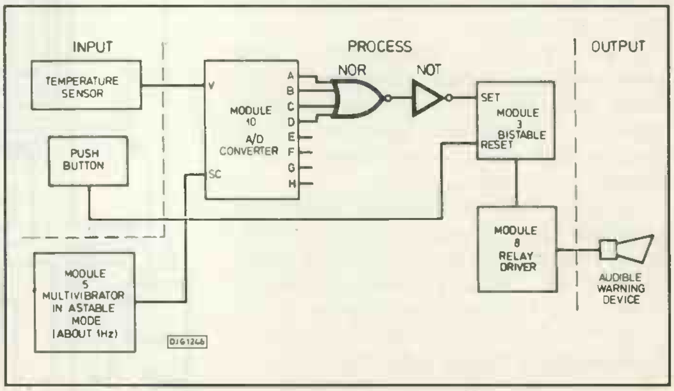


Fig.20. *(left) System diagram for a digital thermometer.*
Fig.21. *(above) System diagram for a frost alarm.*

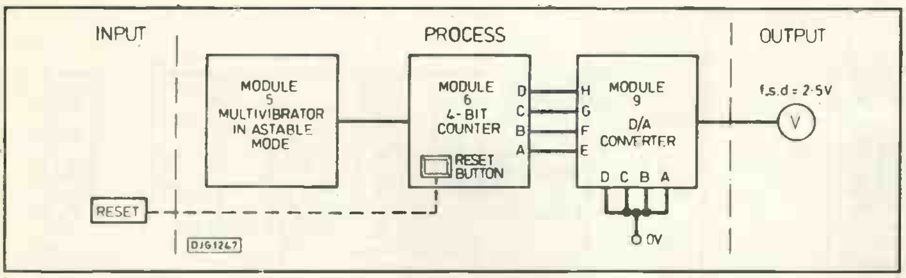


Fig.22. *System diagram for a digital phone call timer with analogue read-out.*

system to perform different functions at other temperatures.

Another approach is to feed the digital output to a microcomputer. This is programmed to read the 8-bit input, then calculate and display the temperature in degrees.

Although digital displays are 'all the rage', there are many people who find old-fashioned dials easier to read and understand. This is why watches and clocks with circular dials and a pair of hands remain popular. Electronic watches may have such a dial even if the circuit is purely digital up to the display stage. You may also find such a display more suitable for your own digital circuits. A 4-digit lcd or led display is quite costly to build and the driving circuitry is complex. If you do not need 4-figure accuracy, it is often simpler, cheaper, and possibly more satisfactory to have an analogue readout. A cheap moving-coil meter costs only two or three pounds. You can open it and replace the scale with one graduated in whatever you are intending to measure. Fig. 22 shows a moving coil meter being used for the readout from a phone call timer. We realise that this kind of device could be built completely from analogue circuitry but, since this series is devoted to the ramifications of binary digits, let's keep everything digital until the last possible moment.. Timing is performed by the astable. It is possible to have switchable resistors to allow a choice of timing rates. The rate of the astables is set so that it produces 16 pulses in whatever maximum period you wish to spend on the phone. A possible addition is a NOR and NOT gate with Module 3 to trigger an alarm when your time is up (Fig. 21). As you chatter away, the needle moves menacingly across the dial. At the 16th step it reaches the right-hand end of the scale – time to sign off! **PE**

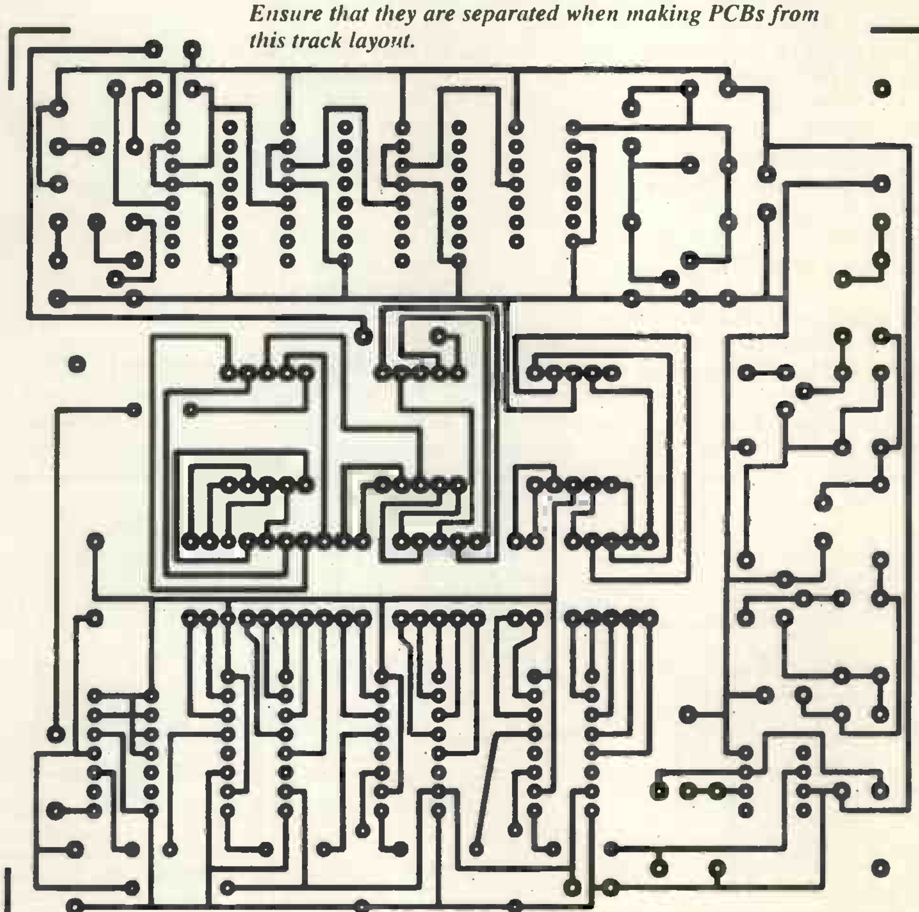
TELE UNSATURATED

Inconsistency appears to be the hall-mark for government departments in many areas. On the one hand there has been legislation permitting both Astra and BSB satellites to transmit new tv channels into British homes. On the other hand, there are legal restrictions which impede public acceptance of the new networks.

The Government has confirmed that tv viewers may not use more than one satellite dish unless they obtain planning permission. There are additional restrictions to how high the dishes can be placed with regard to the height of the building. It also appears that blocks of flats are only permitted one dish without planning permission, irrespective of the number of occupying family units. The penalties for illegally installing an additional dish are considerable since a fine of £2000 can be imposed, plus a further £200 for each day the second dish remains in place. With the potential for several million households wanting to receive the new, satellite programmes, plus those from already operational European satellites, the planning authorities will be so totally overwhelmed with applications that installations will be very slow in materialising. The environmental considerations are recognised, but the planning controls could have drastic consequences for the early success of the new channels.

It would appear to mean, though, that any entrepreneur who is quick enough off the mark could make a fortune by introducing a single antenna system capable of receiving all the satellite channels. The technical problems are probably formidable, but if sense is to be made of the valuable new services a single steerable antenna appears to be the only solution to governmental restrictiveness. Ed.

Note: The pads in the centre are very close together, Ensure that they are separated when making PCBs from this track layout.

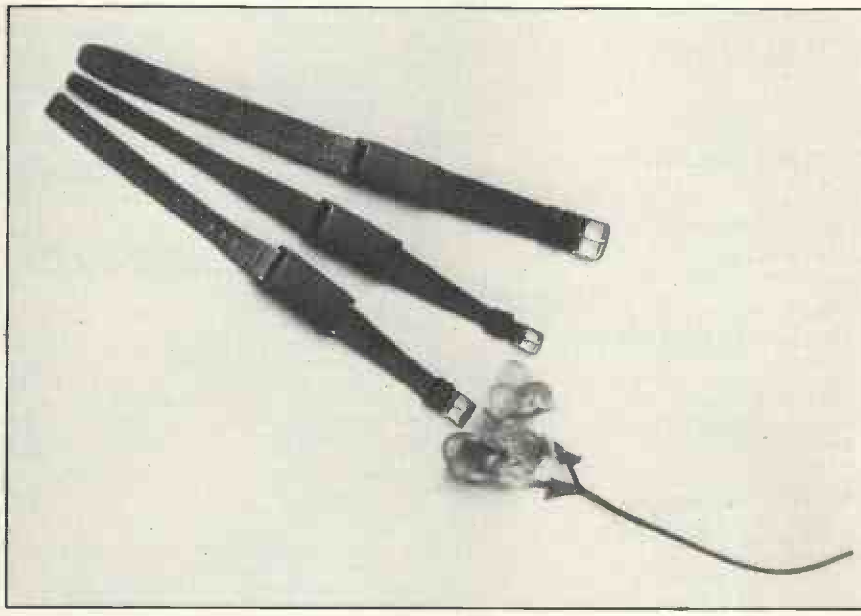


TACTILE DEAF AID

BY VINCENT JOHNS

TAM, TAM THE PIPER'S ON

Even small amounts of sound information are useful to a profoundly deaf person. A new device under development translates sound into vibrations which can be received by touch.



Profoundly or completely deaf people could find lipreading much easier in future if the results of a new electronic-based research programme at Exeter University are successful.

The idea of using tactile stimulation to provide profoundly deaf people with an indication of the presence of sound is not new. Bone-conduction hearing aids have been used for many years, but their effectiveness is limited because of acoustic feedback and the small amplitude of vibration available. So some years ago the RNID, The Royal National Institute For The Deaf, in conjunction with the University of Exeter, decided to design a simple device which would provide a high level of vibration and give deaf people an awareness of sound around them.

The design was deliberately restricted to only providing an indication of the temporal pattern of the sound and its amplitude. By limiting the aims of the project, Exeter's Department of Physics felt the design objectives could be more readily met and the cost would be kept low, thereby keeping it within the budget of the target market, the profoundly deaf.

The result of this research was the Tactile Acoustic Monitor (TAM), an unobtrusive wrist-worn vibrator unit, very similar to a wristwatch to outward appearances, but with the rest of the unit small enough to be placed in a pocket.

Fig. 1 shows the design of TAM which has a constant frequency, constant amplitude output. In short, it works like this: the incoming signal is amplified and feeds a level detector, the threshold level of which can be adjusted by the user-operator.

When a signal goes above this level it causes an oscillator to operate and, through the output driver, activates a piezo-electric vibrator. The vibrator is a tuned bimorph and the oscillator runs around 190Hz. A led is switched in on the output of the driver system to indicate visually to the wearer that the system is operating, and is also a visible indicator of the presence of sound.

Fig. 2 shows the sensitivity of the device over the frequency range from 100Hz to 10Hz. The output from the wrist-worn vibrator has been measured on an IEC mechanical coupler (artificial mastoid). This provides a suitable means

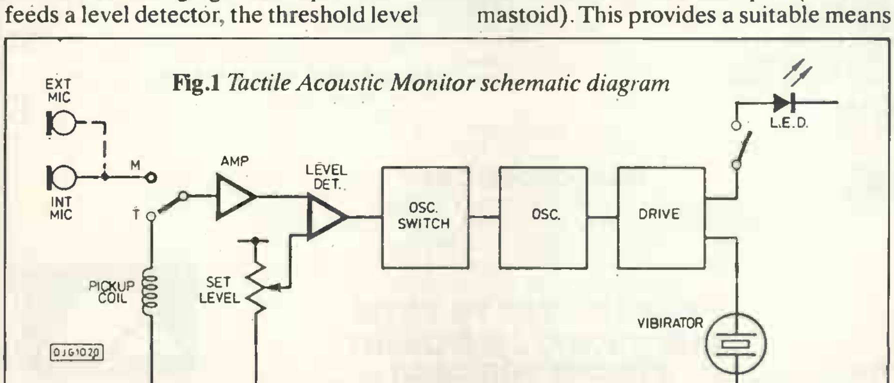


Fig.1 *Tactile Acoustic Monitor schematic diagram*

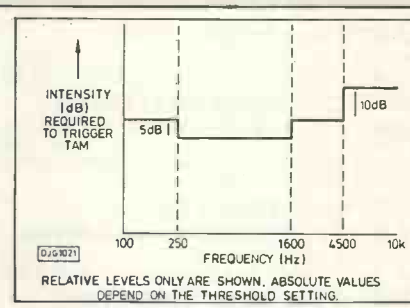


Fig.2 *Sensitivity of TAM*

for measuring the output from a range of tactile devices in a resonably realistic manner.

