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NEXT MONTH
Have we got news for you? Yes indeed - next month PE will look even better and brighter. We’re nearing our 25th birthday and to prepare for it we’ve got the decorators in! And we shall be asking for your help in deciding how your favourite magazine should look as we approach the 1990s. There’s the customary great mix of projects and features too, plus another fabulous competition to enter!

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PRACTICAL ELECTRONICS
VOL 25 NO 4 APRIL 1989

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PE TAKES TECHNOLOGY FURTHER - BE PART OF IT!
WHAT'S NEW

Canon Stills Video

A new compact High-band still video system has been launched by Canon with many applications, particularly in the areas of audio visual presentations. The NTSC-compatible system comprises the RC-470 fully automatic compact still video camera, the RV-301 video player, and a new colour video printer is also available, the RP-420.

The RC-470 is a lightweight autofocus camera capable of a fast 20 images-per-second operation using a half-inch ccd with 360,000 pixels and a video resolution of 400 lines both horizontally and vertically for high quality pictures. In frame mode, the camera can record up to 25 images on video floppy disk in optimum quality, with each image using two tracks, while 50 images can be recorded in field mode in situations where use of the maximum number of images is more important. The disks can either be stored or erased for re-use.

A bright bifocal lens offers a choice of 9mm wide or 16mm tele (equivalent to 48mm and 86mm camera), and automatic functions include exposure control, backlight compensation, and variable built-in flash.

Images on the floppy disk can be viewed on an NTSC tv screen or monitor by inserting it in the RV-301 video player, and output can also be recorded on any compatible video deck. For fast colour printing of images from any NTSC video source, including still video, the RP-420 colour video printer offers a variety of formats by a colour ink/film thermotransfer method.

CONTACT: Canon (UK) Ltd., Canon House, Manor Road, Wallington, Surrey, SM6 0AJ. Tel: 01-773 5173

How Green Is Your Battery?

If you're switched on to environmental issues you may want to switch to the powerful new Philips Greenline range of mercury-free batteries.

As well as being friendlier to the environment these batteries have a 10% longer life than their "Super" batteries. They are produced in three sizes - R20G, R14G and R6G and available immediately from battery retailers.

"Mercury is a strong environmental issue in Europe and although the mercury content in our zinc-carbon batteries was always low, it has now been reduced to zero," explained Peter Croker, marketing manager, Philips Consumer Lighting. Greenline are interchangeable with normal batteries so have a wide variety of uses from alarm clocks to toys and are particularly useful for "high drain" equipment such as personal stereos and radios. Philips claim that under normal use they are 100% leakproof.

The introduction of these batteries to the UK follows closely upon the immediate success of the new range in Germany where 'green' issues are also widely supported and Greenline batteries are the leading mercury-free brand.

CONTACT: Publicis Ltd., 67 Brompton Road, London, SW3 1EF. Tel: 01-823 9000

We have recently received the following catalogues and literature:

Five Star Connectors (a division of STC) have produced a new 446 page A5 catalogue covering a comprehensive range of connectors from 16 of the world's leading manufacturers. It's easy to use format makes it essential reading for anybody buying connectors. Five Star Connectors, Edinburgh Way, Harlow, Essex, CM20 2DF. 0279 442851.

Fane are well known for the quality of their loudspeakers and their new 52 page brochure well illustrates speaker enclosure design and construction. Its schematic drawings will also be of interest to anyone wishing to build their own enclosures. Fane Acoustics Ltd., 286 Bradford Road, Bailey, W.Yorks, WF17 4PT. Batley 476431.

D and M Components' computer listing of their product range has been received - 14 pages of parts of interest to any constructor. D and M will also do their best to obtain specialist components to order, they have a bulk purchase offer, and a discount scheme for electronics club members. D and M Component Supply Service, 2 Glentworth Avenue, Whitmore Park, Coventry, W.Mids, CV6 2HW. 0203 333195.

Unite! Ltd, Unitel House, Fishers Green Road, Stevenage, Herts, SG1 2PT. 0438 312393.

'Allo 'Allo

Listen very closely, I shall say this only once:

You might think that in calling its latest product a universal calibrator, the French company Aoip is pitching it's new 8 page catalogue Unite! Ltd, Unitel House, Fishers Green Road, Stevenage, Herts, SG1 2PT. 0438 312393.

Any and M Components' computer listing of their product range has been received - 14 pages of parts of interest to any constructor. D and M will also do their best to obtain specialist components to order, they have a bulk purchase offer, and a discount scheme for electronics club members. D and M Component Supply Service, 2 Glentworth Avenue, Whitmore Park, Coventry, W.Mids, CV6 2HW. 0203 333195.

Unite! Ltd, Unitel House, Fishers Green Road, Stevenage, Herts, SG1 2PT. 0438 312393.
**Ironing Out Hot-spots**

Greenwood Electronics have introduced a new version of their highly-successful electronically-controlled Oryx Platinum 45 mains iron. While still offering such advanced features as spike-free switching and proportional control electronics, a radical redesign now relocates the warmer parts of the control circuit to the base of the safety stand. Not only does this eliminate heat from the handle, it also reduces the weight of the iron and enables the platinum sensor to concentrate on measuring the heating element without having to compensate for other hot spots. This leads to far greater accuracy of temperature control – now to within just 2°C.

The solid-state electronic control system has been designed for conditions where stability, reliability and mechanical strength are prime requirements. The 45W iron is available in 24V, 115V and 220-240V versions and is now supplied with a safety stand at no extra cost.

**CONTACT:** Greenwood Electronics, Portman Road, Reading, Berkshire, RG3 1NE, England. Tel: 0734 395843

**Double Hyding**

The new Boplast Plus housing from enclosure specialists West Hyde has two separate compartments, one for the electronics and a smaller one with its own lid for the terminations.

This compact housing has been developed from the best-selling Boplast range of sealed plastic enclosures. The case is moulded in light grey ABS and has a neoprene rubber gasket in each lid, providing a dustproof and hoseproof seal. The lid of the main compartment may be used as additional enclosure. The case is moulded in light grey ABS and has a neoprene rubber gasket in each lid, providing a dustproof and hoseproof seal. The lid of the main compartment may be used as additional enclosure. The case is moulded in light grey ABS and has a neoprene rubber gasket in each lid, providing a dustproof and hoseproof seal. The lid of the main compartment may be used as additional enclosure.

**CONTACT:** West Hyde Developments Limited, Unit 9, Park Street Industrial Estate, Aylesbury, Bucks, HP20 1ET. Tel: 0296 20441

**Telecom-puters**

British Telecom have launched a new family of powerful business computers of its own design and manufacture, with sales prospects of £200 million during the next few years. The new machines, known as the M6000 series, use a Unix operating system. They are able to interwork with many existing machines from other suppliers. This will give users rapid access to up-to-date information stored on computers sited elsewhere – whether in the same building or on the other side of the globe.

In addition, they will have the power of the M6000 processors at their fingertips for the full range of administrative and business activities such as integrated office automation, word processing, spreadsheets, database access, electronic mail, graphics, tele management, personal organiser, and desk calculator.

The M6000 machines have been designed by British Telecom and are made in its Fulcrum factories in Birmingham.

Commenting on the new machines, Mr. John McMonigal, Managing Director Operations, of British Telecom's Communications Systems Division said: "Our M6000 computers are yet another indication that British Telecom is steadily implementing its strategic intention of becoming a major player in the information services market place.

**CONTACT:** British Telecom Centre, Floor A3, 81 Newgate Street, London, EC1A 7AL. Tel: 01-726 4444

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

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


Apr. 4-6. Scottish Computer Show. Scottish Exhibition Centre, Glasgow. 061 832 4242.

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


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

May 9-12. Autumn Robotics and automation exhibition. NEC, Birmingham. 01-891 5051.


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


Nov. 7-11. Protoelectronics. 8th International Trade Fair for Electronics Production. Munich Trade Fair Centre. 01-948 5166.
proposed that all electrical appliances in the near future should have a special connector called CEBus, which would act like an RS232 serial port interface on computers. CEBus would enable domestic appliances to be connected to each other and also, by using a command language similar to BASIC, to be controlled by computers. It is clear from shows like this, as well as the London conference on which we report on page 12, that internationally, manufacturers believe domestic automation is no gamble.

### Young Women Engineer Award

Susan Holbrook, age 27, a Telecommunications Engineer from Gosnall, W. Yorkshire, has won the 1988 Young Women Engineer of the Year Award. At a recent ceremony in London, The Rt Hon Kenneth Baker MP, Secretary of State for Education and Science, presented her with the prize of £500 and an inscribed rose bowl. Two special awards of £100 each were presented to Kathryn Maund, age 27, a Research and Development Engineer from Northolt, Middlesex, and Carol Smith, 24, an Electrical Designer from Warrington, Cheshire, the joint runners-up in this nationwide competition. Sponsored by The Caroline Hasten Memorial Trust (CHMT) and The Institution of Electrical and Electronics Incorporated Engineers (IEEIE), this Award - formerly The Girl Technician Engineer of the Year Award and now in its eleventh year - focuses attention on electrical and electronic engineering as a worthwhile professional career for women, and highlights the role of the Incorporated Engineer.

CONTACT: John Chumnell, IEEIE, Savoy Hill House, Savoy Hill, London, WC2R 0BS. Tel: 01-836 3357

### Yeda Awards 1989

Now officially launched, the 1989 Young Electronic Designer Awards scheme has won the enthusiastic backing of the Confederation of British Industry and renewed sponsorship from leading semiconductor and computer manufacturers Texas Instruments Ltd, and electronics distributors Circit Holdings plc.

Commenting on the YEDA Scheme, CBI director general John Banham said, "As we move into the 21st century British business faces ever growing international competition. If we are to succeed it is vital that we ensure today's young people - tomorrow's workforce - not only have the necessary technical and commercial skills, but also a sense of the excitement and challenge of developing a product or service which will meet a market need. Over the last five years the YEDA scheme has made a most impressive contribution to doing just that, by encouraging young people to combine their technical skills creatively with an appreciation of the commercial demands of the marketplace. I have no hesitation in commending this initiative and wishing it continued success."

The basic challenge of the scheme is for students to produce an electronic device of their own which is original, effective and has a worthwhile application in everyday life. YEDA seeks to encourage young people to recognise areas in which innovative electronics could be of benefit and to carry the matter through from initial concept to marketable commodity. Thus, preparation requires not only theoretical knowledge but the development of commercial awareness.

A prestigious trophy and valuable cash prizes are presented to the winners in each category and in the senior age group there is the prospect of a job in electronics and course sponsorship.

Each school or college with one or more entrants reaching the regional judging stage in each category for a special award of useful electronic equipment from Circit, whilst a desktop publishing system valued at around £10,000 will be given by Texas Instruments to the educational establishment producing the project with most commercial potential. Every finalist wins a personal prize, as do their teachers.

The presentation ceremony will be held next June/July in London followed by an awards luncheon attended by finalists, their tutors and parents, representatives from the world of commerce, industry, education and the press.

For further information CONTACT: The YEDA Trust, 24 London Road, Hoxton, West Sussex, RH2 1AY. Tel: 0403 211048

### Biotech

Zola McMalcolm’s Biochromatic Electronics parable of PE April 88 would appear to be taking on greater reality - McMillan have published three new reference works on biotechnology. They are the International Biotechnology Directory 1989, the Biotechnology Guide USA, and Biotechnology in Singapore, South Korea and Taiwan. They cost £85, £80 and £45 respectively, plus £2 post and package, and are available from Globe Book Services Ltd, Stockton House, 1 Melbourne Place, London W1C 4LF. Tel: 01-379 4687.

P.S. If anyone is hoping to find an update on Zola Mc Malcolm’s work to commemorate the April Anniversary, so sorry but space has precluded it.

### Commanding Full House

The Winter Consumer Electronic Show, major US showcase for electronic products, was this year held in Las Vegas from 7th until 11th January. The show embraced personal computers, TVs, videos, stereo equipment, robotics and other consumer electronic products.

It was held at four different locations in this gambling capital of the world and according to the show spokesman, nearly 1,500 exhibitors from the US and abroad and spread their products covering an area of 17 football (American) pitches. All major companies were represented. The total attendance over four days was 130,000 visitors.

The main theme of this year’s CES was the automation of the home. Several US exhibitors at the show...
PRACTICAL ELECTRONICS APRIL 1989

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**MINIATURE RELAYS**
- Suitable for RF

**MINIATURE RELAYS**
- Suitable for RF
The Government White Paper on the future of Broadcasting in Britain promises several extra terrestrial TV channels in the 90s, in addition to the new satellite channels. Two quite different technologies will enable this; the more efficient use of existing frequencies in the uhf band, and extension of broadcasting into new, much higher, frequency bands.

Before publishing the White Paper — as a trigger for discussion and debate — the government had been waiting for a series of technical reports on high frequency (microwave) broadcasting commissioned by the Home Office and DTI. These tell us what is technically feasible.

The DTI had hired management consultants Touche Ross to advise on the feasibility of using microwave video distributing systems to give British TV viewers a wider choice of channels (Report on the potential for microwave video distributions systems in the UK, HMSO £8.75). The report looks at mvds as a way of providing 70% of British households with at least six, and ideally twelve extra TV channels; alternatively letting cable companies use microwave links instead laying cable under the ground.

Some countries, eg the US, already use mvds at relatively low frequency (between 1 and 6GHz). But the equipment comes mainly from Japan and this frequency band is already congested. At higher frequency (between 6GHz and 20GHz) more bandwidth is available but the receivers need gallium arsenide microchips which are not ready for mass production.

There is no margin for error when aligning the receiver dish at these frequencies, so do-it-yourself installation is impractical. Touche Ross believes that the development of circuitry to receive direct satellite broadcasts, at 12GHz, may make mvds equipment which operates at around this frequency available within eighteen months.

Frequencies above 20GHz are free, but transmitters which work with millimetre wavelengths are more expensive and receiver technology is still at the research stage. The DTI's researchers think low cost integrated circuitry may be ten years off. Touche Ross talks of 5-7 years. Only British Telecom, which is experimenting with high frequency mvds links at Saxmundham in Suffolk, talks optimistically about the technology being ready for exploitation now.

All microwave frequencies travel along line of sight, so the taller the transmitter the further they reach, provided there are no obstructions such as buildings or trees. Extra transmitters are needed to cover areas shaded from the main mast by obstructions. When atmospheric conditions make conventional uhf/tv transmissions fade, the effect is slight and brief. With microwave transmissions, fades are deep and last for minutes.

At frequencies below 14GHz, reflections from buildings are most likely to spoil the signal. Above that, bad weather and atmospheric pollution cut transmission range. At specific frequencies, chemicals block the signal path: water vapour at 22.5GHz and oxygen at 60GHz. This can be an advantage, for instance to keep transmissions private, or in a cellular radio system where separate transmitters serve individual zones.

Touche Ross believes that a 12 channel mvds service with 70% coverage of the UK is possible from around 40 transmitters — but only if space is found in the lower frequency band for which imported equipment is already available. Higher frequencies would need 50% more transmitters.

Touche Ross says that mvds is a cheaper way of offering extra TV channels than either cable or satellite. So if introduced early, it could stifle the growth of cable and satellite.

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So the DTI and Home Office now have some tricky decisions to make.

**TERMINAL ENCORE**

Recently I got a shock. Computer firm Unisys announced that it had sold some new computer equipment to the Federal Aviation Administration in the US. The equipment will help air traffic controllers guide aircraft in and out of Kennedy, La Guardia, Network and Islip airports. I asked for more details. When I finally got them I was left wondering how many people realise that New York's terminal radar approach system, known as NY Tracon, has until a few months ago been handling 1.7 million air operations a year with computer equipment that was installed in 1970.

As a result the NY Tracon computer has, until the Unisys upgrade, been relying on a 256k byte memory, made from magnetic cores. This technology was invented in the 1950s, by the Massachusetts Institute of Technology and was the first solid state memory. Each memory element is a doughnut-shaped ferrite core, wound with wires which carry an electric signal to switch the core magnetism between north and south, to store a binary one or zero. Groups of cores are wired together, in a flat cat's cradle, and sheets of wound cores are then stacked in a three dimensional memory module.

The advantage of core memory is that it is non-volatile. The digital code remains if the power fails. But core memory is very slow. Accessing each bit takes 850 nanoseconds. And modern computers have backup power supplies to keep the RAM working even when there is a power cut.

The new Unisys system uses conventional random access memory, of the type now standard for all personal computers. Memory capacity in the Tracon facility remains at 256k bytes, but access time reduces to 350ns. ram is far smaller too. The 256k bytes of core memory spread over six cabinets each a metre high, whereas only eight microchips are needed to provide 256k bytes of ram. The bulk storage system remains the same, a 100 Mbyte magnetic disk.

The NY Tracon facility has until now also used a primitive display system, with each controller working on a "dumb" terminal which simply displays images provided by the central computer. Tracon now gets 37 "smart" terminals of the type found in most modern offices, each incorporating its own microprocessor. The main computer software takes advantage of this intelligence to save more time.

