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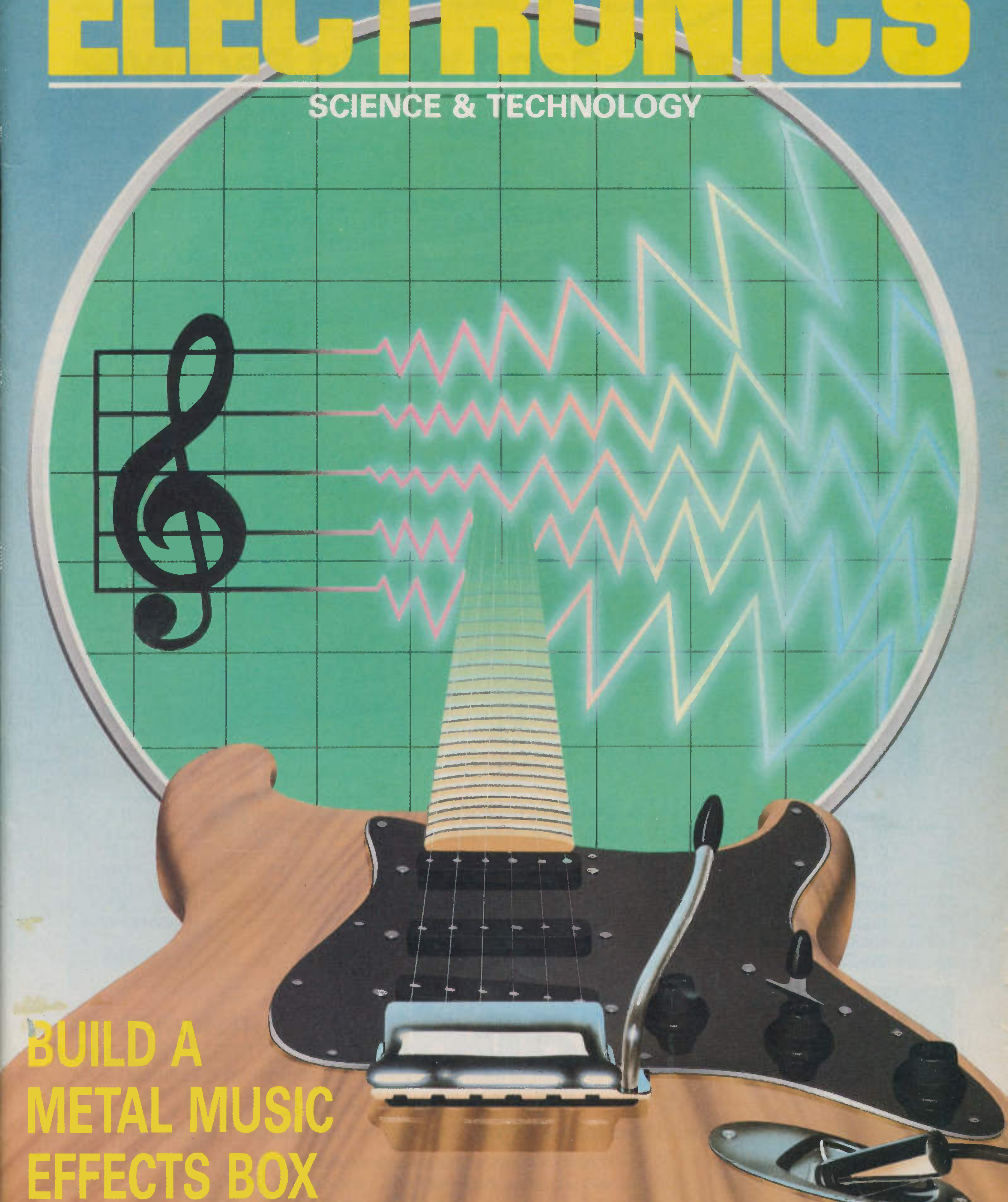

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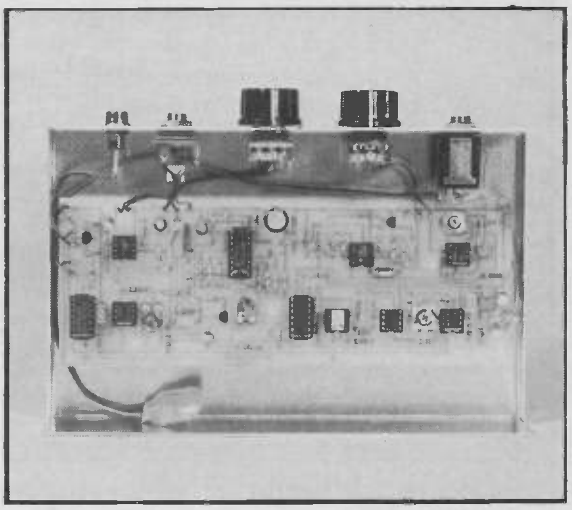
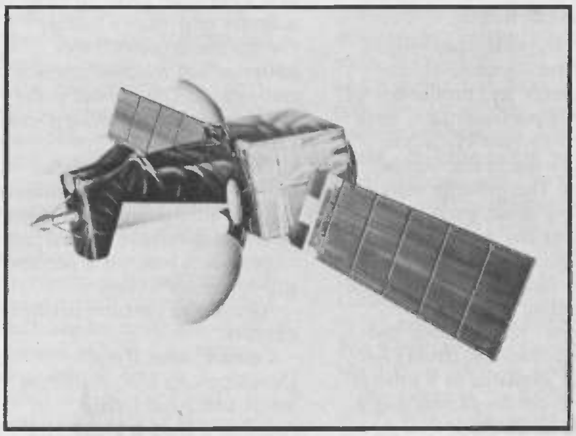
PRACTICAL ELECTRONICS

PE VOL 24 NO 4 APRIL 1988

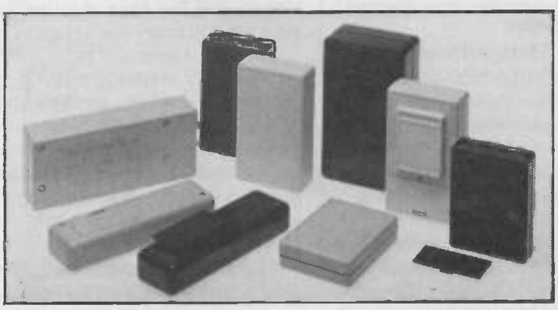
CONSTRUCTIONAL PROJECTS





SPECIAL FEATURES

REGULAR FEATURES

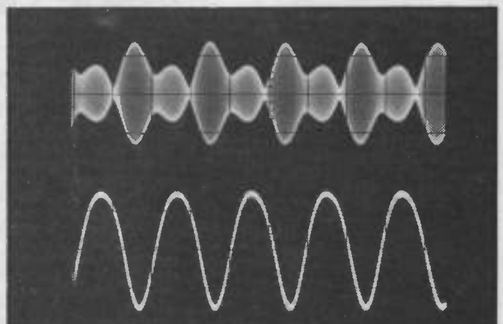


PRODUCT FEATURES

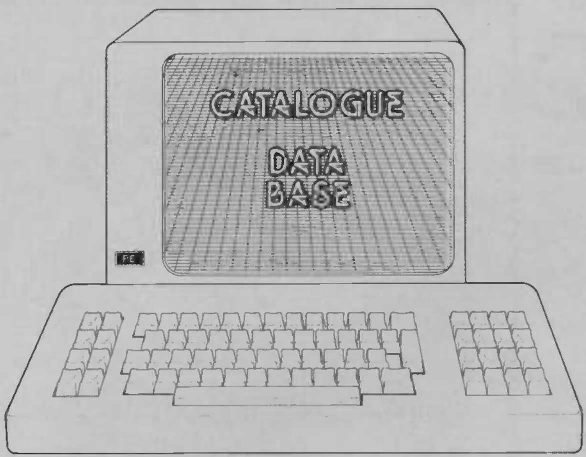
NEXT MONTH . . .

SPRING HAS SPRUNG AND SO HAVE WE TO BRING YOU – MAINS MODEM • SPEECH PROCESSING • INTELSAT VI AND BEYOND • DAT – THE REALITIES • MOSFET APPLICATIONS • CONSUMER ELECTRONICS REPORT • AND OTHER TOP LINE FEATURES WILL BLOSSOM FORTH•

DON'T LET THE GRASS GROW UNDER YOUR FEET BY MISSING THE PE MAY 1988 ISSUE ON SALE FROM FRIDAY APRIL 8TH



THE SCIENCE MAGAZINE FOR SERIOUS ELECTRONICS ENTHUSIASTS



We have recently received the following catalogues and literature:

Sansui, who are a subsidiary of the Hi Fi Markets Group, have issued a booklet, *'The Sansui Collection'*, detailing their **consumer audio-video products.** These include amplifiers, tuners, equalisers, cd players, cassette decks, speakers, turntables, and a range of video equipment. **Sansui Electronics UK Ltd,** Axis 4, Rhodes Way, Watford, Herts, WD2 4YW. 0923 228584.

Versactec have published a new free brochure called *'Electrostatic Plotting – the choice in wide format graphics output'*. Its intention is to help users select the most suitable **electrostatic printer-plotter** by providing information on colour and monochrome plotting widths. **Versatec Electronics Ltd,** 5 Oxford Road, Newbury, Berks, RG13 1QD. 0635 517200.

Audiokits have announced their most comprehensive component notes and catalogue of **audio quality capacitors for constructors,** service engineers and audio manufacturers. Coded ACN12, the notes are available free to the trade, but are priced at £4 (incl post) to non-trade constructors. **Audiokits Precision Components,** 6 Mill Close, Borrowash, Derby, DE7 3GU. 0332 674929.

Volex have released a colourful promotional brochure outlining their product **range of electrical accessories,** including plugs, sockets, cables and wiring harnesses. Their products appear to be more relevent to the trade, but anyone interested should contact **Volex Group plc,** Volex House, Lissadel Street, Salford, M6 6AP. 061 736 5822.

STC's 8-page full colour brochure outlines the **widest selection of cells and batteries** offered by any electronics distributor in the UK. It is available from The Battery Group, **STC Electronic Services,** Edinburgh Way, Harlow Essex, CM20 2DF. 0279 626777.

EXCLUSIVE!
IN THE NEXT ISSUE OF PE

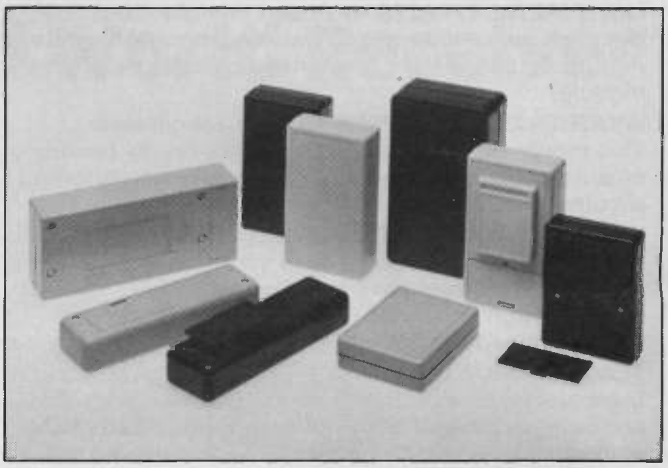
LATEST on the US Electronics and Technology scene with a special report from

THE CONSUMER ELECTRONICS SHOW IN LAS VEGAS
BY DR WAYNE GREEN

Well known US Author, Publisher (Founder of over 50 Computer Technology Magazines including *Byte, MicroComputing,* and *73*) and currently Vice-Presidential Candidate.

READ IT IN THE MAY ISSUE!

WHAT'S NEW



Hand Held Boxes

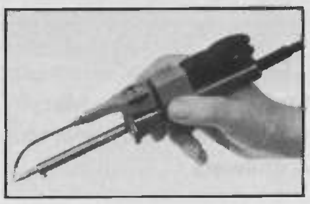
Two electronic case ranges, designed exclusively for development and production of hand-held portables have been launched by West Hyde, the Aylesbury based enclosures company. The growing market for pocket sized, hand-held equipment has led to the development of two extremely versatile ranges from one of the UK's leading enclosures companies. Named Tinos and Elos, these low-cost (from £1.44) cases are available in a total of nine different sizes and in a light grey and black abs.

The Tinos range have on one side a textured finish to provide a firmer grip, also a battery compartment for PP3 9V batteries and rounded corners throughout. One model in the range even has a moulded pocket clip.

The Elos, while being the more general purpose range and without a battery compartment, carries as standard moulded pads to provide a base for a pcb and sub-chassis mounting.

All case sizes are now available ex-stock.

Contact: West Hyde Developments Ltd, 9–10 Park Street Industrial Estate, Aylesbury, Bucks, HP20 1ET. Tel: (0296) 20441.



Solder Feeder

Tele-Production Tools Ltd, the Westcliff-on-Sea soldering specialists are now marketing a new Swedish solder feeder device.

The feeder can be attached to any pencil iron and the feed tube adjusted to ensure that the solder is fed directly on to the soldering tip. Solder is wound on to a cassette, which is attached to the reverse end of the device, and is then fed by advancing a knurled wheel with the index finger. It is suitable for left or right hand use.

The solder feeder is a useful third hand when objects have to be held in position while soldering; it also alleviates problems caused by operators continually handling high lead content solder. The price is £10 plus VAT.

Contact: Tele-Production Tools Ltd, Stiron House, Electric Avenue, Westcliff-on-Sea, Essex SS0 9NW. Tel: 0702 352719.

Big Brother Speaks

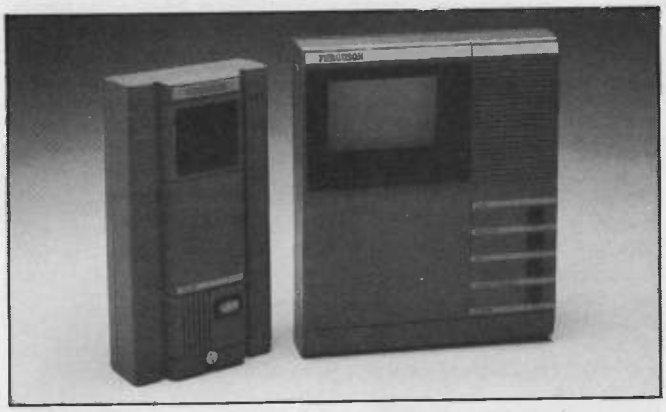
November the 5th 1987 saw the launch of a new addition to the JBL Control Series loudspeaker range. The Control 5 is the new big brother to the well established Control One system that has been massively successful in many market areas.

The JBL Control 5 is immediately available and measures a very compact 15 × 10 × 9 inches. It is capable of handling 175W with usable output down to 50Hz. With this power handling, each Control 5 can generate over 114dB SPL (1m).

The drive units have been specifically developed for this project. The HF is a pure titanium driver which has added protection built into the dividing network to minimise damage caused by overdriving and errant amplification. The bass driver has been designed for low distortion performance even at very high levels.

The Control Five is designed with ease and flexibility of installation as a primary feature, and a pair of them cost just £279 including VAT.

Contact: Harman (Audio) UK Ltd, Mill Street, Slough, Berks SL2 5DD. Tel: 0753 76911.



Homescanner

Ferguson are launching two new products to help protect you and your home under their Homescan banner.

Increasingly, the public is concerned about that which Crime Prevention Officers call "Access Control", that is, monitoring exactly who comes into the home and why. Security consciousness is on the increase – and this is welcomed by the authorities. In the last six years consumer spending on security has rinse from £84 million to £175 million.

Ferguson is introducing two access control systems, both of which can be easily installed, in a couple of hours, by anyone competent in diy.

One system, the FHS1 comprises a video camera and control unit, which are capable of operating in total darkness.

The camera is mounted by the front door and the picture of the caller is fed through to a designated channel on a domestic television which gives one-way audio visual communication. By wiring the control through the doorbell system, an audible alarm will interrupt any tv programme being watched to inform the viewer to switch to the appropriate channel to see and hear the caller.

The other system, the FHS2, comprises a video camera mounted in a unit including a bell push, microphone and speaker, and a separate dedicated video monitor/control unit, both with wall-mount brackets. Once again, the camera can work in total darkness and also offers two-way audio communication, (a useful benefit for the blind and disabled). An electric door lock can be released by pressing a button on the monitor unit after the visitor has identified himself, and a led indicator shows when the door is open, or unlocked.

Two cameras can be linked up to the video monitor to give access control at the front and back doors or one can be used indoors for baby minding.

The FHS1 costs around £449, and the FHS2 about £749.

Contact: Anne Waterman, Ferguson Ltd, Cambridge House, Great Cambridge Road, Enfield, Middx. EN1 1ND.

Digit Control

HOW would you like to be able to control ALL your heating, lighting, machinery, air conditioning, in fact anything that depends on electrical energy from one mobile control point? An expensive pipe dream? Not anymore. A new mains signalling system has been launched at a cost that should bring easy energy saving and security within the reach of even the smallest business.

The Emlux MS System, as it is called, uses state-of-the-art electronics throughout, but is designed to operate in a straightforward, uncomplicated way and brings ultra modern energy management techniques under finger tip control.

The command signals are transmitted along existing standard 240 volt supply cables which means that the costly and often inconvenient installation of dedicated wiring is avoided. In fact, installation couldn't be simpler since all that is necessary is the plugging in of the command module to a standard 13 amp socket. The most junior employee can operate the system, since the touch of a button is all that is needed to set it into motion. Inclusion of the proven Emlux patented Filter as an integral part of the system ensures that all commands generated are contained within the premises.

The basic starter pack, which comprises one console, four slave modules (2 plug-in, 2 wire-in) and one filter, sells for less than £300. Extra slaves can be supplied at about £35 each. In addition to the basic MS controller, a programmable clock controller is available to provide automatic control.

Contact: Emlux Ltd, Industrial Estate, Black Bourton Road, Carterton, Oxford, OX8 3EZ. Tel: 0993 841574.

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.

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.

Regular courses for R.A.E., and also for Morse. Grafton Radio Society, Elizabeth Garrett Anderson School, Riseing Hill Street, London N1.

Regular weekly courses for Radio Amateurs Exam (C8G 765). Tuesdays 7.30 to 9.30. Hendon College, Corner Mead, Grahame Park, Colindale, London NW8 5RA. Tel: 01-200 8300.

Mar 20. Pontefract and District Amateur Radio Society annual components fair and boot sale. Carlton Community Centre, Carlton, Pontefract. 0977 43101. (Good luck you enterprising lads! Ed.)

Mar 22-24. Internepcon Production Show and Conference, plus Electro Optics and Laser UK. National Exhibition Centre, Birmingham.

Mar 29-30. Instrumentation Harrowgate. Trade only. Harrowgate Exhibition Centre, Harrowgate, N. Yorks. 0822 4671.

Apr 12-14. Scottish Computer Show. Scottish Exhibition Centre. Glasgow.

Apr 13-14. Laboratory Cambridge. Kelsey Kerridge, Cambridge. 0799 26699.

Apr 26-28. British Electronics Week 88. Olympia. 0799 26699.

Frame Foam

Wybar Electronics have introduced cut-to-size conductive foam for its range of printed circuit board assembly holders. The foam can be supplied with new units or retrofitted to existing units enabling the safe handling of static sensitive components.

Pull spare parts, such as springs, bearings, clips and additional rails are also available from stock.

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

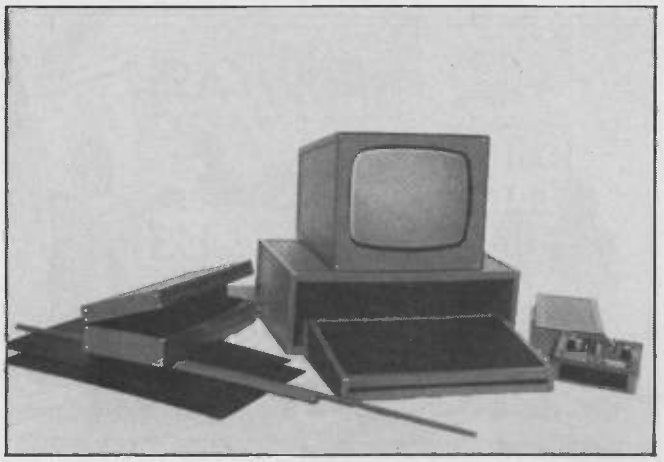
Damp Heat

Solex, the sole UK representative for the Soar range of test and measuring equipment, has recently launched the HT-150 multifunction module that measures temperature and humidity simultaneously.

The unit is ideal for panel mounting and has a high resolution, °C or °F selectable, large liquid crystal display. In addition to the basic functions, it provides a hi-lo alarm, max-min record and discomfort index display functions. Simultaneous data signal outputs of both temperature and humidity allow the unit to be used in connection with external devices such as controllers and printers.

External long probes up to 100m maximum for remote control of both humidity and temperature are available as an optional extra for various kinds of applications.

Contact: Solex International, 95 Main Street, Broughton Astley, Leicestershire LE9 6RD. Tel: 0455 283486.



Boxing Clever

Encore Enclosures are marketing an enclosure system developed as a result of a suggestion from a lecturer at Bath University for a make-it-yourself, easy-to-assemble box since one of the most difficult tasks of a student project is to find an enclosure which is inexpensive, the correct size and looks professional.

Encore supply plastic sheets and sections, together with construction details, which can be used to make any particular design. The individual pieces occupy little space, an advantage if stocked for future requirements.

The system is relatively forgiving of mistakes in construction as all the raw edges are covered up and a generous tolerance allowed for the fitting. To change the position of a misplaced cutout, at worst you only have to change one panel. The more complex the structure, the greater the financial advantages.

For the faint-hearted, or those who have more important things to do with their time, Encore now offer to build to anyone's enclosure design (even an one-off) at prices below what they would probably pay for a standard enclosure.

Contact: Encore Enclosures, Unit 3, Willand Industrial Estate, Cullompton, Devon EX15 2QW. Tel: 0884 820955.

Young Electronic Engineers Awarded

Paul Dagley-Morris (left) and Roger Lucas (right), two sixteen-year-old pupils at Cheltenham College, are seen with their animal trauma meter, which gained them and the school third place in this year's Young Engineers for Britain competition, sponsored by the National Engineering Council.

Although the trauma meter is designed for measuring shock in animals, 'patient' Dusty seems in relaxed mood here. In the centre is Vet Mike Daley, whose practice gave encouragement and support to the two young electronic engineers in the design of this device, the first of its type.

Contact: PRB Public Relations and Marketing Ltd, 3 Wolseley Terrace, Cheltenham GL50 1TH. Tel: 0242 510760.

Young Radio Amateur Awards

Anybody under the age of 18 who has made waves in the world of amateur radio should enter the Young Amateur of the Year Award now.

The award, sponsored by the Department of Trade and Industry as part of the 75th anniversary celebrations of the Radio Society of Great Britain, is designed to increase awareness of amateur radio amongst young people and highlight the skills and benefits that participation in this unique activity can bring.

The £250 prize will be awarded to the person judged to have made an individual contribution of outstanding merit (between 1 April 1987 and 31 March 1988) in any area of amateur radio. This might include technical innovation, exceptional operating skills, success in promoting amateur radio to a wider audience, the fostering of international goodwill, social work for the handicapped or emergency communications. It is hoped that the prizegiving will take place at the RSGB's national convention in July 1988.

The winner will also spend a day with the Department's Radiocommunications Division learning at first-hand about the varied work of the Department in the radio field.

The award is open to any resident (who need not be a current holder of the Amateur Radio Licence) of the UK, the Channel Islands or the Isle of Man who has not reached his or her 18th birthday by the closing date.

Applications or nominations must be sent to The Secretary, RSGB, Lambda House, Cranborne Road, Potters Bar, EN6 3JE. **The closing date is 31 March 1988.**

Bristol Maplinised

Maplin Electronics, have announced the opening of their latest shop, situated close to Bristol city centre, at 302 Gloucester Road, Telephone 0272 232014.

In formerly opening the new shop, Brian Lodge, Director of the Department of Industry South-West Region, said that many local electronic enthusiasts would welcome the arrival of a new Maplin store in Bristol, as many youngsters find positions in local companies which are heavily involved in electronics. Brian Lodge congratulated Maplin on the range of products on show together with the highly professional appearance of the store. He hoped that Maplin would continue to source as much material as possible from UK-based manufacturers. He wished all concerned every success.

Kent Cider Flows

Kent Veriflux VTC flowmeters are being used for metering cider and apple juice transfer to road tankers at Symonds' plant in Stoke Lacey. The signal output from the flowmeters is taken to a local display unit to show the quantity of cider transferred. As this can amount to approximately 25,000 litres per load, it is essential to have accurate flowmetering.

Pasteurisation in the process plant is monitored and controlled by Kent instruments, circular chart recorders and control units, while conductivity cells allow the monitoring of caustic concentrations during cleaning processes and electrodes are used in the laboratory for sample analysis.

Symonds' have been producing premium quality ciders since 1727. The plant at Stoke Lacey, Herefordshire, has been dramatically expanded and modernised over the last three years and is now one of the largest and most modern cider production units in Europe. The company specialises in producing high quality ciders and perry and combines the latest production technology with traditional methods.

Successful operation of the processing plant depends on the quality of the Kent instrumentation used.

Contact: Kent Industrial Measurements Ltd, Oldends Lane, Stonehouse, Gloucestershire GL10 3TA. Tel: (045 382) 6661.

CHIP COUNT!

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

83C43. 8-bit microcontroller with 4K bytes of ram, 128 bytes of rom and an on-chip lcd driver supporting four backplanes at a maximum driving capacity of 96 segments. **(ML)**

FXD580 series of Ferroxdure materials for permanent magnets in dc motors. The FXD500 has typical remanence and coercivity values of 385mT and 360kAm respectively. The FXD520 has equivalent values of 425mT and 260kAm. **(ML)**.

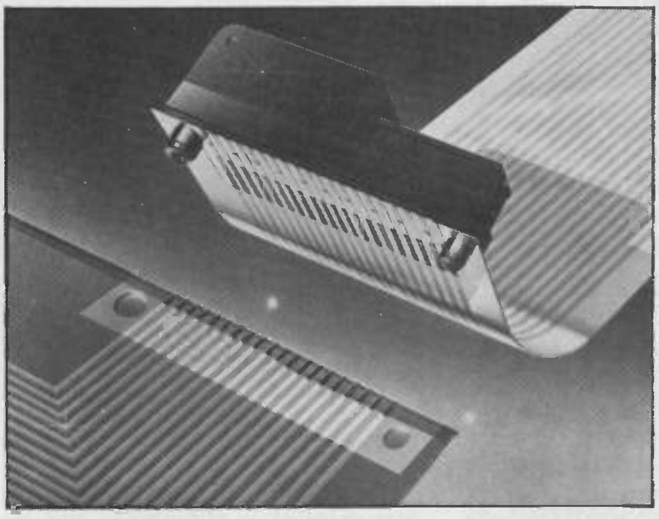
HA19213NT. Low power monolithic 7-bit flash ADC. Typical power dissipation 250mW, conversion rate 30 msps. **(HT)**.

LM282XF. LCD 640 x 400 dot display with built in cold fluorescent lamp backlighting, offering increased lifetime and superior visual performance. **(HT)**.

PLC473. The first Mullard erasable pld. Manufactured in cmos, it features uv erasability and demands much less power than its bipolar equivalents. **(ML)**.

Manufacturers, and contact telephone numbers:

(HT) Hitachi Electronic Components UK Ltd, 21 Upton Road, Watford, Herts, WD1 7TB. 0923 246488.
(ML) Mullard Ltd, Mullard House, Torrington Place, London WC1E 7HD. 01 580 6633.



Snap, No Crackle

Dowty's SNAP (sustained necessary applied pressure) has now been successfully evaluated to meet environmental classifications and provides gas tight contact between conductors on rigid circuit boards and tape cable or custom designed flexible circuits.

The new design has a number of advantages over conventional IDC and permits its use in many applications at lower cost. The combination of SNAP and production runs of pcbs provides a material cost saving since the mounting site does not require through-hole plating or mating connectors. It also has a greater intrinsic reliability than IDC due to its single interface between flex and rigid circuit. IDC would require three interfaces to make an equivalent connection.

The SNAP system is available as a single unit capable of 20 or 40 connection lines per 25 mm.

Contact: Dowty Interconnect, Knaves Beech Business Centre, Loudwater, High Wycombe, Bucks HP10 9UT, Tel: 0628 810810.

CD-ROMPS On

Britain's leading compact disc manufacturer, Nimbus Records, has completed the first commercial production of a cd-rom. The disc, commissioned by Clarinet Systems Limited for distribution to the international oil community, features a digital cartographic database of the world. It marks yet another first for Nimbus in technological achievement.

With the capacity to store up to 200,000 pages of text or 1,500 floppy discs, cd-rom (compact disc read only memory) is the latest means of storing vast amounts of data on a world standard optical storage medium.

The cd-rom manufactured by Nimbus holds 550 Mbytes of mapping data and runs on a PC linked to a plotter. While three scales and two projections are published on the disc, the software allows the user to zoom in and out with a choice of 26 projections.

The software supplied by Clarinet means that the user can distinguish specific geographical regions, cities or landmarks, highlighted by a colour display of distinctive boundaries and geographical features. Using a large scale or PC plotter, a full colour plot can then be displayed. Stephen Scholefield of Clarinet commented on the production of the disc: "Nimbus offered us a very quick turnaround time combined with extremely fast and efficient service."

Emil Dudek, cd-rom manager at Nimbus said that they are delighted to have reached the position where they can now offer a complete cd-rom manufacturing service. While this first disc is a combination of text and graphics, the versatility of cd-rom in other areas of storage such as audio-visual data is not being overlooked. Nimbus are committed to technological development and are determined to forge ahead with exciting new applications of compact disc.

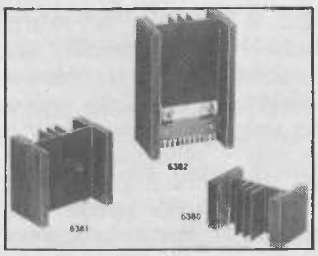
Contact: Emil Dudek, Nimbus Records. Tel: (0600) 890 682.

Cool Sip-Zip

If you are using integrated circuits encased in single or zig-zag in-line plastic packages, then you will be interested to learn about Thermalloy's latest 6380 Series heatsinks which are designed for both sip and zip, providing heat dissipation up to the 10–15W range.

The series is fitted with standard solderable roll pins, but users can also specify these with stand-off shoulders. There are several labour saving mounting options. The heatsinks can be screw mounted, using the pre-drilled device tab, or supplied with self-clinching fasteners or threaded studs. The TO220 case style devices is also available with a slotted hole pattern for mounting with a secondary clip.

Contact: MCP Electronics Ltd, 26–32 Rosemont Road, Alperton, Wembley, Middx HA0 4QY. Tel: 01 902 1191.



Firelight

Photain Controls are now manufacturing a new smoke detection unit which operates on the light scattering principle.

The unit comprises a white circular plastic housing which is normally fitted on the ceiling and contains an infra red light source which is pulsed and thereby produces a beam of invisible light. When smoke enters the unit through the special inlet holes the smoke scatters the beam which is then reflected on to the photocell. The photocell passes this information to an evaluation circuit within the unit which measures the amount of light received and compares it to a reference. The unit is triggered into an alarm state when the amount of smoke, which is in direct proportion to the amount of light falling on the photocell, exceeds a pre-set level.

The unit operates over a voltage range of 10–30V dc and any number of detectors can be wired in parallel across the same supply lines.

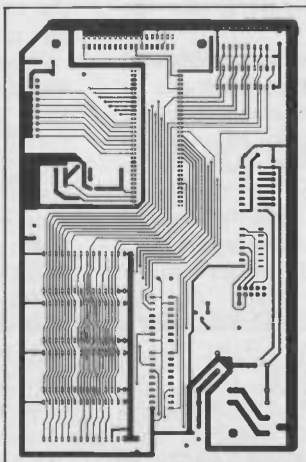
The price complete with plug in base is £36.00. Trade and quantity discounts available.

Contact: Photain Controls Ltd, Ford Aerodrome, Arundel, West Sussex, BN18 0BE. Tel: 0903 721531.

Snow Track

Skiers unfortunate enough to be buried by an avalanche may no longer be dependent upon rescue teams using tracker dogs and long metal probes. A Swiss firm, Asulab SA, has filed a European patent application (EP 0 172 445) for a radio activated location indicator device.

The proposed solution is for everyone at risk to wear a bracelet, like a watch strap, in which is a passive transceiver. It has an aerial made of metal foil, but needs neither batteries nor a conventional transmitter. Search signals transmitted by the rescue team are strong enough to generate a current in the bracelet. The current passes through a non-linear circuit which halves or doubles the frequency and rebroadcasts it through the foil aerial. The rescuers listen for signal echoes at the different frequency and determine the exact source of the signal with a directional aerial. Because the bracelet is passive it works automatically, and without the problem of lost battery power.



Track Pack

Lintrack PC, a low cost but professional pcb design package for IBM PCs and compatibles is now available from Linear Graphics Ltd.

It costs £160 plus VAT, but offers many features that are normally only offered on very much more expensive packages. Components can be placed using a 10 thou grid on double-sided boards up to 19 ins × 20 ins allowing maximum flexibility.

The user is provided with powerful editing features that allow any group of items (each item is a pad or section of track) to be selected from throughout the layout and to be relocated, rotated, duplicated or erased. User may also create their own library items speeding up the design process.