Fig. 3 shows the output of the vibrator for a varying input signal. The adjustment of the threshold level control alters the manner in which the temporal pattern is presented, and this indicates the necessity of using a setting which covers the range of sounds in the user's environment. We can also see here how the device can be used to monitor ambient noise levels by appropriate adjustment of the threshold level.

The net result means the TAM has a number of everday uses, including:

● Telling the wearer that some-body is talking to them, even if the wearer is not looking directly at them. This is particularly useful in offices, when the

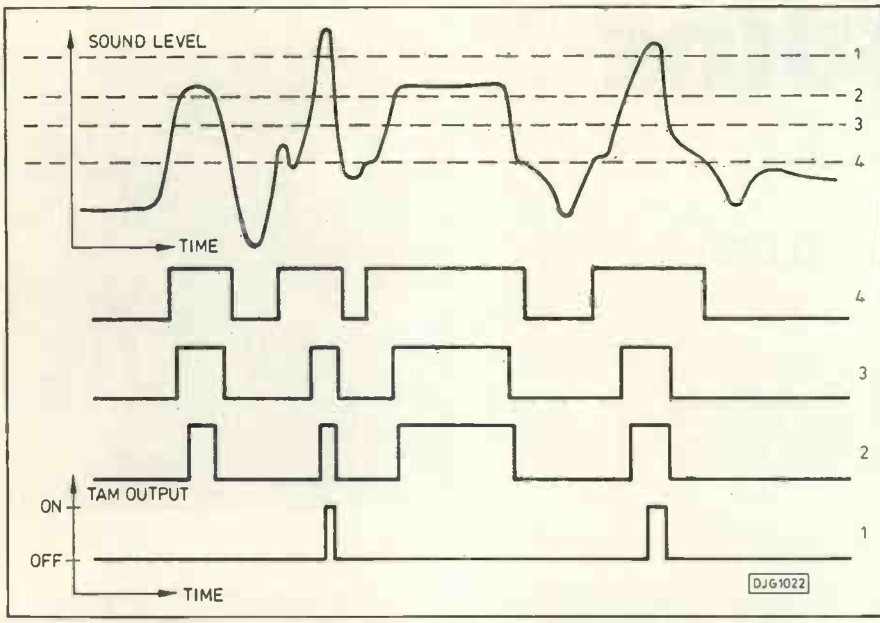


Fig.3 *Effect of changing the threshold level. The output is always at constant amplitude and frequency*

wearer is looking at the desk, and somebody wants to attract their attention.

● Warning signals, such as telephone bells, fire alarms, door bells etc can all be picked up. The temporal pattern of the signal is closely followed, which means the wearer can differentiate between various sounds.

● Monitoring everyday sounds around users, such as footsteps.

● Indicating whether equipment is working – particularly useful in the home where various domestic appliances produce sounds.

● Warning of the presence of traffic and, by suitable adjustment, can even provide an indication of other signals, such as car horns amongst the general traffic noise.

● Helping the deaf person to control the level of their voice, particularly if they use TAM to detect if the ambient noise is high or low.

The TAM is already available commercially, but current research at the University of Exeter is aimed at finding the best way of coding speech-derived information onto a single tactile channel to aid lip-reading. Experts now hope it will be practical to transmit the sort of sound information which is not always visible on the speaker's face, such as stress and intonation or voice inflection.

It now seems likely that even a little information transmitted via the sense of touch will be of significant benefit. By frequency or amplitude modulation of the output signal, it is possible to transmit such information. There are still problems for the Exeter team however – the useful bandwidth of the skin is approximately 20-300Hz, but frequency and amplitude resolution are relatively poor within this range. PE

Further information on the TAM can be obtained from the manufacturers, Summit, 74 Wheeleys Road, Edgbaston, Birmingham, B15 2LN, or from local offices of the RNID.

AUTOGUIDE

BY MICHAEL STRASSEN

A BETTER WAY TO GO

While it's a bit soon to throw away your road maps, work is under way to create a guidance system that will literally let the car find the way home.

The Editorial of PE Feb 89 reported that at the opening of the current Parliamentary session, the Queen had announced that the Government intended to introduce legislation providing for new systems of route guidance for drivers.

The Queen was referring to the system known as Autoguide a computerised traffic guidance network that will have significant benefits for drivers across Britain and, with international cooperation, across Europe as well.

The proposals for a guidance network gained momentum when, in September 1986, the Government launched a discussion document "Autoguide - A Better Way To Go?". This outlined the work at the Transport and Road Research Laboratory and put forward for discussion proposals for a national Autoguide system, initially based around London.

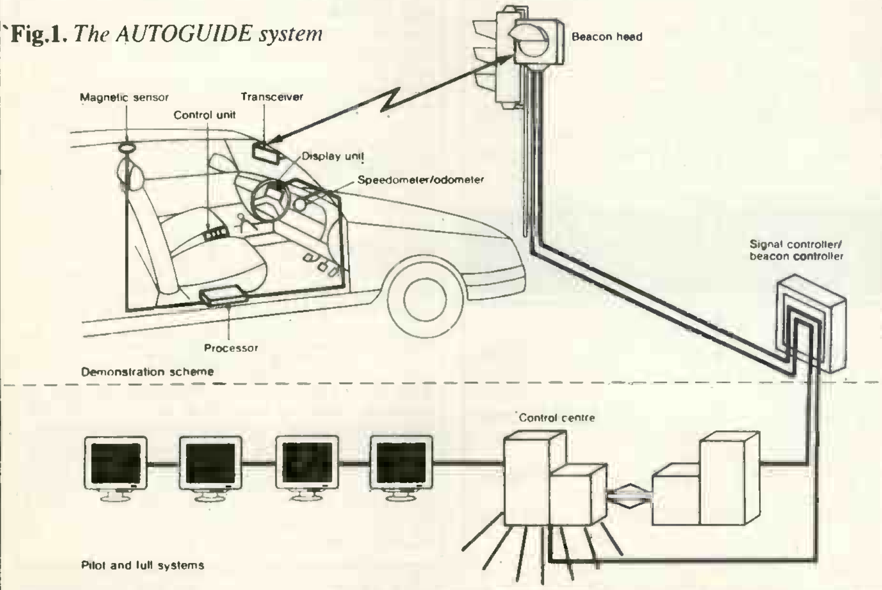
By April 1987, the responses to the proposals were overwhelmingly in favour, following which an experimental infrared system of transceiving beacons was installed between Westminster and Heathrow Airport. Among those participating were London Buses, British Airports Authority, AA, RAC, GEC Traffic Automation, Plessey Controls, Austin Rover Group, Texas Instruments, Westminster City Council, W.S. Atkins and Partners, Wootton Jeffreys and Partners, and SIA Ltd. Organisations in West Germany are also carrying out similar trials around Munich and Berlin. The Parliamentary legislation required will cover licensing arrangements for the network operators, participating drivers, and such mundane things as the right to dig up the street to put in necessary cables!

THE SYSTEM

Autoguide is a system giving drivers recommended routes to their selected destinations using a dashboard-mounted display. (Fig.1). It gives advice based on constantly updated information about traffic congestion, accidents, roadworks and bad-weather conditions. The data will originate from a variety of sources, including the police, urban traffic and motorway control centre, the motoring organisations, meteorological centres, and highway authorities. Safeguards are to be built in to prevent the system from shifting congestion from one area to another.

Along the route are electronic signposts - small infrared beacons transmitting coded maps to an in-vehicle computer. This decodes the information and displays simple advice to the driver on an lcd monitor screen, possibly accompanied by a synthesised speech message. It is expected that Autoguide could help to reduce average journey times by as much as 10%, and reduce mileage by about 6%. Assuming around half a million users in the London area, annual savings in the region of 125 million could result. An expected reduction of road casualties by around 500 annually will be a further benefit.

Fig.1. *The AUTOGUIDE system*



EARLY TRIALS

In the early stages of the trials the merits of microwave and infrared transmission techniques were examined. It was found that microwave reception was erratic under busy traffic conditions, and infrared techniques appeared to offer a better technological solution.

The initial scheme sited three beacons in Westminster, one at Heathrow and one on the M4 motorway. (Fig.2). Each trial beacon is independent and not connected to a control centre, consequently there is no dynamic re-routing taking current conditions into account. Despite the limitations, this scheme demonstrates the feasibility of taking journeys of up to 20 miles under full route guidance.

JOURNEY COMMENCEMENT

The vehicle driver at the start of the journey uses a keypad to enter the co-ordinates of the destination, currently by means of a national grid reference, though ultimately a postcode or telephone number might be entered. In a full system commonly used destinations would have their references stored in memory for immediate keyed recall.

Once the destination has been entered the lcd screen will display the "as the crow

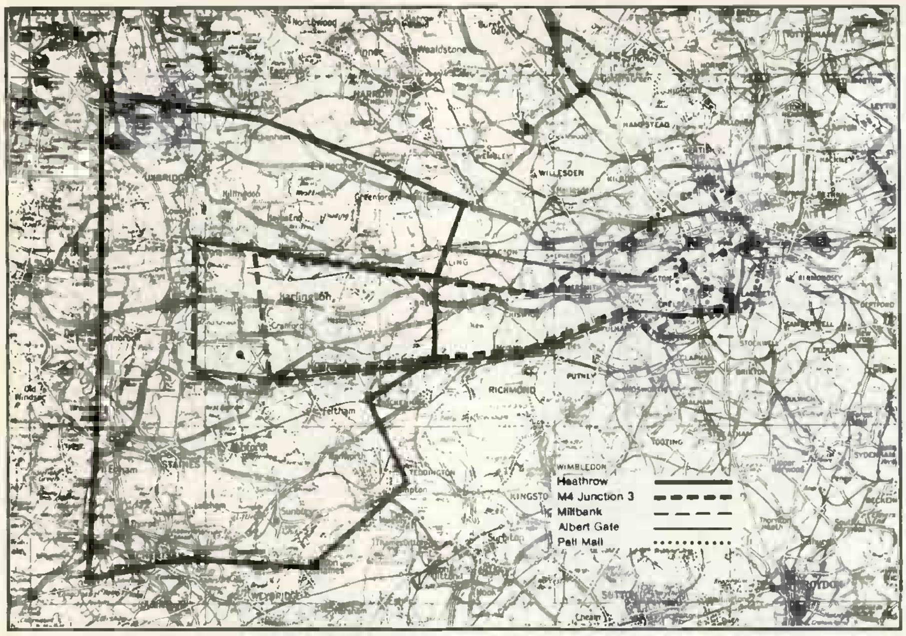


Fig.2. *Demonstration scheme beacon regions*

flies" distance to it and its direction (Fig.3A). At this time the unit will not yet have received data from an on-route beacon, and so will not know the best route to take. Until the first beacon is reached, the system will remain in an autonomous mode and simply keep track of the distance covered and the overall direction. On receipt of data from the first beacon encountered, the system will switch over to the fully automatic guidance mode.

In this mode the display will show a three-arrow symbol, as in Fig.3B, indicating that the "road ahead" should be followed, however much it may twist and turn. Prior to a turn from the main direction the unit gives an audible warning, and the display changes. The warning distance will depend on the type of road - typically about a kilometre on a motorway, 300 metres on a suburban road, though in narrow slow-speed city roads it could be as little as 50 metres.

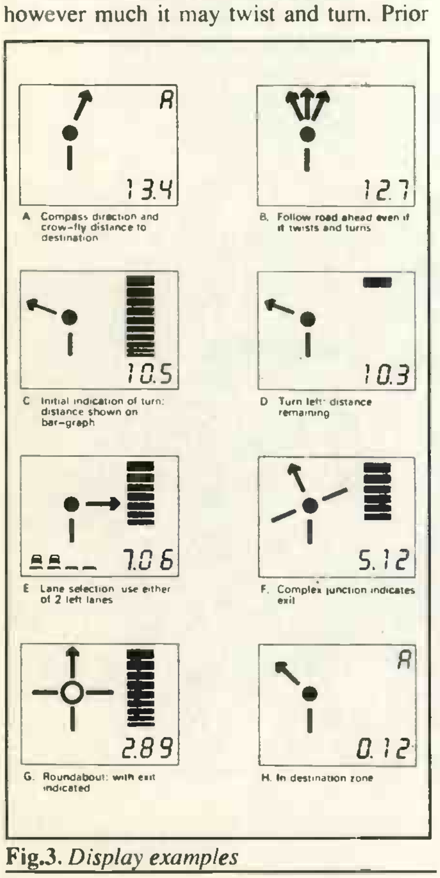


Fig.3. *Display examples*

TURNING INDICATION

The "turn ahead" message is shown by an arrow in the relevent direction, together with a bar graph indicating the distance to the turn (Fig.3C). The bar graph markings will decrease as the vehicle gets nearer to the turn. As an additional aid to some turnings, a lane recommendation will be displayed as well, facilitating the driver's smooth transversal of a roundabout, for example. Textual messages can also be displayed, telling drivers which road signs should be followed.