The old system could handle 1200 aircraft at any one time. The new system manages 1500. By 1990 it will be able to track 2800. According to Unisys, many of the major air traffic control centres in the US are still using magnetic core memory.

I wonder how many people know that....
Recently, I came across a word I hadn’t heard before, an apparently concocted word, and one which I dislike intensely. But like it or not, it’s a word that could become increasingly part of our vocabulary. The word is domotic.

Its definition, judging by its usage, is “that which pertains to automation of the home”. The word’s origin is not known, but I have also seen it used in French technical literature, with the spelling of “domotique”, so perhaps they’re to blame! Certainly, with that pronunciation, it has a better ring to it than the Anglicised version. Whether French or English, the word probably comes from the integration of domestic and robotic.

Granted that, and my dislike of the word, I tried to think of another word which would express the same concept, but with a more appealing sound. Going back to origins, the words domestic and robotic stem from Latin and, you may be surprised to know, from Czech. The Latin source probably will not come as a cultural shock to those who know how the Romans revised our language as much as they did our transport system. (And some of today’s roads are still pretty historic!) Domus is the Latin root, meaning home or house.

But, “Robot is Czech?”, do you cry in automatic disbelief? So it seems. The root is supposedly robota, meaning statute labour. History has it that a certain Czech by the name of Karel Capek coined the word to describe a person of machine-like efficiency for the 1920 play “R.U.R.” (“Rossum’s Universal Robots”). Curiously, I recall once being told the root was the Polish word robare meaning to work. Still, perhaps one should be beware of memory and history (“History is bunk”, said Henry Ford in 1919, and someone I can’t remember said, “Memory is the thing you forget with”; note that, all computer users!) It could just be, of course, that both have their origins in the Latin roboro – to strengthen.

So what about another root meaning home or house? Problem, dom seems to be a common syllabic root for many languages, even Serbo-Croat appears to use it. How about Ancient Greek? The only thing AG ever did for me was to teach me the letters of the electronic alphabet, micros, omegas, things like that. However, the 1920 play “R.U.R.” (“Rossum’s Universal Robots”). Curiously, I coined the word to describe a person of machine-like efficiency for the 1920 play "R.U.R." (“Rossum’s Universal Robots”). Curiously, I recall once being told the root was the Polish word robare meaning to work. Still, perhaps one should be beware of memory and history ("History is bunk"); said Henry Ford in 1919, and someone I can’t remember said, “Memory is the thing you forget with”; note that, all computer users!) It could just be, of course, that both have their origins in the Latin roboro – to strengthen.

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I’m not often defeated, but I am this time, I can’t think of better word to use in place of domotic. This is a pity, because home automation technology is a subject currently receiving multi-billion pound international attention. Its implementation is no science fiction or amateur-boffin dream and it ought to have an acceptable short descriptive title. Heath-Robinson concepts are now relegated to the realms of fantasy (or the new museum soon to be opened!), big business is actively determined to make home automation a practical and desirable part of all our lives. Find out how real the technology is becoming by reading our Home Automation report.
### PRINTERS & PLOTTERS

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### UVERASERS

- **UVERASERS**

### UVERASERS

- **UVERASERS**

### EXT SERIAL/PARALLEL CONVERTERS

- **EXT SERIAL/PARALLEL CONVERTERS**

### RIBBON CABLE

- **RIBBON CABLE**

### DIL HEADERS

- **DIL HEADERS**

### ATTENTION

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<th>74ALS series</th>
<th>4000 series</th>
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<td>74HC139</td>
<td>74HC156</td>
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The objective of this article is to describe a circuit that can be easily driven from the Amstrad PC1512, or other PC-Compatibles, and will enable interfacing with both analogue and digital devices. The outline specification is as follows.

**SPECIFICATION:**
- Eight lines of digital output, ttl compatible.
- Eight lines of digital input, ttl compatible.
- Eight lines of multiplexed analogue input.
- One line of analogue output.

In the i/o address map of the PC1512 addresses 300H to 31FH have been designated for prototype cards, so that the use of these addresses is user definable. Thus for this circuit card the ports that are to be used will be contained within this range.

**EXPANSION SLOT**

The expansion slot is essentially an extension of the microprocessor bus that has been repowered and demultiplexed, so greatly simplifying the task of interfacing to the computer.

With the expansion bus there are certain constraints for effective interfacing to the microprocessor. For this particular system there is obviously a constraint on the current that a card can draw, though for this application the current drawn by the card is minimal. Another constraint is that the maximum number of loads per signal line should be no greater than two low-power Schottky, Is, devices. This presents a problem with the board as there are more than two devices to be connected to the data bus. It is thus necessary to buffer the data bus to ensure that the correct logic levels are maintained on all expansion slots. The type of device that will be used for this is a bi-directional non-inverting tristate buffer, type 74LS245.

**BASIC CIRCUIT DESIGN**

In the outline specification there are eight lines of analogue input, and there are basically two ways in which this could be provided; to use an eight channel analogue to digital converter, or to use a single channel adc and to multiplex the analogue inputs, the selection being performed in software.

Although the first method seems to be the easiest it is unfortunately the most expensive by a considerable margin, so the second method is adopted for this particular design.

For this implementation it is necessary to use an analogue multiplexer. These devices are only available in the cmos range of ics, and the particular type of device chosen is the 4051 8-to-1 device.
The input that is effectively connected to the ADC is selected by software. The three select inputs on the 4051 are held in their required states by a 74LS75 4 bit D type latch. The ADC used is the ZN448E, an 8 bit device with a linearity error of ±1/2 lsb. If a lower linearity error of ±1/4 lsb is acceptable the ZN447E could be used; another alternative is the ZN449E which has a linearity error of ±1 lsb.

The analogue output is provided by the type ZN425E 8-bit digital to analogue converter and a 741 opamp.

The digital input and output lines are provided by an octal transparent latch with tri-state outputs, type 74LS373. The high impedance tri-state output options are not required for this project and accordingly the outputs are held permanently active.

The distribution of control and data lines is shown in the block diagram or Fig.1.

CIRCUIT DESCRIPTION

Since I am using the port addresses from 300H to 303H for both input and output, the following signals have to be asserted to gain access to the board:

<table>
<thead>
<tr>
<th>SIGNAL</th>
<th>ACTIVE STATE</th>
</tr>
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<tbody>
<tr>
<td>AEN</td>
<td>LOW</td>
</tr>
<tr>
<td>ADDR3</td>
<td>LOW</td>
</tr>
<tr>
<td>ADDR4</td>
<td>LOW</td>
</tr>
<tr>
<td>ADDR5</td>
<td>LOW</td>
</tr>
<tr>
<td>ADDR6</td>
<td>LOW</td>
</tr>
<tr>
<td>ADDR7</td>
<td>LOW</td>
</tr>
<tr>
<td>ADDR8</td>
<td>HIGH</td>
</tr>
<tr>
<td>ADDR9</td>
<td>HIGH</td>
</tr>
<tr>
<td>ADDR10</td>
<td>HIGH</td>
</tr>
</tbody>
</table>

When these lines are in their respective active states the output of IC4a (Fig.2) will be low, indicating that the correct address is present to access the board. Although the address may be valid it does not necessarily mean that the CPU is trying to address I/O; it could for example be trying to access memory. It is therefore necessary to see if the CPU is trying to access I/O, and this is achieved by using IC4b and IC4c. If the CPU is trying to perform a read operation then the output of IC4c will go low due to it being low. However, if a write operation is to be effected then the output IC4b will go low due to it being taken low. If either of the outputs of IC4b or IC4c are low this indicates that a valid I/O operation is in progress, in which case the data bus buffer, IC1, has to be enabled by IC4d. The direction of the data flow is determined by the state of IOR.

Assuming that a valid I/O operation is in progress the next function is to decode address lines 1 and 0. For this purpose a dual 2-to-4 decoder, type 74LS139, is used. If an output operation is required then IC5b is enabled, otherwise, for an input operation IC5a is enabled. The port address map is given below:

**Address Allocation**

<table>
<thead>
<tr>
<th>INPUT:</th>
<th>300H digital input</th>
</tr>
</thead>
<tbody>
<tr>
<td>301H</td>
<td>analogue input</td>
</tr>
<tr>
<td>302H</td>
<td>n/a</td>
</tr>
<tr>
<td>303H</td>
<td>n/a</td>
</tr>
<tr>
<td>OUTPUT:</td>
<td>300H n/a</td>
</tr>
<tr>
<td>301H</td>
<td>digital output</td>
</tr>
<tr>
<td>302H</td>
<td>analogue input select</td>
</tr>
<tr>
<td>303H</td>
<td>analogue output</td>
</tr>
</tbody>
</table>

**INPUT CIRCUITY**

When address 300H is selected for a read operation the output IC7 is enabled and its latch disabled, ensuring that the data being read from the device is stable.
When address 301H is selected the data on the output of the adc is read in. The signal source input, ie A10 to A17, must have previously been selected to provide a start conversion signal. The reading of data from this device is conditional neither on the adc having finished its conversion, nor on the analogue switch ic11 having finished switching. In this mode of operation it is thus necessary to allow the adc and associated components a fixed amount of time to finish their respective operations. In practice, this means a delay between triggering and reading of around 20 microseconds. It should be noted that any of the voltages fed into the analogue multiplexer must be within the range of −5V to +5V, otherwise the board and maybe even the PC could be damaged.

If addresses 302H or 303H are selected for a read operation the data read would be equivalent to looking at the data bus in its tri-state condition.

OUTPUT CIRCUITRY
Selection of address 300H for a write operation is invalid.
When address 301H is selected for a write operation the data on the locally buffered data bus is latched into ic6 and, after the normal propagation delay, is available on the output. When address 302H is selected for a write operation ic10 is enabled and the lower four bits of the data bus are clocked into it. Three of its outputs are then used to drive the switch selector of ic11, allowing the required analogue input to be fed to ic12. R7 to R9 are the tie up resistors required when interfacing ttl outputs to cmos inputs. Another event occurring upon writing data to this port is that the adc is supplied with a start conversion signal.

The analogue signals fed into the analogue multiplexer are taken off the main circuit board in such a way that they are interleaved with ground signals to avoid channel cross coupling.
When address 303H is selected the contents of the data bus are latched into ic8. The output of which is used to drive the dac, formed by ic13, ic14, and associated components. The analogue output from ic8 is always available.

POWER SUPPLIES
The 5V power supply to the unit is obtained from the host computer, with decoupling provided by c4 to c10.

I/O BUFFER BOARD
The i/o buffer of Fig.3. provides the following facilities:
1. Enables all of the digital input and output lines to be tested. This is done by fitting links 1 to 16 only and setting switched 1 to 8 to off. (Links 9 to 16 are only to be fitted for test purposes.) The test software is then run to write data to the output port read it back to check the transfer accurately.
2. Enables all digital outputs to be monitored by fitting links 1 to 8.
3. Allows the logic level of any digital input line to be set within the ±5V limits.
4. Allows any of the analogue inputs to be set within the ±5V limits.
5. Allows the analogue output to be monitored.
   In addition to these features a small prototype area has been included.

**BOARD CONNECTION**

This can be easily achieved by a reasonable length of 34-way ribbon cable, less than about 1.5 metres, and two 34-way IDC sockets.

**BUFFER BOARD SEMICONDUCTORS**

IC1, IC2 74LS04

**RESISTORS**

RN1 330Ω sil network
RN2 4k7 network

**CAPACITORS**

C1 100nF polyester

**CONNECTORS**

PL1 34-way vertical mounting IDC header
PL2 to PL9 2.5mm PCB mounting jack sockets
PL10 3.5mm PCB mounting jack socket

**SWITCHES**

S1 to S8 DIL switch to SPST 8-way

---

**BASIC program PORTS**

```basic
10 REM *
20 REM PORTS
30 REM *
40 REM 2nd September 1988
50 REM *
60 REM Allows any port to be accessed by the user
70 REM *
80 CLS
90 PRINT "PORT EXAMINATION PROGRAM"
100 PRINT "Enter the address of the port to be written too (in decimal) : ";
110 INPUT port
120 PRINT "Enter the value to be written to port ", port " (in decimal) ; ";
130 INPUT value
140 IF value < 0 OR value > 255 THEN 220
150 OUT port, value
160 RETURN
170 PRINT
180 GOTO 90
190 REM Write data to port option
200 PRINT
210 PRINT
220 PRINT "Enter the address of the port to be read from (in decimal) : ";
230 PRINT "Enter the value to be written to port " , port " (in decimal) ; ";
240 PRINT "Value to output valid ?
250 IF value < 0 OR value > 255 THEN 225
260 OUT port , value
270 RETURN
280 REM Read data from port
290 PRINT
300 PRINT "Enter the address of the port to be read from (in decimal) : ";
310 INPUT port
320 PRINT
330 PRINT "Value read from port " , port " \nx \nx . INS (port) "
340 REM Exit option
350 REM)
360 END
```

**ABBREVIATIONS:**

DO: DIGITAL OUTPUT
DI: DIGITAL INPUT
AO: ANALOGUE OUTPUT
AI: ANALOGUE INPUT

Fig. 4 Circuit diagram of i-o buffer board

Fig. 5 Board connector SK2 (viewed from front)
CALIBRATION

To calibrate the dac run the program PORTS and write to port 303. Note that all the values referred to are given in hex. Set all bits to the dac low, then adjust VR1 until the output voltage equals zero volts. Set all bits to the dac high, then adjust VR2 until the output voltage equals 3.825V, (this gives an output of 15mv per lsb). Repeat the process again.

ADC CALIBRATION

To calibrate the adc the program ADC- CAL should be run. This continually reads data from analogue input zero. Then observe the following sequence to set up the device:

1. Apply a voltage of -4.9805V to analogue input zero and adjust VR4 until the data read back flickers between 01 and 00.
2. Apply a voltage of 4.9414V to analogue input zero and adjust VR3 until the data read back flickers between FF and FF.
3. Repeat step 1.
4. To halt the program press BREAK.

Obviously, this degree of accuracy is only available those with a sophisticated digital multimeter and a precision power supply. In most instances less precise setting up should provide satisfactory.

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- Screen using the stylus with the touch 2811 Cumana touch pad for the BBC B
- Z817 Exciting electronic football game - Also a quantity of 'returns' available - see the original cost!
- LM324 optical shaft encoder.
- Similar to RS631-62, but 80% cheaper! £8.50
- **SEMICONDUCTORS**
- Numbers in Cat - look at these sample prices:

  - LM171K £1.00, 6408RSL £3, 2725C-25 £6, 8423 £1.20, LM323K £3, DL146 £7, RS80101 £1.20, DL146 £9.50, 255 £10.15, 740 £14.20, 74HC124 £25.50

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- Brass spindle has 44mm long black plastic handle attached. Z4116 24 way (8 x 3) membrane keypad.
- Rubber suction feet. 200 £9.95
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- Screen using the stylus with the touch 2811 Cumana touch pad for the BBC B
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28_CABLE TIES - Extra thin, £5 per 100. Ref: BD91.

29_CABLE TIES - Extra short, £5 per 100. Ref: BD59.

30_CABLE TIES - Extra thick, £5 per 100. Ref: BD45.

31_CABLE TIES - Extra long, £5 per 100. Ref: BD13.

32_CABLE TIES - Extra narrow, £5 per 100. Ref: BD11.

33_CABLE TIES - Extra thin, £5 per 100. Ref: BD10.

34_CABLE TIES - Extra wide, £5 per 100. Ref: BD6.

35_CABLE TIES - Extra thick, £5 per 100. Ref: BD2.

36_CABLE TIES - Extra long, £5 per 100. Ref: BD1.

37_CABLE TIES - Extra narrow, £5 per 100. Ref: BD6.

38_CABLE TIES - Extra thin, £5 per 100. Ref: BD2.

39_CABLE TIES - Extra wide, £5 per 100. Ref: BD1.

40_CABLE TIES - Extra thick, £5 per 100. Ref: BD2.

41_CABLE TIES - Extra long, £5 per 100. Ref: BD1.

42_CABLE TIES - Extra narrow, £5 per 100. Ref: BD6.

43_CABLE TIES - Extra thin, £5 per 100. Ref: BD2.

44_CABLE TIES - Extra wide, £5 per 100. Ref: BD1.

45_CABLE TIES - Extra thick, £5 per 100. Ref: BD2.

46_CABLE TIES - Extra long, £5 per 100. Ref: BD1.

47_CABLE TIES - Extra narrow, £5 per 100. Ref: BD6.

48_CABLE TIES - Extra thin, £5 per 100. Ref: BD2.

49_CABLE TIES - Extra wide, £5 per 100. Ref: BD1.

50_CABLE TIES - Extra thick, £5 per 100. Ref: BD2.

51_CABLE TIES - Extra long, £5 per 100. Ref: BD1.

