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DESIGN

Spectrum
analyser on
the cheap

COMPUTING

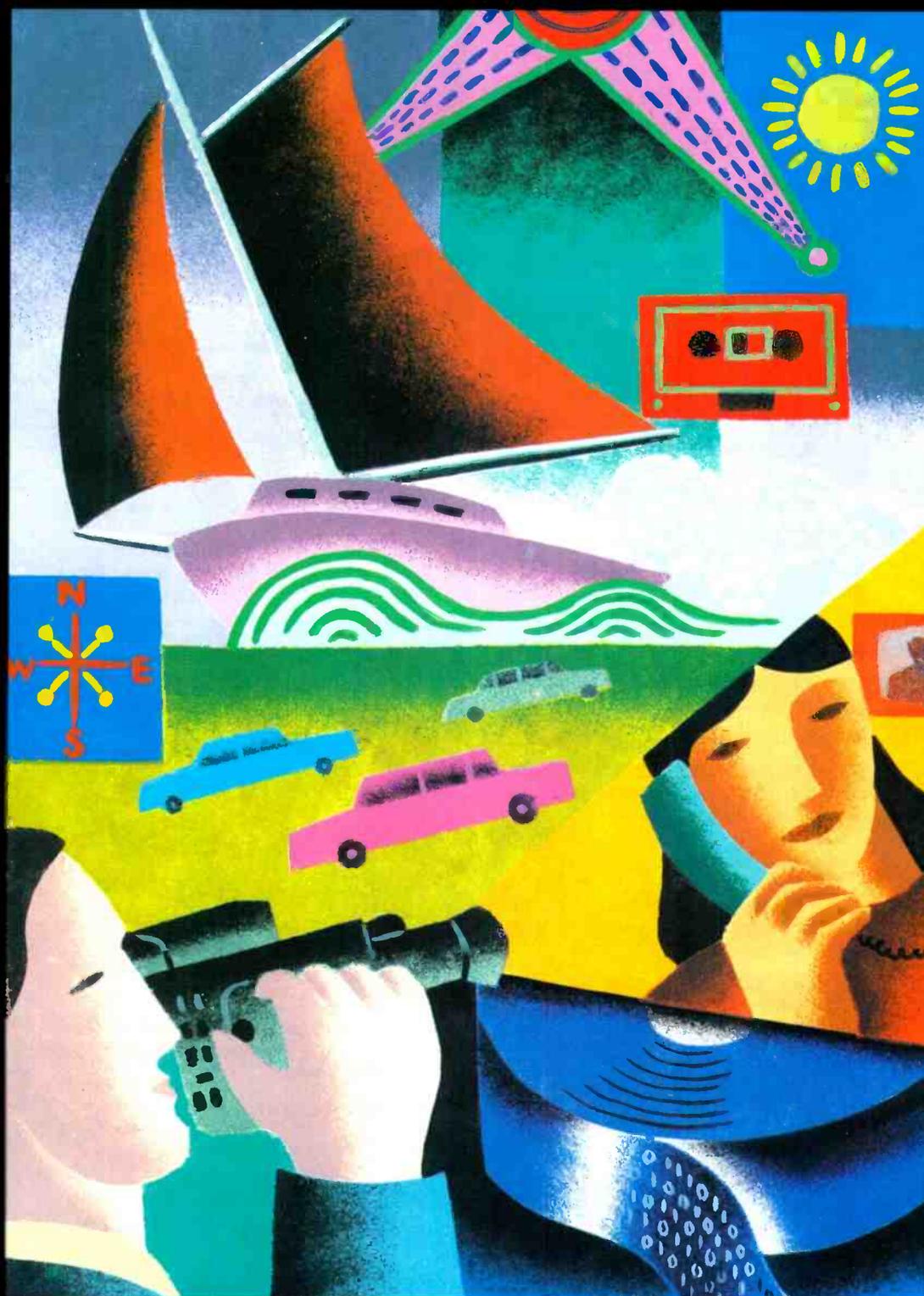
Fractals to
transform
image
compression?

HISTORY

Development
of the valve

PC REVIEW

Workstation
logic
simulator
performance
for £200?



Consumer electronics in turmoil



Low Cost Programming - from Stag

ORBIT: Palm Top Programmer - £595

Orbit is an advanced battery/portable programmer incorporating all of the features usually found in expensive 'desk-bound' programmers.

Careful attention to detail has resulted in a compact and portable unit which is also fast and easy to use.

Features:

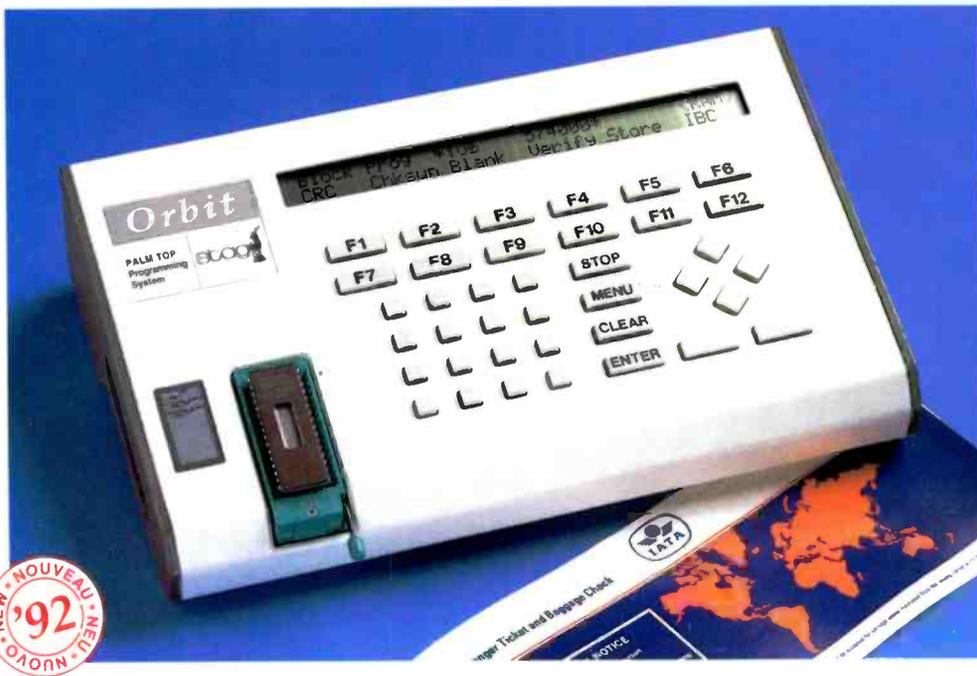
- Totally portable, battery/mains powered programmer
- Programs EPROMs to 32-pins and to 4 Mbit, EEPROMs and FLASH
- Optionally programs 40-pin EPROMs (16-bit) and 'Intel style' micros
- Small enough to be hand held - only 236mm x 145mm x 56mm - weighs only 0.85 kg
- Fast programming - uses latest algorithms
- Approved by major silicon vendors including Intel and Texas Instruments
- Integral EPROM emulator - can be connected directly to target system to speed up development
- Powerful on-board data editor
- Tactile rubber hexadecimal, cursor and function keys
- 2 line x 40 character LCD for data and 'soft keys'
- 512 Kbit RAM as standard, expandable to 2 Mbits

Communications:

- Serial port to 19K2 and parallel port - supports label printing
- Remote control as standard
- Supports 16 popular interface formats including Motorola S-record, TekHex, binary, DEC binary, Intel hex and Hex ASCII

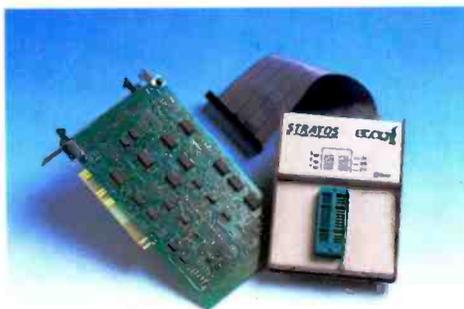
Power Supply

- Optional mains operation from supplied adaptor/charger unit: available for 110 or 240 volts
- Up to 35 hours use from one charge (edit mode)
- Fast boost charge in just 3 hours - with safety cut-off
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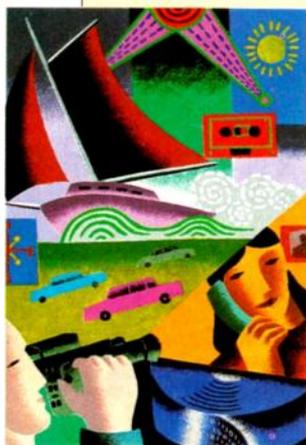
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In next month's issue. It is over two years since Electronics World aired the public concern over the biological effects of low frequency electro-magnetic fields. Alasdair Philips reports that the generating companies have become even more dismissive since privatisation despite fresh evidence implicating ELF fields in disease. We also present design details of a low frequency fluxmeter.

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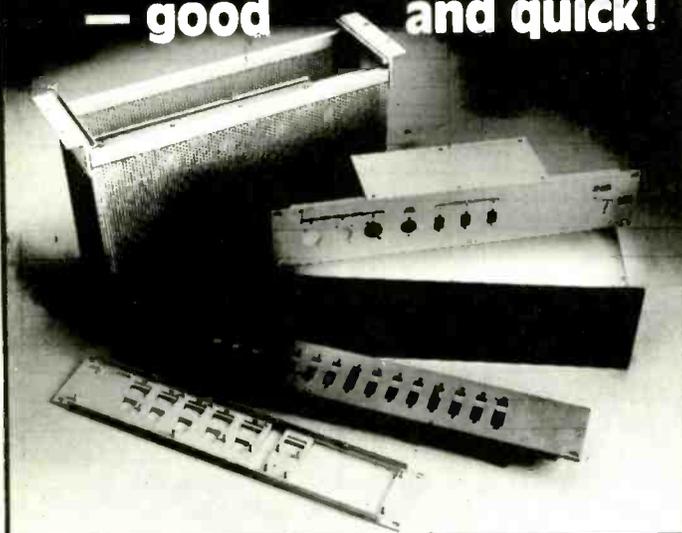
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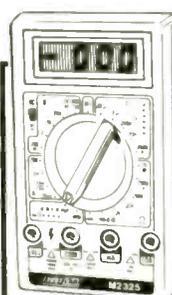
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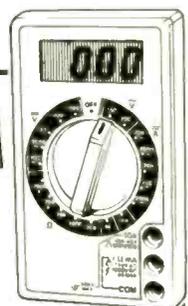
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Learning from the future

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Change of telephone numbers

From this month our exchange number has changed from 661 to 652. So, for example, a telephone number that was 081 661 1234 has now become 081 652 1234

The view that much of what comes out of the development labs of electronics companies is technology for technology's sake deserves sympathy. But once in a while, things do emerge which touch everyone. Personal computers and video recorders have visibly changed the developed world yet the next arrangement of transistors will alter our lives more radically than these. CD-I will arguably be as important to us as William Caxton's press was to people who lived in Europe during the 15th century.

CD-Interactive doesn't instantly appear consequential. Compact Disc in its audio form has done more for the equipment and record companies than for the general enjoyment of music. Video disc appeared several times in front of the consumer who promptly rejected it on every occasion. Computer disks... they are and will continue to be important but, in their present form, are more convenient than portentous.

So what will give CD-I a special place in the world? It is simply this. It promises to be a most powerful educational tool capable of replacing many, but not all, the aspects of lecturer and course work. For the first time it becomes possible to hold a variety of information sources - sounds, moving image sequences, mathematical data, written and spoken words and integrate them into a silver disc in a manner limited only by our imagination. Although a remarkable development, this would not be enough to change the world. What makes CD-I truly different is the ability of the audience to interact with the recorded information.

Look at it this way. Imagine a video recording of a lecture. The camera and microphone will make a faithful record of what was said and shown by both the lecturer and the audience. As interesting as the lecture and subsequent exchange might be, viewers of the recording are unable to pose their own questions and receive individual clarification to a particular point.

CD-I can alter the perspective. The same facts which came out in the lecture can be presented in an order determined by the viewer. Because CD-I provides a tree-like structure to its information content, it gives

the possibility of branching to detailed explanation at the viewer's request, clarifying a particular aspect of the subject matter. Indeed, it might even encourage introverted students to be more determined by avoiding the possibility of public humiliation.

Because the CD-I medium runs under computer control its information display can branch conditionally, dependent for instance on the student offering particular solutions - right or wrong - to the propositions presented.

Here is an example. A CD-I lecture on organic chemistry might deal with the dynamics of a condensation reaction. The student questions the importance of temperature. Get it right and the feedstock combines with itself to form the expected brown gunge at the bottom of the reaction vessel. Choosing too low a temperature will produce a video sequence where nothing happens complete with spoken commentary to that effect. Make it too high and the sodium hydroxide which normally acts passively as a catalyst commences hydrolysis of the polymer with the subsequently visible release of ammonia gas.

The power of this teaching tool is limited only by the imagination of the software writers. But be warned. The first releases on CD-I won't seem important in any way. Expect discs on photography, cooking and golf and a whole rash of interactive arcade games. Only when we become bored with this first indulgence will the true value of CD-I be appreciated.

Frank Ogden

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REGULARS

UPDATE

Keeping tabs on callers

The much debated 'caller ID' feature on phones has now reached reality with the launch of a low-cost 8-pin DIP by Sierra Semiconductor. The service anticipated for digital networks enables the called party to see the displayed phone number from which he or she is being called.

The decision can then be made to take the call or ignore it.

In the US, generally reckoned to be several years ahead of the UK in terms of phone services, the pros and cons of implementation of a caller ID feature have been widely discussed. Fears have been voiced that the system might be open to abuse, primarily by callers.

Whatever the arguments for or against the system, Sierra has succeeded in implementing the required features – receiver amplifier, carrier detector and FSK demodulator – in its 8-pin SC11210, which costs under \$2 in 10,000-off quantities. The circuit is designed for use in feature phones or display boxes that sit beside the phone.

Caller ID features have already been included by Sierra in the modems for which the company is perhaps better known. These can decode the caller ID and send ASCII characters back to the host for display. This is particularly useful for dial-back applications, where the host can check the caller's identity before answering the line.

One other point in favour of caller ID is that it will enable nuisance callers to be quickly and easily identified, minimising the adverse effect on their victims.

£1bn+ cost of hacking

Computer problems such as hacking, viruses and accidental failure affect more than half of industrial and commercial companies at an estimated annual cost of £1.1bn claims Technology Minister, Lord Reay.

These are some of the findings revealed in a new computer security survey carried out by the National Computing Centre in association with the DTI and ICL. More optimistically some 57% of the 8200 organisations questioned in the survey said that they had contingency plans to deal with computer fraud and failure.

Fast fibre lights up

AT&T Bell Laboratories is experimenting with an ultra-fast optical fibre ring-based local area network that it says may be capable of handling a peak data rate of 100Gbits/s – 1000 times faster than the most up to date electronic solution. The experimental network is based on solitons (light pulses that travel distortion-free over long distances) and all-optical logic gates. Solitons are trapped and dragged (slowed) to produce on/off signals for digital communication. The network's design is also said to be "very ambitious".

Sound investment in nicam

The advent of stereo sound broadcasting in television has opened up a slot in the market for add-on nicam adaptors to enable stereo sound reception without having the expense of a new television.

The box from Ash Television, a company set up specifically to exploit the market, includes an integral 8W/channel stereo amplifier and is interesting from the design point of view. Rather than adopting a conventional extraction of the nicam signal from the intercarrier sound, Ash founder and designer Stan Henderson produced a custom processing IC which synchronously demodulates the nicam signal in its 26MHz IF form. The chip uses a phase locked crystal oscillator for the second LO.

The adaptor has its own push-button tuning head and includes a conventional intercarrier demodulation strip for mono sound. It costs £176. Ash Television 081-443 2727.

Neighbourhood watches engineers

The UK's Engineering Council has launched the Neighbourhood Engineers scheme, under the auspices of which secondary schools receive practical support from professional engineers and technicians.

The scheme is designed to equip young people with a better understanding of the work carried out in engineering and technology. Participants are working with teachers to provide encouragement in support of the school's curriculum as well as becoming involved in a range of activities including project work. Although launched in London, the scheme is to operate in most parts of the UK.



Space-age honour

Somerset town, Minehead, is planning to honour space and science fiction writer, Arthur C. Clarke, in a week-long space age festival to be held next July. Clarke, who celebrates his 75th birthday next year, was born in the town. He wrote the seminal article on satellite communications "Extra-Terrestrial Relays" first published in this magazine in October 1945.

Durham gets connected

Durham University has prepared itself for the 21st century by connecting all of the major buildings across its campus using a 15 kilometre fibre optic backbone and spur cable. The cable links 52 buildings, enabling members of the University to communicate rapidly with colleagues and computers as well as nationally and internationally.

The network, which has been installed at a cost of £1 million, makes the university one of the few organisations outside the commercial world to have such an advanced communications structure.

Daventry falls silent

The BBC's shortwave broadcasting station at Borough Hill, Daventry is to close after 67 years of continuous scheduled broadcasting on March 29, 1992.

It opened on January 1, 1925 with broadcasts on 1600m under the callsign 5XX.

In 1932, it broadcast the "Empire Service" which eventually became the BBC World Service. It was also the site which, in 1935, provided the transmissions for Robert Watson-Watt's classic experiment in radio-location of an airborne target which was eventually to produce British radar.

The BBC's Ariel amateur radio group will take over the site for the weekends of April 4/5 and 11/12.

Sony enters portable data market

Sony hopes to shrug off its consumer image with the launch of a hand-held electronic book. Data Discman reads CD-rom discs that adhere to the universally-recognised Electronic Book (EB) standard. It can also play standard 8cm audio CDs.

Through the CD-rom, Discman offers a 200Mbyte data capacity, providing the equivalent of 100,000 pages of A4 text or 32,000 visual images or any combination of the two.

The conformance to international standards is deemed by Sony to be of great importance. Discman can read EB software and also be connected directly to a monitor or video projector.

Although Discman reads 'commercial' CD-roms, Sony is also keen to promote its use as a storage mechanism for tailor-made 'books', such as stock inventories, price lists, corporate profiles and reports or 'expert systems' for use by legal, medical and engineering practitioners. Discman can thus provide wide access to information for business and professional users.

Discman is being supplied bundled with three EB titles as standard, plus rechargeable NiCd and dry cell battery packs, AC adapter and video cable. The bundle will cost around £350. Data Discman is seen by Sony as the first stage

in a complex interactive personal communications network. The importance attached to CD-rom is underlined by the findings of analyst Frost & Sullivan, which predicts a \$3.1 billion US market for CD-rom by 1996.



Close call for satellite operators

Continuing concern over possible interference with its satellite transmissions has prompted Astra to launch a critical salvo at rival operator Eutelsat.

At the "Images of the Future" conference held in London in February, Jonathan Hart, managing director of Astra's UK marketing company strongly reiterated a call for "more efficient use of the orbital arc" - which he described as "a scarce natural resource."

The comments reflect Astra's worries about the current (and possible future) problem of interference between its satellites at 19°E and Eutelsat II-F3 in the next door orbital slot at 16°E.

Originally, spacing of orbital positions was determined at a time when it was thought dishes would need to be at least 90cm for reception of medium-power satellites. At that size and that distance there was no risk of side-lobe interference.

But with smaller dishes, a 3° spacing does create a risk of interference, though, as Jonathan Hart explained, a number of factors would have to coincide. "It would have to be planned in a way that would deliberately cause it; there are a lot more options where interference will not be caused."

Hart also attacked Eutelsat's claim to priority in registering II-F3.

"Being first does not allow anyone to cause interference or even threaten it - it only determines who should consult with whom."

According to Hart, the key to the problem lay in "Eutelsat's policy of gobbling up the orbital arc with identical satellites."

The solution, he said - presumably involving relinquishing or restricting some slots, and stacking satellites, like Astra, in others - "lies with the signatories." **PW**

Additional consumer benefits for pal plus?

By the end of 1995 European broadcasters and TV set makers plan to introduce a new, enhanced, "compatible" pal terrestrial broadcasting service. Pal-plus aims to give the viewer higher quality pictures and sound on the new wide-screen 16:9 aspect ratio TV sets now coming on the market.

The higher quality vision will derive from better utilisation of the existing luminance bandwidth of the pal channels, and better separation of luminance and chrominance information to reduce cross-luminance and cross-colour degradations. Improved sound will probably be obtained by a dual-channel digital system comparable to Nicam, but this has not yet been settled.

Broadcasters in the pal-plus group come from Austria (ORF), Germany (ZDF and IRT), Switzerland (SRG) and the UK (BBC and independent broadcasters) and set makers involved are Grundig, Nokia, Philips and Thomson.

At present eight specialist groups from the consortium are still engaged in various aspects of system development and definition. But come July 1992, a public demonstration of pal-plus is planned for IBC92 in Amsterdam. Next stage will be equipment development in 1993/94 and experimental transmissions in 1994/95.

To judge from a recent IEE/RTS international colloquium mainly devoted to the pro-



The setmakers and the broadcasters are arguing the toss over letterbox tv sets. But does the public really want something like this in its living room?

ject ("Enhanced and wide-screen pal") the case for the proposed new service does not seem to be entirely overwhelming. The pal-plus consortium itself sees the project in technical/commercial terms as a bridge between the present pal service and a future HDTV or all-digital system.

Clearly it would fill the gap left by the current hiatus in the development of Eureka 95 and a world-wide HDTV standard. It also might give terrestrial broadcasters a compet-

itive edge on other forms of picture delivery such as satellite and video cassettes.

Demand for new wide-screen sets incorporating special pal-plus decoders could provide a much-needed early boost for the European consumer electronics industry – a useful commercial stop-gap until HDTV arrives.

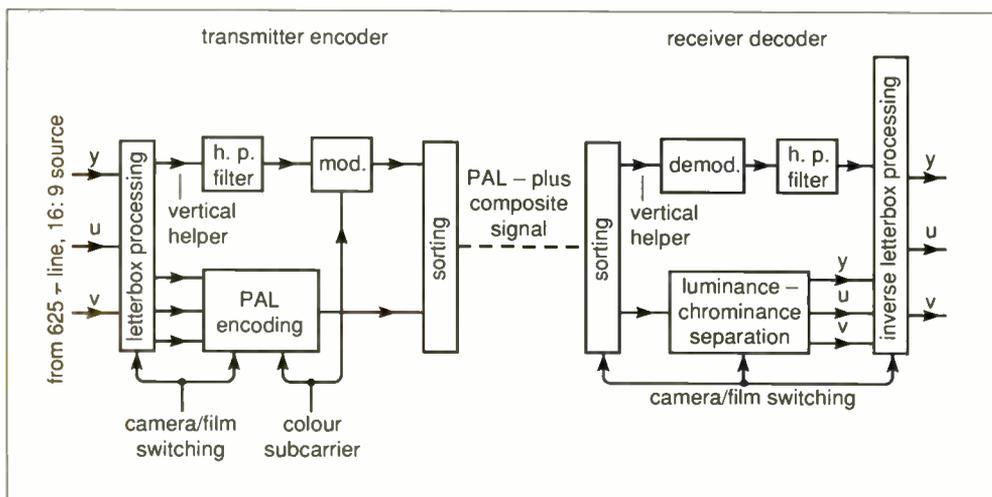
Unknown public reaction

But how will the public and other users react? Some speakers at the colloquium were alarmed at the current prices of the 16:9 wide-screen sets. Nokia, Philips and Thomson were demonstrating production models – showing off-air and recorded standard pal pictures – ranging from £2650 to £3500. Speakers declared there would be "enormous customer resistance" and that the public would be unwilling to fork out for such receivers for just an interim period, with HDTV and its double-picture resolution just round the corner.

F W P Vreeswijk of Philips and D Westerkamp of Thomson assured doubters that volume production and smaller screens than the current 86cm (36in) diagonals would bring down prices to something like those of standard pal sets. (Nokia plans to introduce a 71cm model during 1992). C Dalton of Thames Television pointed out that HDTV, requiring very expensive receivers, was not all that close anyway.

A worry over the claimed compatibility of the pal-plus system was voiced by Paul Gardiner of the ITC (formerly IBA). On standard 4:3 pal receivers the pal-plus 16:9 image format would occupy the middle 432 of the 576 active lines of the 625-line signal.

Fig. 1. Essentials of encoding at the transmitter and decoding in the receiver in the pal-plus system architecture.



leaving black bands 72 lines deep above and below the picture. This "letterboxing" is currently used for transmitting widescreen films on television. But UK terrestrial broadcasters were worried, said Gardiner, that a sudden move to full letterbox, even if initially only on feature films, might alienate existing viewers – a serious concern for broadcasters. He quoted a survey of acceptability of the letterbox format on Channel 4 and BBC2 films. Thirty one per cent of viewers said they didn't like it and 18% that they did. Of the remaining 51%, some didn't notice it and the others felt it made no difference.

UK broadcasters were reluctant to transmit non-film letterbox material on the mainstream channels. However Gardiner suggested a compromise solution to the problem: a possible interim 14:9 letterbox format – to be used during the pal-plus introductory period – that would introduce viewers gradually to black bands on pictures.

Attempting to allay concern on whether letterboxing really does satisfy compatibility, D Westerkamp said that many European viewers were already familiar with the practice. In any case broadcasters could introduce the new format gradually, deciding to transmit either standard pal or pal-plus on a programme to programme basis.

Pal-plus architecture

Westerkamp also gave an outline of the pal-plus system architecture. The pal-plus source signals (Fig. 1) are in Y, U, V component form and represent a 16:9 image format. The source standard is 625/50/2:1 and could, for example, result from down-conversion from HDTV equipment.

The signal is first low-pass filtered in the vertical dimension with a cut-off at 0.75 of the Nyquist frequency. Then, in the letterbox processing section it is sub-sampled by a factor of 0.75, giving the 432 lines that will be placed in the middle of the 576 active lines of the 4:3 output frame. The method gives the correct image geometry for the 16:9 pal-plus picture.

At this point the pal-plus signal has apparently lost vertical resolution – but this is restored. A high-pass filter selects the upper part of the vertical luminance spectrum and the signal is sub-sampled by a factor of four to give 144 active lines, 72 of which are transmitted at the top of the picture and 72 at the bottom. This "vertical helper" signal is band-limited to about 4MHz and modulated in vestigial side-band AM on the colour subcarrier (Fig. 2) with an amplitude of



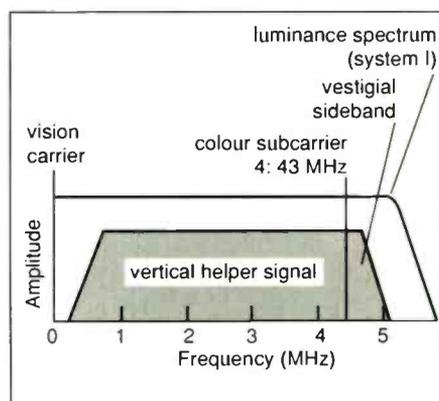
Fig. 3. Pal-plus pictures would be displayed on 16:9 widescreen TV sets similar to this current model for standard transmissions made by Nokia Consumer Electronics. (When standard 4:3 format pictures are shown on wide-screen sets the image can be expanded to fill the full width of the screen, though of course this cuts off some lines at the top and bottom).

$\pm 150\text{mV}$ relative to black level.

In the pal-plus receiver the vertical helper information is decoded and used to give a picture with the full vertical resolution of the source. In the standard pal receiver the information is mainly decoded as chrominance and is "almost not visible" on the black bands. Any residual visibility might be dealt with by line-cut-and-rotate scrambling.

Improved luminance-chrominance separation is obtained by pre-processing at the

Fig. 2. The spectrum of the pal-plus "vertical helper" signal fits into the overall vision frequency spectrum. It is AM-VSB modulated on the colour subcarrier.



transmitter – to avoid most of the cross-effects – and by matched post-processing in the pal-plus receiver. Cross-luminance is reduced, so the luminance filtering normally necessary to minimise this degradation in a standard pal receiver can be avoided in the pal-plus set. Consequently something nearer to the full horizontal resolution allowed by the transmission bandwidth (5.5MHz in the UK) should be achievable in the pal-plus receiver.

Also transmitted through the system is some signalling information, in the first half of line 23, to tell the pal-plus receiver whether a 16:9 or a 4:3 picture is being broadcast and automatically to switch the set accordingly. It also switches the receiver to decode for the different modes of vertical processing and luminance-chrominance separation necessary at the transmitter for camera and film sources.

Various experimental "clean" or enhanced pal systems have been devised over a period of about two decades, mainly for internal use by the broadcasters, though in 1982 the BBC did propose its E-pal system as a candidate for public DBS.

Even so pal-plus still has some way to go. Subjective tests on picture quality have been carried out to choose the best processing algorithm from ten proposals – but the testers were not confident enough to reveal it at the colloquium. C Dalton, who is a member of the consortium's studio group, commented that enhanced pal is still "in the growing pains of infancy" and, concerning pal-plus, "many questions need to be answered."

Tom Ivalle

REGULARS

RESEARCH NOTES

Electronic brain with a human face

Neural networks have been around for a long time, but a realistic electronic model of an animal neuron (nerve cell) has only just become possible. By combining neurophysiological principles and VLSI technology, Misha Mahowald of the California Institute of Technology and Rodney Douglas of Oxford University have produced an analogue ic with the functional characteristics of a real neuron.

In their recent paper (*Nature Vol 354 No 6354*) Mahowald and Douglas say that because the physical principles underlying their silicon neuron are similar to those of

biological membranes, the electronic device can emulate the ion currents that cause nerve impulses. Moreover, it operates in real time, consuming only fractions of a mW.

This silicon nerve cell, built from CMOS circuits, is totally different from previous neural net hardware and occupies less than 0.1mm². Mahowald and Douglas estimate that a linear array of 100-200 such cells could be fabricated along a 1cm² silicon die. Remainder of the area would then be occupied with silicon analogues of dendrites, the substances that form the interfaces of biological neurons.

Although the circuitry of this "neuromime", as it is called, is relatively simple, the device replicates faithfully many of the properties of its biological counterpart. One such interesting property is that of adaptation.

When the neuromime is stimulated, it initially generates a rapid series of action potentials that become slower as the stimulation continues. In biological systems this mechanism is part of the explanation why any stimulus, be it pain or a loud noise,

Continued over page

Self-cleaning tools improve chip yield

Among a number of interesting reviews, *IBM Research* magazine (Fall 1991) includes a survey of the latest methods of reducing the contamination that is estimated to cost the world semiconductor industry US\$1 billion worth of product loss each year.

According to IBM, clean rooms have now advanced to the point where atmospheric contamination, such as skin particles, contributes only 15% of the debris that can land

on a chip during processing. A good modern clean room can filter the air so efficiently that it contains no more than a single half-micron particle per cubic foot of air. That's a thousand times better than the average operating theatre and up to a million times better than the dirtiest of city streets.

Most of the particles that cause trouble during chip manufacture come not from the air itself but from the chemicals and tools

used in plasma processing. Contaminants float in the space between the electrodes and can be observed by the way they scatter laser light.

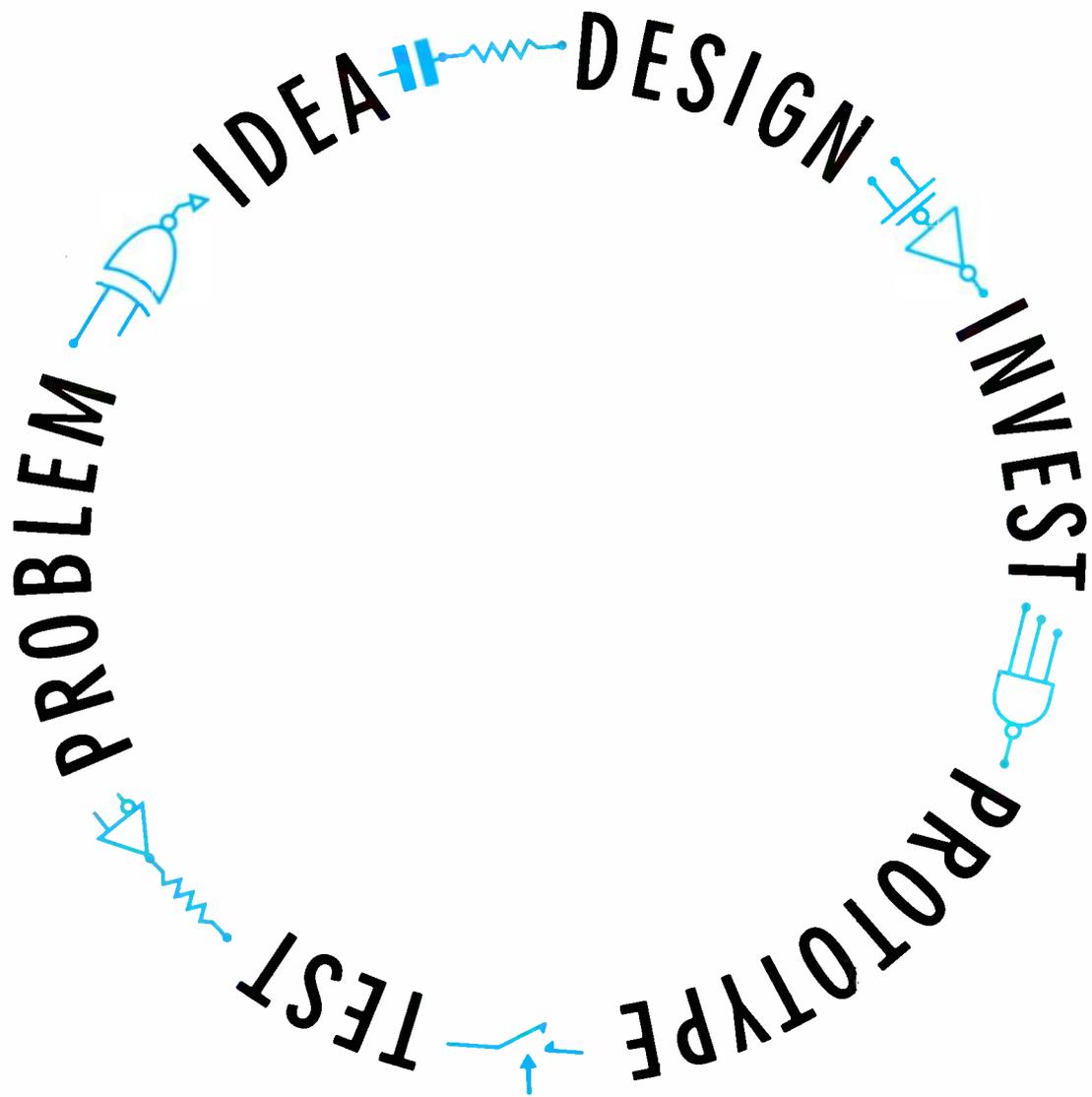
One clue to attacking this problem came when IBM researchers noted that such particles tend to clump in areas with particularly high electric fields. These occur at sharp edges or at other physical non-uniformities of the electrodes. The team at the Thomas J. Watson Research Center therefore deliberately machined grooves around their experimental electrodes in the hope of creating 'decoys' for the contaminant particles.

Taking this idea a stage further, they optimised the grooves so that the gas flow in the chamber would turn them into tiny conduits that would continuously channel particles away from the critical region. So far, these 'self-cleaning tools' have proved effective in reducing contamination by an average of 50%.

Optimisation of the electrode groove design is still a matter of ongoing research, but already the benefits are far outweighing the relatively low cost of implementation.

IBM's John Heidenreich, Ed Patterson and Gary Selwyn, part of the team at Thomas J Watson Research Center who have been working with the "self-cleaning" grooved electrode





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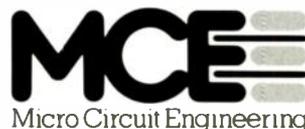
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becomes less irritating as time goes on.

Impetus for research into understanding the human nervous system has obviously been given a considerable boost. In an accompanying "News and Views" article in the same edition of *Nature*, Andreas Andreou of John Hopkins University in Baltimore says that while analogue neuronal models are not as accurate as digital simulations, they do have an enormous advantage in that they capture the true dynamics of the situation. The analogue model has noise, irregularities and non-linearities like real neurons and real brains. Such irregularities, Andreou points out, are computationally expensive to simulate on a digital computer.

Mahowald and Douglas are currently assembling their neuromimes into circuits like those that process signals from the retina of the eye. Although an artificial eye or even an artificial brain is a long way off, researchers in this field are already thinking of intelligent prostheses for disabled people.

This fascinating new area of research is currently generating as many problems as it solves. How, for example, can imprecise analogue devices achieve the precision of human vision? How can they cope with transducing optical, chemical and mechanical signals with the dynamic range found in nature? How thermally stable would such systems be?

Clearly there are lots of questions still to be answered. Andreou believes, however, that a combination of biological and engineering know-how may eventually lead to new electronic information-processing systems that approach the performance of biological ones.

Six year space exile leaves time for experiment

Just over two years ago there were fascinating TV pictures from space when the Space Shuttle Columbia rescued the huge 10.5 tonne LDEF satellite using a Canadian-built remote-controlled grappling arm. The delicacy of the operation, which took more than 15 minutes once it had started, has been likened to towing a weightless bus into a garage using only a piece of string.

LDEF, launched in 1984, was not so much a satellite as a flying test-bed, covered with 57 experiments designed to find out how various materials and components would survive the rigours of space. Originally that period in orbit had been planned to last between nine months and a year; in the event, the Challenger disaster set the US Shuttle programme so far back that LDEF

Continued over page

Millimetric lasers open up communications

One of the natural obstacles to opening up the millimetre wavebands is the difficulty of generating signals. Smaller wavelengths mean smaller active devices which in turn can handle less and less power.

Researchers have generally responded to this problem by building arrays of devices integrated into what purports to be a single millimetre-wave transistor. Alternatively, the devices can be paralleled, either at the circuit level or even as parts of a composite active antenna. All components operate at the same frequency and add together to boost the final transmitted power.

An alternative to this paralleling technique is currently being explored by a team under Assistant Professor Richard Compton in the Electrical Engineering Department at Cornell University. It makes use of a technique that has been borrowed from the world of lasers and is known as mode-locking.

Instead of having all the oscillators running at the same frequency, they are run at slightly different frequencies. If the frequencies are equally spaced, then at one instant they will all add together to give a large signal, but for all other times tend to cancel one another out.

The Cornell team has demonstrated a five element array operating at the very modest frequency of 10GHz which produces a pulsed signal much more powerful than the continuous wave emitted by a conventional parallel array. A CW source with five elements emits five times the power of a single element, whereas a mode-locked array generates a peak power twenty-five times larger. In general, mode locking increases peak power by the square of the number of circuit elements. While Compton's source is still relatively low-powered (in the range of several watts), it is suitable for communications and is claimed to be better than the milliwatt devices currently available.

Several car manufacturers are working

on collision-avoidance systems and a good millimetre wave source could provide a significant advance in this area that would lead to a large demand for such devices. Crowding of communications channels also will provide impetus for the development of devices that use frequencies in the millimetre range.

In addition to new television and satellite telephone transmitters, cellular telephones and paging devices, millimetre systems could form the basis for powerful military jamming equipment or small airborne radars that could provide enhanced detail of terrain and more precise information about location.

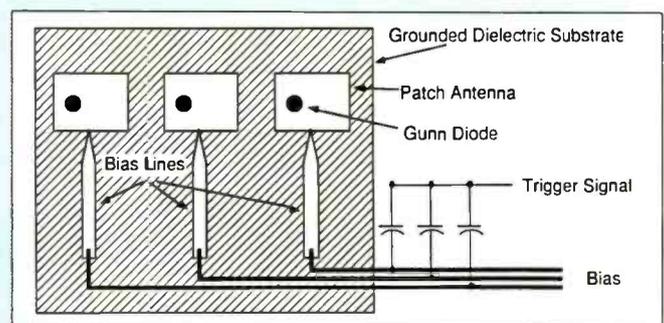
The chief hurdle to practical applications according to Compton is the cost of fabricating, packaging and testing devices. At present he uses the National Nanofabrication Facility at Cornell to make the microscopic gallium-arsenide devices, but points out that an automated industrial facility would bring costs down to a reasonable range.

The millimetre bands contain some frequencies, such as 35 and 94GHz, that propagate well through the "atmospheric window" to satellites. At 60GHz, however, the atmosphere blocks transmission, which makes this frequency ideal for military satellite-to-satellite communication that is undetectable by listeners on the ground.

The mode-locked millimetre source has an unexpected but useful property: the direction of the pulsed signal automatically shifts around at a very rapid rate. This feature frequently must be added to a communication device so that it will transmit omnidirectionally. In mode-locking, however, beam scanning arises as a natural consequence of the system.

The next step in his research, Compton says, is to build larger arrays that operate at higher frequencies. He selected 10GHz for the five-element array because 10GHz transistors are relatively inexpensive and easily available.

A three element mode-locking array. The Cornell team has demonstrated a five element array operating at 10GHz which produces a pulsed signal much more powerful than the continuous wave emitted by a conventional parallel array.





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outstayed its welcome in orbit by five years.

While this put a big question mark over whether it would ever be recovered, many of the experiments, like good wine, were clearly going to yield better results from further maturation. These experiments, from Britain, the USA and many European countries, varied from simple painted panels designed to test durability to optical components, electronic components and a cosmic ray detector. Biological material included shrimp eggs and 12.5 million tomato seeds, many of which have since proved viable.

One problem for the Columbia astronauts was that LDEF's orbit had decayed from 500km to 300km. This was partly expected, but partly a consequence of turbulence in the outer atmosphere resulting from high levels of solar activity. If Columbia had not rescued LDEF when it did, the satellite would have re-entered the atmosphere about a year ago (09/03/91) and burned up. This meant that the mission had to succeed. It was also an extremely delicate operation because of the fragility of many of the experiments.

In the event, LDEF was successfully loaded aboard the Shuttle and returned to earth for detailed scientific investigation - an activity made more difficult by the fact that, over the six years, many of the research teams had disbanded and many companies had merged or gone out of business! Original data had been lost and measuring equipment lost or modified.

It is hardly surprising, therefore, that much valuable scientific data is only now beginning to emerge. Analysis by the Georgia Institute of Technology of 136 electro-optic components carried by LDEF has revealed significant changes in the performance of items such as band-pass filters and mirrors, possibly because of deterioration in their structure and in materials used for their manufacture.

Other components appear to be unchanged by their six year sojourn - while at least one material seems to work better after being struck by meteorites, shocked by temperature changes and scoured by upper atmospheric oxidants.

In interpreting the performance changes they measured, the researchers had to consider the variations that would have been produced by normal aging processes. Examination of the materials continues, and particular interest is being paid to holographic crystals which could be used for computer memories.

Organic materials like paints and polymer films, along with mirrors and filters made by depositing dielectric films, are degraded in space, according to Dr. Don Blue, Principal Research scientist with the Georgia Tech. "We were surprised because we really didn't anticipate anything of real significance would happen to these components during the few months they were originally expected to be in orbit."

Certain filters are used to help satellites receive laser signals by screening out all but the colour of light produced by the signalling laser. The researchers have found that six years in space has shifted the frequency of light admitted by the filters - and reduced the amount of light transmitted. Blue suggests that space scientists should consider these colour shifts and transmission losses in planning future missions.

Holographic crystals, which have the potential to store large amounts of computer data, did not appear to be damaged, although the holograms originally stored on them have been degraded due to the length of the LDEF mission. Studies of bulk crystalline properties are particularly significant in view of several planned ventures to use electro-optic crystals such as lithium niobate in holographic mass memories.

Some components carried on LDEF did

not seem any the worse for wear. Infrared detectors performed as well after their return from space as they did when first installed on an LDEF test tray back in 1978. A silicon-based infrared detector still performed as designed, despite a crater caused by the impact of space debris.

The researchers were surprised to find that six years in space appeared to improve the performance of black paints used for thermal control and low-reflectivity coatings. Preliminary studies show that the ability of the paints to absorb far-infrared emissions seemed to improve, possibly due to the creation of new light-absorbing sites by the breakup of paint binders and pigments.

The filters, mirrors, diodes, lasers and other components were part of a tray assembled in 1978 by Georgia Tech researchers to study the effects of space on electro-optic components. ■

Recipe for hot squid

Squids, or superconducting quantum interference devices, are extremely sensitive ring-shaped detectors of magnetic fields. Changes in the strength of nearby magnetic fields induce currents in the ring. Potential uses for squids range from oil and mineral exploration to the detection of cracks and corrosion currents in large structures. More recently they have been finding applications in medicine for measuring the magnetic fields created by electric currents in organs like the brain and heart.

The only reason why squid technology hasn't become more widespread is that it relies on conventional low-temperature superconductors that work only when cooled to 4.2K in liquid helium.

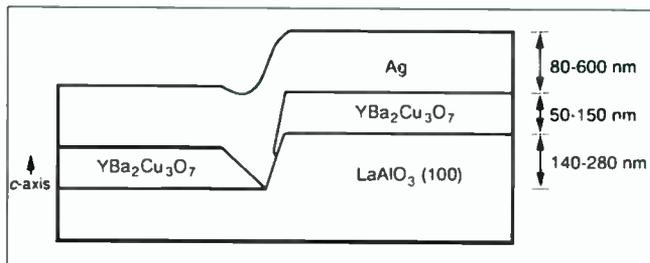
More recently, squids have been made using the new high Tc superconductors, but have proved either difficult to manufacture reproducibly or have been too noisy. Up until now squids that work at liquid nitrogen temperatures (77K) have exhibited a high degree of 1/f noise that makes them much less sensitive than helium-cooled devices at the main frequencies of interest, below 100Hz.

Mark Dilorio et al of Biomagnetic Technologies, Inc. of San Diego, California report (*Nature Vol. 354 No.*

6354) a new reproducible method for making low-noise, 'high' temperature squids based on yttrium-barium-copper oxide superconductor.

The squid is a DC device based on a novel Josephson junction consisting of two elements of superconductor with a normal metal - such as silver or gold - in between. The structure, shown in the figure, can be manufactured with >95% yield. A sharp step is etched in the lanthanum aluminium oxide substrate after which the superconducting films are deposited. The metal (in this case, silver) is then sputter-deposited to join the two films. The authors say that the reproducibility of the process stems directly from the use of the step to generate a precisely defined gap.