Each time another beacon is passed it transmits further data to the vehicle's computer - all the driver needs to do is follow the recommendations. Indeed, the driver will be unaware that the vehicle has passed into another beacon's region. Should an incorrect turning be made inadvertently, the system will automatically show information that will allow the driver to get back on course.

DESTINATION ZONE

Once in the beacon region containing the destination the unit will remain in automatic guidance mode until the vehicle is quite close. Outside London, this could be within 500 metres of the destination, though within Central London could be within 100 metres. When the vehicle crosses into the final zone, the unit will switch back to autonomous mode. For this part of the journey guidance will be by a dead-reckoning assessment of position, but the accuracy could be within 10 metres.

If the destination is outside a beacon region, the recommended route is followed until the edge of the final beacon is reached. The unit then switches to the autonomous mode, giving indications of direction and distance to the destination, though of course, the dead-reckoning errors will begin to accumulate. In such situations the use a normal motoring map may still be needed for the last part of the journey. (Accompanied by occasional glances at the heavens for celestial guidance in the accustomed manner!)

BEACON SITES

It proposed that at each beacon site there will be several beacon heads, positioned so that for most approaches to a junction there will be at least two heads pointing towards oncoming traffic. Each set of beacon heads will be connected to its own controller, this in turn will be connected back to the main control centre. Thus real-time traffic data can be collected and disseminated as appropriate. (The present demonstration system does not include a control centre, though one will be included in the full system.)

Where possible the beacon heads will be mounted on existing posts, such as traffic light posts, though by necessity may be mounted on their own posts, or in other fashions. For example, at the Heathrow experimental site, two beacon heads are mounted to either side of the tunnel portals. On motorway sites, in order to increase the power of the infrared transmission, and so extend the range for fast moving traffic, two heads will be mounted on each side of the carriageway. It is proposed that advantage should be taken of existing signalling installations to minimise the installation of additional road-side equipment and cabling.

Infra-red beacon mounted on traffic lights

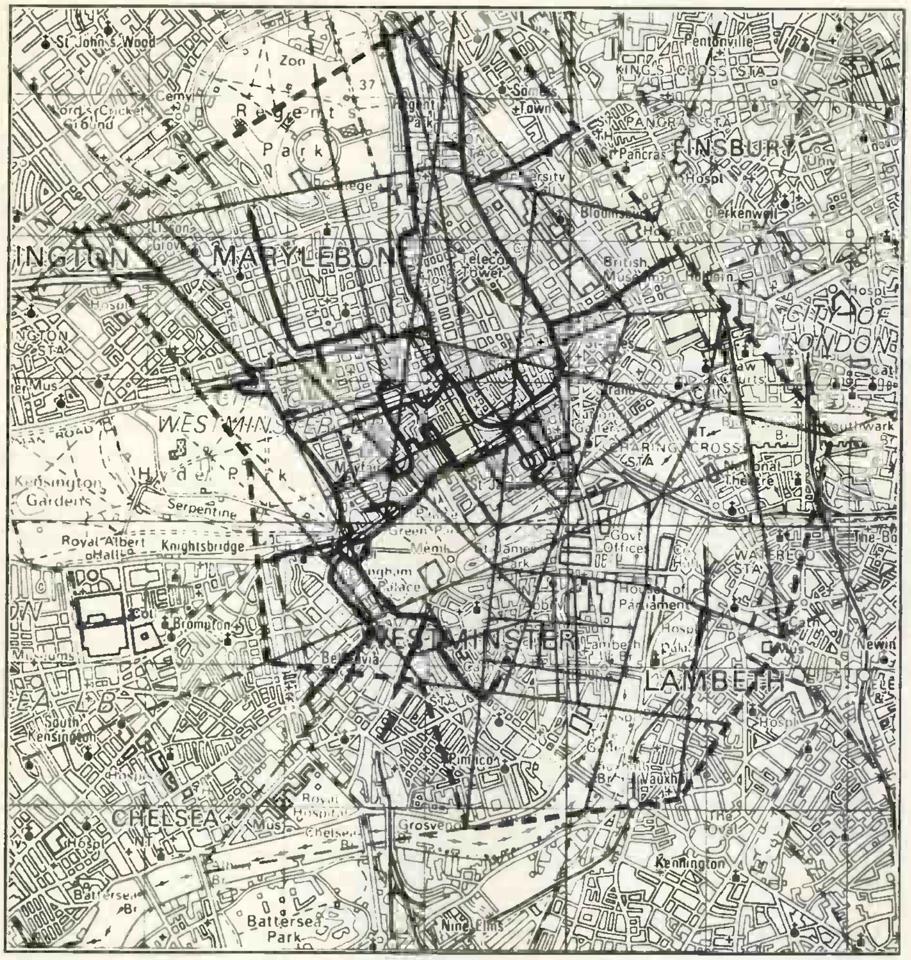


Fig.4. *Example of zoning system for a London region*

VEHICLE UNITS

For the purposes of the demonstration experiment, the vehicle units consist of five main items, display, control, processor, transceiver and magnetic sensor. Additionally, connections are made to the vehicles odometer, for distance monitoring, and to the radio loudspeaker system.

The infrared transceiver is mounted behind the vehicle's windscreen, typically beside the rear view mirror. It receives the data from the beacon heads, and transmits signals back to the beacons. The incoming data is processed by a microcomputer that keeps track of the vehicle's location and sends information to the driver's display screen. It additionally passes journey time details back to the transceiver. For the demonstration purposes the computer is a separately mounted unit, though ultimately it will probably be integrated with the display unit.

The magnetic sensor is a solid-state device that senses the Earth's magnetic field enabling vehicle direction assessments to be made. It will typically be mounted in the roof of the vehicle, well away from the magnetic disturbances of the engine.

BEACON DATA

The beacons hold four main types of data - map data containing information on road links, turning information, zones or destination areas, and recommended routes. The data is stored as an 8 kilobit block and is transmitted at the equivalent rate of 125 kilobits per second.

For each beacon region details are stored of appropriate route links. Each link consists of a series of straight line vectors, and the vehicle processing unit tracks the current location by matching distance and direction travelled against the stored vectors. Map data is stored as tabulated grid references for each vector, together with the connections between links. When in automatic guidance mode, the precise location is updated at the end of each vector so that cumulative dead-reckoning errors are minimised. The processor also takes account of which direction arrow to display, how the bar-graph distance display should be notated, whether lane recommendations should be shown, and if additional texts are required.

The computer is additionally responsible for determining the data to be sent by the vehicle to the beacon. Principally this will relate to details of the journeys between beacons, including distances and transit times.

INTERNATIONAL COOPERATION

Originally, the initial developments of an automatic guidance system had been separately pursued in the UK and in West Germany. By 1986 it was evident that the researchers in both countries were arriving at similar conclusions, and a collaborative approach was adopted. Though there were some differences of opinion, these were resolved and a combined draft proposal was established. The final agreed draft standard is expected to become the basis for wider international agreements for full international compatibility of Autoguide-type systems. The standard does not dictate what form the control centre and in-vehicle equipment should take. Its intention is to ensure that the data transmission conforms to standard format and meaning.

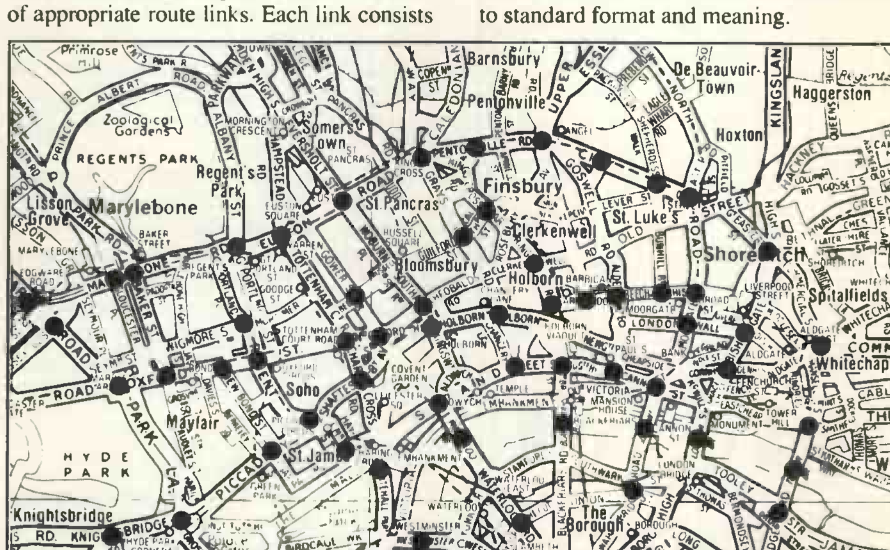


Fig.5. *Possible beacon sites in Central London*

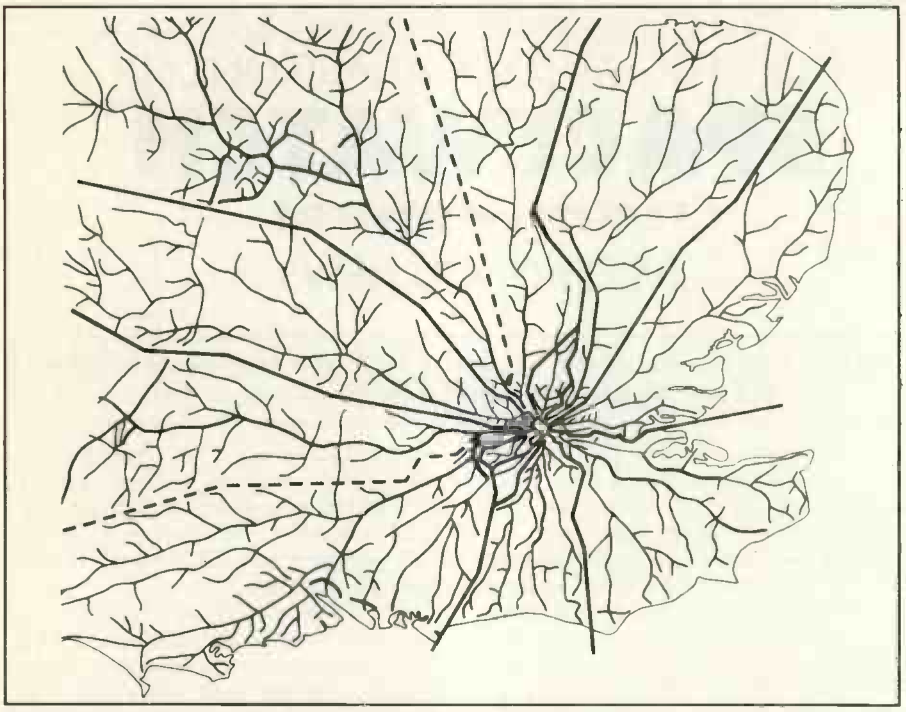


Fig.5. *Example of a partition tree radiation from London*

COMMERCIAL OPERATION

The implementation of Autoguide is intended to be a commercially profitable venture and drivers will have to pay for the privilege of using the system. As a personal opinion, I would have preferred to pay for it through the normal road-tax system - after all, we don't have to pay for the right to use traffic lights and road signs. To me, Autoguide should be regarded as a natural extension to other essential traffic guidance systems, especially as the nation as a whole will benefit from better traffic movements.

However, in keeping with the modern trend away from governmental financing of society's requirements, Autoguide will be operated on a commercial basis. One proposal is that users of Autoguide should pay a licence fee, officially quoted as "nominal", in return for which they would be allocated a private access number (pan). Each pan would relate to an individual in-vehicle unit which would function correctly for a specific period once the number had been entered. (I hope the pans can't expire during a complex dynamic re-routing operation in an unknown locality.)

To maintain international compatibility, foreign drivers visiting the UK would be issued with temporary pans for the duration of their visit. It is expected that UK travellers would be extended similar permits during trips abroad, though it is possible that not all countries will charge for use of the system.

UK operators will have the right to set their own charges made to subscribing motorists, though the upper limit will be set by Parliament.

ENCRYPTION

The draft standard proposal covers the implementation of beacon data encryption so ensuring that commercial revenues are protected. It appears that legislation will prohibit the use of non-registered Autoguide-compatible equipment, and the use of pan-bypassing circuitry.

It also appears that a further safeguard to revenue collection will be implemented - the draft standard proposes that vehicles must communicate back to the beacons in order to receive information from them. The vehicle's response data would consist of inter-beacon travel times, though coded recognition signals will probably be required as well.