52_CABLE TIES - Extra narrow, £5 per 100. Ref: BD6.

53_CABLE TIES - Extra thin, £5 per 100. Ref: BD2.

54_CABLE TIES - Extra wide, £5 per 100. Ref: BD1.

55_CABLE TIES - Extra thick, £5 per 100. Ref: BD2.

56_CABLE TIES - Extra long, £5 per 100. Ref: BD1.

57_CABLE TIES - Extra narrow, £5 per 100. Ref: BD6.

58_CABLE TIES - Extra thin, £5 per 100. Ref: BD2.

59_CABLE TIES - Extra wide, £5 per 100. Ref: BD1.

60_CABLE TIES - Extra thick, £5 per 100. Ref: BD2.

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62_CABLE TIES - Extra narrow, £5 per 100. Ref: BD6.

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64_CABLE TIES - Extra wide, £5 per 100. Ref: BD1.

65_CABLE TIES - Extra thick, £5 per 100. Ref: BD2.

66_CABLE TIES - Extra long, £5 per 100. Ref: BD1.

67_CABLE TIES - Extra narrow, £5 per 100. Ref: BD6.

68_CABLE TIES - Extra thin, £5 per 100. Ref: BD2.

69_CABLE TIES - Extra wide, £5 per 100. Ref: BD1.

70_CABLE TIES - Extra thick, £5 per 100. Ref: BD2.

71_CABLE TIES - Extra long, £5 per 100. Ref: BD1.

72_CABLE TIES - Extra narrow, £5 per 100. Ref: BD6.

73_CABLE TIES - Extra thin, £5 per 100. Ref: BD2.

74_CABLE TIES - Extra wide, £5 per 100. Ref: BD1.

75_CABLE TIES - Extra thick, £5 per 100. Ref: BD2.

76_CABLE TIES - Extra long, £5 per 100. Ref: BD1.

77_CABLE TIES - Extra narrow, £5 per 100. Ref: BD6.

78_CABLE TIES - Extra thin, £5 per 100. Ref: BD2.

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94_CABLE TIES - Extra wide, £5 per 100. Ref: BD1.

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97_CABLE TIES - Extra narrow, £5 per 100. Ref: BD6.

98_CABLE TIES - Extra thin, £5 per 100. Ref: BD2.

99_CABLE TIES - Extra wide, £5 per 100. Ref: BD1.

100_CABLE TIES - Extra thick, £5 per 100. Ref: BD2.
HOME AUTOMATION

PART ONE BY JOHN BECKER

"ACROSS THE RAINBOW BRIDGE ... AND FROM WITHIN THE CASTLE'S CONFINES I YET MAY WIN THE WORLD"
(Wotan, expressing hopes for Valhalla)

The Automating the Home 88 conference and exhibition held during December was organised by the combined forces of the National Economic Development Office and RMDP to create a forum in which to explore the opportunities offered by the new market in home automation. The objective of the conference was to inform delegates about the concept of home automation and its importance as a market, and to provide information on some of the most important technological developments.

It was overwhelmingly clear that the speakers had great confidence in the abilities of home automation to provide society with products and services that will allow greater personal freedom, broader access to information, better conservation of energy and wider protection of the environment. Stress was placed on the importance of ensuring standardisation, on the need for reliability and simplicity of operation, and on the need for European manufacturers to win acceptance in a market threatened by US and Japanese domination.

Whereas Wotan’s Valhalla was destined to collapse through greed and conflict, Europe’s dawning Utopia has every potential for success if manufacturers can get their acts together and ensure that consumers can have confidence in the new products and services. For Britain’s manufacturers in particular, there are golden opportunities if they can meet the challenge and capitalise on their expertise. And for consumers around the world there are countless benefits to be gained from the new technologies emerging for the automated home.

I am grateful to RMDP for their kind permission to publish summaries of the information presented at the conference.

Fig.1. Principle domestic communications access

The first is integration - the interconnection of systems and appliances that currently operate independently, so allowing easier and more sensitive control. We already have familiar examples of integration, such as videos programmed to record directly from the tv, Prestel which makes use of the tv and the phone, and alarm systems that respond to smoke detection. A fully integrated home would allow control of many other functions, and could, for example, maximise efficiency by bringing all energy-consuming appliances under a single control.

Interactivity is the second element, a current example of which is the telephone, allowing a two-way link with the outside world. In an automated home the phone could be used for remote programming of appliances by a householder who is many miles from home. Many other benefits will also follow by taking advantage of existing technologies. The implementation does not require a massive new programme of

Fig.2. Stylised European concept of home automation as seen by APMF
technological development but it does require that domestic appliances, controls and communications must conform to consistent interconnective techniques.

With so much intercommunication between the home and the outside world, the issue of standards assumes even greater importance. The European model of home automation is of a home network to which appliances from any manufacturer can be connected and be able to speak to each other. For home automation to succeed, consumers must have a wide product choice from many different manufacturers, and confidence in the full compatibility between them. If consumers are forced to buy from only one manufacturer in order to maintain appliance compatibility, they could readily become disenchanted with the idea of full home automation. Standards are a kind of universal language, ensuring that intercommunication between products of the various conforming manufacturers are carried out accurately and easily, both within and outside the home.

As yet agreement on acceptable standards has not been reached. If Europe is to remain ahead of the competition in home automation threatened by Japan and the USA, European standards must be determined and published as quickly and widely as possible, and that they should be adhered to. If consumers are offered a hodgepodge of incompatible European products that cause them a lot of hassle and pain, they won't buy. South-east Asian companies that cause them a lot of hassle and pain, potch of incompatible European products that they won't buy. South-east Asian companies that cause them a lot of hassle and pain, potch of incompatible European products that they won't buy.

The economic and social benefits of home automation are considerable, and it is important that the consumer is given a wide choice of products from which to select.

The main task of the project is to develop a European standard. This involves coordinating industry-led groups in France, Italy, Netherlands, UK, West Germany and Sweden. The companies participating are: Siemens, Philips, Thomson and Thorn EMI...

The main objective of the project is to define an industry specification or standard for home systems. The standard will cover all layers of communications protocols from the physical interface to the application command language. Apart from achieving the direct benefit to the consumer of choice, a major reason for standardisation is to inspire the necessary sales volume, and so justify the development of low-cost electronic components for world-wide markets.

Eureka's scope covers three main areas: Control and monitoring - covering security/safety, heating and environmental control, energy management, appliance control. Entertainment/learning - covering audio/video distribution and interactive learning. External services - in the form of information services, home banking/shopping, work from home, telecontrol and telemetering.

The studies indicate that a very flexible communications network is required, and that for maximum flexibility each application should have a separate control box, containing its own control program, situated at a convenient point in the house. This must be able to communicate with other devices and appliances elsewhere in the house. There should be several levels of communications control media available to the systems designer, who would select those best suited to the application, either individually or as a combination. The choice of media should include wire-pairs, coax cable, mainsborne signalling, infrared and low power radio.

Many sub-networks can be created geographically (room-based) or by medium, enabling complex structures to be chosen. Fig.4 shows an example of a small section of such a network comprising three sub-networks. One of the main tasks on the project is to complete the demonstration models in order to test and finalise the specifications for the protocols and media. The remaining technical work on Eureka IHS should be completed in Spring 1989.

In parallel with the Eureka IHS project, other international standards bodies are preparing standards on home electronic systems. World-wide there is a joint committee of the International Standards Organisation (ISO) and the International Electrotechnical Commission (IEC). In Europe CENELEC is working on an official European standard, the planned single European market of 1992 being one of the driving forces. The Eureka group has been contributing to the international standards bodies and is studying the standards emerging from the USA and Japan.

The Eureka work ends during 1989, but the participants are planning an Esprit II Home Systems project to continue the work for the future. Additional major European companies have joined this consortium; ABB, AEG, British Telecom and Legrand. Philips will be the prime contractor and a further eleven smaller organisations have become associate contractors. Esprit II will further develop the work of Eureka, taking full account of new technology and a wider range of applications.
In addition to the applications previously identified, Keith Clarke pointed out the importance of communications via the automated home in terms of help for the disabled and sick, and recognised that many more applications will emerge, becoming more demanding as the years go by.

Many applications will require two-way communication, though some only work effectively in one direction, such as discs, cassettes and most of the radio technologies, with the important exception of cellular. Cellular radio is important because it will link into a European-wide, and possibly world-wide, personal mobility network operated by Telecom and others. Some sophisticated cable tv networks can also provide two-way communication.

Security is vital to communications systems serving the automated home. Programme providers will not wish to lose revenue through unauthorised access, and IT systems within the home will contain confidential information, not only of a personal nature, but possibly relating to companies for whom the occupant may be teleworking from home. Providing complete security for IT systems poses a formidable challenge to operators granted the record of computer hackers, telephone and cable tv freaks, video and software pirates.

The problem is most severe for those media which rely on local decoding devices for their security. Secure devices can be created, but only at a price. Systems which take into the home only the information which is required there, such as the telephone network and optical fibre network of the future, will be better placed to offer lasting security at an affordable cost.

The technically most attractive facilities must be affordable to the customer. There are no easy solutions, but for technically advanced products, low costs to the customer are achieved through volume manufacture. Two mechanisms can help to achieve this - by applying techniques previously proven in the business sector, and implementing satisfactory international standards.

Currently, POTS (the Plain Old Telephone Service!) provides many services, such as Prestel Videotex, for example. This was invented in the UK nine years ago, and has provided a valuable insight into the types of services that customers, when purchasing in an unsubsidised free market, require. They include teleshopping, home banking, agricultural information, and the purchase via the phone of software for home computers. Operating in a completely different and commercial regulatory environment, the French Minitel operation has put four million terminals into domestic homes and has stimulated a whole range of electronic services.

Services based on voice recognition also have major potential and the Royal Bank of Scotland experiment, using equipment developed by BT has had most encouraging results. Additionally, BT has of course been offering burglar alarm monitoring via the telephone for many years.

BT has introduced Integrated Digital Access (IDA). This has upgraded its copper network to carry digital data at rates up to 128 Kbits/sec for the benefit of business customers. Enhanced signalling facilities such as calling line identification currently enhance business security by identifying which customer is calling. This ability will enhance the security of several home

Fig.5. Section of a typical total home bus system (NEC Home Electronics Ltd)
HOME AUTOMATION

automation applications. It will have further impact in visual telecommunications, permitting still and, with some limitations, moving coloured pictures to be transmitted. This opens the way for the "viewphone" of particular benefit in teleshopping applications where good quality photographs can be provided via Photovideotex, allowing closer examination of goods before purchase. Upgrading the bandwidth of the telephone network will improve the range of telecommunications services, allowing system vocabularies to be increased. The greatest contributionIDA could make towards automation in the home is through teleworking. IDA would permit computer programming, and other areas such as graphical design, to be equally well performed from home.

The future of the telephone network lies with optical fibres extending to every home. This will facilitate the two-way transfer of high grade visual images for advanced viewphones and teleworking. The speed of implementation is likely to be influenced as much by regulatory restraints as by technical progress, though development is well under way. It is possible that the networks of the future may well be passive optical networks in which channels are switched without converting light to and from electronics, i.e., they will be photonic. This is probably the only communications system capable of offering the two-directional bandwidth and the security that will be required for the more ambitious applications in home automation.

Future optical fibre telephone networks will be surrounded by radio transmitters operating in a variety of modes and frequencies, giving customers full personal mobility. Cellular radio, cordless telephones and radio pagers are already well accepted, though their systems are currently fragmented. It is not possible, for example, to use a cordless telephone as a cellular radio even though the technologies are similar. However, the expectation is that in the future the customer will have a stylised personal communication, which will operate to any of a large number of receivers and transmitters.

Continuing growth in the transmission capabilities of connections to the home will be matched by a growth in the intelligence stored within the network. Modern exchanges already provide services such as call diversion, three-way calling and charge advice. These are the forerunners of even more sophisticated services.

With a periphery of radio transmitters, the telephone network will be able to route communications directly to the individual receiving the calls, to specific telephone locations as at present. If the called individual is unavailable to take the call, it could be routed to a particular new individual, or stored for later retrieval.

Telephoned telephone bills is another service that will become more widely available – providing the customer actually wants it. Some subscribers may not wish that records are made of the numbers being called, and such facilities may need to be restricted by customer preference, or by regulation - conclusions.

The telephone, or more correctly, the communication networks of the future will have a key role in bringing about the automated home. The networks will be progressively enhanced so that they can carry as much bandwidth as any of the applications now considered will demand. The question remaining is – has society and the market decided what it wants?

CABLE SYSTEMS

Keith Miles is the Director of Finance and Administration at the Institute of Economic Affairs, the well known free market "think tank. Formerly the Director of Finance and Operations at the Cable Authority, he has a past, present and continuing interest in the development of new marketplace services on telecommunication systems. At the time of the conference he had just received the recent White Paper on Broadcasting, and though he'd had little time to digest its implications, he felt obliged to comment on it. He considered that its proposals could have an important effect on the pace of development for cable systems...

Development will also be affected by the infrastructure study being carried out by the DTI into telecommunications. One paragraph in the White Paper succinctly puts the present policy – "The Government has been keen to facilitate the development of broadband cable, at a pace determined by the market, as a way of providing additional programme services, developing new interactive services and also, in the longer term, as a possible route to increasing competition in telecommunications".

The Paper correctly summarises the present position that "the growth of new cable systems has been slow, though it is now picking up... (One reason has been) the high capital costs of installing a cable system and the absence of any significant revenue in the early years... There are currently eleven new operational systems, at least a further fourteen have been awarded, and around sixteen are in the pipeline. The Cable Authority has stated that most of the country could be franchised before the Independent Television Commission takes on its new powers." The Cable Authority has done much to encourage interest and specific experiments have included access to a library of interactive videos, a video juke box service, a video conferencing service, and information databases. The recent availability of Prestel on cable will be a major step forward for both operations.

The new interactive services will be very cost effective on cable systems in the home situation since the major costs of construction are paid for by the entertainment services. The non-entertainment services on cable are likely to be teleshopping, home banking, booking services, telesoftware, energy management, home security systems, remote meter reading, market research, electronic mail, closed user groups, data transmission, interactive education, database access, and traffic management.

It is clear that interactive services which need a national and very comprehensive service will continue to develop on the public telephone network, whereas those which need bandwidth, such as energy management systems or real time security and local services, will develop on cable. However, in the long term, as the services increase so greater broadband capacity will be required and cable systems will increasing provide the delivery method.

As the findings of the DTI infrastructure study are not yet known caution is advised, but if the study is forward looking, we are in for exciting times.

BBC'S RADIO DATA SYSTEM

David Lees works for the BBC, advising on radio and television reception and promoting the world-leading achievements of the BBC's Engineering Division.

Since almost every home has one or more radios, radio broadcasting is probably the most cost efficient means of getting a multiplicity of programme and data channels into the home for education, information and entertainment. Consequently the BBC has for some time been encouraging more use of FM broadcasts, better performance from radio receivers, and the introduction of the fully automated radio – radio provided with intelligence from data channels associated with the broadcast. Such radio data channels may also carry services, independent of the radio programme, into the home.

Data will be digitally encoded information added to a broadcast without disturbance to the programme sound. The BBC has developed a data system for its low frequency broadcasts and has also

![Fig. 6. Radio-data modulation of an LF carrier. Above is a source data sequence and below it, the same sequence bi-phase coded (BBC)](image)
pioneered, together with European Broadcasting Union partners, the radio data system (RDS) which is used with fm broadcasts.

Three if transmitters are used by the BBC and operate as a synchronised group on 198kHz, based at Burghed, Droitwich and Westerglen. They have a range of several hundred kilometres and offer national coverage for sixteen low-bit rate data channels. One transmits an accurate clock-time and the others are available for user data.

The UK electricity supply industry has financed BBC's development of the Teleswitching system which uses some of the if data channels. Teleswitching is used for remote control of electricity use via special electronic time switches (radio teleswitch receivers) installed in the home, so evening out the demand for electricity. This is a prime example of a cost-efficient aspect of home automation.

The long range of if transmissions also suits them for transmission of digital weather information for land and sea areas without the need to listen to spoken reports. Spring 1987 saw completion of the initial RDS service ahead of schedule, allowing manufacturers of RDS receivers to "road test" their products. The service went live on 20 Sept 1988 and the installation of the 98 BBC-designed encoders at 48 sites ultimately will bring an RDS service to 75 per cent of the population.

There are five primary RDS features provided by the BBC – PS, PI, AF, ON and CT. The program service name (PS) is eight text characters used to indicate, on an lcd or similar, the service being received. The programme identification code (PI) is used by the radio to confirm the correct reception of the chosen service. The alternative frequency list (AF) is a sequence of codes representing other radio frequencies used by the chosen service in adjacent areas. This feature is of great value for mobile reception where the RDS radio will tune to the best frequency without having to scan through the whole radio band.

