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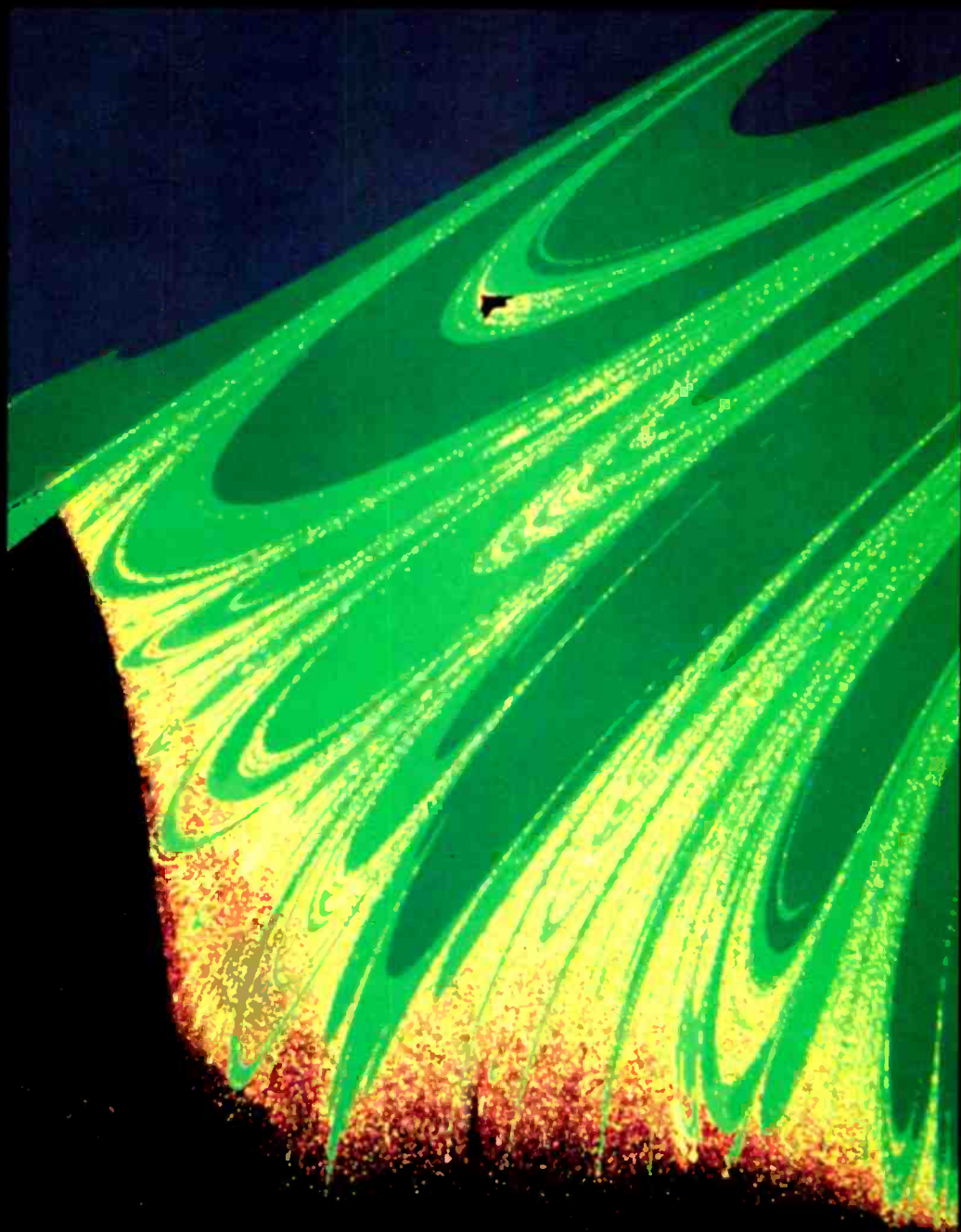
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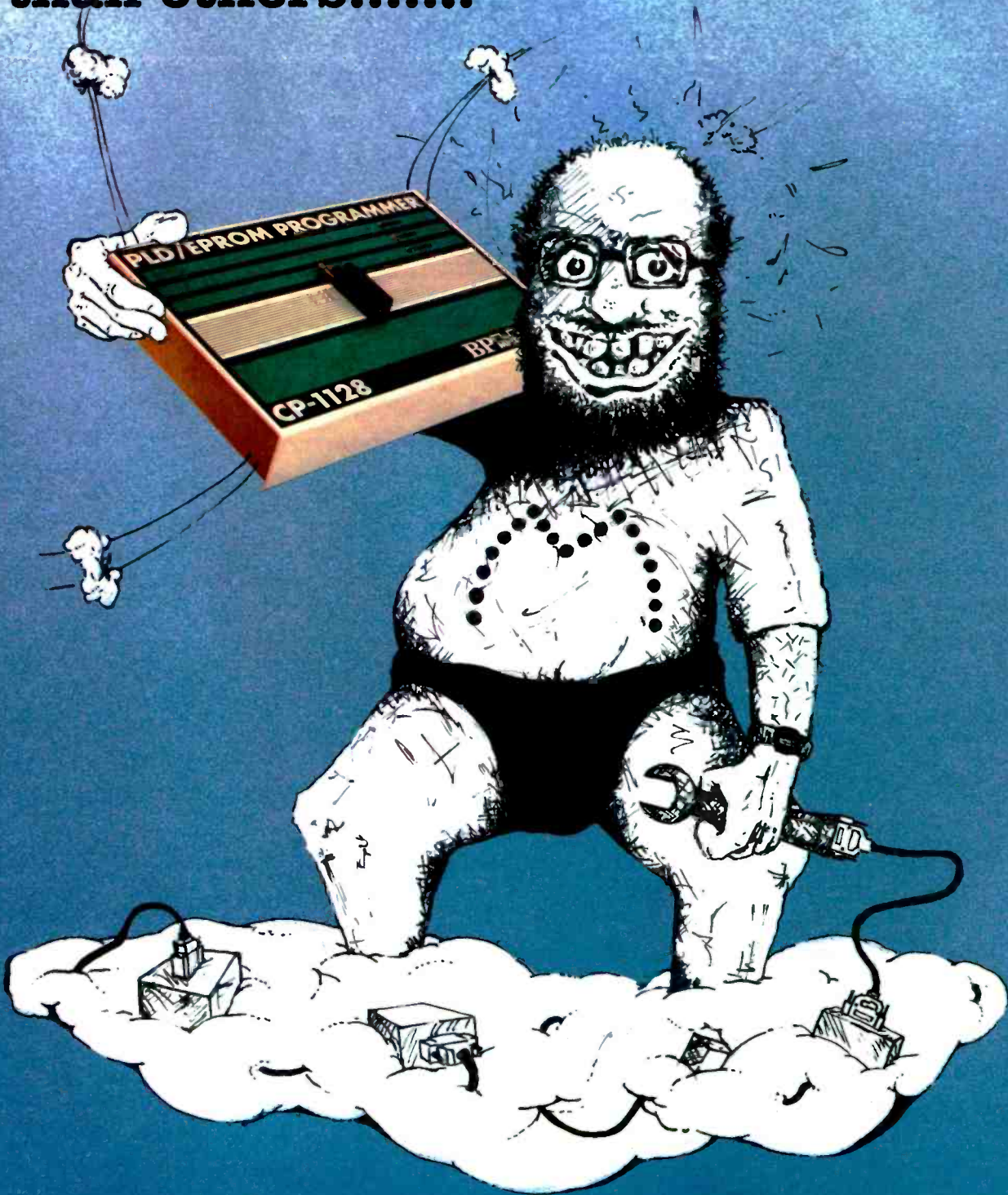


SCIENCE

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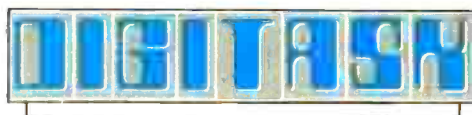
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**Q**uestion. What do corporate computer departments, estate agents and superloos have in common?