Reassuringly, the draft standard emphasises that no permanent record of the vehicle's passing will be stored at the control centre. We know that Big Brother (or is it 'Sister'?) is already watching us in many ways, but it would seem that we shall retain privacy concerning where we travel and for what reason. I also conclude that enforcement of speed limits will not be facilitated by the Autoguide system. It is recognised that exceeding speed limits is major social problem, but if Autoguide were to be used for recording details of offending drivers, the attractiveness of the system would become questionable and perhaps deter drivers from installing it.

Although the scheme will be operated by commercial organisations, the integrity of the system and the responsibilities of the operators will remain subject to Parliamentary control and regulation.

THE NEXT STAGE

Following the Westminster-Heathrow demonstration tests, the next stage will be the commencement of a pilot scheme covering the entire London area out to the M25. The beacon density will be limited to begin with, and only cover the major routes carrying high proportions of through traffic. However, additional parameters will be assessed by experimentally equipping one section of London, the wedge bounded by the M40/A40 and the M3/A316 radial routes, with a beacon density and coverage having the same detail as would be expected in a full system. The intention is to upgrade the system to full commercial availability in the London area by 1991, with a rapid expansion to national coverage in the early part of the 1990s.

SOCIAL BENEFITS

Paul Channon, the Secretary of State states that, "Autoguide will help drivers to avoid hold-ups, reduce unnecessary miles driven and help to reduce road casualties. It will be a major contribution towards reducing the increase in traffic congestion and improving the quality of road travel. It has enormous potential for increasing driver's personal freedom and delivering economic savings. Problems with routing and navigation information currently costs the nation over 2 billion each year.

"There are benefits for all road users: for car drivers, particularly when making unfamiliar trips; for business travellers when time costs money; for delivery drivers ... time can be saved using up-to-date information; and for bus passengers who will benefit from shorter journey times because of reduced congestion."

Autoguide may not cure traffic problems, but it most certainly appears to offer a better way to go and no doubt many back seat drivers may need to seek new employment... PE

See page 47 for Jim Naylor's comment!

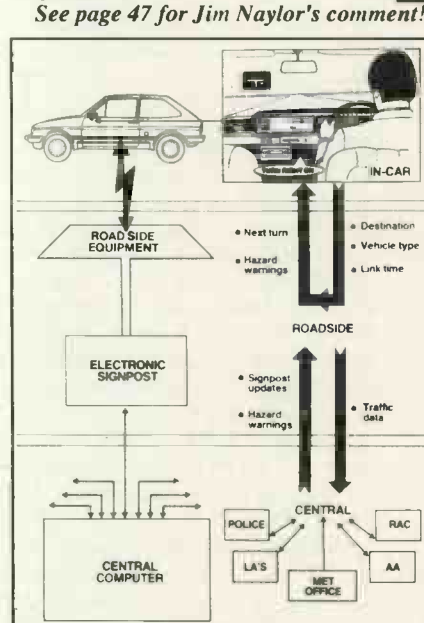


Fig.6. *Autoguide signal flow block diagram*

We are grateful to the Department of Transport for their kind permission to reproduce information relating to Autoguide.

OUR REGULAR LOOK AT ASTRONOMY

SPACEWATCH

BY DR PATRICK MOORE CBE

TIMELY GOOD NEWS

At last, a date for the Hubble telescope in 1989. A missing planet, albeit a small one, is rediscovered, and a probe is on line for Titan

For once there is some good news. Astronomers have long been awaiting the launch of the Hubble Space Telescope – the 94-inch reflector which is scheduled to be put into orbit round the Earth, and should revolutionize all astronomical observation. Successive delays have followed the *Challenger* disaster, and the launch of the HST has been given as early 1990, but the revised date is now December 1989 – apparently there has been a switch with a military payload which was originally scheduled for this launch. The Shuttle will be the *Discovery*, which has made several successful flights.

Two more cometary suicides have been noted. Both were detected by SMM, the Solar Maximum Mission probe, during October of last year; they were officially designated 1988m and 1988n. Both were quite large, but both were destroyed as they approached perihelion.

Another old friend has been found once more. This is the minor planet Hapag, No. 724, which was originally discovered in 1911 by J. Palisa, and named after a shipping line (the Hamburg America line). It was observed only at this opposition – and was then lost. It had been tacitly given up, but in November 1988 two Japanese astronomers, T. Hioki and N. Kawasato, detected an asteroid which was designated 1988 VG(2), but which has now been identified with Hapag. This is surely an achievement. Hapag is not large, and its magnitude never rises much above 15.

This means that of all asteroids which have been officially numbered, only two are still missing. One of these, 878 Mildred, is unremarkable, but the other is 719 Albert, one of the Earthgrazers. Like Hapag, it was discovered by Palisa in 1911. It was found to have a period of 4.4 years, and a perihelion distance only just outside of the orbit of the Earth. Unfortunately it was not recovered, and it has now been lost for so long that its recovery must be regarded as largely a matter of luck. Yet we must not abandon hope. No. 1862 Apollo, which has given its name to a whole class of Earthgrazers, was found originally in 1932 but was then lost until its recovery in 1973 – so perhaps Albert and Mildred will also turn up in due course.

It now seems that the University of Arizona will, after all, be able to build a major observatory on the summit of Mount Grahams, 10,700 feet above sea-level. Environmentalists have constantly frustrated these plans, but have now been defeated by legislation passed through Congress, so that construction may well begin in the near future.

CASSINI

Of all the worlds in the Solar System, one of the most intriguing must be Titan, the largest satellite of Saturn – and, incidentally, the largest satellite in the Solar System apart from Ganymede in Jupiter's family (though there must be lingering doubts about Triton, the senior attendant of

The Sky This Month

Planets are in rather short supply this February! Mercury is theoretically a morning object, but lies in the southern hemisphere of the sky and is not likely to be seen; Venus is moving in toward the Sun and is also to all intents and purposes out of view, while Saturn rises not long before the Sun and is very low down. This leaves Mars and Jupiter, both of which are in the evening sky. Jupiter, in Taurus, remains brilliant, but Mars has now declined to magnitude 0.8 or thereabouts, so that it is not much brighter than Aldebaran, while the apparent diameter has decreased to below 7 seconds of arc. There is no opposition of Mars in 1989, and during the summer the planet will not be much brighter than the Pole Star.

The Moon is new on February 6, and full on the 20th. On the 20th there is a total lunar eclipse, but in Europe it is not visible except for the north-eastern part of the continent. To see the eclipse, go to Australia, parts of Asia, or the Arctic. Totality lasts from 14h 57m GMT to 16h 15m GMT. (However, the total lunar eclipse of next August 17 will be observable from Britain.)

Orion continues to dominate the evening sky. It is worth noting that this year Betelgeux, the orange-red supergiant, is rather less brilliant than it was in 1987-8; it is decidedly variable, and though it has no definite period there is a rough one of around five years. At minimum, however, Betelgeux is still appreciably brighter than Aldebaran, despite the statements found in many books. It merits its title of 'supergiant'; its huge globe could swallow up the entire orbit of the Earth round the Sun. Yet it is 'only' about 15,000 times as luminous as the Sun, whereas Rigel could match at least 60,000 Suns.

This is the best time of the year for watching Sirius, in Canis Major, which is much the brightest star in the sky (though it cannot rival some of the planets). It is pure white, but its low altitude, plus its great brilliance, makes it flash various colours. Strangely, some of the ancient astronomers called it 'red', but this must surely be an error in interpretation.

Capella in Auriga is near the zenith; Cassiopeia is in the north-west, Ursa Major in the north-east. In the east Leo, the Lion, has come into view, and will remain prominent until well into the summer. To find it, use the 'Pointers' in Ursa Major in the direction opposite to the Pole Star; you will reach the curved line of stars always known as the Sickle of Leo, of which the leading member is the first-magnitude Regulus.

There are no major meteor showers this month. As a matter of academic interest, D'Arrest's periodical comet passes perihelion on February 4; it is an old friend, with a period of 6.4 years, and has been at almost all returns since its discovery in 1851 by Heinrich D'Arrest. However, its present magnitude is only about 20, so that very large telescopes are needed to show it.

Neptune, whose diameter is uncertain; we ought to know next August, when Voyager 2 makes its pass of the Neptunian system). Titan has a dense atmosphere, made up chiefly of nitrogen together with a considerable quantity of methane. All the ingredients for life exist, though the intense cold presumably means that Earth-type life has never become established there. The surface temperature is near the triple point of methane; it has been suggested that there may be cliffs of solid methane, rivers of liquid methane, and a methane rain dripping all the time from the orange clouds which constantly cover the sky.

Voyager 1 showed nothing apart from the top of a layer of what may be termed orange smog. Voyager 2 did not go close to Titan – had it done so, it would have moved out of the ecliptic, and would have been unable to go on to Uranus and Neptune. So little more could be learned before the dispatch of a special probe. This has been planned for some year, and has been named in honour of G.D. Cassini, the 17th-century Italian astronomer who discovered the main division in Saturn's rings as well as four satellites (Iapetus, Rhea, Dione and Tethys). The cutbacks in the NASA programme have delayed Cassini, but now there has been an agreement between NASA and the European Space Agency which alters the situation completely. It now seems that Cassini will be sent up in 1996. The journey will be a long one, and the arrival time is given as the year 2002.

However, this is much better than had been expected, and there is no reason to doubt that the project is entirely feasible. It will, of course, involve both an orbiter and a lander. What it will find remains to be seen; we have to admit that at the moment we have very little idea of what the surface of Titan is like – and no doubt there will be many surprises in store for us. PE

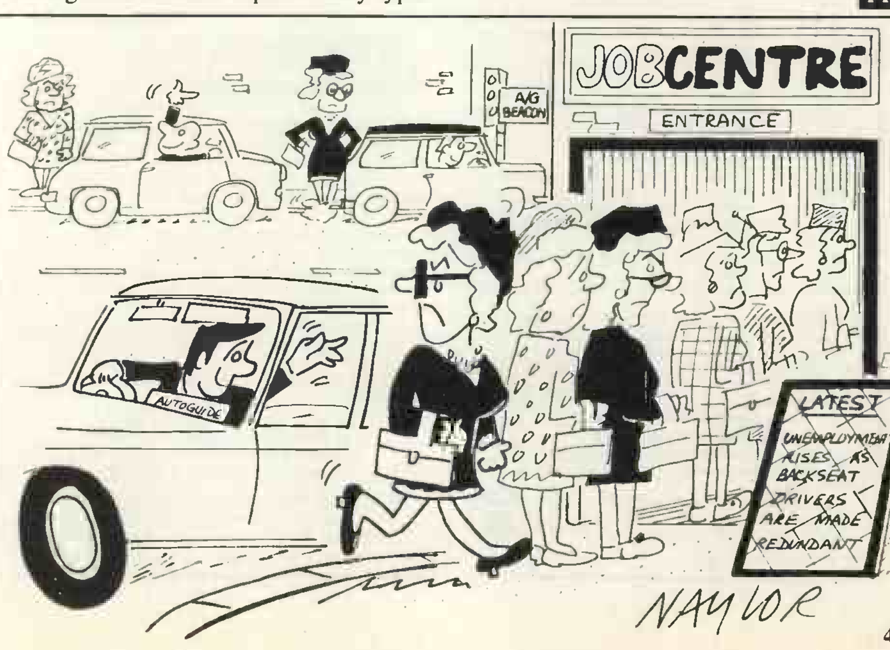
LEADING EDGE
Continued from page 8

In many respects the situation likely to arise over databases is similar to that which already exists with cd rom. There is in theory a standard format for cd rom, called HSG (High Sierra Group, after the hotel in which computer specialists locked themselves away to set a standard). But there is still no guarantee that HSG cd rom disc designed for one hardware/software combination will run on another combination. Silly things, like the presence of a mouse driver or memory management system, can crash some search programs as they sift data from a cd rom, while programs for other discs run happily.

Grateful to Oracle for arranging a non-partisan briefing, but struggling to make sense of what I heard, I could not help thinking back around thirty years to a system which legal offices used to search through case and file reports. They typed information on index cards, with holes and slots punched round the edges. To search for cards with matching data, you pushed knitting needles through the holes and shook the cards. Any cards with a slot instead of a hole fell out of the pack, signifying a matched data requirement. That simple technique was probably the first working example of a relational database. One might say that since then it's been down hill all the way. PE

AUTOGUIDE
Comment to page 45

"...No doubt many back seat drivers may need to seek new employment..."



POINTS ARISING

Weather Centre (May 1988)
In Fig.20, IC8 should be reversed.

Dual Beam Scope (Dec.1988)
In Fig.20, VR3 should go to -VE, not OV line. The PCB is correct.

Sidereal Clock (Feb. 1989)
Fig.11 VR1 should read as C5.