Other networks information (ON) gives tuning information about other services to allow rapid returning to another programme or to travel announcements. Clock time and date (CT) is derived from the National Physical Laboratory and is automatically updated at changes between GMT and BST.

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Motorists will especially benefit from the RDS travel service. The radio can scan for and select a broadcast which carries regular travel messages. When a travel announcement is made the radio is automatically alerted and returns to the local service providing the travel information. The BBC will start a trial RDS travel service in spring 1989 via five local radio stations – Radio WM, GLR, BBC Essex, Radio Bedfordshire and Radio Kent. A full travel service for the entire UK will follow in due course.

RDS will eventually offer many other features, such as additional motorist's information, radio paging and programme type selection. The latter is used to command the radio to search for a particular type of programme, for example, news, sport, jazz etc. The receivers can also be preprogrammed to automatically recognise and switch on to a particular programme. A radio text service will become available to provide programme related information to home receivers fitted with a display screen. Text messages of up to 64 characters will be available.

The BBC considered it essential that an RDS interface should be provided to external devices such as a speech synthesiser, graphics display, printer and personal computer system. As yet the interface has not been fully specified but will have a minimum of seven lines and each external device should provide an interface connector to daisy-chain to other devices.

Looking further to the future the BBC will base developments on a digital broadcasting system. Sixteen radio channels delivered primarily from satellite and supplemented from terrestrial transmitters will be available to a future generation of fully digital, automating receivers.

DIRECT BROADCAST SATELLITES

Walter Anderson, on behalf of the IBA, discussed the new satellite tv services which should become available in the UK over the next few years. By the time this report is published the Astra satellite should already be operational. His expressed opinion is that the BSB satellite will be the most important...

The IBA's two eight metre diameter satellite up-link dishes in preparation.

In the UK, the four earth-bound tv programmes are transmitted from around 900 separate sites and can be received by about 98 per cent of households. Cable distribution networks reach roughly 250,000 households and provide further tv channels, though only where conditions are favourable. The successful launching of the Astra and BSB satellites will permit many more households throughout the UK to receive several additional programmes.

BSB is due to be launched in the autumn and will be a high power direct broadcasting satellite giving three channels. This could be the first operational European satellite service complying with the CCIR standards agreed at the World Administrative Radio Conference in 1977. Although the WARC standards were designed to allow easy reception of high power dbs signals using a one metre antenna, improvements in receiver technology now allow domestic equipment to receive lower power transmissions in the fixed satellite service band. The Astra project is based on a medium power concept and is capable of transmitting 16 channels.
HOME AUTOMATION

Viewers connected to a modern broadband cable network can probably expect the satellite services to be available for an extra fee, and possibly without modification to the existing tv set. Other viewers wishing to receive satellite broadcasts will need additional equipment. Since the signal modulations of the two satellites are different, separate aerials and decoders specifically designed for either Astra or BS1 will be required. Combined equipment capable of handling signals from both satellites will eventually be produced, but is not yet available. The installation of two separate satellite tv antennas will probably need local planning permission since a Home Office circular on this subject specifies only ONE antenna.

Walter Anderson went on to discuss the technicalities and merits of the PAL and MAC systems employed by Astra and BS1 respectively. He also looked at the medium-term future for satellite tv, including the introduction of high definition sets. Since these subjects have recently been well aired in the media, including PE, and have no immediate significance for home automation control, we have omitted his summary.

SMART HOMES

David Gann of the Science Policy Research Unit (SPRU) at the University of Sussex considered the lessons that can be learnt in the residential market for automated homes from the experience gained with “Intelligent Buildings” in the business sector. He stressed two points, the need for long-term collaboration in strategic research and development, and the need for appropriate skills in design, development, installation, operation and maintenance in other words, the need for “smart people”. He pointed out how IT is having an impact on financial services, office automation, the automobile industry, and how American and Japanese firms are gearing up for the Single European Market. With regard to the building industry, he quoted from Kipling:

How very little, Since things were made Things have altered In the building trade.

Should we be surprised at predictions of radical change spurred by IT in the building industry which everyone thinks to be so traditional and slow moving? Can British firms respond to the challenge? The diffusion of microelectronics into buildings provides a massive potential for new market opportunities. The smart home is a scaled down version of the intelligent office – the principles are the same and they both use similar technologies. There are few examples of intelligent buildings, though there are those which incorporate integrated building management in which the energy management system is a central feature.

An intelligent office building would include – Building Automation comprising energy management, temperature and humidity control, fire and security protection, lighting and maintenance management, and access control. Office Automation would consist of LANs, EM, data and word processing, management reporting, and other internal communications such as audio/visual. Enhanced Telecoms would include digital PABX, routing cost analysis, and teleconferencing. Responsiveness to Change would reflect the ability of buildings to accommodate changes in individual requirements and organisational demands. Many of these facilities would be expected in scaled down form in smart homes, substituting entertainment in place of the audio/visual and teleconferencing facilities.

The demand for intelligent buildings has been fueled by the need for greater energy efficiency, better control over the internal environment, and new ways of doing business via IT. Response to this demand has led to a number of new small innovative firms entering the market and competing successfully with large established firms. However, short product life cycles and long lead times in development may force many smaller firms to enter into collaborative agreements. Investment in long term strategic R&D is of paramount importance – as the Japanese have already recognised. The Eureka project discussed earlier is a European example of collaborative R&D. The Japanese involvement in intelligent buildings has prompted large construction firms to invest more on R&D in collaborative ventures. Where possible British manufacturers and construction firms (ie, house builders) should participate in greater collaboration.

Furthermore, there is the need to tie down standards in the industry to provide better systems integration. Firms may resist systems compatibility to preserve a market niche, but this could slow the overall growth of the market.

Firms also need to address education and training on two fronts. Customers and consumers must be made aware of the smart house concept. Why is it useful? What does it do? How does it work? How easy is it to use? There are several cases where building users have turned off their systems because they have not understood them. This is not the sort of image that an industry needs to promote its sales.

On the second front, the industry is in its infancy and needs to consider where the skills will come from to design, develop, manufacture, install and maintain the systems. Inadequate training is threatening to curtail the rate of growth in the business sector. Skill shortages and poaching at all levels are making it difficult for firms to plan their work loads. Cowboys have discredited certain quarters of the building industry, particularly domestic repair and maintenance – will we see the rise of the smart homes cowboy? And will the declining number of school leavers pose a constraint to expansion in the future?

Collaboration in strategic R&D and training a skilled workforce are matters vital to the implementation of the smart homes concept.

Having seen how information can be brought into and out of the home, next month we shall look areas in which home automation can be applied.

Just for interest – Thorn EMI’s purpose-built experimental automated house.

If Wotan had installed Home Automation, Valhalla might have been a dream home come true as well.
POWER CONDITIONER

FEATURED IN ETI JANUARY 1989

The ultimate power is now available in a range of sizes for everyone's requirements. The power factor (PF) is adjustable from 1.0 to 1.0 and the power factor is adjustable from 1.0 to 1.0. The PF is adjustable from 1.0 to 1.0 with no drop in power and the power factor is adjustable from 1.0 to 1.0.

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SATELLITE FUNDAMENTALS

PART ONE — BY TOM IVALL

SPACECRAFT LAUNCHING AND ORBITING

Once launched, its height above the Earth's surface, direction with regard to Earth's axis, and speed of travel all have a bearing on the function of a communications satellite.

This year the British public should be in a position to receive television programmes from a completely new source - direct broadcasting satellites. In October 1988 the French launched their high-power TDF-1 and in December Luxembourg-based company Société Européenne des Satellites put its medium-power Astra into orbit. And if all goes according to plan, British Satellite Broadcasting will be transmitting programmes on high power from a UK-owned spacecraft due to be launched in August this year.

Before the advent of these direct broadcasting types all the satellite tv programmes we have been receiving so far have come from relatively low power communications satellites. Originally the idea was to use these comsats simply to send tv signals from point to point, as if along a cable. This point-to-point communication has two main purposes: to exchange tv programmes between broadcasting organizations in different parts of the world; and to send tv signals to cable television stations for subsequent local distribution.

But because the beams from these communications satellites cover very large areas of the Earth the signals also became available, willy-nilly, to everyone living in these areas. It was broadcasting by accident, you might say. Hence the rise of a small, specialised industry for supplying what is called television receive-only (TVRO) equipment to the general public.

A later article will deal with what you need to know and do if you are thinking of setting up your own station to receive either the low power or the direct broadcast (higher power) tv programmes. But these, of course, are not the only satellite signals which PE readers might be interested in picking up with their own equipment. There are other transmission, for example from the Oscar amateur radio satellites and from weather satellites.

Although the orbits, frequencies, powers, modulation and coding systems and so on widely over the whole range of transmissions from spacecraft, the fundamental principles are the same. They are based on the laws of physics, of course. If you have a good grasp of these principles you can apply them to any particular kind of satellite in which you are interested.

SATELLITE TYPES

There are two major groups of spacecraft orbiting the Earth. The ones nearest to us are mainly used for observing the Earth through various instruments, for scientific, meteorological, geophysical, military and other such purposes. They are at altitudes in the region of 200 to 300 kilometres and travel round the Earth in about 172 hours in what are called low Earth orbits (LEO). This works out to a speed of about 8 km per second.

Because these LEO spacecraft appear and disappear quite rapidly travelling from one part of the horizon to another in about 30 minutes - they are not suitable for communications or broadcasting work. But of course the optical or other physical information they provide has to be transmitted to Earth by radio signals. So ground receiving stations have to track them as they pass overhead, or special high-altitude relay satellites have to pick up the signals as they pass below.

Illustration by courtesy of Inmarsat

Fig.1. Example of orbit of low-altitude satellite, passing over the poles. Many other orbital planes at various angles to the equator are in use. The two launching sites shown on the globe were chosen to be as near to the equator as possible. Other sites are in southern regions of China, Japan and the Soviet Union.
Among the many tasks of Earth-orbiting satellites are several relatively new applications, such as satellite communications. Using such satellites, it is possible to communicate over great distances round the Earth, and the transmitter at one end of the line can appear to be stationary relative to the surface of the Earth. This allows the relay satellite to be used in a number of valuable applications, such as broadcasting over very large areas.

Fig. 2. Satellite in geostationary orbit, picture from a point 'above' the North pole. It travels around at exactly the same speed (angular velocity) as the rotation of the Earth and so appears to be stationary over a fixed point on the equator.

Fig. 3. Launching a geostationary satellite by means of an elliptical transfer orbit. The diagram also carries particular examples of characteristics and measurements used to define all satellite orbits.

One of the latest amateur radio satellites to be launched, Oscar 13 (also known as Amsat II/IC), orbits at an altitude which is varying all the time. The lowest point of the orbit, called the perigee, is 1500 km, while the highest point, or apogee, is at 36,000 km. When traced out in space this path forms an ellipse. All such tracks in which the satellite altitude is continuously varying are called elliptical orbits (see example in Fig. 3).

In contrast, all of the GEO spacecraft and some of the others mentioned above travel at constant altitudes and therefore have circular orbits.

EARTH ORBITS

Let us now look at orbits in a bit more detail. In general terms an orbit is the path followed by an object round a centre of mass. The orbiting object can be a natural satellite like the moon or an artificial satellite as discussed in this article.

The centre of mass is at a point somewhere between the Earth and the satellite. It is where the total mass of the system - Earth plus satellite - can be considered to be concentrated at a single point in space. But as the mass of the Earth is so very much greater than that of the satellite it has a swamping effect, so that the centre of mass is in fact very close to the centre of the Earth.

Strictly speaking, both the Earth and satellite are orbiting this common centre of mass. But because this common centre is so close to the Earth's geophysical centre we can ignore the theory and for all practical purposes simply consider the Earth as 'fixed' and the satellite as orbiting its normal centre.

Once an artificial satellite has been put into orbit by a launching vehicle it is no longer being driven directly by a motor or engine. How, then, does it manage to stay up there, almost indefinitely?

The short answer is that it stays up there for the same reason that the moon remains in orbit and doesn't crash into the Earth. The spacecraft is being moved by the combined effect of two main forces acting on its mass. One is the original force imparted to it by the launching rocket or space shuttle - just as a cricket ball has a force imparted to it by the arm of the bowler and continues on towards the batsman. In physics language this is the inertia of the body.

The second force is gravitational pull, or more precisely the force resulting from the gravitational attraction between the mass of the Earth and the mass of the satellite. As Isaac Newton discovered, this is proportional to the product of the two masses and inversely proportional to the square of the distance between them (the inverse square law).

Leaving aside other influences, the launch on its own would cause the satellite to travel in a straight line right away from the Earth. But the force of gravity prevents this by pulling the satellite towards the Earth. In a sense the orbiting satellite is always falling towards Earth, but it never actually hits the planet because the original launching force and the inertia of the satellite are acting against this. The result of this interaction of forces on the mass of the satellite is the orbital path round the centre of the Earth.
The orbital path thus traced out by the satellite has a size, a shape and a position in space relative to the Earth. First, as we have seen, the spacecraft has an altitude – constant in circular orbits, varying in elliptical orbits. There is a lowest point (perigee) and a highest point (apogee).

If you imagine the orbital path as being drawn on a huge flat surface, this surface forms what is called the orbital plane. And the orbital plane lies at a particular angle relative to the Earth – see Fig. 1 for example. This angle is in fact measured between the orbital plane and the plane of the Earth’s equator, and is called the inclination. Oscar 13, for example, travels in an orbital plane with an inclination of 57°.

An elliptical orbit, as the name implies, has the properties of a mathematical ellipse (one of the conic sections). Its size and shape are defined by measuring its semi-major axis and calculating its eccentricity (distance between ellipse foci divided by length of major axis).

But apart from size and shape the orbit also has a position in space relative to the Earth’s lines of latitude and longitude. In Fig. 1, for example, the plane of the polar orbit cuts across the equator just south of Mexico at a longitude of about 95° East. The position of the orbit is actually measured as an angle relative to zero degrees longitude (the Greenwich meridian). Furthermore, to define an orbit properly we have to know where its apogee and perigee lie relative to the Earth. This is measured as the angle between the perigee and a point, called the ascending node, where the satellite crosses the Earth’s equator from south to north.

Only one thing remains to give a full specification of a satellite’s orbit. This is the time taken to complete one orbit, called the orbital period. As we’ve seen, this is in the region of 1½ hours for LEO satellites and 24 hours for GEO satellites (to be precise, 23 hours, 56 minutes, 4.1 seconds). Oscar 13 has an orbital period of about 11 hours. To get the exact position of the spacecraft at any given moment we also need to know the time at which it passes through the perigee.

LAUNCHING SATELLITES

As the next article will be mainly about picking up signals from geostationary satellites, let us illustrate the principles outlined above with an example of one of these – the launching and injection into orbit of the Eutelsat I-F5 communications satellite. Like earlier ones in the same series, this spacecraft was specified, purchased from the manufacturers and then launched, under the name ECS-5, by the European Space Agency. After putting the comsat into orbit ESA handed it over to the European Telecommunications Satellite Organization (Eutelsat), which now manages and operates it.

Eutelsat I-F5 was put into a geostationary orbit by using what is called a geostationary transfer orbit (GTO). This is elliptical in shape, as shown in Fig. 3. The procedure is the most economical one possible in the use of rocket and spacecraft fuel and therefore minimises the cost of launching and the cost of the satellite system overall. So it is widely used for launching, having now proved itself for 25 years or more.

An Ariane-3 rocket launched the satellite (together with an Indian comsat, Insat 1C) from the launching site of the Arianespace company at Kourou, French Guiana. This is on the Atlantic coast of South America, just north of the mouth of the Amazon river (Fig. 1). Being only about 5° north of the equator, it is in a good position to take advantage of the ‘sling-shot’ effect given by the rotation of the Earth, which has maximum velocity at the equator. The satellites in their rockets are launched in an easterly direction over the Atlantic and they get an extra velocity boost of about 4.5 metres per second from this natural sling-shot effect, again saving some rocket fuel.

Fig. 4 shows the rocket/satellite launching trajectory. The Ariane-3 rocket initially goes up vertically from the lift-off pad but is soon tilted by its controls in an easterly direction. By the time it has travelled about 2000 km down range it is more or less horizontal and parallel with the Earth’s surface.

At this stage the rocket trajectory is virtually part of a low Earth orbit, at an altitude of about 200 km. This trajectory continues for approximately 15 minutes after lift-off, until the rocket is approaching the west coast of Africa, some 5000 km down range.

If the rocket were indeed in a low Earth orbit it would of course continue to travel around indefinitely at a constant altitude of about 200 km. But in fact, with all three of its propulsion stages now fired, the rocket has already increased its speed beyond the 8 km/s necessary to keep it in the circular low Earth orbit. The effect of this acceleration is to throw the rocket outwards, away from the Earth, so that it moves from part of a circular orbit into an elliptical orbit, as shown in Fig. 3.