**A**nswer. They are all expensive conveniences.

Desktop computing has revolutionised the electronics industry. And a few others. A combination of IBM clones and off-the-shelf software gives instant access to design tools which, just a few years ago, would have required a mainframe computer system to run. And a commercial loan to finance.

Windows 3.0, which brings a friendly user interface to the grey world of dos, promises to deliver high powered personal computing to a wider audience although not everyone is happy about this.

Unix, which first appeared nearly fifteen years ago, is the antithesis of desktop computing. Its layered security and networking require a lifetime's career to fathom... which is at least part of the reason for its success. The luckless user needs the services of a full-time computer professional to unlock the power of Unix. And the computer department keeps the keys. It is no wonder that computer managers advise their corporate employers that risc based workstations — with Unix as the preferred operating system — are just the thing.

When individual users point out the usefulness of IBM desktop computing, the corporate computer departments immediately respond by disguising the inherent simplicity with a barrage of batch files, baud rates and technical fog.

Until Windows 3.0, which runs happily on a £1000 IBM clone, appeared, the only machine with a built-in intuitive user interface was the Macintosh. This apparently massive advantage is almost totally offset by the daft marketing and licensing policy of its sole maker, Apple Computer, which refuses to grant third party manufacturing licences. The company may yet pay dearly for the mistake.

The desktop computing industry could put corporate end users back in control if it really wanted to. Since Windows 3.0 presents a standard software interface in the same manner that IBM architecture offers standard hardware, it is a relatively easy task to develop a self-configuring network card which self-installs and operates in a totally transparent manner.

No computer professionals needed.

The network performance would depend solely on the technical characteristics of the external wiring. Other users simply look like extra drives to be accessed like any other.

Computer departments will point to the need for security... a bogus objection. File encryption systems using trap-door DES are virtually unbreakable. These, and other locks controlled by the user, offer at least as much security as the logon process which forms the principal layer of Unix security.

Simply stated, the technology exists to make workplace computing routine, cheap and highly effective. It is safe to predict that computer professionals will fight tooth and nail to prevent this.

**Frank Ogden**



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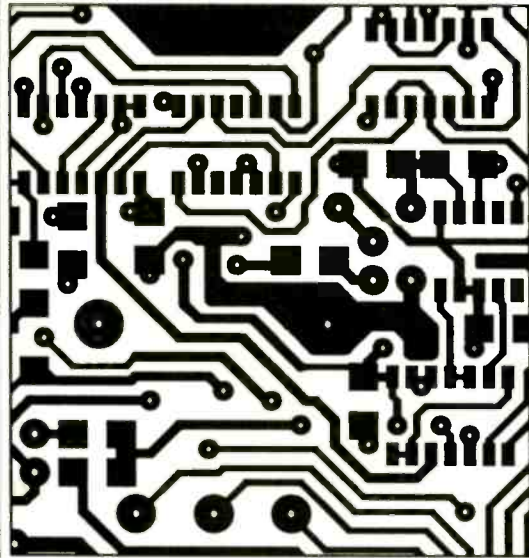
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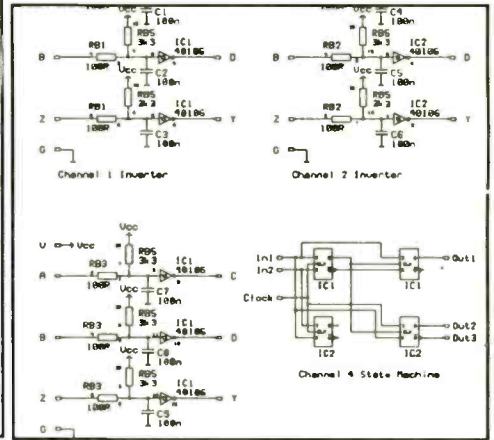
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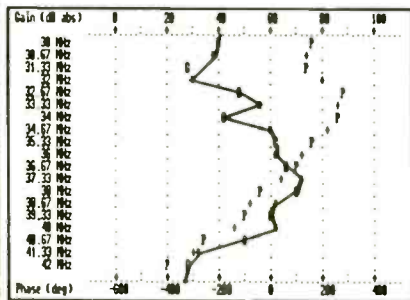
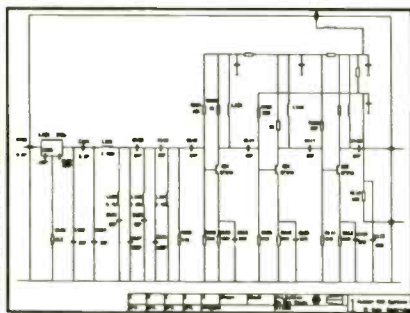
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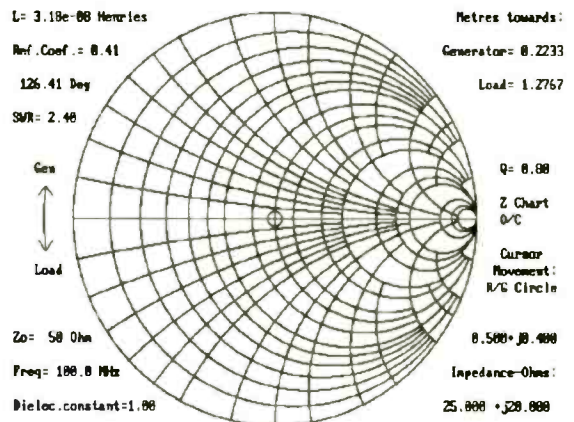
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CIRCLE NO. 126 ON REPLY CARD

# Valve failures open up photonic success

What may have struck most of us as just a rather rare form of valve failure has led scientists to announce a potential new way of making waveguides.

Brought up in the thermionic era, I can not myself remember valves failing because of electron bombardment of the glass. But the subject of "browning" failure, as it is called, was nevertheless studied in considerable detail around 1980. A paper by Gossink *et al* (*J. Non-Crystalline Solids* 37, III) showed that under electron bombardment, a chemical migration process occurs in which certain elements migrate within the glass.

Migration, particularly of sodium and calcium, has an interesting local effect on the refractive index of the glass, and it is this which has led to the novel proposal for fabricating optical waveguides.

The principle is not new, since many of today's high-efficiency optic fibres rely on a grading of the refractive index to channel the light. But electron bombardment has only once been used experimentally to fabricate channel waveguides on a flat surface; in 1976 Houghton and Townsend produced slab waveguides in pure silica, though the process was probably different and change of index was ascribed to compaction of the silica.

J Bell of Mitsubishi Electric and CN Ironside of the University of Glasgow have now published the results of their work on various types of glass in which they report (*Electronics Letters*, vol 27 no

5) creation of optical waveguides by chemical migration.

What they did was to prepare some optically flat glass slides and coat them with a 10nm coat of NiCr to make the surfaces conductive. The slides were then loaded into a scanning electron microscope (SEM) arranged to draw electron beam lines across the surface. Beam patterns were generated by a PC.

After drawing the lines, the researchers stripped off the NiCr and tested the glass for presence of waveguides by firing a 633nm HeNe laser at the edge of the glass and studying emergent beam patterns.

Different types of glass produce different results, but Bell and Ironside were able to demonstrate some very convincing waveguiding, albeit with high loss compared to glass waveguides made by ion-exchange.

What seems crucial, judging from a comparison between different varieties of glass, is the presence of calcium. As yet the mechanism involved in these latest experiments remains to be confirmed by a microscopic chemical analysis of the changes going on in the glass.

Nevertheless, the ability to create what amounts to the optical equivalent of the copper tracks on printed circuits directly without photolithographic masks offers exciting prospects. We could be seeing the basis of quicker and cheaper fabrication for a whole range of new photonic devices.