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BD193	6	5 amp 3 pin flush mounting sockets make a low cost disco panel. Need cable clips
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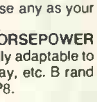

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Some of the many items described in our current list which will you receive if you request it

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LEAD LAMP Motorists' Special. Normal hand-grip type holder, with glass cover to protect the lamp and further protection in the form of a wire guard with a hook for hanging. Ideal as a loft light or for car repairs, etc. Takes 60w lamp. Has good length flex. Price £4. Our ref 4P31.

PHONE LEADS 3 metres long, correctly colour coded, one end has flat plug which fits standard BT socket, other end has tag connectors. 2 for £1. Our ref BD639.

VENNER TIME SWITCH. Mains operated with 20 Amp switch. One one/off per 24 hours. Repeats daily automatically correcting for lengthening and shortening day. An expensive time switch, but you can have it for only £2.95 without case. Metal case £2.95. Adaptor kit to convert this in to a normal 24 hour time switch, but with the added advantage of up to 12 on-offs per 24 hours thus making an ideal controller for immersion heater etc. Price of the advertising kit £2.30.

3½in FDD CHINON 80 track 500k. Shugart compatible interface. Standard connections. Interchangeable with most other 3½in and 5¼in drives. Brand new £28.50 plus £3 insured post.

CASE NOW AVAILABLE FOR THE CHINON F353 This is the 80 track, single sided one which we have been selling at £28.50. The case is sheet metal, finish in hammer-beige with ample ventilation and rubber feet. Overall size 4¼in x 7in x 1½in approx. Designed to take the ribbon cable and 3 core power lead. Price £8. Our ref 8P21.

FDD CASE AND POWER SUPPLY KIT for the 3in or 3½in. £11.00. Ref 11P2 for the Chinon, 11P3 for the Hitachi.

9in MONITOR made for ICL, uses Phillips black and white tube. Brand new and complete but uncased. £16.00 plus £5.00 post.

ACORN COMPUTER DATA RECORDER REF ALF03 Made for the Electron or BBC computers but suitable for most others. Complete with mains adaptor, leads and handbook. £10.00. Ref 10P44

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SOLAR POWERED NI-CAD CHARGER 4 Ni-Cad batteries AA (HP7) charged in eight hours or two in only 4 hours. It is a complete, boxed ready to use unit. Price £8. Our ref. 8P3.

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SWITCH AC LOADS WITH YOUR COMPUTER This is easy and reliable if you use our solid state relay. This has no moving parts, has high input resistance and acts as a noise barrier and provides 4kW isolation between logic terminals. The turn-on voltage is not critical, anything between 3 and 30V, internal resistance is about 1K ohm. AC loads up to 10A can be switched. Price is £2 each. Ref. 2P183.

METAL PROJECT BOX Ideal size for battery charger, power supply etc.; sprayed grey, size 8in x 4¼in x 4in high, ends are louvred for ventilation other sides are flat and undrilled. Order Ref. 2P191. Price £1.

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4-CORE FLEX CABLE. Cores separately insulated and grey PVC covered overall. Each copper core size 7/0.2mm. Ideal for long telephone runs or similar applications even at mains voltage. 20 metres £2. Our ref. 2P196 or 100 metres coil £8. Order ref. 8P19.

6-CORE FLEX CABLE. Description same as the 4-core above. Price 15 metres for £2. Our ref. 2P197 or 100 metres £9. Order ref. 9P1.

13A PLUGS Good British make complete with fuse, parcel of 5 for £2. Order ref. 2P185.

13A ADAPTERS Takes 2 13A plus, packet of 3 for £2. Order ref. 2P187.

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3-CORE FLEX BARGAIN No. 1 – Core size 1.25mm so suitable for long extension leads carrying up to 13 amps, or short leads up to 10 amps. 15mm for £2. Ref. 2P190.

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ALPHA-NUMERIC KEYBOARD – This keyboard has 73 keys giving trouble free life and no contact bounce. The keys are arranged in two number pad, board size is approx. 13" x 4" – brand new but offered at only a fraction of its cost, namely £3 plus £1 post. Ref. 3P27.

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⅛TH HORSEPOWER 12 VOLT MOTOR Made by Smiths, the body length of this is approximately 3in, the diameter 3in and the spindle 5/16th of an inch diameter. It has a centre flange for fixing or can be fixed from the end by means of 2 nuts. A very powerful little motor which revs at 3,000 rpm. We have a large quantity of them so if you have any projects in mind then you could rely on supplies for at least two years. Price £6. Our ref 6P1, discount for quantities of 10 or more.

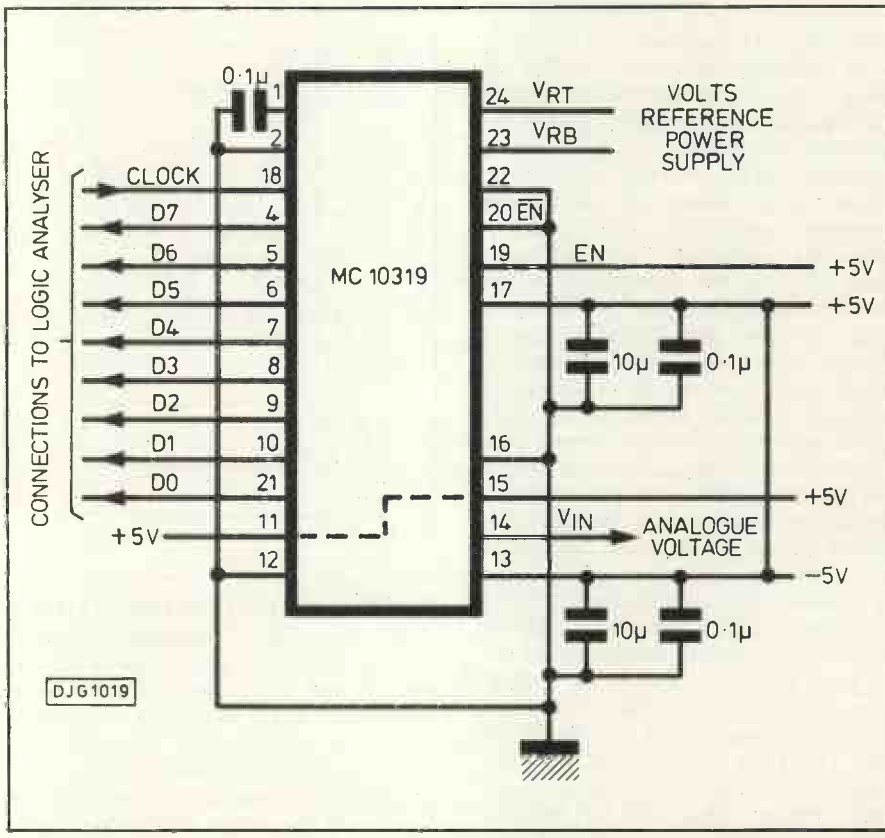
HF SCOPE STORE

BY MICHAEL SWEET

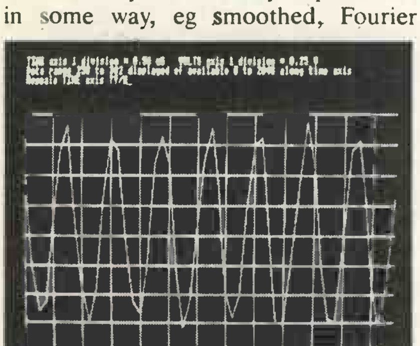
SOMETHING GOOD ON THE BBC

Use your BBC micro and the PE logic analyser board as a high frequency storage oscilloscope that will sample signals up to 8MHz.

In an article in PE FEB-MAR 88 an add-on board which enabled a BBC-B to be used as a logic analyser was described. In use as a logic analyser digital signals generated by a target system are collected into ram and then analysed or displayed. If an analogue to digital converter is used in conjunction with this device the result is a storage oscilloscope which similarly can display or analyse an input analogue voltage signal. The figure shows the connections necessary to use the logic analyser device in this manner. The analogue to digital converter I have used for this purpose is a Motorola MC10319.



Any fast a-to-d converter could be used but since the logic analyser samples at 16MHz the expense of a really fast (100MHz or greater) converter is not justified and for a similar reason exceeding 8 bits is of no value. The MC10319 sampling at 25MHz fits the requirements admirably; it also gives 3-state ttl outputs and a wide input voltage range of ±2V. The wide choice of triggering conditions on the logic analyser may be used in conjunction with the digital outputs on the converter to give any desired trigger level to initiate collection. Once digitised the signal may be displayed as a trace in any way desired by the user by writing suitable software. As an example, in my own case the software allows voltage and time scales to be changed and for any base address within the 2K x 8 collected data to be chosen*. The same data sample may be repeatedly displayed until a satisfactory format is found. Alternatively the data may be processed in some way, eg smoothed, Fourier analysed or correlation functions calculated (1).



1.2MHz sine wave sampled at 8MHz. Adjacent samples joined by straight lines.

It should be realised that the analogue signal is sampled at regular (short) time intervals and not continuously. With the highest frequency of sampling at 16MHz a 2MHz signal will be sampled only 8 times per cycle (frequency ratio = 8). This is adequate for most display purposes but does give a rather jagged impression if the software joins adjacent sampled voltages by a straight line, as the photograph shows. The problem is reduced if a larger frequency ratio is used. For analysis purposes a small ratio may be used and signals up to 8MHz may be sampled at which stage the limitations of the sampling theorem are met (2) and if attempts are made to sample at a lower frequency ratio than 2 aliasing occurs (2) leading to the impression that a low frequency signal is present.

A further problem is encountered in high frequency conversion relating to signal interaction between the digital and analogue parts of the circuit. This is minimised by careful pcb layout to avoid long paths between pins at ground and power line potentials; decoupling near the ic is also important (3). The quality of the reference voltage circuits is always of prime importance in a-to-d conversion. To obtain best results particular attention must be paid to these points.

REFERENCES

(1) Electronics for Experimentation and Research, particularly Appendix 3 and 4, B.K. Jones, Prentice Hall 1986
(2) Ibid page 266
(3) Motorola data sheet MC10319, available from Axiom Electronics, High Wycombe

*This basic software (which may be developed by the reader to personal requirements) is available on floppy disc by sending £3 to cover costs and postage to the author, Dr. M.A.S. Sweet, School of Physics, RGIT, St. Andrews Street, Aberdeen, AB1 1HG.

PE

TIME AND FREQUENCY MEASUREMENT

BY ANTHONY H. SMITH, BSc.

PART FOUR: QUARTZ CRYSTAL STABILITY

Angles of cut and ambient temperature have defined significance for a crystal's application suitability.

The effects of variations in temperature on the timebase frequency stability are amongst the most detrimental factors affecting a uct's accuracy, particularly if the instrument is used "in the field" where temperature changes are most severe.

Even though quartz has the lowest temperature coefficient of all known piezoelectric materials, a temperature change of just a few degrees Celsius can ruin the accuracy of a crystal oscillator.

Fig. 10 shows the change in nominal frequency of a typical AT-cut crystal for several angles of cut, in response to temperature variations around a central value of 25°C (approximate room temperature).

Note how a difference in cut of only a few minutes produces vastly differing temperature characteristics. Also, a certain angle of cut will be much more appropriate for a particular application than another. For example, over a 60°C range (-5°C to +55°C) the 35°07' cut produces a frequency change of only 6ppm, whereas the 35°10' cut gives rise to a change of 18ppm. However, for a 120°C range (-35°C to +85°C), the frequency of the 35°07' cut varies by 54ppm, whereas the maximum deviation for the 35°10' cut over this range is only 18ppm. Thus we can mimimise frequency changes by selecting the optimum angle of cut to match the temperature range over which the crystal is expected to work.

Unfortunately, this expedient is rarely sufficient to provide the stability required by a uct timebase; even if we achieve a stability of, say, 5ppm over a 0°C to +40°C range, this is still large enough to reduce the accurate uct resolution from eight digits down to only five. Thus, we have two options: either we employ a circuit which attempts to cancel out the effects of temperature changes, or we control the crystal temperature in a special "oven".