Lintrack PC offers comprehensive screen viewing, all layers or any one layer for selective editing, plus four levels of magnification. The package comes complete with a pre-defined library of dil outlines, connectors, transistors and pad layouts.

Contact: Linear Graphics Ltd, 28 Purdeys Way, Rochford, Essex SS4 1NE. Tel: 0702 541663/4/5.

LEADING EDGE

By Barry Fox – Winner of the 1987 UK Technology Press Award

FAVOURITE CD TRACKS

Philips CD players use eproms that allow permanent track selections to be stored in non-volatile memory.

There is interesting technology inside the new Philips cd players with fts (favourite track selection). To re-cap briefly, fts means what it says. You can select your favourite tracks on a compact disc, and ignore the ones you don't like.

On existing players you have to program the player with your selection every time you play a disc. With fts you can keep the selection stored in the player so that whenever the disc is loaded, the same selection of tracks is played and ignored. The player is able to recognise a disc and automatically recall the matching menu of hates and favourites for that disc. So far only Philips players have fts, because the technology is proprietory.

Around 97% of the digital bits streaming off an audio compact disc are used for stereo sound; the other 3% are used for "sub codes" which have nothing to do with music. There are eight separate subcode channels. The first two, known as P and Q, are used to control the player – eg tell it when music tracks begin and end. The other six (R-W) can be used for graphics and text displayed on a tv screen.

To make a brief detour from fts, the cd graphics system is already used in Japan for karaoke; that's a musical backing track for drunks in bars to singalong with, while watching the song lyrics come up on screen. There is a choice of 16 colours per picture with a total "palette" choice of 4096 colours. The sub code data comes off disc at around 60 kilobits per second and of this around 45 kilobits/second are available for text and graphics. This is enough to give one fresh picture every two seconds, of resolution 288×192 pixels.

The disc coding follows a world standard but the decoder must match local tv standard, ie one disc will play anywhere in the world but a PAL decoder and tv are needed for Europe and an NTSC decoder and tv for US/Japan. This means there is slight shape distortion, ie a circle looks a bit oval, but it hardly matters for karaoke lyrics. So far only NTSC decoders are available. So British pubs are still safe from karaoke.

Most cd audio players now have a microprocessor which the user can program to search for selected PQ codes. This is how the player can skip between tracks, with the order in which they are played bearing no relation to the order in which they are recorded on the disc. But the memory is volatile.. When another disc is programmed, the last track selection is lost.

Philips fts uses a non-volatile memory which holds instructions even when the mains is switched off. The player automatically recognises any disc on which it holds instructions, and calls up the right menu from its memory. Although it is possible to identify a compact disc by coding its title or catalogue number into the digital sub-code stream, record companies seldom bother to do this. So the fts player must use another trick to identify a disc. It compares the number of musical tracks with their length. Philips reckon there is only a one in a billion chance of two discs having exactly the same characteristic. So as soon as a record is loaded into the player, the fts circuit scans its contents, then scans its memory and if there are two matching entries it plays only those tracks on the disc which the owner previously chose.

The memory lasts for ever, unless the owner chooses to erase or change an entry. The menus are not lost when the player is switched off or even unplugged from the mains. This clever trick is done with eeproms.

Electrically erasable programmable read only memory is a technology, similar to the eproms (eraseable proms) used in portable computers, like the Psion Organiser.

Prom is a matrix of memory cells with silicon junctions or gates which can be opened and closed by an electrical signal to create a digital pattern of ones and zeroes. When the memory is new, all the juntions are switched in the same direction. To store data a control computer sends the memory chip a stream of electrical pulses which progressively switch some of the junctions by forcing electrons to cross a silicon semiconductor barrier. Once switched the junctions then stay switched. The pattern of switching conveys the data. Each chunk of data stored in the chip is labelled so that it can either be recalled for display on screen or erased.

Once switched, the gates of an eprom stay switched, until the whole memory matrix is saturated in ultraviolet light at a frequency of around 2537 Angstrom, for around 20 minutes. This drives the electrons back to their natural state and clears the entire memory. The uv content in daylight, or from a domestic tanning lamp, is not strong enough to do the job unless concentrated into a very narrow beam. With eeprom, as used for fts and (pre-set controls in radio and tv tuners) the data is erased electrically, rather than with uv light.

The memory capacity of the eeprom in the Philips fts players is 2049 bytes, of which 2045 bytes are available for use. Each entry for a disc consists of an eight byte header which identifies the disc by length of music programme. The user selection for the disc takes up between one and five bytes per track, depending on whether times and index points are stored as well as track numbers. A maximum of 20 bytes can be programmed per track.

Obviously the number of discs on which information can be stored depends on how much information is stored for each disc. It takes 13 bytes of memory to identify the running order for five tracks – less bytes for less tracks, and more bytes for more tracks. So total storage capacity can be over 150 discs with information on five tracks each; or around 80 if begin and end times are also stored; or something in between if the amount of information varies from disc to disc.

When data is erased from eeprom, the wiped cells can be used again to store fresh data. This is not the case with eprom; the memory cells are "eaten away" like gorgonzola cheese as data is erased from them. The erase command simply puts a "flag" on some of the labels which tells the control computer that a chunk of data is no longer needed. The switch junctions remained switched. With an eprom you can end up with no data stored, but no memory capacity left. The eprom chip then has to be wiped clean and rejuvenated with uv light. PE

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Mark Taylor, from an idea by John Becker.

WEATHER WATCHING

One of the many benefits brought about by satellites is that of improved weather monitoring on a scale unimaginable during the last century.

Widescale weather monitoring really began in the 1840s when electric telegraphs came into use in a storm warning network across the USA. About the same time daily weather maps became available both in the USA and in England. By the 1850s Europe had a rudimentary weather monitoring network centred on the Paris Observatory which received reports along links made available by the newly formed International Telegraphic Union. International weather bulletins had become available by the 1860s and in the 1870s the World Meteorological Organisation was founded in Vienna.

Over the next hundred years, as technology advanced so radio telegraphy, land and sea cable links followed bringing wider globe spanning observations, facilitated by the cooperation of the ITU and WMO.

By the 1960s the WMO recognised the necessity for long range planning as well as forecasting and created a World Weather Watch programme. Currently, 158 WMO member countries and territories participate in the WWW and have at their command data from over ten thousand weather monitoring stations across the globe. The monitors include those on land, at sea, on aircraft and weather balloons, and since 1959 on satellites as well.

Vanguard II was the first weather satellite to be launched, though Tiros IX was the first satellite to produce full-planet photographs, in 1965. Today over 300 earth stations across the globe collect the data from eight principal satellites in polar and geostationary orbit, and more satellites are planned.

Some of the world's most powerful computers analyse the data and make long term forecasts. Full perfection has not yet been achieved (don't we know it!) and may remain unachievable for many years due to the complexity of airflow mathematics and current shortage of monitoring stations. But, as the technology improves so too will the accuracy, allowing appropriate action to be taken to minimise potential disasters.

Many benefits are already gained from the ability to monitor and predict weather conditions. Travel safety, harvest protection, flood and drought prediction are just some of the obvious areas influenced by increased forecast accuracy. Other aspects of society have benefited too, for example, satisfactory forecasting results in better scheduling of power generation to meet weather dependent demand, so minimising operational costs. Airlines benefit from lower fuel costs when flights can be routed round adverse weather conditions. Environmental polution monitoring and control can also gain from knowledge of atmospheric movements. And naturally, military defense and offense tactics are influenced by sophisticated analysis of forthcoming weather trends.

SF writers often predict that weather control will one day come about, though the practicalities and benefits of this are highly debatable. And I'm not sure that it would be fully appreciated – what would we have to talk about?

THE EDITOR

OUR MAY 1988 ISSUE WILL BE ON SALE FRIDAY, APRIL 8th 1988 (see page 2)

LIGHT METAL EFFECTS

BY ROBERT PENFOLD

Lord of the rings?

Inspired by the former PE "Guitar Tracker", this project uses a vco and vca to produce a ring modulated sound which can be adjusted to follow the guitar's input at a chosen musical interval.

Probably most people who are "into" electronic music will be familiar with ring modulation, and its use in the production of metallic sounds (bells, gongs, etc.). A metal effects pedal is really just a ring modulator plus a built-in oscillator which is used to modulate the input signal. By setting the oscillator at a pitch which is a suitable musical interval from the input note, some quite harmonious metal sounds can be obtained. Unfortunately, a change in the input note will change the musical interval separating the two tones, and it may or may not produce a pleasant sounding output signal. For this reason the metal effect is generally used in moderation, or by those of more extreme musical tastes.

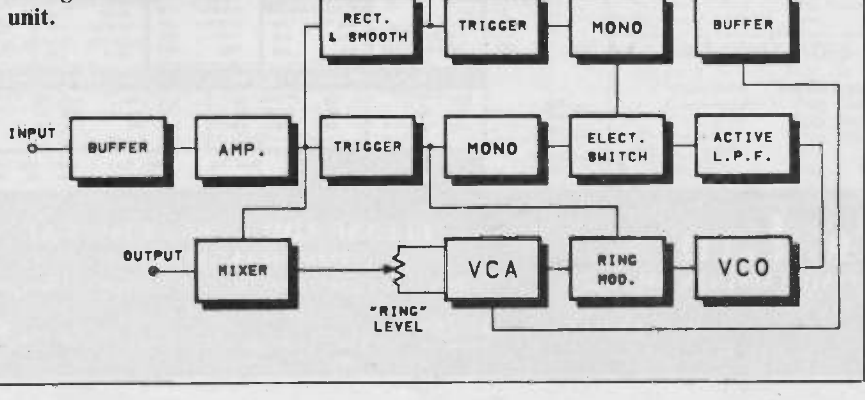
This unit was designed to overcome the rather hit and miss nature of the effect generated by a conventional ring modulator unit, and to give consistent results over a wide range of pitches. If you get a pleasant effect on one note from your guitar, then all the other notes should give more or less the same effect. What would I describe as a light metal effect rather than a heavy one. On the other hand, if you like the unharmonious sounds that can be produced by ring modulation, then the unit can be adjusted to give an equally discordant effect on every note (very heavy metal? – *For a **lead** guitar perhaps? Ed.)*

It operates in what is basically the same manner as a conventional metal pedal. The input signal is ring modulated by an oscillator, and the resultant signal is mixed with the unprocessed signal at the desired strength. The difference between this design and a conventional one is that the pitch of the oscillator is not set at some preset level, but automatically adjusted to match the input frequency. In other words, if the oscillator is set a fifth higher than the input at one input frequency, then it will automatically adjust its pitch on other notes so that it remains a fifth higher.

SYSTEMS OPERATION

The block diagram of Fig.1 shows the general arrangement used in the unit, and helps to explain the way in which it functions. The unit has similarities with the *"Guitar Tracker"* project described in PE June 1986, and it is a development of that project.

Fig 1. Block diagram for the light metal effects unit.



The input signal is taken to a buffer amplifier, and then to a voltage amplifier stage which ensures there is a high enough signal level to drive the subsequent stages properly. Some of the output from the amplifier is fed to a mixer stage and from here to the output socket. The output from the amplifier also drives a trigger circuit, and the roughly squarewave output signal from this circuit is split two ways. The first route is to one input of the ring modulator, where the signal is mixed with the signal from a vco (voltage controlled oscillator.).

The second route is to the input of a monostable multivibrator, and this acts as the basis of a simple frequency to voltage converter. The output pulse duration of the monostable is set by a CR timing circuit, and so the average output voltage depends on the number of times the monostable is triggered in a given period of time. The greater the number of times it is triggered, the higher the average output voltage. This may seem like a rather crude system of frequency to voltage conversion, which I suppose it is, but actually gives extremely good linearity. The output from the monstable is smoothed by an active lowpass filter to give a dc signal to control the vco The operating frequency of the vco is therefore moved up and down in sympathy with the pitch of the input signal.

There is a slight problem with this basic system in that it only provides a control voltage to the vco while an input signal at a reasonable level is present. Noises from the guitar if the fingering and playing is anything less than perfect can also give problems. To overcome these difficulties an electronic switch is used to connect the monostable to the lowpass filter for only a fraction of a second at the beginning of each new note. While this does not absolutely guarantee perfect results every time, it greatly reduces the risk of any mistracking. The lowpass filter is based on an ultra-high input impedance amplifier, and it therefore acts as a "hold" circuit which maintains the control voltage to the vco during the periods when the electronic switch is cut off.

The control signal for the switch is obtained by first rectifying and smoothing some of the output from the amplifier stage, so as to obtain a dc signal at a voltage which is proportional to the amplitude of the input signal. This dc signal is fed to a trigger circuit which is adjusted so that its output only triggers to the high state at the beginning of each note, when the signal from the guitar is at or close to its peak level. This gives a brief pulse which is used to trigger a monostable, and this circuit provides a gate pulse of suitable duration to the electronic switch.

This set up gives an oscillator which tracks up and down, following changes in the input frequency, and it ring modulates the vco's output with the input signal. The output from the ring modulator could simply be fed through to the mixer stage at the output, but this would not give entirely satisfactory results. The main problem is with breakthrough of the vco at the output of the ring modulator, but there is also a secondary problem in that the modulated signal is at a constant level, and does not vary in level in the same way as the input signal.

Both problems are overcome by feeding the ring modulated signal to the mixer by way of a vca (voltage controlled amplifier). This is driven from the output of the smoothing and recitifier circuit via a buffer amplifier. The amplitude of the ring modulated signal therefore varies in sympathy with the strength of the input signal.

The basic action of the ring modulator is to generate sum and difference frequencies from the input frequencies. As a simple example, with the two inputs fed with frequencies at 400Hz and 600Hz the output frequencies would be 1kHz (400Hz plus 600Hz = 1000Hz or 1kHz) and 200Hz (600Hz − 400Hz = 200Hz). In theory the input signals are balanced out and do not appear at the output, although with practical circuits there is usually significant breakthrough of at least one of the signals, and at least slight breakthrough of both. The sounds that result from this form of modulation are metallic in character due to the output containing strong signals at non-harmonically related frequencies.

Most western instruments use strings or similar vibrators that are essentially one-dimensional, and this gives very little output at frequencies other than the fundamental and it harmonics. Metal instruments such as gongs and bells are two or three dimensional in nature, and it is this that gives them the strong output at non-harmonic frequencies. They are effectively resonating at two or more frequencies, and interacting in a way that I suppose is roughly analogous to ring modulation.

THE CIRCUIT

Fig.2 shows the circuit diagram for the input, frequency to voltage conversion, and vco stages, while the rest of the circuit is shown in Fig.3.

I will not dwell on the operation of the circuit of Fig.2 here, since it is much as the equivalent stages in the *"Guitar Tracker"* project referred to earlier. Details of the way in which it functions can be found in this earlier article.

Turning our attention to Fig.3, IC7a acts as the basis of the ring modulator, and this is one section of an LM13600N dual operational transconductance amplifier (ota). The signal from the vco is coupled to both the inverting input and the output of the ota, and this balances out the signal which consequently fails to appear at the output. The amplified guitar signal is fed to the control input of IC7a. It therefore varies the gain of this amplifier, giving only minor breakthrough at the output. This varying of the gain affects the cancelling of the vco signal at the output of the circuit, and provides the complex mixing needed to generate the sum and difference signals while suppressing the input signals. VR4 is adjusted to minimise breakthrough of the input signals at the output. The output is buffered by a built-in Darlington Pair emitter follower in IC7a.

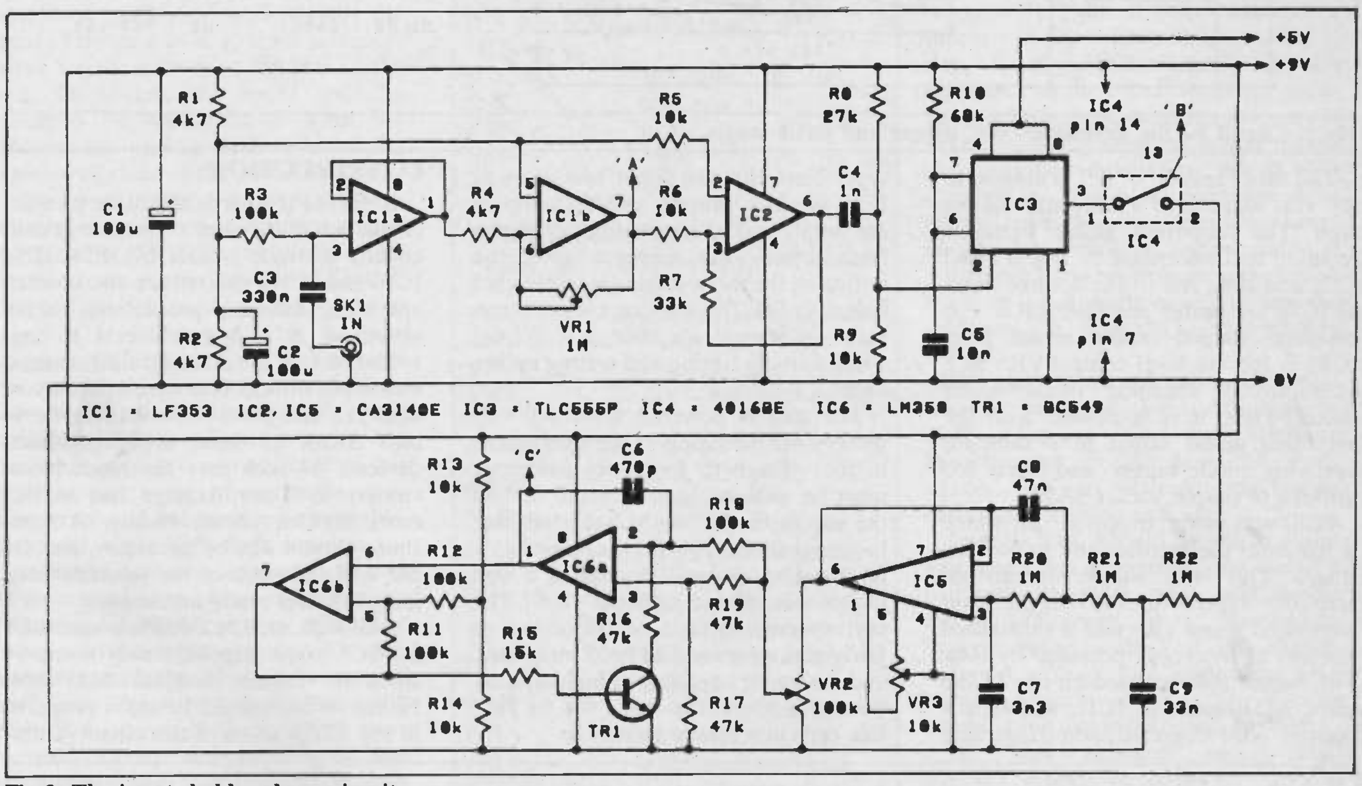


Fig 2. The input, hold and vco circuits.

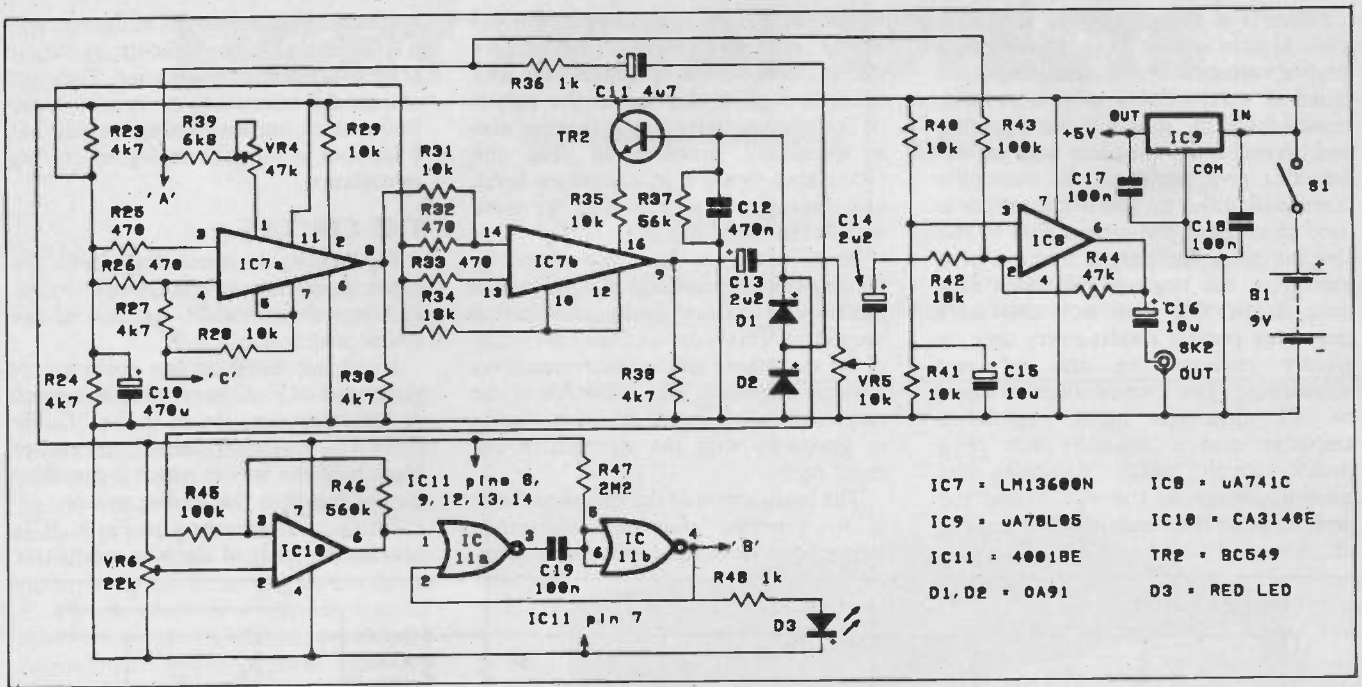


Fig 3. Circuit for the modulator, vca, trigger and mixer stages.

The other section of IC7 is utilised as the vca, and this is a conventional ota type. The amplified guitar signal is rectified and smoothed by D1, D2 and C12, and then fed to the control input of IC7a via buffer amplifier TR2. The envelope shaped output signal from IC7b is fed via level control VR5 to a conventional summing mode mixer circuit. Here it is combined with the amplified guitar signal in a standard summing mode mixer and then fed through to output socket SK2.

IC10 acts as the trigger circuit which is fed from the rectifier and smoothing stages. This is a simple operational amplifier type with the trigger level controlled using VR6 and a substantial amount of hysteresis provided by R46. The monostable is based on two of the cmos NOR gates in IC11, and it is a positive edge triggered, non-triggerable type. Note that the other two gates of IC11 are left unused, and their inputs are simply tied to the positive rail. Apart from driving the analogue gate, the output of the monostable also drives led indicator D3. This indicator is not much value in normal use, but it is helpful when initially testing and setting up the unit.

The unit is powered from a 9 volt battery, but the supply to the monostable in the voltage to frequency converter must be well stablised to avoid drift in the vco as the battery voltage falls due to ageing. The supply for the monostable is therefore derived through a 5 volt monolithic voltage regulator (IC9). The current consumption of the circuit is fairly high at around 20 to 25 milliamps, and the use of a medium or high capacity battery is recommended. I use six HP7 size cells in a plastic holder.

CONSTRUCTION

Refer to Fig.4 for details of the printed circuit board. Several of the integrated circuits are mos types (IC2, IC4, IC5, IC10 and IC11) and require the normal anti-static handling precautions to be observed. It is probably best to use sockets for all the dil integrated circuits, mos types or not. Take care not to overheat D1 and D2 when soldering them into circuit as these are germanium devices. As such they are much more vulnerable to heat damage than are the more familiar silicon variety. A heatshunt should not be necessary, but do not apply the iron to the joints for any longer than is really necessary.

Although an LM13600N is specified for IC7, some suppliers only seem to stock the virtually identical LM13700N. Either device should function properly in the IC7 position of this circuit. If the

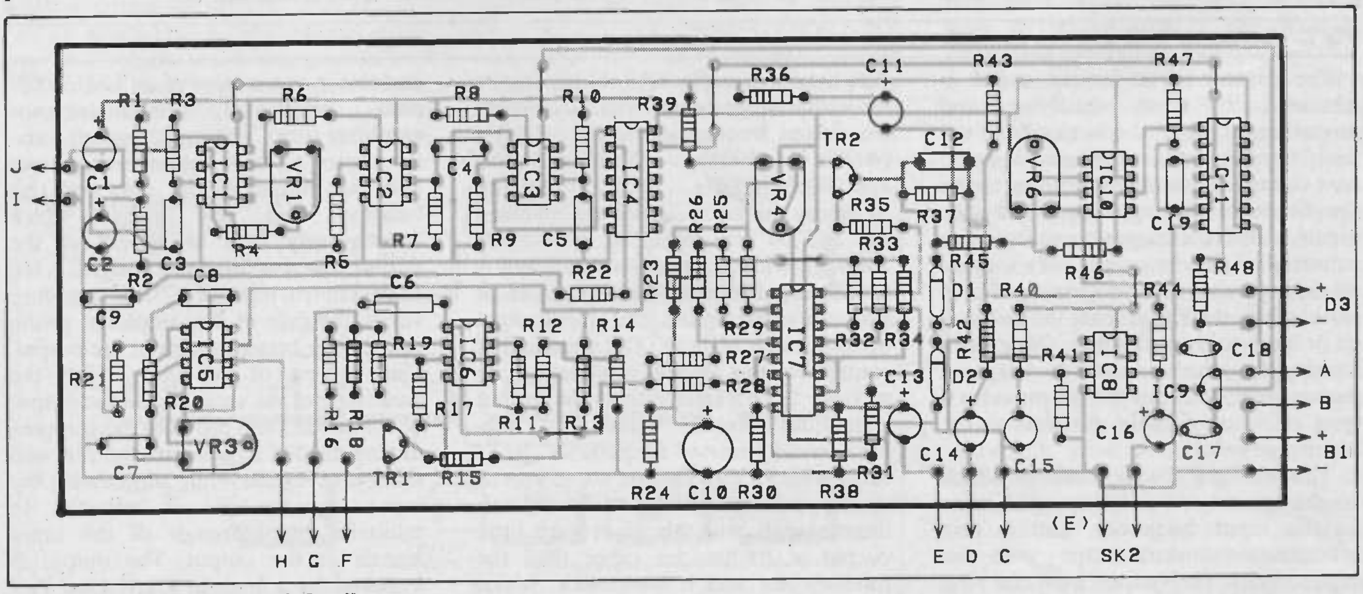


Fig 4. Printed circuit board details.

components are to fit onto the board easily it is essential to use modern miniature components, especially the capacitors which, with the only exception of C6, should be printed circuit mounting types.

I used a metal instrument case about 200 millimetres wide as the case for this project. The length of the printed circuit board and the need for a fairly large battery preclude the use of a case very much smaller than this. The controls, sockets, and led indicator are mounted in a row along the front panel, preferably in an arrangement which matches up well with the positioning of their connection points on the printed circuit board. SK1 should certainly be positioned close to its connections points on the board, or a screened lead should be used here. The printed circuit board should be positioned well towards the front of the case so as to leave sufficient space for the battery at the rear of the unit. Of course, the board must be mounted on stand-offs to keep the connections on the underside of the board well clear of the metal case.

On my prototype the on/off switch is a set of normally open contacts on the input socket (SK1). The unit is therefore switched on when the guitar lead is plugged into SK1, and switched off again when it is unplugged. This is quite common with effects units, and reduces the risk of the unit being accidentally left switched on. Presumably jack sockets will be used as the input and output connectors, and a socket of this type having a set of normally open contacts would not seem to be available. However, types with dpdt contacts are obtainable, and two contacts from one of these can be used to give the required switching action. Of course, it is quite in order to use an ordinary on/off switch such as a miniature spst toggle switch if preferred. The wiring to SK1 and the controls is shown in Fig.5 (which must be used in conjuction with Fig.4), and it is assumed here that a combined input socket and on/off switch are used.

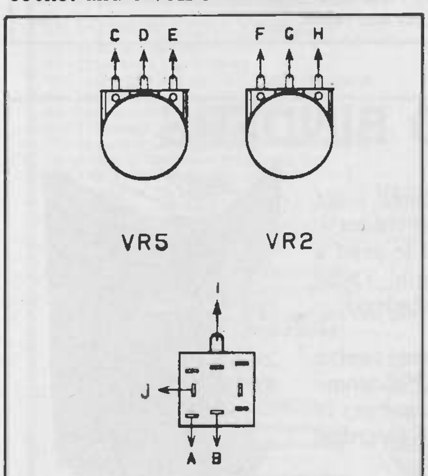


Fig 5. Control wiring

COMPONENTS

RESISTORS

R1,R2,R4, R23,R24,R27, R30,R38	4k7 (8 off)
R3,R11,R12, R18,R43,R45	100k (6 off)
R5,R6,R13, R14,R28,R29, R31,R35,R40, R41	10k (10 off)
R7	33k
R8	27k
R9,R34,R42	18k (3 off)
R10	68k
R15	15k
R16,R17,R19, R44	47k (4 off)
R20,R21,R22	1M (3 off)
R25,R26,R32, R33	470R (4 off)
R36,R48	1k (2 off)
R37	56k
R39	6k8
R46	560k
R47	2M2

POTENTIOMETERS

VR1	1M sub-min hor preset
VR2	100k lin
VR3	10k sub-min hor preset
VR4	47k sub-min hor preset
VR5	10k log
VR6	22k sub-min hor preset

CAPACITORS

C1,C2	100µ 10V radial elect (2 off)
C3	330n polyester layer
C4	1n polyester layer
C5	10n polyester layer
C6	470p polystyrene
C7	3n3 polyester layer
C8	47n polyester layer
C9	33n polyester layer
C10	470µ 10V radial elect
C11	4µ7 63V radial elect
C12	470n polyester layer
C13,C14	2µ2 63V radial elect (2 off)
C15,C16	10µ 25V radial elect (2 off)
C17,C18	100n ceramic (2 off)
C19	100n polyester layer

SEMICONDUCTORS

IC1	LF353
IC2,IC5,IC10	CA3140E (3 off)
IC3	TLC555P
IC4	4016BE or 4066BE
IC6	LM358
IC7	LM13600N or LM13700N
IC8	µA741C
IC9	µA78L05
IC11	4001BE
TR1,TR2	BC549 (2 off)
D1,D2	0A91 (2 off)
D3	Red panel led

MISCELLANEOUS

S1	Part of SK1
SK1	Standard jack with dpdt contacts
SK2	Standard jack socket
B1	9 volt (eg 6 x HP7 in holder)

Instrument case about 203 x 127 x 51mm, printed circuit board, battery connector, 8 pin dil ic holder (7 off), 14 pin dil holder (2 off) control knob (2 off), wire, solder, etc.

CONSTRUCTOR'S NOTE:
The PE PCB Service can supply the printed circuit board.

ADJUSTMENT

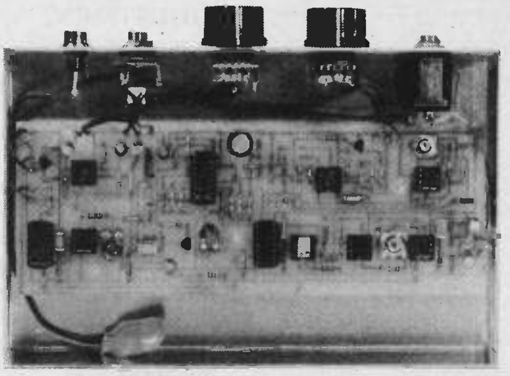
There are four presets to be set up correctly before the unit is ready for use. VR1 must be adjusted to give a level of gain from the voltage amplifier that gives reliable triggering of the unit. It is a matter of using the lowest sensitivity (clockwise adjustment gives decreased sensitivity) that gives reliable triggering of the unit. Higher gain is undesirable as it could result in the signal being clipped at the output of IC1b, and it could also lead to spurious triggering of the unit.

VR3 is the offset null control for IC5, and it is adjusted to optimise tracking accuracy at low frequencies. The output tone from the vco needs to be monitored in order to do this, and something as basic as wiring a crystal earphone between IC6 pin 1 and the negative supply rail will suffice. It is a matter of first adjusting VR2 to match the vco frequency to the input frequency when using a high input frequency (ie about 1kHz). Then, using a much lower frequency (around 100Hz), adjust VR3 to match the pitch of the vco to the input note. Repeat this procedure a few times to get the tracking as accurate as possible. In this application very precise tracking is not really essential, and the setting of VR3 does not seem to be very critical.

The effect obtained varies somewhat with the setting of VR4. Although its main purpose is to minimise breakthrough of the vco and input signals, you can settle for any setting that gives an effect you like.

Initially VR6 should be set at about half maximum resistance, and the unit will probably work quite well at this setting. However, it is worthwhile experimenting with VR6 at slightly different settings, and readjusting VR1 to compensate, in order to find a combination that gives optimum results.