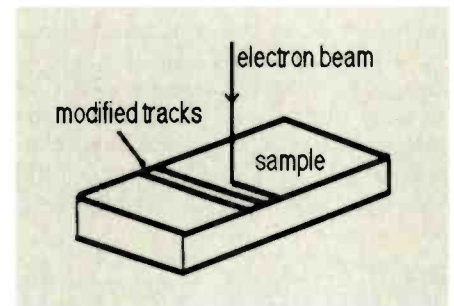


Fig. 1. PC controlled waveguide writing with SEM

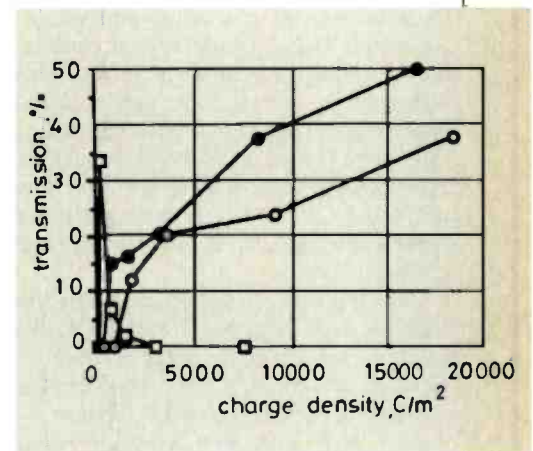


Fig. 2. Different types of glass produce different waveguiding results. ● Blue Star 1.0µm spot size ○ Blue Star 0.5µm spot size □ Corning 1.0µm spot size.

## Plastic transistors — bending the barriers for organics

Writing recently in *Nature* vol 349 no 6312, Professor David Bloor of Durham University describes a futuristic electronic device; a plastic transistor that can be bent without damaging its properties. Not merely a sort of rubberised TO92 package, the transistor is a device in which all the active semiconductor elements are also plastic.

Far from being just a novelty, the all-plastic transistor has a whole range of potential practical applications. This latest device, developed by Francis Garnier *et al* at the Laboratoire des Matériaux Moléculaires in France, is made entirely of organic molecules, principally an oligomer with the intriguing name of sex-

ithienylene — like a polymer but with only six repeating units (monomers).

The "plastic" transistor is in fact a fet type of device in which a polymeric insulating layer separates the active sexithienylene from the gate electrode.

The French workers say that carrier mobility is very much higher with the polymer insulation than with the more usual silicon oxide. So the resulting transistor, though not comparable in performance with devices made of crystalline silicon, can at least match those of amorphous silicon.

As yet, organic materials have made few inroads into a market dominated by silicon and III-V materials. Liquid crystals

are the only examples with widespread commercial significance.

But David Bloor reasons that the special properties of some of the latest organic devices may mark the beginning of the end of dominance of inorganic semiconductors in electronics.

The latest French transistor may not be the last word in speed, but it does have unique properties that will assure a big market niche for devices of its kind, particularly its flexibility. This ability to create large area conformable arrays means that semiconductors will be able to go where no rigid crystalline material has hitherto been practical.

New applications are also possible

thanks to the radically different way the organic semiconductors work. Because applied voltages move electrons from the valence band to the conduction band, polymeric materials can be made to change their optical properties. Materials normally transparent to infra-red become opaque, thus making possible an electro-optic modulator. Recent Japanese work has also produced blue light-emitting

diodes based on similar principles using organic semiconductors.

Ultimately the greatest attraction of organic devices, typified by the latest French advance, must lie in their potential cheapness and ease of fabrication. As with human brain cells, it does not matter how slow they are if you can create and operate billions of them with relatively simple technology.

## Will fast switching bring optical comms up to date?

Compared to its electronic equivalent, photonic technology and optical communications looks almost primitive and undeveloped. Advances in copper cables and complementary multiplexing equipment have gone hand in hand, to such an extent that growth of telephony and data traffic has been relatively steady. Neither cable technology nor electronics has been a limiting factor.

But with optical communications the story is very different. Potential bandwidth — and hence carrying capacity — of even the cheapest optical fibre far exceeds that of the terminal equipment — though this is hardly surprising when demand, in commercial terms, has been so recent.

Such is the pressure on communications capacity that leaps forward have been made in areas such as laser stability, heterodyne detectors and all-optical erbium-doped fibre amplifiers. Switching in the optical domain has also been the subject of a lot of research, much of it in the UK, aiming to develop a photonic switch that can turn on and off in around 1ps.

Most of us are familiar with liquid crystals which can switch their optical properties in a matter of milliseconds. Lithium niobate, a popular new material can perform similar tricks in response to an electrical stimulus within nanoseconds.

But in the search for picosecond switching, the preference is to have an optical, rather than electrical stimulus.

One method (of several currently being developed) involves splitting a light beam in two and sending one part through a non-linear material which, when acted on by another light signal, slows it down

enough to retard the phase by 180° and cancel out the unretarded part of the beam; in effect switching off the whole beam.

Unfortunately materials with the largest non-linear coefficients often have the highest absorption factors, especially at the wavelength of maximum non-linearity. Materials like silica, which have low loss, require hundreds of metres of fibre to get much of a phase change.

Optimisation of these properties is currently being pursued actively at BTRL Martlesham Heath and Chris Winter *et al* (*App Phys Letters* 58, 107) report considerable progress with new materials called nickel dithiolates.

Tests on solutions of these organic materials are already extremely promising. Good non-linear coefficients and low absorption are apparent, especially at the second harmonic of the laser light where, because of non-linearities at high intensities, additional absorption can occur.

Obviously this is very much preliminary work.

Any practical device will require the material to be produced in the form of a solid, either as a crystal or as a polymer. No one is yet certain either how well such materials will withstand constant high level irradiation without degradation (though organics are currently the best performers in this respect).

Nevertheless, in a field where switching technology is still one of the limiting factors, any progress of this kind is almost bound to produce benefits sooner or later. The ultimate goal of a practical ultra-fast all-optical switch can not elude us for much longer.

## Prime purpose for 100 computer ring

A pet hobby among mathematicians is to search for ever bigger prime numbers. But while it is easy to test relatively small numbers it becomes much harder when the number of digits runs into thousands; imagine the effort to trying to divide such a number by every other smaller number!

The search for very big prime numbers inevitably takes a lot of time — often months on the world's biggest supercomputers — and since searching for these numbers has virtually no commercial significance, it is not something that usually rates a very high priority.

Mathematicians looking for huge prime numbers start off by calculating what are known as Fermat numbers (after the French mathematician) calculated from the simple formula:

$$2^{2^n} + 1$$

Suffice to say that by about the time you reach the 7th number in the Fermat series, it is bigger than the total number of atoms in the known universe.

Because of the sheer amount of computing power needed to process these mind-boggling numbers, there is little chance of mathematicians ever being able to obtain enough time on computers with the necessary power.

For that reason, Dr Richard Crandall of NeXT, has decided to try a different approach and make use, not of one big computer, but of all the spare capacity in some 100 networked workstations around the company offices.

A programme called Zilla polls all the workstations and repeatedly asks each one if it is free. If yes, then a small piece of the prime number calculation is fed along to the workstation and the answer fed back to a central point.

Zilla can make effective use of a workstation even if its owner has abandoned it for only ten minutes. Of course, if a terminal is needed for real business, Zilla can extract the calculation and restore normal working within a few seconds.

Crandall says that Zilla has effectively created a supercomputer that costs nothing.

*Continued over page*



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ing: it merely makes use of existing capacity that is sitting idle.

Already Zilla has confirmed that the 13th Fermat number:

$$2^{2^{13}} + 1$$

is not a prime number. When you consider that F13 (as it is called) has about 2500 digits, the full amount of arithmetic becomes apparent.

Zilla is now about to attack F22, which may yield the world's largest known prime number. Richard Crandall reckons it will take about six months to find the answer.

## Flashes of insight into ball lightning

One of the most mysterious of all natural phenomena is ball lightning. Over the years thousands of people have reported seeing football-sized glowing objects floating through the air and then apparently disappearing.

Reports of ball lightning go back hundreds of years and have attracted a great deal of scientific curiosity. Sometimes the balls appear as benign objects that just drift through walls or else explode violently.

Sometimes they are greenish-blue, white and even orange in colour. Trying to investigate ball lightning scientifically is difficult because it does not occur regularly or to order.

But a search though the literature shows that ball lightning usually occurs during electrical storms (as with conventional lightning), has very little weight (being able to float) and may not always be hot (being able to pass through some materials without causing damage) and has frequently been seen moving against the direction of the wind.