At about 18 minutes after lift-off and some 6000 km along this new track the satellite separated from the rocket and continued to travel onward in the same elliptical path. Initially it had a velocity in the region of 10 km/s but gradually slowed down over several hours as it approached the apogee – rather as a cricket ball thrown upwards slows down as it nears the top of its trajectory.

At the apogee in Fig. 3 the orbital velocity was only about 1.7 km/s. In this region 36,000 km away from the Earth the spacecraft doesn’t need as much orbital velocity to satisfy the equation of motion for an elliptical orbit. That is because, at such a great distance, the gravitational attractive force between Earth and satellite is so much less, in accordance with the inverse square law in Newton’s equation.

As the spacecraft returned towards Earth it speeded up again under the increasing gravitational attractive force. Returning to the perigee some 10½ hours after lift-off, it reached an orbital velocity of about 10.2 km/s. Here again this high velocity is needed to counteract the very large gravitational attractive force at the low altitude of 200 km.

The satellite is allowed to remain in this elliptical transfer orbit as long as required by the pre-arranged launching procedure. In the case of Eutelsat I-F5
this period was just over 36 hours, or more than three complete elliptical orbits.

Because Kourou is slightly north of the equator (Fig. 1) the plane of the transfer orbit was not exactly in the equatorial plane as implied in Fig. 3 but at a small inclination of 7°. Subsequently this had to be corrected to bring it to 0°.

To propel a satellite from the elliptical transfer orbit into its final circular geostationary orbit, a small reaction-propulsion motor, called an apogee kick motor, is fired by telecommand from the ground. This is done at one of the times when the satellite is at the 36,000-km apogee.

With Eutelsat I-F5 the kick motor was fired after three complete elliptical orbits, as the spacecraft reached the apogee for the fourth time.

The resulting acceleration to a higher speed again throws the spacecraft outwards, and it now gradually moves into a circular geostationary orbit (inclusion = 0°) at an orbital velocity of 3.1 km/s. In this way the manoeuvre was completed with the least possible expenditure of energy and hence propellant fuel in both the Ariane-3 launching rocket and the satellite’s apogee kick motor.

Eutelsat I-F5 was actually launched at 23.13 hours GMT on 21 July 1988. Its apogee kick motor was fired at 12.23 hours GMT on 23 July, using up 3.5 kg of the total 122 kg of hydrazine propellant fuel carried in the spacecraft. This satellite reached its orbital altitude of 16°E in the geostationary orbit in mid August, later being moved to 10°E.

CELESTIAL MECHANICS

The altitude of a satellite, its orbital velocity and orbital period are all related to each other by the mathematical laws of mechanics. These are derived from Newton’s famous three laws of motion and his laws of universal gravitation mentioned above. Although the equations relating altitude, velocity and period are really quite simple algebraic expressions they are very general and apply to the whole of the universe. But by putting specific values from the Earth-satellites system into these equations we can plot the relationships as useful graphs. Fig. 5 shows the result.

These graphs bring out two things. First, the higher the altitude of an orbiting body the longer is the orbital period. If, for example, we extended the ‘altitude’ scale to the mean distance of the moon from the Earth, some 384,000 km, the ‘period’ graph would indicate an increase to just over 27 days – the moon’s natural period of rotation around the Earth.

Secondly, the graphs show that the higher the altitude the lower is the orbital velocity. This is because the gravitational pull on the satellite decreases the farther it is away from the Earth. Consequently, it is necessary to have the greater ‘balancing’ effect of the orbit mechanics, the satellite does not need as much forward-directed force to counter-act gravity. And this counteracting force (see above) depends on the orbital velocity, being proportional to the square of this velocity.

With the orbit is circular all these conditions remain constant. But with an elliptical orbit the altitude is changing all the time. Consequently as the satellite travels nearer to the Earth it needs more and more orbital velocity to counteract the increasing gravitational pull. Thus with an elliptical orbit the orbital velocity is highest at the perigee and lowest at the apogee.

In the theory of the subject a circular orbit is considered as a special case of an elliptical orbit in which the eccentricity of the ellipse happens to be zero. For example, the orbit of the moon round the Earth may seem circular but in fact is slightly elliptical. The departure from a circle is so small that the eccentricity of this ellipse (defined above) is only 0.0549.

To sum up, the orbit of any satellite can be defined by six values, which are called orbital elements. The first is the length of the semi-major axis of the ellipse. The second is the eccentricity of the ellipse, inclined at the orbit plane, is the third element, while the position of the whole orbit plane relative to the Greenwich meridian (zero degrees longitude) is the fourth.

Orbital element number five is an angle showing where the perigee lies within the orbit plane. It’s actually an angle between the perigee and the point on the orbit plane where the satellite crosses the equator from south to north. Finally, the sixth orbital element is the instant of time at which the satellite passes through the perigee of its orbit. The interval of time between two such instants is the orbital period.

In the next article we’ll look at the fundamentals of receiving signals from satellites – with some practical information on what you need to set up your own receiving station.

![Fig. 5. Graphs showing relationships between satellite altitude, orbital period and orbital velocity. They are plotted from equations of motion derived from Newton’s law of mechanics.](image-url)
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This month we are going to look at some circuits that perform the kind of logic used in computers. We shall not get as far as studying a complete computer circuit—that comes in another part—but the simple circuits that we study this month will help you understand the workings of the rather more complicated ones in a computer.

One logic circuit that forms the basis of a number of other useful computing circuits is the D-type flip-flop (Fig. 1). We tried this out in Part 4 (PE Dec. 88) but, for readers who are new to the series (and for those who can't quite remember what it was all about!), we recap its main features:

- Data (low or high logic levels) is fed to the D input.
- Nothing happens until the clock input is changed from low to high.
- At that instant the data on the D input appears at the Q output.
- The Q output is the inverse of the Q output.

Data is transferred as the clock input changes; we say the flip-flop is edge-triggered. The change occurs only when the clock changes from low to high—it is triggered on a positive-going edge. In addition to the above, most D-type flip-flops have a set (or preset) input and a reset (or clear) input. These inputs are normally held high. When one of these inputs is made low, the Q output goes high (set) or low (reset) immediately, whatever the state of the clock.

In Part 4 we showed how a chain of D-type flip-flops is connected together to make a counter or frequency-divider circuit. Now we will look at some further applications of this flip-flop.

**STORAGE REGISTER**

Fig. 2 shows a storage register made from four D-type flip-flops. It is used to store a number of bits of data. The four bits D3 to D0 are fed to the D inputs of the flip-flops. The clock inputs are all connected to a single clock input. When the clock input rises from low to high, the data at D0 to D3 appears at Q0 to Q3. In a computer, the register could be used to hold data temporarily. Data could be a binary number or a coded instruction. Something of this kind is found inside a microprocessor, though it is usually an 8-bit or 16-bit register. The storage register is a kind of memory device though, as we shall see later, computer memories have additional features that this register does not have. Let us see the register in action.

**Investigation 1**

**Storage register**

The 7474 or 74LS74 IC (Fig. 3) contains two D-type flip-flops. We need two of these ICs to build a 4-bit register. To make the clock to drive the register we use a Schmitt trigger gate, as in Fig. 4. Timing is decided by the value of C1. We have chosen a fairly high value for this so that the clock runs slowly and gives you time to see what is happening. As an alternative you could use a 555 timer, or Module 5 (PE Nov. 88), in astable mode running at about 0.25Hz (one oscillation every four seconds). The reason we prefer to use this type of clock in this circuit, rather than the 555, is that the 555 tends to produce spikes on the supply lines. These can affect the operation of flip-flops and registers, causing them to change state unpredictably.

Fig. 5 shows how to lay out the storage register on the breadboard. If you have only one 7474 IC a 2-bit register is sufficient for this demonstration. IC1 is the clock (74LS13) connected as in Fig. 4. The led D1 shows the state of the clock output. The leds D2 to D5 show the states of the flip-flop outputs Q0 to Q3. There are four flying leads, D0 to D3. The figure shows D0 and D3 connected to the 5V rail (on the right), while D1 and D2 are connected to the 0V rail (on the left).

While the clock is running, try plugging the leads into the 0V rail (low input = 0), or 5V rail (high input = 1). Watch how and when the outputs change. (Answer at the end.)

If you have made last month's analogue-to-digital converter module (Module 10), you could use its four most significant output lines to provide the input for the storage register. The input of the a/d circuit could come from a light-sensitive interface.

**Fig. 1. D-type flip-flop**

**Fig. 2. A storage register**

**Fig. 3. Pin out of 7474 dual D-type flip-flop**

**Fig. 4. Clock made from Schmitt trigger NAND gate.**
The complete system is shown in Fig. 6. As light levels change, the output of the d/a is transferred to the storage register once every four seconds (approx.). This gives you time to read the binary value before it changes again. In this system, the storage register is acting as a sample and hold register. It registers (or samples) the data as the clock goes high and then holds it for a while, until you have had a chance to read it.

Keep the storage register circuit on the breadboard when you have finished, for we shall use most of it again.

SHIFT REGISTER

Fig. 7 shows a 4-bit shift register made from four D-type flip-flops. The flip-flops are joined in a chain, the Q output of one flip-flop is connected to the D input of the next. The clock inputs are joined together, so that all flip-flops are clocked at the same instant. The best way to work out what this circuit does is to build it and try it.

Investigation 2

Shift register

The layout of the storage register (Fig. 5) is quickly adapted to turn it into a shift register.

1. Remove the three flying leads that go to pins 2 and 12 of IC2 and pin 2 of IC3. This leaves the single lead D0, the input to the first flip-flop of the chain. This is known as the serial input.

2. Connect the outputs to the inputs of the next flip-flop by joining:
   - IC2 pin 9 to IC2 pin 2
   - IC2 pin 5 to IC1 pin 12
   - IC1 pin 9 to IC1 pin 2

3. Run the circuit, plugging the flying lead into the 0V rail or the +5V rail. Change it from one to the other frequently.

4. Watch the LEDs. Describe what is happening (answer at end).

USING SHIFT REGISTERS

The shift register of Fig. 7 is the simplest kind. Data goes in at one end, the serial input. It is shifted along the chain of flip-flops and appears at the serial output four clock pulses later. It has applications as a delay circuit. This type of shift register is known as a serial-in-serial-out register, often shortened to siso.

The register we built on the breadboard has outputs from all four flip-flops. We feed the data in a bit at a time, but can read
They may also be used for feeding data of the public telephone system, or by radio. Data from one computer to another by way are modems which are used for transmitting into the computer circuit (eg into memory). When all eight bits have arrived, they are unloaded in parallel from a computer to a disk drive or a printer with serial input.

Fig. 9 illustrates an entirely different use for a shift register. A binary number (00110101) is loaded in parallel into a shift register. A clock pulse is applied to shift the data one place to the left. It is then unloaded, in parallel. The shifted data is (01010101), for a zero has been shifted in as the least significant digit. Before shifting, the value was 00110101, equivalent to 53 decimal. After shifting, the value is 01010101, equivalent to 106 decimal.

Shifting the binary number one place to the left has the effect of multiplying it by two. Another shift, giving 11010100, multiplies it by two again. This is one way multiplication is performed in a microprocessor. 'Shift left' is one of the instructions available in microprocessors.

A data latch

The terms 'register' and 'latch' are often used as if they mean the same thing. But there is a difference. A register registers the data that is being fed to it at the instant when the clock changes from low to high. At other times it ignores the data. The output remains fixed, showing what the data was at the last low-high change of the clock. To see what a latch does, we will examine one in operation.

Fig. 10. Multiplying by 13.

Table: Original number and shift

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<th>Shift Again</th>
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(00010101)

Result (in 8 decimal)

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(11011101)

Fig. 11. Pinout of 7475 quadruple latch.

Investigation 3

A data latch

The 7475 is contains four latches. Each has its own data input, Q output, and data was at the OV rail. The Q outputs of its latches are indicated by the four leds. Run the circuit, experiment with the data inputs, and find out how the latch differs from a register.

Fig. 9. Using a shift register to multiply

Fig. 12 the 7475 is breadboarded with the same clock as we used before. Its data inputs are connected to the OV rail. The Q outputs is 01101010, for a zero has been shifted in as the least significant digit.

The piso registers are useful for data transmission. Suppose you want to send data from a sensing device to a central computer. Suppose too that your data consists of 8-bit bytes. You try to send all eight bits at once, in parallel. This would be the fastest method, but you need eight lines (plus a OV line) running from the sensor to the computer.

The 7475 is contains four latches. Each has its own data input, Q output, and Q output remains fixed, showing what the data was at the last low-high change of the clock. To see what a latch does, we will examine one in operation.

Table: Shift register

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<th>Serial Input</th>
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(00010101)

Result (in 8 decimal)

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(11011101)

Fig. 12. The 7475 is breadboarded with the same clock as we used before. Its data inputs are connected to the OV rail. The Q outputs of its latches are indicated by the four leds. Run the circuit, experiment with the data inputs, and find out how the latch differs from a register.

Fig. 10. Multiplying by 13.

Add numbers stored

Result (in 8 decimal)

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(11011101)
DIY MEMORY

A latch lacks some of the features that we expect a memory to have. But, by 'dressing it up a bit', we can add a few logic circuits to the 7475 latch and turn it into a memory (Fig. 13).

The centre of the circuit is the set of four latches. These are where the data is stored. We have arranged this circuit so that the four latches are in two pairs of two latches each. Latches 1 and 2 store a pair of bits. Latches 3 and 4 store another pair of bits.

In the diagram, the 74LS75 is lost in a forest of connections. But, if we keep a clear head, we can find our way through from the latches to the data bus. The data from the Q outputs of the latches goes to four output buffers (IC4). These are non-inverting or true gates; a 0 input gives a 0 output and a 1 input give a 1 output. The point about these buffers is that they have 3-state outputs. In the high-impedance state the output of the gate is, in effect, disconnected from the circuit (Fig. 14).

When we store (write) data in the latches or read data from them, we use the latches in pairs. Either we use latches 1 and 2 or we use 3 and 4. We can say that the two pairs of latches have two addresses in the memory. Latches 1 and 2 have address 0; latches 3 and 4 have address 1. Fig. 15 shows the connections when we are reading data from address 0.

The buffers connected to latches 1 and 2 are both controlled by the output from a NAND gate. The truth table of this gate is:

\[
\begin{array}{|c|c|c|}
\hline
\text{NAND input} & \text{NAND output} & \text{Effect} \\
0 & 0 & 1 \text{ (buffer control)} \\
0 & 1 & 1 \text{ (buffer control)} \\
1 & 0 & 1 \text{ (buffer control)} \\
1 & 1 & 0 \text{ read data} \\
\hline
\end{array}
\]

Data passes through the buffers only when WE is high and A is high, as in Fig. 15. So what are WE and A, and why do they have these 'bars' over their names? WE is the write enable line. It controls whether data is to be written into (stored in) the memory. WE is high or low — not both at the same time. So we can not write and read at the same time. This is important, because the data terminals D0 and D1 are used both as inputs and as outputs (but not both at the same time). The bar over WE has the same meaning as the little circle on the buffer control — 'has its effect when low'. Low means 'write'. To read data, WE must be high, as in the truth table above.

The control line that is used to select which address is to be written to or read from is called A. To read from address 0, we must make A low. But the truth table shows that we need a high input for reading. We get this by inverting A, to get
Fig. 16. The way in to address 0.

Answers to questions

Investigation 1:

1. Low to high.
2. Captures the first register.
3. The data in the latch is the next register. One new bit of data is captured followed by the data on the clock input.
4. As the clock goes high, the data on

When A is low, A is high (see truth table) and the buffers send the data to the data lines D0 and D1.

Reading from address 1 (latches /) is similar, except that A is high. We use A, not A, as the input to the NAND gate. In this way, when WE is high, the data from address 0 or from address 1 appears at the data outputs.

Summing up – to read data we have to:
* make WE high
* set A to the address we want to read (0 or 1).

RETURN JOURNEY

Now we find our way back in. How do we store or write data into the latches? Obviously we must make WE low. This puts all four output buffers in IC4 into high-impedance state. The data already stored there cannot get to D0 and D1. The low on WE enables the two input buffers, in IC3 (left of Fig. 13). Data passing in through these buffers goes to latches 1 and 3 (D1) and to latches 2 and 4 (D1).

Summing up, to write data we have to:
* set A to the address we want to write to
* make WE low
* set the new data input
* make WE high

Next month we continue this discussion on computer logic and begin by looking at Investigation 4.

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PRACTICAL ELECTRONICS APRIL 1989
As well as being widely used in audio circuits, opamps are used in general signal conditioning circuits. Rather than being used in totally analogue instrumentation systems, many opamps are used to process signals for analogue to digital conversion for use in microprocessor control systems.