The unit produces some good "thicker" sounds, but to my ears anyway, it is at its best with VR5 set for a



moderate amount of ring modulation. Remember that the signal from the modulator contains little output at the guitar frequency. Using a large amount of modulation you may find that the output notes are not the same as the ones you play on the guitar. As it stands the unit does not have any in/out switching. This could easily be added though, and all that is needed is a switch in series with C13 to cut the signal path of the modulation, or a switch to connect pin 16 of IC7 to earth and cut off the vca. An external foot-switch might be the best type of switch to use. PE

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548 – 2 battery operated relays (3-6v) each with 5A c/o contacts 2 pairs
553 – 2 lithium 3V batteries (everlasting shelf life)

5 AMP BATTERY CHARGER KIT. ALL PARTS INCLUDING CASE ONLY £5.00 BUT ADD £1.00 P&P

OVER 400 GIFTS YOU CAN CHOOSE FROM

There is a total of over 400 packs in our Baker's dozen range and you become entitled to a free gift with each dozen packs.
A classified list of these packs and our latest "News Letter" will be enclosed with your goods, and you will automatically receive our next news leter

THIS MONTHS SNIP

3½ FLOPPY DISC DRIVES, made by the Chinon Company of Japan. Beautifully made and probably the most compact device of its kind as it weighs only 600g and measures only 104mm wide, 162mm deep and has a height of only 32mm, other features are high precision head position – single push loading and eject – direct drive brushless motor – Shugart compatible interface – standard connections – interchangeable with most other 3½ and 5½ drives. Brand new with copy of makers manual. Offered this month at £28.50 post and VAT included

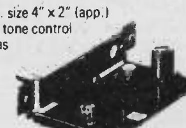
CASE – adaptable for 3" or 3½" FDD, has room for power supply components price only £4 includes circuit of PSU. Our Ref 4P8.

POWER SUPPLY FOR FDD – 5V and 12V voltage regulated outputs, complete kit of parts will fit into case 4P8 price £8 or with case £11.

MULLARD UNILEX AMPLIFIERS
We are probably the only firm in the country with these now in stock. Although only four watts per channel, these give superb reproduction. We now offer the 4 Mullard modules – i.e. Mains power unit (EP9002) Pre amp module (EP9001) and two amplifier modules (EP9000) all for £6.00 plus £2 postage. For prices of modules bought separately see TWO POUNDERS.

CAR STARTER/CHARGER KIT
Flat Battery! Don't worry you will start your car in a few minutes with this unit – 250 watt transformer 20 amp rectifiers, case and all parts with data case £17.50 post £2.

MINI MONO AMP on p.c.b. size 4" x 2" (app.)
Fitted volume control and a hole for a tone control should you require it. The amplifier has three transistors and we estimate the output to be 3W rms. More technical data will be included with the amp. Brand new, perfect condition, offered at the very low price of £1.15 each, or £13 for £12.00



LIGHT BOX
This when completed measures approximately 15" x 14". The light source is the Philips fluorescent 'W' tube. Above the light a sheet of fibreglass and through this should be sufficient light to enable you to follow the circuit on fibreglass PCBs. Price for the complete kit, that is the box, choke, starter, tube and switch, and fibreglass is £5 plus £2 post, order ref 5P69.

TANGENTIAL HEATERS
We again have very good stocks of these quiet runnng instant heat units. They require only a simple case, or could easily be fitted into the bottom of a kitchen unit or book case etc. At present we have stocks of 1.2kw, 2kw, 2.5kw, and 3kw. Prices are £5 each for the first 3, and £6.95 for the 3k. Add post £1.50 per heater if not collecting.
CONTROL SWITCH enabling full heat, half heat or cold blow, with connection diagram, 50p for 2kw, 75p for 3kw.

FANS & BLOWERS
5" £5 + £1.25 post. 6" £6 + £1.50 post
4" x 4" Muffin equipment cooling fan 115V £2.00
4" x 4" Muffin equipment cooling fan 230/240V £5.00
9" Extractor or blower 115V supplied with 230 to 115V adaptor £9.50 + £2 post.
All above are ex computers but guaranteed 12 months.
10" x 3" Tangential Blower. New. Very quiet – supplied with 230 to 115V adaptor on use two in series to give long blow £2.00 + £1.50 post or £4.00 + £2.00 post for two

9" MONITOR
Ideal to work with computer or video camera uses Philips black and white tube ref M24/306W. Which tube is implosion and X-Ray radiation protected. VDU is brand new and has a time base and EHT circuitry. Requires only a 16V dc supply to set it going. It's made up in a lacquered metal framework but has open sides so should be cased. The VDU comes complete with circuit diagram and has been line tested and has our six months guarantee. Offered at a lot less than some firms are asking for the tube alone, only £16 plus £5 post.

LOW COST OSCILLOSCOPE – kit to convert our 9" monitor into an oscilloscope with switched time bases to allow very high and very low frequency waveforms to be observed and measured. Signal amplitudes from as low as 10mV and as high as 1kV can easily be observed and measured. Ideal for servicing, also for investigating TV, radio and audio circuits.
Kit containing all the parts for the conversion and the power supply to operate from mains £25 our ref 25P3.

TELEPHONE LEAD
3 mtrs long terminating one end with new BT, flat plug and the other end with 4 correctly coloured coded wires to fit to phone or appliance. Replaces the lead on old phone making it suitable for new BT socket. Price £1 ref BD552 or 3 for £2 ref 2P164.

COMPACT FLOPPY DISC DRIVE EME-101
The EME-101 drives a 3" disc of the new standard which despite its small size provides a capacity of 500k per disc, which is equivalent to the 3½" and 5¼" discs. We supply the Operators Manual and other information showing how to use this with popular computers: BBC, Spectrum, Amstrad etc. All at a special snip price of £27.50 including post and VAT. Data available separately £2, refundable if you purchase the drive.

POWERFUL IONISER
Generates approx. 10 times more IONS than the ETI and similar circuits. Will refresh your home, office, shop, work room etc. Makes you feel better and work harder – a complete mains operated kit, case included. £11.50 + £3 P&P.

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MAIL ORDER TERMS: Cash, P.O. or cheque with order. Orders under £20 add £1 service charge. Monthly account orders accepted from schools and public companies. Access & B/card orders accepted. Brighton (0273) 734648 or 203500.

NEW ITEMS
Some of the many described in our current list which you will receive with your parcel.

ASTEC T.S.U. Switch mode type so very compact. Normal 230V input. Has 3 outputs:– +5V at 3.5 amps, +12V at 1.5 amps and −5V at 0.3 amps. Should be ideal to drive floppy disc units. Regular price around £30, our price only £10 although brand new and unused. Order our ref 10P34.

POWERFUL 12V MOTOR was intended for the Sinclair electric car. Rated approx ⅓ hp. Our price only £15.00. Ref. 15P8.

BURGLAR ALARM BELL 6in. gong – ok to fix outside if sheltered from rain. Mains operated £8.00. Ref. 8P2.
12V battery operated £8.00. Ref. 8P2A

24 HOUR TIMESWITCH 16A C/O contacts, up to 6 on-offs per day. Nicely cased for wall-mounting. Price £8.00. Ref. 8P6.

CAPICITOR BARGAIN Axial ended 4700 uf at 25V. Superior Jap make, normally 50p each, you get 4 for £1.00 Ref. 613.

AGAIN AVAILABLE – 12" mini fluorescent tubes – Price £1 each. Ref. BD314.

POWER PACK OR AMPLIFIER CASE – Size approx 10" x 8¼" x 4¾" plated steel – with ampie perforations for cooling. Front panel has on/off switch and E.E.C. mains inlet plug with built in RF filter – undoubtedly a very fine case which would cost at least £50 from regular sources, our price is £5 each and £3 post. Ref. 5P111.

MINIATURE BCD THUMB WHEEL SWITCH – Matt black edge switch engraved white on balck – gold plated, make before break contacts – size approx. 25mm high 8mm wide 20mm deep – made by the famous Cherry Company and designed for easy stacking – Price £1 each. Ref. BD601.

EDGE METER – miniature, whole size approxx 37mm x 13mm ua fsd – centre zero scaled 0 to −10 and 0 to +10. Price £1 each. Ref. BD602.

CLEANING FLUID – Extra good quality – intended for video and tape heads – regular price £1.50 per spray can – our Price – 2 cans for £1. Ref. BD604.

DON'T FREEZE UP! – We have had the strongest winds for over 200 years and who knows we may be in for the coldest winter, so if you have not already protected your water pipes you should do so now – our heating wire wound around the pipes will do this and will cost only about 50p per week to run – 15 metres (minimum length to connect to 230/240 v mains). Price £5. Our Ref. 5P 109.

PIEZO ELECTRIC FAN an unusual fan, more like the one used by Madame Butterfly, than the conventional type, it does not rotate. The air movement is caused by two vibrating arms. It is American made, mains operated, very economical and cause's no interference. So it is ideal for computer and instrument cooling. Price is only £1 each. Ref BD605.

SPRING LOADED TEST PRODS – heavy duty, made by the famous Bulgin company. Very good quality. Price four for £1. Ref. BD597.

CURLY LEAD four core, standard replacement for telephone handset, extends to nearly two metres. Price £1. each. Ref. BD599.

TELEPHONE BELLS – these will work off our standard mains through a transformer, but to sound exactly like a telephone, they then must be fed with 25 hz 50v. So with these bells we give a circuit for a suitable power supply. Price 2 bells for £1. Ref. BD600.

ULTRA SENSITIVE POCKET MULTIMETER – 4k ohms per volt – 11 ranges – carry one of these and so be always ready to test ac/dc volts to 1000, DC milliams and have an ohms range for circuit testing – will earn its cost in no time. Price only £7. Ref. 7P2.

BLOW YOUR ROOF OFF – 140 watt speaker systems – new type you must not hide! they have golden cones and golden surrounds and look rally "Bootiful" 12" Woofer, Midrange and Tweeter and comes with a crossover at a special introductory price of £49, carriage paid. Two sets for £95 carriage paid, 140w Woofer only £35 carriage paid.

3½ & 5¼ FLOPPY DISC DRIVES now in stock all are new and made by famous Epson company. All are double sided drives with storage capacity of 1 meg byte. They have standard connections and are fully compatible with conventional systems. Both are small size and light weight. Price – either model is £57.50 plus £3 post. Price includes copy operating data.

APPLIANCE THERMOSTATS – spindle adjust type suitable for convector heaters or similar price 2 for £1. Ref. BD582.

COMPUTERS

Big consignment of computers expected various makes and numbers, write or phone for details.

NOVEL NIGHT LIGHT – plugs into a 13A socket. Gives out a surprising amount of light, certainly enough to navigate along passages at night or to keep a nervous child happy. Very low consumption, probably not enough to move the meter. Price £1. Ref. BD563.

CASE WITH 13A PRONGS – to go into 13A socket, nice size and suitable for plenty of projects such as car battery trickle charger, speed controller, time switch, night light, noise suppressor, dimmers etc. Price – 2 for £1. Ref. BD565

SPEAKER EXTENSION CABLE – twin 0.7mm conductors so you can have long runs with minimum sound loss and for telephone extensions or burglar alarms, bells, intercoms etc. 250m coil only £3 plus £1 post. Ref. 3P28.

ALPHA-NUMERIC KEYBOARD – this keyboard has 73 keys with contactless capacitance switches giving long trouble free life and no contact bounce. The keys are arranged in two groups; the main area field is a QWERTY array and on the right is a 15 key 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.

TELEPHONE EXTENSIONS – it is now legal for you to undertake the wiring of telephone extensions. For this we can supply 4 core telephone cable, 100m coil £8.50. Extension BT sockets £2.95. Packet of 500 plastic headed staples £2. Dual adaptor for taking two appliances from one socket £3.95. Leads with B.T. plug for changing old phones. 3 for £2.

MODULAR SWITCH – Panel mounting highest quality and ideal where extra special front panel appearance is required, can be illuminated if required d.p.d.t. and latching. Price – 2 for £1. Ref. BD607.

WIRE BARGAIN – 500 metres 0.7mm solid copper tinned and p.v.c. covered. Only £3 + £1 post. Ref. 3P31 – that's well under 1p per metre, and this wire is ideal for push on connections.

INTERRUPTED BEAM KIT – this kit enables you to make a switch that will trigger when a steady beam of infra-red or ordinary light is broken. Main components – relay, photo transistor, resistors and caps etc. Circuit diagram but no case. Price £2. Ref. 2P15.

3-30V VARIABLE VOLTAGE POWER SUPPLY UNIT – with 1 amp DC output. Intended for use on the bench for experimenters, students, inventors, service engineers etc. This is probably the most important piece of equipment you can own. (After a multi range test meter). It gives a variable output from 3-30 volts and has an automatic short circuit and overload protection, which operates at 1.1 amp approximately. Other features are very low ripple output, a typical ripple is 3mV pk-pk, 1mV rms. Mounted in a metal fronted plastic case, this has a voltmeter on the front panel in addition to the output control knob and the output terminals. Price for complete kit with full instructions is £15. Ref. 15P7.

TRANSMITTER SURVEILLANCE (BUG) – tiny, easily hidden, but which will enable conversation to be picked up with FM radio. Can be housed in a matchbox, all electronic parts and circuit. Price £2. Ref. 2P52.

SATELLITES

PART TWO BY MIKE SANDERS

INTELSAT V DOUBLES ITS MONEY

The pressures on comms satellite capacity is increasing steadily. Several ways of routing a greater number of signals have been worked out, including on-demand assignment, multiple accessing, higher-frequency bandwidths and carrier repolarisation.

Single channel per carrier, pulse code modulation, multiple access, demand assignment (spade) operations were begun in 1974 by twenty earth stations.

Let us take the definition a bit at a time. Single channel per carrier does not mean only one speech channel but a whole lot ranging from 24 to 960 channels. One of these 'lots' then constitutes a channel on the satellite link. The term channel often refers to different bandwidths and is an often abused word. Carriers with speech channel capacities ranging from 24 to 960 will have bandwidths of 2.5MHz, 5MHz, 7.5MHz, 10MHz, 20MHz, 25MHz, 35MHz. It can be seen that the largest, 35MHz, occupies a whole transponder of 36MHz.

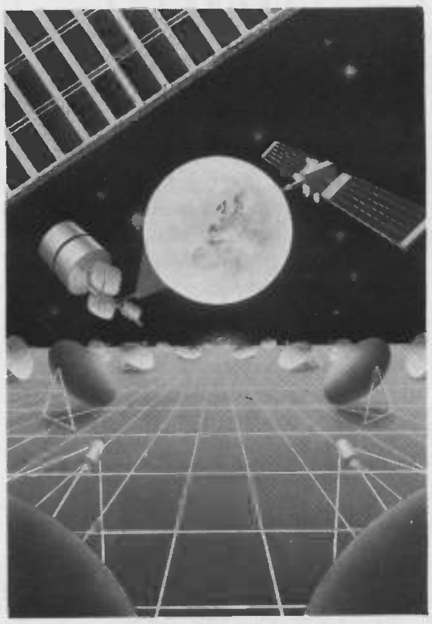
Pulse code modulation refers to the well known pcm technique of converting analogue signals into digital signals. Multiple access means that more than one earth station can access the satellite as for a frequency division multiplexed system. The interesting bit is the demand assignment and an earth station is assigned a carrier only when it actually wants to transmit and not on a permanent basis.

SPADE WORK

So what is the attraction of spade operation? If an earth station can access a satellite only when it has a message to transmit, then small countries with light traffic do not have to tie up satellite capacity as with pre-assigned fdm. However, spade equipment is expensive and operates as follows.

All the signalling information (routing digits, duration of call etc) is separated from the message (speech or data) at the earth station terrestrial interface unit (tiu) before transmission. This signalling information is then conveyed over common signalling channels (csc) between up to 50 earth stations. These signalling channels are not assigned by demand but open all the time. This is because no breaks can be tolerated in the csc links, since the telephone exchanges must know how to route the call even before the speech arrives. Also, csc operating at 128 kbit/s is used by each earth station to keep in touch with the controlling earth station.

At the terrestrial interface unit, the speech is also converted to digital form by pcm. At the earth station both



received speech and signalling are converted back to analogue form since, at the present time, terrestrial networks are mainly analogue.

At the heart of spade operation is a demand assignment signalling and switching equipment (dass) which controls the setting up of calls. One earth station must act as control and transmit a reference burst. All other stations then transmit their bursts in an allotted time window in relation to the reference burst (Fig.1.)

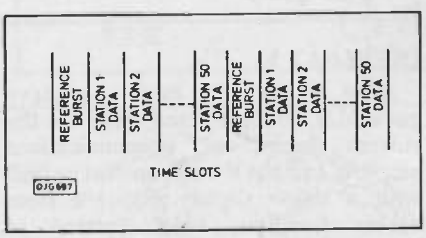


Fig 1. *Spade operation*

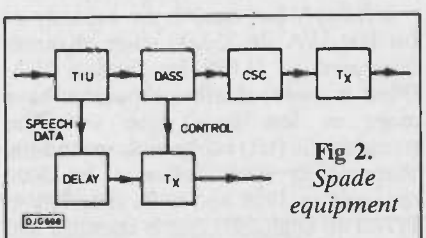


Fig 2. *Spade equipment*

Each time a request is received for a call, the relevant dass selects a pair of transmit/receive carriers and informs the distant earth station. Such communication is carried out via the csc, Fig.2. Also, all dass units are aware of which carriers are free at any given moment. In addition dass can log the duration of a call as well as any faults occurring.

Let us see how many spade channels a transponder can support. We have seen how a 4KHz speech channel when frequency modulated occupies 45KHz of bandwidth. Therefore a 36 MHz transponder will accommodate 800 speech channels. If these channels were in continuous operation, the transponder would be able to supply the power requirement of only half this number, ie 400 channels. But a speech channel is in use for only 40% of the time: only one party speaks plus gaps in conversation, therefore the transponder can manage 800 channels.

SINGLE CHANNEL CARRIER

Four years after spade operations started, there was such a heavy demand for data circuits building up, that single channel per carrier (scpc) was introduced. There are several small countries with only half a dozen circuits to the UK, four of which could be speech and two data circuits.

Scpc is essentially the same as spade, except that the link is pre-assigned and available for use whenever the customer desires. Just as with spade, the carrier is switched on whenever there is a voice transmission, and to avoid losing the leading edge of the spoken word, a delay line is used, Fig.3. This delays the speech for a few milliseconds while the carriers are enabled.

For data at 48kbit/s, 50kbit/s and 56kbit/s there is no point in switching the carriers on and off and therefore the

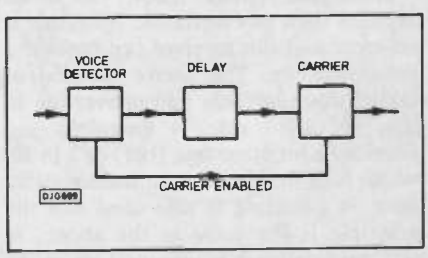


Fig 3. *Speech detector*

speech detector is disabled. Lower data speeds of 1.2kbit/s, 2.4kbit/s and 4.8kbit/s can be multiplexed to give a higher speed. There are also intermediate rates of 9.6kbit/s and 19.2kbit/s for facsimile as well as data transmission.

An increasing use of transponders for data transmission means that each transponder can handle fewer than 800 channels, or the power of each transponder must be increased. If there is a heavy demand for scpc, four transponders on Intelsat IV an IVA can be switched from global to spot beam by ground telemetry. This is the kind of remote control that will be built increasingly into future satellites.

The greater the number of carriers, the more the frequency deviation has to be reduced. In an fdm system using 10 to 20 carriers, a frequency deviation of around 80kHz is good enough. But when there could be as many as 800 carriers on each transponder when used for scpc, then the frequency deviation of the carriers must be reduced to 250Hz to prevent one carrier interfering with its neighbours.

ERROR CHECKING

We have seen from Fig.1. how one station acts as a control and transmits a reference signal. This reference signal or pilot is used by the other earth stations for gain as well as frequency control. Then each station transmits its own burst in its given time window. Apart from containing the message being transmitted, each burst contains header information like station identification and synchronisation words.

As scpc was bascially set up to cope with the increased transmission of data, we cannot leave the topic before considering some means of error correction. Forward error correction (fec) is obtained by converting the bit stream into three paths say a, b, c as in Fig.4. Parity can be even or odd. Parity is said to be even when the sum of all the digits including the parity bit is even. Similarly, odd parity can be generated.

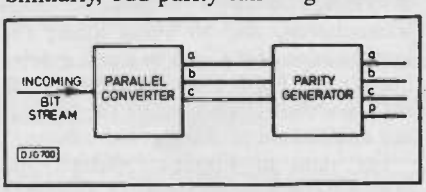


Fig 4. *Forward error correction*

Once the parity mode has been decided then any deviation from this is an error and the receiver can request a retransmission. The above method of taking three streams and converting to four is called rate ¾ encoding and provides a bit error rate (ber) of 1 in 10^7 which is desirable for data transmission. Rate ⅞ encoding is also used and the principle is the same as the above, ie one parity stream is provided for seven data streams.

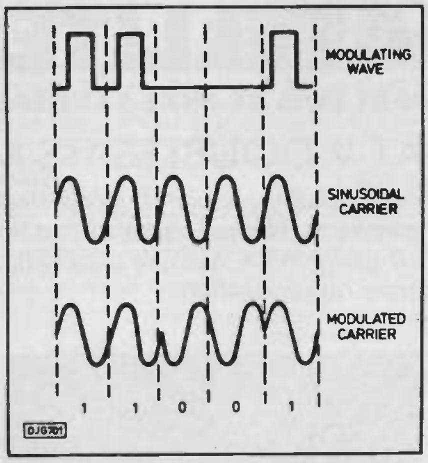


Fig 5. *Phase shift keying*

Now that we have generated four bit streams some means must be found of transmitting them. Quadrature phase shift keying, qpsk or 4psk, is a popular method for doing this and 8psk is used for the ⅞ encoder. A simple explanation of phase shift keying is shown in Fig.5, where an analogue waveform is coded to represent a digital stream. Any change in binary digits from 1 to 0 or vice versa is represented by a phase shift of the analogue wave.

In the same way, the phase of the carrier is shifted in qpsk so that one can tell which bit stream is being transmitted. Two 2-phase modulators are used as shown in Fig.6a and the 46MHz carrier is used to alter phase as shown in the phasor diagram of Fig.6b.

Each time a new generation of satellite goes for greater capacity there are two problems to be overcome: the search for bandwidth and the power to operate this bandwidth. Intelsat V solved the problem of increased bandwidth by operating in the 14/11GHz range as well as in the 6/4GHz. In addition each of these carriers can be re-used if polarised. Increased power is obtained by placing the solar cells on large flat panels since placing them on a cylindrical shape puts half of them in the dark.

MULTIPLE CAPACITY

But to return to polarisation, an electromagnetic wave travelling in a waveguide consists of an electric field perpendicular to a magnetic field, Fig.8. Placing a sheet of dielectric material within the waveguide changes the direction of the field so that the electric field is now vertical and the magnetic field horizontal. These are called horizontal and vertical polarisations and straight away we have doubled the capacity of a single carrier.

But that is not all; we can also polarise a waveform in a circular fashion providing either clockwise or anticlockwise fields called right hand circular (rhc) and left hand circular (lhc), Fig.9. So using the same carrier with both linear as well as circular polarisations has quadrupled the traffic carrying capacity.

There must be 30dB separation between polarisations in order to

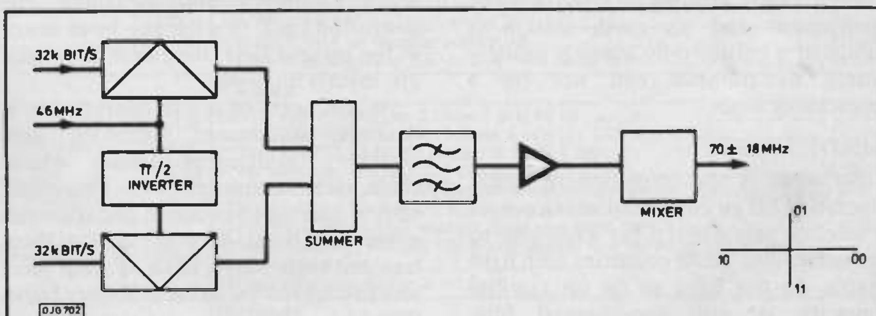


Fig 6a. *QPSK*

Fig 6b. *Phasor diagram*

INTELSAT V

After Intelsat IV, came ... you've guessed it, Intelsat V and these are the current breed of communications satellite. Intelsat V was launched in 1980 with a shape slightly different from earlier satellites, Fig.7. Instead of housing the solar cells on the cylindrical body, they were placed on flat panels.

Intelsat V has double the capacity of Intelsat IVA, ie 25,000 voice channels compared to 11,000 for Intelsat IVA. What is more, satellite capacities have more or less kept pace with the transatlantic (tat) cables with around 400 channels in 1968, followed by 3000 channels in 1969 and 8000 channels in 1977. Two channels, that is transmit and receive, equal one circuit.

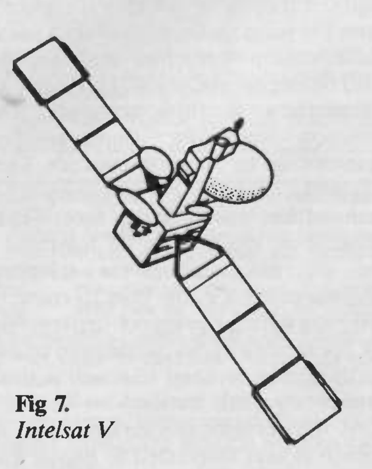


Fig 7.
Intelsat V

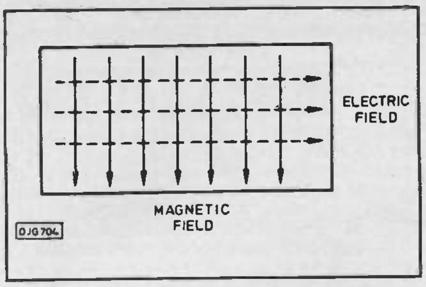


Fig 8. *Electromagnetic fields*

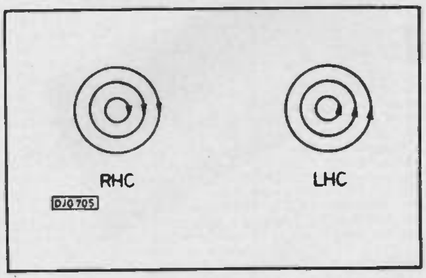


Fig 9. *Circular polarisation*

BEAM	FREQUENCY	TRANSMIT POLARISATION	RECEIVE POLARISATION
Global	6/4 GHz	RHC	LHC
East Hemi	6/4 GHz	RHC	LHC
West Hemi	6/4 GHz	RHC	LHC
East Zone	6/4 GHz	LHC	RHC
West Zone	6/4 GHz	LHC	RHC
East Spot	14/11 GHz	Linear	Linear
West Spot	14/11 GHz	Linear	Linear

TABLE 1

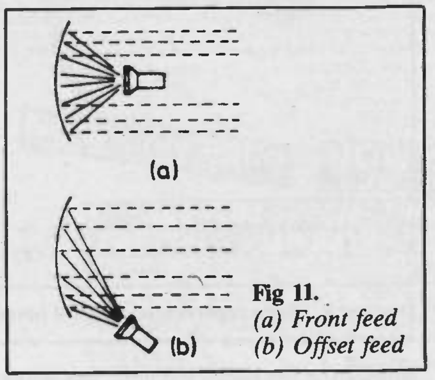


Fig 11.
(a) Front feed
(b) Offset feed

prevent beams from interfering with each other and there are four types of beam. A global beam, as its name implies, covers whatever area of the earth is visible, a spot beam concentrates on areas of high traffic, and zone and hemispheric beams cover slightly larger areas as shown in Fig.10.

The combinations of frequency and polarisation is shown in Table 1.

In order to produce the complex patterns shown in Fig.10, the aerial reflector has 88 feeds, Fig.11a. But many feeds would block the reflector so an offset feed is used as in Fig.11b. The reflectors have less room for movement compared to the global horns and all are steered by ground command.

The gain of each type of beam is stated as if the beam were being radiated in all directions, eg a light bulb. These gains are 35 dBi for the spot beam, 23dBi for the zone beam and 17dBi for the global beam (i = isotropic radiator).

CIRCUIT MULTIPLICATION

We have seen how a satellite is put under pressure to provide power during data transmission compared to speech transmission. However, administrations who have paid for satellite capacity tend to use that capacity to the maximum. In a speech circuit only one channel is utilised since only one person speaks at any one time and taking pauses into account, the usage of each circuit (two channels) is only about 40%. Therefore using circuit multiplication equipment the usage of a satellite link can be easily doubled. Such equipment already exists and puts further demands on satellite power.

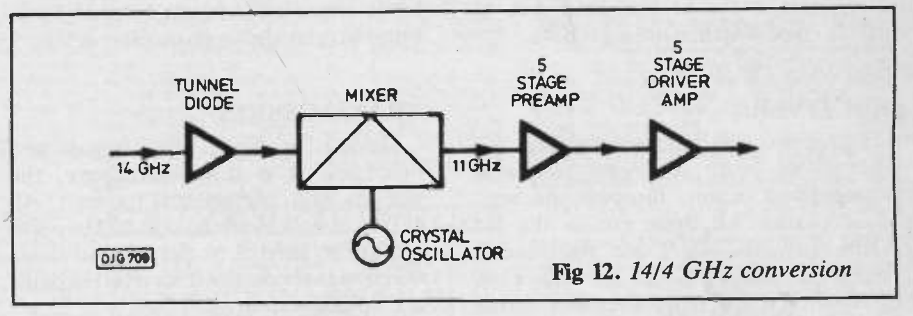


Fig 12. *14/4 GHz conversion*

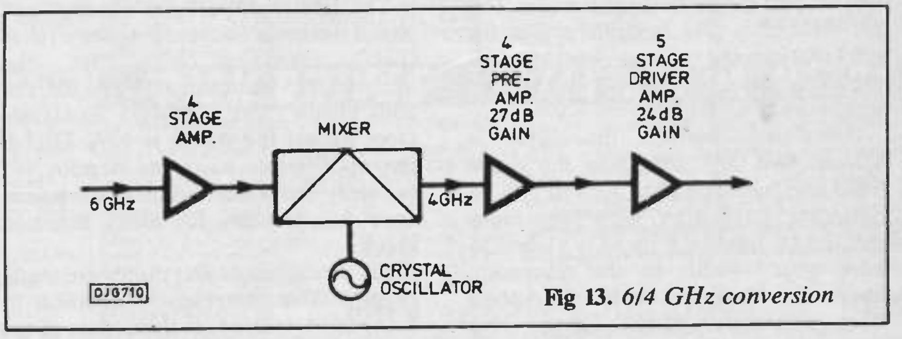


Fig 13. *6/4 GHz conversion*

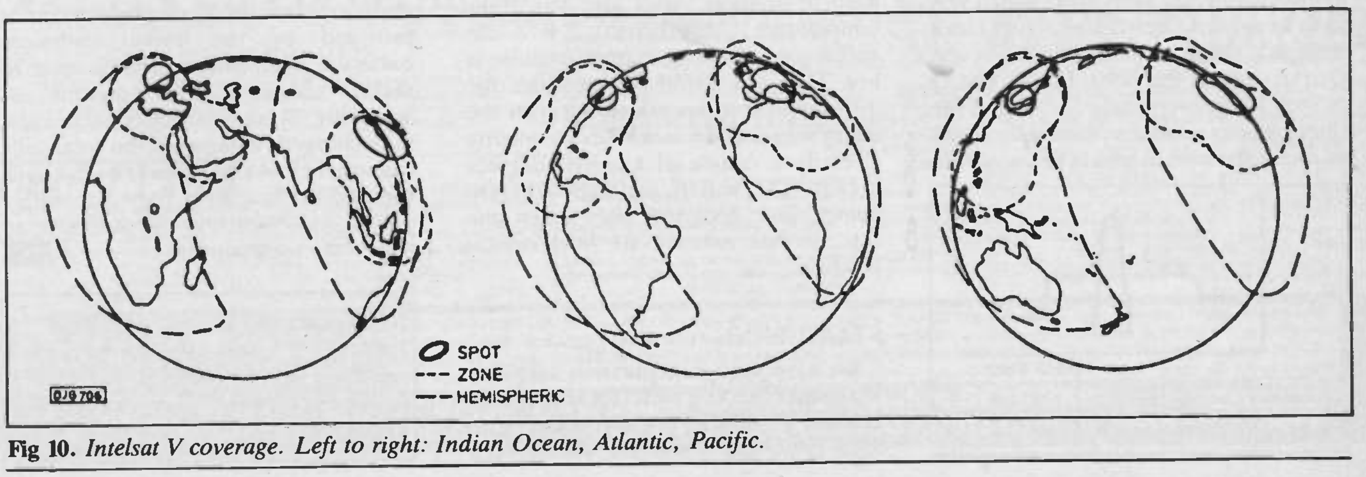
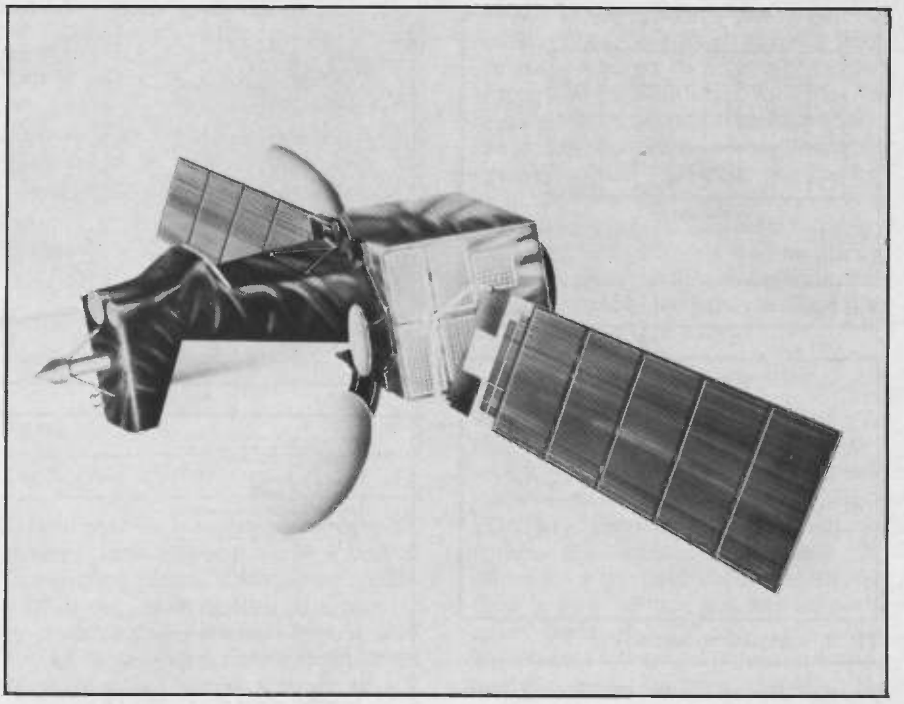


Fig 10. *Intelsat V coverage. Left to right: Indian Ocean, Atlantic, Pacific.*

The transponders on Intelsat V have double the bandwidth of Intelsat IV transponders, ie 72MHz compared to 36MHz. Since signals are received at the satellite at both 14GHz, and 6GHz, these are converted to 4GHz to keep matters simple and assist signal processing.