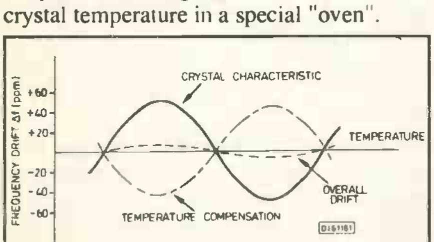


Fig.11. *Effects of temperature compensation*

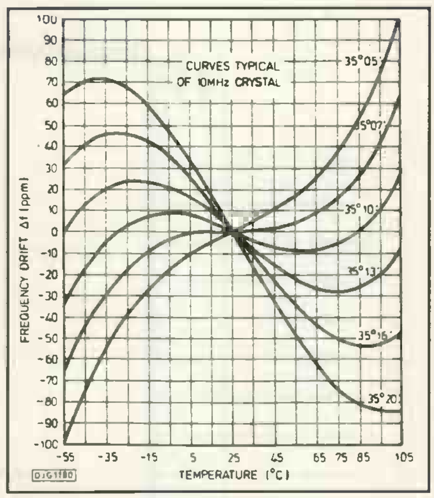


Fig.10. *Frequency drift dependent on temperature and angle of cut.*

TEMPERATURE COMPENSATION

The temperature compensated crystal oscillator (tcxo) incorporates a compensation network, built using temperature dependent components, which produces a voltage that varies with temperature. This voltage is applied to a variable capacitance (varactor) diode placed in parallel, or series, with the crystal such that changes in the voltage cause corresponding changes in the crystal frequency.

The compensation network is designed so that the frequency change caused by the varactor diode is almost exactly the opposite of the temperature induced frequency drift of the crystal itself – see Fig. 11.

An example of a compensated oscillator is shown in Fig. 12. The temperature variation of the thermistors generates a control voltage V_C, having a cubic law which is roughly equal and opposite to the cubic frequency variation of the AT-cut crystal shown in Fig. 10.

During manufacture, each oscillator is cycled through its temperature range and the corresponding frequency variation is recorded by a computer. This information is used to determine the values of R_1, R_2, and R_3 required for optimum compensation.

Several manufacturers supply a range of tcxos, and some of the best models are capable of a frequency stability on the order of ±0.2ppm over a temperature range of -20° to +70°C. There are also specialised circuits which employ a microprocessor-controlled d-to-a converter to generate a precise control voltage: such designs can increase the frequency stability to better than 1 in 10^7. However, even at this level we still cannot guarantee the accuracy of the lsd of an 8-digit uct over the entire temperature range.

OVENISED CRYSTAL OSCILLATORS (OCXOs)

Frequency deviations due to temperature changes can obviously be minimised if we maintain the crystal at a constant temperature. This is achieved by mounting the crystal (and ideally the oscillator circuit, too) inside a temperature controlled environment, or "oven" – see Fig. 13. (Incidentally, the quartz oscillator in your wrist-watch will probably have good frequency stability since it is constantly held at body temperature.)

To keep the temperature constant we require a stabilisation temperature around 20°C higher than the maximum anticipated ambient temperature; a value of 75°C is usually about right. At this temperature, we see from Fig. 10 that the 35°13' cut experiences a minimum in its drift characteristic and is thus ideally suited for use in the oven. The 35°05' cut, on the other hand, would not be suitable since its

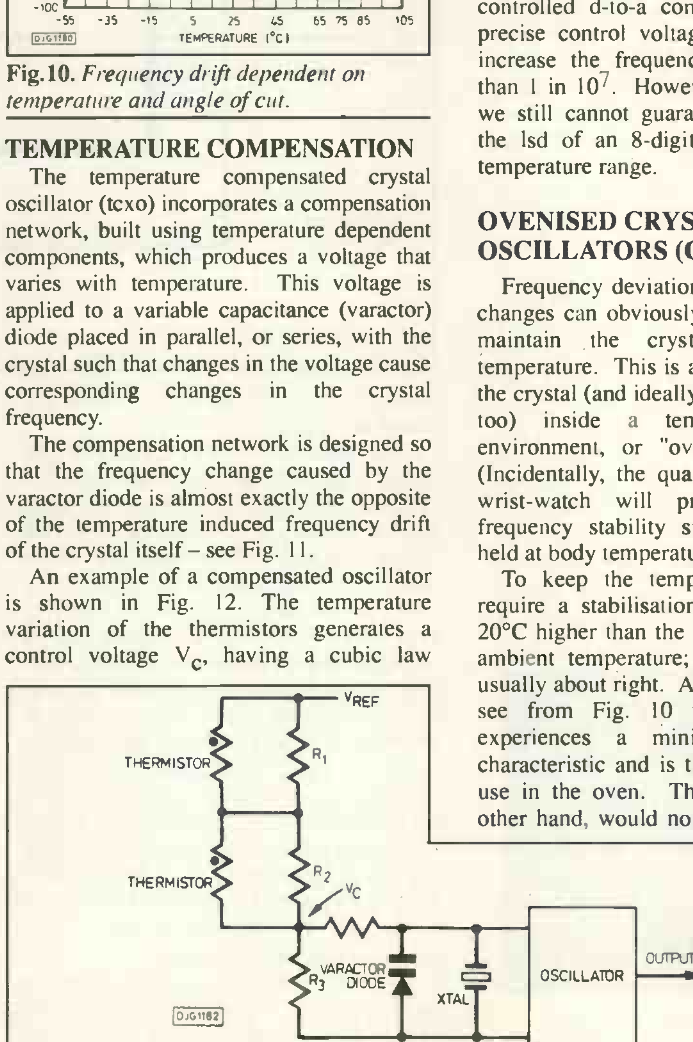


Fig.12. *Typical TXCO arrangement*

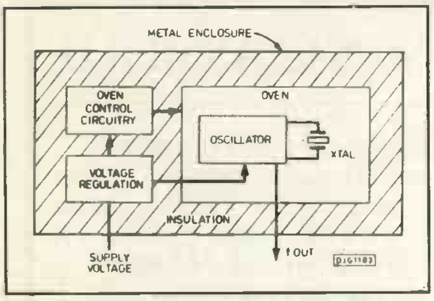


Fig.13. *Constituents of a crystal oven.*

rate of change of frequency with temperature is very large around 75°C. In practice, all crystals within a suitable range are measured to determine the precise temperature of their turning point, and the oven temperature is set accordingly.

In its simplest from, the oven temperature controller turns off the oven power when a maximum temperature is reached, and on again when it drops to a minimum, rather like a home thermostat.

However, far superior temperature control is achieved using a proportional controller which continuously varies the oven power in order to keep the temperature at precisely the set value. In this way, the temperature can be held stable to within ±0.1°C over a -20°C to +70°C range; this leads to frequency stabilities in the region of 5 parts in 10^9 – good enough to guarantee the accuracy of an 8-digit counter over the entire ambient temperature range.

Unfortunately, crystal ovens can be rather bulky and consume several watts of power – distinct disadvantages for battery-powered, portable equipment. Furthermore, a "warm-up" time is required before the timebase gets to its nominal frequency. Several ucts feature an "oven-ready" indicator (nothing to do with turkeys) which informs the user that the stable operating point has been reached.

FURTHER LIMITATIONS

With the use of temperature compensated and ovenised crystal oscillators, we reach a level of stability and accuracy where secondary effects, previously considered negligible, must now be taken into account.

The performance of a quartz crystal (just like the rest of us) changes substantially as it gets older, giving rise to a drift in frequency due to the crystal "aging".

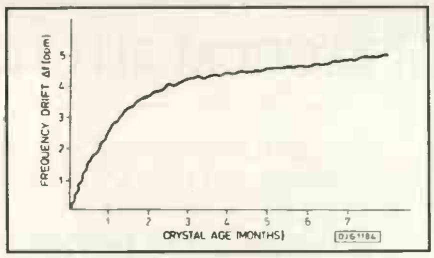


Fig.14. *Frequency change due to aging*

Usually, the aging characteristic is exponential during the first months of a crystal's life, but gradually becomes more linear – see Fig. 14.

Aging effects occur because stresses on the crystal gradually decrease, and the quartz mass itself slowly changes due to the evaporation of quartz or the absorbtion of impurities.

Solder sealed crystals usually exhibit the poorest aging rate since the sealing process causes imperfections to diffuse into the quartz: a frequency deviation of ±10ppm per year is typical. "Resistance weld" and "cold weld" seals can minimise the contamination and thus reduce the aging rate to as little as ±2ppm per year.

However, optimum performance is usually obtained from a vacuum sealed, glass enclosure; furthermore, the absence of gases surrounding the crystal often has the additional benefit of increasing the Q-factor.

Interestingly, the impurities responsible for aging have less effect on thicker quartz plates, and so for higher frequency applications, thick crystals operated at an overtone yield superior aging rates. Also, excessive power dissipation within the crystal usually worsens the aging characteristic – another good reason to avoid high drive levels.

Fortunately, the inaccuracies caused by aging can be minimised by regularly recalibrating the crystal oscillator against a primary standard.

SHOCKING PROBLEMS

Although temperature and aging are the major environmental influences on crystal oscillator accuracy, there are, unfortunately, several other factors which we should be aware of. A graphical representation of environmental effects is given in Fig. 15.

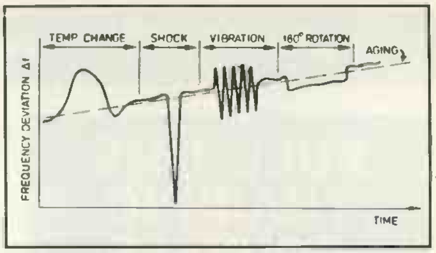


Fig.15. *Environmental influences on crystal accuracy*

Even though the crystal unit is a fairly rugged item, we must remember that a delicate slice of quartz is suspended inside the can. Thus, although a sudden jolt is unlikely to cause permanent damage, a shock of 10G sustained for a few milliseconds, or a continuous vibration of around 5G, can change the resonant frequency by a few parts in 10^8 – enough to affect the uct reading.

Also, ridiculous as it may seem, simply rotating the crystal through 180° can cause frequency deviations of a few parts in 10^9 due to changes in gravitational stresses on the quartz. Similarly, electromagnetic interference can degrade oscillator performance significantly, and even gamma radiation and neutron bombardment can cause a lasting change in the crystal's resonant frequency!

But don't despair: for most applications the quartz timebase serves as a convenient and reliable frequency standard, and is superior to most other standards on a price – for – price basis.

However, if we require ultimate accuracy, then careful design of the quartz oscillator and stringent control of operating and environmental conditions are not enough, and we must look to alternative schemes.

PE

THOSE ALTERNATIVE SCHEMES WILL BE EXAMINED NEXT MONTH WHEN WE LOOK AT ATOMIC FREQUENCY STANDARDS

Low-Cost Robotic Arm

A low cost robotic arm to improve academic learning experiences of severely physically disabled pupils is being developed by Battelle and Ohio State University's College of Special Education.

The device is a simplified version of robotic arms used in industrial applications, it is being used by physically handicapped children to, for example, pick up and examine objects. In operation, it simulates wrist and elbow movement as well as simple grasping functions much like human motor functioning.

During the 18-month project, researchers will adapt existing rehabilitation equipment to fit the needs of disabled children. They will determine appropriate design features by evaluating physically disabled children's use of and reactions to the robotic arm during science education activities.

This is an effort to make school activities and materials more accessible to severely physically disabled children, says Battelle's Dr. Patti Baker. Many of them have never been able to take independent actions such as manipulating objects. This kind of activity is especially important in the science curriculum where the properties of materials are examined and the relationship between cause and effect are studied through 'hands on' activities.

One objective of the program is to keep costs to a minimum. Dr. Baker noted that robotic arms used in industrial applications are expensive because of their requirements for precise movements, speed, force, and payload.

In the present efforts, the computer-driven robotic arm is part of a desktop workstation. A child sits in front of an adaptive input device that replaces the standard computer keyboard and screen, and is presented with standard instructional tasks.

Programmed capabilities for the arm range from single actions such as moving left, right, up, down and opening and closing a gripper mechanism (two metal fingers) to more complex tasks such as picking up a cup or using other educational tools. The computer screen provides visual data on the object's weight, texture, and other characteristics.

For More Information Contact: Battelle Institute Ltd., 15 Hanover Square, London, W1R 9AJ. Tel: 01-493 0184.

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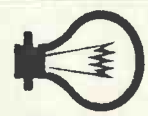

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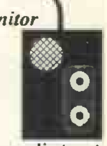

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TINKERING WITH TECHNIC

BY TOM IVALL

WHEN HI-JACKERS DO THE MOST GOOD

Technical education in the UK is a patchwork, started in panic and abandoned in haste. In reality, technical learning should be a major factor in developing growing minds.

The changes we have seen in technical education over the past few years – particularly in electronics and information technology – have been quite bewildering. There have been so many innovations, at all educational levels, with state funding and ministerial enthusiasms appearing and disappearing with equal rapidity, that the mere onlooker gets the impression of an almost haphazard and piecemeal approach. There seems to be no firm and consistent policy based on a clear view of Britain's future as an industrialised country.