While 1/f noise is still the predominant noise below 100Hz, Dilorio *et al* are certain that their new devices will be sensitive enough for many of the applications which at present require liquid helium cryogenics. As with such low temperature devices, the performance of the new "hot" squids will, in all probability, be enhanced considerably by the use of flux transformers to couple with the magnetic field being measured and by the use of electronic biasing.



The superconducting film is epitaxially-grown so that its lattice c-axis is perpendicular to the substrate plane.

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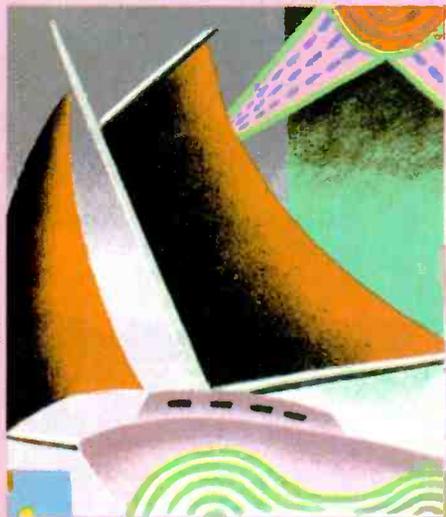
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Weekend sailors are reaping the benefits of radar, sonar and satellite navigation instruments. The chart room and wheel house bristle with complex displays; below-deck wiring is as complex as any networked, automated office. Andy Wright rides the wave in marionics.



Electronics charts new waters

One thousand pounds will equip your small boat with radar capable of looking 16 nautical miles around. Microwave integrated circuits provide 1.5kW of power in a small package; the slot array antenna inside the radome is just 400mm long, yet ensures bearing accuracy of $\pm 1^\circ$, 1.5% or 70m accuracy in distance.

Panasonic's KX-G8100 radar system is typical. Operating at 9.41GHz, its ranging is provided by duplexing two pulse widths and PRFs: 0.08 μ s pulses at 2500Hz provide close-in data between a quarter of a mile to a mile or so. Extending the pulse width to 0.5 μ s at 1000Hz PRF extends the range to 16nm.

Radar maker Furuno has replaced the slot antenna by a microstrip unit. Simpler construction keeps cost down — at the expense of efficiency — but the radome is highly compact. An enclosure 435mm in diameter and 210mm high contains both the antenna and transceiver circuitry.

Making radar a viable option for small users is due as much to the receiver front end as the TX head. They maintain high signal-noise ratios allowing reduction in the engineering (and power) cost of the transmitter side.

Signal processing can improve the situation still further. By averaging a number of echoes,

the instrument eliminates sea clutter while reinforcing the coherent returns from real objects. Rain clutter can also be removed by a technique known as fast time constant, effectively a form of filtering to remove known characteristics of squalls and rain storms. Furuno radars also have routines to eliminate false targets caused by other nearby radars — increasingly important as the radar population grows and inshore waters become more crowded.

Look and sea

Manufacturers are also taking a second look at the marine display interface — still typically green CRTs for daylight viewing, but incorporating detailed alphanumeric data as well as raw echo information.

Radar settings such as range circles are still included but, more usefully, one can now plot tracks of selected echoes, set guard zones with alarms when a target strays into these areas, plot bearings and place markers.

Digital displays aren't limited to a central view of the sea around. The user can offset the display to give a better view of the way ahead for example.

LCDs for radar are still the exception rather than the rule. But, with advances in supertwist

THE RACE TO LIVE PICTURES

When yachts in the Whitbread Round the World Race set off next year, many of them will be equipped to provide something missing from news coverage of previous races – live video coverage from anywhere on the global course.

The additional technology which makes this possible is a video codec (coder/decoder), digitising the signal and compressing it to transmit at 64 kilobits per second – within the capacity of the Inmarsat-A high-speed data satellite link.

Developed by BT with videophones in mind, the codec reduces by a factor of 2000 the data rate required for a TV signal. It will form the basis of three distinct video facilities for the yachts.

First is the realtime video interview. With sound both ways, and pictures from the yacht, it will be possible for TV interviewers to conduct live interviews with the skippers. The signal will be received at an earth station, for instance Goonhilly.

The signal is then passed, still compressed, via an ISDN landline to a centrally-located second codec, possibly at Telecom Tower in London where it can be reconstituted and sent via landline or BT's satellite TV distribution network to any TV studio worldwide. Picture quality will, says BT, be "reasonable". A prototype was successfully sea-trialed on the Maxi yacht Rothmans in last year's Fastnet race.

The second option is the video clip – a pre-recorded clip with sound – which can be transmitted with better picture quality, but not in realtime. A two-minute clip, coded to 384 kbit/s would take about 12 minutes to send. Higher resolution, 768 kbit/s, would take twice that time. Sea tests of this service will be taking place this year.

The third option, experimented with in the last Whitbread race, is transmission of high-quality colour still pictures, which take around 15 seconds each.

Inmarsat-A is a global satellite link capable of handling



direct-dial telephone calls, telex, faxes and high-speed data. More powerful than Inmarsat C (which will also be used, in conjunction with GPS, to track yachts in the race) it requires a small dynamically steered dish for reception and transmission. This was in a radome mounted on Rothmans' stern during the Fastnet trial but, on the Whitbread yachts, will be built into a bubble on the deck just forward of the mast. The control unit, with the codec, would most conveniently be installed in or near the nav station.

The codec is still in development – BT's self-imposed deadline for this with regard to the race is January 1993 – so does not yet have a commercial price. BT will be providing it on free loan to race yachts, but they will have to buy the Inmarsat equipment at a cost of £18,000+.

Peter Willis

Video compression will be the key to beaming (almost) live pictures from boats taking part in the Whitbread round-the-world yacht race. Inmarsat provides a global satellite data link for pictures reduced to a data rate of 384kbits/s

technology, some are starting to appear. For instance, Apelco's LDR9910 has a 5.75in back-lit unit, and claims resolution of 3000 pixels/in².

Depth and other underwater data also interest the Solent set. Once firmly the province of the professional, less than £500 now provides a basic 200W model with a 6-inch colour dis-



Solid state transmitting heads in small boat radar can now develop up to 1.5kW peak power at 9GHz. Digital processing enhances the resulting picture

play. Koden's CVS106 Chromascope can look down to 1280ft using 50, 120 or 200kHz pulses. Transducer technology is still fairly standard – one development though is the introduction of a combined sonar transducer/temperature/speed sensor, frequently mounted on the boat's transom rather than through the hull. Another move is the availability of dual frequency transducers – a design in which both types of pulse are generated by a single element.

But the greatest changes are in display and presentation through colour CRTs and built-in signal processing. Safety at sea is improved by the ability to set alarms for shallow or deep water. The Koden unit can zoom to track the bottom on the screen. More sophisticated models like the Furuno FCV-561 can set alarms when fish echoes are detected.

Newer sonar can also look ahead rather than straight down – ideal if you are a diver searching for seabed wrecks.

Sonar receivers have widely adopted the mixed technology analogue/digital signal processing systems which make small radars so



Digital signal processing techniques have revolutionised the display of sonar imaging

effective and, like radar, video sounders can also present information from other sensors. These provide not just speed and water temperature but navigational data, too.

Navigation

Many helm displays show navigation data from position fixing systems, and display way-points together with information such as



Know where you are to the nearest 100m. This handheld GPS set derives its position by phase triangulation from orbiting satellites. It costs about £1000



Digital processing and storage enables superimposition of chart information on the radar image

distance to way-point. With costs below £1000 and falling, satellite navigation using the GPS network is now within the reach of every boat owner. Onboard processors can calculate a wealth of useful information extracted from the raw latitude/longitude data. True speed (rather than speed through the water), distance and bearing to way-points, course bearing offset and cross track error can all be shown.

But yachties still want more. Some systems allow data to be incorporated on additional displays such as the radar screen. Another family of systems can combine it with electronic maps in the chart-room. Perhaps the state-of the art is represented by one system from Raytheon which does both.

The Raychart 600 plugs into a standard raster scan radar display presenting either digitized charts or detailed radar pictures. Small rom cartridges store detailed chart data. Using a trackerball pointer and zoom controls, features of interest such as buoys and lighthouses quickly identify themselves. Depth contours and coastal features also appear. An alternative output display with the system is a full

colour 14in VGA monitor — ruggedized for use at sea but every bit as impressive as its desktop counterpart when it comes to graphics capability.

However, technology is no substitute for traditional paper charts and that's official. Rules of the Sea still require skippers to use paper — by law. Nevertheless, the system effectively turns the onboard electronics into a command and control system.

A key factor easing the integration of all these electronic modules is the introduction of a standard — NMEA-0183. This provides internationally recognised data sentences for transferring standard marine parameters such as latitude, boat speed, water temperature etc. It allows talk/listen facilities common to a range of electronic systems from various manufacturers.

A number of companies exploit this fact to build boat-wide data networks. The objective is not just to display information. It's possible for example to link steering controls with sat-nav data, chart, boat speed, and tide predictor. The boat practically drives itself. Similarly, with sail-boats, wind speed and direction inputs can be included to drive the tiller hydraulics.

Despite the standardisation of messaging, most such networks are still proprietary. The fastest is claimed to be the Brookes & Gatehouse Network — a system in which intelligent modules (sensors or indicators) are daisy-chained using a physically robust five-wire interconnection.

One of the more interesting networks comes from Denmark. Danaplus' Quadro promises easy installation by using standard RG58 coaxial cable for interconnection. It is effectively a broadcast network with 200 channels operating at 6400bytes/s. The cabling also carries 12V power pulses in each 0.25s cycle. Sensors link into the network through intelligent interfaces called *brainboxes*. The network is segmented so that functionally similar devices are autonomous. In this way, the network can continue operation even if one set of functions (say navigation) is out of action.

In addition to the standard navigation, compass, and wind indication functions, Quadro has comprehensive engine management facilities, with sensors in the engine compartment linked to a multifunction display at the helm. It also allows other members of the crew to access data on remote terminals anywhere the network.

Robertson Marine Electronics offers a bus-type data network, this time a serial link based on RS-485 and operating at 400 baud. Like the other networks, this also has NMEA interface options so that units from different manufacturers can join in to the system.

These developments threaten to turn boating under power or sail into an increasingly automated pastime. Perhaps it is technology for technology's sake. But boat owners are lapping it up. They want every conceivable bit of electronics in their cabins. And electronics designers are showing every willingness to meet that demand.

Listening out for the big numbers

Digital audio was born in professional broadcasting, rapidly becoming commonplace in recording studios and eventually in the home through compact disc. The CD success story needs no re-telling but it begs the question of where digital audio will take consumers in the 1990s. Consultant David Berriman charts the progress of sound by numbers.



Digital audio tape was to have been magnetic tape's answer to CD. A higher sampling frequency and 16-bit coding tipped dat — at least in the eyes of some pundits — as the successor to compact cassette. Unfortunately lengthy wrangling about a copy protection system, which would prevent 'perfect' digital copies being made ad infinitum, lengthened the gestation period and delayed the introduction of hardware and hence pre-recorded software. This went on for such a long time that dat has appeared virtually still-

DCC technical data

Number of channels 2
 Frequency range $f_s=48\text{kHz}$ 5Hz-22kHz
 $f_s=44.1\text{kHz}$ 5Hz-20kHz
 $f_s=32\text{kHz}$ 5Hz-14.5kHz
 Dynamic range over 105dB
 Total distortion —92dB
 Wow and flutter none
 Audio bit rate 384k bit/s
 Tape width 3.78mm
 Tape speed 4.76cm/s
 Track width 185µm
 Track pitch 195µm
 Number of tracks 8 digital audio 1 auxiliary
 code Error correction system C1, C2 Reed
 Solomon product code
 Modulation system Eight to Ten (ETM)
 Recording time up to 2x45 min (D90)
 Provision for 2x60 min. (D120)
 Tape type chrome (video)

Sony Mini Disc technical data

Number of channels 2
 Frequency range 5Hz-20kHz
 Dynamic range 105dB
 Sampling frequency 44.1kHz
 Recording time 74 minutes
 Cartridge size 68 x 72 x 5mm
 Disc diameter 64mm
 Wow and flutter below measurement limit
 Coding system ATRAC (Adaptive TRansform
 Acoustic Coding)
 Modulation system EFM Error correction
 CIRC

which have launched CD-R machines aimed at the professional market. With blank discs at around £20, recordable once only and unlikely to drop as low in price as DCC or MD (see below), domestic potential must be small.

Philips and Sony to do battle?

In 1991 both Philips and Sony announced their separate answers to the domestic digital recording and playback conundrum — how to cram lots of information into a small space and with the minimum mechanical complexity (and minimal cost). Philips' answer is Digital Compact Cassette (DCC) and Sony's is Mini Disc (MD). Both incorporate complex data compression techniques, but use completely different technologies for storage.

Philips' DCC, as you would expect, uses magnetic tape, but instead of wrapping it around a rotary drum and head, the tape is passed over a thin-film magneto-resistive head with eight sections laying down eight tracks. Remarkably, the tape width and speed are the same as for ordinary compact cassette: the special heads, eight parallel tracks and data compression make it all possible. The housing of a DCC is similar in size to a compact cassette, but is quite differently constructed. It is shuttered like a floppy disc at one edge and does not turn over like compact cassette. 'Side' changing is by means of auto-reverse, so there is a small break in sound during change of tape direction.

The dual-purpose heads also play ordinary compact cassettes, making DCC machines backwards compatible with old compact cassettes. Alas, DCC tapes cannot be played on old compact cassette machines.

Mini Disc Sony's Mini Disc, at about 6cm

in diameter, is slightly smaller than a CD single and, like DCC, is housed in a slim shuttered case measuring just 72 x 68 x 5mm which looks very much like a mini floppy disc. Mini-Disc's recording system, however, is magneto-optical (often referred to as MO disc technology). During recording, a high-powered laser heats the disc in the presence of a magnetic head positioned close to the reverse side of the spinning disc. The laser heats the magnetic material in the disc (a layer of terbium ferrite cobalt, having very low coercivity) to 400°C which is above the material's Curie point. As it leaves the laser beam it cools and retains the magnetism from the head at that instant. The head carries the digital data stream and so the disc is left with a spiral magnetic recording of alternate north and south poles.

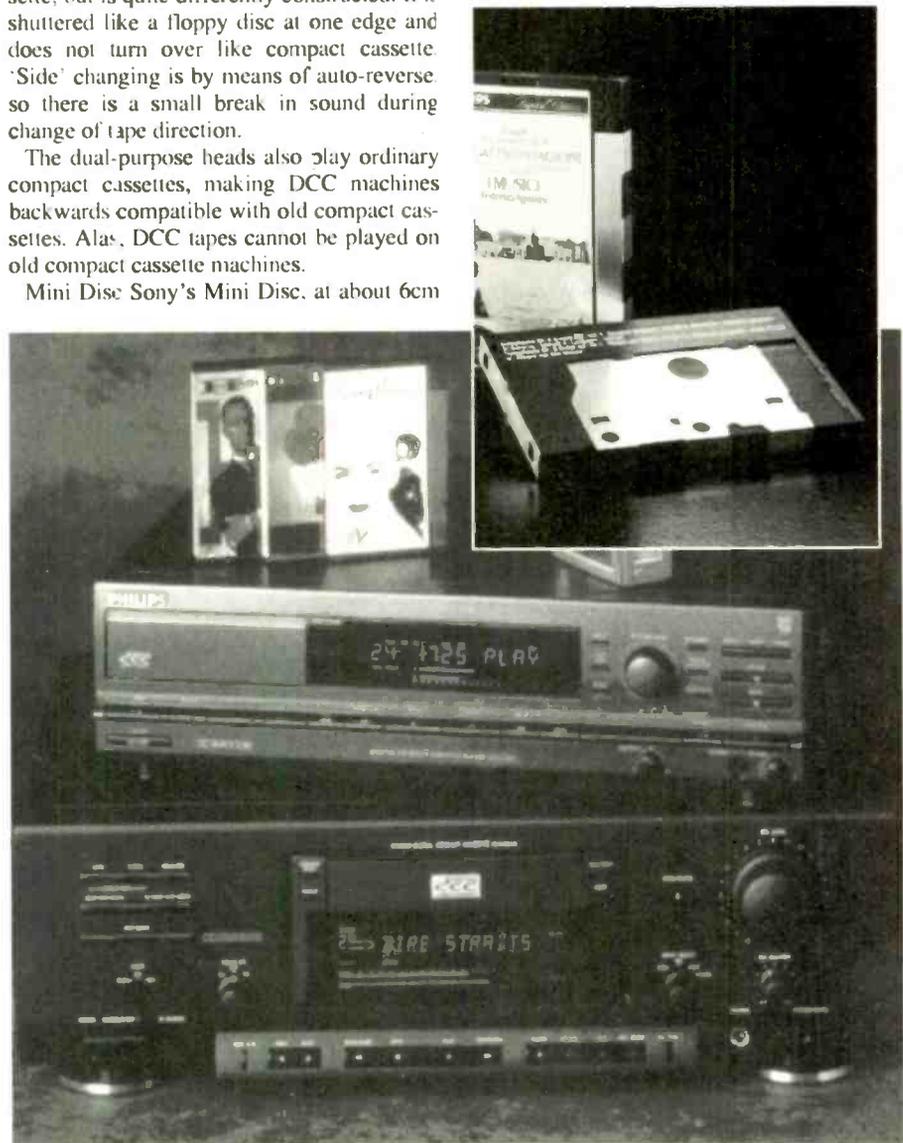
During replay, the laser operates at a much lower power. Due to the Kerr effect, the reflected light's polarisation changes according to the magnetism in the disc. The optical head cleverly uses two photo diodes and a beam splitter to detect the changes in polarisation. Output of the photo-diode amplifiers is a pulse stream much as with CD, but under-

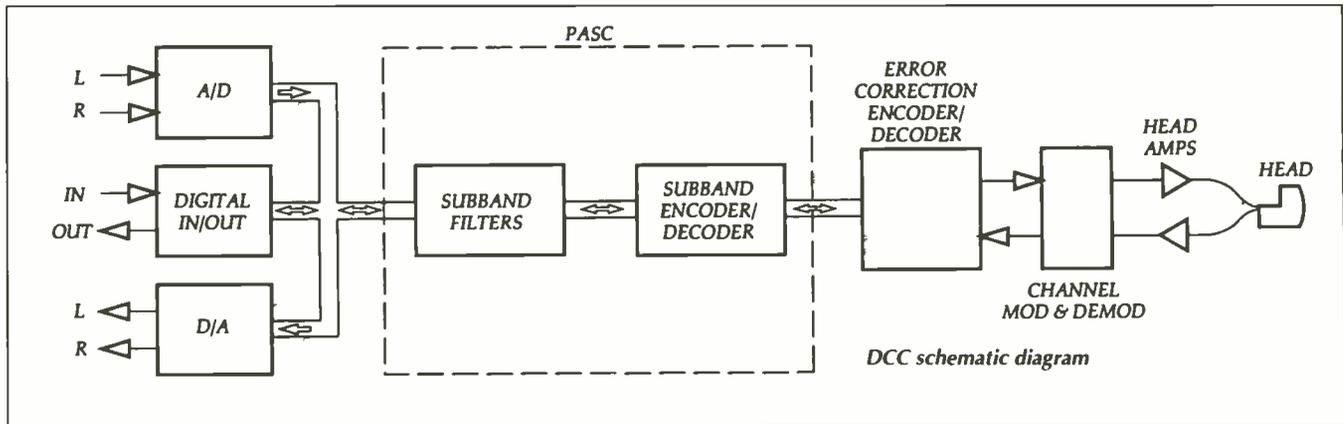
born from the consumer point of view. Even so, dat has been fully embraced by professionals in the recording industry (copy protection was not an issue here) for making high-quality copies of master tapes. Some companies are so confident that they even master directly in the dat format.

Whatever the effect of the copy protection delays, dat has one inherent disadvantage. Like a video recorder it uses a rotary head to lay diagonal tracks across the tape. High tape-to-head speeds achieve the necessary data transfer rate, but with the complication of precision components and tracking controls. Dat was designed for full 16-bit CD sound quality, but is not cut out for the cost-conscious mass market, and certainly not for the miniaturisation demanded for personal stereos.

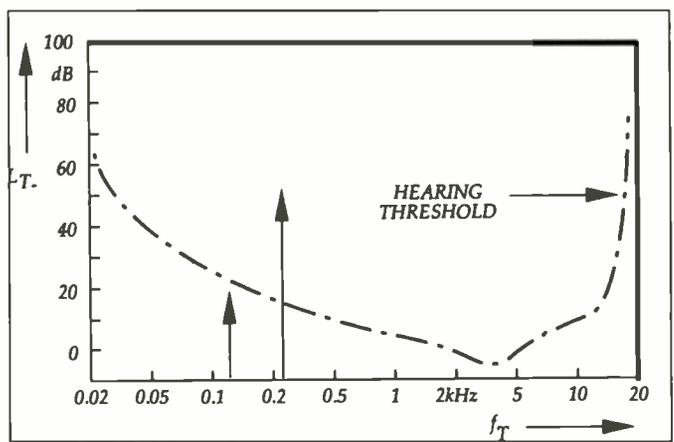
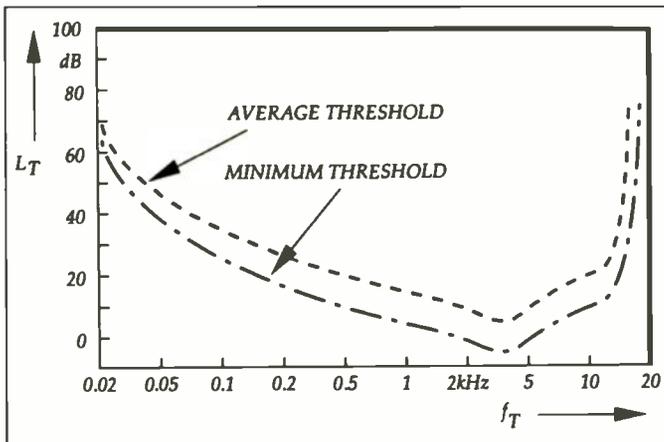
CD recordable dat has a professional disc equivalent in CD recordable, or CD-R. This too is based on 16-bit coding but recording is achieved using a special write-once only disc containing a heat sensitive layer. During recording the laser is pulsed at a high power which heats and deforms the disc internally, making the heated areas less reflective. Thereafter, the disc performs virtually as a normal CD, with the advantages of non-volatility and durability compared to tape. Marantz and Mission are two companies

Philips digital cassette system will be backwards compatible with the old compact cassette format although the digital tracks on the new cassette won't play on analogue machines.





DCC schematic diagram



Threshold of hearing. The ear is more sensitive to middle frequency sounds than low or high frequencies. The threshold level differs between people. Both average and minimum (most sensitive) levels are shown. Only sounds above the threshold are heard. Both DCC and MinDisc use this masking effect to reduce the amount of digitised data which needs to be stored.

goes further processing before D/A conversion (see later).

Curiously, pre-recorded mini discs are not magneto-optical, but are optically identical to CDs. They can be made in normal CD production facilities with virtually no extra capital

outlay, except for that needed to mount the disc into the outer casing. DCC by contrast requires special high-speed tape copiers.

Needless to say, home-recorded mini discs would not play on a normal CD player, even if they could be made to fit, but only the mech

anical differences prevent pre-recorded mini discs being played on a normal CD player. Indeed, if the mini-disc's optical system were to be incorporated into a CD player with suitable mechanics and electronics, such a machine could play either type of disc, though, of course, at greater expense.

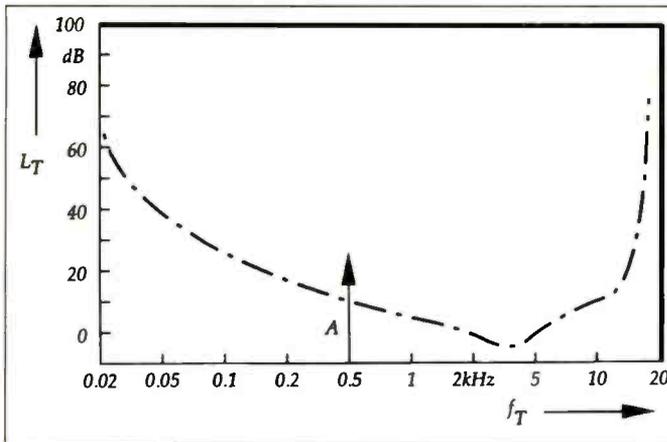
Quart into a pint pot?

Data compression is what both systems have in common. Both start with a 16-bit coded signal but end up with much less, taking advantage of the ear's natural inclination to mask quiet sounds with louder ones and its dynamic threshold of audibility (below which sounds are inaudible). Both systems claim to dispose of sounds which are inaudible for more efficient data storage.

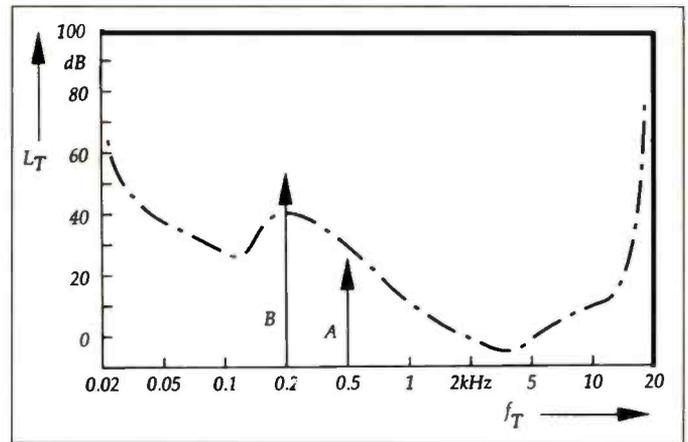
Philips' DCC uses its precision adaptive sub-band coding, or pasc as it is known. Pasc splits the audio band into 32 segments, using digital filters. It 'looks' at each band and codes each according to the threshold of hearing in that band at that instant. Only information above the threshold is encoded. If all the bits available in a band are not used, they are re-allocated to other bands — that's where the 'adaptive' tag comes in.

Sony's MiniDisc player. Amazingly, the optical discs are completely incompatible with standard CD.

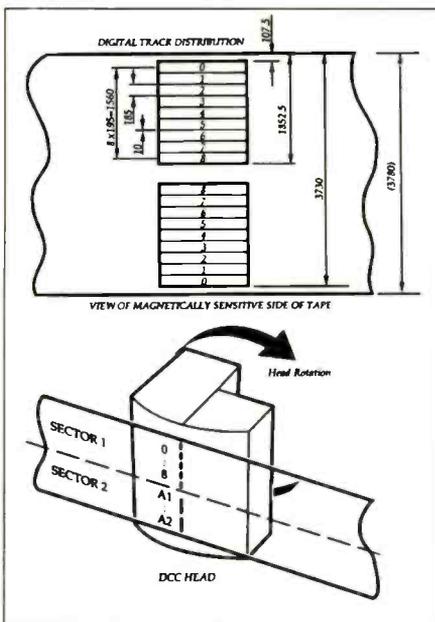




Soft sound 'A' is audible.



Making space in the spectrum: loud sound 'B' increases the threshold above sound 'A' so that the soft sound is masked and becomes inaudible. Sound 'A' no longer needs to be coded, so extra information capacity becomes available for more precise coding of 'B'.



The DCC digital/analog head. showing the (reversible) disposition of digital heads 0-8 and analogue heads A1 and A2

After pasc coding, the information is multiplexed into an eight channel data stream into which error detection and correction codes are inserted, achieving an effect similar to the interleaving used for CD. A ninth channel is added, carrying control and display information, then 8-10 modulation circuits convey all this data to the eight heads.

Philips claims you can't hear the difference between pasc coded and 16-bit sourced uncod-ed music, but isn't this the company that claimed "perfect sound forever" for CD? In tests overseen by Philips, some press comments have been favourable, if qualified.

Mini disc compression

Sony's Mini Disc uses a superficially similar compression system called adaptive transform acoustic coding, or atrac for short, which compresses the information by one fifth. Like Philips' DCC, atrac starts with a 16-bit digital signal, sampled at 44.1kHz. In contrast to Philips' pasc, atrac samples this at intervals of

20ms (approximately 1000 samples) and applies the fast Fourier transform to determine the frequency components for each sample. Then, much as with pasc, it encodes only the information above the ear's masking level, adds EFM and CIRC (error correction) data and passes this on for recording to disc.

On replay, the mini disc and atrac decoders re-constitute the signal and 20ms sample segments into a digital waveform for processing by a 16-bit D/A converter in the normal manner. So, while Philips' and Sony's methods may be different, the aim is much the same.

Is data compression audible?

Sony is rather more candid than Philips and admits that mini disc does not sound quite so good as CD, but point out that DCC doesn't either. Neither is supposed to compete with CD, in any case, since they have been designed specifically for low cost and acceptable sound in the mass market – not critical hi-fi customers.

It makes one wonder why Philips should compete with its own product in this way. Is this sensible marketing?

Any system based on throwing data away is bound to have audible effects, but audible acceptability is another matter. The truth about sound quality will no doubt emerge when both hardware and software for DCC and mini disc become available.

Software Costs

Both Philips and Sony are guarded on software prices, with no official figures being quoted. A price of around £13 for pre-recorded DCC tapes has been aired. This would put DCC roughly in line with CD, which seems high for (presumably) a lower-quality sound. Perhaps this explains the logic behind Philips claiming CD sound quality. Blank DCC tapes are likely to cost around £3 to £5.

No price has been suggested for pre-recorded mini discs, though, as with DCC, I do not see how a price equal to CD could be justified.

Blank mini discs may cost around the price of a metal audio cassette – £3.50 to £5 – in other words, close to that hinted at for DCC blank tapes.

Pros, cons and dropouts

Both systems have their pros and cons. Mini disc has an access time of less than one second, which surely cannot be equalled by DCC, no matter how fast it winds. It delivers 74 minutes of un-interrupted playing time, as opposed to DCC's 45 minutes per side, though the total playing time is 90 minutes. Being a non-contact medium, mini disc cannot wear – unlike DCC – while DCC cannot be 100% tangle-proof. Philips claims drop-outs will not be a problem with DCC.

DCC should be relatively immune to data loss due to vibration and jolting, a potential problem with optical disc reading systems. Sony reckons to overcome this by providing a larger data buffer which can provide error correction by re-reading faulty data sectors. Using a 1Mbyte buffer, Sony says that mini disc can lose three seconds of data; you can whisk the disc out of the player, put it back within three seconds and not hear the join. Impressive stuff if it works.

Both Philips and Sony claim wide support from hardware and software manufacturers, with proposed launches around the end of the year. Currently Philips seems to have the larger roll-call, but anything could happen in the mean time.

Regardless of the technology and marketing hype involved, the public will decide which it prefers. The mysterious way in which people perceive products, how easy they are to use and how much they cost will be crucial factors.

Certainly, whatever the hardware eventually comes down to, software for both will be dearer than compact cassettes by a factor of two, which means we will all pay handsomely for the privilege.

It is a pity that two major consumer electronics companies should choose to fight it out in the market place. It remains to be seen whether two systems can co-exist. The VHS versus Betamax experience suggests not. There is no way of knowing which will be the 'best' system, but as history tells us, the best does not always win. ■

AESOP'S AUDIO FABLE

Alvin's heart raced. Just one more magic sticker under the CD player and he would be there, he thought. With the tiny label-like add-on duly fixed in position, Alvin selected a track, settled back in his easy chair and with a quizzical look turned to his friend. Julian was round for another long evening's tweaking session — lending his ears to help Alvin eke just that bit more from his system.

"Wow, is that better, or what?" exclaimed Alvin.

"Don't know," replied Julian, "just try that last track, you know the one where Rick Large plays fretless bass with his teeth. I'm sure I heard his fillings rattling more clearly before."

"Reckon you're right," intoned Alvin, his heart sinking deeper as he slid further

into his chair. "Four hours we've been at it," he mumbled. "I'd swear that last change was an improvement; those little blighters worked on the speaker stands and in the CD drawer — they neutralise harmful electromagnetic fields, you know."

Julian interrupted .."but they've cost you a fortune, and what about all those special marker pens, the ones which are supposed to absorb stray laser light when you've inked CDs around the edges. They didn't seem to do anything, except you can't get the ink off the ones you've treated."

"Then there are those stick-on rings which are supposed to 'stabilise' the disc, but made no difference until you tried to remove them. The sound changed then, all right, when the silver layer came off."

"Then there are all the gadgets and special cables you've wasted your money on."

"They all claim to improve the sound and most have little or no hard technical evidence as to how they are supposed to work. A few seem honest products with fair claims, but others seem to be simply unscientific and some are so bizarre as to border on the psychic."

"You've gone through the whole system I don't know how many times. I've lost track of all the expensive mains leads, black boxes and what-nots you've tried, the soft rubbery feet, hard spiked feet, tables and hi-tech platforms made of various exotic materials."

"How many have really made an

improvement? To be honest I think you enjoy messing about with the system more than the music."

Julian's outburst goaded an increasingly depressed Alvin into frantic action. He leapt to his feet with renewed vigour and attacked the hi-fi with the passion of a man possessed. Off came the field-neutralising stickers, out went the special suspension feet and the highly expensive pure platinum speaker cables, hand woven by Polynesian Virgins. "Enough to keep a Romanian orphanage going for a month" he muttered to himself. Then with one sweep, he scooped up his graffitied CD's and hurled them into the waste bin.

At long last, Alvin had restored the system to its basic gadget-free state.

Suddenly he became calm. He slipped a CD of one of his favourite pieces of music into the drawer and relaxed in his chair.

"Thank heaven for that," he sighed.

"Does that sound better?" quizzed Julian.

"Don't know and don't care," was the wistful reply as the music wafted across the room. Julian was even more puzzled than before.

"What do you mean?" he enquired. But it was no use: Alvin was already absorbed deep in the music and didn't respond. Instead a broad grin spread across his face. "Just listen to the scoring during the second movement, those double basses have a life of their own... I wonder if I just..."

DB



Fuzzy and friendly technology

Fuzzy Logic can be described as trying to get computers — and that includes the processors that control so many consumer products — to think like humans.

Classic example. You call up a computer file, but mis-spell the file name. The computer registers that no such file exists.

Contrast this with what happens when, say, you find there are no clean socks in your sock drawer. You know that you have clean socks, so you look to see if someone's put them into your underwear drawer by mistake. Yes, they have. Success, and another triumph for fuzzy logic.

Sanyo has developed fuzzy logic circuits for its video cameras to improve performance in three troublesome areas, auto-focus, auto exposure and auto-white balance.

Take auto-focus. In conventional systems, this works fine if the principle subject is where the camera expects to find it — centre-frame. If not, then the camera doggedly focuses on the

far horizon, leaving your children, bottom left, a blurred lump.

With fuzzy logic, if the camera finds no subject in the centre zone then — using the CCD image (and the sock-drawer principle) — it searches the rest of the frame.

The system is based on zoning the frame into twenty sections, or zones. The autofocus starts with the four centre sections, where the finest detail may be expected, then expands to the twelve small surrounding areas, and finally works through the outer zones.

The last zone to be searched, is at the top of the frame, usually containing sky and hence the least likely to offer a point of focus.

Auto-iris again uses the six zones to determine the exposure setting. Conventional auto-exposure systems assess the light value of the whole picture, which in back-lit conditions will under-expose the main subject. Fuzzy logic prioritises the areas containing the subject-matter, and sets the exposure for them.

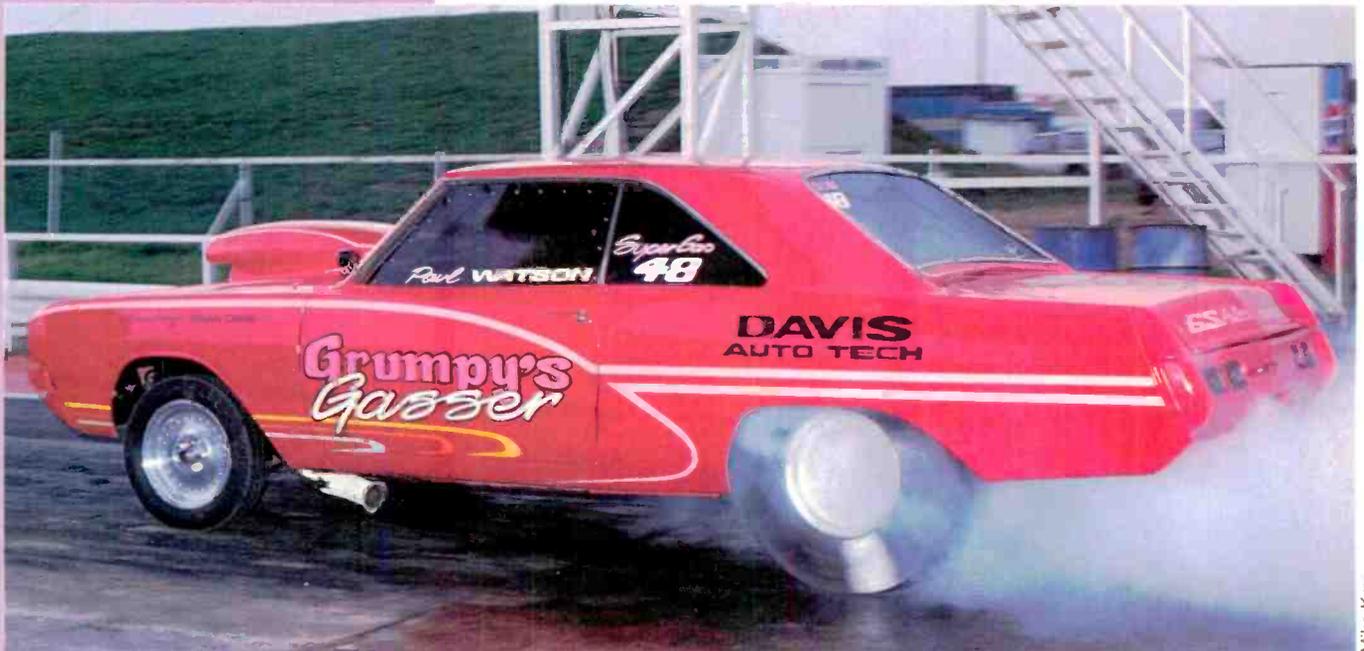
On auto-white balance, the camera assesses 64 picture segments to avoid large areas of dominant colour exerting undue influence on the assessment of colour temperature.

Of course fuzzy logic requires a substantial increase in the number of decisions made by the microcomputer. The extra throughput is of a magnitude order, and is made possible by number-crunching the data with specialised parallel array processor chips.

Thus, the light-reading from the CCD is converted from analogue to digital. It then goes into a gate-array which breaks up the data into the six-zone system. The fuzzy-logic computer takes an 8-bit code for each zone and converts it to two 4-bit codes of which it temporarily discards the least significant.

Having analysed the other code, it then brings the two back together and re-converts to analogue, which becomes an electronic signal that drives the focus motor.

Peter Willis



Mike Key

Byte burners hack into the performance car market

From Martin Cheek in Santa Clara.



Backyard hot rodders once only had to tinker with carbs, manifolds and camshafts. The increasing use of electronics in car engines has changed all that. The preferred way to boost performance is to replace the car's standard microchips with so-called "superchips".

The plug-in engine rom replacements, which retail between \$140 and \$265, are becoming a hot item in the US car market as they can offer a useful increase in engine performance. Tuning chips regularly find their way into General Motors, Ford, Nissan, BMW and Porsche vehicles.

Firms such as Hypertech supply more than 40,000 electronic turbos every year. The Memphis based company was the first to develop engine tuning automobile chips, and presently owns about 90% of this specialised market.

Five years ago, Mark Heffington, company founder, saw that the US tradition of hot rodding stock production engines was in trouble unless computerised engine controls could be hacked to cooperate with other performance equipment.

"My purpose was to master retuning the newer cars with on-board computers for high performance driving in order for people to continue to be able to enjoy hot rodding... it

was absolutely necessary for us to be able to retune the engine, via a replaceable computer chip to allow the installation of camshafts, headers and other speed equipment." Without such chip design capability, he said, the speed equipment industry was "doomed to extinction".

Physically, the eprom engine management chips are of the same type as standard computer devices. Chips for Chevrolets and the other models are 28 pin dual-in-line for insertion into the car's computer system. The amount of stored data varies from 1K to 56K depending on the complexity of the car's computer system. The programming is in hexadecimal assembly language.

The chips are programmed to deliver the best possible tuning for all combinations of engine speed, load, temperatures and other factors. They act on the car's electronic control module by changing the data values in the lookup table which controls fuel flow and spark advance curves for each combination of input data. Parameters typically include coolant temperature, intake manifold pressure, exhaust gas oxygen content, engine speed,

CONTINUED ON PAGE 200

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1021 general purpose oscilloscope from Leader Electronics



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SC110A miniature portable oscilloscope

■ SC110A miniature portable oscilloscope

The SC110A from Thurlby-Thandar is a full feature, single trace analogue oscilloscope packaged into the size of a benchtop multimeter. Fitted with a 32mm x 26mm screen miniature CRT, the bright, sharp image provides resolution and detail associated with much larger instruments. UK designed and built, the internal switch mode power supply draws just 195mA from four C sized batteries (not supplied). The instrument will operate from 4 to 10V DC.

The specification includes a Y bandwidth of DC to 10MHz, 10mV/div sensitivity and an adjustable brightline trigger with AC/DC/TV coupling from both internal and external sources. The X timebase is adjustable from 500ms/div to 100ns/div in 24 steps. The case measures 25 x 5 x 15cm and the instrument weighs about 1kg. SC110A £249+VAT (£292.58).

■ 1021 general purpose 20MHz oscilloscope

The Model 1021 general purpose oscilloscope from Japanese instrument maker Leader Electronics more than meets its published specification and is of exceptional build quality. Features include 20MHz dual channel operation, 8cm x 10cm display area, 5mV/div Y1/Y2 sensitivity at 20MHz, DC to 500kHz X-amplifier response, variable trigger response, multiple sync conditioning and an overall accuracy better than 3%. 1021 £299+VAT (£351.33)



PL320K laboratory triple power supply

TS3022S laboratory dual power supply

PL320K laboratory triple power supply

This power supply from Thurlby-Thandar combines three, totally independent power supplies within a single unit: 0-30V at 2A, 0-30V at 1A and 4-6V at 7A for logic supply. The 30V supplies will operate in a bipolar tracking mode for $\pm 30V$ operation or in a series mode to provide 0 to 60V output. Both supplies incorporate independent remote sensing and independent precision voltage/over-voltage/current-limit preset. Three 3 3/4 digit led panel meters indicate current and voltage to an accuracy of 0.05% fsd. Output stability is typically 0.01% for 90% load change. PL320K £359+VAT (£421.83).

TD201 digital storage adaptor

The TD201 digital storage adaptor from Thurlby-Thandar is a low power, single channel digital storage unit which adds digital storage capability to ordinary analogue oscilloscopes. The maximum sampling rate of 200kHz permits fast transients to be captured while the lowest rate can extend the sampling period to over an hour. The unit stores over a thousand points on the X axis with 256 levels in the Y axis. The internal batteries (not supplied) allow data retention for up to four years. Other features include an AC/DC sensitivity down to 5mV, selectable pre-trigger, roll and refresh modes and a plot mode. The case measures 25 x 5 x 15cm and the unit weighs about 1kg. The TD201 provides the ideal solution for those wanting a well specified and easy-to-use DSO at the lowest possible cost. TD201 £195+VAT (£229.13)

How to order

To order equipment with your credit card, phone Lorraine Spindler on 081-652 3614. Alternatively, to order by post, fill in the coupon on the right and send to: L333, Electronics World, Quadrant House, The Quadrant, Sutton, Surrey, SM2 5AS. All prices include postage, packing and delivery but exclude VAT. Inclusive price in brackets.

TS3022S laboratory dual power supply

This laboratory quality power supply from Thurlby-Thandar provides two fully floating 0-30V 2A outputs for parallel, series or independent operation. Each supply has its own metering of voltage and current by LCD display; with the output switch to off, the display can be used to preset the voltage and current limits prior to connection of the load. Coarse and fine controls permit output voltage adjustment to within 5mV of a predetermined value. The current limit control employs a log law for precise adjustment down to 1mA. Load regulation is typically within 0.01%. Both supplies incorporate remote sensing. TS3022S £299+VAT (£351.33).

TD201 digital storage adaptor



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CONTINUED FROM PAGE 197

throttle position, vehicle speed and transmission gear selection. Based on this data, the ECM delivers the correct timing pulses for fuel injector nozzles and ignition distributor. This electronics system updates the engine's tuning many times per second.

The chips deliver this tuning exactly, no matter how complicated the shapes of the spark or fuel curve become, said Helfington. They take about quarter of an hour to insert into a car's system using a flat head screwdriver and a 1/4in socket.

Developing a new chip program starts with a Superflow 901 computer-controlled engine dynamometer. Each engine for a specific make, model and year is mounted onto the dyno and connected to a factory standard ECM wiring harness. Factory sensors and transducers are also used.

Hypertech performs full-throttle runs in a

steady-state mode where the engine is held at a specific speed. This determines the spark timing and air/fuel ratio needed to produce maximum torque. The tests are run from 1500 to maximum RPM in even increments. One series of loops results in optimised spark advance settings while a second set provides optimised fuel delivery calibrations. There may be further iterative tests re-run on the engine.

This information is used to program an eprom chip designed for that specific model of car. The engine is then retested in acceleration mode to verify performance. Finally, a "fifth wheel" road test is done to determine the real world performance gain provided by the new chip.

It is believed that the chips do not invalidate any manufacturer's warranty because they are not a permanent modification of the car. In addition, a lot of dealerships are reputed to be selling them.

Hacked engines apparently pass the Environmental Protection Agency's requirements for exhaust emission limits. Testing is

currently under vehicle code, but approval from the s within the next few

The company is also ing a camshaft and chip-^{ingent} engine is "cammed" for over the usable RPM range. chip provides exactly the rig and spark advance for perfect the engine/cam combination. substantially better performance cam or control system hack will d own.

Another chip project on the w Hypertech is a chip designed to tune an for use with nitrous oxide. This ch, designed so that when the nitrous ox injection is activated, the component switch to a specific curve set for the application. One example of the conversion demonstrates a 25hp increase at high RPM over a stock nitro injection kit, claims the company. It also greatly reduces the risk of engine detonation, Helfington said.