Each of the spot beams at 14GHz has two receivers (working and a standby). The receiver consists of a germanium tunnel diode coupled into a Schottky-diode mixer, fed by a crystal oscillator, Fig.12. This is followed by a 5-stage preamplifier and 5-stage driver amplifier.

The 6GHz is treated in much the same fashion, Fig.13, with amplification via a 4-stage amplifier employing bipolar silicon transistors. After the mixer, the 4GHz goes through a 4-stage preamplifier and a 5-stage driver amplifier, giving a total gain of 51dB. There is a gain adjustment of 7.5dB which can be switched in or out from earth. So the telemetry commands are not only for altering the position of the satellite and wiggling the aerial dishes but also for switching between transponders and altering the gains slightly. At 11GHz, waveguide switches are used but at 4GHz coax switches are adequate.



Intelsat V. Photo reproduced by kind permission of British Telecommunications plc

RECEIVERS

There are five receivers to cater for the global beam, the east and west hemispheric beams, the east and west zone beams. All these are on the 6/4 GHz path and there are six standby receivers. As in Fig.12 and 13 each receiver is a low noise amplifier, mixer and several stages of amplification. The 6/4 GHz path uses separate aerials for the transmit and receive directions but the same aerial for transmit and receive on the 14/11 GHz path.

After the receiver, the signal is filtered. We have seen how the guard band was cut down from 70% to 10% in designing Intelsat IV. With even more circuits on Intelsat V there is a need to keep guard bands to the minimum. There are 60 filters made of graphite fibre reinforced plastic (gfrp). This material is lighter than invar which was used in earlier filter design. The Q of a filter is a figure of merit, the larger the Q, the sharper the filter, Fig.14. The Q of such filters is typically 10,000 and the filtering is so good that there is no need to divert the odd channels to a separate aerial from the even channels. The latter tactic was employed on Intelsat IV in order to relax the limits on filter design.

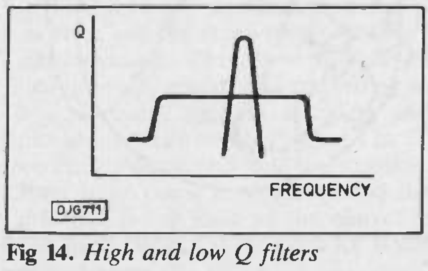


Fig 14. *High and low Q filters*

TRANSMISSION

Having received the signal and processed it as described above, the satellite now prepares to transmit. All 4GHz signals destined for 4GHz paths are at the correct frequency, but those 4GHz signals destined for 11GHz paths are up-converted.

The final amplification for spot and global beams is via travelling wave tubes (twts) providing 8.5W for the hemispheric beams and 4.5W for the zone beams (both at 4GHz). At 11GHz (spot beam) the power is 10W. Global and spot beams have one standby twt for every one in use and the other beams have two standby for every three in service.

The aerial tower and dishes are made of gfrp. This material, in addition to being light, is stronger than other alloys used in aviation. Also, gfrp has a low temperature coefficient, ie the expansion with temperature increase is low. This is a useful feature since the difference in temperature between the sunny side and the dark side of a satellite is easily a couple of hundred degrees celsius. The aerials are folded before launch and deployed only when the satellite has reached its final orbital position.

STABILISING

We have seen how previous satellites were stablilised by an internal spinning. Intelsat V also has a wheel spinning at 3500 rpm, and a standby wheel, each weighing 15kg. The main difference is that Intelsat V is stabilised in all three planes: pitch, roll and yaw, Fig.15.

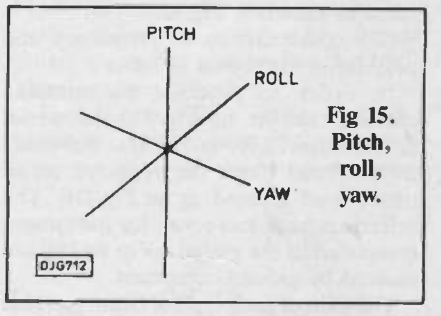


Fig 15. Pitch, roll, yaw.

Electric motors act on the momentum wheel to control the pitch. Gas jets are fired to control roll and yaw. For this purpose 12kg of hydrazine will last seven years. Every couple of months a little hydrazine is broken down into nitrogen, ammonia and hydrogen by passing it through a catalyst. This three-axis stability results in a craft pointing accuracy of ±0.1 degrees.

The 27 transponders on Intelsat V require about 800W of power. This is provided by two nickel cadmium batteries. Each battery is made up of 28 nickel cadmium cells capable of supplying 34 ampere-hours each when fully charged. When new, the solar cells can supply 1.54 kW of power but towards the end of their lives they can supply only 1.16kW which is still sufficient to power the transponders. PE

Next month Mike Sanders looks at Intelsat VI, aerials, and the future of satellites. And don't forget – the winner of the PE satellite TV system will be announced.

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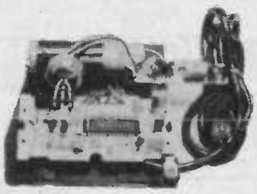

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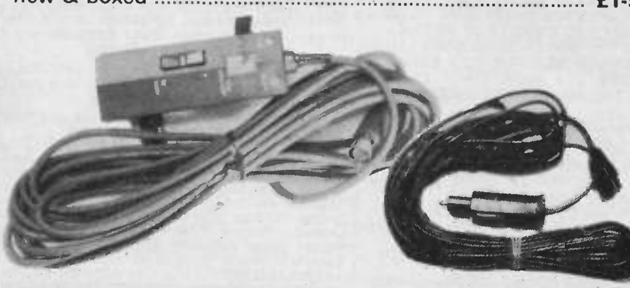

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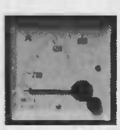
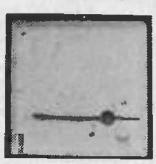

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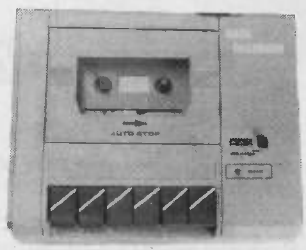

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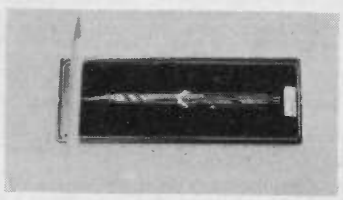

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PART TWO BY JOHN BECKER

SOLVING THE MISTRAL

In part 2 of PE's multiple meteorological metering, all our efforts are in vane, as we get the wind in our sails and convert breezes into binary.

In last month's article six simple circuits were described for monitoring temperature, light levels, rain, soil moisture and wind speed and direction. All are capable of being monitored by a voltmeter via a switch and individual connecting leads.

In part two this month an automatic control circuit will be described that will multiplex the control and reduce the connecting lead count to just three wires.

AUTOMATIC CONTROL

So far we have described the six detectors, and shown that they can be monitored directly by a manually operated switch. I shall now describe the circuitry that will put the monitoring under full automatic control. At the same time the number of connection leads can be cut down from eight to just three. Two of these are the power lines, and one is the data line common to all detectors. A block diagram is shown in Fig.16.

MULTIPLEXING

In order to monitor six remote circuits along a single data line, some form of coding is needed to determine which circuit is being monitored at any particular moment. There are several options from which one could choose. In these days of digital control for practically everything, binary coded data processing techniques are probably the most obvious method. However, I decided instead to explore and exploit a simiple frequency controlled analogue multiplexing method in conjunction with a clocked gate circuit.

Basically, this involves sending a frequency modulated pulse from the control unit down the line to a demodulator. This extracts the pulse which then steps a counter on by one place. Each counter condition is regarded as the address of a particular analogue gate connected to the detector to be monitored. When the gate is open the detector output voltage level passes through the gate, back along the line to the controller, where it can be monitored. Monitoring can be made directly by a voltmeter, or alternatively sent to a computer via an analogue to digital converter.

Inevitably, the circuit has to be a little more complex than this as several other factors have to be allowed for. The principal one is that of synchronising the signals in some way so that we know which detector is being monitored. The second is to ensure that the frequency pulses are not processed and displayed as monitor levels.

PULSE MODULATION

At the control end we first need two oscillators. One generates a high frequency carrier signal, and the other is a low frequency clock that switches the hf on and off the line.

In Fig.17, both oscillators are derived from similar circuits in which the different frequencies are set by the component values selected. The hf oscillator is formed around IC8d and IC8e. The frequency is determined by C13 and the total resistance of R57 and VR7. The latter presets the carrier frequency to match the needs of a demodulator at the detector end.

The clock generator is formed around IC8a and IC8b, with its time constant set by R53 and C12, running at one pulse every two or three seconds. The output is buffered by IC8c, which also serves as a gate that can be manually switched off by S1 to hold the multiplexed gate open to a particular detector for closer examination.

The clock is fed to the decade counter IC9, six outputs of which are coupled to leds. These visually indicate which state the count is at, and thus which detector is being monitored. We shall presently see how synchronisation is achieved.

The clock is also fed via S2 to IC8f which gates the hf frequency on and off, a high clock output inhibiting it. The pulsed hf signal is smoothed slightly by R59 and C14, and then, via R60 and C15, goes out along the data line to the detector unit. There it is passed to a filter consisting of IC1c and its associated components. This filter is set to only respond to the hf clock frequency, from which it extracts the clock pulse. The

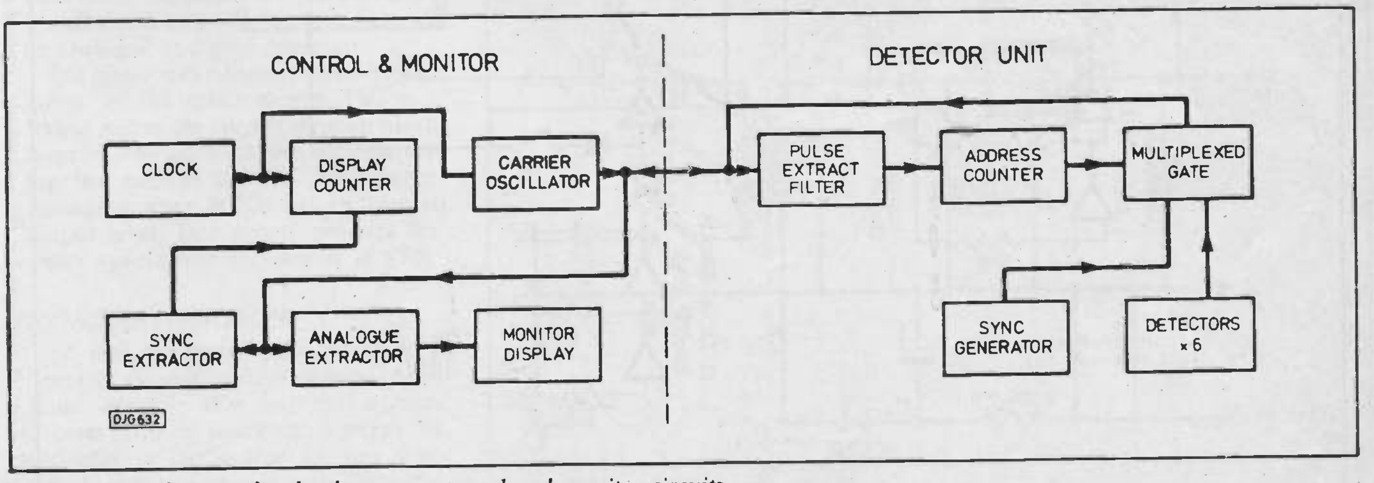

Fig 16. *Block diagram for the detectors, control and monitor circuits*

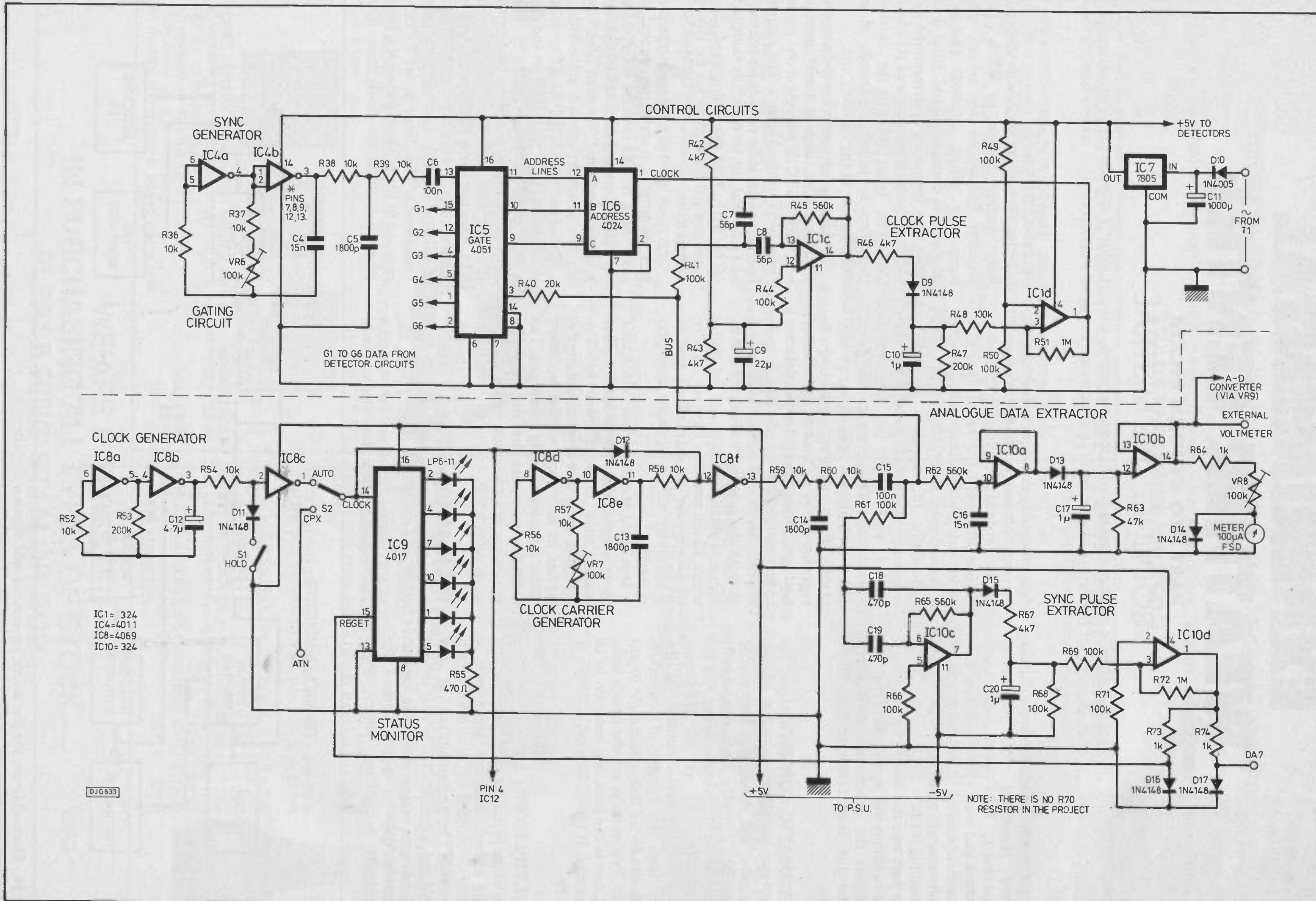

Fig 17. *Circuit diagram for the automatic control and monitor functions of the weather centre.*

band pass range is predetermined by the values of C7 and C8, but the optimum response is controllable by varying the carrier frequency by means of VR7.

The filter output passes via D9 to C10 and the comparator IC1d. Between them D9 and C10 provide an envelope duration control to minimise the risk of the following stage being triggered by short duration interference from other circuit operations. As the charge on C10 rises above the comparator threshold level set by R49 and R50, the comparator trips and its high going output sends a clock pulse to the address counter IC6.

MULTIPLEXED GATE

IC6 is a binary ripple counter the first three outputs of which provide the code that controls the multiplexed gate IC5. This has eight inputs and one output. Each input can be switched individually through to the output in response to a particular binary address code. One input is not used and so is grounded. Six of the others are connected respectively to the outputs of the detector circuits, G1 to G6. The address counter thus selects which detector is to be put on line.

Since IC5 is an analogue gate, the voltage level from the selected detector passes through the gate output to the data line via R40. This resistor prevents IC5 from being adversely affected by the clocked hf pulse. Although R40 is connected to IC1c, the filter will not be affected by the detector voltage levels.

ANALOGUE EXTRACTOR

Once the clocked hf pulse has ceased, the detected dc level passes back along the data line to the analogue data extractor around IC10a and IC10b. The extractor has been oblivious to the hf pulse due to the simple hf filter consisting of R62 and C16. The dc data voltage though, goes through the buffer IC10a, to charge up C17 via D13. The latter two also help to filter out any residual hf signal interference; IC10b buffers the stored dc voltage and makes it available for monitoring by a meter or an analogue to digital converter.

The meter may be any external dc voltmeter, or the meter shown. This is a $100\mu A$ meter, the current through which is set by R64 and VR8, the latter adjusting the current for full scale meter deflection when IC10b has its highest output level. D14 simply protects the meter against incorrect setting of VR8.

SYNCHRONISATION

So that we know which detector is being monitored, synchronisation of the status counter IC9 and the address counter IC6 is required. Another hf oscillator is the source for this sync signal, and its output is gated onto the data line every eighth clock pulse.

The oscillator is formed around IC4a and IC4b, with a frequency set by C4 and tunable by VR6. The output frequency is outside the pass band of the filter IC1c, and so is ignored by it. Similarly, the filtering around IC10a and IC10b eliminates it from the analogue data monitor circuits.

Instead, it passes to a sync pulse extractor filter around IC10c and IC10d. Needless to say perhaps, this filter is tuned to ignore the hf clock pulses. Its pass band is set to allow the sync pulse frequency through D15 to charge up C20, and on to the comparator IC10d. Once the sync pulse has been recognised, IC10d triggers upwards, sending a reset pulse to the status counter IC9 via R73. The pulse is also available for sending back to a monitoring computer via R74. Since the psu on this part of the circuitry has both positive and negative lines, the negative going content of the pulse is removed by D16 and D17.

As IC9 is automatically reset on each cycle, the leds LP6 to LP11 indicate which detector is currently being monitored and displayed on the meter. The sampling rate is slow enough for easy observation of the levels and the leds. S1 allows the cycle to be halted for closer examination of a particular function detector output.

POWER SUPPLY

Although the detector circuits can quite readily be run from a battery, it is more convenient to have the whole system operated from a mains power supply. There are three requirements here; a split level of ±5V to power the monitor circuits, and at least +5V for the detectors. The latter could run from a higher psu level, but circuit control is made easier by keeping the detector and monitor positive supplies at similar levels.

The length of the cable going from the control unit to the detector unit out in the garden somewhere requires that stabilisation of the detector supply should be at the detector end. Fairly high currents are drawn by the detector, largely because of the consumption by the leds. A long length of cable will of course introduce a significant resistance factor into it. With the currents drawn this resistance could cause fluctuations in the supply level at the end of the cable. Consequently, the detector has been given its own rectification and stabilisation circuit.

In Fig.18, transformer T1 is common to both detector and monitor units. The second and third wires of the three core cable going out to the garden carry the ground line, and the raw 9V ac from T1. In Fig.17, D10 and C11 rectify and smooth the power, then IC7 regulates it down to +5V. Back at the control end, +5V is produced via IC11 and the associated components, and −5V is rectified and regulated by D19 and D20. Basically only IC10 needs the −5V level, and as it draws very little current, full stabilisation by a separate regulator is not necessary.

PRINTED CIRCUIT BOARDS

There are two pcb designs, Figs. 19 and 20, which as well as containing the main detector and control circuits respectively, have additional sections on them that are removed and used separately. On the detector pcb in Fig.19, the rain probe tracking should be removed, and this will be mounted outside the box. The control pcb in Fig.20 in part three additionally holds the little sub-assembly boards for status, wind speed and direction leds. These too should be removed, and trimmed accordingly.

If the detectors are to be used with a manually switched meter, IC4 to IC7 and their associated components should be omitted, as should the components associated with IC1c and IC1d. Connections to the meter switch are then made at points G1 to G6 marked on the pcb layout diagram, omitting the link wires shown at those points. The battery con-

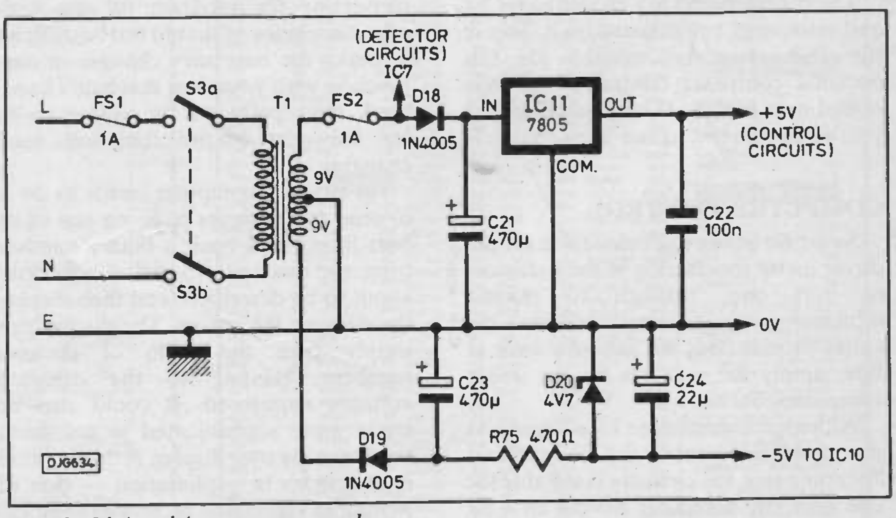

Fig 18. *Mains driven power supply*

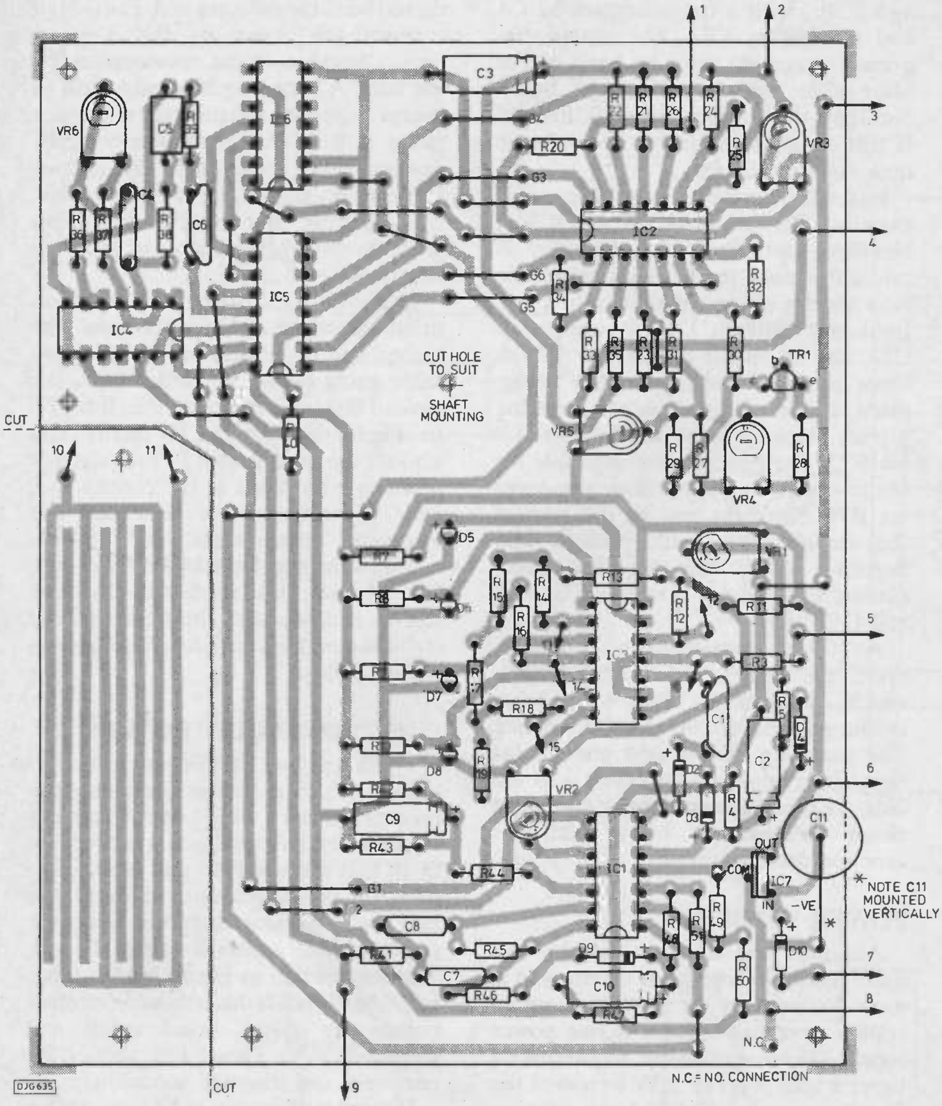

Fig 19. *Detector printed circuit board*

WEATHER — DETECTORS

RESISTORS

R1,R29	1k (2 off)
R2,R3,R5, R7–R11,R22, R24–R26, R30–R35	100k (18 off)
R4,R13,R15,R17, R20,R28	10k (6 off)
R6	270
R12,R14,R16, R18,R19	10k (5 off)
R21,R23	4k7 (2 off)
R27	47k

All resistors ¼W 5% carbon film

CAPACITORS

C1	100n polyester
C2,C3	22µ 16V electrolytic (2 off)

POTENTIOMETERS

VR1,VR2	100k skeleton (2 off)
VR3	25k skeleton
VR4	10k skeleton
VR5	500 skeleton

SEMICONDUCTORS

D1,D5–D8	IR-detectors (5 off)
D2–D4	1N4148 (3 off)
TR1	BC549
IC1,IC2	324 (2 off)
IC3	4069
LDR1	ORP12
LP1–LP5	Red led

MISCELLANEOUS

14-pin ic socket (3 off), pcb 275A.

CONSTRUCTOR'S NOTE

Kits of electronic components and the printed circuit boards are available from Phonosonics (see advert).

nections are made with +V at arrow 6 and 0V (battery negative) at arrow 8. The three sub-assembly sections on the control board will need to be made separately, either as shown, or on Veroboard.

The control pcb in Fig.20 also has IC12 and associated components on it. This is the D-A converter needed for the optional computer control to be described next month. It may be omitted if you do not intend to use a computer.

COMPUTER CONTROL

So far we have progressed from simple direct meter monitoring of the detectors in part one, through to remote monitoring via automatic control circuitry in part two. We can now look at how simply the unit can be put under computer control.

Although the example I shall give was destined for control by the Commodore Pet computer, the circuitry is suitable for use with any computer having an 8-bit control port, such as a Centronics, IEEE488 or User port. The progam listing is directly usable with the Pet, and additional information is given for modifying it for use with the Commodore C64 or the BBC-B. While neither PE nor I can offer information on converting the program for use with other machines, it should not be difficult to make the necessary changes in conjunction with your own machine's handbook. Principally, it is the address codes for the port control that will need changing.

All that the computer needs to do is to send out a trigger pulse on one of its port lines, read back a binary number from the analogue to digital converter about to be described, and then display the data on the screen. The display can simply take the form of decimal numbers, relating to the detected voltages monitored. It could also be made more sophisticated in a fashion similar to my own display. A third option is also open to exploitation — that of writing in correction factors to compensate for non-linearity in the detectors. Performing such corrections in software is much cheaper than using precision designed circuits; a point that Robert Penfold makes in his Real World Interfacing articles in February and March this year.

First, we switch out the clock generator IC8a-c, in Fig.17 last month, and connect IC9 and the hf gate to one computer line. S2 does this, and I chose to use the ATN line of the computer to send the trigger pulse at regular intervals. The multiplexed control for the detectors does not care where the control signal originates, so the trigger and data return routines still continue as before.

FRONTAL SYSTEM

Part three next month will continue the computer control description and illustrate how the detector and control units are housed. Derek, our artist has also done some nice drawings of the final mechanical details, and the gantry on which the detectors are mounted. Till then, keep warm and dry. PE

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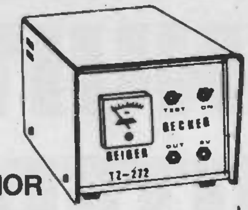

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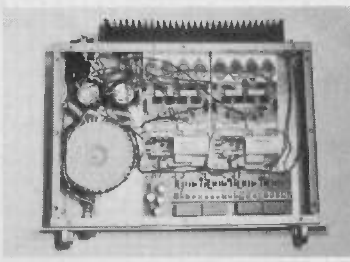

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4012	13p	4501	30p
4013	19p	4502	38p
4014	35p	4503	32p
4015	34p	4504	55p
4016	18p	4505	200p
4017	31p	4506	60p
4018	33p	4507	33p
4019	28p	4508	70p
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4022	38p	4512	42p
4023	13p	4513	80p
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74LS15	15p	74LS83	43p	74LS266	28p
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		74LS126	38p	74LS641	110p
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6503	570p	8243	250p
6520	170p	8250	850p
6522	330p	8087	1100p
6530	1050p	8251	300p
6532	460p	8253	320p
6545	880p	8255	310p
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6800	210p	8257	350p
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6808	500p	8272	1200p
6809	600p	8279	450p
		8282	300p
		8283	400p
		8284	440p
		8287	360p
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		Z80ACTC	250p
		Z80BCTC	480p
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		Z80ASIO-2	700p
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		75122	125p
		75150	110p
		75154	110p
		75158	140p

75159	200p	7815	35p
75160	400p	7818	35p
75161	400p	7824	35p
75162	700p	7905	35p
75172	720p	7912	40p
75182	100p	7915	40p
75183	100p	7918	40p
75188	80p	7924	40p
75189	80p	78L05	28p
75195	185p	78L12	28p
75322	130p	78L15	28p
75324	340p	78L18	28p
75325	155p	78L24	28p
75365	145p	79L05	40p
75450	45p	79L12	45p
75451	42p	79L15	48p
75452	42p	7818KC	100p
75453	65p	7824KC	100p
75454	65p	LM309K	100p
75480	135p	LM317K	220p
75491	80p	LM317T	180p
75492	80p	LM323K	420p
8T26	95p	LM723	40p
8T28	110p	78HGKC	570p
8T31	330p	78H05KC	800p
8T95	90p	78H12KC	700p
8T96	110p	78GUIC	190p
8T97	90p	79GUIC	215p
8T98	110p	79HGKC	800p

VOLTAGE REGULATORS

7805	35p
7812	35p

ZENERS

400MV	
BZY88 RANGE	
2v7 to 39V	6p
1.3W	
BZX61 RANGE	
2v7 to 39V	12p

LED

LED 3mm RED	5p
LED 3mm YEL	10p
LED 3mm GRN	10p
LED 5mm RED	5p
LED 5mm YEL	10p
LED 5mm GRN	10p

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"INGENUITY UNLIMITED"

A selection of novel ideas
BY ENTHUSIASTIC READERS

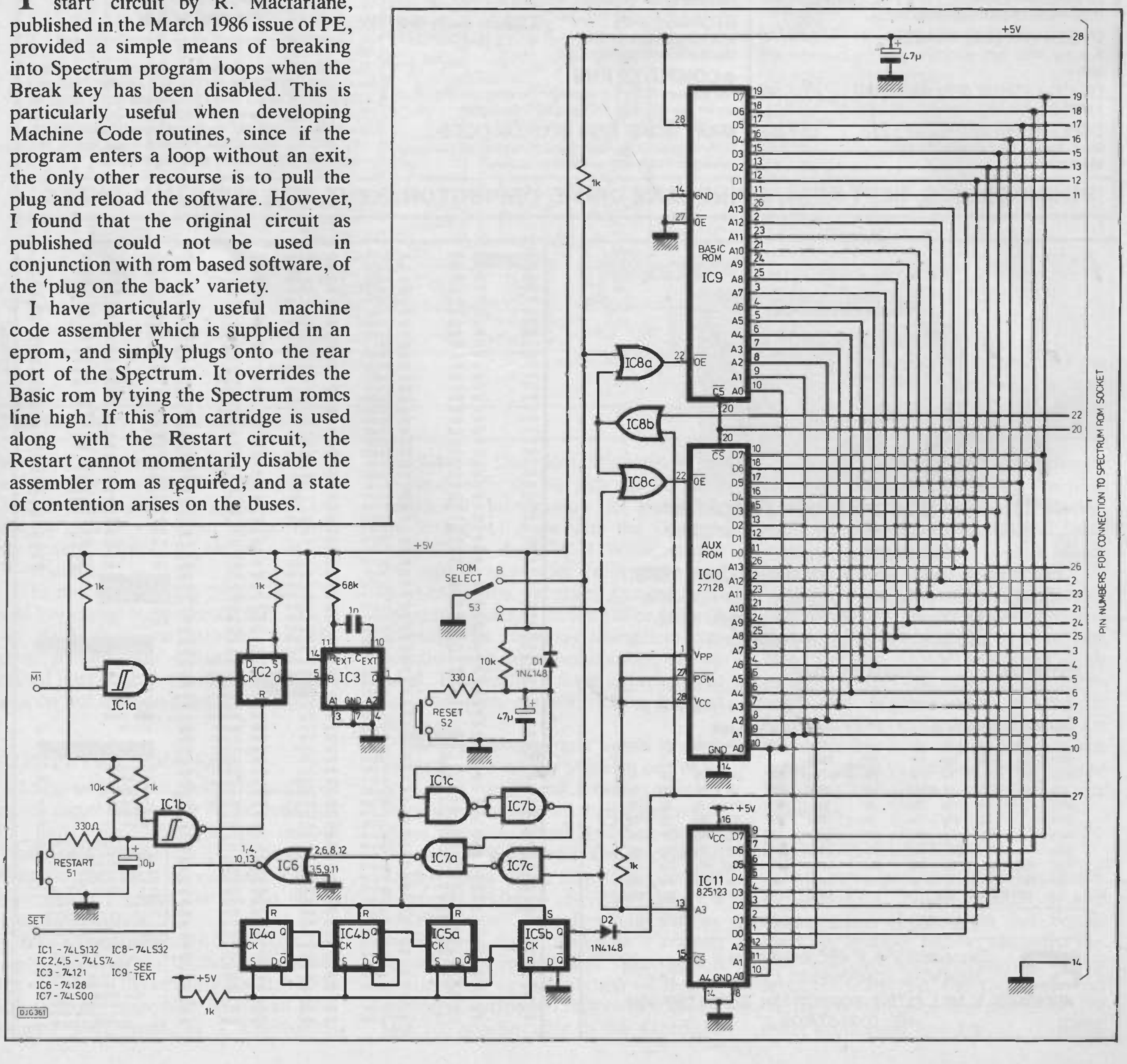
Spectrum Hardware Restart/ ROM Select

THE original Spectrum 'Hardware Restart' circuit by R. Macfarlane, published in the March 1986 issue of PE, provided a simple means of breaking into Spectrum program loops when the Break key has been disabled. This is particularly useful when developing Machine Code routines, since if the program enters a loop without an exit, the only other recourse is to pull the plug and reload the software. However, I found that the original circuit as published could not be used in conjunction with rom based software, of the 'plug on the back' variety.