**One signal conditioning circuit which is more used in audio than instrumentation is the adder shown in Fig. 148. This circuit adds signals A, B, and C and inverts the result. The output is given by the equation**

\[ V_{out} = -R_4 \times \left( \frac{A}{R_1} + \frac{B}{R_2} + \frac{C}{R_3} \right) \]

**The circuit is obviously not limited to three inputs, but three inputs can be convenient as shown in Fig. 149.**

In this circuit the adder circuit is used to add three audio signals. Each audio signal is buffered by one opamp, and the addition is performed by a further opamp. This circuit can conveniently be made using a quad opamp such as the LM324. This circuit arrangement has interesting implications for gain bandwidth product. As far as the opamp is concerned, it is operating at a gain given by \((R_4+R_p)/R_p\) where \(R_p\) is the parallel combination of \(R_1\), \(R_2\), and \(R_3\). The opamp may not be unity gain stable, but in the circuit shown in Fig. 148 the gain at which the opamp is working is much greater than the gain from each input. If all resistors are equal, the gain from the point of view of the opamp is 4. That is to say that the feedback voltage is 1/4 of the output voltage minus the sum of the input voltages. In reality, the feedback voltage relative to \(0V\) is only the error signal, because the non-inverting input is connected to 0V. Therefore the output error is greater than would be the case if only a single input were connected.

**DIFFERENTIATION**

It is sometimes necessary to detect a changing condition rather than measure an absolute value. For example, time to recharge a nickel cadmium battery may be indicated by a sharp fall in voltage. Simply detecting the absolute voltage would not be effective because this can be influenced by the temperature, the current drain, and the age of the cells.

The output signal depends on the rate of change of input voltage and the RC time constant. The currents charging the capacitor and flowing in the resistor are the same, and capacitive charging current is given by the formula \(C \times \frac{dV}{dt}\). Therefore output voltage \(-R \times C \times \frac{dV}{dt}\).

Since the mathematical function of differentiation has an electronic analogue, it is no surprise that the same holds true for integration. The circuit of Fig. 151 illustrates the principle. The output is \(RC\) \(V\) \(dt\). The integral period is from the last reset pulse, which discharges the capacitor. This circuit will, of course, integrate everything impartially, including the opamp's bias current, so it is best used to integrate over fairly short periods.

**RECTIFICATION**

Beloved of academics is the concept of the perfect diode. This fictional beast conducts perfectly in one direction and not
at all in the other. It has no resistance or voltage drop. The addition of an opamp to a real diode can produce a good approximation to this perfect diode for the purposes of signal rectification at low frequencies. The concept is illustrated in Fig. 153.

The circuit of Fig. 154 provides full wave "perfect" rectification. This circuit is good in many ways, but it is affected by resistor tolerance and contains four resistors whose tolerance affects the accuracy of the circuit.

The circuit of Fig. 155 reduces this problem, but in order to work properly it must be driven from a very low impedance, and its output must feed into a very high impedance. Another advantage of this circuit is that it can rectify a signal which goes negative of the opamp's negative power supply intended to run a small desktop computer. The computer itself uses considerable power and contains four resistors whose tolerance affects the accuracy of the circuit.

It must be driven from a very low impedance because any extra impedance in series with R1 will change the gain of the circuit with respect to negative input signals. Positive input signals cause the opamp output to swing as negative as it is able to, and are transferred from input to output by R1 and R2. Clearly any load on the output will attenuate the signal received under these conditions.

The precision rectifier is often used in conjunction with a capacitor to hold the value of the peak voltage. This is known as a peak detector. Generally a bleed resistor is included to limit the peak storage time. This principle is illustrated in Fig. 156. One possible use for this is to make a peak reading ac meter.

Why would one use a peak reading meter rather than a mean reading one, I hear you ask? As one example from a choice of several, consider the case of an uninterruptible power supply intended to run a small desktop computer. The computer itself uses a switched mode power supply, the input of which consists of a rectifier and smoothing capacitor connected to the mains. The capacitor will charge to the peak of the incoming voltage, and it is the peak rather than the mean or the rms value which controls whether the power supply will work properly. A peak detector to measure the voltage in this type of application would probably include a resistor in series with the diode to prevent the circuit from responding to very brief spikes.

The speed of response can be a problem with peak detectors anyway. If a large capacitor value is used, the speed may be limited by the maximum current which the opamp can deliver to charge the capacitor. This will limit the circuit's ability to measure glitches and interference. If, on the other hand, a very small value of capacitor is used, the circuit may detect fast glitches but they may not be held on the capacitor long enough to be displayed.

Even then, the speed response is limited by the slew rate of the opamp. This is more of a problem than it appears, because during all the time that the voltage on the non-inverting input is below that on the inverting input, the output of the opamp will be as negative as the power supply allows it to be. If the opamp is supplied from ±12V, and it has to detect a +3V spike, its output will have to slew 15V rather than the 3V of the signal to be measured. The circuit shown in Fig. 157 can get around this problem in some cases, but it is not always suitable because the voltage on the inverting input follows that on the non-inverting input.

In some cases R1 would need to be connected to 0V, and in these cases a more complicated system would be needed. One way to make the circuit work would be to buffer the voltage on C1, and use the buffered signal as feedback.

There are several ways to detect short spikes and store them for long enough to be displayed. One way would be to use a differentiator following the peak detector to detect a rapid increase in voltage, and to use this to trigger an analogue to digital conversion. Another technique would be to follow the short time constant peak detector with a slower long time constant one. Yet another technique is to use a transistor to increase the available charging current, as illustrated in Fig. 158. This circuit can provide a very high charging current, so the peak current is limited by R1, which forms a time constant in conjunction with C1 rather than a current limit.

The substantial peak currents drawn by this circuit could interfere with other circuitry on the same PCB, either because the power supply voltage dips momentarily or, more likely, because of noise induced on the 0V track by the heavy peak currents. Consequently a local decoupling capacitor, C2, must be inserted, and its value must be considerably greater than that of C1. The heavy currents then circulate in C2, C1 and Q1, and the pulse of current drawn from the supply on the reset of the opamp is longer and lower.
DOING SUMS

It is easy to add and subtract using analogue circuits, but it is a lot harder to multiply or divide two voltages. One way to multiply and divide voltages is to take the log, then add or subtract, then take the antilog of the result. To a first approximation the current in a diode is the log of the voltage across it (ignoring temperature effects) but this is a poor approximation. For obscure reasons to do with the diffusion process, a transistor base-emitter junction provides a much better approximation. Consequently the log circuit shown in Fig. 159 uses a transistor in the configuration known as transdiode.

Disregarding R2 and C1, which are present purely for stability, the emitter current of Q1 is equal to the minus the log of the output voltage. The collector current is approximately the same. The accuracy of the approximation depends on the gain of the transistor, so as high a gain type as possible should be used. The values of the stability components should be determined by experiment, but a reasonable place to start would be 10R and 100pF.

The form of the graph of output against input is logarithmic, but the scale depends on the transistor characteristics and the temperature. For this reason the output is shown multiplied by a constant, which will be the same for all similar transistors at the same temperature. This circuit as it stands is of little use because it is affected by temperature. It is possible to temperature compensate log amplifiers if necessary, but this is not an easy task, and not a necessary one if the end result is to be multiplication or division.

The circuit shown in Fig. 160 uses three log amplifiers, an adder/subtractor, and an antilog amplifier to multiply and divide voltages. If all the transistors are similar — perhaps all part of the same transistor array, and all at the same temperature — then the constant terms cancel to give reasonably accurate multiplication and division.

This circuit can, of course, only multiply and divide positive voltages. There is no proper answer to the log of 0 or of a negative quantity, so the circuit can only function properly with positive voltages large enough to bring the outputs within the range available to the opamp.

What do you do if you want an approximately logarithmic response, but do not want the output to go unbounded at zero volts input? It is possible, but not by using this type of circuit. Instead, nonlinear feedback is applied to an opamp by changing the effective feedback resistance at specific levels of output voltage. Using this system, known as an arbitrary function generator, one can generate almost any input/output curve as a series of straight line approximations.

The circuit of Fig. 161 is an example of an arbitrary function generator. This circuit can only reduce its gain as the signal increases, because more feedback resistors are switched in parallel. R1 sets the maximum gain of the circuit, and the gain is progressively reduced by the addition of R4, R3 and finally R2 in parallel. The voltages at which these resistors are switched in are determined by the potential divider chain R5 to R8.

This circuit is unipolar, accepting positive input voltages and giving negative output voltages. If bipolar operation were required, a second set of transistors (pnp this time) and a separate divider chain connected to a negative reference voltage could be used.

If a circuit which increases its gain with increasing input voltage is needed, then the circuit of Fig. 162 would do the job. In this circuit, extra resistors are switched in parallel with the input resistor as the input voltage increases, thus increasing the gain. The two types of circuit could be combined, to provide, for example, an S shaped amplitude response. The calculations for this, especially based on using preferred value resistors, would be complicated and best done by computer.

The Vbe of transistors can be used to set the response of a circuit, as shown in Fig. 163. This is the circuit of a triangle to sinewave converter, which operates symmetrically by virtue of using the same resistors for each half of the response. Fig. 164 shows the corresponding circuit to increase gain with signal level. Perhaps this could be used for a sinewave to triangle wave converter, whatever use that would be.
OSCILLATORS

No treatise on opamps would be complete without some mention of oscillators. So I have included two specimens to exemplify the subject. Fig. 165 shows the circuit of a squarewave oscillator based on a Schmitt trigger. When the capacitor voltage passes the voltage on the non-inverting input, the output switches to the opposite state and the capacitor starts charging in the opposite direction.

The voltage on a capacitor charged via a resistor follows the law:

\[ V = V_a \times (1 - e^{-t/(R \times C)}) \]

where \( V_a \) is the applied voltage.

Each half cycle of oscillation starts with the capacitor charged to \(-V\) and finishes with it charged to \(+V\) or vice versa. From all this plus the assumption that the output of the opamp gives equal positive and negative output swings one can eventually deduce that the time for one half cycle of oscillation is given by the formula:

\[ T = -\frac{R \times C \times \ln(1 - 2 \times R_3)}{2 \times R_3} \]

In means log to base \( e \) to the base \( e \).

To find the frequency, of course, just multiply the period of a half cycle by two and take the reciprocal.

For many applications a sinewave oscillator is needed. The circuit of Fig. 166 is one such. This is a Wien bridge oscillator, a standard circuit configuration. It relies on frequency dependent phase shift to set its frequency, and oscillates when the phase shift is zero. R1 and C1 form a phase advance network, and R2 and C2 form a phase lag network. When the resistive and capacitive impedances are of equal magnitude the upper network provides 45° phase lead and the lower one provides 45° phase lag. Here is a brief summary of the relevant maths:

For the parallel network, phase shift = -\( \tan^{-1} (\omega \times C \times R) \), and for the series network phase shift = \( \tan^{-1} \frac{1}{\omega \times C \times R} \).

The magnitude equations are:

\[ R \times \sqrt{1 + \omega^2 \times C^2 \times R^2} \]

Parallel network \( \sqrt{R^2 + \frac{1}{\omega^2 \times C^2}} \)

And, substituting \( \omega = C \times R \) we have:

Parallel magnitude = \( R \times \sqrt{2} \)

Series magnitude = \( R \times \sqrt{2} \)

Network gain = Parallel magnitude/ (series magnitude + parallel magnitude) = \( 1/3 \)

Therefore, the oscillation frequency is given by \( f = \frac{1}{2 \pi R C} \), and oscillation occurs when the amplifier gain is 3.

Clearly oscillation cannot start unless the amplifier gain is a little above 3, but if the gain remains above 3 the amplitude rises until the opamp clips and the output is no longer a sinewave. To combat this problem, the negative feedback is adjustable to set the nominal gain to just greater than 3, and an extra resistor (R4) is added in parallel with R3 and VR1 when the amplitude of the signal is great enough to switch on the diodes. This reduces the gain just slightly and stabilises the amplitude with minimal distortion. In practice this circuit can, if carefully adjusted, provide a very clean sinewave.

SALUTATIONS

Well, that about wraps it up for semiconductors. This monster series has covered only a tiny percentage of the subject, and has just about exhausted its author. I hope it has whetted your appetite to learn more, and that some of the application circuits find their way into successful project designs.

Our thanks to Andrew for conducting this series so well - no semi measures here!

Ed.
Microsoft Word Document
Two recent comments concerning space research programmes are worth noting. First, there is increasing anxiety about the effects of man’s activity upon the space environment. Many thousands of artificial satellites have been sent up since the launch of Sputnik 1 on 4 October 1957, and there have been some mishaps; a considerable quantity of debris is now in orbit, and cannot be tracked. There is therefore an increasing threat to future vehicles and even space-stations. A scientific satellite could be badly damaged by a head-on collision with a fragment much less than an inch in diameter, and it has been claimed that unless something is done, the problem may reach an unacceptable level in no more than a decade. Even worse is the danger from nuclear reactors in space – remember Cosmos 944, which crashed in Canada and spread radioactive debris over a wide area. Military preparations in space are an obvious hazard, as well as shifting the emphasis away from scientific research, and there is an urgent need for better monitoring of the whole environment. On a different tack, a Russian commenter, S. Leskov, has criticized the Soviet ‘space-lifts’ of cosmonauts from other countries, and maintains that the countries concerned should bear the cost. At least this shows that the Russians are at last becoming commercially-minded! Brown dwarfs are back in the news. By definition, a brown dwarf is an object with a mass less than 0.08 that of the Sun, so that its core will never become hot enough to trigger off nuclear reactions and make the object shine; it is in fact a star which has failed its entrance examination, and there seems to be a rather blurred boundary between a brown dwarf and a planet. Two American astronomers, Eric Becklin and B. Zuckerman, have now identified a low-mass object in orbit round a white dwarf star, GD 15, which is about 84 light-years from the Sun. The companion of the white dwarf has a surface temperature of no more than about 2000 degrees C, and has only 1/800,000 of the Sun’s luminosity. If it is a true brown dwarf, it adds force to the contention that these very low-mass objects may be important constituents of our Galaxy.

VOYAGER PROBES: SOLAR SYSTEM OVERVIEW?

Both the Voyager probes to the outer Solar System are still in full working order. Voyager 2 will by-pass Neptune next August, Voyager 1 will encounter no more planets, but will go on receding until we lose track of it. Will these probes, then, be able to send back pictures of the complete Solar System from far distance? Sadly, the answer seems to be ‘no’. With regard to Voyager 1, it seems that after the early 1990s the transmitter would be too weak to send back images, and in mid-1990 it is planned to shut down the cameras permanently, thereby saving power and allowing other less demanding instruments to show their stuff.

The Sky This Month

Not many of the planets are well placed this month. Venus is too near the Sun to be seen at all; Mercury is in theory a morning object, but from Britain will not be a naked-eye object, Saturn, at magnitude 0.6, can be seen in the early morning, but is very low, in Sagittarius, and not too easy to observe. This leaves us with Jupiter and Mars, both of which are in the evening sky, lying in Taurus. Jupiter passed opposition in late November last, and will not be in conjunction with the Sun until next June; its magnitude this month is +2.2. Mars, which actually surpassed Jupiter last summer, has now decreased to magnitude 1.2, inferior to Aldebaran and a full three magnitudes below Jupiter; the apparent diameter is now less than 6 seconds of arc, so that not even large telescopes will show much upon its disc. It lies between the Hyades and the Pleiades, and on 12 March it and Jupiter are only two degrees apart. This conjunction is not in the least important, but at least it will be worth photographing.

No major meteor showers are due this month, and no bright comets have been predicted. The Moon is new on 7 March, and full on the 22nd; remember, too, that British Summer Time begins on 26 March. Ursa Major, the Great Bear or Plough, is now almost overhead after dark. Note the second star in the Bear’s tail, Mizar, which has a fainter companion, Alcor, strangely the Arabs of a thousand years ago regarded Alcor as a test of keen eyesight, whereas today it is quite obvious on any reasonably clear night. Telescopically, it is seen that Mizar is itself double, with one component rather brighter than the other. High in the south you will find Leo, the Lion, with its curved arrangement of stars making up the famous ‘Sickle’, the brightest of them, Regulus, is of the first magnitude. Two other first-magnitude stars are also easy to find. Follow round the curve of the Great Bear’s tail, and you will come first to the brilliant orange Arcturus, in the constellation of Boötes (the Herdsman) and then to Spica, in Virgo (the Virgin). Virgo is a large constellation containing many faint galaxies; in this direction we come to the so-called Virgo Cluster of galaxies, around 60,000,000 light-years away, containing many hundreds of separate star-systems. Lower down in the south lies the large but dim constellation of Hydra (the Watersnake), which contains only one fairly bright star, the reddish second-magnitude Alphard.

Orion sets in the west not long after dark, but some members of its retinue, notably the Twins (Castor and Pollux) and Capella in Auriga (the Charioteer) remain on view. Capella never actually sets over Britain, though during summer evenings it almost touches the northern horizon and will probably not be seen.
continue operating. In any case, obtaining views of objects very near the Sun in the sky is a difficult matter, because even from the distance of the orbit of Neptune the sunlight is still bright enough to illuminate the front lenses of the cameras and ruin pictures by scattering.