Those observations have led to a number of theories, mostly involving electrical discharges or the presence of fuel gases such as methane in the atmosphere. One of the most interesting ideas, proposed as long ago as 1955 by the Nobel prizewinning Soviet physicist Peter Kapitza, proposed that ball lightning might form at antinodes of interference phenomena among naturally generated radio waves.

But until recently it has been impossible to carry out the definitive experiment



and re-create ball lightning in the laboratory.

Now two Japanese physicists have described a series of experiments, *Nature* (vol 350, no 614) culminating in the creation of artificial ball lightning in a natural atmosphere. What is more, the artificial lightning seems to show many of the properties of the natural variety; its ability to pass through a wall intact and to move against the wind.

YH Ohtsuka, working at Waseda University and H Ofuruton at the Tokyo Metropolitan College of Aeronautical Engineering, describe a series of experiments using a 1.5kW source of microwave energy at 2.45GHz — in effect a rather big microwave oven.

When power was fed into the empty cavity of the device, several different types of plasma fires were observed, most occurring only when the apparatus was switched on, though not always at the expected electrical hot spots. But on a few rare occasions, a glowing ball punched a small hole in the aluminium foil that formed one end of the cavity.

After emerging through the hole it continued glowing for a second or two after the microwave power had been switched off.

In a final experiment, the Japanese team introduced a copper bar into the cavity.

When the microwave energy was turned on, a ball-shaped glow was seen to move along the bar. Interestingly it moved in the opposite direction to a strong blast of air created in the cavity by a fan.

All these observed properties — the ability to pass through walls, the tendency to move against the wind — seem to indicate that what the Japanese scientists have created is similar to natural ball lightning. If so it suggests that Peter Kapitza was on the right theoretical track 35 years ago.

The Japanese are cautious, though, recognising that high-powered microwave radiation does not exist widely in nature (thankfully). But they do believe it can occur momentarily where, as in a thunderstorm, there is a rapid variation in atmospheric electricity. Such momentary bursts of energy could well be enough to create a lightning ball which — as the experiments have shown — can persist for several seconds after the energy source has been removed.

Precisely why that happens is still a mystery, though the chances of it being solved are vastly greater now that ball lightning can be created in the lab, more or less to order.

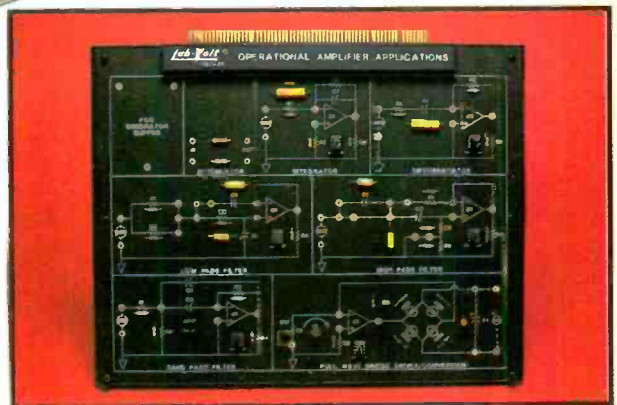
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## Compatible computing?

Twenty one computer companies have got together to link the major operating systems. The group, which calls itself ace (Advanced Computing Environment) hopes to set a future standard by providing a common path from laptops through to large data centre machines.

Although Intel is a member, the show revolves around the US company Mips with its Unix optimised risc architecture. The ace companies, which include names such as DEC, Compaq, Bull, Prime, Wang, Pyramid and Silicon Graphics, have invited all vendors to join the fold providing they adopt Mips 64-bit R4000 technology. It conspicuously ignores the fastest selling spare architectures as well as high performance processors from Hewlett-Packard and IBM.

Using Mips' rise in a scalable form, ace intends to blend together dos and Unix applications under two operating systems supplied by Microsoft and the Santa Cruz Operation (SCO). Connectivity tools will be built into the hardware and the group claims that software can be recompiled to make the leap from PCs to risc systems where necessary.

The ace initiative could offer a unified Unix following the split into two camps: originator AT&T and the dissenting Open Software Foundation. SCO will provide binary compatibility between OSF1 and

AT&T Unix applications under its revised Open Desktop product.

The convergence of PCs running DOS and more powerful machines running Unix on networks has been the spur behind ace. The same factor is also driving computer companies in general to find ways of bridging the various operating systems while including all the existing desktops.

Ace's industry critics maintain that the inevitable committees necessary to work out a shared standard will cause such a delay as to minimise any benefits to the user. They also claim it ignores the extensive investment already made in other implementations of Unix and risc.

There have been several recent deals to smooth incompatibility problems between rival computing techniques. For instance, the Open Document Architecture initiative between IBM, DEC and others allows unmodified transfer of documents between incompatible machines. On the Unix front, HP and Sun are now working together to develop shared object-oriented code for their operating software.

Companies outside the ace club are also pushing technology. Hewlett-Packard's new workstation exceeds 76mips. Hundred mips processors from other vendors are imminent.

**Dom Pancucci**



All politicians like to hear good news for a change and the opening of a £12million plant by Orbital Mobile Communications to manufacture cordless telephone products plainly brought a smile to John Major's lips. The Prime Minister officially opened the plant earlier this year.



Pig fanciers worrying that their prize porkers might be pig-napped can rest easier in their beds — thanks to Texas Instruments. TI's Tiris battery free responder with an antenna and a tamper-proof code built into its electronics (like the one above) can be injected just beneath the animal's skin. It can also track products through manufacture and distribution — so no more porkies over ownership.

## Novel process for 2m transistor chip

Inmos, the UK's only microprocessor company, has finally unveiled the technical spec for its next generation of chips. The T9000 is such a powerful device, and on-chip communication so extensive, that the density of transistors has forced use of a new method of connection of the metal layers.

Embedded systems are the target markets for the T9000 range and Inmos says its capability will see it adopted in imaging equipment such as printers, HDTVs and scanners, and mobile and broadband ISDN communications systems. "Embedded computing" — hard disk arrays and applications accelerators — and fault tolerant or safety critical systems are two more potential markets.

But as yet there is no finished silicon. Given that the processing technology is new, this must cause some grey hairs at Inmos' Bristol headquarters. All the features are of little use if the silicon die ends up too large to process, so layout and design are critical.

The T9000 will have more than two million transistors, built on a 1mm geometry but with three, rather than the more conventional two, layers of metal interconnection. The resulting die is around 180mm<sup>2</sup>, and relies on the new way of connecting the metal layers. Inmos says the chip represents one of the highest packing densities yet achieved.

First silicon is promised by the middle of the year and until then, the T9000

range constitutes little more than an impressive computer aided simulation. But if fabrication technology measures up, and there is no reason why it will not, the chip could end up as the benchmark by which others are judged.

In preparation for the launch the last twelve months have been spent building up software support for the products, including Chorus Unix, a real-time operating system kernel, C, C++ and Fortran compilers. The chip will execute code developed for existing T8 products, so there will be compatibility.

Far from being the usual UK "solution looking for a problem", the T9000 looks a usable product aimed at a definite market — saying much for the influence of Imnos parent, SGS Thomson.

The chip itself has a superscalar core to allow it to perform several tasks, such as instruction fetches, data fetches, and computations, simultaneously. It can issue several instructions in each clock cycle, using a five stage pipeline to decode different parts of an instruction at every stage, as well as grouping instructions to run at maximum speed.

Peak performance from the 32-bit integer processor is 200mips, while a 4-bit IEEE-compatible floating point unit gives 25mflops at 50MHz. The external clock runs at 5MHz and the chip uses smart phase locked loop technology to produce higher on-chip frequencies.

As always, there are four external serial communications links, but speed has been increased from 20Mbit/s in the T8, to 100Mbit/s for the T9. A separate on-chip communication processor VCP handles the communications protocols.

The chip is designed for multi-tasking, and the VCP can allocate a "virtual channel" to each separate process which is then mapped on to the appropriate physical connection when necessary.