LEAD KINDLY TRAFFIC LIGHT

The uncertain task of driving our motor cars from A to B more often than not relies on a dog-eared road atlas which was given to us when we first passed our driving test.

Within ten years that could all change. Electronic navigation systems costing less than many in-car hi-fi systems will be guiding drivers to their destination with the precision of military aircraft.

Troops in the Gulf war were able to calculate their position in the desert to within 100 feet by receiving radio signals from satellites 12,000 miles above the earth. The same global positioning system (GPS) technology is now being used by US and Japanese car makers like General Motors and Toyota as guidance systems in their luxury models.

A GPS receiver costing as little as \$500 is fitted to the car's bumper and it tracks signals from a cluster of 20 navigation satellites put into orbit by the US military. The car's position (longitude, latitude, altitude), its speed and direction can be calculated with awesome precision by measuring the distance travelled by signals from two of the satellites. A precision of better than 100 feet is possible because atomic clocks on the satellites measure the signal's time of travel to an accuracy of a second in 30 years.

The Pentagon had made the assumption that commercially

priced systems would be inferior to military hardware. But during the Gulf war a shortage of military GPS equipment forced the US military to buy off-the-shelf commercial products only to find that the commercial products could be just as accurate as their own. The Pentagon, which controls the GPS satellites, decided to reduce the accuracy of non-military systems by a factor of three by introducing errors into the GPS signals.

All this is academic in Europe where car makers are looking toward more earthbound alternatives for electronic navigation. A dead-reckoning system called *Travelpilot* developed by Bosch, the German automotive electronics specialist, does not need expensive infrastructure such as induction loops under the road, radio beacons or satellites to tell the driver where they are.

The vehicle's position is calculated using an electronic compass and wheel sensors which measure road distances and turn angles. The driver tells the system where they wish to go and it constructs the most direct route using 200,000 pages of maps held on 500Mbyte of CD-rom. This is displayed on a screen on the dashboard.

A danger with dead-reckoning systems is that small errors can accumulate and become unacceptable. Another German system, *Euro-Scout* developed by Siemens, achieves an accuracy of ± 20 metres in urban areas by taking a reference from roadside beacons.

Like the Bosch system, *Euro-Scout* uses dead-reckoning and CD-rom map data to calculate and display route information. But the Siemens system uses data from beacons to correct for accumulative errors.

A trial system in Berlin uses infrared beacons on 250 of the city's 1300 traffic light gantries. For vehicles travelling at 80Km/hour each beacon can transmit up to 64Kbyte of data. In addition to positioning data the beacon network can be used to transmit other traffic information.

In the UK GEC Marconi intends to develop a system which combines dead-reckoning and infrared beacons and a London trial is planned for 1993.

Called *Autoguide*, it was developed by the Government's road research laboratory three years ago but a legal wrangle between GEC and the Government is threatening a trial planned for 1993. It seems in Britain drivers will have to hang on to their A to Z's for a little longer.

Richard Wilson, *Electronics Weekly*



Vehicle navigation by dead reckoning: Bosch *Travelpilot* presents a route map stored in CD-rom and updates the car's position on the map by a mixture of magnetic bearing details, turn angles and distance travelled determined by data from the speedometer system.



Standards battles are currently being fought in the video wars. The camcorder manufacturers have come to an uneasy truce but there will be a death in video disc – and a rebirth which will shake the industry.

By Barry Fox.

Shooting hot up in the video wars

The consumer electronics industry still dreams of finding another product like home video. It was something the public wanted and needed and it came at just the right time, when hi-fi sales were flagging. Indeed, if home video had not been such an attractive proposition, the standards battles which have confused its short history would have crippled the industry and stifled sales – just as the standards battles on surround sound in the seventies killed all the original quadraphonic systems and made the subsequent marketing of Ambisonics a very difficult job.

The bitter video battle between VHS, Beta and later V2000, meant that the winner, VHS, ended up offering all the best features from all three systems. The current battle between VHS-C and Video 8 has progressively reduced the weight and size of camcorders.

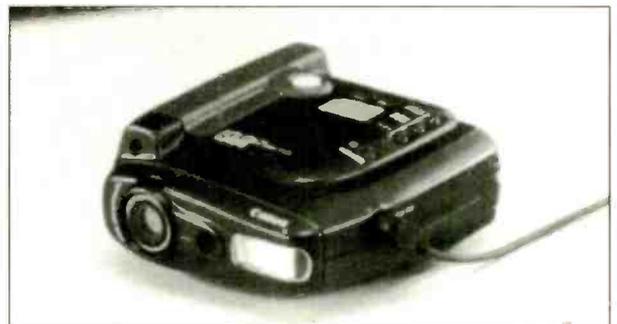
In each case consumers are the winners, getting more for their money than could possibly have happened if the government had set a standard, as happens with radio, TV and related services like teletext.

But there is a flip side, too. The competition to offer ever more exotic features has made many video recorders far more complicated than necessary. Few people ever manage to set the timer on their VCR. This has created a market opportunity for Video Plus, the £60 gadget which bypasses the need to set the timer on a VCR. Video Plus looks like a remote control with a numerical keyboard. The unit contains a timer which is set by the user entering simple numerical codes which newspapers and magazines publish alongside their TV listings. The unit springs to life at the appointed hour and sends out infra red codes to switch on the VCR, irrespective of whether its clock and timer have ever been set.

The biggest missed opportunity of the decade was the failure of the electronics industry to think ahead and make the European pro-

Bottom left: The 8mm video format has been a complete failure for table top video recorders but continues to exist uneasily alongside VHS-C in camcorders, supported by the need for two machines to undertake any form of editing.

Inset: Still video as an alternative to wet film has yet to make its mark. Canon's Ion electronic camera takes 50 pictures, each with about four times the resolution of a broadcast TV picture. At £500 a time, it only finds specialist uses such as taking pictures for all-electronic DTP systems.



gramme delivery control system (christened Startext by BREMA and now being implemented by Channel 4) compatible with Video Plus. PDC/Startext delays the start of a VCR if the broadcast transmission is delayed. The two systems are obvious and ideal bedmates. Together they could make using a VCR for time-shifting easy and reliable.

The industry's obsession with offering as many features as possible has left home video movie makers paying for buttons which, when accidentally pushed, spoil their recordings by adding unwanted special effects, or superimposed date and time markings.

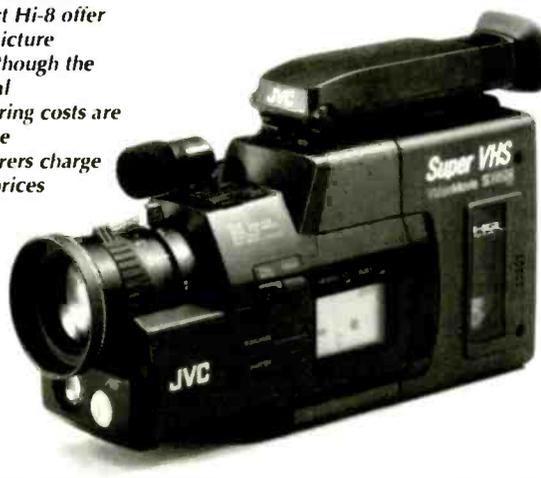
The next trend, already pioneered by Amstrad, will be to make camcorders do just what is needed and no more, under the break point price of £500.

Shake picture for Video 8

After Sony's complete failure in trying to make Video 8 a table top format, V8 and VHS-C are running neck and neck for camcorder sales. Gradually all the VHS manufacturers, except developer JVC, have faced reality and either make Video 8 recorders for other manufacturers to "badge", or make and sell them under their own name.

The flip side here is that camcorders are now

S-VHS and its 8mm counterpart Hi-8 offer sparkling picture quality. Although the incremental manufacturing costs are minimal the manufacturers charge premium prices



so small and light that some manufacturers are building in electronic stabilization circuitry to compensate for the camera shake which is the inevitable result of making cameras too small and too light.

In the long run there was never room for two or three table-top VCR formats. Once the market for pre-recorded videos took off, the software industry wanted only single inventory product. This killed the hardware argument that there was room for a double standard because VCR owners were only playing back their own time-shift tapes.

There could, however, be room for two

incompatible camcorder formats. Most people want to edit their camcorder tapes, however roughly, and this involves dubbing from one piece of cassette hardware to another, from one cassette to another.

The VHS camp argues that it is most convenient to have a camcorder which is of the same format as the home VCR: unedited movie tapes can be stored alongside time shift tapes. To reinforce this message, the VHS manufacturers have developed table top VCRs which play either full size VHS cassettes or VHS-C, compact, cassettes, without the need to load the C-cassette in a full-size adaptor before playing. This solution to a problem which few people knew they suffered has not been a commercial success.

Sales of C/full size VHS VCRs have been slow. On the other hand, Amstrad has been selling all the dual mechanism VHS VCRs it can make. These dub from one full size VHS cassette to another without the need for clumsy external wiring.

The most obvious need is for a dual mechanism, double standard, VCR. This would combine, in one wire-free box, a full size VHS recording mechanism and either a VHS-C or Video 8 playback mechanism. Such a combination would allow easy editing from camcorder tape to full size home tape.

SEEING IS BELIEVING

Alan Sugar, chairman of Amstrad, the first company to sell its personal computers in the high street, has predicted that the videophone could become the next great consumer electronics product. The consumer electronics innovator has created a minor shock wave with plans to put a £500 videophone on the market this autumn.

The main issue with videotelephony is how much picture information can be transmitted over the telephone line. A 625-line television picture requires a bandwidth of around 5.5MHz. High cost video conferencing systems can compress a picture format of 352 pixels x 288 lines onto two 64kbit/s digital ISDN telephone channels. This is achieved using a data compression algorithm: the circuit only transmits the information which records when elements, or pixels, of the picture change.

In this way the picture is not continually redrawn; it is only modified to accommodate movement. Up to 100 times more video information can be squeezed onto the telephone line using this technique.

To achieve the compression required to transmit even lower quality video pictures over existing domestic analogue telephone lines requires a yet more powerful algorithm. Amstrad is working with GEC Marconi to develop a system which will compress a digital video picture of three by four inches into a 10kbit/s data stream which can be transmitted over the standard network.

If they are to be successful the British companies will have to go one better than US telecommunications giant AT&T, which will launch a \$1500 (£800) colour videophone in the US this

May. AT&T showed the Videophone 2500, a 3.3in fold-up liquid crystal display and CCD camera fitted to a standard telephone, to the public in January. The company claims its contraption to be fully compatible with the public switched network.

In order to compress a digital colour video picture onto a copper telephone connection, AT&T has opted for variable picture motion from two to 10 frames per second. As a result the slow motion picture will not be able to resolve mouth or facial movements.

AT&T is expected to be the first of a number of US and Japanese companies which will launch consumer videophones this year. Computer companies like IBM and Apple are also planning to add videotelephony to their personal computers. Both are currently working with video compression specialists such as PictureTel and Compression Laboratories Inc. (CLI) to produce PC expansion boards which will be on sale by the summer.

The UK telephone operators have little doubt that the videophone can become a consumer product. "With Japanese companies offering low cost manufacture it could easily become a consumer market," commented Graham Mills of BT's videophone marketing group.

For once the necessary technology is not exclusive to US and Japanese companies. GEC's telecommunications company, GPT, has worked with BT to develop its own video compression technology.

So Sugar is talking to the right people. Maybe he can work a little magic and turn that expertise into the consumer electronics success story the British electronics industry so badly needs.

Richard Wilson, Electronics Weekly

OVERCOMING THE SHAKES

Camcorders have been pace-setters in many aspects of electronic development, not least miniaturisation. This has led to ultra-small, lightweight models weighing well under 1kg, and easily cupped in one hand.

This, however, brings a problem of its own. The lighter a camcorder is, the less its own weight acts as a damper on the natural tremor of the hand holding it. The result is jitter, camera-shake, or what Panasonic refers to "the image stability problem."

Panasonic, one of the first manufacturers in the market with this type of camera, recognised the problem pre-launch, and sought an electronic solution. The company was already producing an image stabiliser which used angular velocity sensors and a mechanical, moveable optical unit, but regarded this as incompatible with the compact design concept. The brief was to develop a stabilising system which relied solely on image processing, and could thus be put onto an LSI. The key requirements were a motion vector detector and an algorithm which could respond to various conditions of the subject being captured.

The result, marketed as EIS (electronic image stabilizer), starts by sending the input image along two paths. One is direct to a field memory, the other is into the motion vector detector. Within this last piece of circuitry, inter-field comparison is obtained by dividing the image into four field quadrants. Thirty points in each quadrant – 120 points in a full frame or field – are used to obtain four motion vectors for each field. These, together with their correlation data, are delivered

to a microcomputer. This selects the vector which most precisely represents the camera's motion to control the position of the image readout on the image signal stored in the field memory. In other words, the camera is constantly shifting the "frame" of the image to ensure that the edges of the image, and non-moving items within it, stay in the same place.

Obviously, being a movie camera, the image is subject to constant change, either from subject movement or from deliberate manipulation of the camera such as panning and zooming. The use of representative point correlation (each point is 16 lines high by 46 pixels wide) within four field quadrants – of which only one is selected – is the first defence against the system being "fooled" by these events. Electronic zooming and an additional integration formula control motion calculation damping when the camera is being zoomed or panned.

When a person or object crosses in front of the lens, the motion vector quadrant affected becomes unreliable. Correlation changes occur when the object enters and leaves the quadrant, but not while covering it entirely. When this happens, a motion vector quadrant is judged to be unreliable or invalid, and is excluded from calculations until its motion vector is detected to be the same as that for the entire field.

The system uses about 11,000 gates for the motion vector detector, and 8500 gates for the electronic zoom controller. One 8-bit field memory is required. An additional benefit of the system is that it can be used in VCRs to produce fluctuation-free playback.

Peter Willis

But the consumer electronics industry consistently misses obvious opportunities. Just as there is no dual well, double standard dub/editing VCR deck, so there has never been a hi-fi VCR with built in FM radio tuner to time-shift radio programmes running longer than an audio cassette.

Sony, and other Video 8 supporters, continue to sell the format on the strength of the longer playing time available from a Video 8 cassette than from VHS-C. The fact that rechargeable batteries can seldom run a camcorder longer than the running time of a VHS-C cassette remains forgotten. This limitation has also foiled Sony's plans to create a new lifestyle with Video Walkman, a combined V8 player and colour TV of pocket size. When airlines loan Video Walkmen to first class passengers, and let them choose from a basket full of movie tapes, they must also be ready to replace batteries before the movies end.

The high cost of colour LCDs has also helped make Video Walkman a slow burner. VW is too expensive for the mass market to take to like the audio Walkman, and too expensive also for schools to exploit for education. In domino fashion, slow sales of Video Walkman as a portable viewer continue to block Sony's efforts at making Video 8 a table top VCR format as well as a camcorder format. The software industry refuses to support V8 with pre-recorded movies, unless heavily subsidised by Sony.

This has taken the heat off JVC to achieve the well-nigh impossible and cram a full-length feature film on a VHS-C cassette.

All the signs are that Video 8 and VHS-C will survive in uneasy competition as camcorder formats, and full size VHS will remain the *de facto* standard for home viewing and time shifting. The balance of power looks unlikely now to change dramatically until the next big development in video, expected later this decade. This is the inevitable transition from analogue to digital recording. The technology is already ready, and in use by professionals and broadcasters, but it is too expensive for domestic application.

Life after death in video disc

There are good reasons why video will be slower than audio to go digital.

The vinyl LP and music-cassette are old formats, ripe for replacement. VHS and Video 8 are still young and no manufacturer wants to kill a profitable market by introducing a premature replacement, especially if it triggers a new standards battle. The main advantage of digital recording is that it makes copying easier. Professionals need this for editing and special effects, which involve dubbing video tapes through many generations. Amateurs dub only once or twice. The home video software industry has no enthusiasm for a new format which means a return to double inventory stocking in return for the dubious advantage of making it easier for the public to make perfect copies of copyright material.

The home video industry, hardware and software, will not make the transition to digital working until there is a watershed event. This is most likely to be the inauguration of all-dig-

ital, extended or high definition TV services, either by satellite or terrestrial transmitter. The USA could be the first country in the world to introduce all-digital transmission, because the FCC is currently judging a beauty contest of higher definition TV systems. All those remaining in the contest are digital.

Meanwhile the home video industry relies increasingly on digital circuitry to cut production costs and offer new features, while making a full circle return to simplicity of operation.

Picture quality remains a lost cause. Super VHS improves resolution to better than broadcast standards but has been a commercial failure. The main reason is the large and wholly unnecessary price differential between standard and Super VHS decks and tapes. Sony has similar difficulty selling Hi 8, the "super" version of Video 8 developed to meet the largely imaginary threat of S-VHS.

Grand plans by the VHS family to market a widescreen VCR have been slow to materialise. The widescreen VCR records a time-compressed signal on tape which is expanded on playback to fill a 16:9 screen. The new machine was seen as a natural partner for MAC, which is capable of carrying 16:9 programme material. The commercial failure of MAC has removed the need which the widescreen VCR meets. But as 16:9 TV sets come slowly to the market from Philips, Thomson and Nokia, both Philips and Thomson have launched widescreen S-VHS VCRs to go with them. The need now is for widescreen programme material on tape.

TELEVISION ON THE BUSES

Some of the latest sets are sporting a new socket on their back panels. Alongside the RF, Scart, phono (perhaps) and S-VHS connections is another small hole, marked D2B.

It's a socket which will increasingly be fitted to VCRs, camcorders, CD players and other pieces of audio/video equipment. D2B (which has absolutely nothing to do with D2MAC) is a system for connecting all these things together so that they can function compatibly, controlled centrally.

It is a concept which in time will spread to other clusters of domestic equipment – household management and security, for example.

The need for D2B is apparent, and increasing. Many consumers have never come to terms with the controls of their own video recorder and would be petrified if asked to use it to tape something from a CD player.

These problems tend to be compounded by different manufacturers adopting different control methods, leading to a proliferation of remote control handsets, and of software-controlled "consumer benefit" features. These are now reaching a level of complexity challenging to even the techno-confident consumer.

It is true that some manufacturers attempt to simplify matters and encourage brand loyalty by having VCR controls on the TV handset, and vice-versa. But on the whole, consumers tend to buy A/V products independently of each other on features of price and appearance rather than compatibility. Which suggests that, although afflicted by the problem, they haven't yet recognised it.

D2B (short for domestic digital bus) is a system of standardised specifications covering functionality and control, which manufacturers can build in, as software, to their products. It consists of a detailed list of application protocols – rules covering specific aspects of product behaviour. These include all the elements necessary for compatibility between

machines – commands and requests, control algorithms and implementation guidelines. They do not impinge on the sort of consumer benefit features with which a manufacturer might wish to distinguish his product from others.

Once a cluster of products is connected by D2B, the consumer no longer needs to operate the individual units. The user decides on the particular service required and the system takes over initiating the appropriate sequence of control functions. Status messages from any component can be fed to the TV set for on-screen display.

By using a single graphics/text generator, probably but not necessarily in the TV set, various benefits are gained. Consistency of display style can be achieved, and VCRs need not be fitted with the costly hardware required to display OSD (on-screen display) messages via the video channel. Instead, they and any other D2B piece of equipment – an audio player for instance – can send the OSD data direct to the generator.

D2B was jointly developed by Philips and Matsushita, which co-own a company (based in Redhill) set up to develop and apply the system. Although Philips TV sets launched last year are D2B-ready, the consumer launch of the system will take place later this year in Japan.

Parallel systems for home automation are being developed in Europe (Esprit), Japan (CE Bus) and the United States (Home Bus System and Smart House). Discussions are under way to enable D2B to communicate and interwork with them – a gateway with Smart House has already been developed. The ultimate vision of automated living – being able to phone home to turn up the central heating, switch on the oven and programme the VCR – is already within sight. Because D2B is digital, linking it to a tone-dialling telephone system will be relatively straightforward.

Peter Willis

Persuading the software industry to make these tapes will be even more difficult and expensive than persuading the industry to make S-VHS and Video 8 tapes.

The software industry also remains slow, verging on moribund, in its support for video disc. Ten years ago Philips tried and failed with 30cm Laservision. Five years ago Philips tried and failed again, with 30cm CD Video (Laservision with digital sound tracks). Now Pioneer is trying a third time, with Laser Disc (the same as CD Video but without the silly name chosen by Philips to try and cash in on the success of CD audio).

Pioneer has done well with LD in Japan and fairly well in the USA. There is talk of some success now in France and Germany, but it is hard to detect. Video tape has too strong a pull for all but the most quality-conscious video buff. In the UK, there are no signs of the interest which the system merits. There are still no feature films to buy and, astonishingly, Pioneer missed the one trick which could have kick-started sales of players. Although the Walt Disney classic *Fantasia* was released on home video for the first, last and only time, for a limited period, and although *Fantasia* was made available on Laser Disc in Japan and USA, and although the release dates coincided closely with Pioneer's relaunch of Laser Disc

in Europe, Pioneer's new European software division did not think to release a PAL version in Europe.

If, as now seems likely, video disc fails in Europe for the third time, it will be the last time.

Video disc first

This year, 1992, the first digital video disc technology goes on sale. CD-Interactive follows logically from the widespread success of CD audio. The standard size, 12cm, disc contains an infinitely flexible mix of sound, graphics, text, still pictures and moving pictures which the player unravels. So far the moving pictures have either been like cartoon animation or video of poor quality, not comparable to video tape.

Now the industry has agreed a standard for full motion video, and the chips needed for decoding are nearing completion.

Philips has pledged that when CD-I is launched in the middle of the year, all players will have the inbuilt ability to reproduce FMV. One disc can store over an hour of FMV, accompanied by compressed sound. If the compression coding adopted is similar to that used for DCC (Philips' new Digital Compact Cassette) then the sound should approach CD quality.

Initially FMV will be used to illustrate points in encyclopedia-style programme material, or to combine live action with video games graphics. There is, however, no reason why a full length feature should not be recorded on two discs. Philips, along with several Japanese companies, has hinted broadly that sights are now set on a higher density CD which relies on smaller pits to store four times the information available from a conventional CD. This paves the way to a single-side 12 cm disc which will store a two hour feature film, with sound and picture quality closely comparable to a double-sided 30 cm Laser Disc.

This year, 1992, will also see the launch of Photo-CD, the system developed by Philips and Kodak which stores a hundred very high quality still images on a 12cm disc. The original motivation was to provide an electronic storage medium for photographic pictures, sourced from a user's own 35 mm slide or negative film.

With the building of a compatibility bridge between Photo-CD and CD-I, Photo-CD is now being seen as a carrier for prepackaged still video software – a hundred pictures from an art gallery, classic film stills or prize winning photographs.

Spectrum analysis on the cheap

Spectrum analysers are powerful, and expensive, tools. But Nick Wheeler shows how qualitative spectrum information can be obtained – using a TV tuner.

Measurement in the time-domain is so much a part of electronic practice that excellent general purpose oscilloscopes are readily available from many sources. But costs rise sharply with increasing frequency coverage and above 20MHz the conventional oscilloscope has, in general, to be replaced by sampling techniques (though Philips does offer a 400MHz instrument).

Time-domain observations depend on synchronisation of the time-base with the signal being observed. When two or more harmonically unrelated signals are present they cannot all be synchronised at once and measurement becomes difficult, if not impossible.

But there are many RF measurements where such harmonically unrelated signals are the main subject of interest, eg carriers and sidebands under modulation conditions. Spectrum analysers are invaluable in these applications but unfortunately such instruments are expensive because, to be commercially competitive, they need to be well specified in areas such as linearity, measurement accuracy and dynamic range.

TV tuner analysis

In many practical situations qualitative rather than quantitative information about a spectrum is all that is required and in these cases a typical TV tuner can form the foundation for a simple spectrum analyser.

In its basic form the frequency range handled is that covered by the tuner. The simplest tuners only cover the UHF band from Channel 21 to Channel 68 (470-860MHz) though multi-band tuners, which are quite hard to come by, can provide coverage of all bands upwards from Channel 2, 46MHz. Frequency changing is required if out-of-band measurements are desired (worth mentioning because at signal frequencies lower than 46MHz, problems will be encountered with second-channel effects and IF breakthrough).

Modern TV tuners are all varicap-tuned, each band typically being covered by a volt-

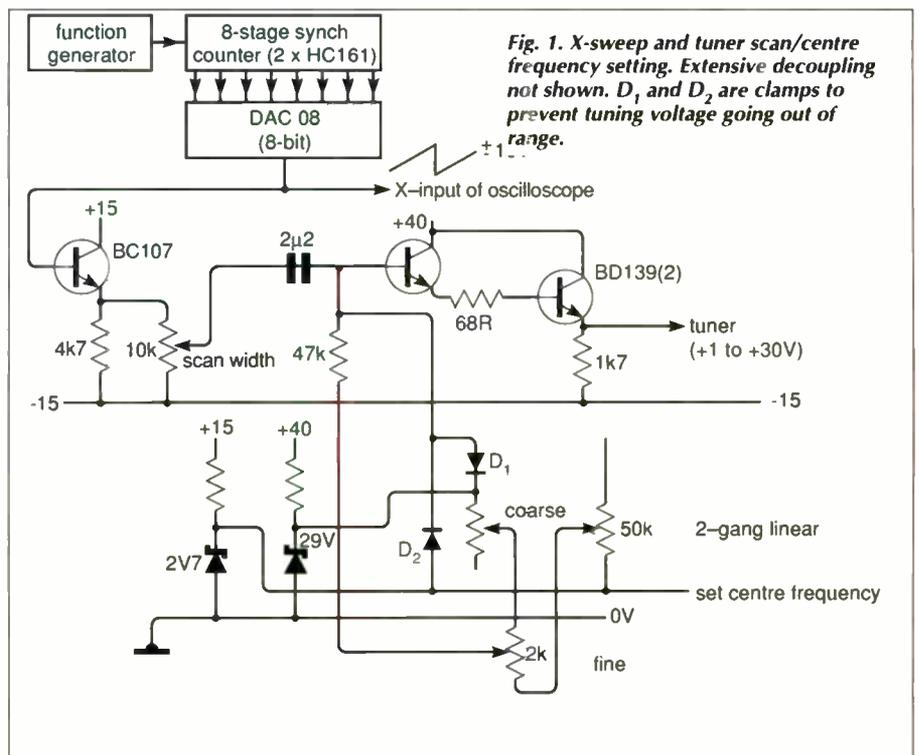
age excursion at the tuning input of between +0.5V and 30V, the lower figure varying slightly from model to model. Decoupling components can be found between the tuning input terminal and the varicap diode, but if the terminal is driven from a low-impedance source such as an emitter-follower the tuned frequency can be rapidly changed.

Three main parameters

A spectrum analyser, in its simple form, has three main frequency-related parameters

- Centre frequency of spectrum being examined;
- Upper and lower limits of band, and
- Scan repetition rate.

Centre frequency and upper and lower limits



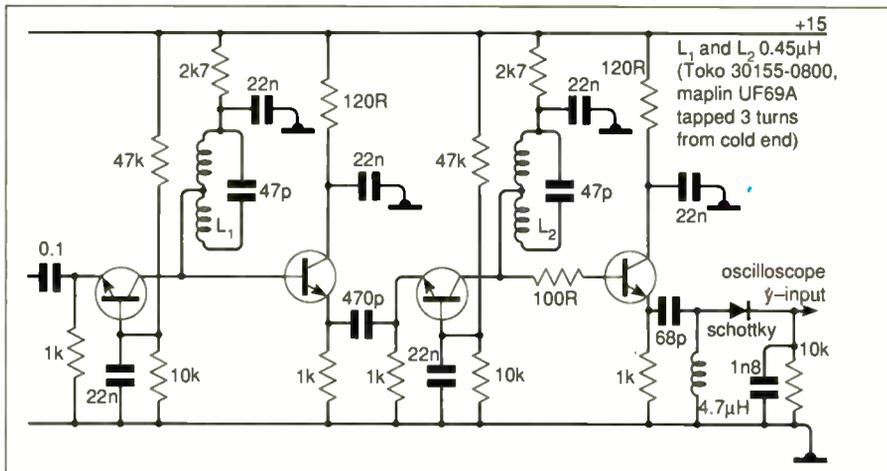


Fig. 2. IF amplifier and demodulator.

are self-evident requirements; but the scan repetition rate involves compromises.

Slow scan rates, below about 25/s, produce visual flicker, detracting from the "overview" which is such a useful feature of frequency-domain observation. On the other hand slow scans produce more sharply defined "peaks" for each frequency.

In some cases photographing the display can produce a more-easily interpreted picture though where the signals of interest change in amplitude, as in typical modulation sidebands, interpretation of the photographs may be difficult. But this would be equally true with the most expensive instrument.

Fast scanning is bandwidth limited. With a bandwidth of 1MHz, chosen for my simple approach, maximum scanning rate is approximately 1MHz/µs. I did provide for a variable scan rate but have found that 86 sweeps/s is so good a compromise that I have made a dedicated 555 oscillator (at 22kHz) to provide this. The oscillator is connected instead of the function generator shown in Fig. 1.

In my work I used a Philips UV615 tuner, offering continuous coverage in four bands from 46 to 860MHz (obtainable from HRS Electronics, Garretts Green Lane, Birmingham B33 0UE). Tuner data can be found in the old Mullard technical handbook, but I have summarised it in the "tuner details" box.

To sweep the tuner (Fig. 1) a saw-tooth of adjustable amplitude is provided by D-to-A

Summary of tuner details

- Numbering of the connection pins starts from the input coaxial connector end. The first four possible pins are omitted:
- pin 5 AGC +0.85V to +9.2V
 - pin 6 +12V
 - pin 7 apply +12V to select 46-110MHz
 - pin 8 apply +12V to select 111-300MHz
 - pin 9 apply +12V to select 300-470MHz
 - pin 10 apply +12V to select 470-860MHz
 - pin 11 +0.8V to 28V tuning
 - pins 12-15 are omitted
 - pins 16 and 17. Balanced IF O/P. I use pin 17 only.

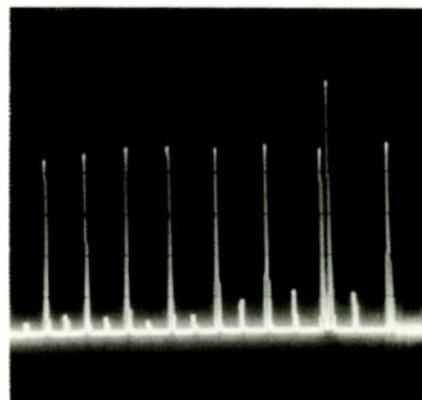


Fig. 3. Spectrum of 8MHz square wave between 18th and 33rd harmonics (large peak is strobe at 250MHz).

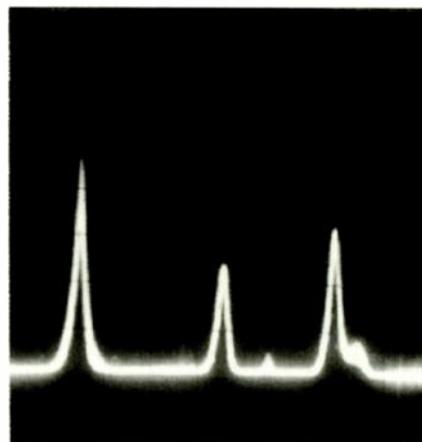


Fig. 4. Spectrum of BBC1 CH26 (left to right trace shows vision, strobe, sound). Note the Nicam signal near the main sound channel (right) and also colour signal (strobe at 514.66MHz).

conversion of the parallel outputs of an 8-bit synchronous counter. A synchronous counter is essential since severe glitches will be encountered if a ripple counter is used.

Coarse and fine adjustment of the standing voltage at the tuner input (and hence the "cen-

tre frequency") is provided, and in practice is very useful. The saw-tooth is also used as the X-input to an oscilloscope in the X-Y mode. A potentiometer applies 0-9V to the AGC terminal of the tuner, as a gain control, but high sensitivity of TV tuners means additional input attenuation is often required. An IF amplifier centred on 36.5MHz - roughly in the centre of the tuner output band - follows the tuner (Fig. 2). Tuners for the US market commonly have an IF centred around 43MHz. The two stages each consist of a grounded-base gain stage and an emitter-follower though there is nothing critical about this. The purpose is to define the bandwidth (1MHz has been used as a compromise between frequency discrimination and sweep rate) and to bring the signal up to a level where it can be demodulated. Output from the demodulator is applied to the Y-input of the oscilloscope - and that is it!

Figure 3 is an oscillogram of part of the output spectrum of a good 8MHz square-wave generator with rise and fall times of <2ns. The region shown is from the 18th harmonic (144MHz) - being even this is of small amplitude and is the small peak on the left - to the 33rd (264MHz), the large peak on the right. The large out-of-sequence peak is a strobe at 250MHz.

The small peaks are even harmonics and largest of these is 15dB down on the adjacent odd harmonics. Magnitude was easily measured by noting its peak amplitude and then inserting input attenuation until the odd harmonics are displayed at the same amplitude. There is ample discrimination between the 31st harmonic at 248MHz and the strobe at 250MHz: note also that because the time-base is not a ramp but a 256-step staircase, slight discontinuities are introduced into the waveform.

Obvious shortcomings are that the peaks do not fall away in amplitude in proportion to frequency, and that the frequency scale on the X-axis is non-linear. But what can you expect for a parts outlay of less than £50?

Alexandra Palace

Figure 4 is the spectrum of the BBC1 transmitter at Alexandra Palace. This was received, at a line of sight location, with 3in of wire at the input socket. Left-hand peak is the vision signal and right-hand, the sound.

The kink on the right of the sound signal, represents the Nicam information at 517.802MHz. Peak in the middle is a strobe at 514.66MHz and the small peak between the strobe and the sound is the colour signal, 4.433619MHz above the vision.

Of course it is not possible to measure to this accuracy, 100kHz being about the limit. But, considering its small cost, there is no doubt that this is a very useful device. ■

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- * Preprocessor, compiler, optimiser
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- * Inline assembler
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68HC11, 6809, 8085/Z80
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6800/01/03/05/09/11 8031/8051
8085/Z80 8086/96

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- * Generates INTEL hex format output
- * Output suitable for 87C751
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- * Low cost 8051 In-Circuit Emulator
- * Low power, 5 volt operation
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- * 32k bytes RAM for program/data
- * Single step and break points
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- * Upload/download INTEL hex files
- * I²C drivers available
- * Real time clock version available
- * PC host software communicates via serial port

ICE51 is a trademark of Intel Corp.

87C751 ICE (ICE751)

- * Low cost 87C751 In-Circuit Emulator
- * Plugs into the target 87C751 socket
- * On-board programmer, PLCC adapter available
- * Monitor uses only 48 bytes of program memory
- * Upload/download INTEL hex files
- * Assign memory and SFRs
- * Break points
- * I²C drivers available
- * PC host software communicates via serial port

I²C

- * I²C drivers under Quick Basic for the PC. The drivers are available in three kits. Kit 1 provides an I²C evaluation board, PC cable and driver code. Kit 2 provides kit 1 plus the driver source code. Kit 3 provides kit 2 plus the Quick Basic compiler
- * I²C drivers for the 8051. Diskette containing source code to drive the bus under software control. Suitable for any 8051 variant
- * I²C drivers for the 87C751. Diskette containing source code for single master and slave modes
- * I²C drivers for the 8xC552/652. Diskette containing source code for master and slave modes

OTHER PRODUCTS

- * 8051 BOOK - The 8051 Architecture, Programming and Applications (£49.95). This book includes a free assembler and simulator for personal or educational use
- * PEB552 - The Philips evaluation board for the 80C552 processor variant, a monitor and programming adapter are available for this product
- * MACH1 - An RTX200/1 PC based evaluation board
- * ICC200 - An 8 channel 10MIPS PC based intelligent communications card using the RTX2001 processor
- * FORTH ++ - A low cost RTX2000/1 compiler.

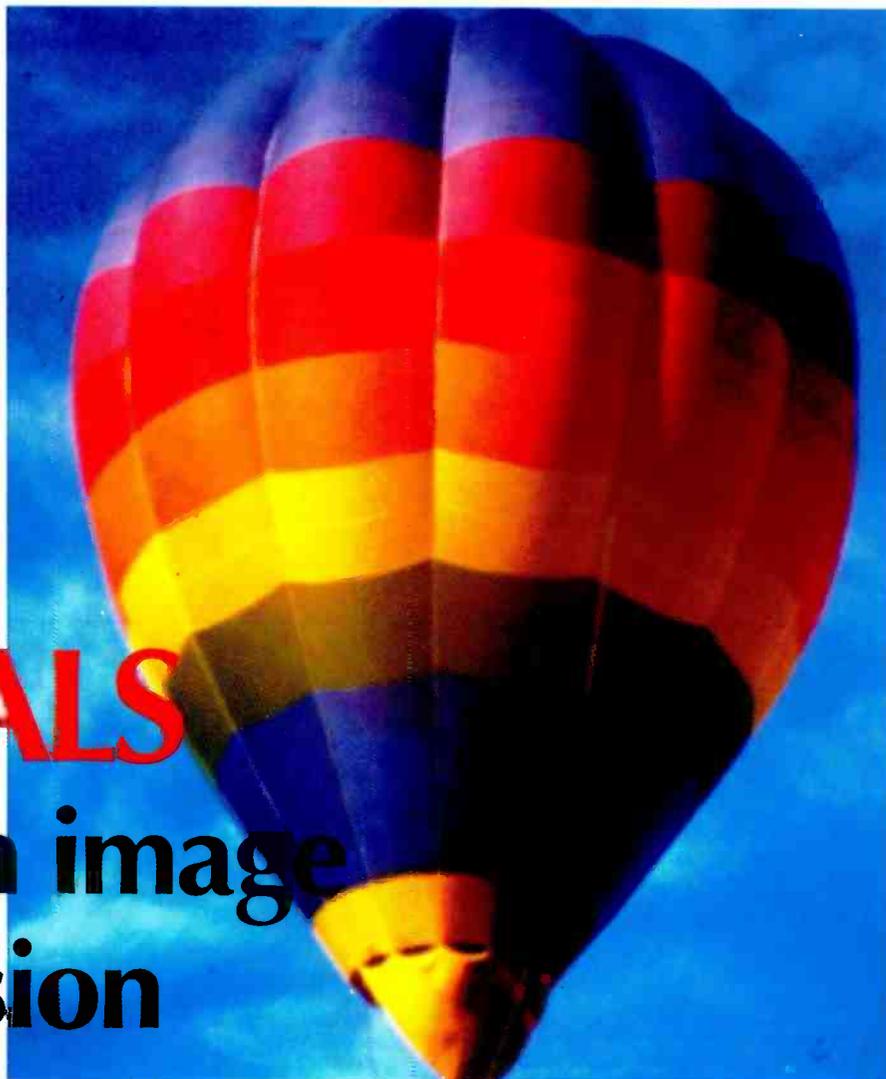
66 Smithbrook Kilns, Cranleigh, Surrey, UK, GU6 8JJ
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CIRCLE NO. 112 ON REPLY CARD

FRACTALS

transform image compression

*A new image
compression technique
based on fractals
promises **data
compression ratios never
before thought possible.**
By Andy Wright.*



When it was first suggested publicly over a year ago that fractals could provide the basis for a whole new generation of image compression methods, most people said: "It sounds like a fantastic theory. I'll believe when I see it!". In October 1991 seeing became believing.

After all, most people associate fractals with demonstrations of high-performance computer graphics and displays. But it is the branch of mathematics behind these infinitely varied and ever-changing patterns that underlies the new compression algorithms. Patterns that are equally complex however close you try to look into them, like the scene through a pair of mirrors face-to-face. Pretty, and pretty impressive. But does the approach really have practical applications?

Visitors to the Time 91 multimedia exhibition last October had the first opportunity to see what the new technology can do. Even hardened cynics could not fail to be impressed by what they saw: several minutes of full motion video played back using software at real-time frame rates from a PC's hard disk; 100 pages of text with 100 full colour images on a single 1.44MByte floppy disk; a VGA-standard image squeezed to just 10KByte.

The technique has evolved from a scepti-

Fig. 1. This is the original ISO standard image uncompressed.

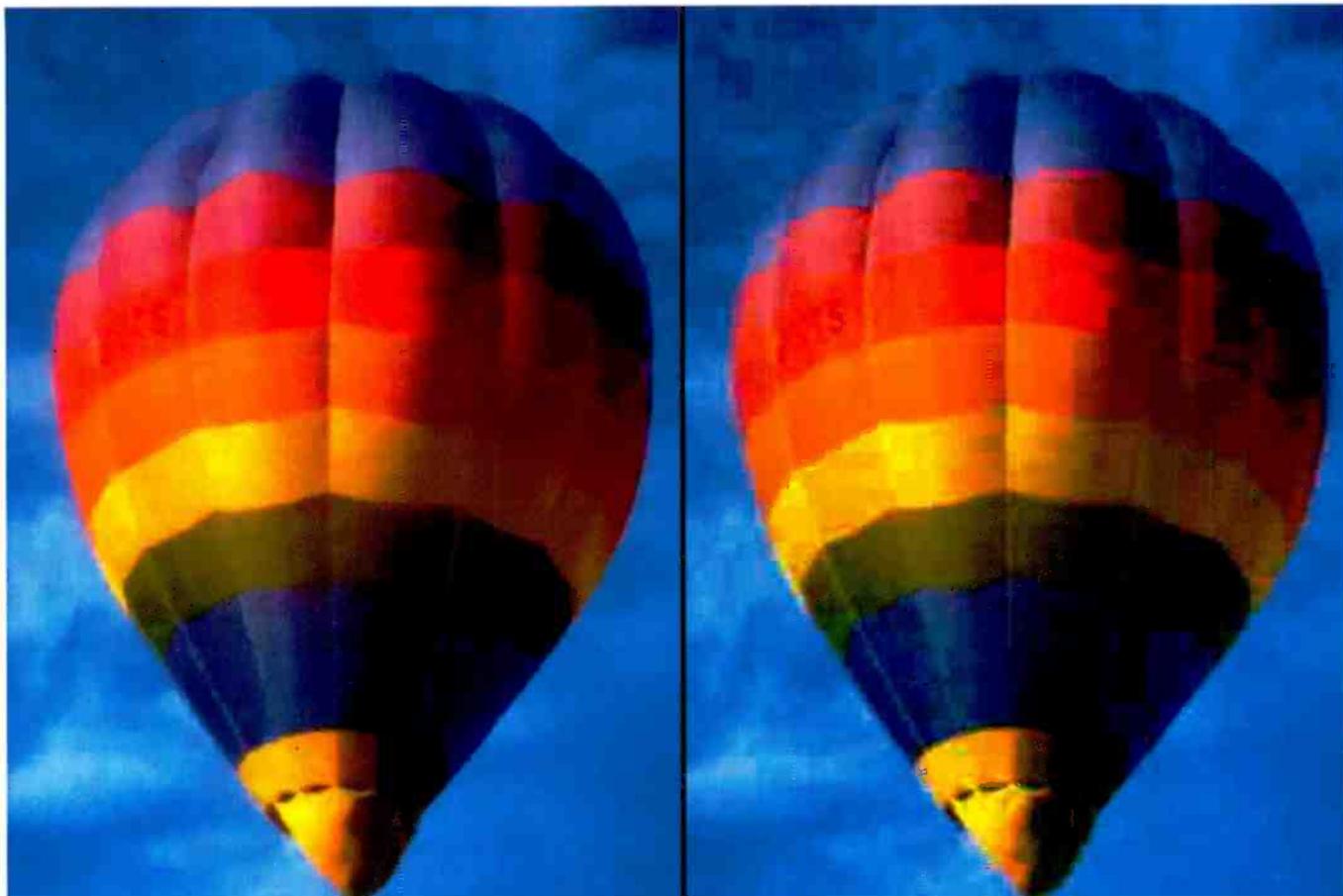
cism-inducing theory to viable reality in just seven years.

Of course the background to this goes back a lot further. It was in 1977 that the term 'fractal' was coined by mathematician Benoit Mandelbrot. His later books like 'The Fractal Geometry of Nature' have captured the scientific imagination, giving an insight into many natural phenomena: from biology through physics to geology and much more. Scientists found fractals in trees and leaves, rock formations, clouds and even the stars and planets.

For mathematicians, fractals are interesting because the images they generate are complex, can be magnified ad infinitum, and are often very eye-catching. From the computational viewpoint, their interest lies in low information content. Complicated patterns can be created by simple program.

It is this that makes them useful for image compression. But the inverse problem is more difficult. How do you go from a complex real-world image to the simple program that can generate that image?

In 1988, Dr Michael Barnsley, previously professor of mathematics at the Georgia



Institute of Technology, discovered the key. He invented the Fractal Transform – an invention he believes: "...will revolutionise image technology just as the silicon chip has revolutionised the electronics industry".

Recognising the possible commercial impact of his fractals work, Dr Barnsley teamed up with a fellow academic Dr Alan Sloan, and in 1987 they formed a company called Iterated Systems. Backed by venture capital, Iterated Systems now boasts a team of leading mathematicians, dedicated to designing, developing and marketing data compression products. So far, more than 120 man-years of development have gone into the technology.

What is a fractal?

To understand how Barnsley's method works, one must go back to first principles. Fractal basics can be described using a thought experiment called the 'Futuristic Photocopier'.

Imagine a single sheet of paper with a dot on it. Place it in a photocopier that has been specially modified. Instead of an identical copy, the system produces a piece of paper with the original dot plus a second dot – the same as the first but moved and twisted to a new place.

Put the piece of paper through the machine again. You now have three dots. The new dot has been moved and twisted. Each time you copy the paper the latest dot is twisted and moved while the original dots stay where they are. After three iterations a seemingly random pattern has been plotted on the page. After 15

Fig. 2. Left: A balloon from the ISO standard image has been compressed to 10KBytes using fractal transform image compression. By comparison, the right hand image has been processed with the JPEG discrete cosine transform.

the dot seems to wander randomly; but after 300 the dot is staying within certain areas of the page. A pattern may be emerging. Finally after 5000 'copies' a real pattern is emerging, and after 100,000 the pattern is recognisable. The interesting thing is that if you continue for another 100,000 iterations, the dots continue to fill in detail within the shape already defined. It doesn't spread out over the page.