I have particularly useful machine code assembler which is supplied in an eprom, and simply plugs onto the rear port of the Spectrum. It overrides the Basic rom by tying the Spectrum romcs line high. If this rom cartridge is used along with the Restart circuit, the Restart cannot momentarily disable the assembler rom as required, and a state of contention arises on the buses.

This modified version of the original design overcomes this problem, and offers other advantages. This circuit takes the Basic rom and any other auxiliary roms such as an assembler, and incorporates them into the Restart circuit, whilst providing a panel mounted switch to select the operating system required. Looking at the circuit diagram, and comparing it to the original, the Restart timing part is essentially unchanged – a few gate alterations were made to incorporate the new features, and to reduce the package count. The main new feature is the inclusion of IC9 and IC10 on the board. IC9 is the Basic rom itself, as supplied with every Sinclair Spectrum. In most machines, this appears to be in a socket anyway, but if soldered in, a little desolder wick will ease removal without damaging the delicate pcb tracks (*though it will probably negate any guarantee. Ed*).

IC10 is a 16k byte rom containing the alternative software, the assembler for instance, taken from the plug-on module. IC11 is the original Restart prom, as described in the article. The idea is that all the circuitry shown is on



a new circuit board mounted above the main Spectrum board using pillars. Obviously, this will not fit into the original Sinclair casing, but then most serious Spectrum users seem to have rehoused their machines in larger 'real keyboard' cases anyway! The numbered connections to the right of the circuit correspond to the pin numbers of the Basic rom socket in the Spectrum itself. If a ribbon cable, terminated in a 28 pin dil header plugged into the Spectrum rom socket, is used to form these interconnections, only two other wires need to be used to complete wiring up, these being M1 and reset, made directly to the Spectrum's Z80 or alternatively to the edge connector. Of course a rear mounting edge connector arrangement could be used for all of the bus connections, as in the original article, but using the dil header proves to be very neat and reliable.

Switch S3 acts as a selector for the rom software. To select a rom, its appropriate output enable pin, pin 22, must be driven active low. This occurs when the Spectrum makes pin 22 (RD strobe) and pin 27 (romcs) of its rom socket both active low, checked via IC8b, and when S3 transfers this signal via IC8a or IC8c to one of the roms, whilst disabling the other. Address line A3 of the Restart prom is derived also from S3, and this allows the Restart addresses in IC11 to be individually selected for each rom, similar to switch bank S3 in the original design

Extra logic, in the form of IC7, provides a further feature. If S3 is a break-before-make switch, the output of IC7c flicks low momentarily each time the switch is altered, since its inputs both go high during the transition. This, via IC7a and IC6, produces a system reset pulse, to ensure that when the selected rom is changed, the newly enabled software starts executing at its reset vector. Note also that D1 has been added to ensure the reliability of an automatic reset at power-up, even if the supply is only momentarily interrupted.

Finally, if desired, the circuit can be simply expanded to cater for as many extra roms as needed, by expanding S3 and providing more versions of IC8c, and adding more inputs to IC7c.

G. Durant, Cambridge.

Stereo grannyphone interface

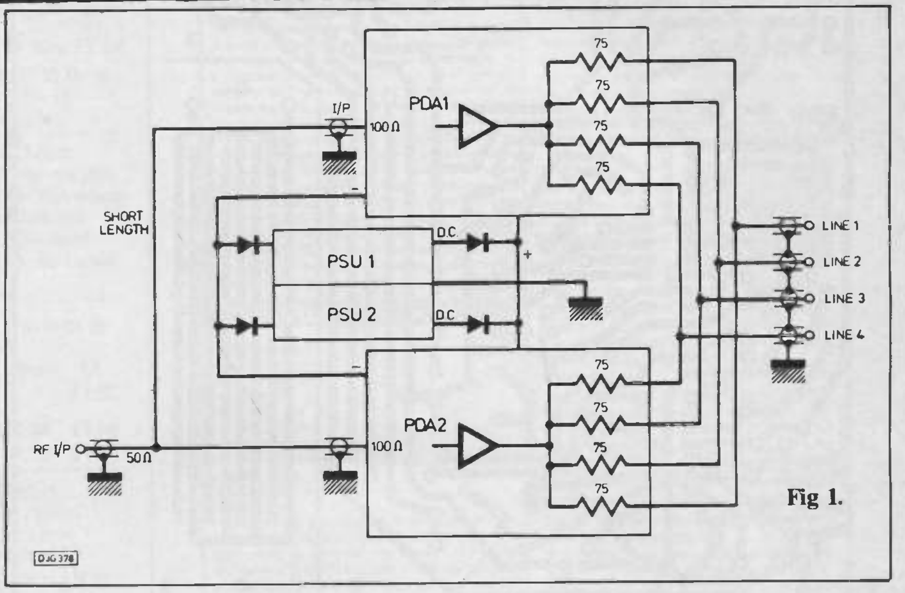


Fig 1.

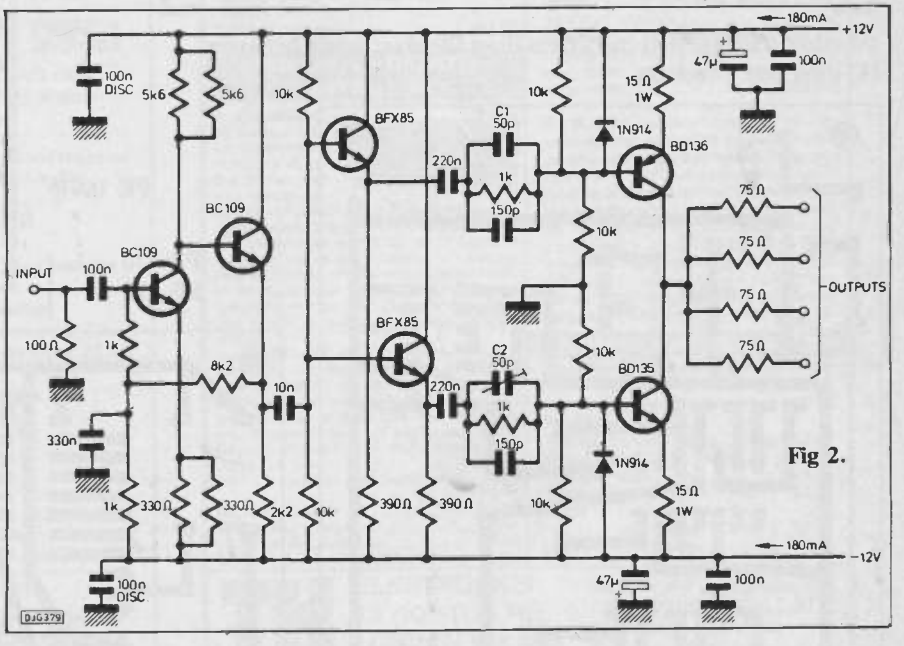


Fig 2.

High Reliability Pulse Feeder

The author was recently asked to produce a distribution system which had to distribute four feeds of 2 MHz rf carrier over long 75Ω coaxial lines. The signals were 8V P-P with fast rise and fall edges of 50ns. A feature of the system was that it had to be highly reliable.

It was decided that the distribution amps would operate in parallel for increased reliability, and that two wired-OR power supplies should be used. Both these features would enable "no break" maintenance checks to be undertaken.

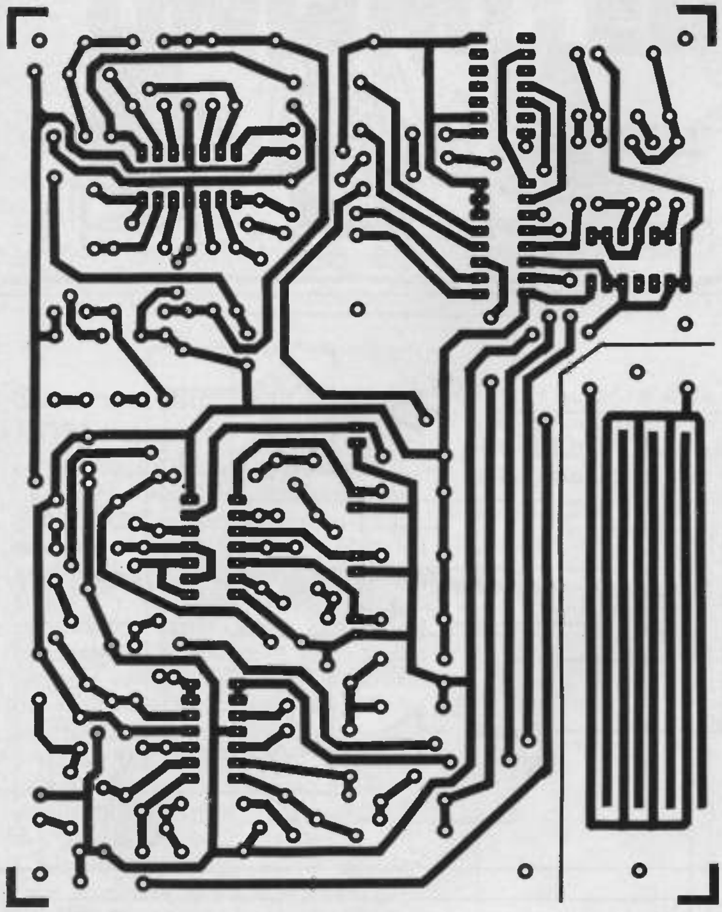
If one of the coax lines were to become faulty, i.e. short or open circuit, this situation must not affect the remaining feeds.

An output port to port isolation of 20 db was required and the amplifier had to be easy to construct and use only easily available devices.

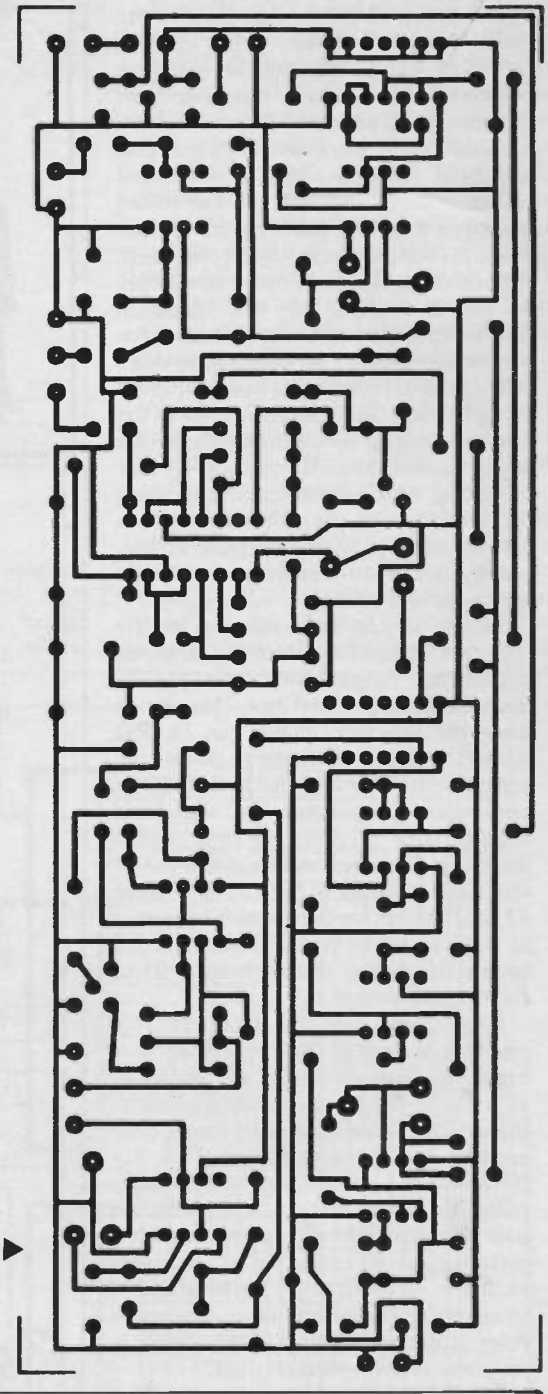
Fig 1 shows the general arrangement, and Fig 2 shows the circuit of the distribution amplifier.

A.B. Bradshaw, Sandy.

PCB TRACK PATTERNS

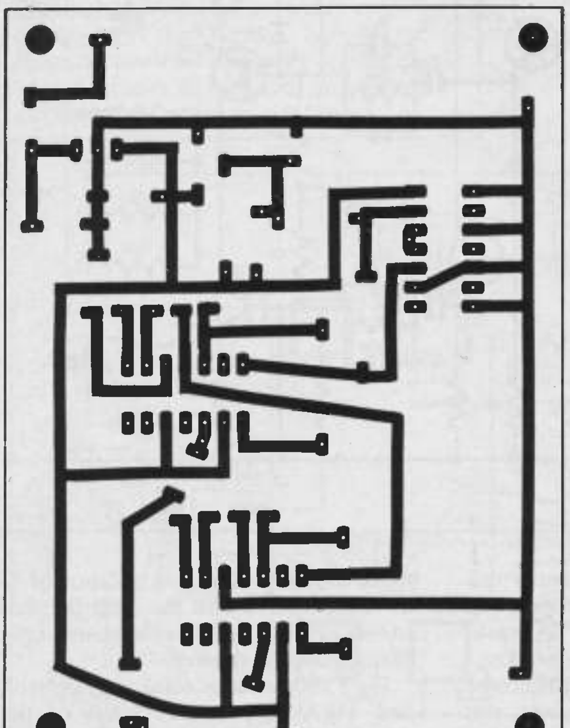


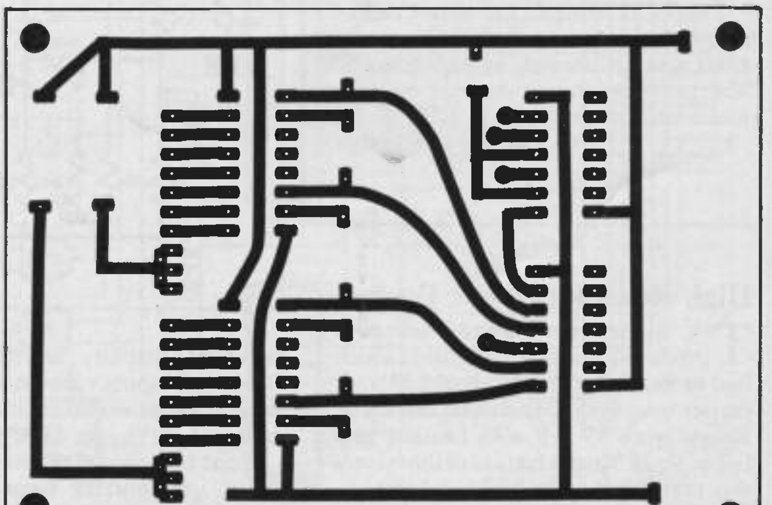
Weather Centre: detectors (less than life size: space between IC pins is 0.1 inches).



PE 169 ▶

PE 170
PE 171





BIO-CHROMATIC ELECTRONICS

BY ZOLA McMALCOLM

BIOLOGICALLY BASED OPTO ELECTRONICS BROADENS INTELLIGENT COMPUTING HORIZONS

The ability of some photo-sensitive plant substances to undergo a chemical colour change on exposure to high-intensity sunlight is providing clues which may lead eventually to genuinely organic, self-replicating data storage matrices.

SPEED, density and reliability are among the keywords paramount in laboratories researching into new and better ways of manufacturing semiconductors. With each new generation of silicon based device, the requirements of industry, commerce and the military, far from being satisfied, are tantalised by the prospect of taking technology yet another step forward.

Thus, since the introduction of the humble transistor, increasingly sophisticated semiconductors have been regularly appearing, including the recently introduced and revolutionary transputers.

Each generation of device has come into existence through the unstinting efforts of research scientists, pressure from prospective end users, and the incentives of reaping large financial rewards. Indeed the field of electronics is an exemplary illustration of the old saying that Necessity is the Mother of Invention.

Some of the inventions are more precisely logical extensions of existing technology. Others have required the use of new materials, expensively and painstakingly researched. Additionally the achievements of other technologies and diciplines have also had their impact upon the ability to manufacture faster and smaller semiconductors.

DISCIPLINARY INTEGRATION

One notable example of interdisciplinary application is the availability of higher definition photographic emulsions suitable for circuit imaging. As many photographers will be aware, the structure of photosensitive emulsions can lead to 'graininess', through clumping of the chemical compounds. The human eye usually ignores the coarse appearance of a photographic image, but in electronics grain size and image sharpness become significant when components and signal paths are printed photographically, and even graded grains may be too coarse.

Chemistry has played an important part in the increased sophistication of photographic emulsions and in the production of new semiconductor materials. Allied disciplines have enabled advances in crystalography and diffusion techniques to be applied to the growth of precision semiconductor structures. Through these techniques, complex integrated systems have become commonplace, with capabilities, speeds and reliabilities that were only dreamed of a few years ago.

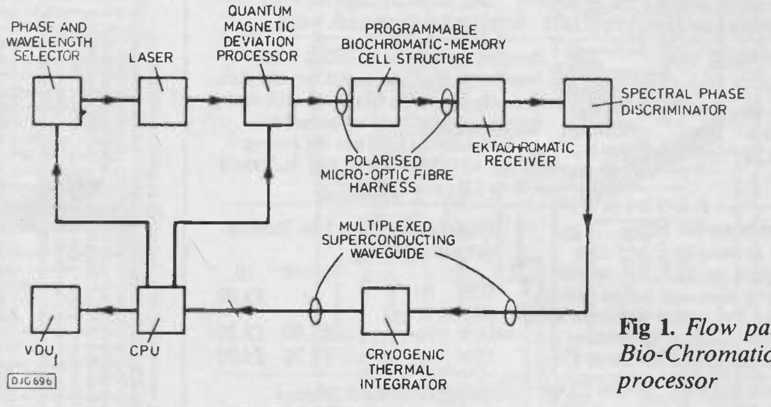


Fig 1. *Flow path for Bio-Chromatic data processor*

Much to the benefit of electronic miniaturisation, another technology has also been put to good use – lasers. About the same time that integrated circuits were being introduced, lasers were in the process of becoming fact rather than science fiction. Strangely, at the time they appeared to be a product without a purpose. I recall that either *New Scientist* or *Science Journal*, or probably both, speculated heavily about the functions to which these remarkable devices could be put. Now, over two decades on, we are probably complacent about their benefits to society at large, from use in medicine, entertainment, industry, defense, data storage, communications, as well as electronic component manufacture. In the latter application, the precision imaging techniques are capable of literally cutting components and signal paths into specially prepared mineral compounds of materials like silicon, germanium, gallium, arsenic and so on.

INFANT TECHNOLOGY

Although not widely publicised in the popular press, a new technology is now in the early stages of making its impact felt on the electronic manufacturing scene. It is very much in its infancy, and there is much yet to be researched and achieved. While premature speculation should be regarded with caution, the techniques being developed may lead to achieving truly intelligent computers by methods radically different from those being examined in other spheres.

Several well established disciplines have been brought together for the research project in which I am currently involved at an investigative science laboratory in Kent. While the laboratory's primary interest is in electron theory applications, the fields of solar reactive chemistry, regenerative microbiology, and epi-polycryptic communication systems are heavily featured on the research curriculum.

SOLAR REACTIVE CHEMISTRY

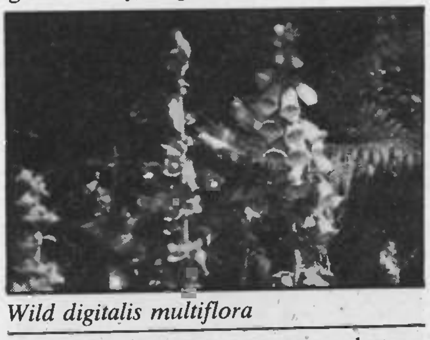
Solar reactive chemistry was probably first studied in depth during the early nineteenth century in experiments that ultimately led to the invention of photography. Although it was eventually found that silver-iodide was the substance that showed the best chromatic change in response to exposure to light, numerous other substances, such as albumen and starch were also given close attention. Both substances were readily available in the form of eggs and potatoes. The latter's reaction to light will be well known to anyone who has forgotten to keep peeled potatoes covered. Many other biological examples are readily observable around us, including the reaction of foliage to light, resulting in pigmentation changes through production of substances like chlorophyl.

My own interest in photochemical reactions started after a lengthy sunbathing session when I painfully observed that even human tissue can be changed in hue by exposure to sunlight. It was also noted that areas are selectively affected, depending on the exposure duration and intensity.

Following this simple observation, and repeating the researches of the nineteenth century, I began examining the reaction of other substances, in particular the way that various plant structures behaved differently to light stimulii. Further research showed that different light wavelengths created different chromatic changes. Though many were permanent, some changes could be reversed by exposure to the inverse end of the colour spectrum. It was also of interest that, to a certain extent, the areas affected could be moderately well controlled by rudimentary focusing of the light source.

LASER CONTROL

With the advent of lasers, it was found that the precision focusing and opto-frequency control techniques were capable of initiating chromatic changes to individual cells, leaving surrounding cells unaffected. Using different biological sources as the experimental specimens, it was found that some were faster to react than others. One species of plant was particularly rapid in response, showing a reversible reaction time of only a few milliseconds. This was one of the hybrid varieties of the fox-glove family, Digitalis-Multiflora.



Wild digitalis multiflora

It then became apparent that a biological substance had been synthesised that, in conjunction with the precision of laser technology, could be reversibly used as a programmable data store. The logic state would be determined by the colour of the cell, and could readily be assessed using miniature chromatic sensitive opto-detectors. Although photographic emulsions can store optically coded data, the process is basically non-reversible and incapable of reprogramming. Within this plant though, there appeared to be a highly reactive bio-chromatic substance that could be rapidly reprogrammed. It was however, subject to data loss as the plant decayed.

BREAKTHROUGH

A breakthrough came when discussing the problem with a colleague at the laboratory who was involved in micropropagation techniques for horticultural applications. I explained the reluctance of the samples to stay unwilted for more than a few days and asked if there was a method of preserving Digitalis, in the same way that some other flower species can be dried and preserved. He suggested that there might be, by crossing Digitalis-Multiflora with Surillious Preposterosa, a Moroccan desert plant well suited to longevity in arid conditions.

Cultivated surillious preposterosa

Specimens of this plant were acquired and crossed with Digitalis. Ultimately the seeds were collected and sown. The resulting hybrids were then analysed for their ability to respond to laser beam programming.

The results surpassed expectations, with not only the permanence of the recorded data being considerably extended before natural decay set in, but also a ten-fold increase in the recording response rate was experienced, subsequent chemical and spectral analysis of this hybrid showed arsenic hydroxide and minute traces of lithium Stearate coming from Digitalis, and silicon dioxide from Surillious. It appeared to be the combination of these that was responsible for the reaction rate.

FORTNIGHT AT F8

Over the next several months, eight successive 'F' generations of the hybrid were produced in accordance with accepted horticultural practice, selecting the best from each generation and using them as the parents for the next. To speed growth and stabilise a 100% arsenic-silicon alignment (ASA 100) within each generation, bi-diurnal

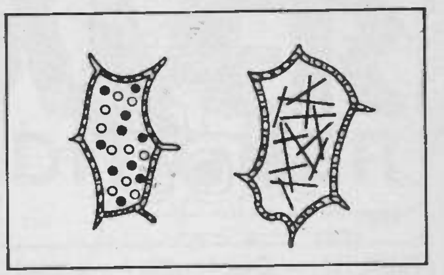


Fig 2. *Cellular chromoplasts. (Left) from Digitalis. (Right) from Surillious.*

microwave progagation techniques at the nano-angstrom level were rigidily enforced. The ASA 100 exposure factor was determined computationally and for each generation up to F8 it was found to be around a fortnight.

Using the F8 hybrid we took advantage of the rapidly developing technology of micro-biological propagation, in which selected plant cells are cloned. This involves the plant with the best chosen characteristics having cells removed from a growth nodule, and growing them in a precisely forumulated culture medium. Since the clones obtain their entire nutrient from this medium, it has to consist of a standard growth hormone plus the base elements found in the natural plant, in this case lithium (Li), arsenic (As), and silicon (Si). Earlier tests had shown that slight impurities of chrome and nickel (Cr and Ni) could enhance the colour monotonacity and durability of the opto-cellular response. Using an inert heavy duty polycellular hydro-carbonic (H$_2$0-C$_3$) gel base, the nutrients and required proportions of each element were added, and the cells implanted. The culture plates were then put into a centrifuge rotating at 5G.

BINARY EXPANSION

Normally cloned poly-cells will grow according to the genetic codes inherent in the original plant. This usually results in the total replication of the original. However, using an artificial gravity of 5G, the cellular multiplication direction is inhibited. Consequently, the growth develops as a geometricically precise disc. Growth was permitted until the horizontal cell count was 2^{32}. Due to the 5G factor, the growth stopped vertically at the 128th cell. Somewhat to our surprise, it was then found that the

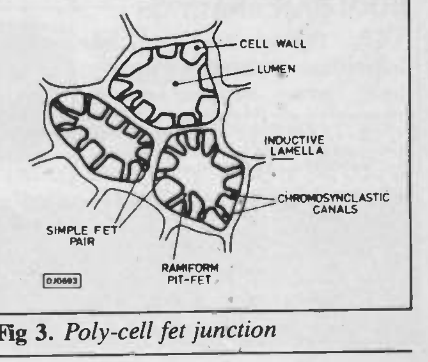


Fig 3. *Poly-cell fet junction*

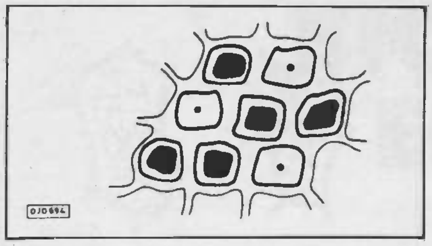


Fig 4. *Typical 8-bit binary chromoplast structure. Darkened areas are at Logic 1.*

dendrites of the outer cells were several microns thicker than the inner ones and all had a high proportion of nickel in them. However, this was an advantage since the rigidity of the growth was such that it was capable of being supported in a normal optical frame using polarised stress sensors to maintain uniformity.

DOUBLE DENSITY PLOTTING

Subjecting this bio-structure to pulsed laser beams, the expected reversible colour changes were found to occur as in the original experiments, though at a greatly enhanced reaction rate. It was noticed, though, that some cells did not respond as predicted; either they failed to react at all, or they had a density twice that of the majority. In case this was due to slight inaccuracies in the supporting frame and its sensors, the sample was repositioned, and the sensors checked and reset. A similar unevenness was experienced. After several attempts at repositioning and resetting, it became obvious that there was a correlation between the cells affected, and the polarity of the sensors.

It became obvious that the chromaticity of the opto-reaction was being affected by induced currents generated in the nickel based dentrites by the stress sensors, in a piezo-electric fashion. This was being modified further by the presence of the silicon compounds in the cell structure. The effect was that those cells of a neutral electrical polarity responded normally, those having a negative potential across them failed to respond, while those of positive potential responded by doubling their density change. In other words, the cellular structure had a tri-state mode of operation and possessed the characteristics of a sophisticated semiconductor.

BOOLEAN ANALYSIS

The logical next step was taken. Individual connections were made to a small group of cells so that a tri-

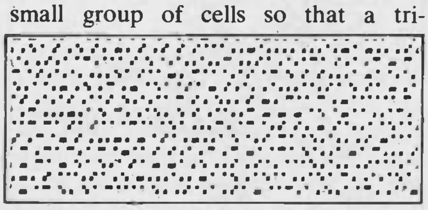


Fig 5. *Typical cross-section of programmed poly-layer structure.*

dimensional matrix was produced. These were connected to three buffered 32-bit RS332 computer ports, and Boolean logic levels systematically applied in conjunction with synchronously clocked laser pulses. Cell density data was collected via ektachromatic transducers and the results conformed to the predicted truth tables.

The implications were profound. We had produced a bio-electronic tri-state laser programmable data store. Digitalis Multiflora had been hybridised to become Digitalis Electronicus!

have the opportunity to benefit further from exploitation of this natural phenomonon. However, as this research saga shows, it is only through the ready interchange of technological knowledge between disciplines, irrespective of their disparity, that material advances beneficial to society in general can be achieved. The success of our collaborative investigations is a classic example of the application of knowledge from two such disciplines. Electro-horticulture may well prove to be the most significant growth product of this

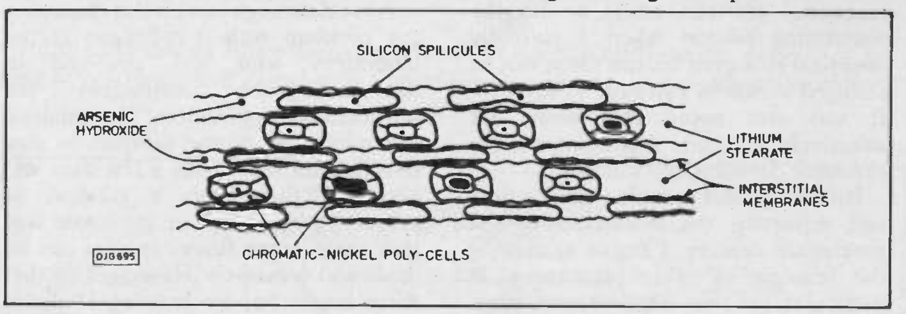


Fig 6. *Enlarged cross-section of multiplexed epidermic structure*

ULTRA HIGH SPEED

A further surprise was yet to be revealed. When checking the complete clone growths for data conversion time, it was found that an additional gating factor existed, and depended on the respective laser wavelength phases. This resulted in data transfer rates as fast as 0.5 femto-seconds. A major advance in the search for even faster data processing devices had thus additionally been achieved. The importance of high speed processing is that it is one of the vital parameters required for the ultimate production of intelligent computers. Consequently, it is believed that our researches and achievements represent a significant step towards man-made systems that will one day match, and probably surpass the abilities of the human brain.

The problem of eventual data decay has not yet been fully overcome, but the current generation of devices has extended refresh cycle times of around 17 weeks at 20°C and 33% humidity. since the data refresh routine only requires the addition of two drops of any standard hydroponic culture solution per device, and can readily be put under capillary irrigation control, this rate is insignificant under normal operating conditions. It should also be noted that, as with eprom devices, exposure to uv light has to be avoided. As part of the continuing research program we are also investigating the possibility of cloning fully pre-programmed devices for mass production in large scale culture trays.