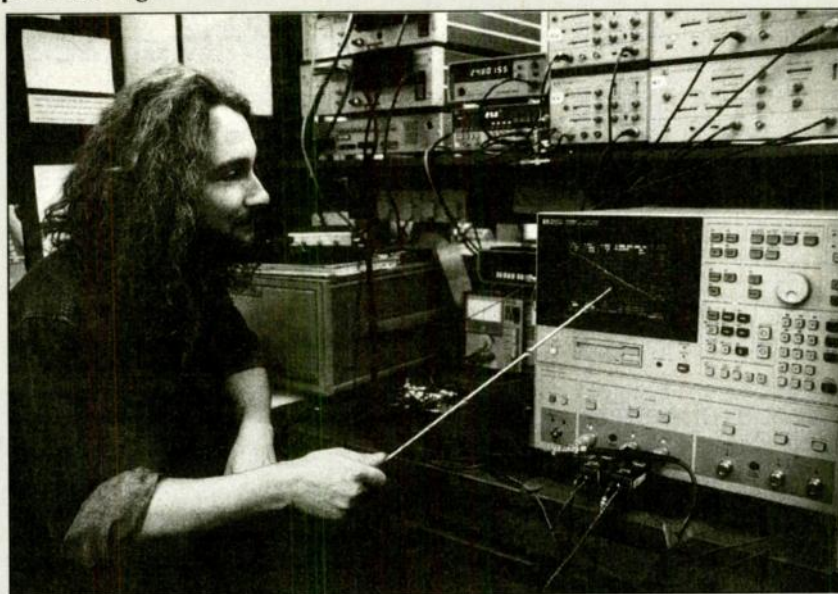
To support targeting of embedded systems the chip has 16K on-chip memory, useable either as cache or part cache: part main memory. A programable memory interface means it can talk to ram, sram and eprom in the same system.

Imnos is claiming a total external memory bandwidth of 200Mbyte/s, and the chip needs to be able to handle all of this, plus any data arriving at the communications links. Four internal buses shunt data to where it is required

**Andy Gothard**

## Lucky strike runs slow

**Jim Luck, of King's College London, demonstrates the use of insulated gate gallium arsenide fets in building switched capacitor filters. The igfet has some odd characteristics which limits its use at low frequencies. However clocking the devices at an incredibly slow 25MHz has allowed researchers to build a circuit which consumes less than one thousandth the power of other implementations. With production device technology, claims Luck, circuits could be built which switch at up to 625MHz yet maintain the power saving.**



## Red, hot tech push

Communist China is engaged in a massive technology push, according to *China Report* published by the People's Republic. It is undertaking a programme to develop its own colour TV cad system and, secondly, it hopes to manufacture a greater proportion of set components. The cad system is based on 32-bit minicomputers and can be used for simulation, mechanical and PCB design work.

The country has also designed a two-chip IC set for its Zhonghua brand colour TV "by modifying the irrational internal parameters of imported ICs".

Chinese manufacturers can already produce components such as diodes, transistors, power devices, wire frames and packaging moulds.

The country's inscrutably named No. 15 Research Institute has developed an AT286 look-alike with a VGA display

called the KT2500 which, the *Report* says, will exert a considerable impact on the domestic computer market "providing it is put into mass production". It has also developed a microprocessor based on the Motorola MC68020 which operates at a clock speed of 20MHz, complete with 32-bit data and address busses. It comes with Unix V as standard.

This work has apparently attracted interest from US firms; Stratus has said it will set up an office in Beijing in a partnership with Xin Tai Electronics.

The Tianjin Research Institute has developed a dual-channel FFT dynamic analyser based on an IBM PC board with a frequency range up to 100kHz. It uses the TMS320C25 DSP card and can do a 1024 point complex FFT process in 50ms. It has also developed a multi-standard modem which uses pal technology.

## British Technology seeks sound funding

The British Technology Group is looking for licensees to develop a product for controlling and increasing the loudness of audio waveforms.

Called *simitar* (simultaneous near-instantaneous and time averages response), it operates by combining the functions of a mean loudness controller and a wave shape compressor. The two processes are similar, differing mainly in the rate at which gain changes are applied to the input signal to control its amplitude.

Inventor Dr Louis Thomas claims wave shape compression can increase the loudness of an audio signal without increasing its overall amplitude, making it particularly useful for speech which has a low average power level compared with its peak power. Improvements in intelligibility are achieved by raising the level of the intelligence carrying and the quieter sounds such as consonants.

The measured quantity in the waveform is the peak amplitude of individual waveform half cycles between consecutive crossings of the zero axis. Only the magnitude is used, not the sign. Changes in gain are applied to the waveform at zero crossing instants and hence the input and output half cycles

have the same shape and differ only in their peak amplitudes.

The technique can be applied to music or data waveforms and to wider bandwidth systems such as public address, broadcasting and hearing aids. A full report appears in *Electronics World* next month.

## Space station faces cut

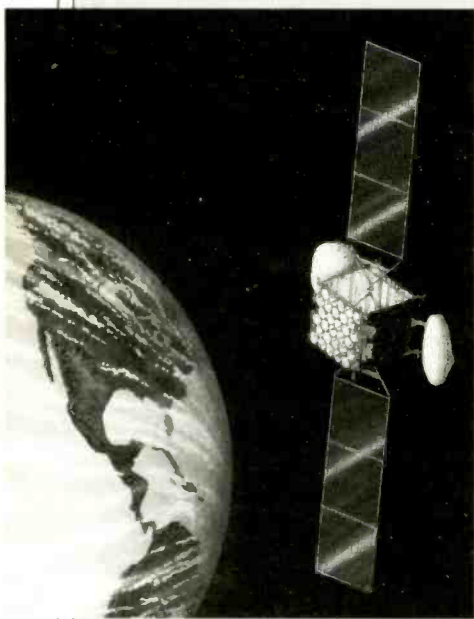
US budget cuts have forced Nasa to design a cut-price version of its Freedom space station.

The redesign was done in four months and has involved simplifying the modules, to make them easier to assemble in orbit, and reducing dimensions by up to 40%. It will also take fewer shuttle flights to build.

The station will be launched early in

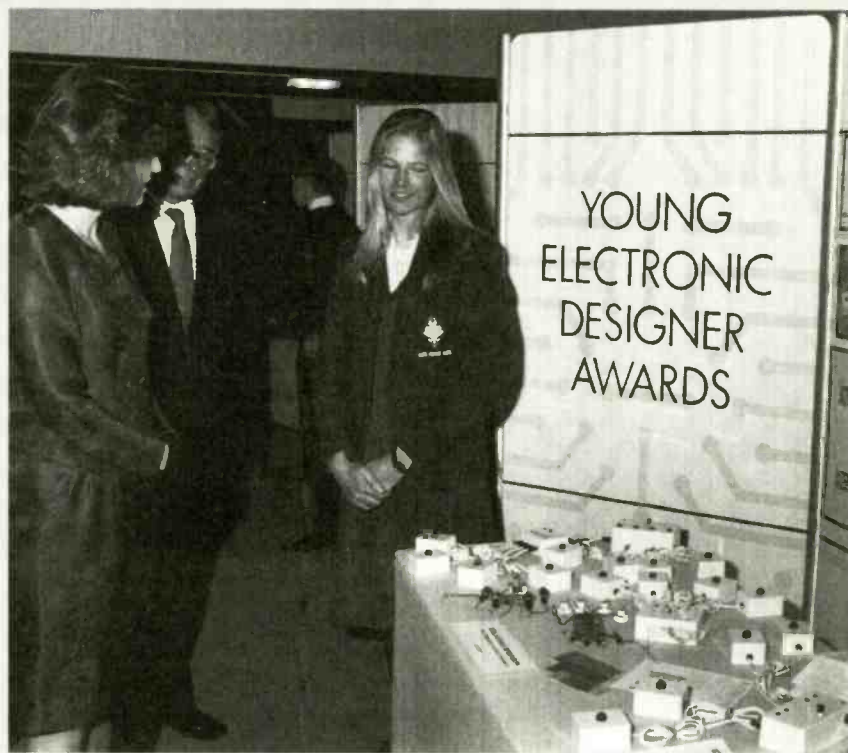
1996 and will be ready for astronauts to work in mid 1997. They will be able to stay there for up to two weeks. It is hoped that the station will be permanently staffed by 2000.