The example reduces to this: a complex pattern can be described by an origin and the move-and-twist instructions. Just six numbers, 12 bytes, can generate an image as complex as a fern leaf. More complex graphics like those in the real world can be created from many fractal pictures laid one over the other. Several thousand may be needed.

Inside a fractal transform

The fractal transform identifies the fractals that make up an image, hence finding the fractal formulas that can recreate it.

In outline, the way that it works is to look for self-similarities in the image. The image area is divided into small blocks. For each block, the mathematical algorithm looks for similar blocks throughout the image that have been moved and twisted from the original

block. From the second block it looks for a third... and so on. Exactly how the program does this is of course proprietary information. New and better algorithms are being developed all the time. Even the name 'fractal transform' is a registered trade mark.

Unlike other image compression techniques, the fractal transform is a very asymmetric process. Where a great deal of special computational power is needed to generate the fractal formulas from an image, the reverse process is much simpler.

When the fractal transform was first developed, it took eight or nine days to compress an image. Refinements in the numerical methods have improved on that. Even so, application-specific hardware has had to be developed to make compression times reasonable.

Iterated Systems' P.OEM fractal transform compressor is an EISA bus add-in card with eight ASICs to do the fractal transform, some fast static ram, and an i960 risc processor for control. Starting with data in Targa, raster or tiff format, users can select the quality of image they require to trade against compression time and file size.

Typically grey-scale images can be compressed down to a 3KByte file size; colour images take up 10KByte and video frames an average of 800 bytes per frame. The compression ratio is around 77:1. Compression time varies from one second/frame for video to four seconds for still images.

Video enjoys a high relative compression because the developers have combined their

fractal transform with some more conventional image processing methods. With moving images, little information changes between successive frames. Just storing the difference data can result in significant data reduction.

A technique known as motion compensation takes this one stage further, by also looking at groups of pixels that move in the same direction, by the same amount, from one frame to the next.

The beauty of the fractal transform tech-

nique is that it can simply be bolted onto these existing techniques.

Much less computational-intensive decompression can be done in software. Available software can read, decompress and display to 640x400 pixel, 24-bit quality in around five seconds on a 25MHz 80386 PC.

Video can be decompressed and displayed at 30frame/s and resolutions up to 640x400 for grey scale video, 320x200 for colour. Full motion video can run solely in software on a 386SX based PC.

Relative performance

When making comparisons, it's important to remember that image compression methods only work well with image data. Geometric 'images' such as those produced by CAD systems are most economically stored as geometric data: as polygons or other primitives.

Nevertheless, as interest grows in computer graphics, desktop publishing and multimedia applications, new standards for image compression have emerged.

At the bottom end of the spectrum, lossless methods of data packing can squeeze a file into half its original size. Moving on to techniques where image quality is bound to suffer, techniques such as the discrete cosine transform can achieve compression ratios around 40:1. These methods have now been standardised internationally. For example the Joint Photographic Experts Group (JPEG) has defined a DCT-based standard accepted by hardware and software vendors alike.

Meanwhile proprietary standards such as Intel's DVI are gaining third-party support, and specifications such as CD-I are emerging as *de facto* standards for embedded interactive compact disk systems. For moving pictures, there is also the MPEG standard, but so far products are not widely available to support it.

None of these comes close to the fractal transform's capability in terms of sheer squeezing power, and other methods face real barriers as to how far they can develop.

For example, the discrete cosine transform algorithm can only achieve higher compression ratios by displaying the image as bigger and bigger blocks. At the extremes, a highly-compressed image becomes an unrecognisable mass of square pixels. By contrast, an over-compressed fractal transform picture simply looks fuzzy.

Aesthetic and psychological factors aside, fractals have other advantages. Because the fractal is like an infinite series, decompression is independent of display resolution. It doesn't matter how closely you zoom into the image, the level of detail is the same.

You can take a 640x400 24-bit image that has been compressed into a 10KByte file. That file can then be decompressed to a resolution of 1,280x800x24 – an effective decompression ratio of 308:1. Moreover, it is possible to decompress a section of the same image and display it to the same 1,280x800x24 resolution. Iterated Systems has achieved a 4916:1 decompression ratio by zooming one-eighth of the original image.

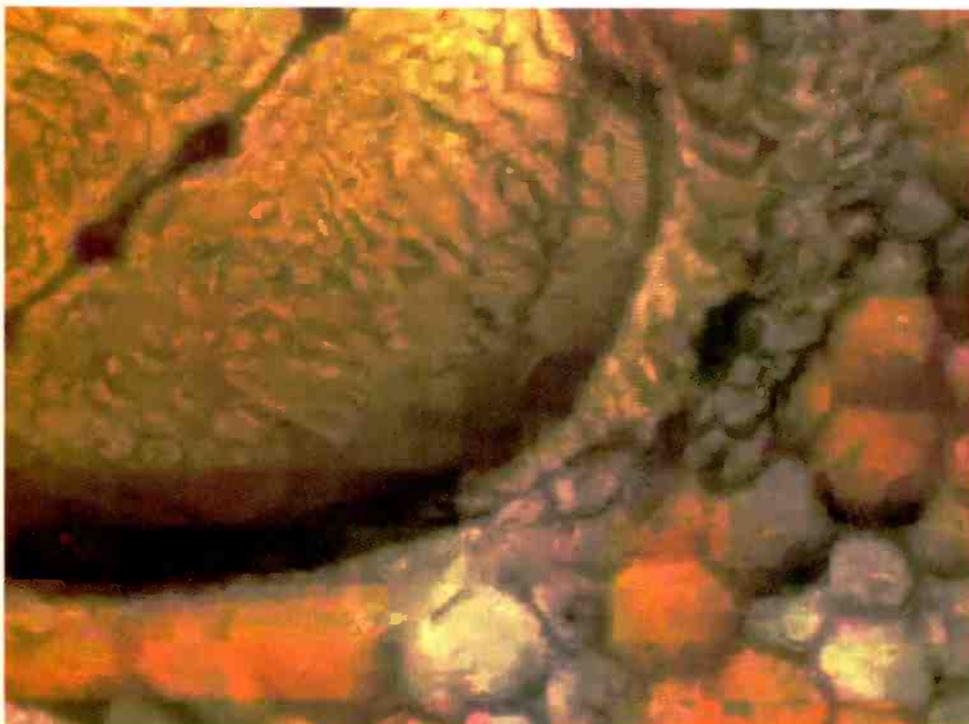
As a result, fractal transform compressors will be able to cope with better standards of display resolution as Super VGA, XGA and TIGA standards take over from VGA.

So, while research on conventional image compression is focused on performing the calculations faster or more economically, fractal transform developments can truly offer better image quality: a closer approximation to reality for a given size of compressed file. Faster processors will simply speed this process up.

Fig. 3 (right). An image of a gecko compressed to 10KBytes using the fractal transform.

Fig. 4 (below). This is a x4 zoom showing part of the image of Fig. 3. It demonstrates the resolution independence of the fractal transform.

Fig. 5 (bottom). As Fig. 4 but with zoom factor increased to eight times over the



Despite these benefits, there are situations where fractal compression remains unsatisfactory. It doesn't work well for images with a low information content such as engineering drawings or for text, factors that may limit its use in embedded applications such as scanners or facsimile machines.

Existing fractal algorithms tend to fit well with natural images such as plants. They tend to find these patterns first rather than geometric shapes relevant to the man-made world. Therefore, an important line of enquiry is aimed at 'seeding' the search probability algorithms so they find appropriate patterns more quickly. Such developments are likely to be applied in the first instance to areas where the compression program 'knows' what it is looking for. Examples include industrial vision systems and defence technology.

This illustrates an important point: there is no fundamental limit to the effectiveness of the fractal transform. While DCT and similar methods run into solid barriers, the fractal transform can go on improving indefinitely. Even as things stand, image quality can be improved simply by running the algorithm for longer – or running it for the same time on a faster processor board.

Thus the fractal transform has two buttresses against the future: its ability to benefit from improved processors and its resolution independence. The latter makes it automatically compatible with ever-improving graphics display standards.

Not surprisingly, the computer industry is keeping a watchful eye on the fractal transform. Amongst silicon vendors prominent in the graphics field, Intel, Immos and Texas Instruments are said to be looking seriously at the technology. At the recent launch of its microprogrammable DVI-B chips, Intel quoted the fractal transform as one algorithm that could be coded into the devices, along with JPEG.

Software suppliers such as Microsoft and Lotus are also keeping abreast. As an enabling technology, fractal compression has the potential to offer better graphics for desktop publishing and other applications.

What's possible now

Within one to three years, Iterated Systems expects to see licensed Fractal Transform software embedded into facsimile machines and scanners as well as multimedia applications, such as games and entertainment systems. In workstations, the asymmetric nature of the compression/decompression cycle makes it well-suited to client-server networks. Soon we will see DTP and graphics on networks where the compression board resides in a powerful server, whilst fast decompression software runs on local client terminals.

A further promising application is in image analysis or enhancement. If fractals are good models of the natural world – as Mandelbrot's original work hinted – then the fractal transform becomes an effective image enhancement tool. It could be used to look more closely at seismic data for exploration, or to analyse

patterns in satellite imagery.

Further in the future, video phones and video or fast graphics modems are a distinct possibility. It will not be long before full motion monochrome video – after compression – can be transmitted via the existing 960bit per second telephone system. Hence there is no need to wait for newer ISDN infrastructures to become commonplace before voice, video and other data can be transmitted down the same links.

Such systems could be useful in remote monitoring or dial-up security systems.

Some interesting applications are already emerging. For instance, the first 'Floppy Book' was published in September 1991: a single 3.5-inch disk containing 100 pages of text with 100 compressed colour illustrations. Such books – with contents pages and indexes – can be accessed interactively on any 80286 or better PC with VGA graphics. User-friendly authoring software makes it quick and relatively cheap to publish similar volumes oneself.

Getting started

If fractal compression seems to be in the realm of science fiction, a family of entry-level products is already available to learn about fractal transforms and get hands-on experience of the technology.

As an introduction to fractals, Michael Barnsley has written a computer-based tutorial called the Desktop Fractal Design System, aimed at students, engineers and scientists.

Another learning tool is called Castle Keep. This is a massive 16MByte compressed image with software to enable the user to zoom-in and display 300 different views of the picture.

For those who have climbed the learning curve and are ready to develop real applications, a variety of developers' systems is available including C libraries, Windows 3 decompression and demonstration image files.

Such a range of software and hardware shows just how quickly the Fractal Transform has grown from a fantastic theory to a serious technology. Iterated Systems believes it will be the *de facto* standard for images by 1993, much as Postscript has become the standard for page printers, or Dolby for audio noise reduction. If interest in high-performance graphics and multi-media grows at the rates projected, fractal impact could be at least as great as its inventor predicted.

Acknowledgement

This article was prepared with the help of Alan McKeon, managing director of Iterated Systems Limited. The company can be contacted on tel: 0734 880261, fax: 0734 880360.

References

'The Desktop Fractal Design System' by Michael F Barnsley, published by Iterated Systems Inc 1989 and distributed under licence by Academic Press Inc.

BOOK REVIEW

Setmakers: If there is one product which spans the social, economic and scientific/technical history of the 20th century it has to be the radio set, and its later relative the TV.

Broadcasting has dominated the decades from 1920, and receivers – from early crystal sets and self-build valve models designed in part to evade the BBC tariff, through first mono and later colour TV sets to satellite dishes – carried the phenomenon into virtually every home in the land.

The *Setmakers*, a comprehensive history published by Brema (the British Radio & Electronic Equipment Manufacturers Association) centres on the products and their manufacturers, but also does justice to the up-stream relationship with broadcast technology, and the downstream one with retailers.

Joint authors Keith Geddes of the Science Museum and Gordon Bussey, historical advisor to Philips, have combined technical background with human tales – many evidently gathered at first-hand – of the people who built up the industry.

Illustrations are many and varied. Naturally, plenty of model shots are featured, as are advertisements – including one from a 1928 *Wireless World* which bears the pious subscription "Advertisements for 'The Wireless World' are only accepted from firms we believe to be thoroughly reliable". There is also a liberal helping of publicity vehicles – vans built to resemble radio sets (including, *lese-majeste*, a KB set constructed on a Rolls-Royce chassis). Among other recondite oddities are Luftwaffe aerial photographs showing the location of British radio factories.

The history of the industry, as Frank Chapple points out in his preface, is largely one of success until about 1960, and decline thereafter, with a multinational-based revival in the last decade.

In the 1950s and 60s the government effectively ripped the guts out of the industry with its stop/go financial policies. This led to a series of mergers and takeovers, followed by joint ventures (from which the British partners quickly bowed-out) with Japanese companies.

It's all documented in this well-produced, 464-page volume, a bargain at £19.95, and an essential reference for anyone interested in the history of the industry.

The Setmakers, pub BREMA, Landseer House, 19 Charing Cross Road, London WC2 OES.

PW

THE COHERER:

preparing the way for wireless

As we approach 100 years of wireless (1995), Leonid Kryzhanovsky recalls the role of the coherer and the men who made modern communication possible.



Coherer inventor: In 1890 Edouard Branly discovered that a nearby electric discharge dramatically lowered the resistance of a layer of ground copper (Courtesy: Mme Branly-Towinon, grand-daughter)

One of the key building blocks for wireless communication was undoubtedly the device which eventually became known as the coherer – the component whose resistance drastically changes under the action of incident electromagnetic radiation.

In fact the history of the coherer goes back to the 18th century, to a time when the only laboratory sources of "electric virtue" were based exclusively on frictional electrification (the first galvanic battery in the form of Volta's pile did not make its appearance until 1799).

The story begins with Benjamin Franklin (1706-1790) inquiring into the "conducting quality" of earth. As part of his experiments in communicating electricity over a distance, he rammed earth in a glass tube at both ends, inserted a wire hook at each end and discharged a Leyden jar through his body and the tube in series.

In a 1748 letter describing these experiments, Franklin states that, in contrast to damp earth, dry earth "would not conduct the least perceptible shock"¹. He does not use the term *resistor*, although the earth-filled glass tube provided with wire leads served as a resistor just as his body served an ammeter.

The term *resister* (in the original spelling) and a description of devices to which this term unexceptionally applies are first found in a letter of Edward Delaval (1729-1814) dated 15th March, 1759. He actually used the term to designate not the device but the materials that offered "resistance" to the passage of the "electric fluid."

Delaval's resistors were constructed of glass tubes filled with rammed dry powders of calcined metals. He put a piece of iron wire into

each end of every tube and fastened them with sealing wax. Upon hanging one of the wires, bent for the purpose, on the prime conductor of an electrostatic generator and holding the other in his hand, Delaval conducted electricity to earth and estimated the resistance by his sensation of the passage of the "electric fluid" and sparks.

He concluded that the resistance was due not to mere pulverisation of metals but to calcination of them. He wrote: "The finest filings or powders of metals conduct as readily as the intire [sic] substances do"². Delaval's resistor may be considered to be the coherer's "grand-parents". The "parents" appear in an 1835 paper by the Swedish physicist P S Munck af Rosenschöld (1804-1860), reporting his experiments on powders of mercury sulphide, tin or carbon etc in glass tubes provided with wire leads. He also experimented with a hardened mass of melted sulphur with carbon powder.

In a similar approach to Franklin's experiments, Munck discharged a Leyden jar through powders or hardened compounds, with his body in series to test the resistance.

But he noticed that when the Leyden jar had been charged to a sufficiently high voltage, discharge drastically lowered the powder resistance which then remained low as long as the powder was not poured out of the tube.

When the tube was refilled with the same powder, the resistance became high again and shaking the tube also restored the initially-high resistance value.³

So, using techniques available as early as the mid-18th century, Munck had made a step towards creation of the coherer. His experiments also anticipated invention of the varistor.

Similar results were also being obtained by

other researchers using contemporary electric measuring instruments and power supplies. In 1866 the Varley brothers of England patented a device, for lightning protection of telegraphic equipment, containing two copper electrodes separated by a thin layer of carbon powder mixed with an insulating material. The powder had a high resistance at low voltage and a low resistance at high voltages. In 1884 the Italian physicist T Calzecchi-Onesti (1853-1922) studied the resistance of metal filings in an ebonite or glass tube. Breaking the circuit which contained the tube and an inductance considerably reduced the tube resistance.

Missed discovery

Anglo-American physicist David Edward Hughes (1831-1900) might have become not only the inventor of the coherer but also the first discoverer of electromagnetic waves, had it not been for a stroke of bad luck.

In 1879, nine years before Hertz's experiments confirming Maxwell's prediction of the existence of electromagnetic waves, Hughes noticed that when Ruhmkorff's coil (a step-up transformer with a magnetic interrupter to produce spark discharges) was operated near a circuit containing a carbon microphone and a telephone, the microphone resistance varied, sounds being heard in the telephone.

Hughes justly supposed that this might be accounted for by the action of the electromagnetic waves produced by the Ruhmkorff coil on the carbon powder. Unfortunately colleagues invited by him to the demonstration of his experiments convinced him that the observed effect was due merely to electromagnetic induction.

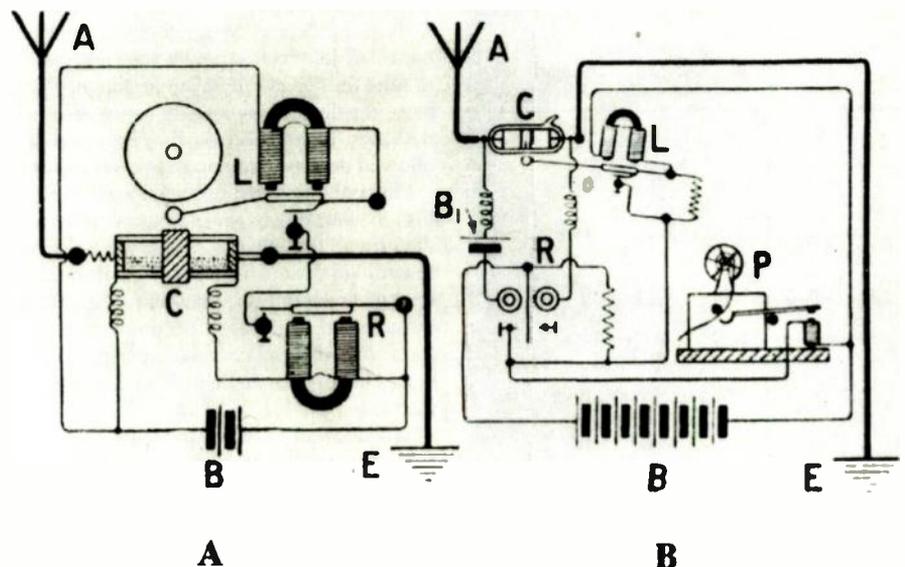
This episode in the history of science was not made public until 1899⁴ and brings to mind the words of John Desmond Bernal (1901-1971) who said on another occasion: "The difficulty in science is often not so much how to make the discovery but to know that one has made it".⁵

French invention

It was left to French physicist Edouard Branly (1844-1940) to claim credit for a mindful invention of the coherer.

In 1890 Branly found that a nearby discharge dramatically lowered the resistance of a layer of ground copper (sometimes with an addition of tin to improve adhesion) applied to a glass or an ebonite plate. The metal powder was connected to an external circuit by copper plates clamped by micrometer screws.

Branly successfully performed similar



Different approaches to coherer design in the first receivers of Popov (left) and Marconi (right).

experiments on filings of iron, aluminium, antimony, cadmium, zinc and bismuth, sometimes mixed with hardened insulating liquid in glass or ebonite tubes. Discharges were produced by electrostatic generators (with or without Leyden jars), Ruhmkorff's coils, etc.

In his 1890 paper, Branly wrote: "Using Wheatstone's bridge, I could determine the effect more than 20m apart, the spark apparatus being operated in a hall separated from the galvanometer with the bridge by three large rooms so that noise from sparks could not be heard". The resistance remained low, sometimes for more than twenty-four hours. Shaking the tube immediately restored the initially high resistance value.

This was not "radio communication." But it was a step forward compared to Hertz's experiments with a resonator relying on a spark gap as the detector in a dark basement to allow observation of minute sparks.

Astonishingly sensitive

Sir Oliver Joseph Lodge (1851-1940) soon saw Branly's tube in proper perspective as a radio wave detector. In his 1894 lecture, Lodge said that the coherer was: "The most astonishingly sensitive detector of Hertz waves."⁷ It should be noted that Lodge had made what may be termed radio detection

experiments as early 1889. He arranged two small metal spheres in close proximity. The current from a small battery was unable to pass between them – proved by zero reading of a galvanometer placed in circuit. But when the Leyden jar was discharged in their vicinity, a current passed through the galvanometer.⁸

It was Lodge who coined the term "coherer" based on an hypothesis of filings cohesion under the action of incident electromagnetic waves. Branly, the originator of the instrument, would not use this term because he did not concur with Lodge on the conduction mechanism involved. He termed his instrument a radio-conductor.⁹

But the controversial physical mechanism – not yet completely understood – has not impeded practical application of the instrument. How rare it is that we know how to make and use a thing without knowing how it works.

The coherer turned out to be the last (not least) component required to implement the idea of wireless communication repeatedly brought forward after Hertz's experiments.

Early designs

Coherers used in the first receivers of Popov and Marconi (see figure¹⁰) were built in different ways. In an effort to attain high sensitivity and stability of his coherer, Alexander Popov (1859-1906) developed a horizontally spring-mounted glass tube, about 1cm in diameter and 6-8cm long, with platinum



Sir Oliver Joseph Lodge, who coined the term *coherer*, saw application of Branly's invention as a radio wave detector.

stripline electrodes pasted onto the inside of the tube along almost its whole length, extending outward at opposite ends. Inter-electrode

gap, at the bottom, was about 2mm. The tube was almost half-filled with iron powder, resting on the electrodes, and stopped with corks at both ends.¹¹

Guglielmo Marconi (1874-1937) used a glass tube, 4cm long, with piston-like silver electrodes tightly fitted at both ends of the tube. Inter-electrode gap, in the middle of the tube, was about 0.5mm, filled with a mixture of nickel and silver filings with a trace of mercury. The tube was evacuated and sealed.¹²

Automatic tapper

Both Popov's and Marconi's receivers contained an automatic tapper whose purpose was to reset the coherer to its initial state (to "decohere" the device), by a slight concussion upon detection of an electromagnetic wave. This allowed detection of another wave to come.

Marconi employed two separate batteries in his receiver: one battery to power the coherer circuit and the other to power the tapper and recording instrument. The design allowed setting of an optimum quiescent point for the coherer and could have been one of the reasons why Marconi covered much greater distances than Popov in their first wireless experiments?

Self-decohering detectors soon made their appearance, one of them being the carbon microphone (recall the Hughes story).

In one form or another the coherer remained in practical use until about 1906 when it was superseded by other detector types. But as a semiconductor device, depending for its action on imperfect electric contacts, the coherer must be the first suggestion of the idea of the crystal detector

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The author is with the Popov Central Museum of Communications, St Petersburg.

BOOK REVIEWS

Wireless: the crucial decade 1924-34.

Number 13 in the IEE History of Technology series, this book by Gordon Bussey traces the events of what is considered to represent the most technologically eventful decade in the development of broadcasting and broadcast receivers.

In 1924, the novelty of broadcast entertainment, as opposed to shipping transmissions, time signals and met. data, was still evident and the building of receivers (often crystal detectors) by the general public was in full swing. As the decade closed, the basic form of superhet that was to endure had been established, broadcasting was as much part of our lives as the newspaper and equipment design was too demanding for the average man to consider building, even if the saving were worth while.

Bussey has done a good job in his searching of the archives, although the "material that is not generally available in public collections" mentioned in the blurb appears to consist in the main of old copies of *Wireless World*, with little mention of other publications or sources apart from Bill Baker's Marconi history and the monumental work by Asa Briggs.

This is a worthy book, in that all the information seems to be there, but there is little in the way of

atmosphere, and even less on the people who made it all happen; names are mentioned, but only in passing. All the same, it is good to see a mention of HB Dent of the WW staff and of Vincer-Minter, who was to enjoy subsequent fame as Free Grid.

In spite of the major constraint of space, Bussey has managed to present a commendable amount of information, normally only found after a search through widely scattered piles of paper, in a readable form. It is a useful addition to the growing list of histories of our field.

Peter Peregrinus Ltd, 126 pages, hardback, £29.
Phil Darrington

Microcomputer fault-finding and design.

by Robin Holland.

There can be few experiences more immediately daunting than to be faced with a computer that does precisely nothing except, perhaps, to illuminate its mains pilot lamp. When a piece of equipment operates a display such as the computer's screen, it is obviously a window through which one is usually able to obtain some idea of the ailment; deprived of this assistance, one has to revert to more basic procedures, after recovering from

the feeling of rejection. This book will help students and service technicians to approach computer fault-finding and repair in a logical manner and with only a slight feeling of panic.

A first chapter forms an introductory look at the architecture of microcomputers, after which the unresponsive computer problem makes its appearance, with the requisite methods of restoring sanity. Board-level testing is covered next at a practical level, with the introduction of logic probes, logic monitors and IC testers.

From there on, the book becomes rather more general, dealing with diagnostic software and methods, rather than specifics. There are chapters on signature analysis, logic analysis and the testing of peripherals, but the remainder of the chapters describe the design of equipment such as VDUs, printers, eeprom programmers and DVMs. A rather odd chapter describes in detail the hardware and software of a talking DVM.

Useful appendices are microprocessor data sheets, TTL functions, the ASCII character set and a glossary of relevant terms.

Macmillan, 202 pages, hardback £35 ((paperback £12.99).

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BREATHING LIFE INTO SCHOOL ELECTRONICS

Computer animation is an ideal way to show students how components operate in use. Martin Cummings finds if Ace has the power to move.

System requirements
 IBM-compatible
 286 or higher
 colour VGA
 display
 mouse (Microsoft compatible)
 hard disk
 Dos 3.0 or later

One of the topic menus; capacitors, inductors and relays.

Bringing diagrams "alive" so that students can see voltage, current, fields and charge, and the effect they all have on circuit elements is the idea behind Bradford Technology's animated circuits for education (Ace). A library of electrical and electronic circuits can be animated on screen to give the student a better insight into their operation.

Bradford has aimed the package at the GCSE science syllabus for 11 to 16 year olds – though students of any age needing an appreciation of basic electronics could benefit from it.

But it is surprising, for educational software, that an IBM-AT-compatible is needed to run the package. Bradford has as yet no plans to release it for other machines even though much schools software is aimed at derivatives of the BBC computers such as the Master or A3000. However higher

education establishments usually have access to IBM compatibles.

Easy action

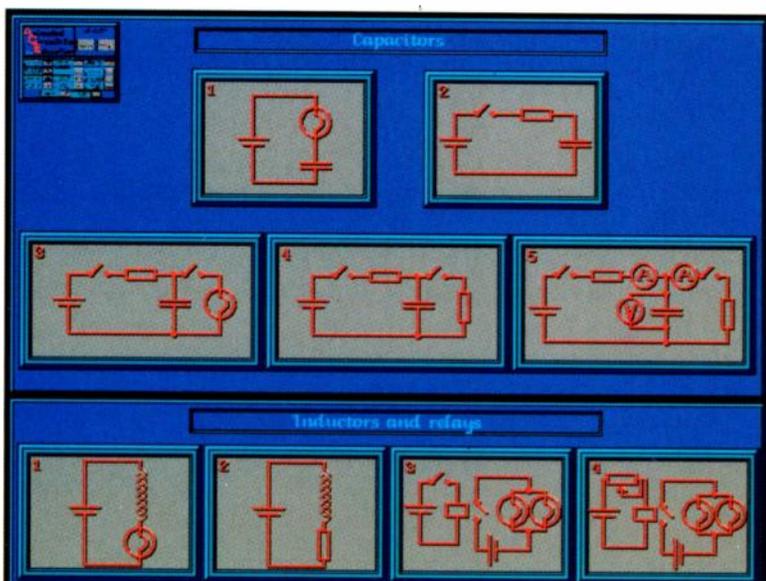
Installation onto the hard disk is simple. You must have a VGA card and at least 3Mbytes of disk space available but beyond this, no knowledge of computers is necessary because operation of Ace is simplicity itself. Everything is done via the mouse and there is no need to refer to the manual.

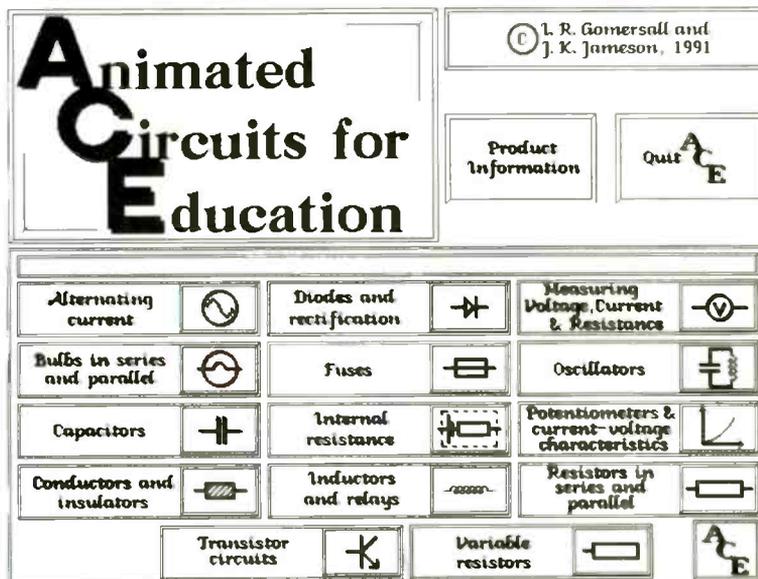
Ace's opening menu screen is perhaps the most impressive graphic in the package. Below the company logo are icons for all the circuit categories available and subjects range from basic conductors and insulators through to oscillators and transistor circuits. Choose one of the 14 topics with the mouse and a fresh screen presents you with a selection of circuit diagrams. Select a circuit and you are ready to animate.

Animating a circuit

Circuits are well laid out on the screen and could have been plucked straight out of a text book. Component symbols are easily recognisable and are drawn to emphasise what they do rather than adhering to any particular standard. For example resistors are represented as rectangles with baffles to inhibit flow and batteries have "buckets" to carry charge from one terminal to the other. Conductors are pipes in which moving dots show the flow of current and colour of the conductor represents its potential at any instant. A scale of eleven colours corresponds to voltages from -10V (green) through 0V (blue) to +10V (red). Curiously this is the only reference to numbers, the rest of the program is purely qualitative.

Progress of the animation is controlled by five "buttons" at the bottom of the screen that can be "pressed" using the mouse. The buttons are instantly recognisable as video recorder type controls such as PLAY, REWIND and PAUSE – a guarantee of instant appeal to younger users. Circuits





remain dead until START is pressed at which point the battery provides voltage and the circuit begins to operate, subject to the position of any switches.

The buttons are a great idea but given the video recorder analogy it seems a shame that it is not possible to inch back just a little way; the rewind button forces a start from time zero.

With the simpler circuits, there is nothing to do but observe. But elements such as switches, potentiometers and thermistors are included in other examples and can be adjusted with the mouse. There is even a light-dependent resistor, complete with torch icon that can be turned on and off to change its characteristics.

Using the computer to animate and explain is well exploited by Ace.

As capacitors charge, more plus and minus signs appear on the plates; diodes are particularly appealing with a little plug that pops in and out like a mechanical valve depending on direction of flow.

But graphics are coarse and ragged edges distract the eye – which seems unnecessary with VGA performance available.

Ammeters and voltmeters are also a little crude with only five positions from zero to full scale. Perhaps this is perfectly adequate to illustrate the point, but realism suffers and the graphics stand out against a dial on say the average flight simulator which seems much smoother.

Choose your complexity

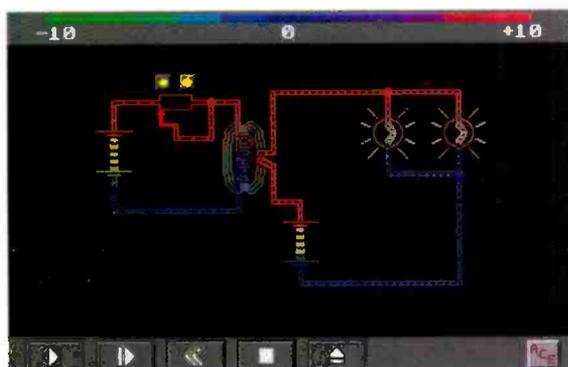
A broad, though thorough, range of circuits covers all the basic components: resistors, capacitors, inductors, lamps, relays, batteries and so on, presented in ways which illustrate alternating current, non-linear circuits and exponential effects.

The simpler circuits can be understood within a matter of seconds. For example Ace shows quite clearly that as a capacitor charges through a resistor, the current reduces after an initial surge. To the novice, seeing is believing and perhaps animated circuit diagrams can illustrate this better than meters and bench equipment.

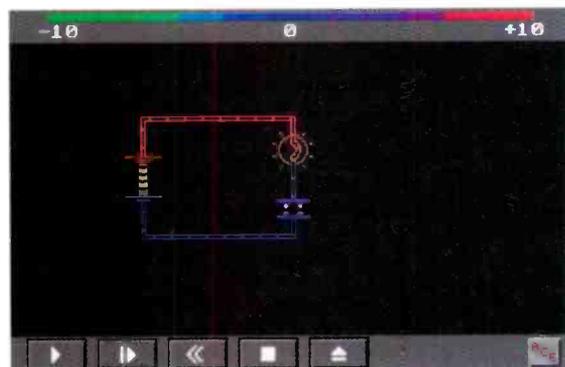
There are fourteen transistor circuits and it is at this level of complexity that the technique comes into its own, particularly where there is, say, a potentiometer that can be adjusted so the characteristics of the circuit can be explored.

Go beyond this in complexity and there is almost too much to take in at once – even those with degrees under

Topics covered
conductors and insulators; resistors; series and parallel; bulbs, series and parallel; measuring, voltage and current; potentiometers; variable resistors; diodes and rectification; capacitors; inductors and relays; internal resistance; alternating current; oscillators; transistor circuits.



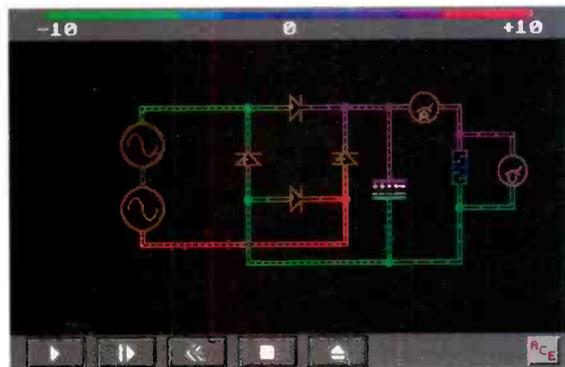
(Top far left) Relay circuit showing component operation.



(Left) As capacitors charge, more plus and minus signs appear on the plates.



(Lower far left) Conductors and insulators. Conductors are pipes in which moving dots show the flow of current.



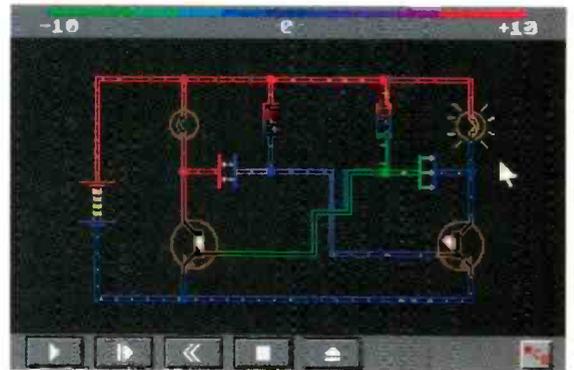
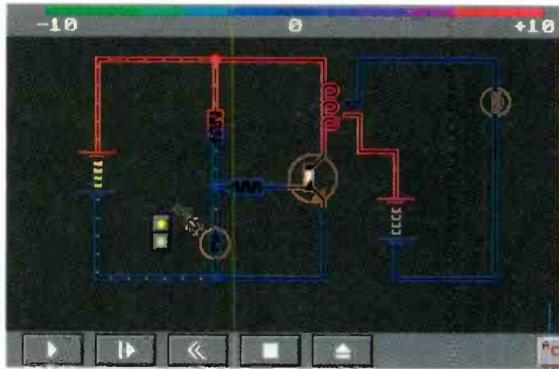
(Left) Full wave rectification and smoothing.

In a light-dependent relay circuit the relay can be turned on and off to change its characteristics – relay off...

...And relay on (far right).

There are fourteen transistor circuits and it is at this level of complexity that Ace comes into its own.

(Far right) Astable oscillator circuit shows how complex Ace can go.



their belts will stare perplexed at the astable circuit, trying to fathom out what is happening as it cycles slowly from one state to the other.

Minimum quantitative information

There are several ways Ace can be used in the classroom. Perhaps the most obvious is as an animated blackboard to

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complement the words and explanations of the lecturer. Clearly the author has set out to avoid numbers and explanations that may distract from the visual presentation of the program. In fact at times it is a little frustrating that the computer does not do more to quantify and explain what is going on. The same feeling presents itself in students as impatience to move on, and perhaps text, numbers and time-based graphs could have been included, turned on or off depending on mood, ability or the lecturers approach to the subject.

The package can also be seen as a computer game where students adjust settings and explore the different circuit configurations, learning at an individual's own rate in the process.

But in this mode the program lacks the challenge or framework to conceal the learning process, so it boils down to an electronic text book which the more motivated students will browse through but probably don't need anyway.

Shortfalls

The manual is well presented with plenty of screen dumps embedded in the text. A brief introduction and installation guide is followed by a couple of pages of operating instructions, almost superfluous due to the program's ease of use. Most of the manual is a compilation of all 78 circuit diagrams together with a few lines of explanation for each one. Again this is almost superfluous because it is aimed at the lecturer who we can reasonably expect to know the subject.

A more useful contribution would have been some well prepared and presented worksheets designed to ensure the student extracts all the relevant points from each screen. Such worksheets would save hours of preparation over a

year and be an attractive feature to potential buyers. Although the range provided is quite adequate Bradford Technology will provide tailor-made circuits for a particular requirement, no doubt for an appropriate charge. While it is useful to have this flexibility, the program cries out to be user-configurable. Once you have observed the standard circuits operating, there is an inevitable desire to construct your own, but Ace stops short of this.

If students could draw their own circuits and bring them to life, it would be possible for them not only to achieve an understanding but to put that understanding to the test confirming that their circuits perform as expected. This would also go some way to providing the interaction and challenge that students have come to expect when they sit down at a computer.

Cost vs use

Anything that approaches the subject from a slightly different angle increases the opportunity for understanding, and overall Ace is a useful teaching tool. The principle of using the computer to animate subjects such as circuitry, algebra and chemical reactions has a lot of potential and I believe we are seeing an example of the first generation of such programs in Ace. But the educational market is well supplied and although currently unique in its field, Ace can expect some stiff competition to come along soon.

Its price tag of £200 pushes it over the financial horizon of many science departments, and while we can expect to see much more software like this in the future, for Ace itself to be a success it needs on screen explanations, more interaction, better use of graphics and a significant reduction in price. ■

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ALARM TRANSMITTERS. No data available but nicely made complex radio transmitters 9v operation. £4.00 each ref 4P81R.

12V 19A TRANSFORMER. Ex equipment but otherwise ok. Our price £20.00

GX4000 COMPUTERS. Customer returned games machines complete with plug in game, joysticks and power supply. Retail price is almost £100. Ours is £12.00 ref B12P1

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IBM AT KEYBOARDS Brand new 86 key keyboards £15.00 ref 15P612

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TWEETERS 2 1/4" DIA 8 ohm mounted on a smart metal plate for easy fixing £2.00 ref 2P366R

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SPECTRUM JOYSTICK INTERFACE Plugs into 48K Spectrum to provide a standard Atari type joystick port. Our price £4.00 ref 4P101R

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DISC DRIVES Customer returned units mixed capacities (up to 1.44M) We have not sorted these so you just get the next one on the shelf. Price is only £7.00 ref 7P1R (worth it even as a stripper)

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OZONE FRIENDLY LATEX 250ml bottle of liquid rubber sets in 2 hours. Ideal for mounting PCB's fixing wires etc. £2.00 each ref 2P379R

QUICK SHOTS Standard Atari compatible hand controller (same as joysticks) our price is 2 for £2.00 ref 2P380R

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CIRCLE NO. 116 ON REPLY CARD

Specialised design package for RF power amplifiers

Ian White tries out Hepa – software offering a quick route to design of optimised high-efficiency RF power amplifiers

Supplier details

Hepa-Plus WB costs \$2450 (demo disk \$30) from Design Automation, Inc, 809 Massachusetts Ave, Lexington, MA 02713-3992, USA.
Tel: USA 010 1 617 862 8998 Fax: 010 1 617 862 3769.

RF power amplifiers are finding many uses besides their traditional role in communications – even the name is changing in response to market forces. Now industrial, medical and scientific users require “RF power supplies” which provide RF energy with no more fuss than a DC power supply.

Key to efficient, controllable and reliable RF power supplies is the design of the final power amplifier stage, where RF power mosfets are increasingly supplanting tubes and bipolar transistors.

Although power amplifier design is straight-forward enough in principle, calculations soon begin to accumulate when the practicalities of meeting specifications for power output, efficiency and wide-band performance have to be met using real-life semiconductor devices.

This is where the Hepa series of programs from Design Automation can help, offering a quick route to design of optimised high-efficiency RF power amplifiers, either operating under gain compression in Class AB, B or C or operating in switching-mode Class E or F.

Ready-made library

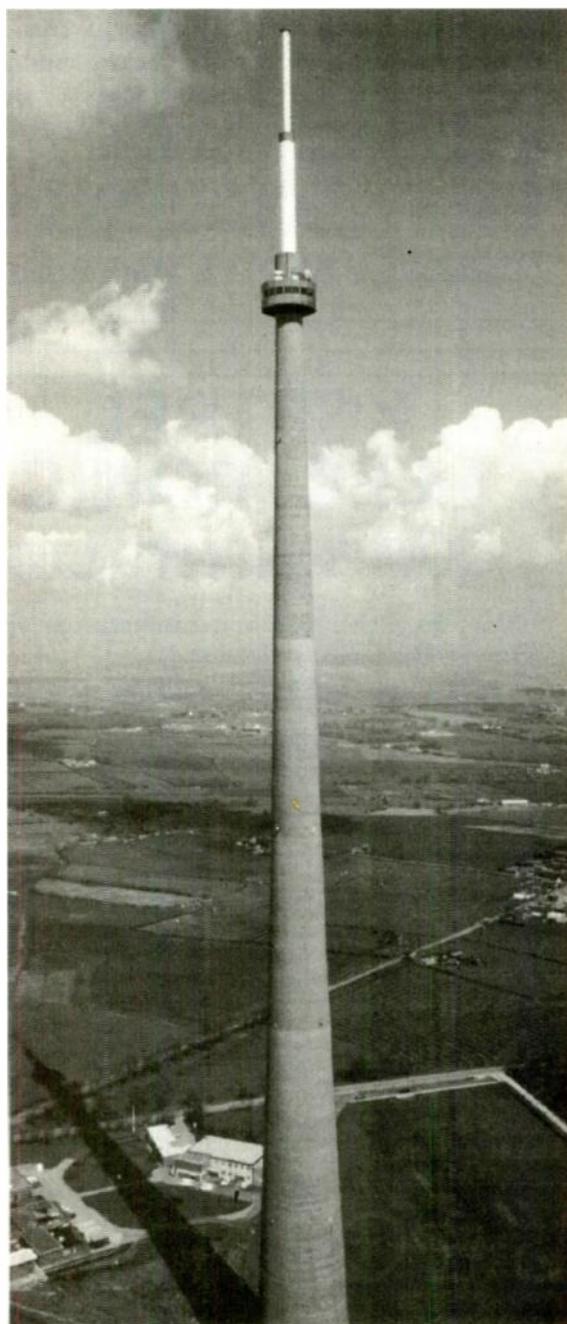
Unlike a general-purpose circuit analysis program, Hepa contains a ready-made library of suitable circuit topologies and basic designs for its own specialised application. These circuits can be modified if required, and are then analysed with respect to time and frequency to yield voltage and current waveforms and predictions of DC input, RF output, efficiency and the power dissipation in various circuit components.

With computer control in mind, Hepa can also compute the values of circuit parameters required to maintain any specified output voltage, current or power. The whole design can then be optimised automatically for narrowband or wideband performance, with user control of optimisation criteria and relative weightings.

At \$2450 for the top-of-the-line version, Hepa is not the kind of software you would buy *in case* you might need it. But if you are actively involved in RF power amplifier design, Hepa deserves a serious look – it could pay for itself very quickly.

System requirements

Supplied on either 3.5 or 5.25in disks
XT, AT, PS/2 or compatible PC
At least 512K ram
Colour or monochrome graphics displays require CGA, Hercules, EGA, PGA/PGC or VGA
Maths coprocessor recommended



Integrated Schematic Capture & Digital Simulation?

Its not as expensive as you think!

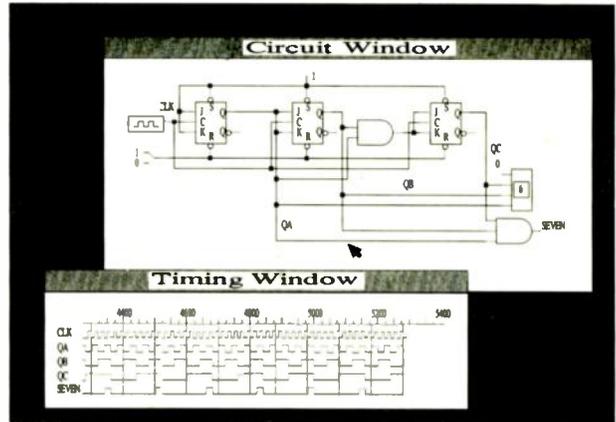
DesignWorks and LogicWorks provide interactive Schematic Capture and Design Simulation from as little as £300!

By using the friendliest user interface on the market to make schematic entry and simulation fast, easy and economical you will be doing productive work in hours or even minutes. Interactive means simulation continues while you design your circuit on screen using schematics, with waveforms displayed 'scope style in the timing window. No compiling, No typing in netlists!

Current device libraries include: Generic devices, basic gates, 7400 series, 10K series, 4000 and VLSI.