Efforts have been made to manoeuvre Voyager 1 so that the cameras remain in the shadow of the large dish antenna while photography is being attempted. Unfortunately, success has been only partial, and it has not been possible to record any objects closer to the Sun than Mars.

With luck, we should be able to maintain contact with the probe until it reaches the heliopause—that is to say, the region where the solar wind becomes undetectable—but Voyager 1 will not penetrate as far as this until about the year 2020, so that imaging would be quite out of the question in any case. As has been pointed out by scientists at the Jet Propulsion Laboratory an 'overall view' of the Solar System must be left to a future probe much better adapted to the task than the present Voyagers.

Presumably both Voyager 1 and Voyager 2 will continue travelling between the stars, unseen, unheard and untraceable, until they are destroyed by collision with some solid body, and this may not occur for many millions of years. There is always a chance that they will be picked up by some alien civilization, and they even carry plaques and recordings which would—it is hoped—give a clue to their system of origin, but one has to admit that the chances of anything of the kind are extremely slight. All the same, it is a measure of our changed attitude that it was thought worth while to include the information at all.

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**RESISTORS**

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- 1 ohm - 1 Meg
- E24 range

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**METAL FILM**

- 1 ohm - 1 Meg
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**IC SOCKETS**

- Low Profile 6 Way
- 8 Way
- 14 Way
- 16 Way
- 18 Way
- 24 Way
- 26 Way
- 40 Way

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**NUTS & BOLTS**

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<td>6 BA 3/4&quot;</td>
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HI-TECH TIMING

BY ANTHONY H. SMITH BSC

ATOMIC FREQUENCY STANDARDS

Few things are more certain than \( f \), where it equals \( E/h \). Yet to create a chronometer around this equation requires the sub-atomic equivalent of a lot of cogwheels.

At the International Bureau of Weights and Measures at Sevres near Paris, there is a platinum-iridium cylinder whose mass has been assigned by international agreement to be exactly one kilogram. This cylinder is the primary standard of mass: occasionally, it is taken out of its protective enclosure so that other mass standards can be checked against it.

Unfortunately, the unit of time is intangible: it is not possible to keep a second locked away inside a vault. Instead, it must be generated by a suitable piece of equipment which itself constitutes the standard of time.

For example, we could use a monostable device to generate a pulse whose width is precisely one second; however, because a time standard has the dual role of providing an accurate reference of time and frequency, the aperiodic output of the monostable is useless, and invariably the standard has always taken the form of some kind of oscillator.

This oscillator is not only responsible for generating an accurate time \( t \) equal to one second, but should also be ideally suited to the task of timekeeping.

Timekeeping involves keeping track of events which occur in relation to an established time scale; navigation, astronomical observations, satellite tracking, and, indeed, our own comings and goings, all depend to a greater or lesser extent on an accurate timekeeping system.

Correcting the output of a frequency standard consists only of resetting it to agree with a primary reference; however, if this standard is being used to drive a time clock, correcting the frequency does not correct the time.

Consequently, our time and frequency standard must not only be accurate, but must also be stable (it must not drift with time), and be reliable.

Various time scales such as 'apparent solar time', 'mean solar time', 'universal time', and 'ephemeris time' have been used at one time or another, and all depend upon the relative periodic movements of bodies in space. Indeed, up until recently, the unit of time itself was based upon the rotation of the earth about its axis, and the second was defined as the fraction \( \frac{1}{86,400} \) of the average daily rotation of the earth.

However, it had been known for some time that the earth's axial rotation was subject to unpredictable irregularities and long term drifts, and so in 1956 the International Committee on Weights and Measures chose to define the second as \( \frac{1}{31,556,925.9747} \) of the tropical year for January 0, 1900 at 12 hours Ephemeris Time.

The ephemeris second was an improvement over the previous definition since it depended on the more stable rotation of the earth about the sun. However, astronomers could not accurately enough to meet the increasing demands of scientific research and communication and navigation systems.

Thus, having exploited the resonant qualities of the solar system, of pendulums, tuned-circuits and quartz crystals, it became necessary to find some other phenomenon which could be used to realise a far superior time standard.

Fortunately, Essen and Parry working at the National Physical Laboratory (NPL) in Teddington, England, had developed a new kind of time and frequency reference whose accuracy exceeded that of previous standards. Their device, the caesium resonator, became known as the 'atomic clock' since it depended for its operation on precise energy changes in the atoms of the caesium 133 isotope.

Eventually, after refinements and improvements had been made to the atomic clocks at NPL and other international laboratories, the caesium resonator was adopted as the new standard of frequency and time, and in 1967 the 13th General Conference on Weights and Measures redefined the second in the following terms:

"The second is the duration of 9,192,631,770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the caesium 133 atom."

The atomic standard realised levels of accuracy, stability and convenience far in
excess of earlier techniques, and it became possible to make precise measurements which had previously been impossible.

For example, the perturbations in the earth's axial rotation mentioned previously could now be measured with considerable accuracy: Fig.1 shows the variation in rotation over an eight year period.

Notice how the rotation rate is higher in summer than in winter; this is due to seasonal motion of the earth's winds. Note, also, how the rate is gradually decreasing, due largely to tidal friction between the water and land. Other variations are caused by melting and refreezing of polar icecaps.

QUANTUM PHYSICS

The atomic phenomena exploited in the caesium resonator are by no means unique to caesium - many other elements have been used as the source material in a variety of successful atomic clocks, such as the ammonia maser, the methane laser, the thallium beam tube, and so on.

Three of the most highly-developed devices are the rubidium gas-cell resonator, the hydrogen maser, and the caesium beam resonator. However, in order to understand the operation of these devices, we must first review some of the fundamental principles of quantum physics (but before you reach for the Valium, don't worry - we'll only be considering the basic ideas.)

Our starting point is the familiar 'planetary' atomic model developed by Niels Bohr in 1913 - Fig.2 shows examples for the hydrogen and sodium atoms.

Bohr postulated that the negatively charged electrons revolve around the positive nucleus only in certain discrete orbits, and that each orbit can contain no more than 2n² electrons, where n, the principal quantum number, defines the particular orbit.

Because the electron and the nucleus are oppositely charged, an electrostatic force of attraction exists between them: if we were to move an electron from its present orbit to one of greater radius, we would need to supply energy to the electron in order to overcome the attractive force pulling the electron toward the nucleus. For this reason, electrons in outer orbits have greater potential energy than those close to the nucleus.

Furthermore, since the electrons can occupy only particular allowed orbits, the electron energies can only take certain discrete values. Consequently, the overall energy of the atom itself is quantised into discrete levels. Fig.3 is a graphical representation of atomic energy levels; when all the electrons are in their lowest orbits, the energy is a minimum and the atom is said to be in its 'ground state'.

If we now energise the atom - for example, by heating it - one or more electrons may acquire sufficient energy to move into outer orbits, and the atom is no longer in its ground state but is said to be excited.

However, the electrons do not remain in their excited states, but gradually return to orbits of lower energy, and in the process of falling from a high energy level to a lower one, the electron emits radiation of frequency f, according to the formula:

\[ E = hf, \text{ or } f = E/h. \]

where h is a constant known as Planck's constant (equal to 6.62 x 10⁻³⁴ Joules-sec), and E is the difference in energy states (for example, in Fig.3, the energy difference is shown as being E = E₂ - E₁.) The relationship E = hf represents perhaps the most significant principle in quantum physics, namely that the radiation resulting from a particular energy change has one - and one only - characteristic frequency. This fact immediately suggests that we have an atomic mechanism capable of realising a precise, invariant frequency source.

Each atom has its own particular set of emitted frequencies which can be used to identify the atom rather like an 'atomic fingerprint'.

Unfortunately, quantum physics is not quite so straightforward. Experimenters discovered that where there should be only one energy level for each value of the quantum number n, energies of slightly different values showed up as well. It became apparent that other atomic mechanisms were responsible for these energy differences, and it was necessary to introduce additional quantum numbers to take account of their effects.

For example, the quantum number l specifies the angular momentum of the electron, while the spin quantum number s takes account of the fact that each electron is spinning about its own axis, as well as around the nucleus.

Extra complications arise due to the magnetic interaction of the electrons and the nucleus, causing a splitting of the basic energy levels into additional, 'hyperfine' levels denoted by the quantum number F. Furthermore, if we expose the atom to an external magnetic field, the hyperfine energy levels themselves split into further quantum levels, known as Zeeman levels, represented by the number mF.

Nevertheless, in spite of all these additional effects, the atomic energy levels still remain quantised, as do the frequencies of emitted radiation. The problem is, how do we utilise these quantum effects to create a high-accuracy, ultra-stable oscillator?

MASERS AND LASERS

The maser (microwave amplification by stimulated emission of radiation) is essentially the same device as the laser, the main difference being that the maser handles microwave frequencies, whereas the laser works with the much greater lightwave frequencies.
In addition to its important application as a low-noise microwave amplifier, the maser is also ideally suited for use as a high-precision oscillator.

If we were to look, for example, at a hydrogen molecule, we would see various electrons excited to higher energy levels as they absorbed thermal energy from their surroundings. Eventually, these electrons would fall back to lower energy levels, emitting radiation as they do so. Because this thermal agitation is a random process, the atomic energy levels are continually increasing and decreasing in a haphazard manner, and the emitted radiation - although quantised - varies randomly, and is said to be incoherent.

If we now extend our analysis to a gas of many hydrogen atoms, we find that most of them exist in lower energy states, whereas the higher energy levels contain fewer and fewer atoms; as an example, Fig.4a shows the average population of energy levels for a temperature of 100° Kelvin.

At higher temperatures - Fig.4b - more atoms have gained sufficient thermal energy to move into higher energy levels; nevertheless, the greater population of atoms still exists in the lower energy states.

If by some means a higher energy level were to contain more atoms than the lower levels, we would have a condition known as 'population inversion'. Fig.5 shows such an inversion in energy level E2.

Initially, the atoms are bombarded by radiation having the right energy to 'pump' atoms from lower levels up into the higher E2 state, thus creating a population inversion.

Next, incoming radiation of energy E (= E2 - E1) impinges on the excited atoms, triggering some of them to fall to level E1, thus emitting radiation also, of course, of energy E. The incoming radiation continues on its way, augmented by the stimulated radiation, and goes on to trigger the emission of more radiation of energy E, thus producing an 'avalanche' effect.

The result is that the small incoming radiation is considerably amplified, and the output radiation - which is all in phase and of the same frequency - is coherent microwave energy (or coherent
light in the case of the laser). We are not, of course, getting 'something for nothing', since we must continually provide 'pumping' energy to maintain the population inversion.

**THE HYDROGEN MASER**

Such, then, are the amplifying qualities of the maser, but how can we make use of maser principles to create a high accuracy oscillator? This can be explained by referring to the hydrogen maser shown in Fig.7a.

Fig.7b shows the ground state hyperfine energy levels for hydrogen; we see that the energy of the two upper states, denoted \([F=1, m_F=0]\) and \([F=1, m_F=-1]\), *increases* in the presence of an external magnetic field, whereas the energy of the lower states, namely \([F=1, m_F=1]\) and \([F=0, m_F=0]\), *decreases*.

Consequently, the hexapole field of the state selection magnet focuses the upper state atoms into the storage bulb, while the lower states are deflected away. This results in a population inversion within the storage bulb, since it becomes populated only with atoms in states \([F = 1, m_F = 0]\) and \([F = 1, m_F = 1]\).

Now, when atoms in the \([F = 1, m_F = 0]\) level relax down to \([F = 0, m_F = 0]\) state, the hyperfine transition radiates energy at the frequency of \(f = 1,420,405,751.778\text{Hz}\); this is the desired output frequency. However, it is also possible for atoms in the \([F = 1, m_F = 1]\) level to relax and emit unwanted radiation; consequently, the storage bulb is placed inside a microwave cavity whose dimensions are precisely set such that it is 'tuned' to the required transition frequency, thus discouraging unwanted emissions. The storage bulb is necessary to hold the atoms long enough to ensure maser operation begins. The walls of the bulb are coated with Teflon to minimise the disturbances caused by the many thousands of collisions each atom makes with the bulb walls.

The atoms are held for a second, or so; during this time, they relax, giving up their energy to the microwave field in the cavity. This field stimulates more atoms to relax, increasing the radiation until steady state maser operation is established. The output signal is coupled from the cavity by a small wire loop immersed in the microwave field.

So much for the impressive theory of the hydrogen maser, but just how sophisticated is the practical device? Well, the maser is accurate to at least 1 part in 10^12, and has an incredibly high Q-factor of around two thousand million - a thousand times greater than the best quartz crystals! This leads to a stability of better than 1 part in 10^9 per year - thus, a hydrogen maser atomic clock will have drifted by less than one pico-second after running for a year.

However, the operation and environment of the maser must be carefully controlled if this degree of excellence is to be maintained.

For example, the system must be enclosed in a vacuum to prevent contamination of the storage bulb, and the microwave cavity must also be evacuated to prevent atmospheric disturbance of the tuning.

External magnetic fields can also cause problems, since the transition frequency has a quadratic field dependence, and the exact frequency is given by:

\[ f = \left( f_0 + 2750 \times 10^4 \times B^2 \right) = (1,420,405,751.778 + 2750 \times 10^4 \times B^2) \text{Hz}, \]

where \(B\) is the external flux density in Tesla. Since the earth's magnetic field is around 50\(\text{uT}\), this is enough to cause a frequency deviation as large as 690Hz. Fortunately, the effects of external fields can be minimised by the use of concentric shields surrounding the microwave cavity.

Next month we take a look at Rubidium resonators.
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Components for sale, resistors semiconductors, caps, etc. Cheap. Send SAE for list to: B. Smith, 2 Largo Street, Arbroath, Angus DD11 5ET.


Royal Signals handbook of line communications Vol1 1947: 875 pages. £4.00 plus postage. Tel: Cokeshill 62308.

Advance OS 250 TV dual trace oscilloscope plus soft case and instruction circuit 1300K. Tel: 0785 840474.

Modem: brand new Dhecy Minimo Plus 3 modem. £150 ono. Shaun Norton, 4 Richardson Walk, Witham, Essex. Tel: (0376) 521205 evenings.

I will exchange handicraft goods from Iran for a Kempston Interface for ZX Spectrum. Please write to me. Mr. Mehran Jalai, IRAN, Esfahan, Bashan Banafsheh Shomali Ave, 12m Sepideh No. 17 Post Code: 81959.

Ray Nucleons Geiger counter £58. Maplin/Texas computer speech synth £29. Heathkit V7AU valve voltmeter £27. Mr. Hearm, 10 Speedwell Close, Pakefield, Lowestoft, Suffolk, NR33 7DU.


Heathkit ET3201 digital electronic training course, plus training rig. Excellent condition, £110 ono. Rob Edwards Tel: 0202 688023.

AVO multimeter £25 fluke digital £50. 30KV AVO probes £15 01-554 2913 8-10pm.

Please publish the following small ad. FREE in the next available issue. I am not a dealer in electronics or associated equipment. I have read the rules.

Signature: Date: 24/04/89

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Send this form (or a photocopy of it) to: PE Bazaar, Practical Electronics, 193 Uxbridge Road, London W12 8RA.
When I went into hospital for an operation recently, one of the questions fired at me by the reception nurse from a long list was: "Have you any spare parts?"

I was tempted to reply "No, sorry, I need them all" but decided that any deliberate misunderstanding for the sake of humour was probably not very wise on the run-up to major surgery. Of course I realized that she was actually referring to things like artificial limbs and heart valves. But the routine nature of the enquiry made me fully aware that repairs to the human body using man-made devices - prostheses as they're known in the trade - are now a well-established service available to Homo sapiens.

It goes without saying that electronics is playing an increasingly important role here. Probably as may PE readers know about heart pacemakers as are aware of artificial hip joints. Perhaps less familiar among the mechanical prostheses are artificial ligaments, tendons, knee joints, sphincter muscles, blood vessels and larynxes. For cosmetic purposes, silicone rubber is used to replace tissue which has been lost through injury or surgery. The man-made implantable heart will probably follow the biological transplant but is still at the research stage.

Some of these mechanical devices are already being controlled through electronic systems, when control of movement is needed. For example, artificial hands and forearms can be actuated at will by bioelectric potentials picked up by electrodes from muscles which remain. The user learns to generate these electrical signals from the muscle fibres by making suitable movements.

Feedback or closed-loop control systems - which already exist in natural form in the physiology of animals and humans - are most valuable for prosthetic devices. Their essence, of course, is to monitor what is actually happening and compare it with what is wanted, in order to produce a difference or error signal that shows what has still to be done. Thus, in some devices developed at Bath University to enable leg-paralysed patients (paraplegics) to stand up or perhaps even walk a little, the bending angles of the two knees are continuously measured by potentiometers mounted on callipers to provide the 'actual-position' electrical feedback signals.