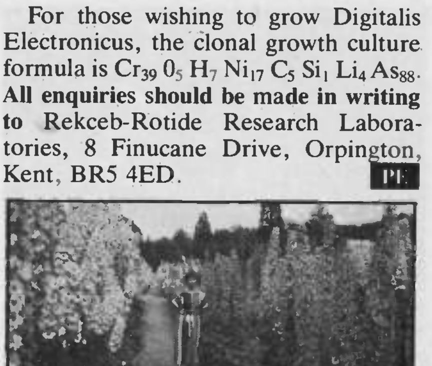
COOPERATIVE SOCIETY

The effects of vegetative chromaticism have been observable for countless generations, and they are essential to universal ecological stability. We now

century, profoundly enhancing the socio-economic benefits of applied technology. It has only come about though, through interdisciplinary co-operation.

While it is unwise to definitively predict the outcome of full commercial distribution of Digitalis Electronicus based devices, one possible side effect is that home computers may well eventually be retailed by garden centres as well as high street electrical stores. With further research and innovation it also may be practical for sophisticated systems to be grown in back gardens. Should such advances be made perhaps one day the Chelsea Flower show and the All Electronics Exhibition may become a combined event. Undoubtably relevant magazines would also undergo significant changes, possibly combining their resources, resulting in such titles as *Practical Gardening Electronics: the horti-science magazine for serious floral electronics and vegetative computing enthusiasts.*

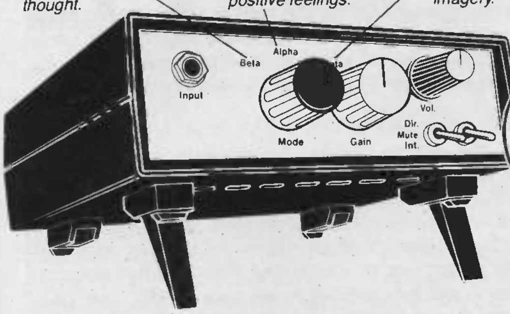
For those wishing to grow Digitalis Electronicus, the clonal growth culture formula is $Cr_{39}\,0_5\,H_7\,Ni_{17}\,C_5\,Si_1\,Li_4\,As_{88}$. **All enquiries should be made in writing to** Rekceb-Rotide Research Laboratories, 8 Finucane Drive, Orpington, Kent, BR5 4ED. PE



Zola McMalcolm with F5 generation hybrid digitalis multiflora

Brainwave monitor

β BETA – *Concentration, problem solving, active thought.*
α ALPHA – *Relaxation, pleasure, tranquility, positive feelings.*
θ THETA – *Imagination, creativity, hynagogic imagery.*



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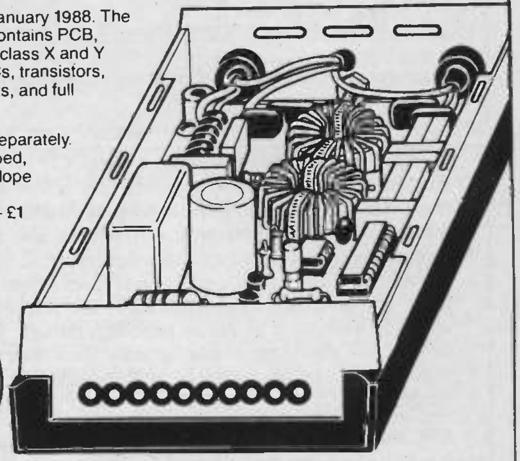

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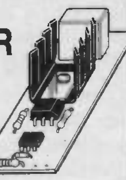

FEATURED IN ETI, JANUARY 1987

Have you ever wondered what people *do* with all those computer interfaces? 'Put your computer in control,' say the ads. 'The Spectrabeeb has eight TTL outputs.' What on earth can you control with a TTL output? A torch bulb?

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KNIGHT RAIDER

FEATURED IN ETI, JULY 1987

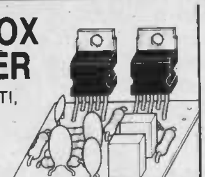
The ultimate in lighting effects for your Lamborghini, Maserati, BMW (or any other car, for that matter). Picture this: eight powerful lights in line along the front and eight along the rear. You flick a switch on the dashboard control box and a point of light moves lazily from left to right leaving a comet's tail behind it. Flip the switch again and the point of light becomes a bar, bouncing backwards and forwards along the row. Press again and try one of the other six patterns ... An LED display on the control box let's you see what the main lights are doing.

The Knight Raider can be fitted to any car (it makes an excellent fog light!) or with low powered bulbs it can turn any child's pedal car or bicycle into a spectacular TV-age toy!

The control box parts set consists of case, switches, LEDs, PCB, components, hardware and instructions. The sequence board includes PCB, ICs, power FETs, components, hardware and instructions.

KNIGHT RAIDER CONTROL BOX ONLY £6.90 + VAT!
KNIGHT RAIDER SEQUENCE BOARD ONLY £13.90 + VAT!

MATCHBOX AMPLIFIER



FEATURED IN ETI, APRIL 1986

No ordinary amplifiers, these. When our first customers took an interest, it was for the diminutive size (both modules will fit in a matchbox!), the total disregard for power supplies and speaker impedances, and the impressive power output from these little amplifiers. When they re-ordered, it was for the sound quality.

Two amplifier modules were described, both based on the powerful L165V IC. The single IC version will deliver over 20 Watts with a suitable speaker and power supply. The bridge version can provide up to 50W! Although the specified supply voltage and speaker impedance must be used to achieve maximum power, both modules are quite happy to work from any voltage between 12V and 32V, and will accommodate any type of speaker. The bridge version is ideal for giving a boost to car Hi-Fi systems, driving two 4 Ohm speakers in parallel on each channel for best effect.

Both designer-approved parts sets consist of a roller tinned printed circuit board and all components. The L165V ICs are also available individually, with a free mini data sheet giving specifications and suggested circuits.

SINGLE IC 'MATCHBOX AMPLIFIER' SET (20W into 4 Ohms) **£6.50** + VAT	BRIDGE AMPLIFIER SET (50W into 8 Ohms) **£8.90** + VAT	L165V IC, with data. **£3.90** + VAT

POWERFUL AIR IONISER

FEATURED IN ETI, JULY 1986

Ions have been described as 'vitamins of the air' by the health magazines, and have been credited with everything from curing hay fever and asthma to improving concentration and putting an end to insomnia. Although some of the claims may be exaggerated, there is no doubt that ionised air is much cleaner and purer, and seems much more invigorating than 'dead' air.

The DIRECT ION ioniser caused a great deal of excitement when it appeared as a constructional project in ETI. At last, an ioniser that was comparable with (better than?) commercial products, was reliable, good to build . . . and fun! Apart from the serious applications, some of the suggested experiments were outrageous!

We can supply a matched set of parts, fully approved by the designer, to build this unique project. The set includes a roller tinned printed circuit board, 66 components, case, mains lead, and even the parts for the tester. According to one customer, the set costs 'about a third of the price of the individual components'. What more can we say?

DIRECT ION PARTS SET
WITH BLACK CASE £11.50 + VAT
WITH WHITE CASE £11.80 + VAT
Instructions are included

SPECIAL OFFERS

AD7541 Precision 12-bit multiplying DAC	£1.20 + VAT
LM3524 Switch mode regulator IC	£0.80 + VAT
CF585 Calculator IC	£1.00 + VAT
LM339 Quad comparator IC	3 for £1.00 + VAT
MC1458 Dual op-amp	3 for £1.00 + VAT

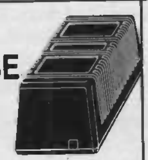
All ICs supplied with **FREE DATA.**
Prices apply only while stocks last.

LM2917 EXPERIMENTER SET

Consists of LM2917 IC, special printed circuit board and detailed instructions with data and circuits for eight different projects to build. Can be used to experiment with the circuits in the 'Next Great Little IC' feature (ETI, December 1986).

LM2917 Experimenter Set £5.80 + VAT

RUGGED PLASTIC CASE



suitable for mains conditioner and mains controller.

ONLY £1.65 + VAT

LEDs

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DIGITAL AND AUDIO EQUIPMENT LEDs
Assorted 3mm LEDs: red, green, yellow and orange. 25 of each (100 LEDs) for **£6.80**

Prices shown are exclusive of VAT, so please add 15% to the order total. UK postage is 70p on any order. Carriage and insurance for overseas orders £4.50. Please allow up to 14 days for delivery.

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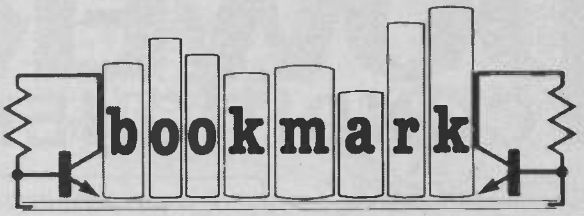

Another selection of newly published books to while away the rainy days.

Audio Amplifier Fault-Finding Chart. C.E. Miller. Babani BP120. 95p. ISBN 0-85934-095-3. This is not a book, but a chart that has been designed to help the reader approach fault finding in audio amplifiers in a systematic and logical way. It claims to also assist in the repair of equipment, and this it does to the extent that some items, such as fuses or faulty mechanical parts, can be located and replaced by the non-technical. More technical aspects of amplifier problems though, like electronic component checking, needs far more data than this chart has room to provide. Nonetheless, at 95p, many will find it a useful guideline.

BBC Basic86 On The Amstrad PCs and IBM Compatibles. Book 1 – Language. N. Kanaris and K. Thompson. Babani BP243. £3.95. ISBN 0-85934-188-7. The book is specifically designed for use with the above titled computers that can run BBC86. The latter is the structured language that many users of the BBC computer will have come to know. Statements in this language are introduced and explained with the help of simple programs. This is intended to enable the user to build up a considerable library of programs and procedures, which in turn could become the building blocks of advanced programming techniques. As a programmer who taught himself the art through reading books and experimenting, your Ed recognises that any like-minded person will eagerly acquire practically any book on the subject. However, my reaction to this one is 'so what's new?'. Paging through, I feel that I've seen it all before, and more comprehensively done.

Electronic Hobbyists Handbook. R. Penfold. Babani BP233. £4.95. ISBN 0-85934-178-X. We have come to expect well written and informative books from Robert Penfold, and this one is no exception. It offers a source of easily located information that many electronics enthusiasts may often need. It covers colour codes, characteristics and pin outs of many popular semiconductors, and illustrates many simple circuits. It also contains other useful data, such as circuit symbols, interface details, amateur and CB frequency allocations.

An Introduction to the Amstrad PCs. R.A. and J.W. Penfold. Babani BP197. £5.95. ISBN 0-85934-172-0. Specifically written for the PC1512 and PC1640, this book is aimed at those who have little or no previous knowledge of computing, and shows that using a business computer is a lot less difficult than many people may imagine.

The Robot Builder's Bonanza: 99 Inexpensive Robotics Projects. G. McComb. Tab Books. £12.00. ISBN 0-8306-2800-2. In over 300 pages, the book shows how you can build and combine the various parts that make up a robot, and to create your own original, custom designed, personal robot. If you love using your hands and your brain, you will find much pleasure from this book of mechanics and electronic circuits. It also gives a list of tools and equipment, a logic interfacing guide, and a drill bit and bolt chart. Beware that the addresses given for mechanical parts sources are all in the USA, though it seems likely that equivalent UK suppliers will exist.

An Introduction to Control and Measurement with Microcomputers. R.L. Dalglish. Cambridge University Press. £15.00. ISBN 0-521-31771-1. The book is intended to be a complete introduction to microcomputers and their application to control and data acquisition, and attempts to simply and clearly describe how microprocessors work and the basic architecture of a microcomputer. Since the book is based on courses given by the author for undergraduates, professional scientists and engineers, it is not so well suited for the early beginner, nor should it be regarded as a constructional guide.

44 Power Supplies for Your Electronic Projects. R.J. Traister and J.L. Mayo. Tab Books. £12.85. ISBN 0-8306-2922-X. The book claims to be a 'treasury of high- and low-voltage power supplies for all types of electronics applications'. As interesting as the book is, I feel that it does not live up to this claim, and I am aware of quite a few other types of power supply that I believe should have been included. I am also concerned that transformer-less mains operated supplies are recommended without, in my opinion, sufficient warnings about the potential safety hazards entailed. Aside from these niggles, the book does have some very useful information on power supply theory and applications that will be beneficial to many constructors.

State of Solid State. Tab Books. £7.75. ISBN 0-8306-2733-2. Written by the editors of the American magazine Radio-Electronics and comprises a selection of their articles published between 1982 and 1985. They include semiconductor theory, information on various solid state devices, and projects that use them. Some aspects of electronic technology may not change, but others are in a constant state of improvement; consequently I feel that articles going back to 1982 may only be of historic interest. There is the additional danger that some of the specified components may be unobtainable to UK readers, either because they have now become obsolete, or because the quoted suppliers are in the USA. The fact that original dates of publication for the articles are not given, and the use of statements within the text like "...catalogue is a new (1983) edition..." give me some cause for concern.

Solid-State Electronics Theory with Experiments. M.J. Sanfilippo. Tab Books. £13.20. ISBN 0-8306-2926-2. This book should be of interest to those who want to know more about the hows and whys of semiconductor devices. It ranges from the basic concepts, through diodes, transistors, and opamps through to initial considerations of integrated circuit technology. It is well filled with drawings, but keeps formulae to a minimum. Experiments are included and are designed to complement the topics. Although the book originates from the USA, its appeal will be far more international.

An Introduction to 8086/88 Assembly Language Programming for Engineers. N.M. Morris. McGraw-Hill. £12.95. ISBN 0-007-084173-X. In addition to dealing with the principles of programming, this book also provides a range of carefully designed programs, introducing readers to the arithmetic and text handling capacities of the chip. The programs are presented in a 'recipe' form, so making programming easier to learn. The book also describes the use of practical interrupt programs, and covers both digital and analogue input and output. Those studying 16-bit programming will find this book particularly useful.

The Real Hi Fi Story, P. Herring. The British Audio Dealers Association and the Federation of British Audio. A beautifully produced promotional book published by the BADA and available **FREE OF CHARGE** (though for some reason it has £2.50 marked on the cover) from **The Sound Advice Centre,** 40-41 Great Castle Street, London W1N 7AF. It measures just over 12 x 12 inches (about 32 x 32 cms) and has 24 pages split into two sections, one covering advice on hi fi facts, the other a selection of post-paid advertiser's reply cards. It is in full colour and should delight anyone who needs basic advice on the nature and requirements of hi fi equipment. There are also generous offers on trade-in equipment and special finance available, so it could help you to enjoy your music and save money into the bargain. Hurry though, for it published as part of a promotional campaign to increase the public's awareness of quality hi fi and specialist retailers, and as such may be in limited supply.

Normal good book shops should be able to get the books for you, but in the case of difficulty, these are the publisher's addresses:

Cambridge University Press, The Edinburgh Building, Shaftesbury Road, Cambridge, CB2 2RU.

Tab Books – through John Wiley & Sons Ltd, Baffins Lane, Chichester, W. Sussex, PO19 1UD.

Babani Books, The Grampians, Shepherds Bush Road, London W6 7NF.

McGraw-Hill Book Company, Shoppenhangers Road, Maidenhead, Berks. SL6 5BR.

READERS' LETTERS

FROM FRED

Dear John,

Congratulations on the fine job you are doing with PE. Until seeing the Jan 88 issue, I had been out of touch with PE since it moved to Poole many years ago. It is nice to know that it is still thriving as a London based mag once again and under the very capable hands of one of its old contributors! I remember very well the occasion in 1971 when you demonstrated your Telephone Answering Machine in our workshop at Fleetway House. That was the start of a good relationship which was to prove rewarding to PE and, I trust, to yourself over the years.

I wish you all success in 1988. Keep up the good work.

Fred Bennett, Middx.

Many readers of PE will well remember that Fred Bennett was the founding Editor of PE in 1964, building its success until Mike Kenward took over when PE moved to Poole at the end of 1977.

We are proud to have Fred's approval for our style of publishing PE. Many readers, as well as myself, greatly benefitted from his capable and kindly editorship. Had it not been for his influence, it seems possible that my own interest in electronics might not have flourished, nor would I now be following in his editing footsteps.

Fred set the standards, the goals and the achievements; I hope that I too may likewise influence many of you in your appreciation of a worthwhile and exciting technology.

Thanks Fred, and best wishes.

Ed.

BUSH TELEPHONES

Dear John,

I was most interested by the *Recalling History* article in PE Dec 87, particularly the way it was written in the past tense. Overhead phone lines with transpositions are alive and well here in South Africa.

Our telephone is still a magneto instrument with local battery. The 'local' operator switchboard is 55 miles away, mostly by overhead lines. There are also some 10 subscribers on the same line, so we have code-ringing to see who the incoming call is for (my code is short-long-long). Nevertheless, the system works well and conversations are 'loud and clear'.

Atkinson (*Telephony Vol 1*, Pitman 1948) states 'where it is not practicable to provide lines of the requisite standard of insulation and ohmic resistance... the magneto system is still probably one of the most practicable methods of signalling'.

Even calls to overseas countries come over very well. When one considers the thousands of contacts, wire joints, relays, up-links and down-links to satellites and so on, one cannot be critical of the service.

One slight disadvantage of the long overhead lines is that when lightening flashes all the bells tinkle!

In fairness to the post office, they have promised us an automatic service later this year. But they said that last year too!

R.H. Shepperd, Darlington, South Africa.

One of my mottos is "never interfere with a working system" Unless profound benefits are likely to ensue, if something works, however archaic it may be, why change it? We are sometimes brainwashed into thinking that all technological advances should be implemented. It ain't necessarily so! **Ed.**

MICROJAM

Dear Ed,

I sympathise with Mr Gough whose letter concerning radio jamming you published in PE Jan 88.

It would seem that in some way my neighbours are using computers which are interfering with my vhf radio reception. Is it legal for them to do so?

Name and address supplied.

Many types of electronic circuitry can emit electromagnetic radiation, computers included. My own interferes with a small vhf radio I have when it is within a couple of feet of the computer, especially when putting data out to disc. I understand that in the world of espionage (dare I mention that these days?), it is possible to 'eavesdrop' on a computer by monitoring its radiation with highly sensitive and specialised equipment.

It is also well known that tv receivers radiate their own signals, which is how license dodgers can be caught out by detector patrol vans.

Under normal use, domestic equipment is unlikely to be radiating with a power sufficiently strong to contravene regulations, but anyone who believes that a neighbour is allowing radio interference to occur should follow the advice I gave in Jan 88 – contact the Radio Investigative Service of the Department of Trade and Industry through the local post office.

Ed.

MAINTAINED

Dear Ed,

Having decided to refresh my rusty electronics knowledge as I am deeply into microcomputers and their applications, I recently bought a copy of PE after not having taken it for a considerable number of years. May I say how pleasantly surprised I was to find such a high standard of editorial and technical content. What a highly readable mag it still is.

Please help me on two questions. I have many computer items each running off separate transformers, can I run them all of one transformer via DIN connectors? Secondly, I have read a lot of warnings regarding destroying chips with static electricity. What sensible precautions should one take, and which is the best practical earthing method?

I look forward to reading your mag regularly in the future.

T.G. Colledge, Chester.

Welcome back. Providing the transformer chosen is capable of delivering the correct voltage at the correct current you should have no difficulties in unifying your system, as long as you also ensure that the connecting cable is capable of carrying the current to avoid voltage drops with changes in load. The connecting plugs and sockets should also be chosen with good regard for the current drawn. I assume you refer to DIN style audio connectors – these can carry 100Vac or 150Vdc at 2A.

Much has been written about static problems and avoidance. There are many methods used commerically to ensure that static is not experienced, ranging from antistatic clothing, floorcoverings and so on, to operator earthing straps and pads. For the casual home constructor the simplest method is to periodically touch the conductive surface of something that is known to be earthed. The metal body of an earthed soldering iron is probably the most convenient item regularly at hand. You don't need to hold it, just touch it briefly every few minutes, especially if you are moving around in nylon or other static generating clothing. Chips are far hardier than many people give them credit for, and if you handle them sensibly it is unlikely that you will kill them.

Ed.

POP PICKING RADIO

Who would have believed that an April Fool text could take on reality? Some time ago I was shown an amusing tongue-in-cheek speculative article concerning radios that could automatically select the type of programme transmission you most wanted to tune into. A recent report says that such radios will become available during this year.

The report states that these radios will initially be for in-car entertainment and will find the type of programme you want, whether it is jazz, chat, drama, sport, news or classics, irrespective of which station is transmitting it.

The facility is becoming possible because of a development called the Radio Data System. This is computer controlled and sends out a coded signal with transmitted programmes that enables the radio to search out the particular code relating to your listening preference.

Additional facilities offered by RDS include searching out traffic reports, and even paging individual listeners in emergencies. The road report service comes as no surprise since some radios in new cars (including my own) have a button that is intended to activate a search facility.

RDS is being introduced by the European Broadcasting Union and at least 11 countries are likely to introduce it over the next two years. Apparently the BBC are ready to do so now, and that they regard RDS as "the most significant advance in radio technology since the introduction of stereo broadcasting".

Once again it seems that SF is becoming science fact, and that even AF texts may sometimes be based on reality. I can't help but wonder if research scientists don't sometimes get their inspiration from authors like Daedalus of *New Scientist*, Arthur C Clarke, Isaac Asimov, Brian Aldiss, Larry Niven and other such heroes of mine. **Ed.**

TEACHER COUNTER

PART ONE BY TIM PIKE

The last in a series of projects aimed at students of GCSE Electronics preparing for project work for examination this year.

Tim Pike analyses a seven segment display and the logic needed to drive it, with the help of Boolean algebra and Karnaugh maps. Why do things the hard way? Because it makes the easy way easier. The result is an event counter.

IN this the seventh and last constructional article in the present series, I have decided to return to my favourite branch of the subject. Readers who have followed the series will recall that in the second article, '*Teacher Locker*' (PE Oct 87), I looked at some of the principles of digital electronics and specifically at the use of logic devices. In designing the circuit for the simple digital lock, a combination of discrete devices and integrated circuits was used to provide both the desired logical function and the necessary timing and ordering of events.

In commercial design, it is unlikely that such a proportion of discrete devices would be used. If the complete design could not be produced by a combination of standard integrated circuits with just a minimal number of discrete devices to support them, then a specialised integrated circuit would be designed to meet the exact needs of the particular application. Almost inevitably such a device might possess both digital and analogue facilities.

In order to justify the relatively high costs involved in developing such a device, one would need to be fairly sure of commercial success. It is hardly likely that a circuit simple enough to form the basis of a GCSE project is destined to receive such acclaim, no matter how useful it might be!

In this last article, I hope to extend the introductory work on logic contained in the October 87 article and to use these ideas to decode a standard seven segment display. By adding a binary counter, I will produce a simple multipurpose event counter.

THE SEVEN SEGMENT DISPLAY

In order to define the system which we require the logic to produce, let us begin by examining the output device in detail.

A seven segment display consists of seven separate light-emitting diode elements arranged in a figure of eight such that all ten decimal digits can be displayed, together with many other patterns.

Each diode element would seem to require two connections (anode and cathode) but it is possible to reduce the total from fourteen to eight by making all segments share one connection. There are therefore two possibilities: common anode types in which the seven cathodes are each separately available together with one shared anode connection or the opposite (common cathode types) where the seven anodes are separately available together with one shared cathode connection. For many applications, it does not matter which type is chosen.

It is of course always important to know which type is in use to avoid problems of incorrect polarity when the device is put into the circuit.

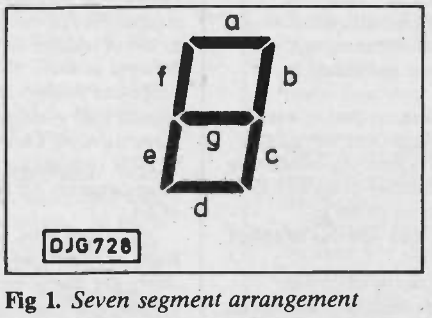

Fig 1. *Seven segment arrangement*

Fig.1 shows the standard arrangement of segments (labelled a to g). Fig.2 shows the pin-out for a common anode display

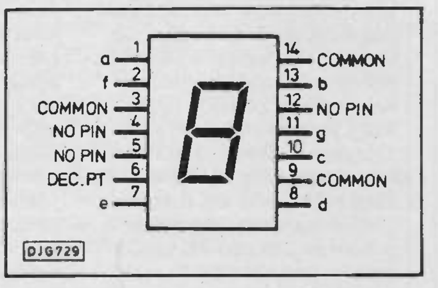

Fig 2. *Typical common-anode pin-out.*

contained in a standard dil (dual-in-line) package. Note that in addition to the seven segments there is also a further led unit to provide the option of a decimal point. The three pins marked 'common' are all connected to the anodes of all led segments.

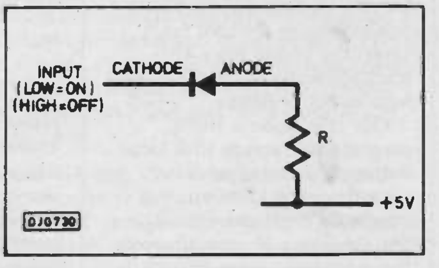

Fig 3. *Single segment drive*

In order to turn on any one segment it is necessary only to lower the voltage on the cathode of this segment below the common anode voltage by about +2V. The required forward current to illuminate one segment to a specific level of brightness will depend upon the physical dimension of the display and upon the colour of the display segments. A series resistor of appropriate value will be needed for each segment to limit the current. In practice, one resistor may sometimes be used for all segments where consistency of brightness level is considered to be unimportant. Values between 82Ω and 330Ω for 5V operation are common. Considering just one segment as if it were a discrete led, Fig.3 shows how it can be turned on or off by driving the input voltage to the cathode low or high.

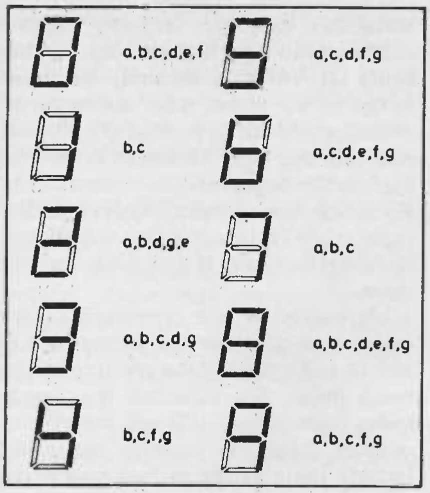

Fig 4. *Segments for digits 0 to 9*

PRODUCING DECIMAL DIGITS

Now that we have control of each segment independently, our next concern is to form intelligible symbols by combining the segments to form the familiar shapes of the ten decimal digits (0 to 9).

Examination of the way in which the digits might be represented allows us to determine which segments must illuminate for each digit.

Fig.4 shows the details. Of course, these ten patterns are but a few of the total number of arrangements which could be produced. For those readers with a mathematical interest, each of the seven segments can be either on or off. There are, therefore, 2^7, or 128 possible arrangements, including the two extreme cases of either all segments OFF or all segments ON (the digit 8). Some of the other 118 arrangements can be useful in certain circumstances. Some letters of the alphabet can be created either in lower or upper case. This facility is commonly used to represent numbers in hexadecimal (hex) which is base sixteen. Hex requires six additional symbols to represent the decimal values from ten to fifteen. The first six letters of the alphabet may be conveniently used. For reasons which are obvious when the seven segment display is examined, some of these six letters must be represented as capitals and some must be represented in their lower case form. The symbols used are A, b, c, d, E and F.

To return to the production of the decimal digits let us consider as an example, how the symbol for the digit '3' must be created.

From Fig.4, we see that we need to drive the five segments a, b, c, d and g. Each of these five segments can be considered as an output from our system. The inputs to the system will be the outputs from a binary counter, set to count from zero to nine.

In order to represent the ten decimal values from zero to nine, a four-bit binary code will be required. In this number system, the value for decimal '3' is 0011. We therefore have four inputs (one for each column of the binary code). If we call these inputs A, B, C and D, where A represents the least significant bit (lsb), then this particular combination of inputs must produce the correct pattern of outputs in order to drive the display.

Fig.5 shows the generalised system diagram to produce the logic circuitry which links the binary counter to the seven segment display. Fig.6 shows the system diagram with the inputs and outputs required to produce the decimal value '3'. Here we have assumed that the input to a segment must be high to turn on that segment.

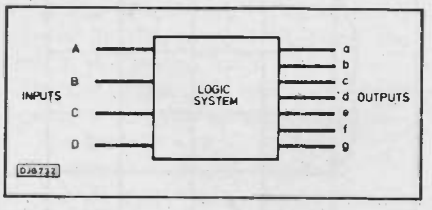

Fig 5. *Generalised logic system*

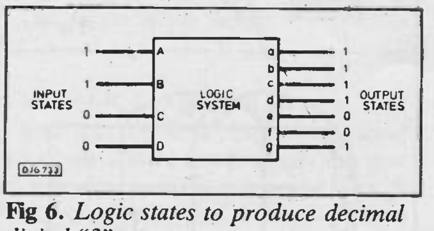

Fig 6. *Logic states to produce decimal digital "3".*

Clearly we could design a separate logic system for each of the ten output states. It should be possible to economise, however, and to consider all ten requirements simultaneously.

The table in Fig.7 relates all ten input states to their corresponding output states. One of the advantages in presenting the information in this form is that it allows us to define, for each output, the particular combinations of inputs which require the output to be on.

Consider the output which will drive segment 'a'. 'a' must be on for the 0, 2, 3, 5, 6, 7, 8 and 9 states. It is common practice to represent this relationship by writing an equation. The equation states all the input states which produce a certain output state.

BOOLEAN ALGEBRA

In order to specify the equation in an abbreviated form, we use a type of algebra which is named after George Boole, the 19th century English logician, who first proposed this method.

In this algebra, the standard logic functions are represented by symbols which link the input variables together.

AND is represented by a dot (.)
OR is represented by a plus sign (+)
NOT is represented by a bar over the variable e.g. $\bar{A}$ means NOT A

(Whatever possessed a logician not to define AND as '+', a symbol which in language terms means 'and'? Ed).

So, to express 'A AND B AND C' we simply write A.B.C. To express 'A AND NOT B', we write $A.\bar{B}$.

To express 'B OR C OR NOT D' we write $B+C+\bar{D}$.

Looking back at Fig.7 to the output column for segment 'a', we see that eight of the ten input combinations will turn segment 'a' on. We could therefore write down that 'a' is to come on when the inputs register 0 or 2 or 3 or 5 or 6 or 7 or 8 or 9. In Boolean algebra this would be written as:

$$a = \underset{\text{(zero)}}{\bar{A}.\bar{B}.\bar{C}.\bar{D}.} + \underset{\text{(two)}}{\bar{A}.B.\bar{C}.\bar{D}.}$$
$$+ \underset{\text{(three)}}{A.B.\bar{C}.\bar{D}.} + \underset{\text{(five)}}{A.\bar{B}.C.\bar{D}.}$$
$$+ \underset{\text{(six)}}{\bar{A}.B.C.\bar{D}.} + \underset{\text{(seven)}}{A.B.C.\bar{D}.}$$
$$+ \underset{\text{(eight)}}{\bar{A}.\bar{B}.\bar{C}.D.} + \underset{\text{(nine)}}{A.\bar{B}.\bar{C}.D.}$$

The same method could be applied to the other six outputs (b to g). Each of these would generate an equation in Boolean algebra. These seven equations will completely define the operation of the seven segment display as it counts from zero to nine.

Fig 7. *Truth table of input and output states*

D	C	B	A	a	b	c	d	e	f	g
0	0	0	0	1	1	1	1	1	1	0
0	0	0	1	0	1	1	0	0	0	0
0	0	1	0	1	1	0	1	1	0	1
0	0	1	1	1	1	1	1	0	0	1
0	1	0	0	0	1	1	0	0	1	1
0	1	0	1	1	0	1	1	0	1	1
0	1	1	0	1	0	1	1	1	1	1
0	1	1	1	1	1	1	0	0	0	0
1	0	0	0	1	1	1	1	1	1	1
1	0	0	1	1	1	1	0	0	1	1

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SIMPLIFICATION

Considering just the output to segment 'a', we could produce a logic design to implement this equation directly.

We would require:

4 NOTgates (one for each variable, A to D).

8 AND gates (each having four inputs).

1 OR gate (with eight inputs!).

This would need at least six integrated circuits. Assuming that the other six output segments would require much the same amount of logic circuitry, we would seem to need about forty integrated circuits!

Clearly, this is ridiculous. Readers who are familiar with seven segment display devices will know that the complete display driver circuitry is available on one integrated circuit. In normal circumstances one would simply select and use one of these devices. However, since we are interested in learning about the way in which logic can be used to solve problems, it does not suit our purpose to be so pragmatic at this stage. We must find a method of simplification which will lead us to a solution which we have developed ourselves, and therefore which we understand, and yet is simple enough to be practicable to construct.

Let us look again at the equation for segment 'a'. Notice that the term which represents the zero state ($\overline{A}.\overline{B}.\overline{C}.\overline{D}$) and the term which represents the eight state ($\overline{A}.\overline{B}.\overline{C}.D$) are identical except for the variable D.

One method of simplification which will be familiar to GCSE students of mathematics is to regroup the terms in the whole expression and then to 'factorize' and collect like terms.

e.g. $\overline{A}.\overline{B}.\overline{C}.\overline{D}. + \overline{A}.\overline{B}.\overline{C}.D. =$
$\overline{A}.\overline{B}.\overline{C}.\ (\overline{D}+D)$

and by the basic rules of binary arithmetic, $(D+\overline{D})$ must be equal in value to '1'.