LogicWorks offers THE design environment for educational users. Features include: Creation of custom devices, support for simulation of PROMs, PALs and RAM, complete or partial circuit and timing diagrams can be easily included in DTP documents through image files.

DesignWorks offers a professional design environment with all the features of LogicWorks plus the powerful MEDA Developers kit enabling behavioural modelling using C, custom and Standard reports and netlists compatible with most of the major CAE packages and fully bi-directional access to circuit data.



Software is available for Apple, IBM Compatibles and Acorn Archimedes.

Educational discounts available. For more information and a demo disk, please contact:



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6551P	2.00	1.40	74HC153	0.20	0.16
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8251A	1.10	0.75	74HC194	0.24	0.18
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SIMULATOR WITH STAR QUALITY?

Can a simulator costing just £200 compete with workstation products? **John Anderson** puts Pulsar through its paces

Pulsar is the new digital logic simulation package from Number One Systems Ltd. Number One has made its name in the supply of low-cost circuit analysis and PCB layout tools and this latest offering aims to take the PC into the domain of workstation logic simulators.

At first, the product actually takes a little understanding. But I found that after a while I warmed to it, and the resulting performance looks to be well worth the effort.

Visually, Pulsar's exploding graphical windows mean its user interface certainly looks interesting. But the approach is rather gimmicky and adds nothing to functionality, though it does give the package a very professional feel.

Mouse selection of individual actions is a simple matter of clicking. Using the keyboard requires memorising the single short-cut keystrokes, and for convenience I regard mouse use as obligatory.

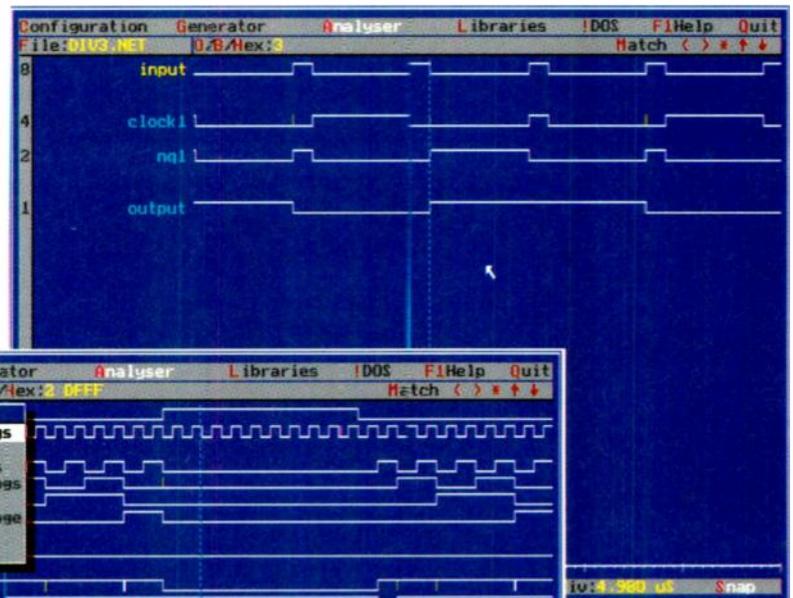
Starting operation

Installation is simple: copy the files to the directory and run. The software can be configured for a variety of settings and printers – handled from inside the package itself – and there are no dongles or other copy restriction devices.

But starting to use the package, with netlist input, is probably the weakest aspect of the system. There is no schematic capture, although the manual states that the net list may be extracted from the Easy-PC schematic capture facility. Deciding to enter the net by hand can bring a second shock because although the libraries use standard TTL and 4000 series CMOS, individual device pins must be referred to by an identification defined by the library item – which explains the presence of device schematics in the manual. Pin numbers can not be used.

But simulation is in an altogether different league! Performance is electric!

Once the net is loaded – and it is parsed on loading to



Divide by three
simulation

Pulsar's display of
binary counter
simulation



System Requirements
Industry standard PC
EGA/VGA screen,
preferably colour
Minimum 512K ram
Dos 3 or later
Double floppy
minimum, but hard disc
recommended
Mouse supported, and
makes use much easier
Optional printers
supported: Epson 9 and
24 pin dot matrix ; HP
Laserjet II

ensure that it is consistent – just select a generator, reset the simulated circuit and presto. The result is a logic analyser or oscilloscope style display produced with amazing speed. Results are always presented as a set of graphical waveforms, no code based logic analyser display is available.

The package recognises more than just two logic levels, including weak high and low – driven by pull-up and pull-



The net list can be entered by using the built in on-line netlist editor.

A positive reset pulse

More complex generators can be built using the generator create facility.



down resistors, high impedance and undefined. During simulation, it looks ahead to each change in logic state and only stores data when a change occurs.

Presented with a complex simulation, Pulsar offers a neat search-and-locate facility built around a match pattern. The facility is based on the binary pattern working down from the top of the screen. A match word can be input as binary, octal or hex, with a don't care operator to mask out parts of the sequence. To make the whole display more readable, simulation results can be re-ordered on the screen and grouped so that, for instance, outputs from a counter can be placed together in order of binary weight.

Designs libraries

First step on the route to circuit simulation is to enter the net list by using a standard ascii editor, or the built in "interactive" net-list editor.

Using the editor a net name can be assigned to every pin of each device, structured on a device hierarchy. It is this hierarchy that is the key to probably the most powerful feature of Pulsar - device abstraction. The idea is that functional groups of logic components can themselves be saved

as a module and used in the same way as any logic component. The method opens the door to simulation of complete logic systems of high complexity.

Pulsar's simple library manager allows designs to be stored and recalled and designs themselves can be expressed in a modular form. So sub-systems, themselves consisting of components from the TTL library, can be saved. At a higher level, the system description can include reference to these sub-systems.

Glitch traps and generators

Apart from general functionality-testing, logic designers also need to know about glitches - the short changes in logic level brought about by hazards or race conditions determined by intrinsic delays in the devices. Pulsar simulates these conditions well, and a nice touch is that no matter how short a glitch is, it is shown as a line on the time display.

As a result, a picosecond event can be "seen" on a one second display window.

Pulsar also has a quite versatile generator system, providing single pulses and pulse trains of any width or repetition frequency.

More complex generators can be built using the generator create facility which allows base sequences of 1s and 0s to be concatenated and repeated. Indeed, the repeated generator sequences can be nested and re-entrant - though I suspect this is probably going over the top. Generators used on

CONTINUED OVER PAGE

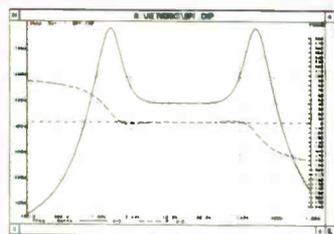
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Non-Linear Analogue Circuit Simulator £245 complete

Those Engineers have a reputation for supplying the best value-for-money in microcomputer-based circuit simulation software. Just look at what the latest fully-integrated SPICE Advanced Graphics Environment (AGE) package offers in ease-of-use, performance, and facilities:

SPICE•AGE performs four types of analysis simply, speedily, and accurately.

- Module 1 – Frequency response
- Module 2 – DC Quiescent analysis
- Module 3 – Transient analysis
- Module 4 – Fourier analysis



Impedance sweep

1 Frequency response

SPICE•AGE provides a clever hidden benefit. It first solves for circuit quiescence and only when the operating point is established does it release the correct small-signal results. This essential concept is featured in all Those Engineers' software. Numerical and graphical (log & lin) Impedance, gain and phase results can be generated. A 'probe node' feature allows the output nodes to be changed. Output may be either dB or volts; the zero dB reference can be defined in six different ways.

2 DC Quiescent analysis

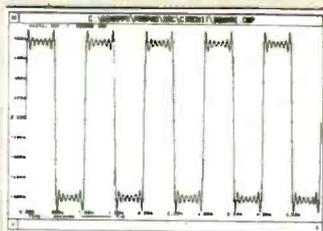
SPICE•AGE analyses DC voltages in any network and is useful, for example, for setting transistor bias. Non-linear components such as transistors and diodes are catered for. (The disk library of network models contains many commonly-used components – see below). This type of analysis is ideal for confirming bias conditions and establishing clipping margin prior to performing a transient analysis. Tabular results are given for each node; the reference node is user-selectable.

Node	DC Volt	Node	DC Volt	Node	DC Volt
0	0.000000	1	1.708600	2	7.707000
3	1.416400	4	8.271100	5	7.625400
6	1.416400	7	7.625400		

DC conditions within amplifier circuit

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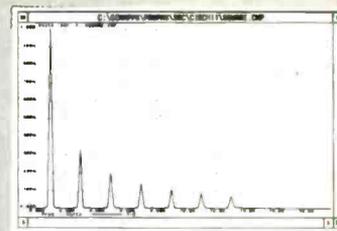
Square wave synthesis (transient analysis)

3 Transient analysis

The transient response arising from a wide range of inputs can be examined. 7 types of excitation are offered (impulse, sine wave, step, triangle, ramp, square, and pulse train); the parameters of each are user-definable. Reactive components may be pre-charged to steady-state condition. Up to 13 voltage generators and current generators may be connected. Sweep time is adjustable. Up to 4 probe nodes are allowed, and simultaneous plots permit easy comparison of results.

4 Fourier analyses now with Hanning window option

SPICE•AGE performs Fourier transforms on transient analysis data. This allows users to examine transient analysis waveforms for the most prevalent frequency components (amplitude is plotted against frequency). Functions as a simple spectrum analyser for snapshot of transients. Automatically interpolates from transient analysis data and handles up to 512 data values. Allows examination of waveform through different windows. Powerful analytical function is extremely easy to use.



Spectrum of synthesised square wave (Fourier analysis)

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- Rohde & Schwarz Decade Signal Generator, Type SMDH-BN41103, 0-50MHz **£200**
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CIRCLE NO. 122 ON REPLY CARD

No matter how short a glitch is, it is shown as a line on the time display. Here we see a 48ns glitch captured in a divide by three simulation.



Help windows can sometimes appear a little cryptic.

workstation simulations usually include random number generators (termed pseudo random binary sequence or PRBS). These are used to exercise a design outside its expected operation sequence, looking to try the logic in abnormal logic states. Pulsar does not have a PRBS generator.

To examine results of the simulation, there are commands to zoom and un-zoom the display around a cursor which can be positioned by the user. A second cursor line can in turn be used to measure time displacements relative to the first cursor. A neat feature is that the cursors can be made to snap to the edges of the simulation output, ensuring good accuracy.

Net list revisited

Why is it that every vendor selects a different format for data storage? In the case of net lists, there are many different schemes, but a common theme is that a net has a net name, and associated with that name is a set of pins on devices.

Unfortunately, Pulsar uses a totally different approach, with every pin on each device listed, and the net names associated with that pin. No translation software is supplied, so Pulsar cannot be used with your favourite schematic capture program.

On the subject of net lists, when I first ran the program with an experimental circuit the net-list being prepared using a standard ascii editor. However, the net would not load - Pulsar indicated that it was a fatal error and I should call Number One. The problem turned out to be the use of an extra hash character in the net list, but the problem would have been found much sooner if the Pulsar net parser had indicated location of the problem.

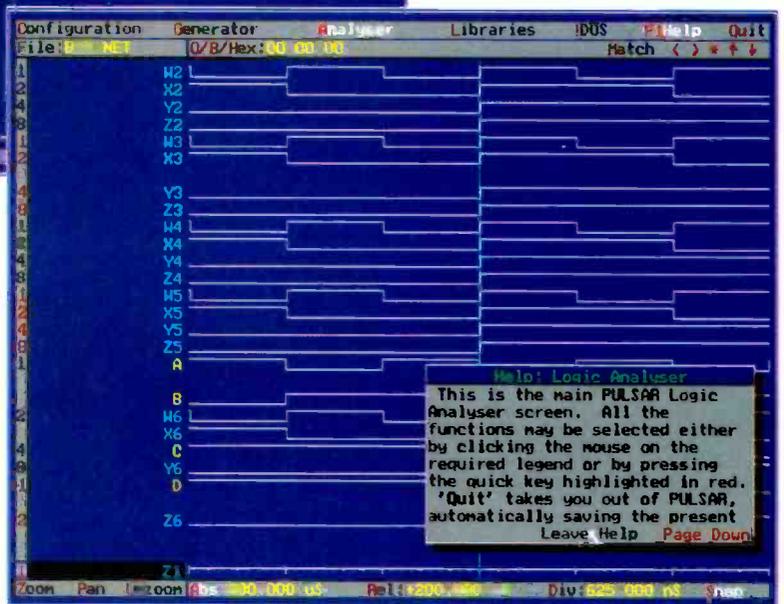
Manual restrictions

Pulsar's manual is a well-presented A5 ring binder of about 100 pages. This includes a set of annotated TTL and 4000 cmos library device schematics to cope with the fact that individual device pins must be referred to by an identification defined by the library item.

But layout of the manual is not good, though it starts well with a "first impressions" section, and then moves on to a "grand tour". But there is no catalogue of available functions and the index is poor. The result is that the excellent simulator is not properly documented.

Unfortunately the adjunct dos browser is presented in excruciating detail.

Dos-like commands can be executed on files, such as delete a file or make a sub-directory etc and the facilities are covered in some detail in the manual. But these features are entirely superfluous to operation of the product and should be removed or replaced by a "shell to dos" facility in the next version.



Challenge to workstation products

Pulsar is a very impressive package with a graphical user interface as smooth as any product I have seen.

The simulation engine is very good with amazingly fast operation. Even with very short picosecond glitches simulated over several seconds the simulation time was acceptable.

Certain aspects of use, and the level of documentation, were not as user-friendly as the software itself. So let's hope that Number One integrates schematic capture and provides translation from other netlist formats in the next version.

However all in all this simulator can, with a little effort, compete with workstation products. At under £200 this valuable tool threatens to become the logic designer's indispensable screwdriver.

Supplier details

Pulsar £198 + delivery and VAT
Available from Number One Systems Ltd, Harding Way
Somersham Road St Ives Huntingdon PE17 4WR.
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CIRCLE NO. 123 ON REPLY CARD

REGULARS

LETTERS

S-s-scepticism

With reference to the article on Marconi's first transatlantic signals radiated by his Poldhu transmitter on December 12 1901 (*EW + WW*, December 1991) may I add that few scientists believe that Marconi heard the legendary "S" letters at 12.30, 1.0 and 3.30 Newfoundland time.

What Marconi and Kemp may have heard are atmospheric pulses which can occur in groups of three (I have heard them myself).

The Poldhu transmission would have been over a daylight path, so the waves, approx 360m long, would have been absorbed by the ionosphere's "D" region. The receiver used was also extremely inefficient.

However, during trials early in 1902, on the same wavelength, but with an increase in transmitter power, reception trials were conducted with a more efficient receiver on board the Philadelphia as it steamed across the Atlantic.

During the Philadelphia trials, Marconi noted that at a distance of 700 miles, signals over a daylight path became too weak to operate the tape inker. But over a night-time path, signals were recorded at up to 1500 miles while "S" signals were receivable at 2100 miles. Reason for the "night effect" was not understood.

Nonetheless, the Philadelphia trials demonstrated that Hertzian waves

could follow the curvature of the earth, though medium wave transatlantic signalling seemed to be possible only over a night-time path. Now, of course, it is now known that during darkness the D region disappears, allowing medium waves to reach the higher E region from where they are reflected back to earth.

However, Marconi and others soon discovered that with passive receivers, reliable twenty-four-hour a day transatlantic signalling was possible by employing very long waves and high power, typically hundreds of kW. Present day knowledge is that very long waves propagate through the cavity between the earth and the ionosphere in a way analogous to acoustic pressure waves in a voice pipe; attenuation is therefore extremely low. Indeed, this cavity is now commonly known as the earth/ionosphere "waveguide".

Tesla had in effect visualised the earth/ionosphere waveguide when he conceived his system based on the rarified gases of the stratosphere being a good conductor of high frequency currents. The stratosphere would form the outer plate of a capacitor with the earth forming the inner plate.

The irony is that had Tesla used his sensitive syntonised receivers at a long distance from his transmitter, instead of relying on theoretical data, signals from his powerful Colorado

"magnifying transmitter" would almost certainly have been heard on this side of the Atlantic and possibly worldwide, despite what is now considered very inefficient coupling to the waveguide. Indeed, Tesla had announced that he intended to send signals to Paris. But as a result of Marconi's 1901 claim, financier Morgan withdrew his support and the project was abandoned.

Commercial transatlantic signalling became a reality in 1906 with the commissioning of Marconi's very long wave (45kHz) 200kW CW quenched-arc type transmitter at Clifden, Ireland; this introduced the era of national very long wave transoceanic super stations operating on frequencies down to 20kHz and which lasted until about 1925 when the Marconi company introduced short wave beam stations.

The German super station at Nauen, which was said to be the largest, had a range of more than 5000 miles with passive receivers and was employed before the First World War to maintain two-way communication with similar stations installed in German colonies in Africa and the Pacific.

George Pickworth
Kettering

National service

I would like to correct the information given by Terry Parrott (*Letters*, January) on RDS.

In his letter Mr Parrott challenges the statement that RDS is available throughout the UK, and in particular cites the Western Isles as an example of an area not served by the BBC RDS service. Mr Parrott is entirely mistaken in his belief; the BBC does offer a full service of basic RDS features across all areas on most services. The Western Isles, which admittedly were amongst the last to be equipped by the BBC, were completed in Summer 1990. The RDS signal is carried equally successfully by both mono and stereo transmitters.

As regards the switching of travel announcements, the BBC is certainly not lagging behind the continental stations. The system used by the BBC is unique and certainly far in

Active voice

I have read Brian Pollard's comments (*Letters*, January) on my article on active filters (*EW + WW*, October pp. 812-818).

I presume that the main purpose of his communication was to draw my attention to an error in quoted component values in Fig. 3 of my article, rather than to see how many terminological hairs could be split in seventeen column inches of your letters pages.

With regard to Fig. 3, in my own manuscript the capacitor in 3a was shown as 15n9, and in 3b, the two capacitors were 15n9 and 1n59 respectively (not 15µ9, 15µ9 and 1µ59 as appeared in the article as published). However in neither case would the response show a peak at 199Hz. If Mr Pollard feels the need to criticise inaccuracies I think that he should make sure that is own calculation are correct.

John Linsley Hood
Taunton

advance of that used anywhere else.

The travel announcement flag is, in the majority of cases, raised and lowered automatically from the travel jingle using a signalling system, and does not rely on manual operation of buttons.

In the few other countries which offer an RDS travel service (principally the countries which offered the earlier ARI system), the announcement start is usually signalled manually by a presenter pushing a button which generates an audible DTMF tone on the programme audio circuit to activate the transmitter equipment. In contrast the BBC uses inaudible signalling methods initiated automatically by the travel jingle and communicated via the RDS control computer to activate the travel announcement flag at the transmitter.

The BBC is still the only organisation to offer the full EON (enhanced other networks) RDS feature having implemented EON as far back as 1988. The feature makes the travel announcement available to

No sensation

I was naturally pleased to see that you have printed "Extra Terrestrial Relays" in your November issue. However, I must correct one statement in your introduction.

Far from creating a sensation, I don't recall any reaction whatsoever to the appearance of the piece. But at least there were no expressions of scepticism; the V2 and the atomic bomb had put an end to that (though I believe that on its original submission, some members of the editorial board objected to publishing science fiction!)

My forthcoming book, *How The World Was One* (Gollancz, Spring) which covers the whole history of telecommunications, has a section devoted to satellites, and reprints the article, as well as giving the background to its writing.

Arthur C Clarke CBE
Sri Lanka

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In response to Allan Jones' letter in the same issue, seeking information on decoding RDS, may I refer him to my colleague Simon Parnall's article in March 1989 *EW + WW*, and advise that kits of parts are still available from him, at the BBC Design Department, Avenue House, Chiswick, London.

Mark Saunders
BBC Radio
Radio Data System
London

Magnetometer astronomy

I was particularly happy to read the article by Richard Noble ("Fluxgate magnetometry," September 1991, pp. 726-732), touching on the mainstream of amateur astronomy.

But a following issue of *EW + WW* contained criticism of the Noble article (Letters, December, Arnold & Pickworth) some of it not very valid as I will show, especially regarding the Helmholtz formula.

First I wish to derive the formula for the Helmholtz configuration. Formula for a single coil can be found in any text-book of basics in electronics: the magnetic flux density, in Tesla, along the central axis of a thin, flat circular coil is shown in equation 1.

$$B = \mu \frac{NI}{2R} \sin^3 \alpha \quad 1$$

$$B_A = 4\pi \times 10^{-7} \frac{NI}{R} \sin^3 63.43 \quad 2$$

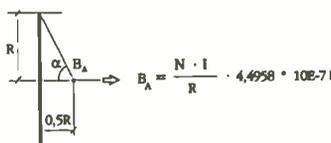


Fig. 1. Substituting to find the flux at BA.

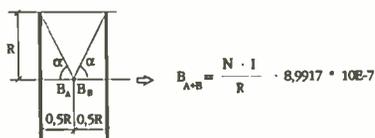


Fig. 2. Adding a second coil.

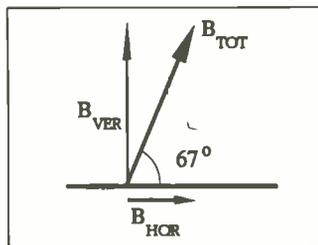


Fig. 3. Accounting for the horizontal factor.

This formula gives the value of the magnetic flux density on the axis at the centre of the Helmholtz configuration.

Just for the fun of it I have calculated the relative flux along the axis out to a distance of R on each side of the Helmholtz coils (Fig. 4).

Now why is there a discrepancy between the authors Noble, and Arnold & Pickworth? I can foresee some difficulties to be faced if one

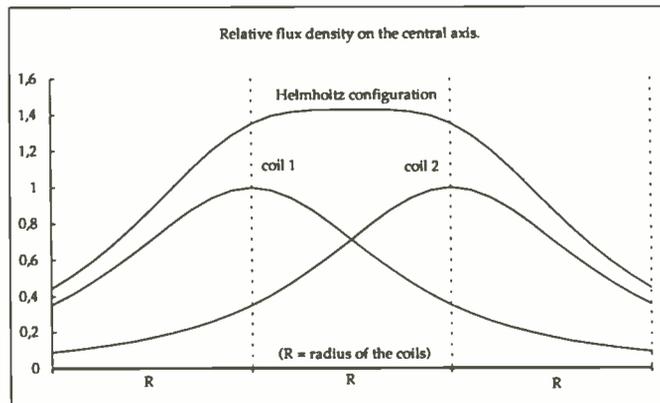


Fig. 4. Relative flux along the axis out to a distance R on each side of the Helmholtz coils.

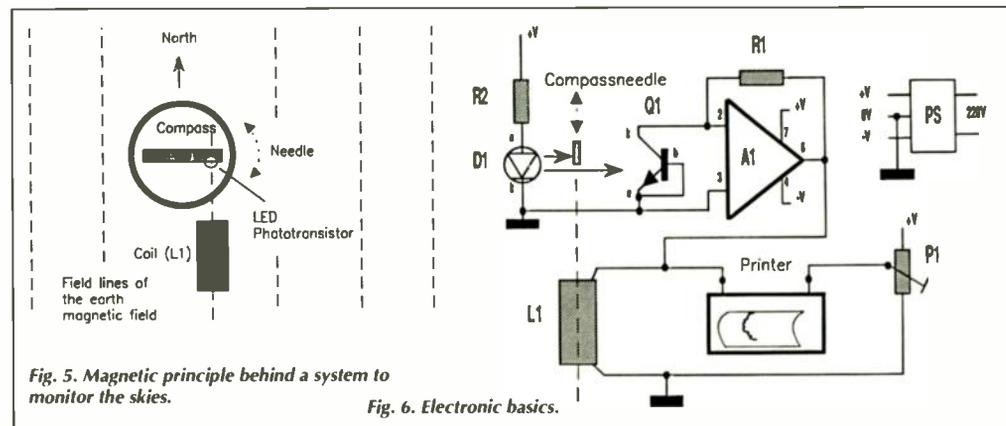


Fig. 5. Magnetic principle behind a system to monitor the skies.

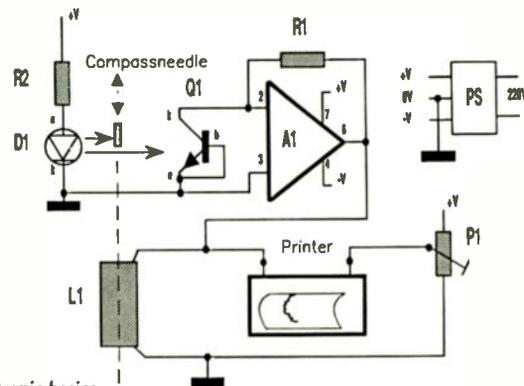


Fig. 6. Electronic basics.

$$= \frac{NI}{R \cdot 4.958 \times 10^{-7}} \quad 3$$

$$B_{A+B} = \frac{NI}{R} \cdot 8.9917 \times 10^{-7} \quad 4$$

where $\mu = 4\pi \times 10^{-7}$ Vs/Am (in air); I =current in Ampere; N =number of turns; R =radius of the coil in meters, and α =the angle from the point of interest on the axis to the coil circumference.

Suppose we want to calculate the flux at 0.5R distance along the axis, at the point BA. Substituting proper values, the flux at point BA is given in equation 2 (Fig. 1).

Now if we add another coil with the same parameters (N, I, R) parallel to the first coil and sharing the same magnetic axis as the first one, at a distance of R from the first one (Fig. 2), then the two fields add together and become a Helmholtz configuration, given in equation 4.

wants to achieve the full eight digits accuracy claimed by Arnold & Pickworth regarding their measured value of the magnetic field of the earth:

- 95% of the magnetic field of the earth is stable and 5% is influenced by the solar wind plasma. It has a diurnal as well as short term variation. (Where is this magnetically undisturbed place needed to make the measurements?).

- How well controlled are the physical dimensions of the Helmholtz coil?

- How accurate is the E-W orientation?

- How accurate is the north magnetic pole direction?

- Is the compass placed in the true middle of the coil?

- How accurate is the reading of the 45° deviation of the compass and the 6mA current in the coils.

- Without inclining the compass at a 67° angle to the horizontal to align it with the magnetic vector, the horizontal component only of the vector would be measured (Fig. 3): $B_{TOT} = 47 \mu T$ and $B_{HOR} = 47 \cdot \cos 67^\circ = 18.4 \mu T$.

Arnold & Pickworth due to this error missed the correct value by a factor of 2.5. Although they want to use a factor of 2.0 to fix the situation and put the blame on N (why not two coils!), 2.5 is never-the-less in the right order of magnitude of the error. One thing though still puzzles me: I can not guess from where the constant of 9.1 in the Noble article stems.

Watching the skies

Some years ago I designed a most simple and yet versatile magnetometer centred around an ordinary compass

The aim was to find the preconditions for watching auroras during dark skies. That is, to monitor

the magnetic activity, which has a direct coupling to events in the ionosphere.

I have used this magnetometer in a residential area for some time now and the accumulated experience has shown it to be a reliable aurora detector. If my pen-recorder displays steep signal gradients as well as large amplitude variations you can bet there is a great display in the sky (if you are lucky, that is, and it is an evening without full moon, with no clouds, no freezing temperatures etc) and you should go out and enjoy a spectacular event.

I enclose some schematics (Figs. 5 and 6) of the current design. The principle is simply to sense the position of the needle within a light beam and then amplify the signal to reposition the needle with a change of the current through the coil (L1). The global factor that shifts the position of the needle is the horizontal component of the magnetic field of the earth.

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CIRCLE NO. 127 ON REPLY CARD

Although quantification of the output signal is not so important in my case, it still was interesting to get a feel for the sensitivity by using the Helmholtz coils.

I estimate the present sensitivity to be about $250nTcm^{-1}$ written on the paper of the recorder (noise-level is about a few mm). It is easy to distinguish a magnetic event that is interesting from an auroral point of view.

Göte Flodqvist
Sweden

Scratching... a little more deeply

In his article "Scratching the surface of electromagnetism" (December and January) Dr Millar complains that: "It is difficult to tell what is going on in electromagnetic research without access to high-powered mathematics, in particular the methods of quantum electrodynamics." But this can be remedied by reading Professor Feynman's non-mathematical book *QED - the strange theory of light and matter* which outlines the general ideas in quantum electrodynamics.

The chapter "Electrons and their interactions", where Feynman explains that photons are emitted or absorbed whenever electrons change velocity or direction, would be particularly relevant.

A more advanced book on what has been going on in electromagnetic research is *Concepts in particle physics* by Gottfried and Weisskopf. As regards the proposition that the photon consists of a pair of complementary sub-particles which oscillate at the frequency of the radiation, that might well be true, in which case it should be possible to postulate the rules governing the formation, stability and dissolution of the composite particle.

The following ideas are put forward with that objective in mind.

Feynman explains (p.120) that according to QED, photons have four "polarisations" - X, Y, Z and T.

In photons that travel over long distances the Z and T polarisations cancel out, leaving only the more familiar X-Y polarisation.

But in electron-proton interactions in the atom it is the Z and T polarisations that matter most. What might this mean in terms of a two-sub-particle photon?

It is interesting to speculate that the sub-particles are, to a certain extent, independent, with individual frequencies and unconstrained phase relationship, and that in long-distance photons both sub-particles must have identical frequencies and oscillate 180° out of phase with each other.

Perhaps the sub-particles must never be in identical polarities of

Class conscious audio

I am grateful to W Groome for his excellent letter (*EW + WW*, January) which I hope will put life back into the class B Amplifier debate. His comments and description of the classification (class-BA) of my approach seems appropriate - apart from the obvious similarity with "your favourite airline's" name.

Prompted by him I looked back at the amplifier design by WO Richards in October *EW + WW* (pp. 860) and have some concerns about the audio amplifier's design.

In common with my earlier approach, the output transistors are fed with unidirectional signals from the two rectifier stages (IC₃ and IC₄) which should be a reasonable \pm split of the amplified version of the input audio signal.

However, as Mr Groome points out, Mr Richards' push-pull amplifier design uses capacitors (C_{3, 4, 5, 6}) to couple the output from these ideal op/amp rectifiers IC₃ and IC₄ to the power output transistor pairs. These coupling capacitors must integrate the asymmetrical audio drive current from the op/amp rectifiers, giving rise to large, delayed voltage changes at the input of both output circuits.

I suspect this accumulated charge on the capacitors will result in the output pairs not performing correctly or predictably as either a class A or class AB amplifier after any large input signal has been handled.

The second concern is more on the basic operation of the amplifier rather than the detail of the circuit.

I cannot see the reason, at the moment, for making the power output pair (T₁ and T₂ or T₃ and T₄) drive not only the load but also the other output transistor pairs when an audio drive signal is routed by the rectifier IC₃/IC₄ and visa versa.

This "double driving" of both the load and other output pair must cause large currents to flow from the positive to the negative power supply through the power transistors etc.

One could calculate the value of this current (or simulate with Spice if I had the time) to show it is directly related to the reactive impedance of the drive capacitors, the gain of the transistors, and the $47\Omega R_{18/19}$ resistors.

The combination of these two problems suggest the design needs to be reconfigured if a predictable high performance amplifier is the final goal.

However, given these reservations about this "Class A" push-pull amplifier design, the outline approach is indeed similar, as suggested by Mr Groome, to my Class B proposal published at the beginning of time, back in 1971.

Finally, I must thank Mr Richards for publication of the circuit as it has been beneficial not only to me - it has set me thinking once again about class B power amplifiers - but also, I hope, raises interest in novel analogue design techniques, pushing engineers to try new ideas with the hope that one may become a winner.

Peter Blomley
Bishops Stortford
Herts

oscillation - when one passes through the positive half-cycle then its partner must pass through the negative half-cycle and vice versa. This would require that in long-distance photons the frequencies be identical and phased at 180° .

But in short-range travel, over distances less than one wavelength, the "never in the same polarity" requirement could be met with sub-particles that don't have the same frequency, or where the frequencies are identical but phasing is not 180° .

That would explain why Z and T "polarisations" (in reality data concerning sub-particle phasing) are important in short-range interactions.

What would happen if the two sub-particles did enter the same polarity? Could the sub-particle phasors reverse direction of rotation and the composite particle change direction of propagation whenever this

happens, the "imperfect photon" thus moving back and forth at the velocity of light and becoming part of a medium that could transport electric currents and electromagnetic energy generally?

Could two imperfect photons swap two of their four sub-particles, such a process continuing until a perfect photon forms and joins outgoing radiation? If so, then the atom might well be the principal site where the photon's sub-particles become correctly equalised and aligned in energy exchanges before long-range emission can take place.

The earliest form of quantum mechanics (matrix mechanics), developed by Heisenberg in attempts to impose order upon previously amassed spectral data concerning the emission and absorption of radiation, is based on certain "energy tables" the use of which cannot be related to

any classically understandable physical model.

In his original paper Heisenberg explicitly abandons all faith in the "solar system" model of the atom and goes on to develop a purely mathematical scheme. On the hypothesis that the photon consists of a pair of semi-independent sub-particles, the energy table scheme would undoubtedly have to cope with sub-particle rearrangement possibilities.

The picture of quantum electrodynamic processes outlined by Feynman suggests that the course taken by the two-sub-particle photon would be guided by probability waves - a concept that has been criticised by a number of the founders of quantum mechanics and their successors.

Professor Dirac, the British pioneer of quantum mechanics and electrodynamics, expressed the opinion (in *Directions in physics*, pp. 9 and 10) that there is a fundamental error in our world-view that we have always accepted without question something that appears to be self-evidently true but is in fact false. Consequently we are unable satisfactorily to relate quantum mechanics to our common sense expectations.

My personal view is that contrary to what common sense tells us, human consciousness is not continuous. It makes more sense if it is assumed that consciousness is discontinuous, cinematographic, and that the "probability waves" that guide particle interactions are of the same kind and could therefore be better described as "consciousness waves".

G Berzins
Camberley Surrey

Cad add on

I read with great interest the electronics cad "Buyers Market" by Steve Rogerson in January *EW + WW* and thought your readers would be interested in two of our products, Sauna and Active, which were not included in the product summary. Sauna is a low-cost 3-D thermal analysis program aimed at non-heat transfer specialists. Sister program, Sauna MS is aimed more at experienced users.

Active is an active filter synthesis program which supports Monte Carlo tolerance testing. It has a built-in (but user accessible) library of standard tolerance components and will find the best fit standard values to achieve nominated performance.

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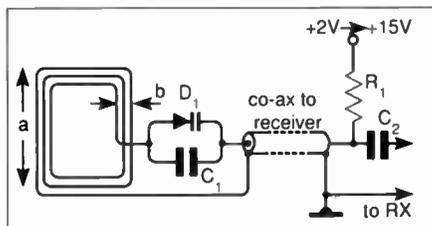
Resonant-loop antenna for medium waves

Resonant-loop antennas¹⁻³ are not quite as simple as they may appear. Induced voltage increases as the number of turns multiplied by loop area, while inductance varies as n^2 , depending in a complex way on dimensions and winding method. Self capacitance and Q also must be considered.

Inductance is given by Sommerfeld⁴ as approximately $L = (2\mu_0 N^2 / \pi) \ln(16a/b)$, where $\mu_0 = 4\pi \times 10^{-7}$, a and b being shown in the diagram, which gives only three turns; normally there are more. Turns are spaced either in a flat coil as shown in the diagram or along the loop axis, spaced a distance $b/(N-1)$ from each other and not much more than the wire diameter.

Capacitor C_1 and the tuning diode D_1 resonate the loop and the coax, should match the receiver input impedance, which is usually 75Ω . Q will be less than $\omega L/R_0$, since the effective series resistance of the loop should be less than R_0 . Make L high enough to give a sufficient Q for the selectivity needed, but not high enough to reduce C_1 to a very small value.

A rigorous test for the design is the reception in London of the 567kHz Dublin station RTE1 in the presence of a strong local transmission on 558kHz. To use a tuning capacitance of 200pF, a loop inductance of $400\mu\text{H}$ is needed, which gives a Q of 20. With $a = 1\text{m}$ and a 50mm spacing, the above expression gives $N = 10$. This was correct with 20SWG wire, the loop resonating at



Resonant-loop antenna provides gain and interference rejection at medium-wave frequencies.

567kHz with 230pF, so C_1 is 210pF and the MV1634 diode then operates somewhere near the middle of its 15-30pF range; bias voltage for the diode comes from the receiver via R_1 .

Reception of Dublin was excellent with the loop in the roof space, at S9 instead of S4 with a long wire, and interference was negligible.

T H O'Dell
London W2

References

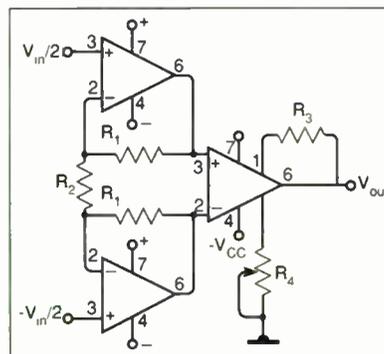
1. Marris R. The mini-loop antenna, *Radio and Electronics World*, Nov. 1986, pp42-3.
2. Millmore GW. The long-arm loop, *Short Wave Magazine*, Vol. 45, No 6, Sept. 1987, p.21.
3. Ratcliffe J. A hexagonal loop antenna, *Short Wave Magazine*, Vol. 47, No 4, April 1989, pp28-9.
4. Sommerfeld A, *Electrodynamics*, Academic Press, New York, 1952, p.111.

Feedback for lower amplifier noise

Feedback to the input of an op-amp is known to affect adversely its noise performance. In the instrumentation amplifier shown, feedback goes to the offset trimming pins rather than to the input of the difference amplifier.

Voltage gain is then $(1+2R_1/R_2)k/R_4$, the value of R_4 being in $k\Omega$. Constant k lies between $2.5k\Omega$ and $5k\Omega$, depending on the type of op-amp, and should be determined by experiment.

Kamil Kraus
Roykany Czechoslovakia



Taking feedback to trimmer points instead of input terminals preserves noise performance of the differential amp. in this instrumentation amplifier.

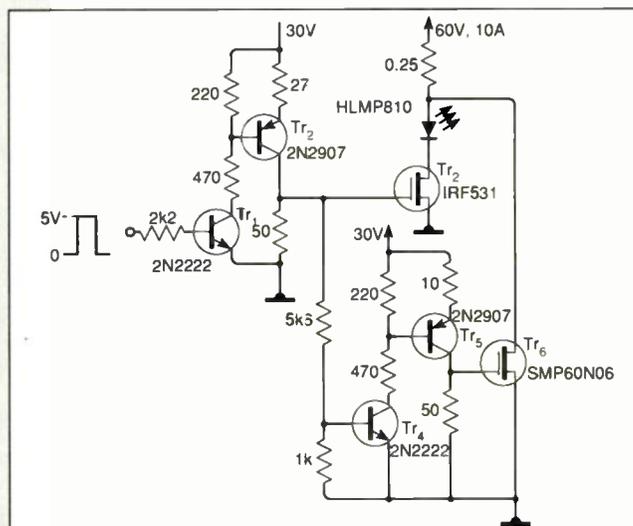
Pulsed light source

If coherence and purity of spectrum are not important in the application, this led source is capable of replacing a laser. The amplifier formed by transistors $Tr_{1,2,3}$ accepts an input from a pulse generator and turns on the HLMP8104 led. After a short delay, determined by the rise time of current in Tr_5 , Tr_6 conducts and diverts current from the led – a method of turn-off that improves noise performance.

A current of up to 10A flows in the led, at a duty cycle of less than 10^{-4} , for pulse times of 100ns to 500ns. The led was chosen for its low response time, even when overdriven. Peak light intensity is several W/cm^2 , equivalent to about $1\mu\text{J}$. After up to 2×10^6 pulses at this level, light intensity reduces to about half the starting value.

Luigi Schirone
Università "La Sapienza"
Rome
Italy

Simple led source can produce $1\mu\text{J}$ pulses of light and will replace a laser in measurements where coherence is not needed.



85mA op-amp output

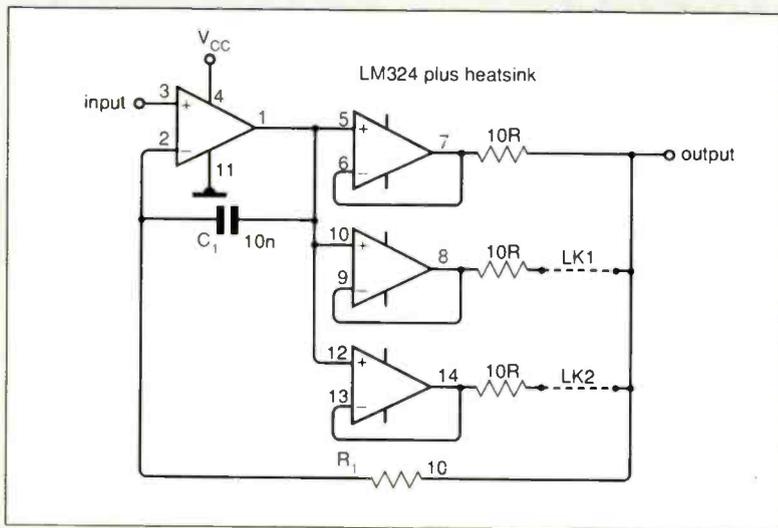
Output current from op-amps is commonly between 20 and 40mA. In this LM324 quad op-amp circuit, a parallel connection of three amplifiers gives up to 85mA and retains short-circuit protection.

This is a unity-gain circuit providing a bandwidth of 200kHz, R_1 and C_1 taking care of loop stability. Current-sharing resistors of 10Ω avoid the effect of inherent differing input offsets, which would otherwise cause different output

currents from each op-amp. For long-term, high output current, a bonded heat sink will probably be needed.

A M Wilkes
Brentwood
Essex

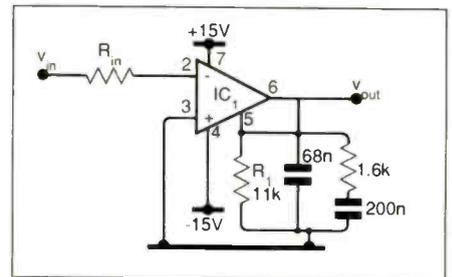
This parallel connection of the op-amps in one package will give up to 85mA output current. Bandwidth of this circuit is 200kHz at unity gain.



RIAA amplifier uses current feedback op-amp

In a current feedback op-amp such as the Analog Devices AD844 with access to the buffer, the active devices to make an RIAA amplifier are in one package.

An RIAA network on the input to the



AD844 transconductance amplifier/unity-gain buffer combination enables this simple realisation of an RIAA amplifier.

buffer, which is a unity-gain stage, effects the required equalisation. Input impedance is equal to R_{in} , since the inverting input is at low impedance without the assistance of external feedback, and DC gain is $A_v = R_1/R_{in}$. Slew-rate limitation is not a problem with the AD844, rise and fall times of the output being almost independent of the amplitude.

A point to watch is that maximum current through R_1 is around 10mA, which must be borne in mind when setting gain and overload margin. Decoupling components should be close to the pins.

Richard Heycock
Beverly
North Humberide

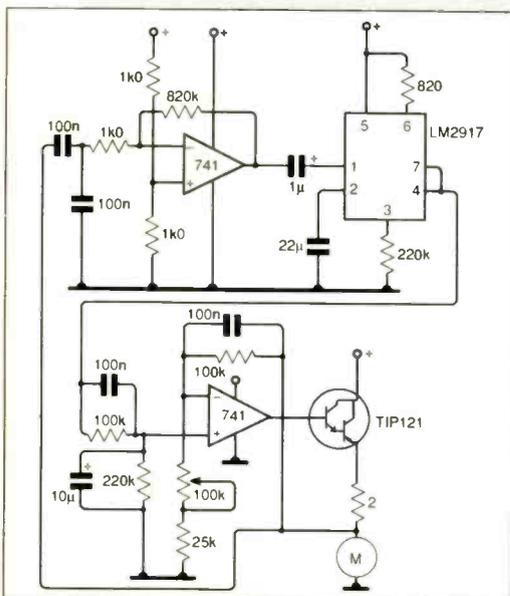
Constant-speed motor drive

Making a virtue of necessity, commutator noise from the motor is used in place of the usual shaft-speed sensor in this design.

Noise signal is taken from the motor to the 741 amplifier, which has a voltage gain of 820. This drives the LM2917 tachometer chip, whose output is buffered by the second 741 before going to the TIP121 motor drive darlington. Speed control is by the 100kΩ potentiometer on the motor buffer.

Andy Bartram
University of Exeter

Using commutator noise as feedback in this constant-speed motor drive circuit avoids need for shaft-speed sensor.



FRESH IDEAS

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Voltage-tolerant temperature probe

In the presence of reverse voltages up to 44V, this circuit is an improvement on the common type using only the Analog Devices AD590F temperature sensor, which can tolerate up to 20V reverse voltage.

Figure 1 shows the arrangement, which uses a bridge rectifier to allow the sensor to conduct for either polarity of power source

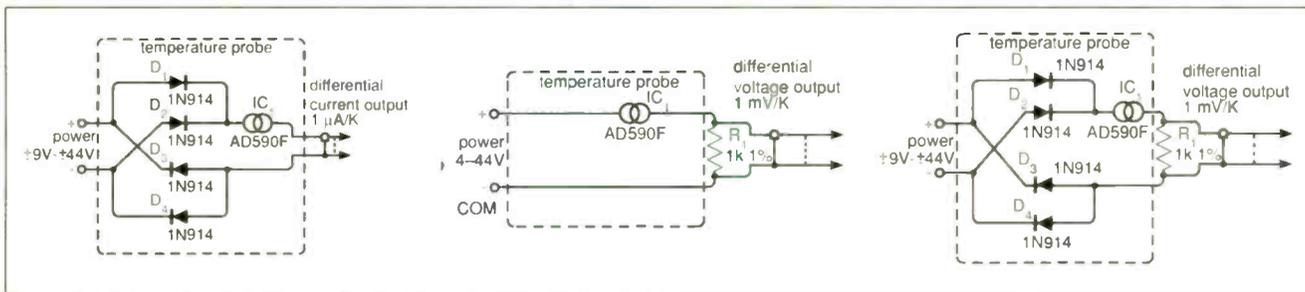
and which protects the AD590F in the event of a change in polarity. Output is either current ($1\mu\text{A}/\text{K}$) or voltage ($1\text{mV}/\text{K}$), depending on the presence or absence of the resistor R_1 .