Where electronics really shows to advantage in prosthetic devices is, of course, in relation to the electrical activity of the human body. This is centred in the nerve cells - in both the central nervous system of the brain and spinal cord and the peripheral nervous system with its sensory and motor nerves.

The complex electrochemical processes of nerve fibres convey physiological signals as 'travelling reversals' of the polarisation that exists between the inside and outside of the fibres. Each temporary depolarisation, which is automatically repaired a millisecond or so afterwards, can be detected as an electrical impulse or 'action potential'. Whole sequences of these events travel along the nerve fibres and can be picked up as pulse trains by electrodes.

So electronic devices can detect, amplify, process and transmit these nerve signals. But they can also generate them artificially to feed into nerve fibres which are not receiving their normal input of natural impulses because of some injury or disease. This is called functional electrical stimulation and is mostly applied to the motor nerve fibres, which cause muscles to contract and so produce movement. The surgically implanted heart pacemaker, which helps the heart muscle to function properly, is a good example of this.

Implanted stimulators, of course, owe a great deal to the miniaturisation and low power consumption made possible by microelectronics technology. But the designers and manufacturers of these implants have to take an immense amount of trouble to ensure that they will work reliably in the most hostile environment imaginable for electrical devices. Inside the human body, of course, is wet, warm, salty and continually shifting about.

I've been able to learn a good deal about one particular implanted stimulator from its designer and user. This implant, developed by the Medical Research Council's Neurological Prosthesis Unit and made by Finetech (Engineering) Ltd, allows the patient to stimulate at will certain motor nerve fibres. These have lost their normal input of actin potentials from the central nervous system as a result of injury or disease.

One application is to help the patient to breathe. Because of the loss of motor nerve function - which normally makes the respiratory muscles contract and expand automatically in a regular cycle - the patient often has to live inside a respirator or 'iron lung' in order to breathe properly. An implanted stimulator sending appropriate impulses into the respiratory muscles makes this unnecessary.

A more widespread use for the same implant is to allow paraplegic patients to urinate when they wish to. Usually a serious injury to the spinal cord causes all muscles in the lower part of the body to go out of action, including those of the bladder. Before the implant technique became available, dealing with urinary problems was uncomfortable and unpleasant for the patient. What the implanted stimulator does is to send impulses to the muscle which compresses the bladder to empty it and also to the sphincter muscle which opens to allow an outflow of urine - all under control of the patient.

To activate the stimulator, which is surgically implanted under the skin in the lower front chest wall, the patient switches on a small, external, hand-held unit and places it over the implant. This unit generates the necessary pulses, which modulate an rf oscillator. The rf power is transmitted by inductive coupling through the patient's clothing and skin to a miniature receiver in the implant. As this receiver is a simple passive circuit (basically a tuned coil and diode detector) - it needs no other power to operate it.

In the implant, the received rf pulses are demodulated into dc pulses and then carried by an implanted flexible cable to the stimulating electrodes. These electrodes are attached to the roots of the motor nerves concerned, which are actually inside the spinal cord - an extremely delicate operation for the surgeon to perform.

Medicine is leaving behind wooden legs and iron lungs, and learning to connect the body's own electrical system in to its artificial parts - like a telephone exchange.

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PRACTICAL ELECTRONICS
BOOK SERVICE

Here is your Editor's choice of books he thinks will be of interest to electronics and computer enthusiasts.

BEGINNERS AND EARLY STARTERS

**Mini-Matrix Board Projects.**
R.A.Penfold. 112 pages. £2.50.
Order Code BP99
Shows a selection of 20 useful and interesting circuits that can be built on a mini-matrix board of 24 holes by 10 copper strips in size - an ideal book for early experimenters.

**From Atoms to Amperes.**
F.A.Wilson. 160 pages. £2.95.
Order Code BP254.
For the absolute beginner, clearly explaining the fundamentals behind the whole subject of electricity and electronics.

**Electronic Projects for Beginners.**
F.G.Rayer. 128 pages. £1.95.
Order Code BP48
Specially for the newcomer to electronics who is looking for a book containing a wide range of easily made projects. Some circuits need no soldering and many others show actual component and wiring layouts.

**Electronics Build and Learn.**
R.A.Penfold. 128 Pages. £5.95.
Order Code PC 101
Combining theory and practice, the book describes a circuit demonstrator unit that is used in subsequent chapters to introduce common electronic components and circuit concepts, complete with practical experiments.

**Practical Electronic Building Blocks.**
R.A.Penfold. There are two books -
Book 1: 128 pages. £1.95.
Order Code BP117
Book 2: 112 pages. £1.95.
Order Code BP118
Book 1 is about oscillators and gives circuits for a wide range, including sine, triangle, square, sawtooth and pulse waveforms and numerous others from voltage-controlled oscillators to customised types. Book 2 looks at amplifiers ranging from low level discrete and opamp types to full power amps. A selection of mixers, filters and regulators is included.

**30 Solderless Breadboard Projects.**
Each project is designed for building on a Veroboard breadboard and is accompanied by a description, circuit and layout diagrams and relevant constructional notes. Many of the components are common to several projects. Book 1 covers linear devices, and Book 2 covers logic chips.

**Beginners Guide to Building Electronic Projects.**
R.A.Penfold. 112 pages. £1.95. Order Code BP 227
Shows the complete beginner how to tackle the practical side of electronics and includes simple constructional projects.

TEST AND MEASUREMENT

**How to Get Your Electronic Projects Working.**
R.A.Penfold. 96 pages. £2.50.
Order Code BP110
Essential reading for anyone who wants first-time success in project assembly. Covers testing mechanical faults as well as testing for failures of active and passive components of most types.

**Modern Electronic Test Equipment.**
K. Brindle. £8.95.
Order Code NT4
Detailed information and discussions on analog and digital meters, oscilloscopes, signal sources, frequency, time and event counters, spectrum and logic analysers, displays and other test equipment.

**Practical Oscilloscopes.**
I. Hickman. £6.95.
Order Code NT3
Subtitled 'How to Use Them, How They Work' the book is illustrated with diagrams and photographs and is essential reading for anyone who wants to know about scopes, from first principles to practical applications.

SATELLITE TV

**NEW* Satellite TV Installation Guide - 2nd edition John Breeds. £11.95. Order Code STV1
Full of vital information for any competent diyer who wishes to install a satellite tv antenna and obtain optimum reception quality.

**An Introduction to Satellite Television.**
F.A.Wilson. 112 pages. £5.95.
Order Code BP195
Informative answers to many of the questions about this communications revolution. The information is presented on two levels, one aimed at the complete beginner, the other at professional engineers and serious amateur enthusiasts.

AUDIO AND MUSIC

**Introducing Digital Audio.**
I.Sinclair. 112 pages. £5.95.
Order Code PC102
A non-mathematical introduction to the new digital technology, discussing the principles and methods involved in devices such as cd, dat and sampling.

**Electronic Music Projects.**
R.A.Penfold. 112 pages. £2.50.
Order Code BP74
24 practical constructional projects covering fuzz, wah, sustain, reverb, phasing, tremolo etc. The text is split into four sections covering guitar, general, sound generation and accessory projects.

**More Advanced Electronic Music Projects.**
R.A.Penfold. 96 pages. £2.95.
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Complementing BP74 by covering more advanced and complex projects including flanging, chorus, ring modulation, plus a selection of drum, symbol and gang circuits.

**NEW Computer Music Projects.**
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Order Code BP173
Shows how home computers can produce electronic music and covers sequencing, analogue and Midi interfacing, digital delay lines and sound generators.

**Practical Midi Handbook.**
R.A.Penfold. 160 pages. £5.95.
Order Code PC103
A practical how-to-do-it book for musicians and enthusiasts who want to exploit the capabilities of Midi. Covers keyboards, drums, sequencers, effects, mixers, guitars, and computer music software.

**Midi Projects.**
R.A.Penfold. 112 pages. £2.95.
Order Code BP182
Practical details of interfacing many popular home computers with Midi systems, and also covering Midi interfacing to analogue and percussion synths.

**NEW Electronic Synthesiser Construction.**
R.A.Penfold. 112 pages. £2.95.
Order Code BP185.
Even relative beginners should find the monophonic synthesiser described here within their capabilities if the book is thoroughly read. Individual aspects of the synth are dealt with separately and pcb designs are shown for the main modules.
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DIGITAL AND COMPUTING

A Concise Introduction to MS-DOS.
N. Kantaris. 64 pages. £2.95.
Order Code BP102
A ready-reference guide for those who need a quick insight into the essential command functions of this operating system, but who don't have the time to learn it fully.

An Introduction to Computer Peripherals.
R.A. and J.W. Penfold. 80 pages.
£2.50. Order Code BP170
Covers such items as monitors, printers, disc drives, cassette, modems, etc., explaining what they are and how to use them with your computer and with each other.

Microprocessing Systems and Circuits.
F.A. Wilson. 256 pages. £2.95.
Order Code BP77
A comprehensive guide to the elements of microprocessing systems, covering the fundamental principles behind this important subject.

Introduction to 6800/6802 Microprocessor Systems.
£10.95. Order Code NT9
The book covers systems hardware, programming concepts and practical experimental work that will assist in understanding the 6800/6802 microprocessor, with additional information on the 6802/8582 evaluation system.

An Introduction to 68000 Assembly Language.
£2.95. Order Code BP184
Covers the fundamentals of writing programs that will vastly increase the speed of 680X based machines such as the Commodore Amiga, Atari ST range, Apple Macintosh, etc.

NEW Electronic Science Projects.
Owen Bishop. 144 pages.
£2.95. Order Code BP104
A bumper bundle of experimental projects ranging in complexity and including a colour temperature meter, electronic clock, a solid state (led display) scope, an infra-red laser, a fascinating circuit for measuring the earth's electrical field strength, and many more.

Electronic Security Devices.
R.A. Penfold. 112 pages.
£2.50. BP56
Full of ideas for keeping your valuables safe. The circuits include designs for light, infra-red, ultrasonic, gas, smoke, flood, door and baby sensors.

£2.95. Order Code BP190
Follows on from where BP56 leaves off and describes a number of more up-to-date and sophisticated projects, such as gyro-sensor, infra-red and doppler-shift detection, fibre-optic loops, and many others.

NEW Electronic Projects for Cars and Boats.
R.A. Penfold. 96 pages.
£1.95. Order Code BP94
15 fairly simple projects that can be used with a car and/or boat. Stripboard constructional details are included, as are explanations of the circuit theory.

Power Supply Projects.
R.A. Penfold. 96 pages.
£2.50. Order Code BP76
A selection of power supply designs, including simple, unregulated, fixed voltage regulated and variable voltage stabilised, ni-cad charger, voltage step-up, and inverter.

More Advanced Power Supply Projects.
R.A. Penfold. 96 pages.
£2.95. Order Code BP192
Covers more advanced topics than BP76 and includes precision supplies, switch mode and computer controlled supplies, plus a selection of miscellaneous circuits.

Popular Electronic Circuits.
R.A. Penfold. 160 pages.
£2.95. Order Code BP80
Containing a wide range of circuit designs for experienced constructors who are capable of producing working projects direct from a circuit diagram without specific constructional details.

Getting the Most from Your Printer.
J.W. Penfold. 96 pages.
£2.95. Order Code BP181
How to use the features found on most dot-matrix printers from programs and popular wordprocessors, showing examples of what must be typed to achieve a given effect.

Micro Interfacing Circuits.
R.A. Penfold. Two books, each of 112 pages.
Book 2: £2.25. Order Code BP131
Both books include practical circuits and useful background information through pcb layers are not included. Book 1 mainly covers computer input-output techniques. Book 2 deals primarily with practical application circuits.

An Introduction to 6502 Machine Code.
£2.50. Order Code BP147
Covers the main principles of machine code programming on 6502-based machines such as the Vic-20, Oric-1/Atmos, Electron, BBC and Commodore 64. It assumes no previous knowledge of microprocessors or machine code and gives illustrative programming examples.

A Z-80 Workshop Manual.
E.A. Parr. 192 pages.
£3.50. Order Code BP112
A book for those who already know Basic but wish to explore machine code and assembly language programming on 8080-based computers.

Practical Digital Electronics Handbook.
M. Tooley. 208 pages.
£6.95. Order Code PC 104

DATA AND INFORMATION BOOKS

Digital IC Equivalents and Pin Connections.
A. Michaels. 320 pages.
£5.95. Order Code BP140
Linear IC Equivalents and Pin Connections.
A. Michaels. 256 pages.
£5.95. Order Code BP141
Between them these two books show equivalents and pin connections of a popular user-oriented selection of European, American and Japanese Ics. They also include details of functions, manufacturer and country of origin. The Digital Ics book also quotes details of packaging and families.

Oamps.
B. Dance. £5.50.
Order Code NT2
Substituted Their Principles and Applications this interesting book is written in a simple non-mathematical style and provides a source of practical circuits that use both common and more sophisticated oamps.

Electronic Hobbyists Handbook.
R.A. Penfold. 96 pages.
£4.95. Order Code BP233
Provides a source of useful information that the amateur enthusiast is likely to need for day-to-day pursuance of hobby electronics.

Practical Electronics Handbook.
I. Sinclair. £7.95.
Order Code NT1
A useful and carefully selected collection of standard circuits, rules-of-thumb and design data for enthusiasts, students and engineers involved in radio, computing and general electronics.

Newnes Electronics Pocket Book.
I. E. Parr. £6.95.
Order Code NT10
Presents all aspects of modern electronics in a readable and largely non-mathematical style, and is a good source of valuable information for enthusiasts and professional engineers alike.

NEW Key Techniques for Circuit Design.
G. C. Loveday. £6.95.
Order Code BM 101
Tackles the problems of designing circuits from scratch, introducing the concept of target specifications, the design sequence, device selection, rules of thumb, and useful equivalent circuits.

HOW TO ORDER

State your order code and your name and address clearly. Enclose a cheque, PO or international money order (add 50p postage per book - £1.00 for overseas surface mail), and send to: PE Book Service Intra House 193 Uxbridge Road London W12 9RA

Books are normally delivered within 10 days but please allow 28 days for delivery.
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PRACTICAL ELECTRONICS APRIL 1989
ED'S CRYSTAL TV WINNERS!

At last it can be revealed - the hat-drawn triumphant three who have each won a superb Ferguson PTV01 pocket-sized LCD TV!

STEPHEN HORAN of HELENSBURGH
KAMELESH PATEL of WEMBLEY
JAMES DAVID of UPMINSTER

Congratulations folks!

And best wishes plus twelve month's free subscription to PE go to the three runners-up: Alex Shepherd of BFPO 49, Keith Robins of Lanarkshire, and V.H. Thomas of Ipswich.

The correct answers I was looking for to the first eight questions were in order of: Capacitance, Battery, Microprocessor, Farad, Henry, Chip, Resistance, Impedance. The next two answers I wanted were: Practical Electronics (or PE) and Ferguson.

FACTS AND FIGURES
85% of you had all ten correct answers. 4.6% swapped Impedance and Resistance. Three people swapped Watts and Henry. One person swapped Henry and Ferguson. Two people can't spell Chip and wrote Substrate, and one wrote Load instead of Resistor. (How on Earth could these last three do that? I gave the words I wanted in the instructions!) One person was almost totally all at sea giving the answers in order of F, B, M, H, I, Chip, Cap, Res. No-one got battery wrong!

All except three people knew that PE was the answer to Q9. One of these said "Your Computer", two gave no answer at all, how odd. Q10 got a wide variety of answers - 29 other companies were stated instead of Ferguson, the most common being Thorn/EMI, IEEE and Amstrad. Some people gave PE or Intra Press as the answer. However meritorious these other answers to Q10, it was Ferguson I wanted quoted - after all it was with their kind help that we were offering the LCD TVs!

86% of readers know how to write programs to lesser and greater degrees of expertise. (It's coincidence that 86% use computers - some know a language without having access to a computer, others use them without programming knowledge.) 81% know Basic, 24% are familiar with several varieties of machine code, 17% know Pascal, 10% Fortran, 6.5% "C", 4% FORTH, 2.5% Cobol, 2.5% Logo. A large array of other dialects was quoted, though none of these showed significant statistical merit. Interestingly, a fair number of you consider that knowledge of system protocols and custom software qualifies as programming language knowledge.

LINGUISTICS
Although 44% of you know only one language, some of you are really multilingual. 22% know 2, 11% know 3, 5% know 4, 1% know 6, 0.6% know 7. One person says he knows 10. Another claims knowledge of all programming languages; if he's including all 60 variations the rest of you quoted, he's amazing!

Also interesting is that a few of you sent in more than one entry form, usually on different dates. Nothing wrong with that, I didn't say you couldn't - it certainly shows enthusiasm and there were not enough to upset the statistics. I noted many regular entrants, and previous winners - hi folks!

Thanks for telling me some fascinating and useful facts. We'll be having another competition in our May 89 issue, and shall also be asking for more opinions and statistics.

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