■ One set of Freedom solar arrays will generate about 22kW of power of which a minimum of 11kW will be available to users.



Mexico is set to get two second-generation satellites to back up its existing Hughes Morelos system. Called *Solidaridad*, it will be based on two Hughes HS601 model spacecraft (like the one above) and will provide television, telecomms and business network services over C and Ku band and mobile comms with L band operation.

**Quick off the mark:** Fourteen year old Pollyanna Robinson's *Quizmaster* won her first place in the Junior category of the Young Electronic Designer Awards, and a visit from the Duchess of York. Her device, which shows the first contestant to respond in a quiz game, also won a TI award for commercial viability.



## Astra flies into EC attack

By June 3, Commissioner Pandolfi, head of the EC's telecommunications directorate DGXIII, will have had to reach a decision on whether to make the mac transmission standard mandatory for satellite television. In attempting to do so he is faced with an apparently irreconcilable dilemma. Either he must anger millions of people by making their existing satellite receivers obsolete or risk being accused of pulling the plug on Europe's HDTV initiative opening the door to the Japanese, and letting the EC's authority be flouted with impunity.

The decision is needed to set the terms of the new EC directive on mac and the problems arise from the shortcomings of its predecessor issued in 1986 and due to expire at the end of this year.

That directive (86/529) specified the mac transmission standard for all direct-broadcast satellite TV. Unfortunately it also specified the frequencies to which it would apply, the so-called BSS broadcasting satellite service frequencies as allocated by WARC '77.

Thus, when Astra started up using a different set of frequencies it was under

no obligation to use mac. Astra has always claimed with justification that mac was not ready when broadcasting started.

### Huge additional costs

The result is that the most commercially successful satellite operation is outside the scope of the outgoing directive. To rewrite it to bring in the BSS frequencies is unrealistic.

It stands to alienate all owners of Astra dishes. There are now about three million in Europe (including 1.4 million in the UK) forcing them to buy mac converters costing at least £140 each. Huge additional costs would be imposed on broadcasters and cable operators.

The first EC meeting called to discuss the new directive took place in Brussels in February. It was attended by various interested parties including manufacturers — Philips, Thomson, Nokia and studio equipment specialist DTS (part Philips-owned) — satellite operators including SES (Astra's owners), broadcasters and state agencies.

Although there was a split between the pro-mac group (manufacturers and

governments) and others like SES and commercial broadcasters, there was a general consensus that high definition TV, was desirable.

### Anti-mac bias ?

Astra claims that it has always regarded its satellites as transparent as far as transmission systems are concerned and indeed there are four D2mac channels broadcasting to Scandinavia on Astra 1A/1B. Its position is that there is no particular logic in imposing mac in the interim for two main reasons. First, an HD-mac standard has not yet been defined; therefore a mac standard which would be compatible with it cannot be defined. Secondly, the BSS frequencies on which Astra transmits are unsuitable for HDTV so anyone broadcasting on them in Pal or mac would still have to simulcast to transmit in HDTV. Astra has applied for HDTV-suitable BSS frequencies for its 19.2° E orbital slot to be used by 1D.

### A way out?

Commissioner Pandolfi has been following up the March meeting in an attempt to find a way out. Most people however are convinced that there isn't one. Astra is a fait accompli. To remould it now to fit what EACEM calls "the agreed European scenario" would simply cost too much money. It would also risk destabilising the growing but fairly fragile satellite TV market.

Pandolfi has reportedly ruled out making the consumer pay, but his only other option looks like being a fudge — the imposition of mac made conditional on some meaningless target.

This would be little help to the European HDTV effort. It is to be hoped that Astra is right after all, and it can succeed without mandatory mac.

Peter Willis.

### MAC LOBBY PRESSURE

Mac's future still looks confused. Back in February (see next page) a working group was set up — including pro-mac Philips, Thomson and DTS and, in the "anti-imposition" camp, SES-Astra and ACT, the Association of Commercial Television of which BSkyB is a member. The group reported back at the end of March. Predictably, given its constituents, it failed to reach a unanimous conclusion. Equally predictably, there appears to have been an attempt to hijack the working party by the mac lobby. A paper presented at the report-back meeting which contained a specific timetable for the imposition of mac has been disowned and dismissed as a mere working document by SES and other working-group members. It follows on from a highly tendentious document *Satellite TV — the facts* put about under the banner of EACEM — the European consumer electronics manufacturers association — of which the mac-supporting manufacturers are key members.

As well as brow-beating the EC over its legal duty to extend the mac directive and fulminating that "those who tried to circumvent it are now facing the consequences of their own actions", the EACEM document proposes a five-year transition period — "a period of grace" — which would "ensure that ordinary viewers do not suffer in any way." Any way that is

apart from having to buy a mac converter (from one of the EACEM members naturally) at a cost calculated elsewhere in the same document as an "inexpensive" 200 ecus (about £140).

The working-party working document is more specific: D2mac and *Eurocrypt* for Europe by 1994 and for the UK by 1996. It makes this conditional on "a certain threshold penetration" of mac receivers being achieved by these dates but leaves the question of what that level should be to a later date and another committee.

It also proposes that all TV sets above a certain size (to be established) and all satellite receivers sold after the directive comes into force must include a mac decoder. Mac/Pal receivers are already on the stocks: they were shown at the recent Cable Satellite Show in London; estimated price premium over Pal-only models was £80.

A subvention of cash for broadcasters who simulcast during the changeover period is mentioned but the cost of replacing home receivers is thought to be too high for subvention. It is reckoned to be between 800 million and 1.8 billion ecus (£600m - 1.3bn). Extra costs would be incurred upgrading cable networks — which currently account for many more viewers than the DTH market. These have been estimated at 10bn ecus.

*Editorial survey: use the information card to evaluate this article. Item B.*

Thank you to all those readers who have so far sent in their evaluations of *EW + WW* editorial items. We are currently processing your comments — so keep them coming..

# THE SCIENCE OF CHAOS

Chaos suggests anarchic disorder although the word itself has a more subtle technical meaning. Nick Beard spells out the message in the noise.

**C**haotic systems are absolutely predictable, at least in theory. The theory immediately breaks down in practice because chaotic systems are so sensitive to the initial circumstances from which predictions are made.

The classic example is the weather, the source of the so-called "Butterfly Effect" chaos example. The physical processes that determine the weather are not particularly mysterious: they fall largely into the category of explicable physics. If it were possible to measure to arbitrary precision all the variables involved in climatic development, it might - just - be possible to predict the weather from now on for ever.

Chaos foils such efforts. If absolutely everything were measured to sub-atomic detail, apart from the flap of a butterfly's wing, the predictions of subsequent climatic behaviour could be wildly wrong. Thus the unaccounted-for butterfly in Brazil is said to have "caused" a typhoon in Texas.

Of course, the butterfly in Brazil does not really carry any more of the responsibility for the storm than the people exhaling in Esher or shouting in Sheffield. It is simply that the essence of a chaotic system means the slightest error in the initial circumstances used to calculate a system's

future behaviour results in predictions that are hopelessly inaccurate. *Chaos amplifies what we don't know.*

## Chaos theory

Chaos theory is part of the wider discipline of non-linear dynamics. Not all non-linear systems are chaotic, and not all chaotic systems display chaos all the time. A classical feature of non-linear systems is that by varying some parameter, a *qualitative* change in dynamics is induced. Such changes are called *bifurcations*. A simple example is the dripping tap. As you slowly turn on the tap, a regular drip-drip-drip develops. With a further increase in flow, the dripping becomes irregular. It then becomes smooth again and continuous. Further increases prompt another change to turbulent flow, and so on. The maths underlying bath taps is complex - the sprawling equations of fluid dynamics - but examples of similarly chaotic behaviour can occur in simple equations.

A chaotic system can be expressed in simple mathematics. In the differential equation:

$$\frac{dx(t)}{dt} = f[x(t), r]$$

Bifurcation is said to occur at  $r = r_0$  if qualitatively different dynamics occur for

parameter values of  $r$  above and below  $r_0$ . Here  $r$  is referred to as a "control parameter" - it is the equivalent of the rate at which water leaves the tap in the example above. A bifurcation would be the shift from, say, irregular dripping to continuous laminar flow. Bifurcations can lead to chaos.