Miss Railesha
Tamilnadu
India

Fig. 1. Addition of bridge rectifier to AD590F temperature sensor allows use of up to 44V positive or negative supplies without danger to the sensor.

Fig. 2. Standard AD590F tolerates only up to 20V reverse voltage.

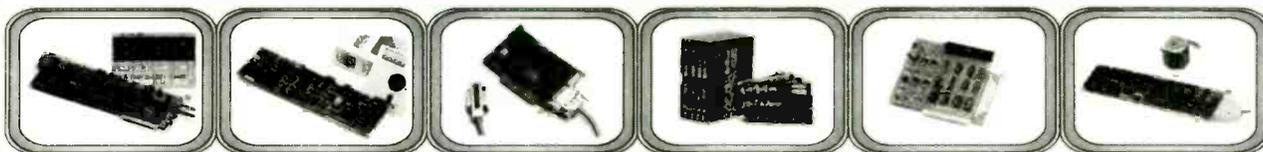
Fig. 3. Bridge rectifier circuit with voltage output



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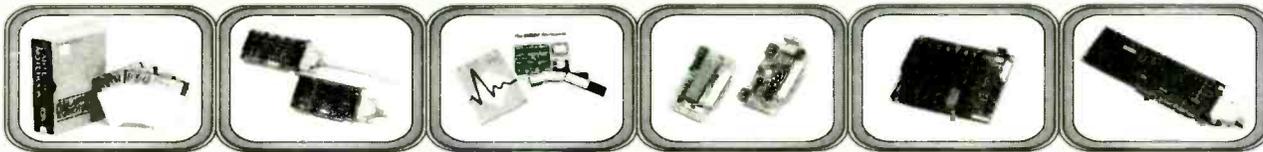
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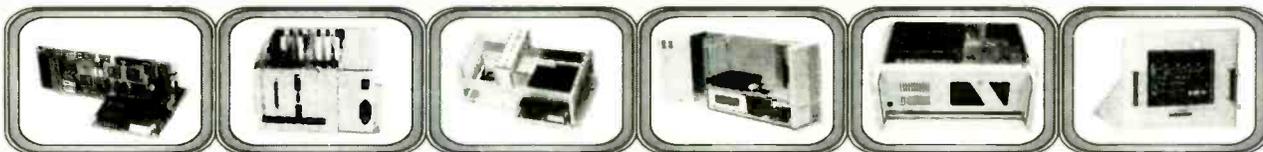
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B.K. ELECTRONICS are offering the readers of *Electronics World* the choice of five quality HAMEG dual trace oscilloscopes, plus a graphic printer with a 5% special discount off of the list prices, including free delivery within the U.K. Overseas readers should contact us for an individual quotation for air mail delivery. All oscilloscopes are supplied with two probes, a very comprehensive Operator's Manual and a two year warranty, including parts and labour, carried out by Hameg (UK) Ltd in there extensive calibration and repair laboratory.

WHY CHOOSE HAMEG?

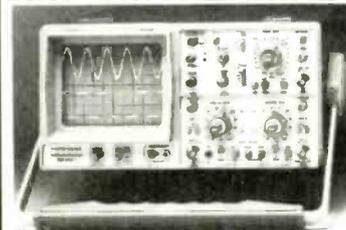
For more than 30 years, Hameg has been engaged in the manufacture of oscilloscopes in West Germany. With a broad range of successful instruments, Hameg is known throughout the world as a supplier of attractively priced oscilloscopes based on innovative technology that continues to set new standards of quality and performance. An outstanding example of this is the new generation of digital storage oscilloscopes which has enabled tens of thousands of users to enter the world of digital storage technology for the first time. The price/performance attributes of Hameg's analogue oscilloscopes continue to be second to none on the international market. The recently introduced HM1005 is proof, once again, that high performance oscilloscopes need not be expensive. This also explains why Hameg today sells more oscilloscopes in Europe than any other manufacturer of test equipment.

All models incorporate a clear, 8 x 10cm display and are of a compact size - 285 x 145 x 380mm.
Mains Supply - 110/220,240V AC, 50/60Hz

ANALOGUE

DIGITAL-ANALOGUE

HM 203-7 20MHz STANDARD



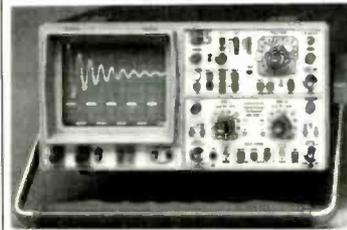
SPECIFICATION

- ★ 2 Channels
- ★ Bandwidth: DC - 20MHz
- ★ Sens: Ch. 1, Ch. 2, 1mV/cm
- ★ Timebase: 0.1s - 20ns/cm
- ★ Triggering: DC - 40MHz
- ★ Active TV - Sync - Separator
- ★ Variable hold-off
- ★ Trigger LED indicator
- ★ Calibrator: 1KHz Square wave
- ★ Component tester
- ★ Plus many more features

The HM203-7 is Western Europe's best selling oscilloscope because it responds thoroughly to customer demands for **reliability, superior performance** and **ease of operation**.

PRICE £321.00 + £56.18 V.A.T.
FREE DELIVERY

HM 205-3 20MHz DIGITAL STORAGE



SPECIFICATION

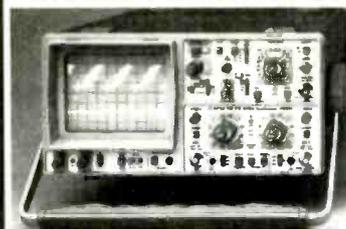
- ★ 2 Channels
- ★ Digital storage (and analogue)
- ★ Analogue real time (as 203-7)
- ★ Bandwidth storage: DC - 2MHz
- ★ Sens: Ch. 1, Ch. 2, 1mV/cm
- ★ Timebase Analogue: 1s - 20ns/cm
- ★ Timebase Digital: 5s - 1µs/cm
- ★ Triggering: DC - 40MHz
- ★ Active TV - Sync - Sampling
- ★ Max sampling rate: 2 x 20MHz
- ★ Memory: 2 x 2048 x 8 Bit
- ★ Dot joiner
- ★ Component tester
- ★ Printer/plotter output

FREE DELIVERY

Now with a maximum sampling rate of 20MHz and an improved storage depth of 2048 x 8 bits per channel, the new HM205-3 has achieved a truly unique standard of performance. The HM205-3 is Europe's best selling digital storage oscilloscope.

PRICE £579.00 + £101.33 V.A.T.

HM 604 60MHz UNIVERSAL



SPECIFICATION

- ★ 2 Channels
- ★ Bandwidth: DC - 60MHz
- ★ Sens: Ch. 1, Ch. 2, 1mV/cm
- ★ Timebase: 2.5s - 5ns/cm
- ★ Triggering: DC - 80MHz
- ★ Active TV - Sync - Separator
- ★ After delay trigger
- ★ Sweep delay
- ★ Delay line
- ★ Trigger LED indicator
- ★ Calibrator: 1KHz & 1MHz Sq. Wave
- ★ Component tester

With its variety of operating and trigger modes, the HM604 is a new innovative general purpose oscilloscope satisfying a wide range of exacting requirements in laboratory, education, production and service.

PRICE £579.00 + £101.33 V.A.T.
FREE DELIVERY

HM 408 40MHz DIGITAL STORAGE



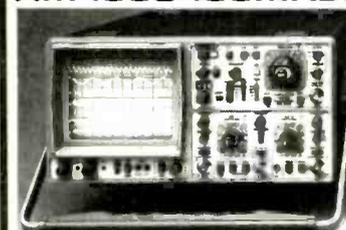
SPECIFICATION

- ★ 2 Channels
- ★ Digital storage (and analogue)
- ★ Timebase analogue: 1s - 5ns/cm
- ★ Timebase digital: 50s - 0.1µs/cm
- ★ Sens: Ch. 1, Ch. 2, 1mV/cm
- ★ Bandwidth analogue DC - 40MHz
- ★ Bandwidth storage DC - 2MHz
- ★ Max sampling rate: 40MHz
- ★ Max storage capacity 4096 x 8 Bit
- ★ Dot joiner
- ★ Active TV - Sync - Separator
- ★ Printer/plotter output

With the introduction of the HM408 dual channel digital storage oscilloscope, Hameg is once again setting an unprecedented standard for highest performance at lowest cost. The user friendly design combines easy and convenient operation with a wide variety of analogue and digital functions.

PRICE £1423.00 + £249.00 V.A.T.
FREE DELIVERY

HM 1005 100MHz MULTI-FUNCTION



SPECIFICATION

- ★ 3 Channels with up to 6 traces
- ★ Bandwidth: DC - 100MHz
- ★ Sens: Ch. 1, Ch. 2, Ch. 3 1mV/cm
- ★ Timebase A: 2.5s - 5ns/cm
- ★ Timebase B: 0.2s - 5ns/cm
- ★ Triggering DC - 130MHz
- ★ After delay trigger
- ★ Delay line
- ★ Trigger LED indicator
- ★ Overscan LED indicator
- ★ Active TV - Sync - Separator
- ★ Calibrator: 1KHz & 1MHz Sq. wave

The HM1005 is a multi-function oscilloscope loaded with features such as true 3 channel operation, a genuine second time base, and even a separate second trigger facility. Up to 6 traces can be displayed for evaluating waveform relationships.

PRICE £752.00 + £131.60 V.A.T.
FREE DELIVERY

HM 8148-2 GRAPHIC PRINTER



SPECIFICATION

- ★ Non-impact printer
- ★ < 20 seconds for hard copy
- ★ Resolution > 11 dots/mm
- ★ Built-in real time clock
- ★ Zooming 2x to 10x
- ★ Built-in help menu
- ★ Same size as oscilloscope, which sits neatly on top.

Hameg's versatile HM8148-2 Graphic Printer meets the expanding need in the world of electronics for producing fast and accurate documentation of measurement data. With both Hameg digital storage oscilloscopes (HM205-3 and HM408), the existing Hameg bus transfers stored waveform data to hard copy output.

PRICE £752.00 + £131.60 V.A.T.
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CIRCLE NO. 132 ON REPLY CARD

ACTIVE

A-to-D & D-to-A converters

21-bit signal-conditioning A-to-Ds. Transducers such as strain gauges, thermocouples and other low-level devices can be coupled directly to the AD771X family of A-to-D converters, which offer no-missing-code conversion, $\pm 0.0015\%$ non-linearity and an amplifier whose gain is software programmable from unity to 128. Mains-frequency rejection is 100dB minimum; there is digital low-pass filtering with software-programmable cut-off; and calibration factors written by the user if beyond the device's self-calibration. Analog Devices, 0932 232222.

18-bit audio data converter. A dual-output D-to-A converter from Burr-Brown, the PCM67, is meant for portable and car audio application. Its design eliminates low-level distortion without recourse to expensive one-bit conversion, although it is a combination of more conventional and one-bit types. Dynamic range is 108dB. THD+noise is 46dB down at -60dB of full scale and level linearity is ± 1 dB at -90dB signal level. Only a single clock signal is needed. Burr-Brown International Ltd, 0923 33837.

Fast A-to-D converters. ADC08231/4/8 analogue-to-digital converters available from Jermyn (0732 740100) are 8-bit serial i/o types which convert in 2 μ s and dissipate only 20mW. The devices are compatible with the earlier ADC0831/4/8, but with increased speed. They need a single 5V supply. National Semiconductor 0793 614141

Discrete active devices

Low-current RF transistors. BFT25A and BFG25A/X wide-band RF transistors are meant to operate at collector currents of 0.3mA-0.5mA, while retaining gains of more than 18dB at 1GHz. At 1mA collector current, noise figure at 1GHz is less than 2dB and transition frequency is greater than 6GHz. Philips Semiconductors Ltd, 071 580 6633

Digital signal processor

Programmable filter processor. M27HC68PFP is an integrated filter processor by SGS/Thomson for

working up to 40MHz with an 8-bit data signal. It uses an integral eeprom to store look-up tables of products for the required filter, thereby avoiding the need for multipliers. There are 59 taps, which enable the designer to implement a large number of filter types, including finite impulse response designs. With more chips, greater precision or multi-dimensional filtering can be obtained. A PC-based programming system is available. Impulse Electronics Ltd, 0883 346433

Linear integrated circuits

Digital sound generator. With on-chip digital data processing and D-to-A conversion, the ICS1399 from ICS is flexible and powerful. It has 25 independent voices to allow polyphonic sounds of a multi-timbral quality to be generated with no voice priorities or the the complicated software needed in some popular sound chips. Built-in filters reduce the number of external components and wave-table interpolation reduces memory requirement by nearly 40%. Amegh Electronics Ltd, 0256 843166

Voltage-controlled amplifier. With a THD of 0.025% at a gain of ± 20 dB from 20Hz to 20kHz and a dynamic range of 118dB, the SSM-2018 is meant chiefly for use in professional audio gain control of mixers, processors, compressors etc. Slew rate is 10V/ μ s, input noise 14nV/Hz and GB product 12MHz. The device's gain stage is programmable to either Class-A or Class-AB operation in a trade-off between low distortion and good S:N ratio, although it is pointed out that THD varies only slightly between the two modes. Analog Devices, 0932 232222.

Active filter. A universal active-filter IC, the UAF42, is configurable in low-pass, high-pass, band-pass and band-stop forms. It contains an inverting amplifier and two integrators, trimmed to provide $\pm 1\%$ frequency accuracy and 2% Q determination. Frequency range is 0-100kHz, slewing 10V/ μ s and G/B product 4MHz. Maximum Q is 400, noise density 10nV/Hz and THD 0.0004%. A DOS-compatible program is provided for Butterworth, Bessel, Tchebyshev and inverse Tchebyshev filter design. Burr-Brown International Ltd, 0923 33837.

Video processing. Encoders, line stores, decoders and programmable shift registers are all included in a range of video processing chips from Hakuto. The ICs work in original colour

or Y colour difference modes to NTSC and PAL and there is a decoder for Secam. Input colour difference chips give RGB outputs to NTSC and PAL. Digital line memory is in 8-bit or 10-bit format up to 40MHz and a 1-Mbit three-port video memory is available. Hakuto International (UK) Ltd, 0992 769090.

Better HF op-amps. Dielectric isolation is a process used by Harris to improve the performance of op-amps for video and pulse work. HA2841 is a 54MHz device with 11mA supply current, 3ns risetime, 1mV offset 90ns settling time, 200V/ μ s slewing, 0.03% differential gain and 0.03% diff. phase. HA2842 differs in having 325V/ μ s slewing, 80MHz g/b product 100mA output and 15mA supply current, avoiding the need for an output buffer. Harris Semiconductor (UK), 0276 686886.

Nicam chip set. This three-chip set from Philips provides all functions needed for Nicam728 stereo television sound reception. TD1543 is a dual D-to-A converter, intended originally for CD players and is driven by the other two purpose-designed chips. TDA8732 and SAA7280. The first of these is a DQPSK demodulator containing a carrier-phase recovery PLL, a bit-rate clock-recovery PLL and a differential decoder. SAA7280 performs all decoding for the system. Gothic Crellon (0734 788878) supply the chip set. Philips Components, 071-580 6633.

Analogue filter for sigma delta. Toshiba's TA2009F two-channel analogue filter is meant to reduce the number of components in D-to-A converters for digital audio equipment. It is well suited for use with the TC9237F sigma-delta D-to-A converter with on-chip digital filtering. The device provides low-pass filtering and has two differential amplifiers for L and R channels. Noise distortion factor is -93dB, S:N ratio 100dB and L/R matching is within 0.5dB. Toshiba Electronics (UK) Ltd, 0276 694600.

Logic building blocks

Faster gate array. A gate array family from Hitachi, the HG62G series, offers better i/o and improved pin:gate ratio over earlier devices and supports designs with on-chip ram and Autodiagnosis. There are four devices in 0.8micron cmos with gate counts of 14000 to 35000. I/o buffer delays are 0.8ns for inputs and 1.8ns into 50pF at the outputs. Hitachi Europe Ltd, 0628 585000.



Programmable filter processor from SGS Thomson samples at 40MHz.

Memory chips

Non-volatile srams. First in a family of silicon-nitride on silicon (snos) memory products from GEC Plessey are P10C68 and P11C68, non-volatile static rams, which combine cmos and snos techniques to achieve access times of 35ns or 45ns — claimed to be faster than any other nvrams. Density is 64K (8K by 8K) and data retention is one year at 10K endurance cycles. Each static ram cell has a non-volatile eeprom, which holds independent nv data while the sram is being read or written to. Data is shuffled between the two by pin toggling or by software. GEC Plessey Semiconductors, 0793 518000.

Fast 1M sram. 1Mbit cmos srams with access times of 20ns and organised 4bit wide, μ PD431004LE from NEC is for use in cache memories and other high-speed systems. The devices are pin-compatible with earlier 256K rams and offer not only higher speed, but power consumptions down to 150mA active and 2mA on standby. Available from Impulse Electronics (0883 346433). NEC Electronics (UK) Ltd, 0908 691133.

Microprocessors and controllers

16-bit micros. New single-chip microcomputers from Hitachi, the H8 family, exhibit wide range of built-in features, in particular 16K rom/eprom, 512B ram and 46 i/o pins. Either four or eight channels of A-to-D conversion are incorporated, having a resolution of 10bit and conversion time of 132 μ s. Architecture is based on eight multi-purpose accumulator/address registers, an approach which allows compilers to be written for high-level languages such as C. Hitachi Europe Ltd, 0628 585000

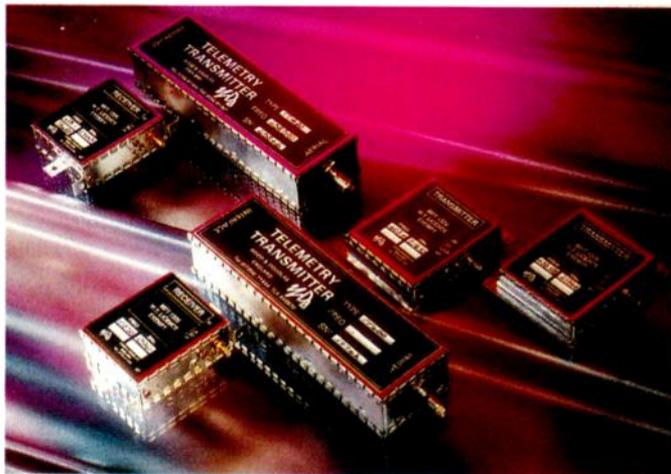
Risc microcontroller. With a CPU several times faster than that of many other devices and a range of high-level i/o and other peripherals, Microchip's PIC17C42 8-bit microcontroller is meant chiefly for real-time embedded-control use. Its 16-bit, single-cycle instruction and 8-bit data word risc architecture extend the Harvard architecture used in the company's PIC16 family. There is 2K by 16 eprom, 223 by 8 general-purpose registers and 48 special registers in sram. Microchip Technology Ltd, 0628 850303

Risc microprocessor. In addition to the functions of the Motorola 88100 RISC processor, 88200 cache and memory management unit, the company's new chip, the 88110, adds 3D graphics and extended floating-point capability all on one chip. It is binary software-compatible with the multi-chip combination but is three to five times as fast. Superscalar architecture where many execution units work in parallel is used instead of superpipelining, which needs fatter pipelines and faster clocking to increase speed and power. Motorola Ltd, 0908 614614.

Mixed-signal ICs.

Power factor correction. Micro Linear's ML4812 is a power factor correction IC is meant for use in DC supplies for computer systems, which have a tendency to trip breakers by the high charging currents of the input capacitor. This device provides a PF of better than 0.99, using waveform synthesis to make the input current waveform track the phase and shape of the input voltage after the bridge rectifier. Since the chip supplies the voltage needed by the modulator from anything between 90V and 265V, no switching is needed for 110V or 220V working. Ambar Components Ltd, 0844 261144.

Video encoder. On one chip, the Brooktree Bt858 video encoder allows the graphics output of workstations and PCs to be seen on low-cost composite-video monitors or videotaped in all popular formats to studio quality. Users can download



Series 400 low-cost telemetry modules from Wood and Douglas: two transmitters and a receiver

video presentations to video in NTSC or PAL; no clock frequencies or crystals need to be changed for either system. The encoder accepts RGB or YCrCb. Clock frequencies are variable, so that rectangular television pixels become square for computer-generated images to eliminate distortion. Brooktree Ltd, 0844 261989

Video converter. CXA1228S is an IC decoder for the conversion of composite video to colour difference for television and video recorders working in either NTSC or PAL. Video signals are separated into Y and C by filters, a trap and delay line and then taken to the CXA1228S, which produces R-Y, B-Y, Y, composite sync., subcarrier, line alternate and burst flags, auto colour control, colour killer and phase control. Hakuto International (UK) Ltd, 0992 769090.

Low-pass filters. MAX 270 is a dual, second-order low-pass Tchebyshev filter, each half of which can be separately programmed by strapping or under microprocessor control. Each filter has two sets of programmable capacitors controlled by a 7-bit memory to set the cut-offs between 1kHz and 25kHz. Ripple in the passband is better than 0.15dB and noise is between 12 μ V RMS at 1kHz and 38 μ V RMS at 25kHz. There is also an uncommitted op-amp and power shut-down for 15 μ A idle current. Maxim Integrated Products Ltd, 0734 845255.

Video switch IC. CXA1450M is an accurate, wideband switch for video and CXA1451M is the same, but with two 75 Ω drivers to give two outputs with the same voltage gain. Both are meant for use in video recorders. The 1450 works up to 30MHz to give one output from one of two inputs. Crosstalk is, typically, less than -55dB at 10MHz and 1Vpk-pk; input offset less than 10mV. 1451 operates at up to 25MHz.

Optical devices

Multi-spectral led. CMS104 is composed of three leds, emitting blue, red and green light, mounted on one substrate with their light mixed and dispersed through a translucent lens. The leds are driven separately, so that the emitted light can be set to any wavelength in the entire visible range, its brightness being adjustable by current in the usual way. The manufacturer is the German company Elcos (010 498 441 4044). Flint Distribution Ltd, 0530 510333

Power semiconductors

DC-to-DC converter. With the addition of a surface-mount inductor, a diode and a capacitor, the LT1109 chip forms a complete 5V or 12V step-up converter from 3V or 5V. At 12V, output current is 60mA and a shut-down pin allows reduction of supply current to 320 μ A. Packages are 8-pin dip, SO-8 surface-mount and TO-92, the latter without the shut-down. A high-frequency oscillator means small reactive components. Linear Technology (UK) Ltd 0932 765688.

Microwave power transistor. In the common-base, Class-C stages of medium-power transmitters, Philips's PLB16030U transistor meets the cost requirement of equipment such as the location and comms system now being developed in the USA and Europe. Power gain is 8.2dB and it delivers 30W of output power at 1.6GHz; collector efficiency is 52%, which helps with the design of mobile equipment. Philips Components Ltd, 01-580 6633

UHF TV transistor. Philips's BLV62 linear UHF TV transistor delivers 150W between 470MHz and 860MHz, working in Class-AB. Gain is 8.5dB minimum and output capacitance is less than 1pF/W per side. Two n-p-n silicon epitaxial transistors in push-pull

are internally matched and provided with polysilicon emitter-ballast resistors for temperature stability. Maximum DC collector current is 12.5A. Philips Semiconductors Ltd, 071 580 6633

2W mosfets. Complementary surface-mount mosfets, the n-channel ZVN2106G and the p-channel ZVP2106G from Zetex, have a 60V breakdown and will handle 2W. For pulses, they can take 8A and 4A respectively, or 0.7A and 0.45A continuously. Gate/source threshold of the ZVN is 2.4V, with static ON resistance of 2 Ω and maximum input C of 60pF to give rise and fall of 5ns and 10ns. The ZVP figures are 3.5V, 5 Ω , 100pF and 15ns. Zetex plc, 061 627 4963.

PASSIVE

Passive networks. Networks consisting of resistors and/or capacitors to an accuracy of 0.5% for the resistors in the range 100 Ω to 2.2M Ω and a temperature coefficient of \pm 100ppm are announced by AVX. Ladder networks are meant for data conversion and exhibit bit errors of \pm 0.5LSB maximum, while the RC type, using thick-film R and ceramic C give pull-up and filtering for interfacing between logic families. A further RC type contains twin-T filters at 9kHz and 10kHz for radio or at 50Hz and 60Hz for hum elimination. Custom design is available. AVX Ltd, 0252 336868.

Inductor cores. Soft iron and nylon in combination form a material from which inductor cores can be injection moulded, rather than pressed. The material is of low loss and possesses a distributed air gap as part of the moulding. Multiple inductor arrays (MIAs) can be wound by hand with confidence that production runs will replicate their performance. Automatic Windings, 0202 826888

Crossover electrolytics. Bipolar electrolytics from Nichicon are designed for audio crossover networks. Capacitance is in the range 1-60 μ F at \pm 10% and \pm 20% tolerance. Leakage current is a maximum of 3 μ A and ripple current is 1200mA and 1120mA for the DB and GB types. Working voltage is 50V DC maximum. Nichicon (Europe) Ltd, 0276 685393.

Ferrite material. Permeability of 6500-7000 is claimed for Siemens's T37 ferrite, intended for frequencies up to 200kHz. Typical application is to be found in toroidal chokes for RFI suppression. Other materials in the range are T35 (400kHz/6500) and T38 (100kHz/10000). Siemens, 0932 752682.

Instrumentation

Multimeters. Two digital multimeters, DT-870 and DT-8045, together cover the needs of both field and workshop technicians. DT-870 is a handheld instrument, a 3 3/4-digit autoranging type for alternating and direct voltage and current and resistance, which also has a bar-graph display. DT-8045 has a 4 1/2-digit display, 0.3% maximum error and a true-RMS facility. ECW Instruments Ltd, 0376 517413

RF generators. Two signal generators from Fluke/Philips, the PM5327/5328, cover the 100kHz-180MHz frequency range with a resolution of 10Hz and provide for internal and external modulation by AM, FM, optional FM stereo and swept frequency. PM5238 has an IEEE488.2 interface and a 200MHz frequency meter. Operation is by menu, with the emphasis on accuracy of setting of frequency and attenuation; 99 complete set-ups are contained in memory. ESD Instrument Services, 0279 641641.

Spectrum analyser. The AN930 22GHz spectrum analyser by IFR offers low-order, pre-selected mixing and a synthesized RF system for amplitude and frequency measurement from 9kHz, measurements being under microprocessor control. Analogue resolution is 300Hz to 25MHz, digital resolution 3Hz to 100Hz; there is a frequency meter, fast time-domain sweep, an AM/FM receiver and RS-232 and IEEE-488 interfaces. Fieldtech Heathrow Ltd, 081 897 6446.

Digital multimeter. Model 2001 from Keithley is priced "substantially lower" than other 6 1/2 and 7 1/2 digit DMMs, yet presents true 7 1/2 digit, 28-bit resolution to give a direct-voltage accuracy of 18ppm over 90 days or 8ppm for 24 hours. Reading rates vary with the resolution demanded by the user, but can be up to 2000/s. If reading rate is specified, then the resolution adjusts to that required for that speed. Facilities include AC crest factor measurement, Peak spike readings, true RMS and average readings, frequency to 15MHz and in-circuit current measurement. Multiple measurements on a signal are displayed simultaneously. Keithley Instruments Ltd, 0734 575666.

Panel meter. DPM 700 from Lascar is a version of a popular instrument with led backlighting for good display in any conditions. It offers autoranging, autopolarity, 200mV full-scale reading and programmable decimal points. DPM 700S is a modification with integral negative-rail generator for single-supply operation; input low can be connected to ground. Lascar Electronics Ltd, Fax: 0794 884616

Digital oscilloscopes. Model 9310L

and 9314L oscilloscopes from LeCroy display (2 channels and 4 channels) possess 300MHz analogue bandwidth, independent 100Msample/s digitisers on all inputs and 1Mbit memory per channel. The new instruments offer fast automatic setup of repetitive signals and a sequence mode for storage of multiple events in segmented acquisition memories, "fastglitch", dropout and window triggering, signal processing and fast Fourier transform analysis. LeCroy Ltd, 0235 533114

Radio test set. Marconi's 2955B radio communications test set offers greater processing capability and better software for improved RF performance. Residual FM is now guaranteed at 26Hz up to 1GHz for measurements on radios with up to 60dB S:N; frequency and channel scanning of signals in a specified band is also provided. Facilities are incorporated for AM, FM and phase-modulated radios, full duplex RT, digital pagers, base stations and repeaters. Marconi Instruments Ltd, 0727 59292

Digital multimeter. A low-cost (£48.95) DMM, the Fluke series 10, offers the "V-Chek" facility for detecting whether circuits are open or closed or powered, autoranging, capacitance and min/max recording with time-stamping. At £63.95, the model 12 also offers a display of open circuits or shorts down to 250µs. Philips Test and Measurement, 0923 240511

5GHz modulation analyser. Covering 50kHz to 5.2GHz, the R & S FMB modulation analyser does everything that the FMA model will, but with the extended upper frequency range. It now covers the needs of FM broadcast and microwave landing systems. Options include distortion measurement, an AF filter, stereo decoder and others and there are spare slots for extension. Frequency measurement is to an accuracy of better than 0.1Hz and phase to within 0.5%; power is measured to within 0.5dB up to 2.72GHz. Rohde & Schwarz UK Ltd, 0252 811377.

TV/FM field measurement. Unaohm EP5990 is a lightweight field-strength meter for MATV and CATV engineers carrying out measurements directly from aerials or distribution points. Range is from 45MHz to 860MHz, reading being of the analogue variety. EP5990 measures in dBµV, regardless of modulation, and there is an audible signal for ease of aerial alignment. A four-digit frequency readout is provided, as is a return-loss scale on the panel meter for use with an external reflectometer. Satellite Solutions (UK), 0604 670900

Analogue/digital oscilloscope. Digital and analogue operation are

combined in the Tek 2210/02 oscilloscope, which offers 20Megasamples/second working, with 8-bit resolution and 4K record length. In non-storage mode, bandwidth is 50MHz or 2MHz storage bandwidth for single-shot or repetitive waveforms. Since all 4K points are on screen, traces take on an analogue appearance. Carston Electronics (081 977 0078) offer the instrument ex-rental. Tektronix, 06284 600C.

Pattern generator. A pattern generator from Thurlby-Thandar, the 408NPS, works on NTSC, PAL or Secam and provides RF, video, YC, RGB, sync. and black burst. There is a 100-point addressable non-volatile memory. A selectable video sweep is from 100kHz to 15MHz in two bands with markers, and a genlock ensures sync. with other sources and sync., burst, C and Y can be adjusted independently. Thurlby-Thandar Ltd, 0480 412451.

Power supplies

Power factor corrector. For power factor and harmonic correction in existing switched-mode power supplies, the PFHC-2600 gives a minimum power factor of 0.995 at full load and a worst THD of better than 10%. Universal input accepts 85 to 265VAC. Output and efficiency are 1.3kW and 88% at 110V input and 2.6kW and 93% at 220V; output rated voltage is 350VDC. Coutant Lambda Ltd, 0271 863781

30W DC-to-DC converters. For telecomms and data comms use, the PKE series of converters will work continuously with natural convection cooling from a 48-60V supply, while mounted on a printed board. Input-to-output isolation is 1.5kV and there is a low-voltage shutdown. Output short circuits are non-fatal and the input transient suppressor absorbs up to 1 joule. Ericsson Components AB, 0203 553647.



Keithley's Model 2001 digital multimeter, which is claimed to give top-end performance at low-end prices.

Literature

RMS-to-DC conversion. A 12-page application note from Analog describes the uses of these devices in measuring instruments in which the RMS value of a signal is to be determined without regard to its waveform. The note explains the operation of the converters and offers advice on their selection. Analog Devices, 0932 232222.

Data acquisition. Datal have available a new catalogue of data conversion products at board level, intended for PC, EISA, Multibus and VME boards. A number of intelligent analogue DSP systems, with local CPUs, memory and executive software are described. Datal (UK) Ltd, 0256 469085.

Analogue data. A 700-page data book of analogue circuits from Elantec includes ICs for video, graphics, ATE, communications and others. Examples include a 70MHz video distribution amplifier and a triple 60MHz current feedback amplifier. Available to design engineers who write on company paper. Elantec, 071-482 4596.

Radio communications products. Log. amplifiers. A range of RF and IF logarithmic amplifiers, which possess high log. linearity over 70dB, is on offer from Aspen Electronics. Ranges are 60MHz, 160MHz or 370MHz or to cover bands of 20-100MHz, 40-140MHz, 100-200MHz, 120-480MHz and 750-1250MHz, using cascaded stages in a successive detector design to obtain log. ripples of better than ±1dB. Maximum tangential sensitivity is -75 to -80dBm. Aspen Electronics Ltd, 081 868 1311.

2GHz amplifiers. Two low-noise, hybrid amplifiers from Philips, OM929 and OM956/2, work at up to 2000MHz and are intended for use in the IF stages of satellite television and cellular radio. OM926 is a two-stage device for 10-2000MHz working, providing a gain of 15-18dB over the range 950-1750MHz to compensate for cable losses. Output is 103dBµV at -60dB intermod. distortion and noise figure is 6.5dB. The 956/2 is a three-stage type for surface mounting, working at 950-1750MHz to give 24dB gain ±1dB and 114dB output for -35dB intermod. Philips Components Ltd, 071-580 6633

RF telemetry modules. A range of three low-cost modules is designed to handle the RF end of telemetry in the UK frequency band 458.500MHz to 458.800MHz, or the band 400-500MHz when required. There are two transmitters — TT400 for 500mW working with a frequency stability of better than ± 1.5 kHz for 12.5kHz channel spacing and the TT405 25mW unit, together with the TR450 receiver.

Transducers and sensors

Temperature sensor. A high-temperature sensor, the ECH3010, detects the presence of plastics, rubber, glue, wax and glass. Its capacitive head is made from stainless steel and ptfе and does not hold a static charge, which makes it capable of detecting plastic or resin pellets in injection moulding machines and drying equipment feeders. Sensing distance is 4-15mm, adjustable electronically, and drift is better than 20% over -30° to 180° — a figure to be compared with the 90% commonly found in other sensors. Output indication is by led. Carlo Gavazzi Electromatic, 0252 29324

Accelerometer. A single-axis, 7.5 square mm, surface-mounting piezoresistive accelerometer to handle $\pm 2g$ to $\pm 500g$ is made by IC Sensors and marketed by Eurosens. It is a three-layer silicon sandwich with the suspended mass and sensing bridge in the middle. Self-test electrodes provide a confidence check and a means of calibration by simulating a known force to the mass, which is critically damped, with stops. Eurosens, 071-405 6060.

Hot-wire sensors. Sensors NAP-2A and NAP-7A from Nemoto are for the detection of flammable gases at prices compatible with the consumer equipment market. Gases are passed over a heated wire and are oxidised onto a catalyst covering the wire, causing a resistance change. This is compared in a resistance bridge with

PC development system for PSI Systems's Mini-Module microcontroller using C.



the resistance of a compensator, sealed from the gas. NAP-7A has the wire and compensator in two units, while the NAP-2A is an integral type; both are in double stainless steel mesh to protect against explosion. Quantelec Ltd, 0993 776488

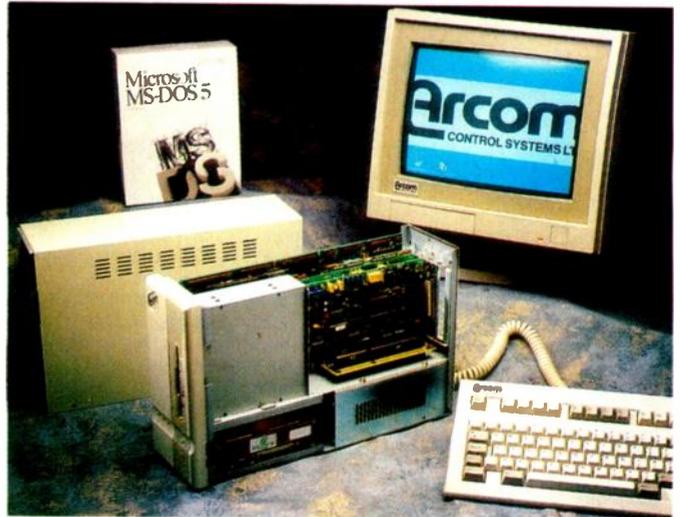
COMPUTER

Computer board level products

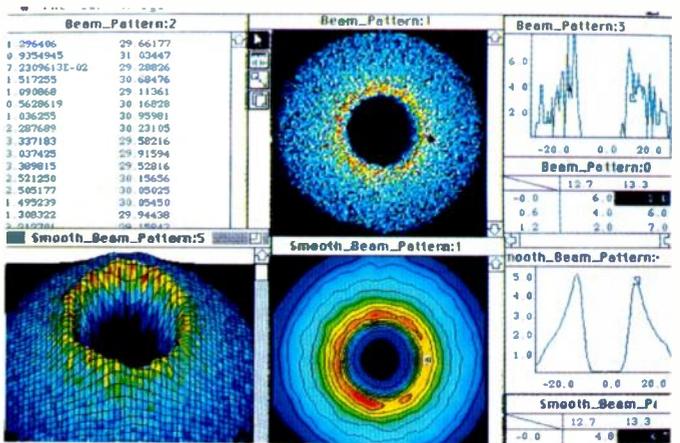
Four-port serial comms board. Each of four ports on the PC40 board is switchable for RS232, 422 or 485. It is meant for PC XT/AT working and has a 64180 processor on board for either fast, continuous communication or to take special data when the host is busy. Software provided is DOS driven and users' software is downloadable to the on-board 32K RAM. Amplicon Liveline, 0273 608331.

VMEbus modules. BVM have introduced the BVME390 family of modules based on the 68040 processor, which affords a performance increase of about four times over the older 68030 for integers and around seven times for floating-point operations. At a clock rate of 25MHz, options include up to 32Mbyte of dual-ported ram and 8Mbyte of flash eprom, supporting 32bit-wide cache burst filling. All types have 256K of non-volatile battery-backed static ram and up to 1Mbyte of eprom. BVM Ltd, 0703 270770.

Multi-processing DSP board. Using TI's TMS320C40 parallel DSP chip, Loughborough have designed the DPC/40 board, which allows scaleable processor architectures to be implemented. With the dual processor version, 550MOPs are available and each additional module brings another 275MOPs. This is computing power up to the job of radar array processing. TI's C40 has six comms ports with multi-channel direct access, CPU, memory, program cache, 32-bit



Arcom's 386 PC AT-compatible, which has a passive backplane and plug-CPU



Mac graphics by courtesy of Adept Scientific's new Spyglass software

global and local memory buses, two timers and an analysis module on-chip. DPC/40 uses either one or two C40s. Loughborough Sound Images Ltd, 0509 231843.

Computer systems

386 computer. A 386SX-based PC AT-compatible computer system, the PCbus5 from Arcom, is mainly intended for scientific and industrial use. Basically, PCbus5 has a 1.44Mb, 3.5in floppy drive, 86Mb hard disk, 386SX plug-in CPU with up to 8Mb of ram, Super-VGA, MS-DOS 5, keyboard and colour monitor. CPUs working at 16, 20 or 25MHz are available. A passive backplane helps with the various i/o needs of an industrial setting. Basic configuration costs £1754. Arcom Control Systems Ltd, 0223 411200.

Development and evaluation Debugger for Windows. Simplehost is a full-screen debugger in a Windows 3.0 setting for the hardware and software of NEC's μ PD17K single-chip microcomputer family. Source code modifications are easily done without leaving the debugger to reassemble and automatic patching sends only the modified lines to the IE-17K emulator. There is a variety of error-detection

functions and four levels of break and trace can be nested; up to 32K real-time trace events are stored and displayed. NEC Electronics (UK) Ltd, 0908 691133.

Microcontroller development. A PC development system for the company's Mini-Module microcontroller using the C compiler MCC68K and XRAY debugger from Microtec Research can now be obtained from PSI Systems. The C language is integrated with the multi-tasking facilities of the Mini-Module's operating system and interrupts and low-level programming are supported. PSI Systems Ltd, 0371 876088

Software

3-D graphics for the Mac. The graphics software recently shown in the BBC programme The Dream Machine is available in the UK from Adept Scientific, distributor for Spyglass, Inc. Transform 2.0 allows 2-D data to be displayed as a raster or polar image, a line graph or as a contour or vector plot, while Dicer 1.1 is for colour display of 3-D data in the form of cubes, cutouts and slices in three planes. Dynamic animation can be generated. Each program costs £395 plus vat and delivery. Adept Scientific Ltd, 0462 480055

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REGULARS

APPLICATIONS

Brushless DC motor drive

For compact disc and computer disk drives, video player drives and anything needing an efficient, extremely fast-accelerating motor, the brushless DC type is hard to beat. The trouble is that such motors need fairly exotic electronics for commutation and rotor-position determination, which goes some way towards reducing the benefits mentioned above and the freedom from brush and arcing problems.

TDA514X, described in Technical Publication IC 008, is a range of ICs from Philips. It handles all the commutation internally and does away with the need for Hall-effect or magnetoresistive position sensors by sensing zero crossing of the back-EMF generated by the three stator windings when not energised. TDA5140A/AT gives 600mA of three-phase drive current; TDA5141 is the same, but provides up to 1.8A for driving

hard disks and fans, while TDA5142T gives three-phase full-wave 150mA drive current to three pairs of power transistors in heavier-duty applications. Figure 1 is the basic internal diagram of the 5140 and 5141.

Fig. 1. Bare bones of the Philips TDA5140/1 brushless motor drive IC, which needs no external commutation circuitry.

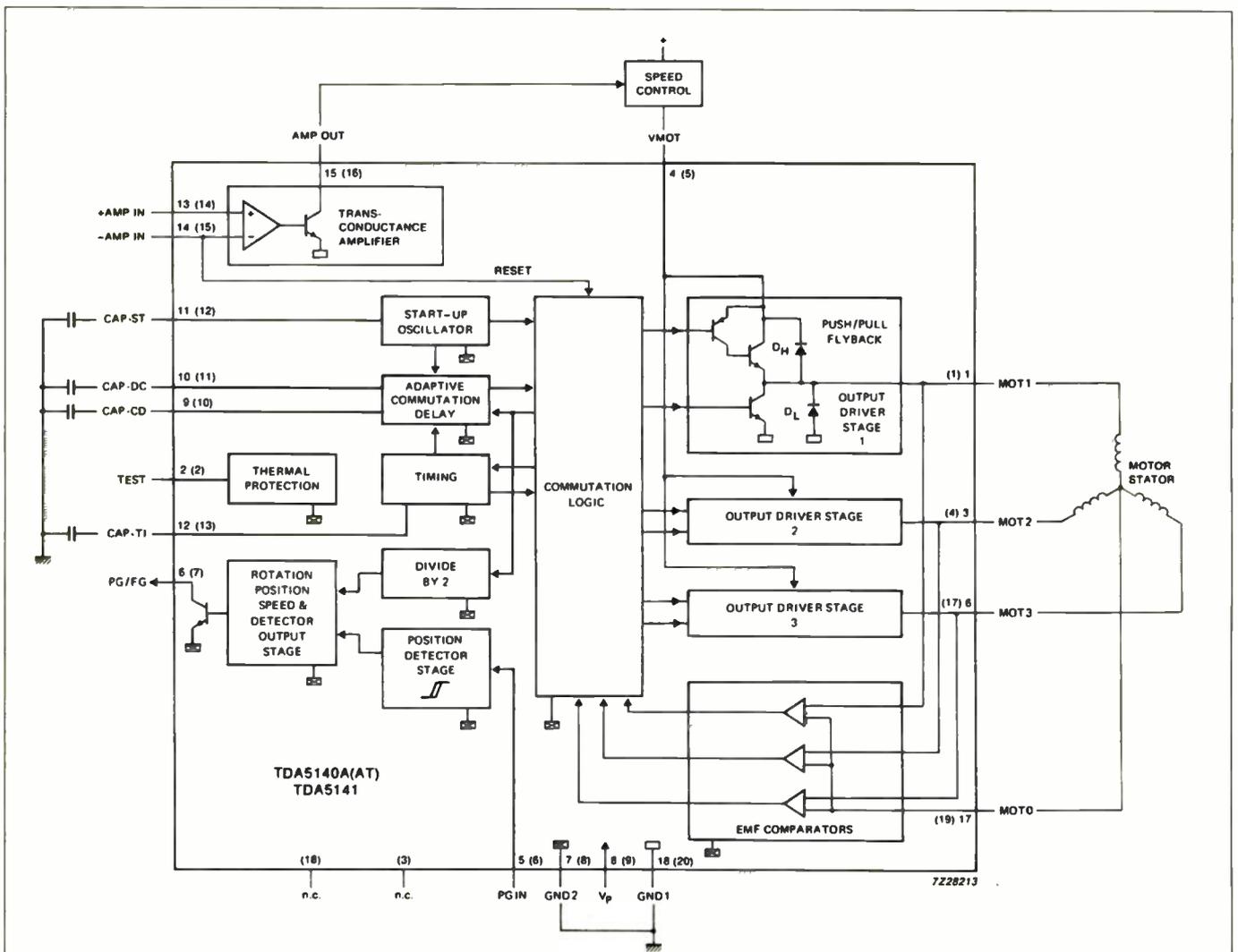
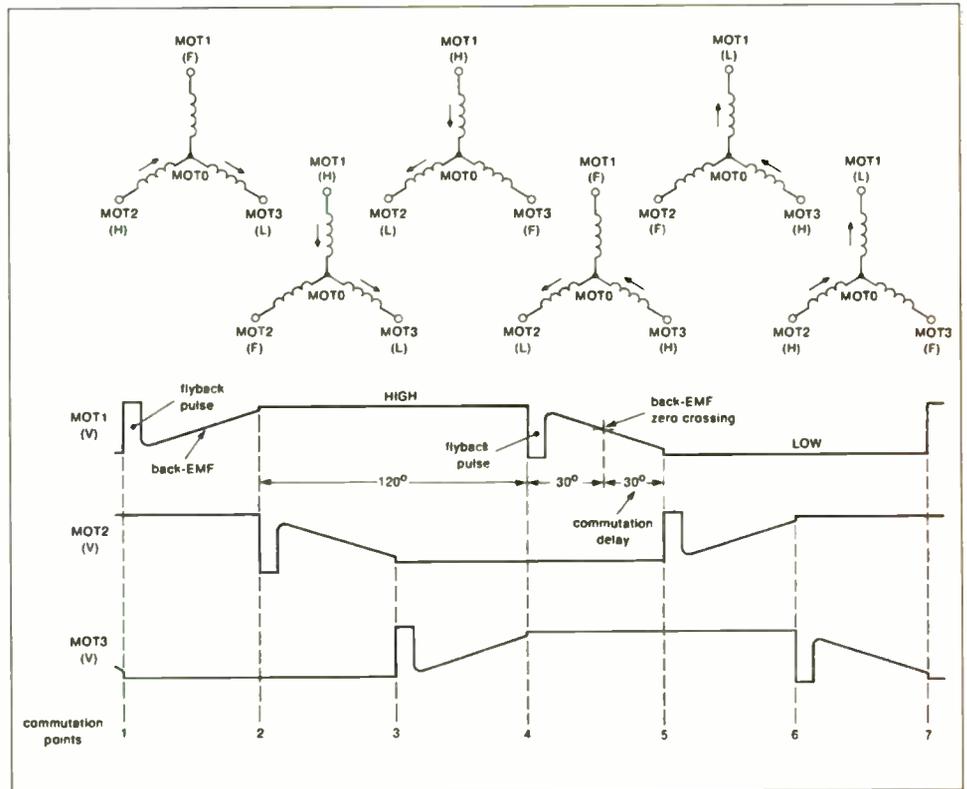


Fig.2. With three states for each of the outputs, there are six combinations of high, low and high-Z to produce the waveforms shown.