The only consistent thing motivating everyone is sheer panic. Our economic performance, measured by things like GNP per capita and share of world manufacturing exports, has been steadily moving down the league table of industralised countries for thirty years or more. This was underlined strongly last November by the worst trade deficit ever experienced in the UK. Our manufacturers simply couldn't supply the goods the population was demanding – electronic products being in the forefront – so the rest of the world kindly obliged and inundated us with imports.

Both government and industry realise full well that education is the root of the trouble. To begin with we don't have the right stuff in charge of our companies. The confident leaders of men produced by the public schools may be fine fellows, but they are no match for the commercial onslaught from the highly-trained professionals of Germany, Japan and the USA. Farther down the industrial hierarchy, the UK workforce is poorly educated by comparison and still alienated by social divisions which hardly exist in the other countries. Overall, working in industry is perceived in Britain as dirty, dull and poorly rewarded – definitely not a place for high-flyers.

Fortunately, electronics seems to have a certain atmosphere of glamour and excitement about it. Perhaps this is due partly to the tremendous speed of innovation, with its opportunities for rapid business success, and partly to its applications in highly visible activities like television, aviation and warfare.

At any rate, the excitement and glamour, plus the rapidly decreasing prices of microelectronic devices, gave the educational authorities a great opportunity. They were able to introduce electronics, computers and information technology – the very games at which our industrial competitors were beating us – to quite young schoolchildren.

One initiative in this field by the present government was the Microelectronics Education Programme. As far as I can discover, this experiment in further education was a great success, particularly the activities for 12-13 year olds based on a kit called Microelectronics for All. Other work, centered on computer programming, robots and buggies, was comparatively less successful in developing children's abilities. But in March 1986 the whole project ended. No more funding was provided.

Why not? one is bound to ask. Five and a half years – for that was the life of the scheme – is simply not enough time to have a lasting influence on the education and training of our young people. A residual advisory organisation, the Microelectronics Education Support Unit, was set up but has now been absorbed into the National Council for Educational Technology – which, of course, is concerned with educational technology, not technical education. It looks if there was a failure of confidence or political will, or a reaction that electronics was not so important after all.

I've already discussed two other innovations by the present government, the City Technology Colleges (March 1987) and the national curriculum (March 1988). There are also the new GCSE, 'AS'-level and BTEC courses and qualifications to add to the continually shifting educational kaleidoscope – and probably half-a-dozen more I don't know about. In technical education, what is certainly a very direct government response to the industrial challenge from our competitors is the Technical and Vocational Education Initiative (TVEI).

This scheme, which aims to provide technical and vocational education for 14-18 year olds, was started experimentally in 1983 with pilot projects run by 14 education authorities. It became a national scheme in 1987 and is now operated by most of the authorities. Some 70,000 pupils are taking part.

At first TVEI was regarded with great suspicion by many teachers, who saw it merely as a crude experiment in social engineering. In the words of one official, reported by a headmaster, "People must be educated once more to know their place." The teachers also saw it as just a means of providing a steady supply of factory fodder, drawn from the less privileged and lower-ability children in our schools.

Happily, the teachers hi-jacked the scheme and made a much better thing of it than the Manpower Services Commission had ever intended. They adapted TVEI to provide not only an introduction to the world of work and its necessary skills but also a vehicle for real education – in the sense of drawing out and developing the pupil as a human being. But even now some educationalists remain opposed to it.

Undoubtedly technical education does provide a doorway into full education. I have seen an example of the process. A young man who started off thinking logic was a electronic switching technique done with semiconductor chips soon discovered symbolic logic, propositions, arguments, deduction, inference, syllogisms and the whole, vast intellectual enterprise stretching back to Aristotle. Through this he became interested in philosophy and eventually took and passed several exams in this subject at graduate level. Such broadening out is a natural progression. The very first thing we learn is how to imbibe milk to stay alive. It's limited and specialised and therefore technical. Everything else branches out from this narrow bit of empirical knowledge.

But technical education can be more than just a means to a short-term economic end, forgotten when it has served its immediate purpose. It's not an accretion but an integral part of education. Used thoughtfully, it can lead to a deep understanding of physical reality, to an unfolding of intellectual powers and to the creativity that gives us new discoveries and inventions. The French, German, Japanese and Swiss education systems are guided by this long-term principle. Our political masters should take a lesson from them. PE

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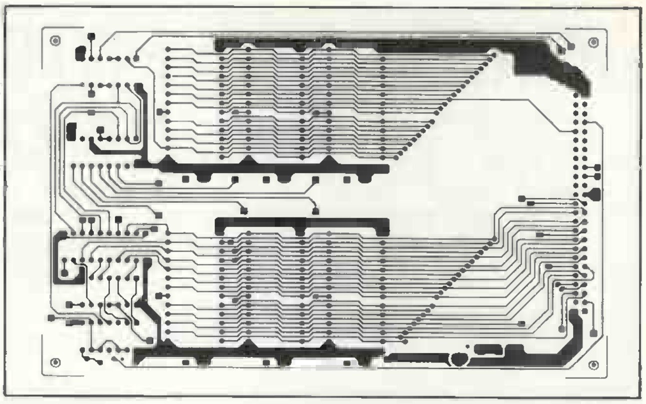

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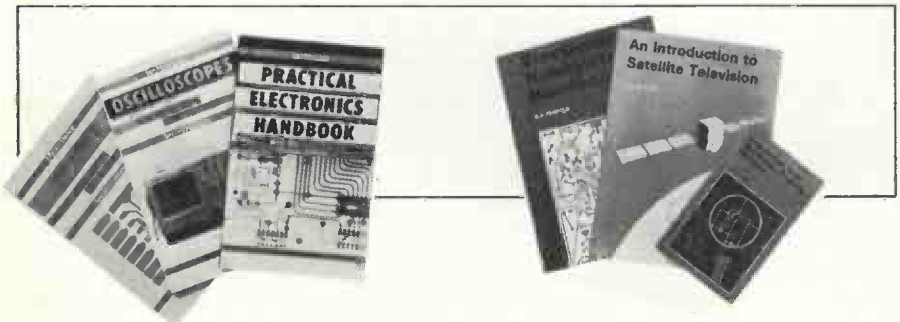

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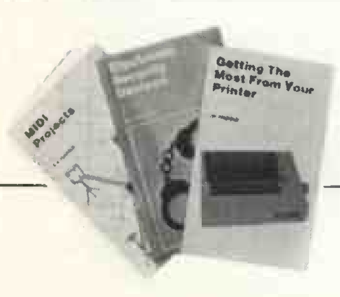

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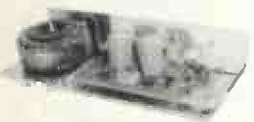
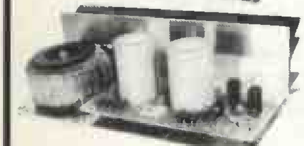


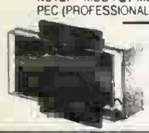
OMP/MF 100 Mos-Fet Output power 110 watts R.M.S. into 4 ohms, Frequency Response 1Hz – 100KHz −3dB, Damping Factor, >300, Slew Rate 45V/uS, T.H.D. Typical 0.002%, Input Sensitivity 500mV, S.N.R. −125dB. Size 300 × 123 × 60mm.
PRICE £39.99 + £3.00 P&P.

OMP/MF200 Mos-Fet Output power 200 watts R.M.S. into 4 ohms, Frequency Response 1Hz – 100KHz −3dB, Damping Factor >300, Slew Rate 50V/uS, T.H.D. Typical 0.001%, Input Sensitivity 500mV, S.N.R. −130dB. Size 300 × 155 × 100mm.
PRICE £62.99 + £3.50 P&P.



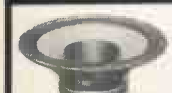
OMP/MF300 Mos-Fet Output power 300 watts R.M.S. into 4 ohms, Frequency Response 1Hz – 100KHz −3dB, Damping Factor >300, Slew Rate 60V/uS, T.H.D. Typical 0.0008%, Input Sensitivity 500mV, S.N.R. −130dB. Size 330 × 175 × 100mm.
PRICE £79.99 + £4.50 P&P.

NOTE:— MOS-FET MODULES ARE AVAILABLE IN TWO VERSIONS, STANDARD — INPUT SENS. 500mV BAND WIDTH 100KHz PEC (PROFESSIONAL EQUIPMENT COMPATABLE) — INPUT SENS. 775mV, BAND WIDTH 50KHz. ORDER STANDARD OR PEC



Vu METER Compatible with our four amplifiers detailed above. A very accurate visual display employing 11 L.E.D. diodes (7 green, 4 red) plus an additional on/off indicator. Sophisticated logic control circuits for very fast rise and decay times. Tough moulded plastic case, with tinted acrylic front. Size 84 × 27 × 45mm.
PRICE £8.50 + 50p P&P.

LOUDSPEAKERS



LARGE SELECTION OF SPECIALIST LOUDSPEAKERS AVAILABLE, INCLUDING CABINET FITTINGS, SPEAKER GRILLES, CROSS-OVERS AND HIGH POWER, HIGH FREQUENCY BULLETS AND HORNS, LARGE S.A.E. (30p STAMPED) FOR COMPLETE LIST.

McKENZIE:— INSTRUMENTS, P.A., DISCO, ETC.

ALL McKENZIE UNITS 8 OHMS IMPEDENCE

8" 100 WATT C8100GPM GEN. PURPOSE, LEAD GUITAR, EXCELLENT MID., DISCO.
RES. FREQ. 80Hz. FREQ. RESP. TO 14KHz. SENS. 99dB. .... PRICE £28.59 + £2.00 P&P.
10" 100 WATT C10100GP GUITAR, VOICE, ORGAN, KEYBOARD, DISCO, EXCELLENT MID.
RES. FREQ. 70Hz. FREQ. RESP. TO 6KHz. SENS. 100dB. .... PRICE £34.70 + £2.50 P&P.
10" 200 WATT C10200GP GUITAR, KEYBOARD, DISCO, EXCELLENT HIGH POWER MID.
RES. FREQ. 45Hz. FREQ. RESP. TO 7KHz. SENS. 103dB. .... PRICE £47.48 + £2.50 P&P.
12" 100 WATT C12100GP HIGH POWER GEN. PURPOSE, LEAD GUITAR, DISCO.
RES. FREQ. 45Hz. FREQ. RESP. TO 7KHz. SENS. 98dB. .... PRICE £36.66 + £3.50 P&P.
12" 100 WATT C12100TC TWIN CONE) HIGH POWER WIDE RESPONSE, P.A., VOICE, DISCO.
RES. FREQ. 45Hz. FREQ. RESP. TO 14KHz. SENS. 100dB. .... PRICE £37.63 + £3.50 P&P.
12" 200 WATT C12200B HIGH POWER BASS, KEYBOARDS, DISCO, P.A.
RES. FREQ. 40Hz. FREQ. RESP. TO 7KHz. SENS. 100dB. .... PRICE £64.17 + £3.50 P&P.
12" 300 WATT C12300GP HIGH POWER BASS LEAD GUITAR, KEYBOARDS, DISCO, ETC.
RES. FREQ. 45Hz. FREQ. RESP. TO 5KHz. SENS. 100dB. .... PRICE £85.79 + £3.50 P&P.
15" 100 WATT C15100BS BASS GUITAR, LOW FREQUENCY, P.A., DISCO.
RES. FREQ. 40Hz. FREQ. RESP. TO 5KHz. SENS. 98dB. .... PRICE £53.70 + £4.00 P&P.
15" 200 WATT C15200BS VERY HIGH POWER BASS.
RES. FREQ. 40Hz. FREQ. RESP. TO 4KHz. SENS. 99dB. .... PRICE £73.26 + £4.00 P&P.
15" 250 WATT C15250BS VERY HIGH POWER BASS.
RES. FREQ. 40Hz. FREQ. RESP. TO 4KHz. SENS. 99dB. .... PRICE £80.53 + £4.50 P&P.
15" 400 WATT C15400BS VERY HIGH POWER, LOW FREQUENCY BASS.
RES. FREQ. 40Hz. FREQ. RESP. TO 4KHz. SENS. 102dB. .... PRICE £94.12 + £4.50 P&P.
18" 400 WATT C18404BS EXTREMELY HIGH POWER, LOW FREQUENCY BASS.
RES. FREQ. 27Hz. FREQ. RESP. TO 3KHz. SENS. 99dB. .... PRICE £167.85 + £5.00 P&P.

EARBENDERS:— HI-FI, STUDIO, IN-CAR, ETC.