In a chaotic system, if a control parameter is gradually increased, a whole series of well defined bifurcations may occur. For example, in the logistic map:

$$X_{n+1} = rX_n[1 - X_n]$$

As  $r$  is increased, a series of period doubling occurs, where the attractor changes from a stable point through successive stable cycles of period 2, 4, 8 and so on - up to a point (around  $r=3.5$ ) at which "chaos" ensues (*see screen illustrations p465, 466*).

This behaviour can be seen in real-world systems too. The capacitance present in the junction of a reverse biased semiconductor diode can behave in a chaotic fashion when driven from an AC voltage in a circuit with series inductance and resistance. Normal capacitors exhibit a linear relationship between voltage and charge; varactors behave altogether differently through the non-linear relation between charge  $q$ , and voltage  $V$ :

$$V(q) = \left[ 1 + \frac{V(q)}{0.6} \right]^{0.43} \times \frac{q}{C_0}$$

The relationship for the time dependence of charge,  $q$ , is given by the differential equation:

$$Lq + Rq + V(q) = V_0 \sin(2\pi f_1 t)$$

In this system, the voltage  $V_0$  serves to function as the control parameter - like the rate at which water flows through the tap - and as it is increased, the system displays a bifurcation route to chaos similar to that shown by the logistic map discussed above. Alternatively, plotting the current-



versus-voltage phase portrait shows that as voltage increases, the period of oscillation repeatedly doubles until a chaotic signal appears.

The bifurcation sequences found in various non-linear systems can be grouped into quite a small number of categories. These recur in many different situations: a collection of so-called routes to chaos. It is this sort of observation which has prompted so much speculation about universality in chaos.

Note that the variables in the equations can be vector-valued, which means that each variable in the system is in fact described by a collection of independent values, rather than just one. In these cases the equations might look like this:

$$\frac{dx_1(t)}{dt} = f_1[x_1(t), x_2(t), \dots]$$

$$\frac{dx_2(t)}{dt} = f_2[x_1(t), x_2(t), \dots]$$

## Phase space

In cases with many independent variables, the system can be said to describe motion in a phase space of many dimensions. For instance, the behaviour of a pendulum can be observed in two dimensions; if the cord is of fixed length, the motion can only be on a surface (albeit a spherical one). If there are more degrees of freedom, such as where the pendulum weight is made of gradually melting ice, the number of dimensions increases. As each new dimension is considered as being plotted at 90° to each other one, an abstract hyperspace develops - phase space.

Earlier we observed that a chaotic system is so sensitive to its initial state that in practice, this state cannot be specified with sufficient precision for long term predictions to be made. The "initial set of circumstances", then, refers to a point in phase space. The system's behaviour may then be considered as a trajectory through phase space from this point. The definition of chaos can now be understood as *the degree to which nearby trajectories*

*come together or separate.*

During chaotic behaviour, the system may have many trajectories through phase space that follow each other very closely for a while, but which then veer wildly off in different directions. It is easy to see how a prediction of such a system's behaviour could go wrong. The specification of a starting point need only be very slightly wrong to place it at a point on a trajectory that swiftly diverges from the one which describes the particular future of interest: this, again, is the Butterfly Effect.

A crucial concept, then, is of sensitivity to initial circumstances. Examples of this sensitivity are almost unbelievable. Crutchfield *et al* (1986) describe a hypothetical snooker robot, that is able to play with absolute, perfect accuracy, on a very low friction table. It is linked to a hypothetical computer, something like a hypercube of Crays - almost unimaginable computer power. The starting point for the robot, the state of the snooker table, the positions of the balls etc, is specified in

## ATTRACTORS

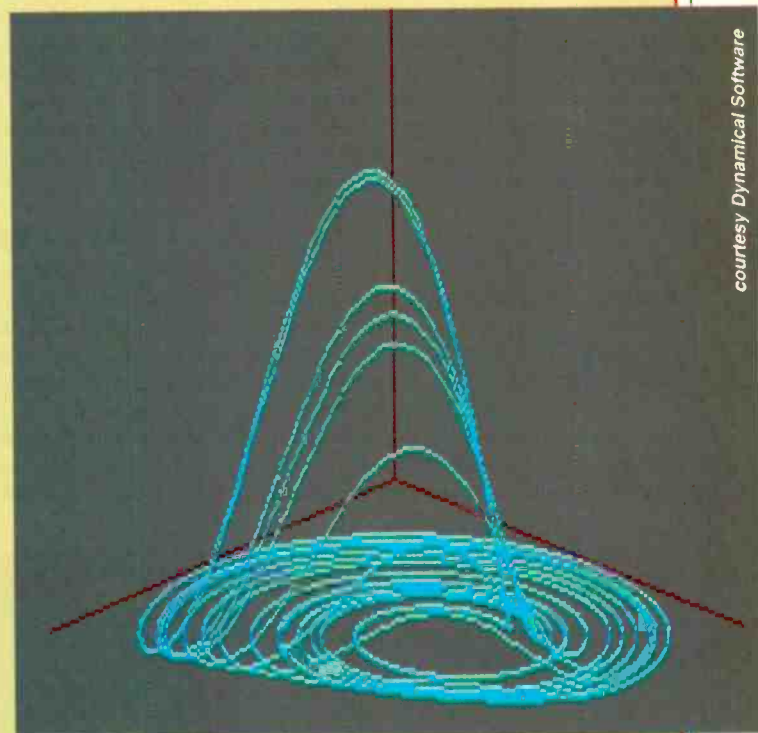
An attractor is a simple but important notion in dynamics. It indicates the point to which the system is attracted in time. For example, consider a simple pendulum. No matter where you start it swinging, it finishes its to-and-fro session in the same place: at rest, with its string precisely vertical.

It can help to consider the state of the system at any particular time as a point in phase space - the space defined by the dimensions of the system in question. This point will move around phase space until - in the case of the pendulum - it finally comes to rest at a particular point. This point is the attractor - the state in which the system ends up if left to settle.

The pendulum - or rather an idealised version of it - was studied by 19th Century French mathematician Henri Poincaré and Swedish mathematician Ivan Bendixson. Together they gave their names to the Poincaré-Bendixson theorem. This posits that for a system represented by a differential equation in a plane (ie with two degrees of freedom - like a pendulum) there are typically only four types of behaviour - called sinks, sources, saddles and limit cycles. These are steady states, though with different types of stability. A limit cycle is a repeating sequence which, once started, goes on forever. Other types of behaviour exist, but are vanishingly rare. However, Poincaré and Bendixson could not prove their theorem for higher dimensional systems.

In the 1960s, Stephen Smale joined in. He couldn't either - but he succeeded in finding a new type of attractor in systems of higher dimension. These attractors - neither points nor circles - were called strange attractors by mathematicians Floris Takens and David Ruelle. They have become a hallmark of chaos. Strange attractors have complex shapes in high-dimensional space. The important point is that although the trajectories of the system remain bounded by a region of phase space, they never converge onto a unique closed curve or limit cycle.

How do we know that these things exist and have any meaning for real dynamical systems? How do we get to see a strange attractor? The mathematical description of a strange attractor developed by Takens and Ruelle is abstract - it is not built of measurable variables. You cannot take the equations that describe some real physical system (like the Navier-Stokes equations for fluid dynamics) and mathematically derive a topological description of a strange attractor. Instead, Takens derived a strange attractor from an experimental time series. The principle is simple. The signature of the overall (multi-dimensional) system behaviour is visible in each of its single dimensions. This is



courtesy Dynamical Software

not unlike being able to guess what someone is doing in three dimensions from a silhouette. To reconstruct a 3-D image of an attractor from a time series, two dimensions of dummy measurements are derived by using three successive values along the time series as coordinates: the actual coordinate and its two neighbours. This is a process of embedding the data in higher dimensions. Surprisingly, this gives a good approximation of the attractor shape. This is sometimes called reconstructing the phase portrait. Ideally, the results of embedding the data in successively higher dimensions should converge on similar dynamical properties.