Commutation proceeds as shown in Fig. 2. Each output driver has three states: high when acting as a source; low when sinking current; and a high-impedance condition. Two of the three motor windings are therefore connected between a high and a low driver output, which gives six possible combinations of the three outputs. Since the high-impedance stage isolates the commutation logic from the non-energised winding, the back-EMF from that winding can be detected by one of the EMF comparators and selected by the logic.

For each phase of the stator, there is a train of positive and negative-going energised periods, separated by non-energised intervals in which the zero crossings of the back-EMF occur. Since the interval between a zero crossing and the next energised period must not be more than 30° of the cycle, the intervals are measured and stored on external capacitors (CAP-CD and CAP-DC). These charges are sampled by the commutation block to determine the previous commutation delay.

Tacho pulses of 50% duty cycle are also produced by the zero crossings, which indirectly will provide phase information for video recorder motor drives. An inexpensive pickup coil connected to the PG IN pin indicates that certain tacho pulses are also position or phase pulses, the two sets forming a TDM train at the PG/FG output, where the identified pulses show a greater mark:space ratio.

Figure 3a shows digital control of speed. The uncommitted OTA in the TDA514X is

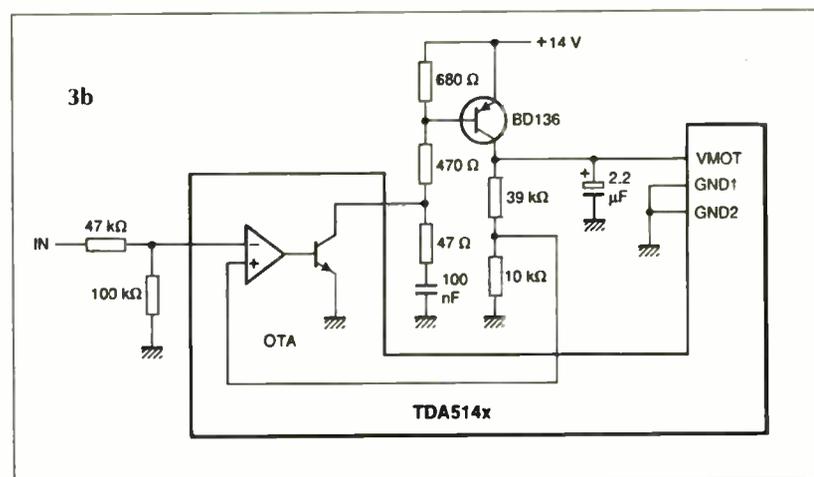
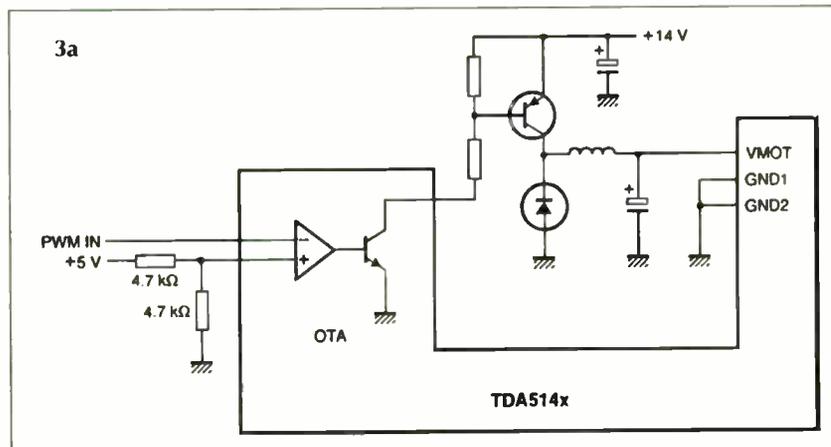
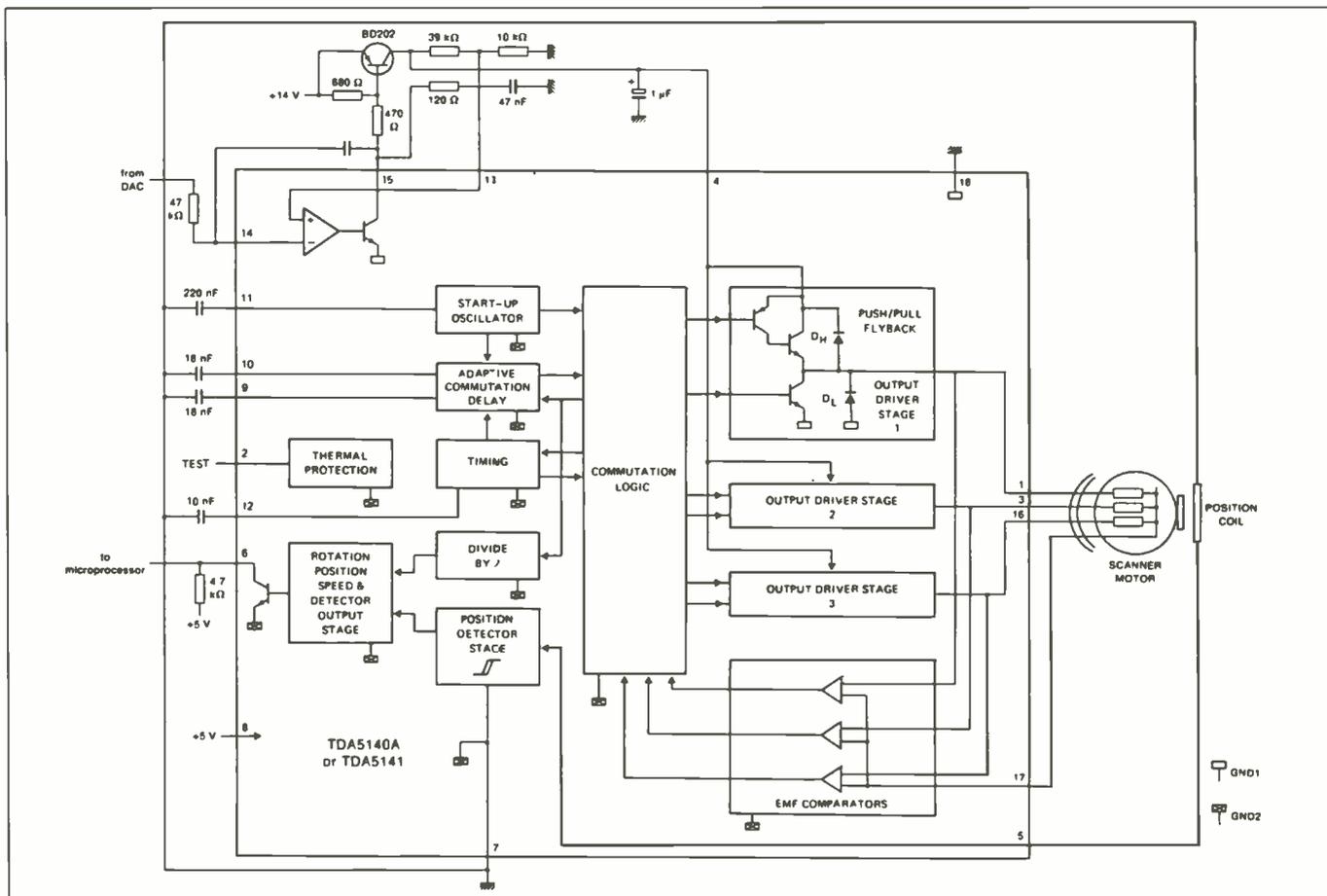


Fig.3. Digital control by PWM input (a) via the operational transconductance amplifier and analogue control (b) where the OTA amplifies a DC input and drives an external voltage amplifier.



needed since the normal method of DC motor control – PWM controlling a DC-to-DC converter to supply the windings, acting as flywheel for the converter – cannot be used because switching spikes would interfere with zero-crossing detection. This system works by setting the level of DC to the

driver stages at the VMOT pin. A microprocessor senses tacho pulses and provides input to the amplifier as either PWM for digital control or as a DC level for analogue control (Fig.3b).

Figure 4 shows an evaluation board for driving VCR scanners and hard disks.

Fig.4. Evaluation board to drive VCR scanner motors using the TDA5140A or hard disk motors with the TDA5141.

Philips Components Ltd,
Mullard House, Torrington Place, London
WC1E 7HD. Telephone 071 580 6633.

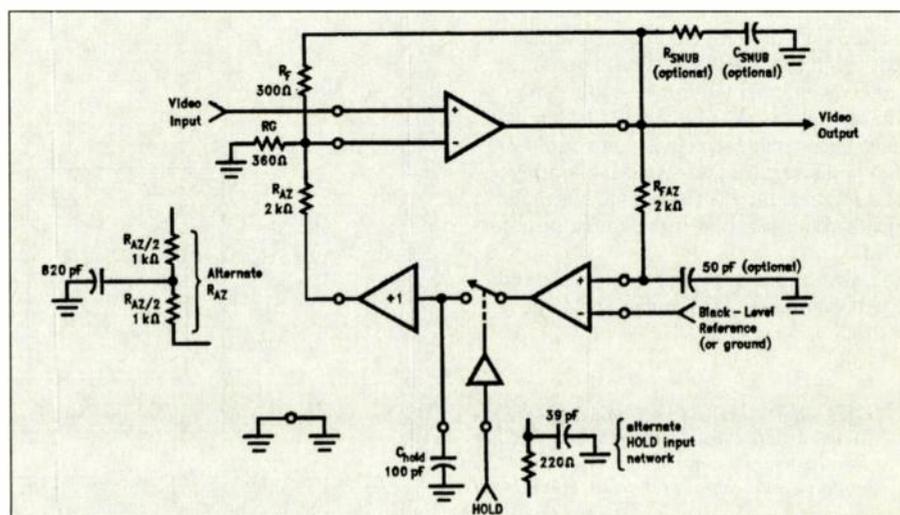
100MHz video amp is DC-restored

Elantec's EL2090C is claimed to be the first complete DC-restored IC video amplifier sub-system. It has a high-quality 100MHz video amplifier and a nulling sample-and hold amplifier for stabilisation. During a line sync period, a hold input is at logic 0 and the SH amplifier behaves as an ordinary op-amp to null the video amplifier's DC offset. When hold returns to logic 1, the correction voltage remains on a storage capacitor to keep the DC correction during the next line period. In the circuit shown, DC restoration is achieved in five scan lines, even with a hold pulse of only 2μs.

Performance of the video amplifier in the NTSC system is claimed in the 1992 Data Book, (Microelectronics Technology Ltd, 0844 278871) to be "nearly perfect", giving 0.01% differential gain and 0.02° differential

phase; since it uses current feedback, the -3dB only changes a relatively small amount with varying gain settings and drives 75Ω loads with ease.

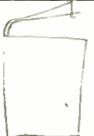
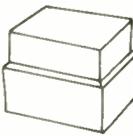
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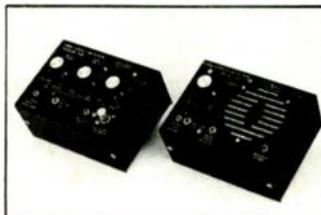
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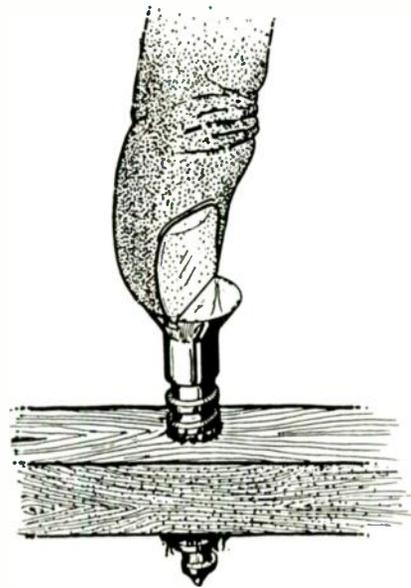


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CIRCLE NO. 137 ON REPLY CARD

Circuits, Systems & Standards

First published in the US magazine EDN and edited here by *Ian Hickman*.

Digitise analogue functions using simple procedures

Time domain signal processing

As an analogue engineer, I found this article useful, informative and an interesting introduction to an area where I seldom need to tread.

IH

As microprocessors become smaller, less expensive and more powerful, increasingly designers are using them to implement signal-processing functions that once were considered exclusively analogue in nature.

Digital implementations of filters, integrators, compensators and similar functions yield greater flexibility, lower temperature drift and much smaller unit-to-unit variation than their analogue counterparts, which use op amps.

Digital versions may also be cheaper, particularly if they are part of a system that already contains many digital components.

But even expert analogue designers sometimes find it difficult to change the analogue version's frequency-domain parameters to time-domain parameters needed by the corresponding digital versions. However it is not that difficult if you divide the task into three major stages:

1. Design the function in the frequency domain.
2. Convert the parameters from the frequency domain to the sample-data domain.
3. Convert the parameters from the sample-data domain to the time domain.

Design in the frequency domain

Generally, analogue designers are familiar with the basic principles of frequency-domain design – root-locus and Bode plots, for example. These principles are based on the Laplace operator s , which is sometimes written as “ $j\omega$.” Normal practice is to write the transfer functions as $H(s)$. To implement an integration expression, replace instances of $1/s$ with integrators consisting of op amps and capacitors, and use resistors for scaling.

But to convert an analogue function to the time domain for digital implementation a few restrictions apply. First the function must be written as a ratio of zeros to poles; and second, the poles and zeros must appear either as real and single elements or as complex conjugate pairs. As many analogue functions inherently impose these restrictions, most frequency-domain functions are already in this form.

A familiar example is a single-pole low-pass filter, for which the frequency-domain expression is:

$$H(s) = 2\pi f / (s + 2\pi f),$$

where f is the break frequency. If the break is set at 100Hz, the filter's expression becomes:

$$H(s) = 628.3 / (s + 628.3)$$

Second stage is to convert the frequency-domain (s -plane) expression to an equivalent sample-data (z -plane) expression. Difference between the two planes is that s -plane functions are based on integrations, and z -plane functions are based on time delays. It is convenient to use z -plane expressions as an intermediate step because they are much closer to the operations of a digital system expressions, and thus are easier to convert to the final time-domain expressions for which a program can be written.

For each s -plane function, an equivalent z -plane function exists (Table 1 shows an abbreviated list of s -plane functions and their z -plane counterparts).

But before the s -plane functions can be converted to z plane the sample time (cycle time), T , of the system must be selected. The value of T is somewhat arbitrary, but as a general guideline, select a value of T such that the sample frequency is at least 10 times the system bandwidth.

The 100Hz low-pass filter mentioned in step one serves as a good example of how to use Table 1. Beginning with the first stage:

$$H(s) = 628.3 / (s + 628.3).$$

If a 1kHz sample rate is selected then $T=0.001$; replacing this value in entry 3 of Table 1 yields:
If the function is very complex, the full s -plane function can be broken down into two or more simpler sub-

$$H(z) = \frac{z(1 - e^{-0.6283})}{z - e^{-0.6283}} = \frac{0.4665z}{z - 0.5335}$$

functions, each of which is represented by one of the s -plane functions in Table 1. The final z -plane function is therefore the product of all the z -plane counterparts of the s -plane sub-functions.

In Table 1, the term T , although defined as the sample time of the system, also implies a relationship to DC gain

(an integrator is a good example: doubling the sample rate doubles the final count). The inclusion of gain terms is advantageous because it eliminates the need to adjust the overall gain of the filter at the end of the design process. Many z-transform tables do not include DC-gain terms, and so differ from Table 1. However, any set of transform tables can be used to obtain sub-functions of a complex s-plane function, provided they are used correctly and any additional steps (such as gain adjustment) that may be required are taken into account.

Once the function has been converted to the sample-data (z-plane) domain, the next step is the final design stage of the digital implementation, converting from the sample-data domain to the time domain. To do so, it is important to understand that, because data is normally updated once every cycle, the variables in the system are only "snapshots." Consequently, data is represented either as new or as delayed by some integer number of samples.

Normally a subscript is added to a function to indicate, in shorthand form, the number of delay cycles. For example, f_k indicates the most recent value of $f(t)$ (that is, in the current cycle). The expression f_{k-1} indicates the value of $f(t)$ delayed by one sample period (that is, the value of $f(t)$ during the previous cycle).

One of the basic properties of the z plane is that dividing a value by z yields the value obtained after a delay of one sample time. Thus, the goal of this stage is to rewrite the z-plane function, replacing each z with a delay. Conversion to the time domain can be accomplished by performing the following steps:

1. Write the transfer function in the z plane as a function of output to input.
2. Multiply out the equation so that no "z"s appear in any denominator.
3. Divide the terms in the equation by the highest power of z that appears in the equation.
4. Replace the z-plane functions with functions that represent a delay of one sample period for each negative power of z. For example, replace $z^{-2} \times \text{out}(z)$ with out_{k-2} .
5. Move the undelayed output term to the left side of the equation and move all other terms to the right side.

Using the steps to implement a low-pass filter

The 100Hz low-pass filter is simple enough to provide a complete demonstration of the entire digital-implementation process:

Stage 1 (write the s-plane function):

$$H(s) = \frac{2\pi f}{s + 2\pi f} \\ = \frac{628.3}{s + 628.3}$$

Stage 2 (convert to z-plane function):

$$H(z) = \frac{0.4665z}{z - 0.5335}$$

Stage 3 (convert to time domain):

- step 1: $\text{OUT}(z)/\text{IN}(z) = 0.4665z/(z - 0.5335)$
 step 2: $\text{OUT}(z) \times (z - 0.5335) = \text{IN}(z) \times 0.4665z$
 step 3: $\text{OUT}(z) - 0.5335 \cdot \text{OUT}(z) = 0.4665z \cdot \text{IN}(z)$
 step 4: $\text{OUT}_k - 0.5335 \cdot \text{OUT}_{k-1} = 0.4665 \cdot \text{IN}_k$
 step 5: $\text{OUT}_k = 0.5335 \cdot \text{OUT}_{k-1} + 0.4665 \cdot \text{IN}_k$

Table 1. s-plane/z-plane counterparts

Entry No	s-plane expression		z-plane counterpart
1	Integrator: $1/s$	\leftrightarrow	$\frac{Tz}{z-1}$
2	Differentiator: s	\leftrightarrow	$\frac{z-1}{Tz}$
3	Real pole: $\frac{a}{s+a}$	\leftrightarrow	$\frac{z(1-e^{-aT})}{z-e^{-aT}}$
4	Real zero: $\frac{s+a}{a}$	\leftrightarrow	$\frac{z-e^{-aT}}{z(1-e^{-aT})}$
5	Complex poles: $\frac{\omega^2}{s^2 + 2\alpha\omega s + \omega^2}$	\leftrightarrow	$\frac{z^2(1-2e^{-\alpha aT} \cos(\sqrt{1-\alpha^2} \cdot \omega T) + e^{-2\alpha aT})}{z^2 - 2ze^{-\alpha aT} \cos(\sqrt{1-\alpha^2} \cdot \omega T) + e^{-2\alpha aT}}$
6	Complex zeros: $\frac{s^2 + 2\alpha\omega s + \omega^2}{\omega^2}$	\leftrightarrow	$\frac{z^2 - 2ze^{-\alpha aT} \cos(\sqrt{1-\alpha^2} \cdot \omega T) + e^{-2\alpha aT}}{z^2(1-2e^{-\alpha aT} \cos(\sqrt{1-\alpha^2} \cdot \omega T) + e^{-2\alpha aT})}$

Where $a=1/\text{time constant of pole}$; $\alpha=\text{damping rate}$; $e=\text{exponent}$;
 $T=\text{sample time}$, and $\omega=\text{natural frequency } (2\pi f)$.

```

1 REM 100HZ SINGLE-POLE LOW-PASS FILTER WITH
2 REM INPUT OF 25HZ
4 REM OUT0 AND IN0 ARE THE MOST RECENT
5 REM VALUES OF OUT AND IN
8 REM OUT1 IS OUT DELAYED BY ONE SAMPLE TIME
10 TIME=0
20 T=.001
30 OUT1=0
40 PRINT " TIME INPUT OUTPUT"
50 FOR K=1 TO 200
60 TIME=TIME+1
70 IN0=SIN(6.283*25*TIME)
80 OUT1=OUT0
90 OUT0=(0.4665*IN0)+(0.5335*OUT1)
100 PRINT USING "#.### ###.###", TIME, IN0, OUT0
110 NEXT K
120 END

```

You can now write a Basic program that simulates the function of a low-pass filter with the characteristics specified in step 5. The program (Fig. 1) simulates the action of driving the filter with a 25Hz sine wave and displays the filter's first 200 outputs. Running the program will show that the output is attenuated by 3% of the input and that it lags the input by a delay of 1 to 2ms, corresponding to phase angles between 10 and 20°. A low-pass filter driven at 25% of its break frequency (as this one is) should theoretically provide 3% attenuation and 14° of lag – which correlates well with the experimental result.

Applying steps to complex functions

The step-by-step design procedure can be applied to transfer functions much more complicated than the low-pass filter in the previous example. For instance, consider an integrator with lead compensation. Assume that the

Fig. 1. Simulation of a low-pass filter

STAGE 1:

$$H(s) = \frac{s+62.83}{s+251.3} \times \frac{100}{s}$$

$$= \frac{s+62.83}{62.83} \times \frac{251.3}{s+251.3} \times \frac{62.83}{251.3} \times \frac{100}{s}$$

STAGE 2:

$$H(z) = \frac{z-0.9391}{0.0609z} \times \frac{0.2222z}{z-0.7778} \times 0.25 \times \frac{100 \times 0.001z}{z-1}$$

$$= 0.09122 \times \frac{(z-0.9391)z}{(z-0.7778)(z-1)}$$

STAGE 3:

STEP 1: $\frac{OUT(z)}{IN(z)} = 0.09122 \times \frac{(z-0.9391)z}{(z-0.7778)(z-1)}$

STEP 2: $OUT(z) \times (z^2 - 1.7778z + 0.7778) = 0.09122 \times IN(z) \times (z^2 - 0.9391z)$

STEP 3: $OUT(z) \times (1 - 1.7778/z + 0.7778/z^2) = 0.09122 \times IN(z) \times (1 - 0.9391/z)$

STEP 4: $OUT_k \times 1.7778 \times OUT_{k-1} + 0.7778 \times OUT_{k-2} = 0.09122 \times IN_k - 0.08567 \times IN_{k-1}$

STEP 5: $OUT_k = 1.778 \times OUT_{k-1} - 0.7778 \times OUT_{k-2} + 0.09122 \times IN_k - 0.08567 \times IN_{k-1}$

Fig. 2. This simple three-stage design procedure will work to digitise just about any frequency-domain function. In the first stage, write the function in its s-phase form. In the second stage, transform the expression to the sample-data (z-plane) domain. The third stage transforms the expression to the time-domain form that can be implemented digitally. The example presented here is a digital implementation of a lead-compensation integrator.

lead zero is set to 10Hz, the pole is set to 40Hz, and the DC gain is 0.25. The integrator is to have a gain of 100 at 1rad/s, and the sample time is 0.001s. Applying the three-stage design procedure to the integrator yields the results of Fig. 2.

From these results, a Basic program can be written to simulate the operation of the filter when it receives a 20Hz input (Fig. 3). From the definition of $H(s)$, the gain of the transfer function is -8dB at 20Hz, and the output lags the input by 53.1°. When the program is run you will find that if the DC portion of the gain is eliminated (by subtraction) the output is 40% of the input (an attenuation of about 8dB), and the output lags the input by 7ms (equivalent to approximately 50° at 20Hz). These results correlate well with the s-plane design characteristics.

Limit input frequency to avoid aliasing

When designing digital filters, care must be taken to avoid aliasing effects. Aliasing is the name of a phenomenon that causes input frequencies greater than half the sampling frequency to appear in the output, transformed into frequencies less than half the sampling rate. Fig. 4 shows the effects of aliasing on a system with a sample rate of 100Hz. All input frequencies greater than 50Hz (which is half the sampling rate) appear in the output as frequencies between 0 and 50Hz.

For integral harmonics of the sampling rate, the apparent frequency is 0. All other frequencies are transformed to the difference between f (the input frequency) and nx , where n is the sampling rate and x is an integer representing the nearest integral harmonic of the sampling rate. Thus, in Fig. 4, an input frequency of 230Hz appears as an apparent output frequency of $230 - (2 \times 100) = 30$ Hz; an input of 270Hz would appear as $(3 \times 100) - 270 = 30$ Hz. Aliasing continues indefinitely as input frequency is raised.

Thus, to avoid spurious output signals, maximum input frequency must be limited to a value that is no greater than half the sampling rate of the system. This limit can be achieved by raising the sampling frequency so that aliasing will not begin until a frequency occurs that is higher than that of any expected signal; this is the preferred - and least expensive - method. If it is impractical (or otherwise undesirable) to raise the sampling rate, insert an analogue low-pass filter in the signal path before the digitising circuitry.

Procedure to suit many applications

The three-stage design procedure presented here is suitable for a wide variety of s-plane functions, including

Fig. 3. Simulation of lead-compensated integrator.

```

10 REM LEAD-OPERATED INTEGRATOR WITH AN INPUT
    AT
11 REM 20Hz
20 REM OUT0 AND IN0 ARE THE MOST RECENT
    SAMPLES
30 REM OF OUT AND IN
40 REM OUT1 AND IN1 ARE OUT AND IN DELAYED BY
    ONE
50 REM SAMPLE TIME
60 REM OUT2 IS DELAYED BY TWO SAMPLE TIMES
80 DEFDOUBLE I,O,T
90 DEFINT K
100 TIME=0.0
110 T=0.001
130 IN1=0.0
140 OUT1=0.0
150 OUT2=0.0
160 PRINT " TIME INPUT OUTPUT"
170 FOR K=1 TO 200
180 TIME=TIME+T
190 OUT2=OUT1
200 OUT1=OUT0
210 IN1=IN0
220 IN0=SIN(6.283*20*TIME)
230 OUT0=(1.778*OUT1)-
    (0.7778*OUT2)+(0.09122*IN0)-(0.08567*IN1)
240 PRINT USING "#.### ###.### ###.###",
    TIME, IN0, OUT0
250 NEXT K
260 END
    
```

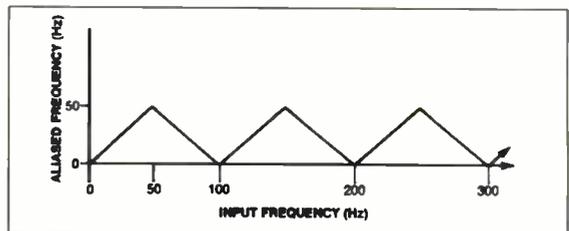


Fig. 4. Aliasing is a phenomenon of sampled-data systems and results in spurious output signals. Input frequencies that are greater than half the sampling rate appear in the output as frequencies between 0 and half the sampling rate. To avoid aliasing effects, place an upper limit on the input signal frequency.

notch filters and PID compensators in servo systems. Not only does it produce more accurate break frequencies than some other popular methods (for example, the bilinear transformation or the w-plane transform), it is also a good deal more straightforward. The procedure can be relied on to produce accurate digital implementations of traditionally analogue filters, with minimal complications.

However, in certain circumstances, stage three does not always produce the optimum result with respect to arithmetic noise - to which integrators are very sensitive. So you may find it desirable to separate an integrator from other functions and design it for minimum noise.

Likewise, for higher-order functions, you may wish to break up the frequency-domain functions into parallel (not cascaded) sub-functions and implement each part separately, using the three-stage design procedure for each sub-function.

Finally, if computing time imposes an undue delay between the instant at which the data is sampled and the instant at which the corresponding output value becomes available, rewrite the equations in a manner that allows the processor to perform much of the background computation before the data cycle begins.

George Ellis, Industrial Drives

Mosfets provide low-loss rectification

Rectifiers strongly affect the efficiency of a low-voltage power supply. Silicon diodes, for example, carry a 0.7V forward-voltage penalty. Much of the power dissipation and heat burden associated with diode rectifiers can be avoided by using the high-efficiency mosfet rectifiers shown in Fig. 1. This approach is especially useful in vacuum work, where the lack of convection cooling limits the allowable power dissipation.

The secondary of the transformer shown in Fig. 1 maintains opposite-polarity V_{DS} voltages across the mosfets Q_1 and Q_2 ; it reverses these polarities once per input cycle. With each change of polarity, the secondary voltage also toggles the mosfets' on/off states by causing the output of each comparator (IC_{1A} and IC_{1B}) to switch between the comparators' supply rails. As a result, a unidirectional and nearly constant current flows from the transformer's centre tap through the load and back through each mosfet in turn.

In Fig. 2, note how an IRFF110 mosfet's familiar first-quadrant curves extend into the less familiar third quadrant. In particular, note that the channel is off for V_{GS} less than 3V (first quadrant) and fully on for V_{GS} in the 4 to 6V range (third quadrant). Thus, by switching the V_{GS} level a diode with very low on-resistance and low forward bias can be simulated. What's more, this approach avoids activating the mosfet's parasitic diodes, which usually prevent the application of mosfets as rectifiers.

In the circuit shown in Fig. 1, the comparators' open-collector outputs provide a rapid transition to the low state, but the 1k Ω pull-up resistors produce a slower transition to the high level. The mosfets thus avoid conduction overlap by turning off rapidly and turning on slowly. Diodes D_1 and D_2 offer protection by clamping the comparators' inverting-input voltages with respect to the negative supply voltage (pin 4). These diodes are normally superfluous, however, because the mosfets' low forward drop will not allow the diodes to turn on.

Using a square-wave input, this circuit can produce a 6V, 1A output with 97% efficiency (resistive losses are 60mW, and each transistor dissipates another 60mW).

For even lower losses, you can parallel two mosfets for each switch. Using diode rectifiers, the efficiency would be about 90%. The use of a sine-wave input also lowers the circuit efficiency but not to the level of a diode-rectifier version: the duty cycle of the switches in fig. 1 goes from almost 50% with a square-wave input to about 20% with a

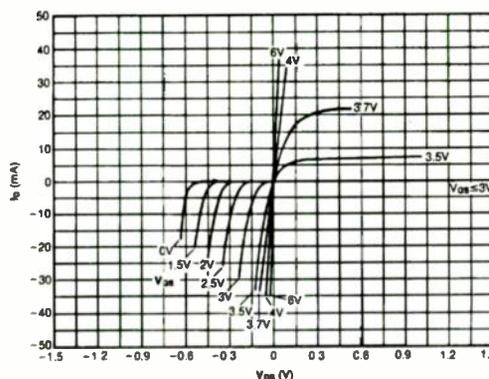


Fig. 2. Characteristic curves for an IRFF110 mosfet show how it can simulate a nearly ideal diode when its V_{DS} and V_{GS} voltages are simultaneously switched.

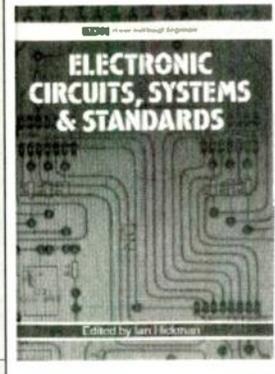
sine-wave input.

Consequently, the switches deliver greater-amplitude current pulses to the load filter, which increases the power dissipation.

William Chater, The Aerospace Corp, Los Angeles, CA.

Low-loss rectification

I first saw active devices, notably bipolar transistors, proposed as low-loss rectifiers many years ago. Here is a low-loss rectification scheme implemented using mosfets. IH

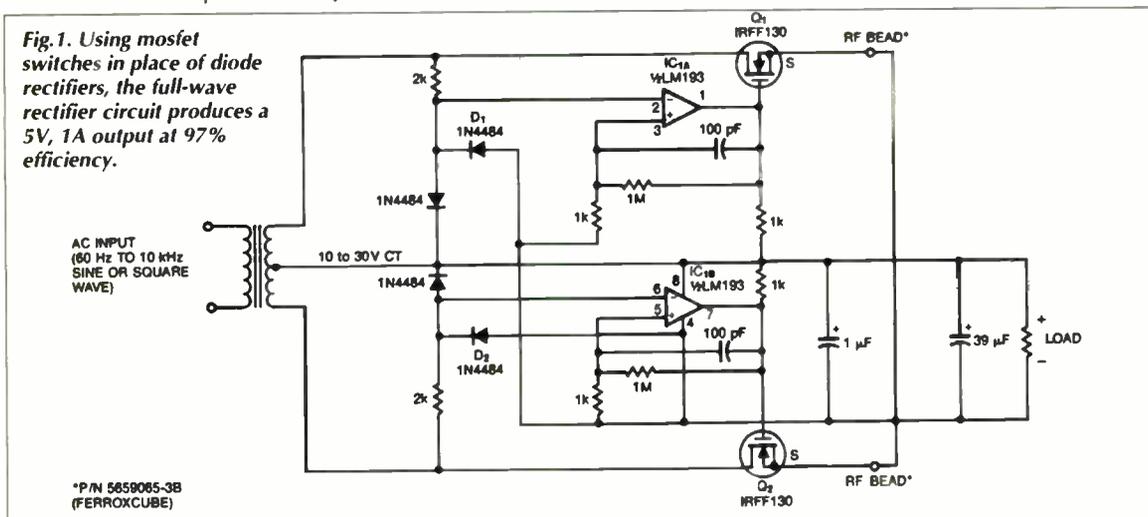


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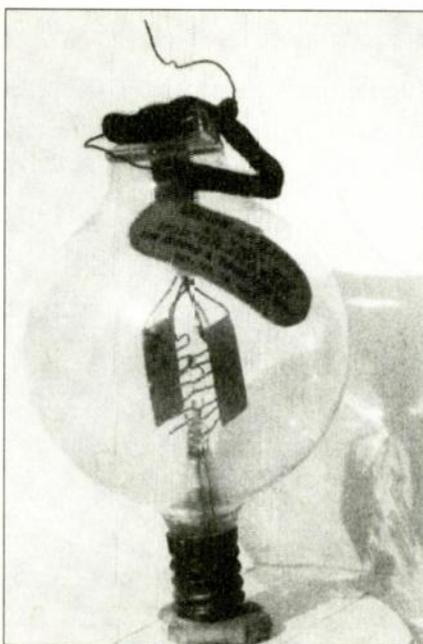
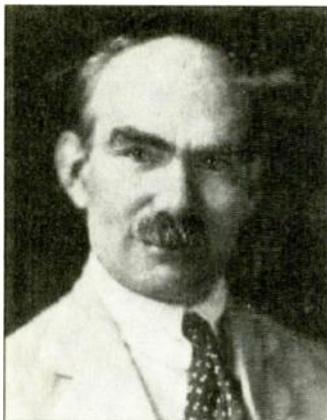
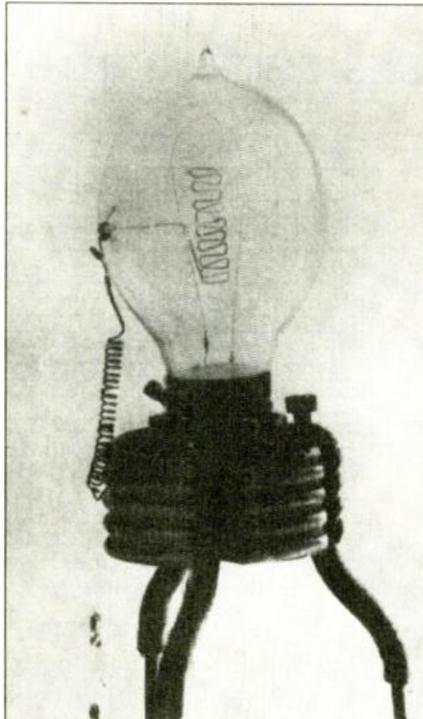
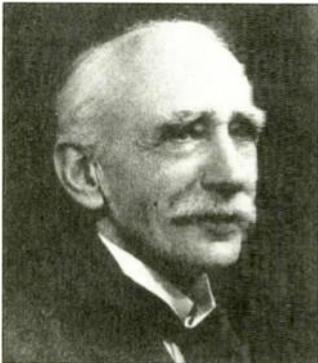
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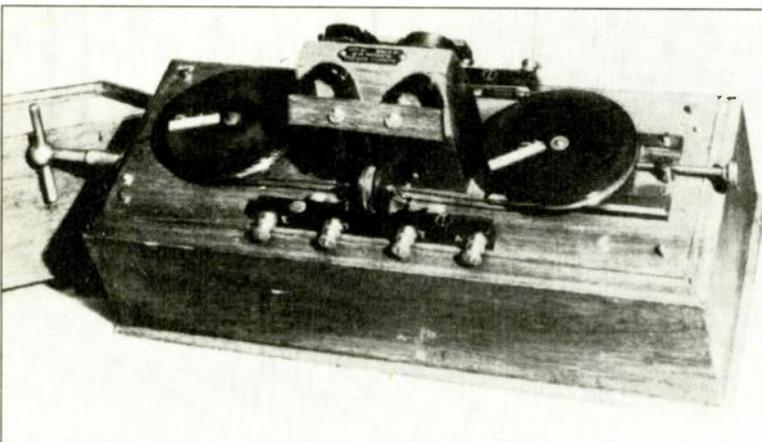
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J A (later Sir Ambrose) Fleming and his Diode, invented in 1904. Below, Lee De Forest and a 1908 version of his Triode.



Marconi's magnetic detector, introduced in 1902 and the predecessor to the valve.



ARRIVAL OF THE VALVE

By Stanley Wood

The thermionic valve was to the electronics revolution what the steam engine had been to the first industrial revolution. Its invention was the key to all the possibilities of wireless communication and other applications of electronics which have proved to be the distinguishing achievement of this century.

The first radio valve was created in 1904, when J A Fleming, working for the Marconi company, took an old Edison lightbulb from a cupboard and reran an 1882 experiment. This resulted in his "oscillation valve", or diode.

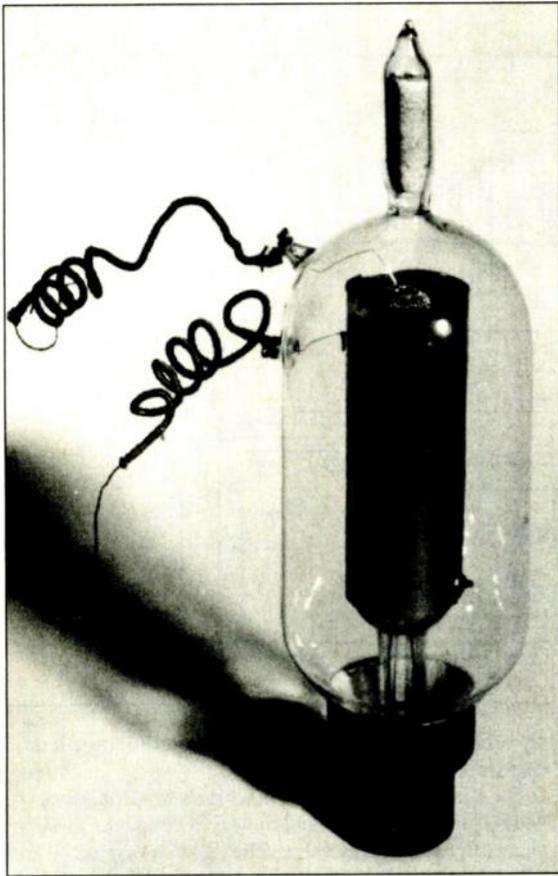
In itself, the diode was a less practical tool than Marconi's existing magnetic detector, introduced in 1902 to replace the coherer and used in ship and shore installations until 1918.

The "Maggie" comprised a continuous band of soft iron wires, turned by a clockwork motor, and passed through a glass tube. On the tube was wound an RF transformer, connected to the aerial and earth, and a telephone earpiece. Magnetisation was induced in the wires by a pair of stationary magnets, but subjected to distortion (hysteresis) by the motion of the wires. A high frequency signal would overcome this and produce an audible click. The "Maggie" increased traffic flow to 30 words per minute.

Fleming's diode was swiftly superseded by a 1906 American breakthrough, Lee de Forest's triode. This incorporated a third electrode which permitted the development of the valve as an amplifier.

The outbreak of the first World War had a galvanic effect on wireless, driving forward developments in many fields. But nowhere did the pressure of military requirements produce more dramatic results than in the evolution of the valve. These entered the war scarcely past the experimental stage - hand-built, delicate and unreliable in performance. They were "soft" valves, incompletely evacuated, with residual gases affecting their function. By the end of the war, the "hard" valve had emerged, highly-evacuated, robust, consistent in performance and relatively easy to mass-produce. Developed by Langmuir in the USA, they were manufactured by the military authorities in France, and became known as the "French" valve.

The type R triode valve was the English version of the French type TM, a most successful practical triode designed in 1915 under pressure of war by the French



The pre-war Round valve, named after its inventor, Capt H J Round, was a "soft" valve, containing residual gases. To activate the valve, the long "beak", which contained a small quantity of spongy platinum, had to be warmed with a match-flame to liberate gases and bring the valve to the necessary degree of softness.

Military Telegraph Service, directed by General Ferrie. First the weaknesses of De Forest's Audion were analysed. Then they evolved a fine design for a simple, robust, easy to manufacture, general purpose hard triode which was put quickly into large-scale production in France.

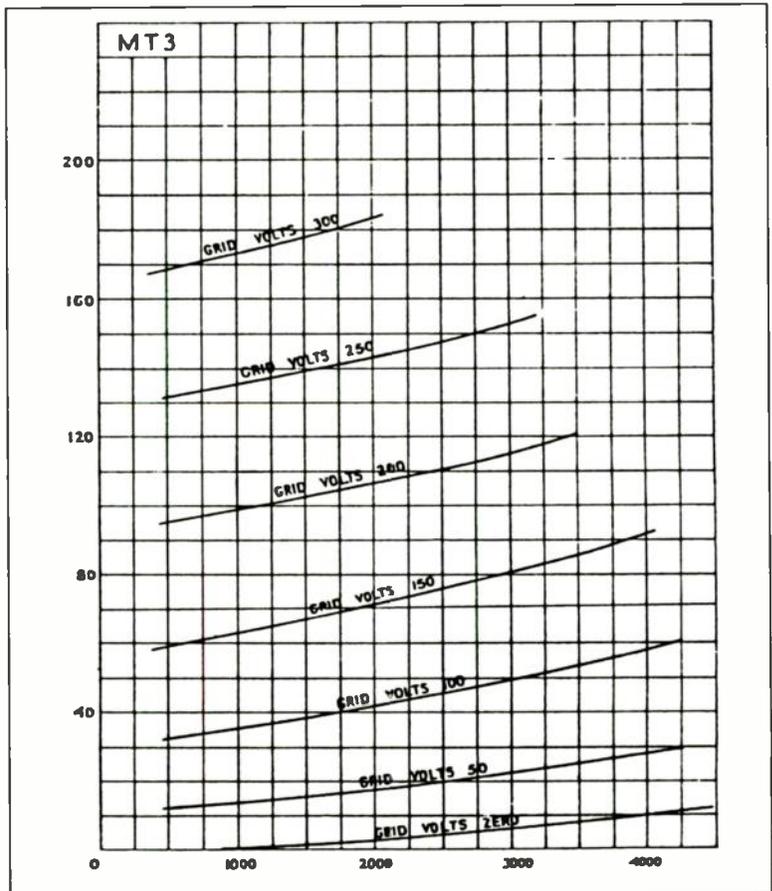
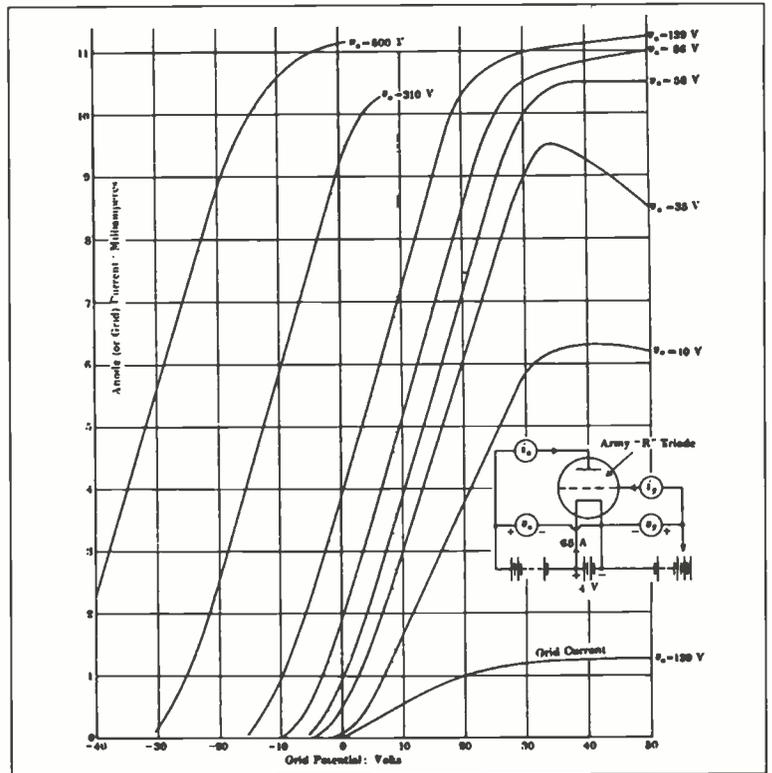
In 1916 the British authorities ordered this design (and many variants) to be made by five UK valve and lamp manufacturers.