ALL EARBENDER UNITS 8 OHMS EXCEPT EB8-50 AND EB10-50 DUAL 4 AND 8 OHM.
BASS, SINGLE CONE, HIGH COMPLIANCE, ROLLED FOAM SURROUND

8" 50 WATT EB8-50 DUAL IMPEDENCE, TAPPED 4/8 OHM BASS, HI-FI, IN-CAR.
RES. FREQ. 40Hz. FREQ. RESP. TO 7KHz. SENS. 97dB. .... PRICE £8.90 + £2.00 P&P.
10" 50 WATT EB10-50 DUAL IMPEDENCE, TAPPED 4/8 OHM BASS, HI-FI, IN-CAR.
RES. FREQ. 40HZ. FREQ. RESP. TO 5KHz. SENS. 99dB. .... PRICE £12.00 + £2.50 P&P.
10" 100 WATT EB10-100 BASS, HI-FI, STUDIO.
RES. FREQ. 35Hz. FREQ. RESP. TO 3KHz. SENS. 96dB. .... PRICE £27.50 + £3.50 P&P.
12" 60 WATT EB12-60 BASS, HI-FI, STUDIO.
RES. FREQ. 28Hz. FREQ. RESP. TO 3KHz. SENS. 92dB. .... PRICE £21.00 + £3.00 P&P.
12" 100 WATT EB12-100 BASS, STUDIO, HI-FI, EXCELLENT DISCO.
RES. FREQ. 26Hz. FREQ. RESP. TO 3KHz. SENS. 93dB. .... PRICE £32.00 + £3.50 P&P.

FULL RANGE TWIN CONE, HIGH COMPLIANCE, ROLLED SURROUND

5¼" 60 WATT EB5-60TC (TWIN CONE) HI-FI, MULTI-ARRAY DISCO ETC.
RES. FREQ. 63Hz. FREQ. RESP. TO 20KHz. SENS. 92dB. .... PRICE £9.99 + £1.50 P&P.
6½" 60 WATT EB6-60TC (TWIN CONE) HI-FI, MULTI-ARRAY DISCO ETC.
RES. FREQ. 38Hz. FREQ. RESP. TO 20KHz. SENS. 94dB. .... PRICE £10.99 + £1.50 P&P.
8" 60 WATT EB8-60TC (TWIN CONE) HI-FI, MULTI-ARRAY DISCO ETC.
RES. FREQ. 40Hz. FREQ. RESP. TO 18KHz. SENS. 89dB. .... PRICE £12.99 + £1.50 P&P.
10" 60 WATT EB10-60TC (TWIN CONE) HI-FI, MULTI-ARRAY DISCO ETC.
RES. FREQ. 35Hz. FREQ. RESP. TO 12KHz. SENS. 86dB. .... PRICE £16.49 + £2.00 P&P.

TRANSMITTER HOBBY KITS

PROVEN TRANSMITTER DESIGNS INCLUDING GLASS FIBRE PRINTED CIRCUIT BOARD AND HIGH QUALITY COMPONENTS COMPLETE WITH CIRCUIT AND INSTRUCTIONS

3 watt FM Transmitter

3W FM TRANSMITTER 80-108MHz, VARICAP CONTROLLED PROFESSIONAL PERFORMANCE, RANGE UP TO 3 MILES, SIZE 38 × 123mm, SUPPLY 12V @ 0.5AMP,
PRICE £14.49 + £1.00 P&P

FM MICRO TRANSMITTER (BUG) 100-108MHz VARICAP TUNED COMPLETE WITH VERY SENS FET MIC, RANGE 100-300m, SIZE 56 × 46mm, SUPPLY 9V BATT, PRICE
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OMP VARISPEED TURNTABLE CHASSIS

★ MANUAL ARM ★ STEEL CHASSIS ★ ELECTRONIC SPEED CONTROL 33 & 45 ★ VARI PITCH CONTROL ★ HIGH TORQUE SERVO DRIVEN DC MOTOR ★ TRANSIT SCREWS ★ 12" DIE CAST PLATTER ★ NEON STROBE ★ CALIBRATED BAL WEIGHT ★ REMOVABLE HEAD SHELL ★ ½" CARTRIDGE FIXINGS ★ CUE LEVER ★ POWER 220/240V 50/60Hz ★ 390×305mm ★ SUPPLIED WITH MOUNTING CUT-OUT TEMPLATE.

PRICE £59.99 + £3.50 P&P.

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PRICE £6.99 + 50p P&P

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NEW MXF SERIES OF POWER AMPLIFIERS
THREE MODELS:— **MXF200** (100w + 100w)
MXF400 (200w + 200w) **MXF600** (300w + 300w)
All power ratings R.M.S. into 4 ohms.

FEATURES: ★ Independent power supplies with two Toroidal Transformers ★ Twin L.E.D. Vu meters ★ Rotary indended level controls ★ Illuminated on/off switch ★ XLR connectors ★ Standard 775mV inputs ★ Open and short circuit proof ★ Latest Mos-Fets for stress free power delivery into virtually any load ★ High slew rate ★ Very low distortion ★ Aluminium cases ★ MXF600 Fan Cooled with D.C. Loudspeaker and Thermal Protection.

USED THE WORLD OVER IN CLUBS, PUBS, CINEMAS, DISCOS ETC.

SIZES:— MXF 200 W19"×H3½" (2U)×D11"
MXF 400 W19"×H5¼" (3U)×D12"
MXF 600 W19"×H5¼" (3U)×D13"

PRICES: **MXF200 £171.35**
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MXF600 £322.00

SECURICOR DELIVERY £12.00 EACH

OMP LINNET LOUDSPEAKERS

THE VERY BEST IN QUALITY AND VALUE

MADE ESPECIALLY TO SUIT TODAY'S NEED FOR COMPACTNESS WITH HIGH OUTPUT SOUND LEVELS, FINISHED IN HARDWEARING BLACK VYNIDE WITH PROTECTIVE CORNERS, GRILLE AND CARRYING HANDLE. INCORPORATES 12" DRIVER PLUS HIGH FREQ. HORN FOR FULL FREQ. RANGE: 45Hz-20KHz BOTH MODELS 8 OHM, SIZE H18" × W15" × D12".

CHOICE OF TWO MODELS

POWER RATINGS QUOTED IN WATTS RMS FOR EACH CABINET

OMP 12-100 (100W 100dB) PRICE £159.99 PER PAIR
OMP 12-200 (200W 102dB) PRICE £209.99 PER PAIR

SECURICOR DEL.:— £12.00 PER PAIR

OMP SLIDE DIMMER 1K WATT & 2.5K WATT

CONTROLS LOADS UP TO 1KW & 2.5KW, SUITABLE FOR RESISTIVE AND INDUCTIVE LOADS BLACK ANODISED CASE, READILY FLUSH MOUNTED THROUGH PANEL/CABINET CUT-OUTS, **ADVANCED FEATURES INCLUDE:—**

★ FULL 65mm SLIDE TRAVEL
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SIZES:—
1KW H128×W40×D55mm
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PRICES:— 1K WATT £15.99
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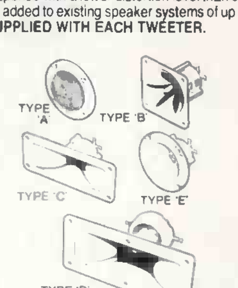
PIEZO ELECTRIC TWEETERS-MOTOROLA

PIEZO ELECTRIC TWEETERS — MOTOROLA

Join the Piezo revolution. The low dynamic mass (no voice coil) of a Piezo tweeter produces an improved transient response with a lower distortion level than ordinary dynamic tweeters. As a crossover is not required these units can be added to existing speaker systems of up to 100 watts (more if 2 put in series). **FREE EXPLANATORY LEAFLETS SUPPLIED WITH EACH TWEETER.**



TYPE 'A' (KSN2036A) 3" round with protective wire mesh, ideal for bookshelf and medium sized Hi-fi speakers. **Price £4.90 each + 50p P&P.**
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TYPE 'C' (KSN6016A) 2"×5" wide dispersion horn. For quality Hi-fi systems and quality discos etc. **Price £6.99 each + 50p P&P.**
TYPE 'D' (KSN1025A) 2"×6" wide dispersion horn. Upper frequency response retained extending down to mid range (2KHz). Suitable for high quality Hi-fi systems and quality discos. **Price £9.99 each + 50p P&P.**
TYPE 'E' (KSN1038A) 3¾" horn tweeter with attractive silver finish trim. Suitable for Hi-fi monitor systems etc. **Price £5.99 each + 50p P&P.**
LEVEL CONTROL Combines on a recessed mounting plate, level control and cabinet input jack socket. 85×85mm. **Price £3.99 + 50p P&P.**

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STEREO DISCO MIXER with 2 × 5 band L & R graphic equalisers and twin 10 segment L.E.D. Vu Meters. **Many outstanding features** 5 Inputs with individual faders providing a useful combination of the following:—
3 Turntables (Mag). 3 Mics. 4 Line including CD plus Mic with talk over switch Headphone Monitor. Pan Pot L. & R. Master Output controls. Output 775mV. Size 360×280×90mm. Supply 220-240v.
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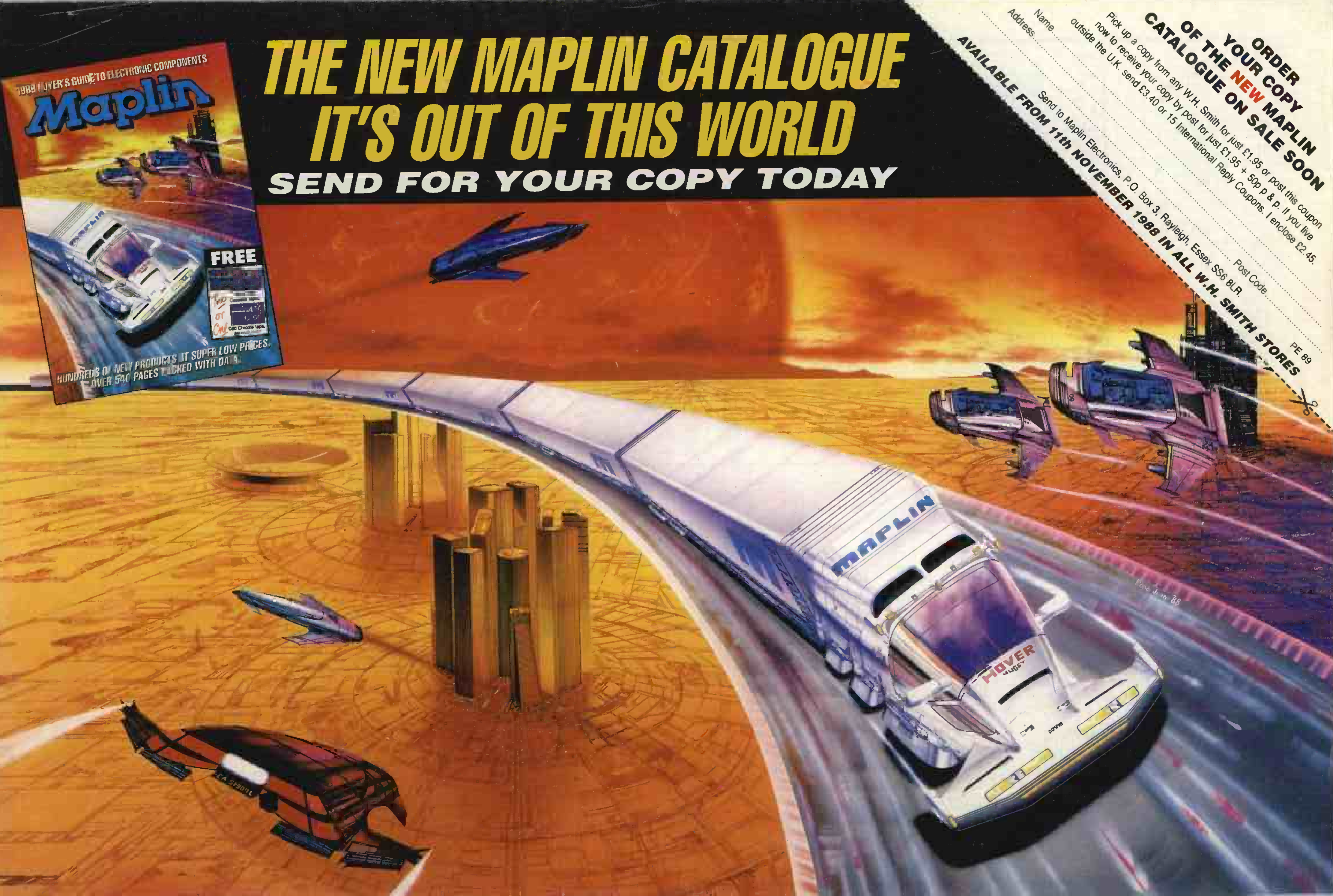
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