So these two terms simplify to ($\overline{A}.\overline{B}.\overline{C}$) the further conjuction with '1' being redundant.

A similar process could be used to simplify the terms representing the six state ($\overline{A}.B.C.\overline{D}$) and the seven state ($A.B.C.\overline{D}$), resulting in just one term, ($B.C.\overline{D}$).

Although this is an effective technique, it is rather slow and not guaranteed to produce the simplest overall expression for 'a'.

THE KARNAUGH MAP

Students of electronics who decide to take their studies beyond GCSE level will later meet a much more powerful technique which gives *the simplest* expression for any logical function if used correctly. The method is essentially a graphical or perhaps a pictorial one.

Looking back again at the table in Fig.7, we understand that with four input variables, there are actually sixteen combinations, the highest binary value being 1111 (or 15 in decimal). We chose to ignore the values from ten onwards, as they would not be present in a decimal count, to one digit. However, before we explore the opportunities offered by the Karnaugh Map, we need to be clear that these other six binary states can exist in an 'imaginary' way if we wish to include them.

Ultimately we will be using a binary counter to generate the inputs A,B,C and D and resetting the counter on the tenth pulse. So, although the binary codes from 1010 to 1111 will not exist as outputs from the counter we could include them in the picture and make them generate outputs to suit the simplification process, knowing that the state of these last six outputs does not matter as they will never appear on the display. Bearing this in mind, let us look at the structure of a Karnaugh Map.

There are a number of simple rules which become obvious once you begin working with these maps.

1. The map will be a rectangular (or square) grid of boxes.
2. There must be one box for each possible combination of inputs. In our case, there are 16 combinations, so there must be 16 boxes. In general there will be 2^N boxes where N is the number of inputs.
3. Each box must have a unique label which refers to its particular input combination.

Fig.8 shows the grid of 4 by 4 boxes and one method of labelling. Notice that the left-hand two columns are representing input A, the right-hand two are therefore NOT A. The centre two columns represent B, the outer two are therefore NOT B. The same ideas apply to the rows for C and D. If you care to check the labelling, you will find that every box represents a different combination of inputs.

COMPLETING THE MAP

There is only one rule for completing the map. Wherever there is a '1' in the input-output chart (Fig.7) or truth-table, a '1' must be placed in the corresponding box on the map. We already know that there are eight '1's for output 'a'. So the map for output 'a' will look like Fig.9.

There are only two known zero outputs — they occur for the states representing 1 and 4. So these can be

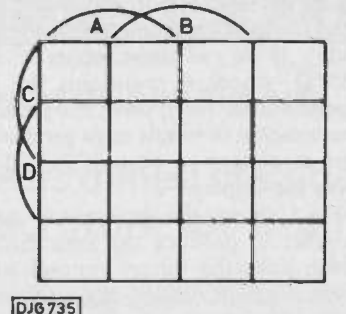


Fig 8.

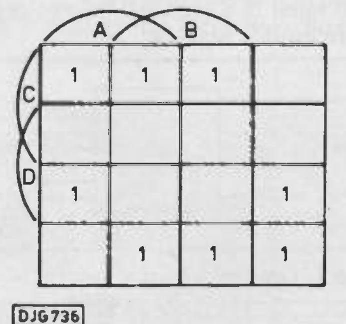


Fig 9.

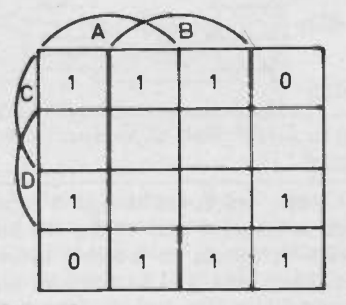


Fig 10.

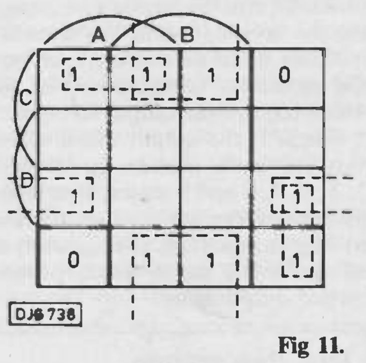


Fig 11.

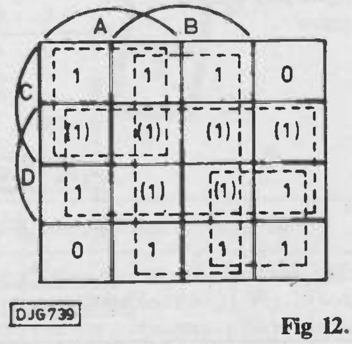


Fig 12.

Fig 8. *Empty Karnaugh map for a four-variable logic function.*
Fig 9. *Map for output segment "a" (required "1" and "0" states).*
Fig 10. *Map for segment "a" (known "1" and "0" states)*
Fig 11. *Use of wrap-around effect to obtain larger groups of boxes.*
Fig 12. *Completing the map with "imaginary" states.*

added to the map (Fig.10). The remaining six boxes represent the binary combinations from 1010 to 1111. Since we are not going to allow these to exist in our counter, it does not matter whether they generate a zero or a one.

READING THE KARNAUGH MAP

So far so good (I hope!). The really clever part about the Karnaugh Map method comes when we read off the information. The strategy is to read off blocks of information rather than single box labels. There are however two or three rules:

1. The groups of boxes must be rectangular groups (i.e. not diagonals).
2. The groups must be binary groups (i.e. one box, two boxes, four boxes, eight boxes etc.).
3. The groups must be as large as possible. Large groups have simple labels.

To help with this process it is useful to remember that the top and bottom of the map are really joined; so too are the left and right edges. This is called the 'wrap-around effect'. It is fairly clear from Fig.10 that the largest group we can obtain is a group of four boxes containing 1s as shown in Fig.11. This group requires the use of the 'wrap-around effect'.

The label for this group is ($B.\bar{D}$). So this will be one term in our simplified expression for segment 'a'. We must read off all the boxes to obtain the full expression and we can include some of them more than once if we wish.

With the map as it stands, there are no other groups of four 1s. The best we can do is to form three other groups, each of two boxes, to cover all the "1 boxes". There is more than one way of doing this but the net result is a final expression for 'a' such as:

$a = B.\overline{D} + A.C.\overline{D} + \overline{A}.\overline{B}.\overline{C} + \overline{B}.\overline{C}.D$
or $a = \overline{D}.(A.C. + B) + \overline{B}.\overline{C}.(\overline{A} + D)$.

Although very much simpler than the original expression, this will still require the following gates:

4 NOT gates (1 for each variable).
+ 3 AND gates } or { + 4 AND gates
+ 3 OR gates } { + OR gate.

We would still need three or four integrated circuits to implement this solution.

INCLUDING THE 'IMAGINARY' STATES

Looking at the Karnaugh Map of Fig.10 again, it is fairly clear that if we had more boxes with 1's in them then we could write a much simpler expression.

In fact if we fill in all the other unused boxes with imaginary 1's then a very much simpler expression results. Fig.12 shows the original map plus the imagined states in brackets.

There are now two groups of eight boxes (B and D), leaving only the two corners of the principal diagonal to be included. These can be incorporated into two groups of four boxes. One corner is included in the group (A.C) and the other in the group ($\bar{A}.\bar{C}$).

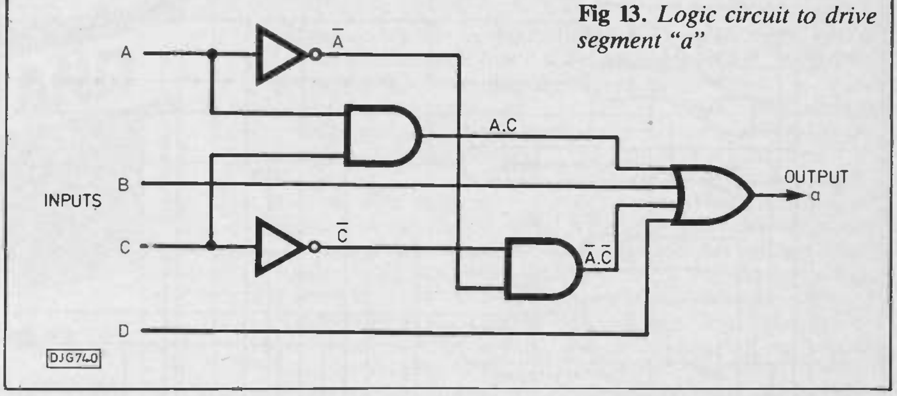


Fig 13. *Logic circuit to drive segment "a"*

The final expression which will drive segment 'a' correctly up to decimal 9 is:–

$a = B + D + A.C. + \bar{A}.\bar{C}$

This can be produced with just:

2 NOT gates
2 AND gates
1 OR gate.

The logic circuit design is shown in Fig.13.

FURTHER ECONOMIES

Now that we have reached this level of sophistication it becomes obvious that we would be wasting integrated circuits if we were to use three different devices to produce this circuit.

Another fascinating aspect of logic design is that any Boolean expression can be implemented entirely from NAND gates or entirely from NOR gates.

NAND gates are a little easier to work with, starting from the Karnaugh Map. The simple expression above for 'a' can be re-written to suit NAND gates very easily indeed.

De Morgan's theorem states that:–

$\bar{A}.\bar{B} = A + B$ (NOR)

and

$\bar{A} + \bar{B} = A.B$ (NAND)

By applying a double inversion to the whole of the right hand side of the equation for 'a',

$a = B + D + A.C + \bar{A}.\bar{C}$

We are then able to apply De Morgan's theorem to obtain:

$a = \bar{B}\ .\ \bar{D}.\ A.C\ .\ \bar{A}.\bar{C}$

Although this appears to be more complicated than the simple expression obtained from the Karnaugh Map, it does only require NAND gates. Namely:

4 NOT gates (which can be NAND gates).
2 two input NAND gates.
1 four input NAND gate.

Perhaps the NOT gates are best produced from a simple hex inverting device because of its ease of use. We will then need one inverting gate device plus half of each of the two types of NAND device. The best circuit design for output 'a' with just two types of gate is shown in Fig.14.

EXTENDING TO ALL SEGMENTS

Exactly the same analysis for segments b to g produces the results shown below. I will leave it to you to verify that these Boolean expressions are correct!

$b = A.B. + \bar{A}.\bar{B} + \bar{C} + D$
$c = A + \bar{B} + C + D$
$d = \bar{A}.B + \bar{A}.C + A.\bar{B}.C + B.\bar{C}$
$e = \bar{A}.B + \bar{A}.\bar{C}$
$f = \bar{A}.\bar{B} + \bar{A}.C + \bar{B}.C + D$
$g = \bar{A}.C + B.\bar{C} + \bar{B}.C + D$

A quick glance at this set of equations reveals that a number of the terms within them occur more than once. For example ($\bar{A}.C$) occurs three times. Clearly we can economise in another way by utilising the same section of circuitry each time a particular term is needed.

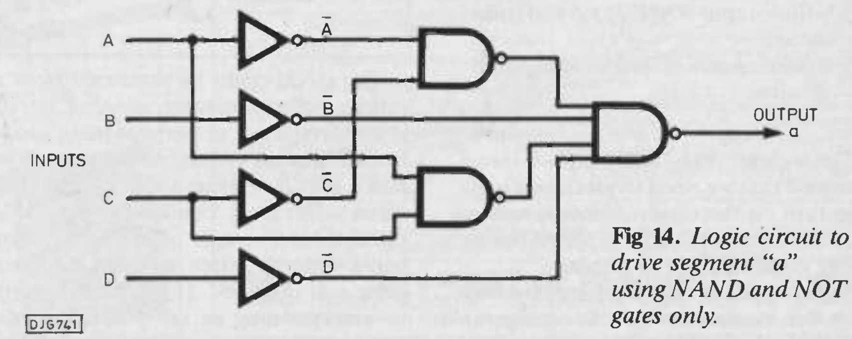


Fig 14. *Logic circuit to drive segment "a" using NAND and NOT gates only.*

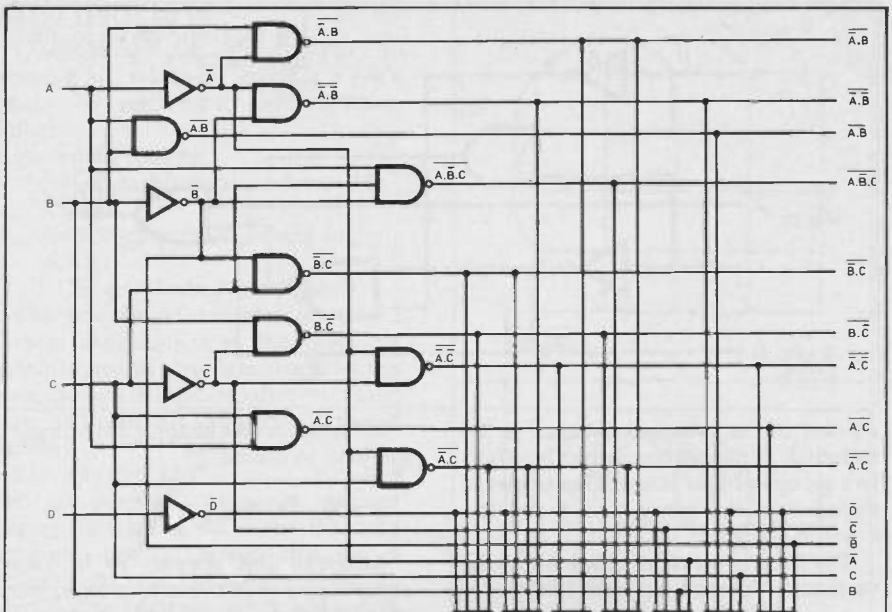


Fig 15. *Complete logic array for all segments using NAND and NOT gates only (suitable for common cathode display).*

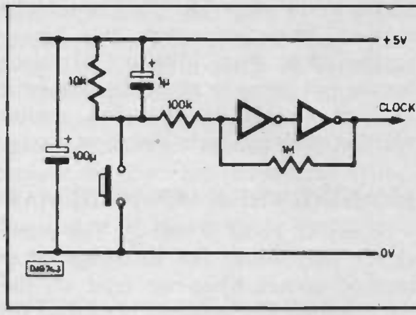


Fig 17. *Simple switch anti-bounce circuit*

Converting these expressions to NAND and NOT only generates the full set of equations given below:

$a = A.C \,.\, \bar{A}.\bar{C} \,.\, \bar{B} \,.\, \bar{D}$

$b = A.B \,.\, \bar{A}.\bar{B} \,.\, C \,.\, \bar{D}$

$c = \bar{A} \,.\, B \,.\, \bar{C} \,.\, \bar{D}$

$d = \bar{A}.B \,.\, \bar{A}.C \,.\, A.\bar{B}.C \,.\, B.\bar{C}$

$e = \bar{A}.B \,.\, \bar{A}.\bar{C}$

$f = \bar{A}.\bar{B} \,.\, \bar{A}.C \,.\, \bar{B}.C \,.\, \bar{D}$

$g = \bar{A}.C \,.\, B.\bar{C} \,.\, \bar{B}.C \,.\, \bar{D}$

COUNTING THE COST

A tally of the gates used in Fig.15 shows that we require:

4 × NOT gates
9 × two input NAND gates
1 × three input NAND gates
6 × four input NAND gates.

The most economical way of producing this circuit would require the use of:

1 × hex inverting integrated circuit
2 × two input NAND gate integrated circuits
1 × three input NAND gate integrated circuit
3 × four input NAND gate integrated circuits.

Throughout this analysis, we have assumed that we need to produce a logic 1 to turn on the disply. If this is not so, then the output must be inverted before being presented to the display.

Many readers may well feel by now that the complexity of the design in Fig.15 is not justified when one recalls that a single specialist integrated circuit can be purchased to perform this very function. Certainly only the most able GCSE candidates should consider building the logic array in Fig.15. The alternative is to use a display driving chip. Whichever option is chosen, I hope that the analysis of the logic array is useful to all budding digital electronic engineers. At the very least it gives a much better appreciation of the sophistication of the display driving chip.

FULFILLING THE ORIGINAL DESIGN BRIEF

One very important aspect of all project work for examinations in electronics is that the final circuit must fulfil the original objectives. In order to create a simple event counter we need to add a four-bit binary counter, resetting on its tenth pulse and a means of clocking the counter. A complete system diagram is shown in Fig.16.

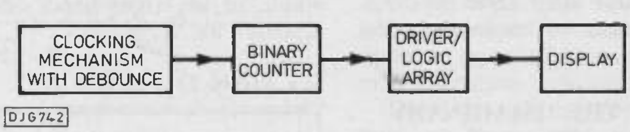


Fig 16. *Block diagram for a simple event counter.*

The clock might be produced from a square wave generator running on its lowest frequency or perhaps more easily from a manual switch. A simple push to make switch or even a microswitch will often suffer from 'contact bounce'. This phenomenon results in multiple pulses being entered when in fact only one pulse was intended. It can be overcome by incorporating an anti-bounce circuit between the switch and the clock input to the binary counter. A pair of hex inverters with resistive feedback (forming a Schmitt trigger) connected as shown in Fig.17 offers one type of anti-bounce circuit. Cmos inverters are more likely to work well in this situation. The 100μf capacitor acts as a large reservoir of charge to help to avoid pulses appearing on the supply rails.

ALTERNATIVE TRIGGER MECHANISMS

Our simple event counter can easily be adapted to count pulses of a different nature if an appropriate transducer and switching circuit is added.

Some ideas might include an optically triggered switch based on an ldr, a photodiode or a photo-transistor, or a magnetically operated switch based perhaps on a reed relay.

COUNTING LARGER NUMBERS

The other likely improvement which we should consider is how to adapt the ideas given so far to extend the range of the counter. Certainly it would be useful to count from 0 to 99, if not to 999 or more. Each additional decimal column requires an extension to the binary counter. If we are to retain the use of the logic array developed in Fig.15, then each subsequent decimal column will need its own four-bit binary counter connected to reset on its tenth pulse. The second column counter will be clocked either from the reset pulses to the first counter or by recognising the transition from the 'nine' state to the 'ten' state of the first counter.

In Part Two next month the circuit for a practical event counter will be shown, complete with constructional details.

PE

Tim Pike is Deputy Headmaster of the Ramsden School for Boys in Orpington, Kent, and has taught Electronics to 'A' level standard for thirteen years.

BBC COMPLETES RDS

Following on from the pop picking radio report (see page 39), the BBC have told us that they are leading the way amongst European Broadcasters with the revolutionary Radio Data System.

Recently BBC engineers completed the installation, ahead of schedule, of RDS equipment at all of it's Network and Local Radio vhf-fm transmitters serving England. These RDS signals will allow an "intelligent" receiver to automatically tune to the best signal, give a visual indication of the station name, and display the current time and date.

The RDS data, which is currently statically configured, is carried on an inaudible 57kHz subcarrier on every vhf-fm transmitter serving England. It will be extended to Scotland, Wales and Northern Ireland in an installation programme beginning during 1988. The codes being transmitted conform to the European Broadcasting Union (EBU) specification, and consist of pi (programme information), ps (programme service), af (alternate frequency), on (other networks information), and ct (clock time and date).

The system will be dynamically configured from April 1988 when the RDS central computer, located in the Control Room at Broadcasting House, London, is put on-line. This will allow codes to be updated, for example when the Radio 2 vhf-fm transmitters are carrying Radio 1 programmes. It will allow a travel service using the ta (travel announcement) and tp (travel programme) codes, which will be added in the Autumn 1988. This potentially will be the most efficient travel information service ever offered, because in-car listeners with RDS radios will, at their choice, have their regular listening entertainment interrupted by local travel flashes from the relevant BBC county station whose area in which they are driving.

The RDS service will be publicly launched at the BBC Radio Show, being held at Earl's Court, London, from 30 September to 10th October 1988.

Ed.

SPACEWATCH

BY DR PATRICK MOORE

OUR REGULAR LOOK AT ASTRONOMY

Russian astronaut Romanenko has returned in good health. Manned flight to Mars must be a step closer.

As I reported in last month's *Spacewatch*, the quasar distance-record has been broken yet again. The quasar Q0000-26, a 20th-magnitude object on the borders of Sculptor and Cetus – has a red shift of 4.11, corresponding to a distance of around 13,000 million lightyears and a recessional velocity 93 per cent that of light. Yet some uneasy doubts are starting to creep in. For years now Dr Halton C. Arp, formerly of Mount Wilson Observatory and now at the Max Planck Institute in Germany, has been maintaining that the red shifts are not pure Doppler effects, and are therefore unreliable as distance indicators. Arp has shown that in many cases, obviously-associated galaxies and quasars, or even pairs of galaxies, have completely different red shifts. In his new book *Quasars, Redshifts and Controversies*, Arp repeats these claims, and produces observational evidence in support. He is not alone in his views; one of his notable supporters is Fred Hoyle.

At the moment, the majority view is that the correlations are coincidental, and that the quasars really are superluminous and so remote that they cannot be too far from the edge of the observable universe. But if Arp is correct, then quasars might even be found in our own Local Group of galaxies, and many of our cherished theories will have to be abandoned. We may not be back in Square One, but we will certainly have returned to Square Two! We must now await the results of further research.

There are reports that a meteorite – the Murray Meteorite, from Kentucky – has been found to contain specks of silicon carbide which are very old indeed: older than the Solar System. If this is confirmed, it will be of great cosmological importance, but again we must await further studies.

The Sky This Month

Venus still dominates the early evening sky throughout March this year. Its magnitude remains at –4.2, but it is not yet at its brightest; this will occur when the phase has decreased to less than half – the lesser distance from Earth more than compensating for the fact that less of the sunlit hemisphere is turned in our direction. In March the phase shrinks, theoretically, from 66 per cent to 53 per cent; but during evening apparitions the time of 'dichotomy' or exact half-phase is always early, and so observers will do well to estimate the phase during the last few evenings of March. This "Schröter effect" (a name which I introduced many years ago, because the phase discrepancy was first noted by the German pioneer observer J.H. Schröter) is due to Venus' dense atmosphere.

On March 6 Venus is only 2 degrees away from Jupiter, and this will be an event worth photographing even though it is not in the least important scientifically. Of the other naked-eye planets, Mercury will not be on view this month, but Saturn (magnitude +0.5) is a morning object, low down in the constellation of Sagittarius.

The Moon is full on March 3, and new on the 18th.

There is a total eclipse of the Sun on March 17/18, but unfortunately nothing of it will be seen from Britain; to see it you most go on a long journey – for example the Philippines, the Aleutian Islands, north-west Australia, New Guinea or western Hawaii. The maximum length of totality will be 3m 46s. For the next British total eclipse we must wait until 11 August 1999.

There are no major meteor showers in March, though we may see a few Virginids (the maximum of this shower is around 12 April, but at best it is very sparse). Neither are there any bright periodical comets on view.

In the starry sky, we have more or less completed the changeover from winter to spring groups. Orion sets in mid-evening, leaving only part of the Hunter's retinue on view – notably the Twins, Castor and Pollux, and the brilliant Capella in Auriga. Ursa Major, the Great Bear, is almost overhead; follow round the 'tail' and you will reach Arcturus in Boötes, the Herdsman, a lovely light orange star which is actually the brightest in the northern hemisphere of the sky (its only superiors – Sirius, Canopus and Alpha Centauri – are all south of the celestial equator). Note the little semicircle of stars close to Arcturus which marks Corona Borealis, the Northern Crown. In the 'bowl' of the Crown you can usually see two stars with any binoculars. One of these is of magnitude 6.6, not far below naked-eye visibility. The other is the famous variable R Coronæ, which is usually of magnitude 6, but which periodically 'viels' itself with clouds of soot and sinks to a minimum so faint that large telescopes are needed to show it at all. One can never tell when R Coronæ is going to fade, so it is worth keeping a check. It is not unique, but stars of the same type are very uncommon.

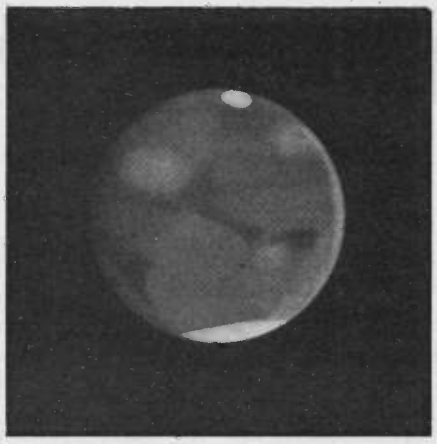
Leo, the Lion, is high in the south, and is the leader of the spring groups; it is marked by a curved line of stars, making up the so-called Sickle, of which the leader (Regulus) is of the first magnitude. The rest of Leo consists of a triangle of stars to the east of Leo. One of these, Denebola, was ranked of the first magnitude in ancient times, but is now rather below the second; either it has faded, or (more probably) there is some error in interpretation. Below Leo lies the vast, sprawling Hydra (the Watersnake). It is the largest constellation in the sky, but contains only one bright star – the reddish Alphard (the "Solitary One") which can be found by using Castor and Pollux as direction indicators.

THE WAY TO MARS?

On 29 December 1987 Colonel Yuri Romanenko, of the USSR, returned safely to Earth after having spent a record 326 days on the space-station Mir. Together with his fellow cosmonaut, Alexander Alexandrov, he came down in Soviet Kazkhstan, well on schedule. The two cosmonauts who have taken over on Mir – Vladimir Titov and Musa Manarov – expect to remain on the station for most or all of 1988.

It is an open secret that the Russians are thinking very seriously about a manned mission to Mars, and Romanenko is on record as saying that this long space mission has brought Mars 'closer'. It could well be that the Russians will reach for Mars without having landed a man on the Moon – though of course this is little more than guesswork. Meanwhile, what are the prospects for Mars?

Though the Soviet instrumentation is in many ways inferior to the American, there can be little doubt that on the whole they are now much more advanced in space – particularly in view of the new troubles with the US Shuttle. (How well I remember Wernher von Braun telling me that he would never willingly use solid fuels for launching a man into space!) So far as Mars is concerned there is every reason to suppose that the electronics techniques are fully adequate. So, probably, is the guidance, though it must always be remembered that Mars is a very different proposition from the Moon; it is much further away, does not keep close beside us as we travel round the Sun, and provides no chances for a 'quick return', as happened with Apollo 13 when there was an explosion on board the spacecraft during the outward journey. On the other hand, Mars does almost certainly have a supply of H_2O, locked up as ice, and the surface gravity is much greater than that of the Moon. The main problem is the fact that the thin, carbondioxide atmosphere is of very little use so far as men are concerned.



Were these the only hazards, there might be no reason why a Mars mission should not be feasible within the next decade or two – but there is another point to be borne in mind: the human body. Can a man (or, for that matter, a woman) endure long periods of zero gravity without suffering permanent harm?

The Russians have taken all possible precautions (exercise, for example), but there are some factors outside their control, and one of these is a possible deterioration in a cosmonaut's bone structure. This is certainly one reason why cosmonauts have been left on Mir for protracted periods. What effects there have been on Romanenko we do not know at the time when I write these words, though he seems to have felt reasonably fit when he landed, and mentally he was in perfect condition. It may well be that he will provide invaluable clues when his state of health is monitored over the next few months.

So – will we get to Mars? I believe we will, within the next half-century and probably well before. If we fail, however, it will be due to human physique – not to electronics! PE

The drawing of Mars was made by Paul Doherty and is from an article on observing the planets in the February 1988 issue of Astronomy Now.

SEMICONDUCTORS

PART 5: POWER MOSFETS
BY ANDREW ARMSTRONG

CMos, VMos, DMos

The versatility of mosfets means that their range of applications is expanding faster than that of other discrete semiconductors, especially for small high frequency signals and large power-handling functions.

In part 4 we looked at some of the characteristics and applications of junction fets. Here we shall look at what I think is the most interesting area of discrete semiconductors, mosfets. This generic term covers a wide range of device types, including dual gate mosfets intended for use as small signal uhf amplifiers, and high power devices capable of switching tens of amps and/or hundreds of volts.

CASCODE

First of all, however, there is one more junction fet application to cover. The circuit configuration is cascode, and it has the advantage of leading on neatly to dual gate mosfets. Fig.47 shows an example of a cascode rf amplifier circuit. In this circuit, the input signal is isolated from the output signal because they use different fets. This means that the output signal cannot affect the input signal via the miller (drain to gate) capacitance of the fet.

Such signal feedback can reduce the gain at moderate frequencies, as well as reducing the apparent input impedance, but at vhf and uhf the phase shift in the fet and circuit can be enough for the miller feedback to cause oscillation. This effect can be tuned out by extra controlled feedback, at least over a limited frequency range. This technique, known as neutralisation, has been used both for valve and fet circuits, and is probably best known by radio amateurs who have built hf linear power amplifiers or two metre converters in times gone by.

More advanced two metre converters used a cascode circuit to avoid the problems of adjusting the neutralisation, and nowadays would almost always use a dual gate mosfet such as the BF981. Fig.48 shows an rf amplifier with an equivalent function to that of Fig.47, but using a BF981 dual gate mosfet.

In this circuit, you will notice that there are small value resistors in series with the decoupling capacitor on the second ground. The test circuits in semiconductor data books normally show a decoupling capacitor without a series resistor, but in practice, with a tuned load connected to the drain, the circuit is likely to oscillate. This effect is apparently a function of internal

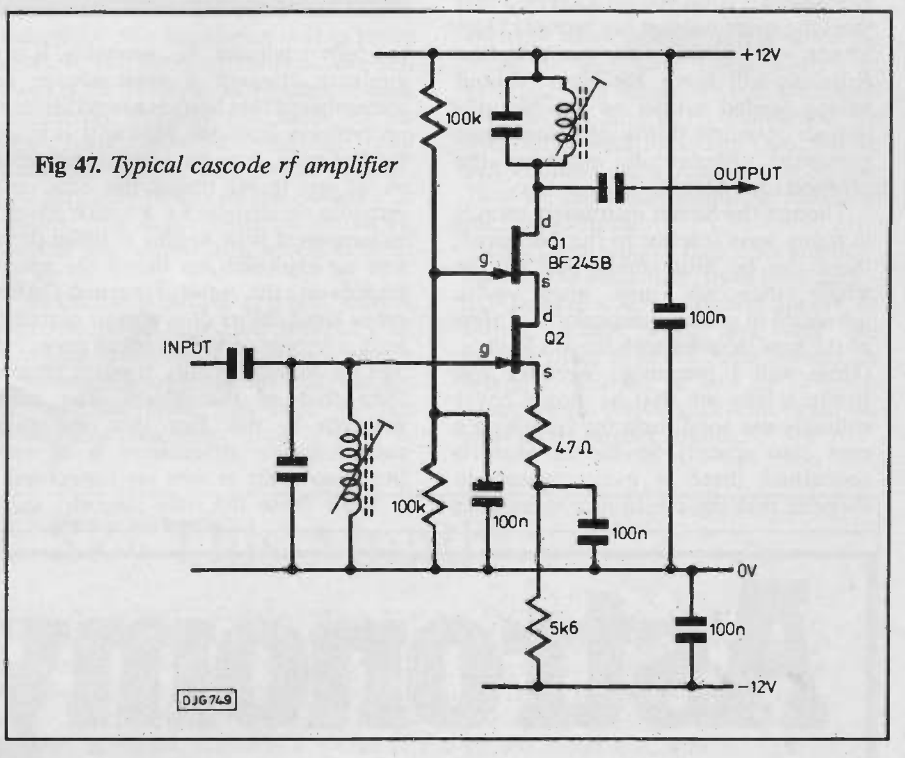


Fig 47. *Typical cascode rf amplifier*

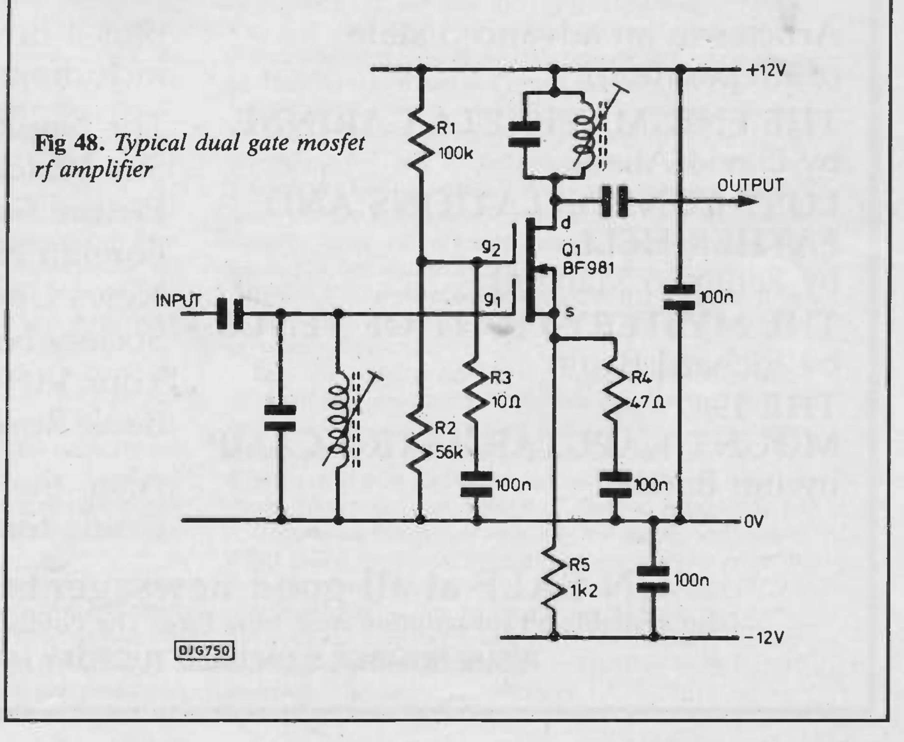
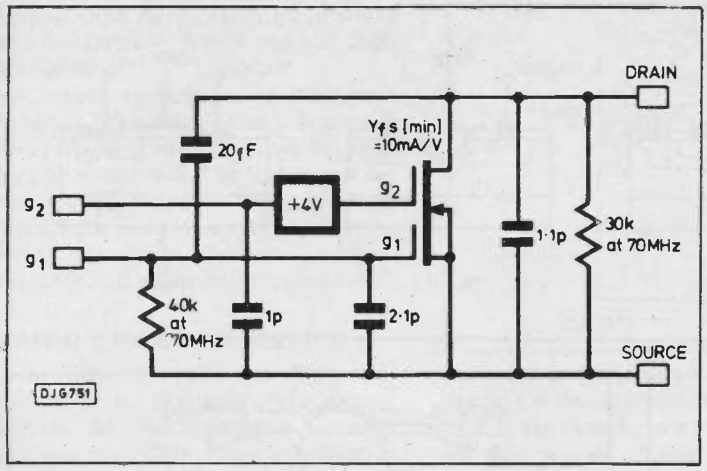


Fig 48. *Typical dual gate mosfet rf amplifier*



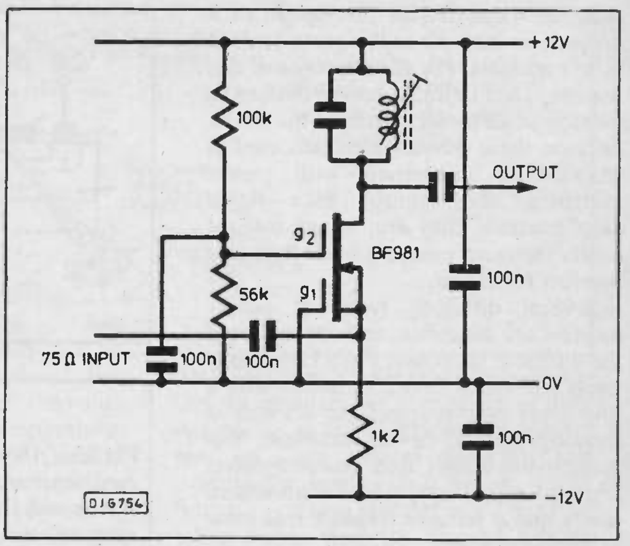


Fig 49. *(Above) Equivalent circuit to BF981*
Fig 52. *(Right) Low impedance source amplifying*

capacitances of the device causing an apparent negative resistance in series with gate two. This oscillates due to stray capacitance from the drain load unless the negative incremental resistance is cancelled by a positive resistance.