Audio and CW field sets were quickly designed by the French around the valve and the British later used it in their trench sets and RAF equipment. Even the Americans used the *TM* on their arrival in France in 1917. *TM* valves were used in French multi-valve amplifiers where the valves, being of close tolerance, were interchangeable.

After the war amateurs used the valve despite its 2.8W bright-emitter filament, which gave almost as much illumination as entertainment. The valve was available via post-war Government disposals or could be purchased new for 15 shillings in the 'twenties.

So the *R* valve was the first practical "modern" valve. Its design was copied for some time and the four-pin base it carried was to become the European standard for many years.

Typical *R* valve parameters were: $g_m = 0.33\text{mA/V}$; $\mu = 10$; $r_a = 30\text{k}\Omega$; $V_a = 70\text{-}400$. Some microphony did occur.

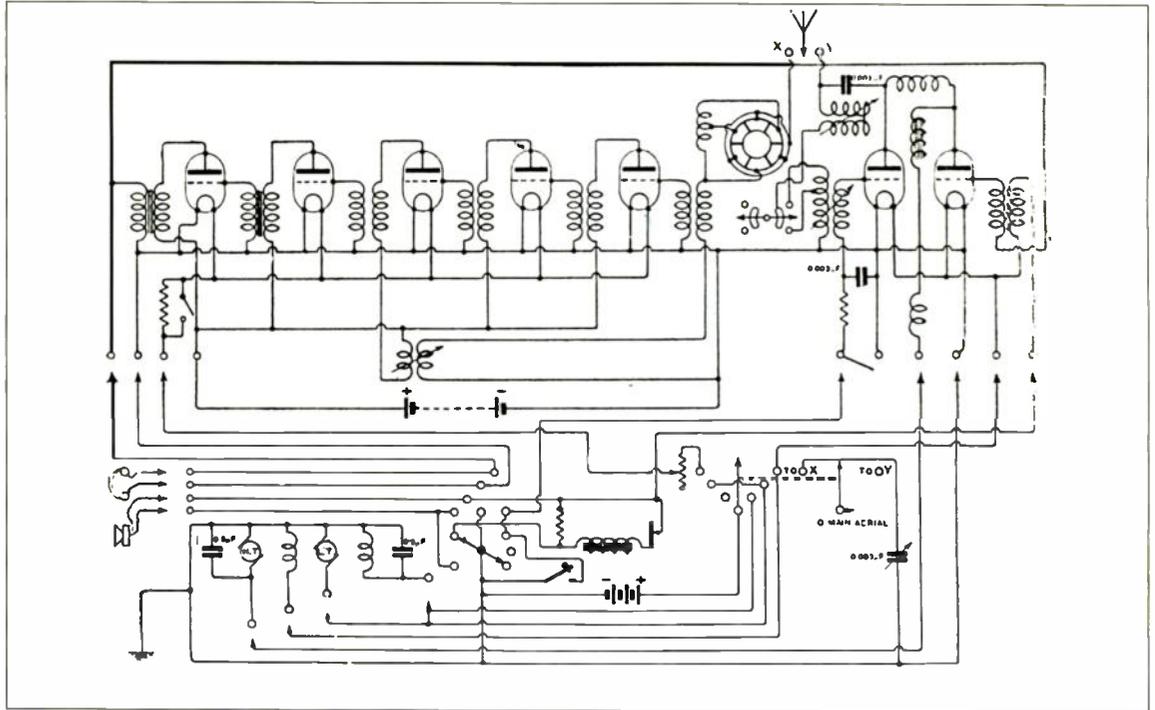


Consider now a transmitting valve designed five years after the *TM* – the Marconi Type *MT3*. This small transmitting valve was the work of Captain Round as part of his remarkable programme of air-cooled glass transmitting valves, Marconi types *MT1* to *MT5*, developed between 1920 and 1922. Marconi post-war transmitters were designed round these valves.

(Top) I_a/V_a characteristic of the type *R* triode, and (lower) I_a/V_a characteristic of the *MT3* for various values of V_g .

HISTORY

Marconi AD2 aircraft radiotelephone transmitter/receiver c.1924 using MT3 valves as oscillator and speech control valves.



Type R triode - British version of the 1915 "French valve".

Marconi's MT3, designed by Round, and used in transmitters and aircraft sets.

The Mazda AC/Pen of 1930, the first indirectly-heated pentode.

The *MT3*, for example, was used for several of their post-war aircraft sets eg type *AD1* Transmitter and type *AD2* airborne telephone/telegraph transmitter/receiver. (The latter, a compact set in a wooden case, used one *MT3* as power oscillator and the second as speech control valve. Its receiver used valves types *Q* and *V24*. Total weight of the set was 63lb). The *MT3* valve was also used in Marconi field portable 100W transmitters type *YB1*.

MT3 parameters: 80W output on LW telegraphy: 40W max dissipation on CW; $\mu = 100$; $r_p = 300k\Omega$; $V_a = 1500$. This valve type was still available for replacements in the mid-thirties.

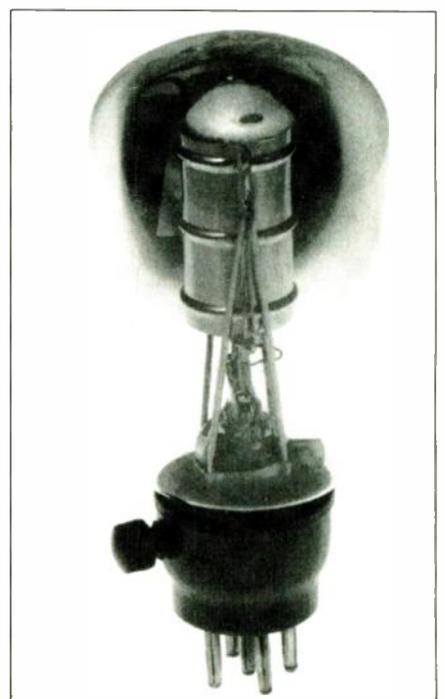
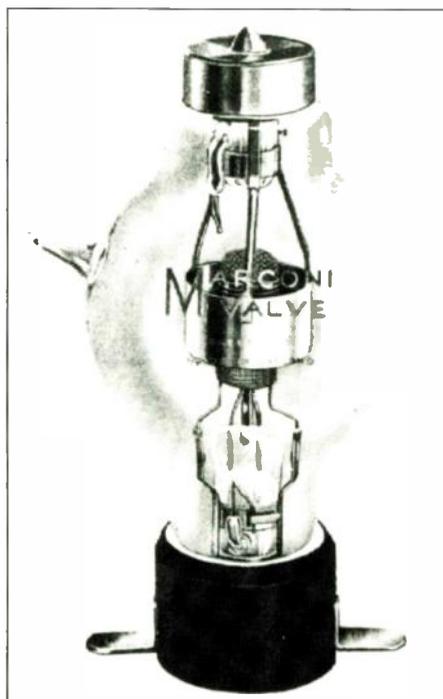
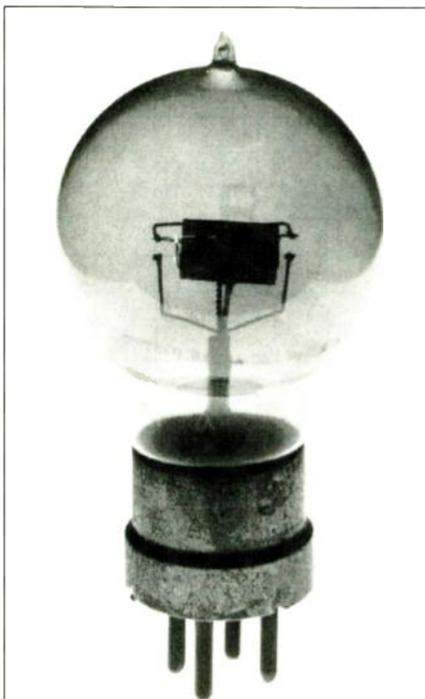
The third valve in this selection, the Mazda *AC/Pen*, followed Philips' introduction of the pentode in Holland in 1927. This was a most significant step in valve development - the pentode, in directly-heated form, was the

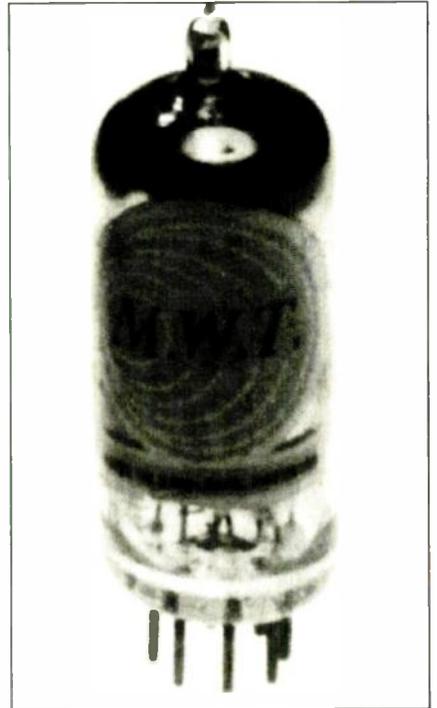
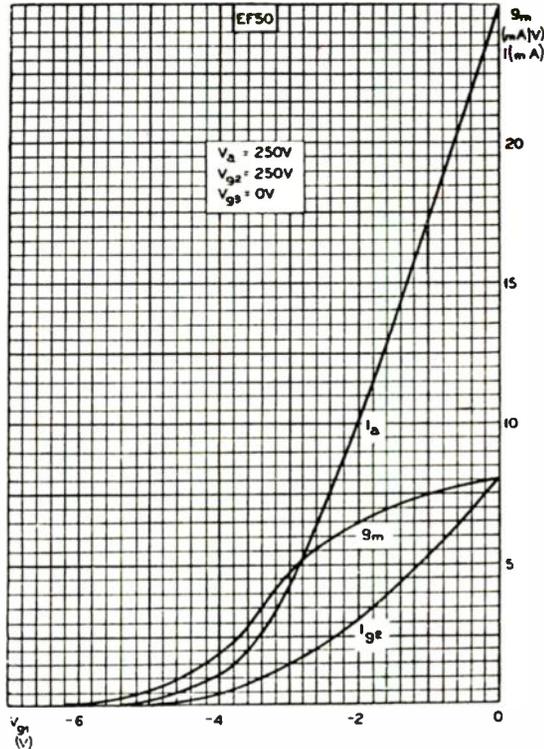
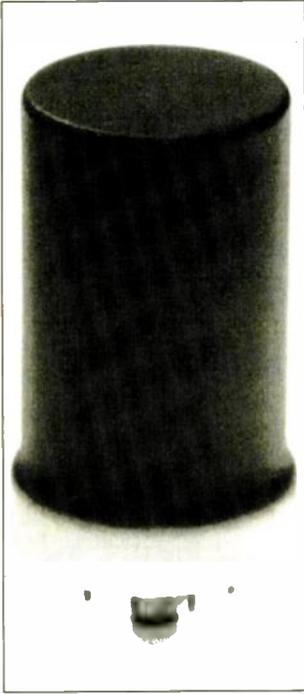
universal valve for receiver output stages to drive loudspeakers.

The Mazda *AC/Pen* was the world's first indirectly-heated pentode. It appeared in May 1930, some three years after the Philips valve. The *AC/Pen* originated from the same stable as the earlier notable Cosmos short path series of *1H* valves, but was sold under the Mazda label.

This very successful valve had a mutual conductance of 2.2, claiming to be the most sensitive pentode and to operate without hum. It demonstrated the great advance made in valve design and manufacturing technique by 1930, with its intricate assembly of five electrodes, delicate heater and supports all held rigidly within a standard envelope.

Amplifying with 10V negative bias, with $V_a = 250$ and $V_{sg} = 200$, the *AC/Pen* delivered 1.5W undistorted energy





when working into a 7500Ω load. So successful was the design that it became the basis of later Mazda valves, such as the high-sensitivity pentode, AC/2Pen, of 1934.

AC/Pen values: $g_m = 2.2\text{mA/V}$; $r_a = 33\text{k}$; $\mu = 50$ @ 150V; Max dissipation 8W.

Our next valve – the first all-glass tube by Philips-Mullard – was announced early in 1939. The times were threatening but this tube, the Type EF50, was to be a most valuable tool in the battles to come.

With a mutual conductance of 6.5mA/V – then an outstandingly high figure – the EF50 was meant for use as a wideband television amplifier, but it was quickly seized on by the back-room boys for a 45MHz IF strip then being produced by Pye for incorporation in 200MHz receivers for the earliest airborne radars. Its r_a was 1MΩ; equivalent noise resistance 1400Ω and reverse transfer capacitance (cold) 0.007 pF; $V_a = 250$.

In radar receiver applications the EF50 soon gave way to Mullard's type RL7, an aligned-grid, low-noise pen-

tode derived from the EF50.

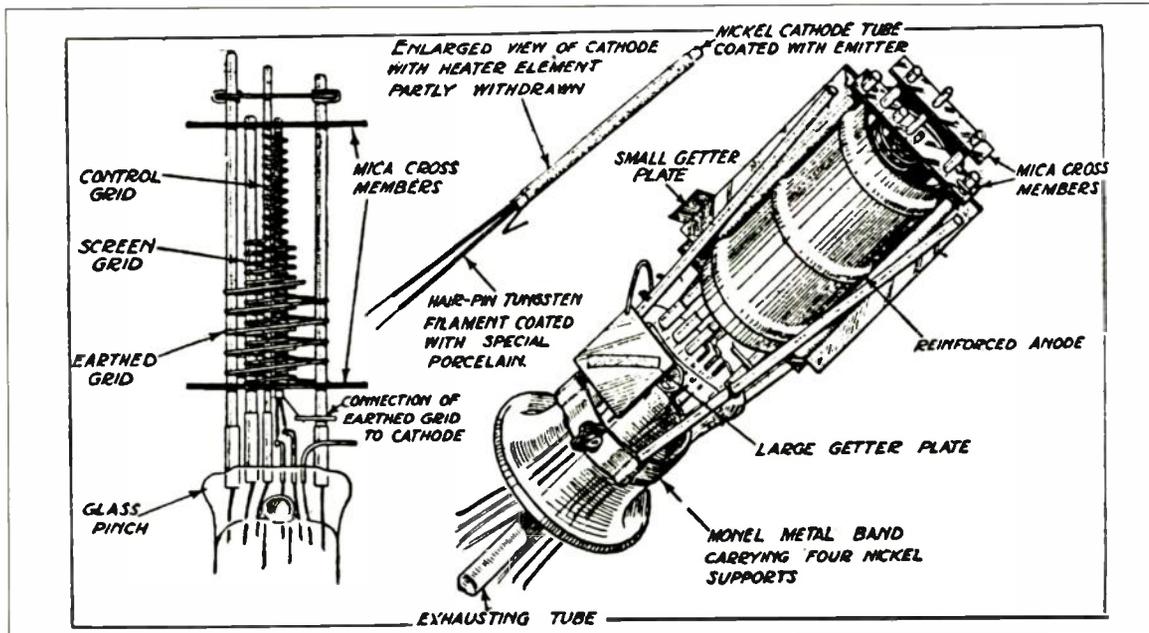
Nevertheless the EF50 was to play so great a part in British wartime equipment that Sylvania (USA) had to be called on to augment supplies of EF50s to the UK. After the war the EF50 was still in great demand and was also the basis of the type EF55 RF pentode and other tubes.

The popular series of seven-pin 6.3V miniature valves introduced into the UK by Marconi-Osram in 1947 makes a suitable point at which to end this short review. The Z77 (CV138) short-base RF pentode (6.3V IH) typifies this range of compact general purpose receiving valves.

Their 55mm length, 19mm diameter and all-glass construction enabled post-war valved radio sets to be much smaller than pre-war sets and their electrode construction and pressed glass bases with direct lead through gave an input capacitance (for the Z77 cold) of 7.4pF. Connected as a pentode with $V_a = 250\text{V}$ the Z77 had $g_m = 7.5\text{mA/V}$ and $r_a = 300\text{k}$. Rigid electrodes made microphony virtually nil.

Mullard EF50 – designed for TV, but used in airborne radar – and its I/V_g characteristics.

Seven-pin general-purpose receiving valves from Marconi-Osram, such as this Z77 (above), permitted reduction in size for post-war radio sets.



The amount of manufacturing skill needed in 1930 to build the AC/Pen IH pentode was considerable – as this sketch shows.

Making a right white noise

The perfect noise for measurement purposes is Gaussian – smooth and without lumps. Ian Hickman explains.

Dedicated audiophiles are often blessed (or cursed) with ears that are extremely sensitive to noise and so they are very concerned with how much noise is added to the signal by their equipment. As in any battle, it is important to know your enemy; it is therefore useful to the development engineer to have available a calibrated source of audio frequency noise of known characteristics.

Two characteristics typical of the sort of noise commonly encountered are that its frequency distribution is "white" and that its amplitude distribution is "Gaussian" (food for another *Design Brief* there). Briefly, the former means that the noise exhibits the same power in any small given bandwidth, whatever its centre frequency, while the latter means that the larger the voltage excursions about the mean level, the more infrequent they are, as described by a mathematical formula called the "normal distribution".

Figure 1 shows three types of noise generator which have all been used in the past. The neon lamp source in 1a works quite well over the audio band but the level of noise starts to fall off at about 20kHz; the requirement for a high voltage is also an inconvenience. The circuits in 1b and 1c are both still useful; b can be used up to VHF or even UHF, given a suitable choice of diode. Circuit 1c is very convenient, given a suitable op-amp.

Op-amps exhibit a "1/f noise corner": a lowish frequency at which their input noise is 3dB up on the mid-band figure and below which it rises at 6dB/octave. Op-amps with a 1/f corner lower than 20Hz are readily available (e.g. 2Hz for the LT1007, LT1037) and prove very satisfactory in the circuit of Figure 1c), providing a source of noise that is substantially flat across the whole of the audio band.

If "substantially" flat is not good enough (op-amp manufacturers don't guarantee that the noise of their product will be flat, only that it won't exceed a specified maximum) then there is an alternative popular approach. This makes use of a maximal length "PRBS" (pseudo random bit sequence) generator.

If the outputs of the last stage and an earlier one of an N stage shift register are input to an XOR gate, whose output feeds the input stage of the shift register, then a stream of apparently random 0s and 1s will be generated. If N

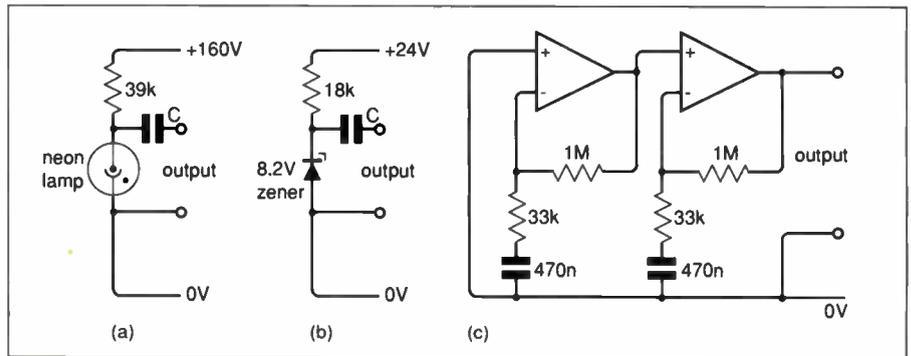


Fig. 1. Three types of noise generator. The neon lamp in (a) is useful in the audio band up to around 20kHz; the circuit in (b) can be used up to VHF or UHF with a suitable diode; that in (c) is convenient if the op amp is suitable.

is small you can amuse yourself working out with pencil and paper what the output sequence will be for different stage inputs to the XOR gate.

You will find that if you choose the right one, a sequence will be generated which only repeats after $2^N - 1$ clock pulses.

As N gets larger, the pencil and paper approach rapidly becomes unwieldy, so one refers to the published tables of primitive polynomials over GF2. GF2 indicates the arithmetic of a Galois field of two elements, which is a little too arcane for the space avail-

able here. However, the tables indicate that for most values of N there is at least one choice (and its inverse) of an earlier stage which will result in a maximal length sequence being generated. For those cases where there isn't, successively XORring the output(s) of one or more other stages will achieve the desired result.

For one of the classical works on the topic see Appendix 1, which covers all polynomials up to $N = 34$, although I have a bibliography giving nine references (some classified) pre-dating this. One of the earlier references² lists trinomials (needing only a single XOR gate) up to degree $N = 45$. Another³ lists trinomials up to degree 1000, which would provide such a long PRBS that it wouldn't repeat in your lifetime, even with the highest practical clock frequency.

Figure 2 shows a 17 stage maximal length

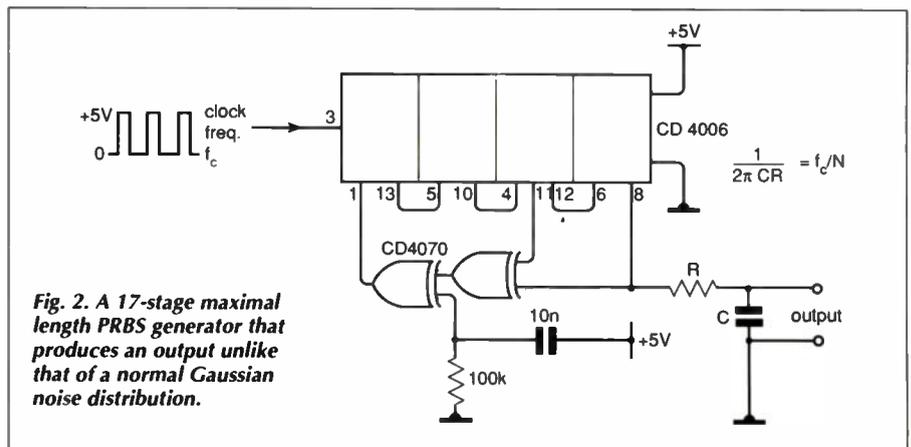


Fig. 2. A 17-stage maximal length PRBS generator that produces an output unlike that of a normal Gaussian noise distribution.

PRBS generator which therefore produces a pattern $2^{17} - 1 = 131071$ clock pulses long before repeating. The additional XOR gate plays no part in normal operation, but prevents the establishment of the degenerate all 0s case which would persist for ever.

The remaining two XOR gates in the package could be used as the clock oscillator; if this ran at 130kHz, the pattern would repeat every second or so. This means the output noise would not be a continuous white frequency spectrum, but would consist of discrete spectral lines 1Hz apart. Moreover, it is only pseudo white up to a frequency of about a sixth of the clock frequency.

A good PRBS noise source needs more than 17 stages for another reason too: the output of the Figure 2 circuit is simply a string of 0s and 1s, nothing like the normal distribution of Gaussian noise. Lowpass filtering can convert the binary output to a Gaussian distribution, at the cost of restricting the noise bandwidth.

Trinder⁴ describes a 23 stage circuit using a 100kHz clock frequency and incorporating a 20 tap FIR filter to give a close approximation to Gaussian white noise up to 10kHz.

The pattern repeats after about 80s, so there are 80 individual spectral lines per Hz, a close enough approximation to a continuous frequency distribution for all but an incredibly selective filter! The circuit uses nine ICs.

National Semiconductor's MM5437 digital noise source, which replaces the earlier MM5837 (no longer obtainable) is about the simplest audio noise generator you could imagine. It is an 8-pin DIP that needs no external components whatever to produce white noise.

If, as is most likely, you need a Gaussian distribution as well, this can be achieved very simply (if not quite optimally) with a first order lowpass filter – just two components.

In the circuit of Figure 3a, where the 10K + 680pF lowpass filter has a 20kHz cut-off frequency (-3dB), the 10µF capacitor is simply a DC block.

It forms a highpass with a 0.0016Hz corner frequency with the 10MΩ input resistance of a 'scope probe. The IC can be used with an external clock frequency, but with CONTROL 1, pin 8 at logic 1 or floating, it uses its internal clock oscillator - about 180kHz - to give a repeat period of about a minute.

Two outputs are available, the 23 stage shift register output stage (OUT 2) at pin 5 and a run-length limited version of the sequence (OUT 1) at pin 1.

Normally, to get a reasonable approximation to a Gaussian distribution with a simple CR low-pass, its cut-off frequency should be no higher than the clock frequency divided by N. Here, N = 23, so a cut-off frequency of about 7kHz would seem to be necessary, otherwise, when a long sequence of 0s or 1s occurs the

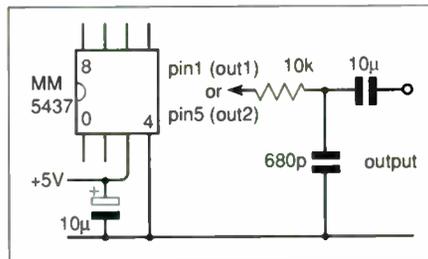


Fig. 3a. National Semiconductor's MM5437 digital noise source is about the simplest audio noise generator imaginable: an 8-pin DIP with no requirement for extra components to produce white noise.

Fig. 3b shows the signal before the application of resistance/capacitance when CR is fed from OUT 2.

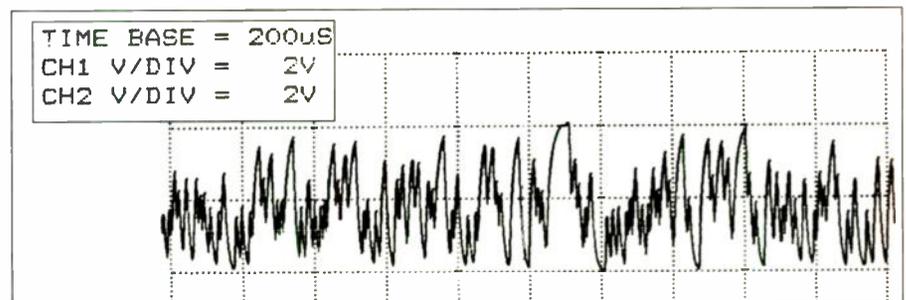
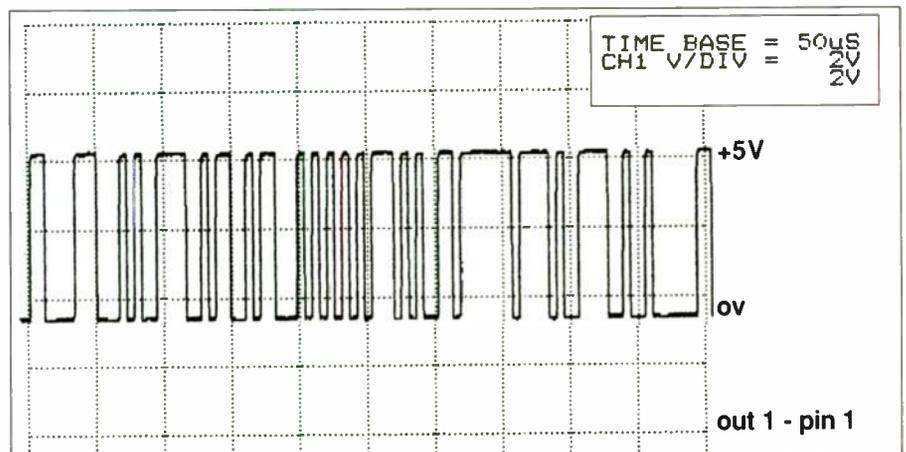


Fig. 3c shows the effect on the signal with CR fed from OUT2. When a long sequence of 0s or 1s occurs, the output fetches up at 0V or +5V (around mid-picture).

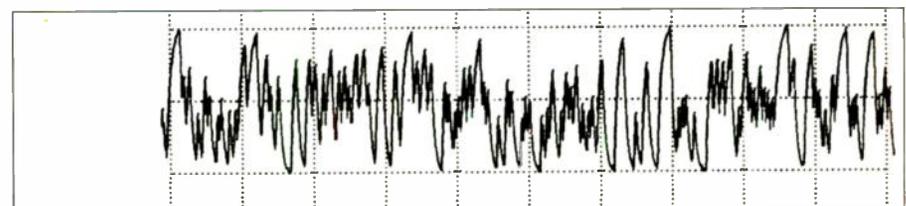


Fig. 3d shows the output obtained when a run-length-limited OUT1 is used.

output will fetch up at 0V or +5V.

When the CR is fed from OUT 2 (Fig. 3b.), it produces the effect shown around the middle of Fig. 3c.

Figure 3d shows the output obtained using the run-length limited OUT 1; a reasonable approach to the normal distribution results. The run length limiting must have some minor effect on the frequency distribution, but I believe it to be quite negligible. Altogether a most useful and versatile chip.

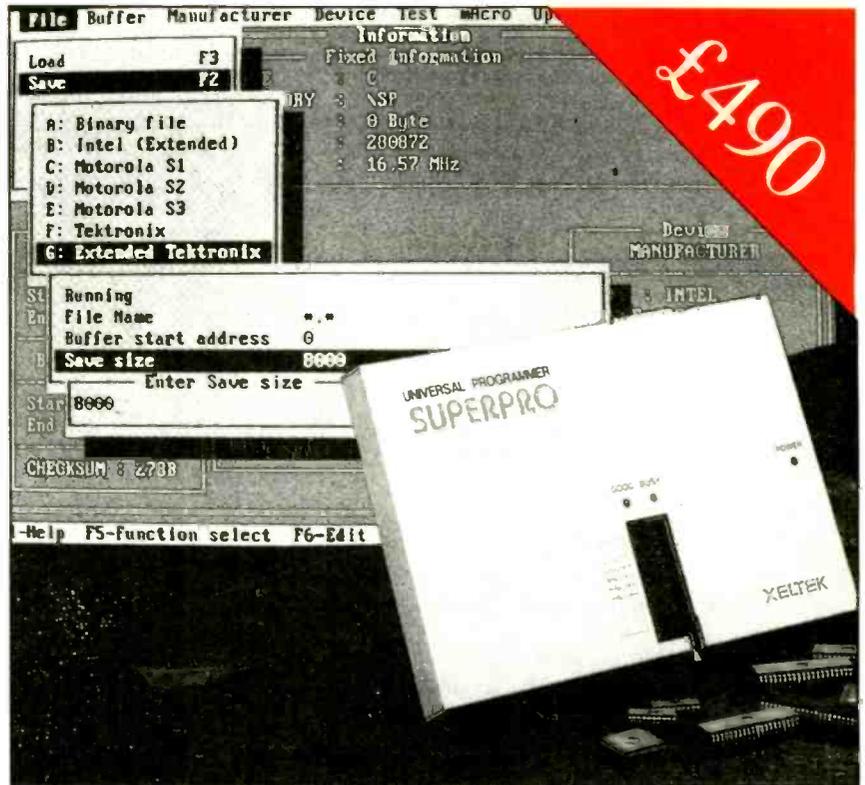
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4. *White Noise Generator with Built-In Digital Filter*. J. R. Trinder, *Electronic Product Design*, December 1983, p 30.

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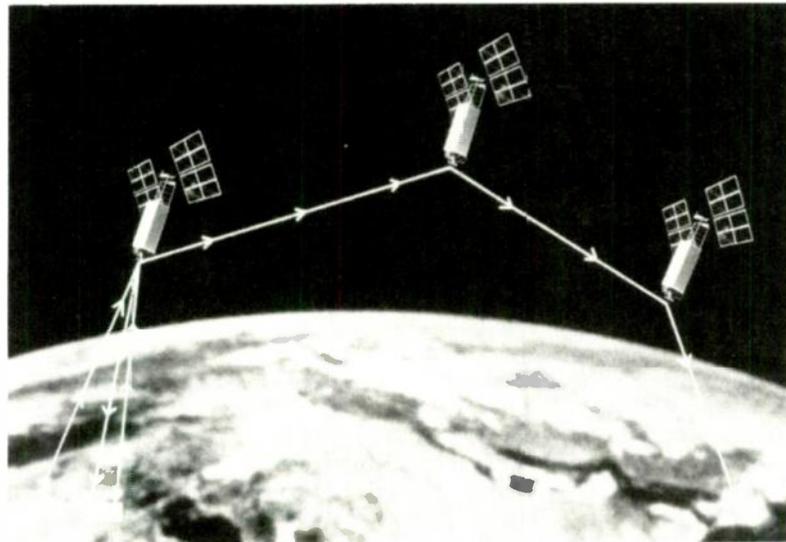
Many years ago, the final goal of telecommunications was defined as being "the ability to communicate with anyone, anywhere, any time.". It should perhaps have added "at an acceptable cost and requiring no special skills on the part of users".

Introduction of national mobile and portable cellular systems linked to the public switched telephone network, plus extended-range radio-paging and Inmarsat-2 maritime/aeronautical/land-mobile satellite systems has begun to increase the likelihood of reaching the final goal within the foreseeable future. Pan-European systems and truly global systems are already in the planning stage.

But it still cannot be assumed that all of the systems that are now technically possible will also prove commercially viable. When setting up a new wide-area telecommunications system, problems arise because heavy capital investment is required before substantial revenues can be generated. The number of disconnections from the mobile cellular networks in recent months shows too that telecommunications is vulnerable to business recessions.

Significant losses were experienced by the three consortia which originally acquired licences to operate UK telepoint services, offering short-range connection to the public switched network from low-cost, compact hand-held transceivers but no facility for receiving incoming calls.

What may prove to have been the final nail in telepoint's coffin was the announcement last October of the suspension of Phonepoint by the powerful consortium comprising BT, France Télécom, Deutsche Bundespost Telekom and Nynex International Europe, following abandonment of the system by the other two original operators. The Phonepoint decision was based, it was claimed, on adverse market conditions, although the (remote?) possibility exists that "a telepoint service may be made available by Phonepoint in the future,



Poserphones in space? Motorola's Iridium project calls for 77 satellites to be placed in low orbit to provide a global cellular service. The satellites will use 20GHz links to pass traffic to each other. Critics maintain that the Iridium project is totally impractical

should conditions become more favourable".

Despite this, planning for pan-European and global radio-paging, telephony, digital data and position-determination systems continues apace. It includes GSM (Groupe Spéciale Mobile), DECT (digital European cordless telephone), ERMES (European radio messaging service on 169MHz), global Inmarsat-3 land, maritime and aeronautical mobile in L-band, and the ambitious Motorola Iridium project. Iridium is based on 77 low-orbiting satellites, 413 nautical miles above Earth and configured in seven polar-orbit planes of 11 satellites each. In effect this forms a moving cellular exchange in the sky and provides continuous line-of-sight coverage to any point on the globe. Seven antennas on each satellite are planned to form a honeycomb pattern of cells on the ground; as the satellites orbit the Earth, the user will be handed over from one cell to the next. Each satellite will have a 20GHz link to the satellite immediately ahead of it in its plane, and to the satellite immediately behind it.

Iridium is expected to have subscriber units in a variety of forms. These will

include hand-held units about the same size as current cellular phones for individual subscribers, solar-powered phoneboxes for remote Third World villages not connected to any terrestrial network and mobile units for cars, airplanes and ships.

Motorola plans a production line for Iridium satellites in 1994 and to have the entire 77-satellite system reaching operational status in late 1996. The project would need to use L-band spectrum; unless special new low-orbit satellite frequency spectrum is allocated at Ware-92, this could present serious problems in achieving effective frequency co-ordination with, for example, Inmarsat-3 satellites. These will provide spot beams with 6dB more gain than the global beams of the current Inmarsat-2 (39dBW.rp.).

The prime contract for Inmarsat-3 satellites was placed in early 1991 with GE Astro and with Matra-Marconi Space as sub-contractor for the payloads. Delivery of the first spacecraft is scheduled for 1994 and extensive details of the Inmarsat-3 project were given at an IEE Colloquium (Digest No 1991/175) last November.

New satellite services spawn R&D

With the new generation of satellites, Inmarsat will for the first time offer radio position-determination as a fully civilian complement to the existing American GPS and Russian Glonass systems. It will also face competition for land-mobile services not only from Iridium but also the American/Canadian MSAT system that provides mobile and radio determination services in North America. Other potential competitors are the Russian Granit (Glavstar) system, the Hughes "Tritium" project and the French "Globalstar" not to mention the terrestrial GSM wide-coverage digital land-mobile system planned to serve 25 European countries.

The planned introduction of so many new services - complementing the existing mobile and personal cellular and radio-paging services is providing a strong incentive for commercial and academic R&D. Among a number of developments described at the 6th International Conference on Mobile Radio and Personal Communications (University of Warwick, December 1991 and IEE Conference Publication No 351) was a report on low-cost direct-conversion receiver structures suitable for TDMA mobile communications at bit rates up to 1Mbit/s¹. The receiver is shown in Fig.1. This group has shown that direct-conversion techniques would be well suited to TDMA transmissions such as the DECT standard and lend themselves to VLSI integration without any adjustments being needed during the production process.

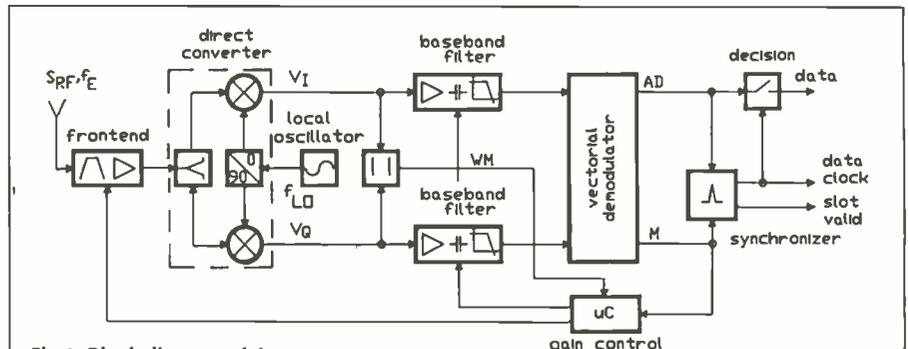
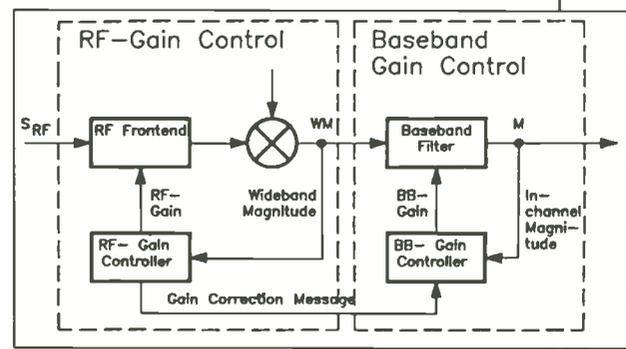


Fig.1. Block diagram of the direct conversion receiver (vectorial receiver) produced by the University of Technology, Vienna and Siemens. Source: IEE Conf.Pub no.351. The receiver's gain control (inset) consists of a slow RF-part and a fast, slot-selective baseband part.



Experimental work with a receiver based on the incoherent direct conversion principle with a vectorial demodulator is claimed to have confirmed the viability of the principle for low-cost TDMA-user equipment.

P B Kenington *et al* (University of Bristol) have also described a multi-carrier amplifier for future mobile communication systems.

This would enable any transceiver to be used on any channel within the system bandwidth without remote-switching, and might even permit a number of different schemes to be utilised simultaneously at the same base station. This would greatly facilitate and reduce the costs of transition from the current UK analogue TACS system to the digital GSM system.

The Bristol team has developed a broadband, highly-linear power amplifier in the region of 880MHz using feed-forward techniques (Fig.2) in which the low-level combined input signal is split to form a main path and a reference path. The team says that "the main path signal is amplified by the high-power amplifier, which will inevitably introduce distortion. A sample of this signal, complete with inherent distortion, is fed to a subtractor which removes the wanted signal components (using a suitably delayed version of the reference signals). The resulting signal contains predominantly the distortion components from the main amplifier which are then suitably amplified and fed forward, in anti-phase, to the output coupler. The output coupler then acts as a subtractor, removing the distortion from the through-path signal. The output signal is thus an amplified and (theoretically) distortion-free replica of the input signal".

References

1. A Schultes *et al*. University of Technology, Vienna and Siemens AG, Austria.

Pat Hawker

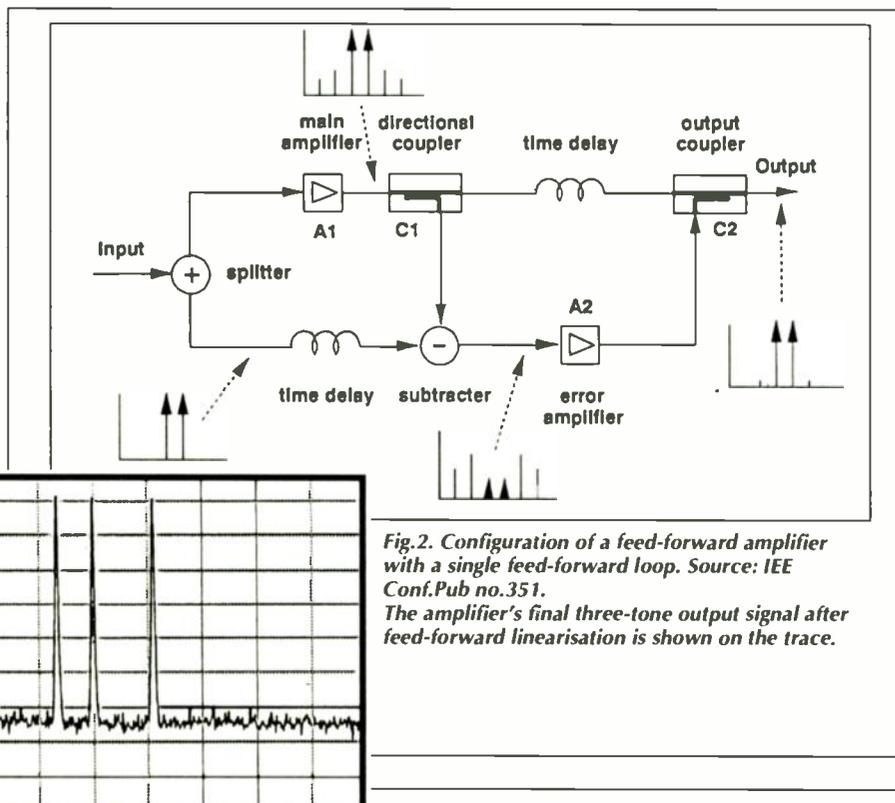


Fig.2. Configuration of a feed-forward amplifier with a single feed-forward loop. Source: IEE Conf.Pub no.351. The amplifier's final three-tone output signal after feed-forward linearisation is shown on the trace.

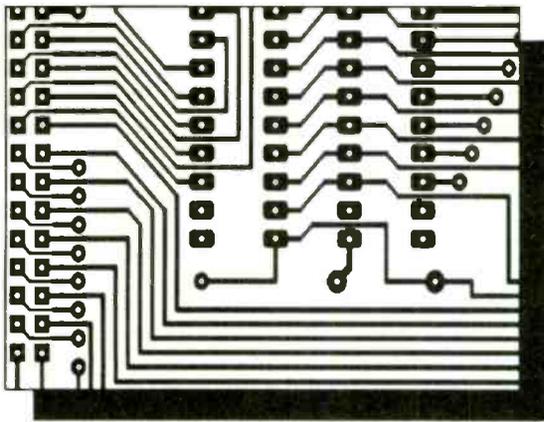
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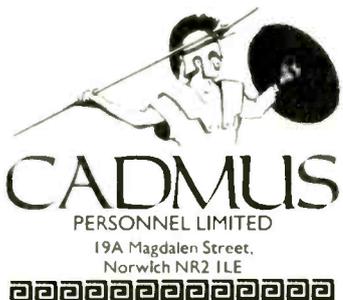
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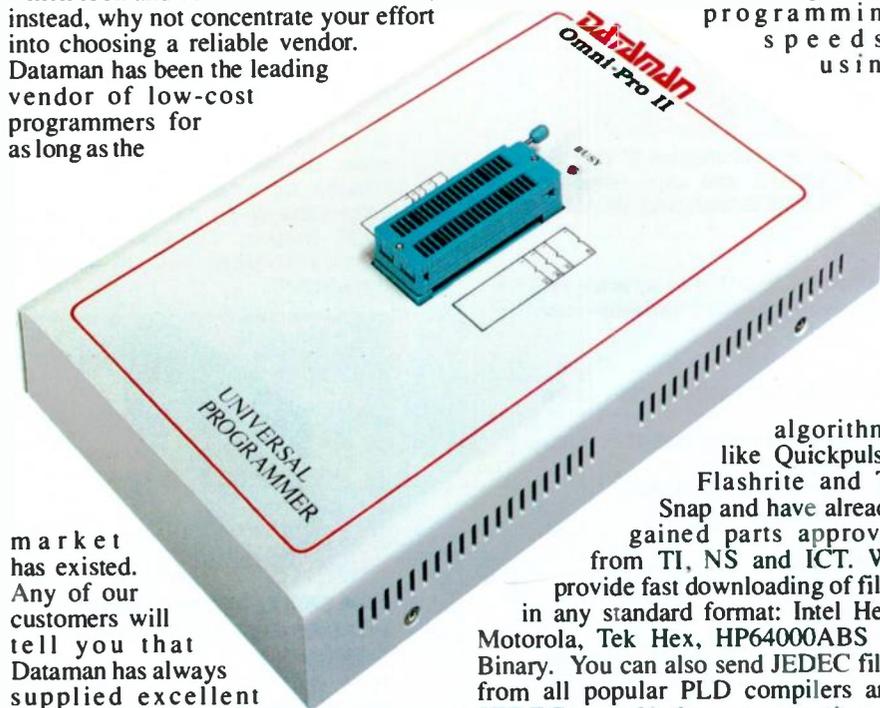
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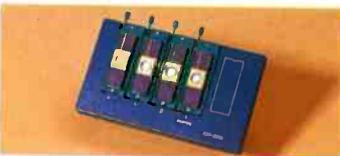
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