MULTIPLICATION

The second gate of the dual gate mosfet does not have to be decoupled to earth. The bias voltage applied to this gate controls the gain of the device, and the effect is approximately linear over a limited range. The obvious application of this effect is to carry out agc gain control in a radio receiver, and dual gate mosfets are used in just this way. Gain reduction by this method can prevent a strong signal from being amplified so much as to overload the next stage, but it cannot prevent overload of the stage being controlled. It is a useful technique, but cannot substitute for a switched attenuator in conditions of very high local signal.

Another slightly less obvious use for gate two is to inject local oscillator signal in the mixer stage of a radio receiver. This is slightly less obvious, but ideally a mixer should be linear with respect to the input signal and the local oscillator, so as not to generate harmonics and cause crossmodulation, noise modulation, and other problems. It should, however, multiply the two signals so as to produce sum and difference signals.

$$\sin(w1) \times \sin(w2) = \tfrac{1}{2} \times (\cos(w1-w2)-\cos(w1+w2))$$

in the ideal case.

The dynamic range is limited, so that this is not always suitable for the first mixer of a communications receiver, but for the second mixer (eg to convert 10.7 to 470 kHz) it is very useful.

CHARACTERISTICS

The BF981 is a particularly useful mosfet for amateur rf construction, so I have included more information on it. Fig.49 shows an approximate equivalent circuit for the device. The capacitances shown behave as you might expect, but the resistances are dependent on frequency, with an effectively infinite value at dc. The resistances, determined at a particular frequency from graphs showing input admittance and output impedance, are due to a combination of the limited operating frequency of the device and its internal stray feedback effects.

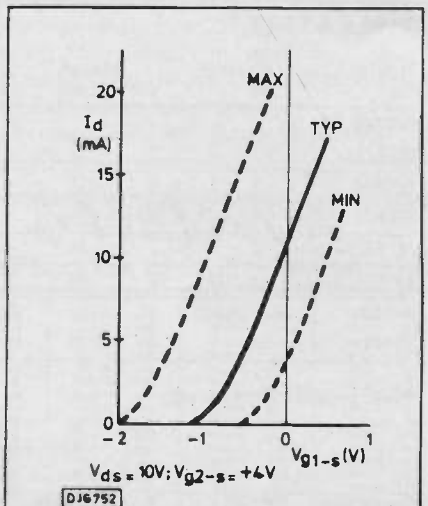


Fig 50. *Bias voltage against current*

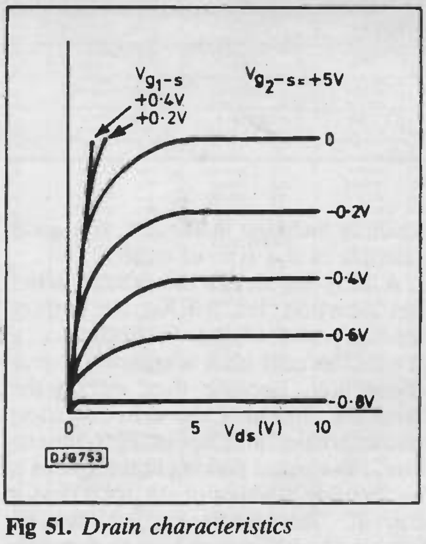


Fig 51. *Drain characteristics*

Further information for the would-be designer is given in Fig.50 and Fig.51, which show the mutual conductance curve and the drain characteristics respectively. As is clear from the graphs, this mosfet is a depletion mode device, which seems to be a characteristic common to most rf mosfets.

The curves in Fig.50 show that the bias voltage to produce any given current can vary from device to device by 1.2 volts, over which range the drain current changes by approximately 10mA. Clearly, a fixed bias voltage between gate and source would not be appropriate, and some means of stabilising the bias would be required. The circuit of Fig.48 demonstrates this. The voltage across R5 is approximately 12V, and fet bias voltage variations will change this by less than 10% from device to device.

Sometimes, for example to achieve the lowest possible noise figure in amplifying the signal from a low impedance source, it can be advantageous to feed the signal into the source terminal of the mosfet, as illustrated in Fig.52. In this case it is important to know the source impedance.

Forgetting any reactive effects, which are usually small, the resistance looking into the source is determined by how much the source current changes for a given change of source voltage, ie the Yfs figure in the data book. The Yfs is quoted as 10mA/V (min) and 14mA/V (typ). No maximum figure is given, but it would be safe to assume that few devices if any will exceed a gain of 20mA/V. 10mA/V corresponds to 100Ω, and 14mA/V to 71.4Ω so the source will provide a reasonable match to a 75Ω signal source.

POWER MOSFETS

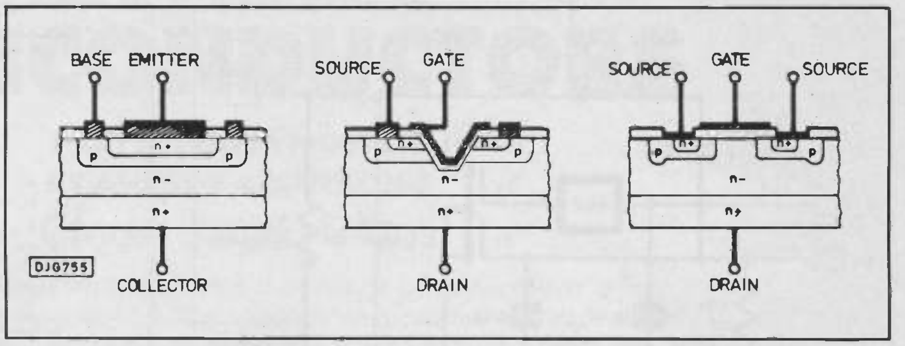
To delve further into the intricacies of rf design using dual gate mosfets would only be warranted in the design of a project, so now we will turn to look at power mosfets. For the purposes of this feature, I am defining power devices to include small mosfets such as the VN10, because these devices are often used in ways more concerned with power switching and control than signal amplification. They are, at any rate, in a very different category from dual gate mosfets for rf use.

Several different types of power mosfets are available, and are intended for different purposes. Fig.53 compares vmos and dmos device structure with a four layer bipolar transistor. As well as showing general device structure, this comparison shows that power mosfets include both an antiparallel drain-source diode and a parasitic bipolar transistor in their structure.

The diode is often a useful addition to the device, and its current and switching time is specified in some data sheets. The transistor, on the other hand, is completely unwanted. Under most circumstances it cannot be biased on, and in any event its gain is very low, but it can cause trouble in some switching circuits, where charge storage can cause an unwanted conduction path for a brief period. Normally, however, it can be ignored.

Both vmos and dmos devices have a relatively low gate capacitance and a correspondingly high on resistance. Producing devices with a lower on resistance almost inevitably results in higher capacitance. For example, the VN67 vmos fet has an input capacitance (Ciss) of 50pF, and a reverse transfer capacitance (Crss) of 10pF. Its R_{DS} (on) is 3Ωμ. The IRFZ30 hexfet has a Ciss of 1600pF and a Crss of 200pF. It takes much more drive current to switch this latter fet quickly, but its R_{DS} (on) is 0.05Ω.

The structure of a hexfet is shown in Fig.54. The typical hexfet has a large array of hexagonal elements, with a correspondingly large gate area. Note the use of a polysilicon gate rather than the metalised type used in vmos fets. It would be more difficult to deposit a metal gate to the required accuracy than to diffuse a layer of silicon.



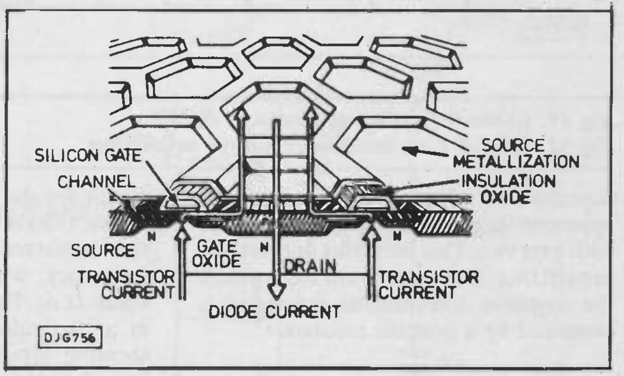


Fig 53. *(Above) Junction transistor, VMos and DMos comparison.*
L-R: 4-layer bipolar transistor, VMos fet, vertical DMos fet.
Fig 54. *(Right) Hexfet structure.*

TABLE 4 FETS

Type No.	gfs(min) mS	Idss mA min	Idss mA max	Vgs(off)V min	Vgs(off)V max	Ciss pF	Crss pF	Chan-nel	COMMENTS
junction fets									
2N3819	3	2	20	–.7	–6	8	4	n	Gen purpose
BF245B	3	6	15	–.25	–8	4	1.1	n	Tighter spec
2N3820	0.8	0.3			8	32		p	complement
MPF102	2	2	20	–0.5	–7.5	7	3	n	vhf/uhf mixers
BFW11	3	4	10		6	5	0.8	n	low noise
mosfets									
BF981	10	4	25		–2.5	2.1	30fF	n	Dual gate vhf
Power mosfets (enhancement)									
		Rds (on) Ohms	Id (on) A	Vgs (th) min	max				
VN10LM	200	5	0.75	0.8	2.5	60	5	n	60V
VN67A	170	3.5	1.5	0.8	2.5	50	10	n	60V
ZVN0106A	250	4	0.32	0.8	2.4	75	25	n	60VE line
ZVP0106A	150	5	0.28	–1.5	–3.5	75	45	p	60Vline
IRF530	4000	0.18	14	2	4	800	150	n	100V
IRF830	2500	1.5	4.5	2	4	800	200	n	500V
IRF9530	2000	0.3	–12	–2	–4	700	200	p	100V
IRFZ30	9000	0.05	30	2	4	1600	200	n	50V

Key gfs = transconductance
Idss = zero gate voltage drain current
Vgs(off) = voltage at which drain current declines to leakage level
Ciss = input capacitance
Crss = reverse transfer capacitance
Rds(on) = fully saturafed drain source on resistance
Id(on) maximum on drain current
Vgs(th) = conduction threshold (for enhancement device)
fF = femto farads
mS = milli siemens

OTHER POWER FETS

There are a couple of other sub-genres of power fets which are of interest. The first is typified by Ferranti's ZVN and ZVP range of devices. These devices have a vertical dmos structure, and are available in a range of packages from E-line to TO3. The E-line devices are suitable for such purposes as switching lamps and relays when driven from cmos, in situations when darlington transistors would otherwise be required. They can also be used effectively for small switched mode power supplies and voltage converters. The ZVN0106A, which is included in Table 4, is a good example of this type of mosfet.

A fairly new device (introduced in the last year) is the HEXsense current sensing power mosfet. In this device, a few of the cells have a separate source connection. Because they are on the same die, and have the same electrical characteristics and operating temperature, the current flowing in these cells is an accurate fraction of the total device current. This lower current can be measured with a much lower power dissipation than by measuring the whole device current. A typical current sense ratio if 1:1500.

A major application of HEXsense devices is likely to be in switched mode power supplies, where the switch current must be monitored. The linearity is not good enough to provide the only source of feedback in audio amplifiers, but the devices should be ideal for servos in which there is an overall control loop.

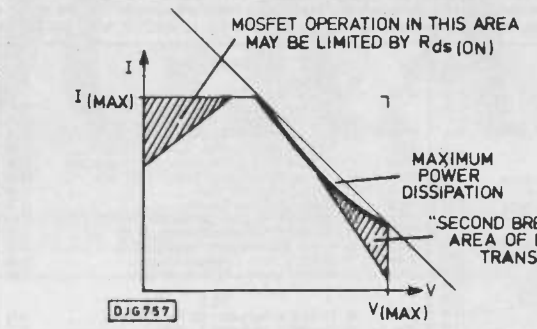


Fig 55. *Safe operating areas of typical power bipolars and fets.*

POWER CHARACTERISTICS

One obvious application for power mosfets is in switched mode power supplies. In this application, mosfets have one major advantage over bipolar transistors, in that they can be connected in parallel to increase the overall current capability without the need for current sharing resistors. If two similar mosfets are connected in parallel and driven with adequate voltage to make them switch, then a reasonable overall current rating for the circuit is 80% of the sum of the ratings of the parallel devices. This applies to larger numbers of parallel devices, though statistically there will be a greater safety margin if the 80% figure is used with larger numbers.

The reason for this is quite simple. While bipolar transistor have a positive temperature coefficient of current, which is to say that collector current increases as temperature increases, fets operate in the reverse manner. The value of R_{DS} (on) increases with temperature, so that if one device in a parallel combination passes more than its share of the current it will warm up and its resistance will increase relative to the other fets in the circuit. Thus any imbalance of current is self limiting.

A factor which is helpful when designing power linear circuits is the absence of second breakdown in power mosfets. The operating conditions are limited by the maximum voltage rating at one extreme, the maximum current rating at the other, and otherwise only by power dissipation. This is illustrated by Fig.55, which compares the safe operating areas of typical power bipolar and field effect transistors.

To understand why power mosfets are better, imagine a large area power device (fet or bipolar) as a number of tiny devices in parallel. Bipolar transistors tend to share current unevenly, and destroy the highest gain device, while fets share current more evenly. The same effect occurs over the area of a large device, just sufficiently to generate hot spots in the collector bias junction which break down destructively at a lower voltage than the normal maximum voltage rating. When you think about it, it is surprising that second breakdown is not a worse problem than it actually is.

That concludes this episode in the semiconductor saga. Next month I intend to cover mosfet circuit applications, and may be able to include an audio power amplifier "mini project." There will also be a number of useful circuit building blocks. PE

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VP16	50	Wirewound Resistors, mixed watt values	£1.00
VP140	50	Precision Resistors, 1% tolerance	£1.00
VP181	100	1 and 2 watt Resistors, assorted values	£1.00
VP287	100	Close tolerance Resistors, .05-2%, 10-910 ohms, mixed	£1.50
VP288	100	Close tolerance Resistors, .05-2%, 1K-820K, mixed	£1.50
VP289	100	Metal oxide high stab. Resistor, ¼w 2%, mixed values	£1.50

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VP10	60	C280 Capacitors, metal foil, mixed values	£1.00
VP11	50	Electrolytics, all sorts	£1.00
VP12	40	Electrolytics, .47mf-150mf, mixed volts	£1.00
VP13	30	Electrolytics, 150mf-1000mf, mixed volts	£1.00
VP14	50	Silver Mica Caps, mixed values	£1.00
VP15	25	.01/250v Min. Layer Metal Caps	£1.00
VP180	25	Tantalum Bead Caps, assorted values	£1.00
VP182	4	1000uf 50v Electrolytics	£1.00
VP192	30	Min. Electrolytics, mixed values, .47mf-1000mf 6/16v	£1.00
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VP138	20	Assorted LED Displays. Our mix, with data	£5.00
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VP199	4	LD707R LED Displays, CA	£1.00
VP203	15	Triangular shape LED's, mixed colours	£1.00
VP204	10	Large Green LED's, 5mm	£1.00
VP205	10	Small Green LED's 3mm	£1.00
VP206	10	Large Yellow LED's, 5mm	£1.00
VP207	10	Small Yellow LED's, 3mm	£1.00
VP208	10	Large LED's clear showing Red, .2"	£1.00
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VP268	15	LED Panel Mounting Clips, metal and plastic. 3-5mm	£1.00
VP269	2	Red Flashing LED's, 5mm	£1.00
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VP32	20	3A SCR's TO66, up to 400v, uncoded	£1.00
VP33	100	Sil. Diodes like IN4148	£1.00
VP34	200	Sil. Diodes like OA200/BAX13-16, 40v 200mA	£1.00
VP35	50	1A IN4000 Diodes, all good, uncoded, 50v min	£1.00
VP49	30	Assorted Sil. Rectifiers 1A-10A, mixed volts	£1.00
VP141	40	IN4002 Sil. Rectifiers 1A 100v, preformed pitch	£1.00
VP142	4	40A Power Rectifiers, silicon, TO48 300 PIV	£1.00
VP143	5	BY187 12KV Sil. Diodes, in carriers, 2.5MA	£1.00
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VP187	10	SCR's 800MA, 200v, 2N5064, plastic, TO92	£1.00
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VP195	50	OA47 gold bonded germanium Diodes, uncoded	£1.00
VP196	50	OA70-79 detector germanium Diodes	£1.00
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VP198	40	BA248 Sil. Diodes, 350v 2A, fast recovery	£1.00
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VP275	3	5A 400v SCR's, TO220, TIC106D	£1.00
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VP277	4	Triacs 2Amp 400v TO-39	£1.00
VP278	4	6Amp 1000v plastic Silicon Rectifiers	£1.00
VP283	5	Diac BR100, triac trigger	£1.00

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VP39	100	Sil. Transistors, PNP plastic, coded, with data	£3.00
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VP48	5	Pairs NPN/PNP plastic Power Transistors, 4A, data	£1.00
VP50	60	NPN Sil. Switching Transistors, TO-18 and TO-92	£1.00
VP51	60	PNP Sil. Switching Transistors, TO-18 and To-92	£1.00
VP60	100	All sorts Transistors, NPN/PNP	£1.00
VP150	20	BC183B Sil. Transistors, NPN 30v 200mA Hfe240+ TO92	£1.00
VP151	25	BC171B Sil. Transistors, NPN 45v 100mA Hfe240+ TO92	£1.00
VP152	15	TIS90 Sil. Transistors, NPN 40v 400mA Hfe100+ TO92	£1.00
VP153	15	TIS91 Sil. Transistors, PNP 40v 400mA Hfe100+ TO92	£1.00
VP154	15	MPSA56 Sil. Transistors, PNP 80v 800mA Hfe50+ TO92	£1.00
VP155	20	BF595 Sil. Transistors, NPN eqvt BF184 H.F. TO92	£1.00
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VP158	15	ZTX107 Sil. Transistors, NPN eqvt BC107 plastic	£1.00
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VP167	1	BUY69C NPN Transistors, TO3 VCB 500, 10A, 100w, Hfe15+	£1.00
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VP210	12	74S74	£2.00
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VP212	10	CD4011B	£2.00
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VP215	10	741P 8 pin	£2.00
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VP295	1	6821P Peripheral Interface Adaptor (PIA)	£1.50
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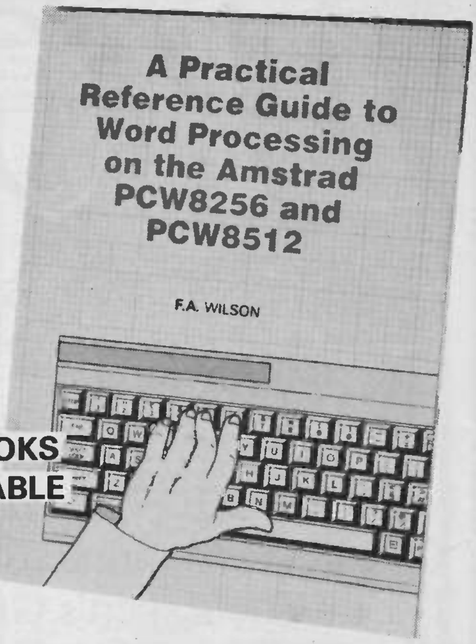

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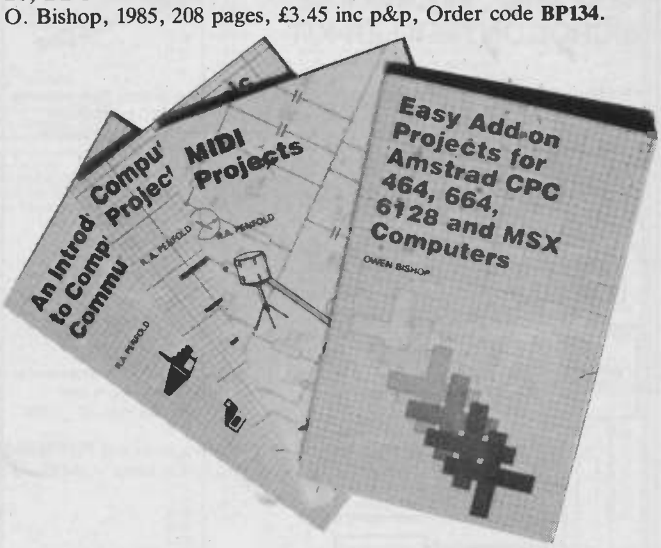

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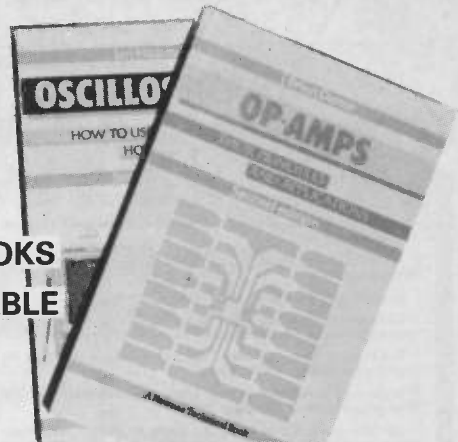

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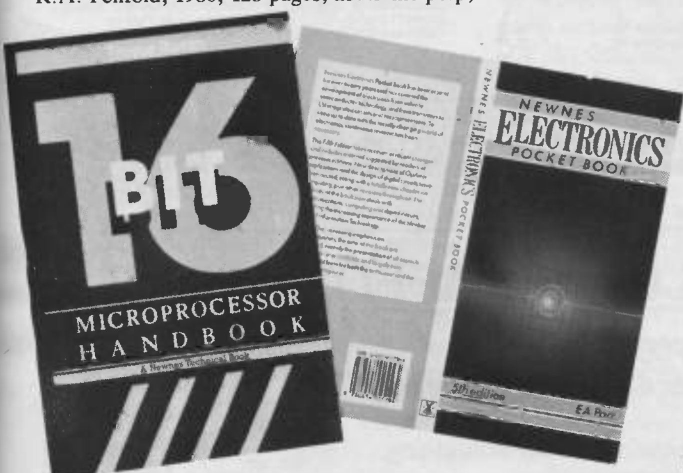

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REPORT BY TOM IVALL

INDUSTRY NOTEBOOK

TWENTY-YEAR SHAKE-OUT

The retreat of the UK semiconductor industry, now regarded virtually as mythical, is only part of a worldwide concentration of manufacturing control.

When Ferranti sold its semiconductor business to Plessy a few months ago we witnessed the last stage in the rise and fall of the British-owned integrated circuits industry. Let's hope that Plessey makes a success of the new merged business. It stands a good chance of doing so, for it has now become the largest manufacturer of application-specific ics in Europe. And the market experts are predicting a world growth of about 25% per annum in this part of the semiconductor industry over the next few years.

But Plessey also finds itself virtually the last bastion of Britain's presence in the world chip-making scene. As such it has become a cynosure. All national hopes are pinned on it. At the same time this very fact shows that the company has had great strength to survive so long in this highly competitive field. It has made the right technical and commercial decisions – particularly to stay out of the cut-throat business of manufacturing standard devices for high-volume production.

Twenty years ago there were five British-owned ic manufacturers operating in the UK: Ferranti, Marconi, Plessey, AEI and Welwyn (in rough order of production volume). Subsequently AEI merged with GEC and semiconductor manufacturing was carried on by the last-named. GEC also had a one-third stake in a European joint-venture company called Associated Semiconductor Manufacturers, the other two-thirds being owned by Mullard, the Dutch Philips subsidiary.

But already in 1968 the big American companies like Texas, Motorola and SGS-Fairchild, assisted by a number of small suppliers like RCA, Sylvania and Transitron, had secured about 70% of the UK market for ics. And this was even before Intel had appeared on the scene with the first microprocessors and before the great commercial onslaught of the Japanese semiconductor firms.

So throughout the 1970s the British-owned ic companies were increasingly on the defensive. Their market share continued to shrink. At this point the rapid development of microprocessors and their associated semiconductor memories placed vlsi firmly in the centre of the electronics stage. The then Labour government feared that the UK would be elbowed out of vlsi chip-making altogether, and, in the absence of private capital, decided to invest public money in a nationally owned enterprise for large-volume manufacture of standard vlsi devices. Thus Inmos was born.

You may have thought I had forgotten Inmos in my preamble about Plessey now being the last bastion of the UK chip industry. It's true that Inmos is still (at the time of writing) a British-owned company. But there is now even more doubt about its future than when I reported on its situation in October 1986.

Although the Transputer family of products has been quite successful, taking about 5% of the world market for 32-bit microprocessors, the overall commercial progress of the company has been downhill all the way. In 1984 the UK government (by then Conservative) sold its majority shareholding to Thorn-EMI, but the new owners failed to turn the business round into steady profitability. Exposure to the supposedly healthy atmosphere of private enterprise was not in itself enough. Inmos is now losing about £95 million a year.

In my October 1986 report I mentioned that Inmos was cutting costs by pulling out of the highly competitive dynamic ram business, running down the Colorado Springs plant in the USA and shedding 670 jobs in the process. Now the contraction has been taken a stage further. Static rams have gone too, having also proved unprofitable, and the Colorado Springs factory has been completely shut down, with a further loss of 300 jobs.

It's no secret that Thorn-EMI wants to sell Inmos. The cost cutting exercises on memories and the resulting concentration on the Transputer products (which now account for over 50% of the chip-maker's revenue) are restructuring moves designed to make Inmos a more attractive package for potential buyers.

During 1987 Plessey was being discussed as possible purchaser, but while Inmos was still making standard chips the Plessey management declared it was definitely not interested. Will the present changed structure of Inmos make any difference? We can only wait and see. But if Plessey does not acquire Inmos, this once bright hope of state enterprise will probably fall into foreign hands. If a Japanese, American or European company did buy Inmos and made a big success out of the Transputer, as seems possible, we could only hope that certain decision-makers in Britain would have the moral decency to kick themselves really hard.

Ferranti's decision to sell off its semiconductor business to Plessey (for £30 million) is not hard to understand. Over two decades or more it made valiant efforts to establish itself as a viable chip-maker and, while doing so, introduced some technically advanced and useful products, such as the uncommitted logic array. But in the end the world competition proved too much.

The 1986/87 trading year was particularly bad because of very difficult conditions in the USA. Turnover was £66 million, but operating profit fell dramatically from the £3.7 million of the previous year to a mere tenth of that figure. The Ferranti management said during 1987 that it saw little prospect of an improvement, so the announcement of the sale to Plessey was not entirely a surprise.

All this contraction in the indigenous British semiconductor industry may seem a terrible tale of woe. But the process is by no means peculiar to the UK. In February of last year, for example, I reported that US companies were getting out of semiconductor memories. More recently the Italian firm SGS has merged with the semiconductor business of Thomson of France. Siemens and Philips have been defensively pooling some of their resources. In America again, the two giants General Electric and IBM have recently got together to develop application-specific ics. By the end of this decade the world semiconductor market could well be dominated by a mere half-a-dozen multinational companies. PE

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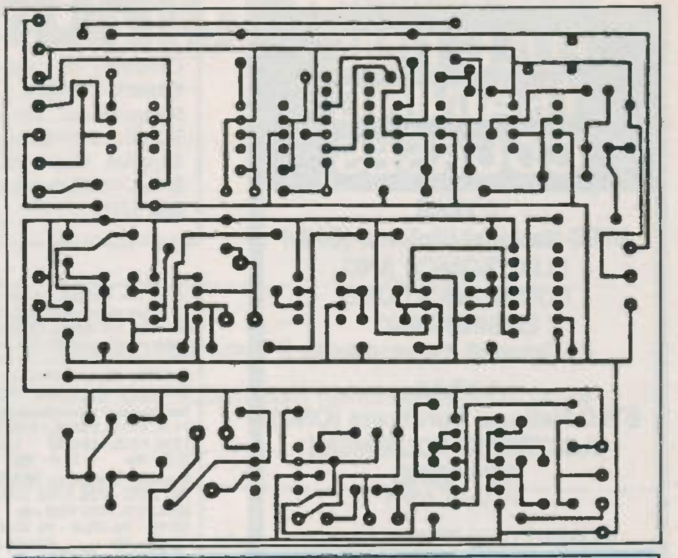

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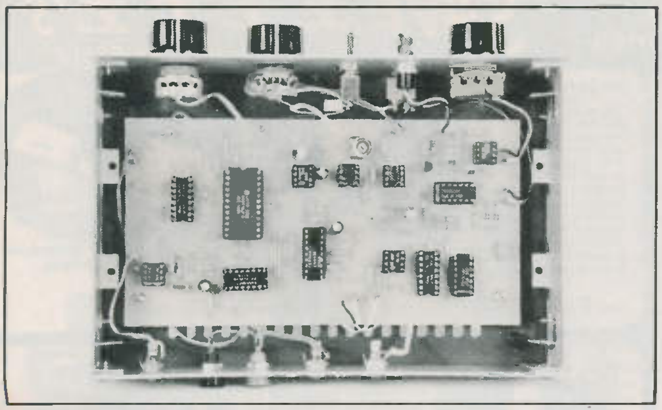

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IDENTITIES

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

TOOLS

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

ASSEMBLING THE PCB

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

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

SOLDERING

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

WIRING

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

TESTING

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

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

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

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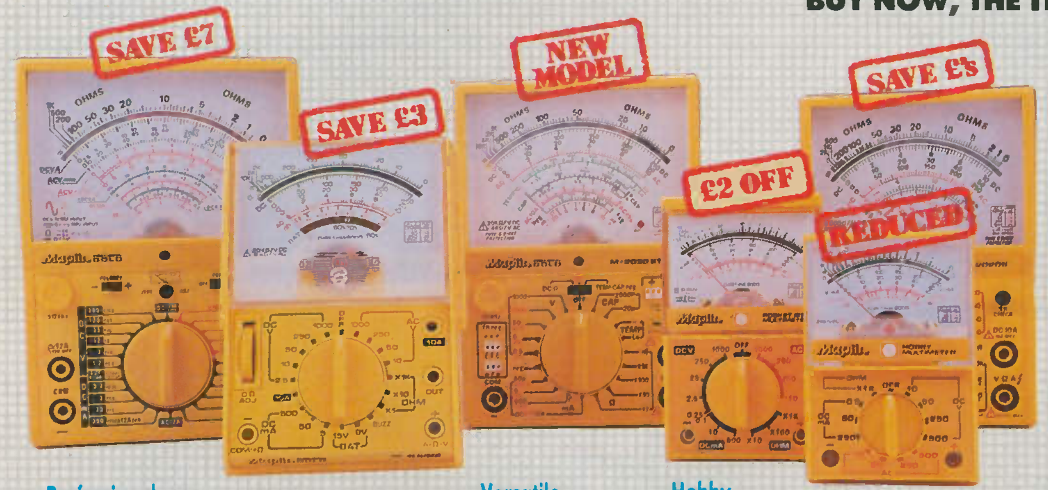

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