**Dynamical Software: Henon attractor.**  
The colours represent the velocity of the trajectories.

beat with a high degree of regularity can indicate heart disease. Healthy hearts beat "irregularly".

The fuzziness that seems to dance around all measured signals might not always be noise. A signal so messy that it looks as though it could never reveal its true dynamics might in fact have quite a simple set of functions at the root of it. The problem is getting at those functions. There are a number of techniques for extracting dynamics from data series, such as the simplest of curve fitting procedures. However, remember the Butterfly Effect? It works in reverse too.

Once you extract the underlying dynamics, you can predict a system's behaviour for ever. However, with chaotic systems, there is no room for approximation. Remember: *chaos amplifies what we don't know*.

Consider the simple equation  $y=ax^2+b$ . Knowing the values of  $a$  and  $b$ , from some starting value of  $x$ , we can predict the values of  $y$  at any point in the future. Chaotic systems are different. An equation describing a chaotic system, when written on paper, is clearly deterministic - its behaviour can apparently be plotted on graphs from here to eternity. However the same equation is almost meaningless in determining the real future. Unless the function is specified exactly, the error in the predictions will rise exponentially with time. This helps to explain why we cannot predict the weather very far into the future, or the stock market's behaviour.

### The good news...

All this might sound as though chaos is an impossible limit foiling efforts to advance knowledge. While it certainly sets limits, it also has a positive aspect: many systems once thought random could in fact be chaotic. For instance, better predictions might be possible than statistical methods would suggest.

Alan Lapedes and Robert Farber attempted to extract the dynamics of a non-linear system. They chose the Glass-Mackey equation, which describes the aspects of the physiology of blood cell development. This may seem a rather specialised application, but it serves as a good example of a chaotic and extremely unpredictable (in practice, of course, not in theory!) system.

To do this, they generated a series of point values from the equation, and then attempted to make a prediction about the system's future behaviour from this time

almost unimaginable detail. Even the impact of the Butterfly in Brazil is taken into account though the snooker tournament, as ever, is in Sheffield.

With such computing power and such detailed knowledge of the state of the world as the cue ball is hit and hurled into the triangle of reds, for how long into the future would the motion of all the balls be computable? According to Crutchfield et al, *if the gravitational attraction of a single electron at the edge of the Solar System is neglected in the sums, the predictions will be wrong within one minute.*

### The Real World

Where else does chaos turn up in the natural world? Since the early efforts of theoreticians, chaotic dynamics have been found in many systems. Examples occur in physics, electronics, and biology. The behaviour of fluids near the onset of turbulence, classical many-body systems (rather like the snooker table mentioned

above), plasma physics, biological models of population dynamics, and natural oscillators - like the heart - all exhibit chaos.

One should note that the indeterminacy of chaotic systems is not due to external noise, nor to the uncertainty of quantum mechanics, nor the system having an infinite number of degrees of freedom. The unpredictability arises solely from the propensity of chaotic systems to include many phase space trajectories that start close together but rapidly diverge exponentially.

### Extracting dynamics

Connect a person to an oscilloscope via a suitable amplifier and the electrical activity associated with their beating heart can be measured - as in an electrocardiograph, or ECG. The result nearly always seems to be wrapped up in a lot of apparently random interference but chaos analysis has changed our views on a healthy cardiac pattern. Indeed, a measured cardiac

### CHAOS AND FRACTALS

Fractals were first described by Benoit Mandelbrot, working at the IBM Thomas Watson Research Center. The term fractal means fractional dimensional, an abstract concept whereby complex structures can be characterised according to a non-integer number of dimensions. The equations of these complex structures are, however, very simple. Fractals, in spite of their complexity, have a very low information content.

The fine structure of chaotic system trajectories in phase space can be fractal, and one of the crucial measures of the degree of chaos of a non-linear system is its Hausdorff dimension - its fractal dimension. As ever, life is not simple. Not all chaotic attractors have a fractal dimension, and indeed, not all

strange (fractal) attractors are chaotic. Fractals can seem rather esoteric, and of little practical value beyond producing pretty computer graphics. Wrong. Fractals are already paying dividends in image encoding. Transmitting large volumes of data associated with high quality computer graphics is expensive. Data compression techniques help. A novel approach, based on fractals, has been devised by Michael Barnsley, a professor of mathematics at the Georgia Institute of Technology. The system uses fractal algorithms to compress images and can achieve compression ratios of over 10,000 to 1. The technique can be combined with conventional algorithms to achieve further compression yields.

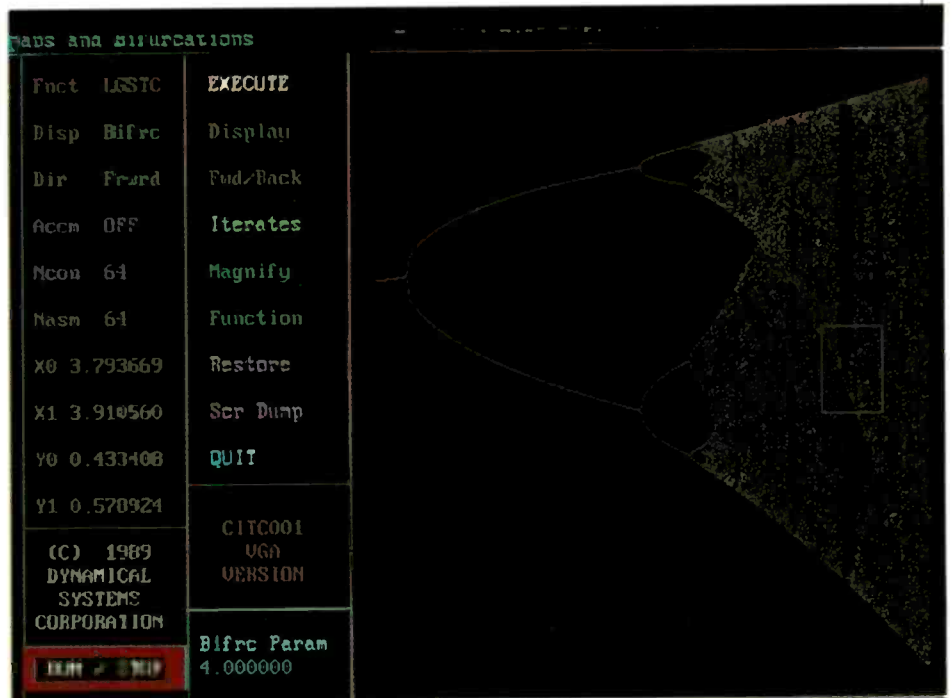
series - or to get the equation back from the samples.

Lapedes and Farber used a back-propagation neural network, set up so as to learn what past leads to what future in this system. (For more details on neural computing see *Harnessing Neural Networks*, *Electronics World*, December 1990). Surprisingly, the network was able to learn the mapping required to predict the behaviour of the time series with accuracy an order of magnitude higher than would be achievable with conventional statistical methods.

### The Stigmata of Chaos

If your system is chaotic, you want to know about it. There are numerous signs of chaos which provide clues to system behaviour. Distinguishing between deterministic chaotic dynamics and noise-prone regular activity requires analytical methods such as spectral analysis, autocorrelation function, and phase-space reconstruction, all of which are qualitative methods: correlation dimension, Lyapunov exponents and Kolmogorov entropy are quantitative. Spectral analysis involves constructing a power spectrum - a plot of frequency against amplitude for the signal or time series under scrutiny. An exponential decay in the power spectrum at higher frequencies is strongly suggestive of chaos.

The autocorrelation function indicates the average value of a signal after a specific delay. It measures the correlation



Screen dump from CITC illustrates the period doubling which precedes chaos. The box section is magnified over page.

between points which are apart in time. For periodic activity, the autocorrelation function is periodic. In chaotic processes, the autocorrelation function decays with time. It helps to know to what extent a system is chaotic. Chaos workers refer to dimensionality of a system's dynamics. High dimensional chaos - from an experimental viewpoint - merges with randomness. At lower dimensions, useful predictions can be made. This is true even in

systems of infinite degrees of freedom such as in fluid mechanics. If the system is not too chaotic, the attractor for the dynamics can be represented in a lower number of dimensions, and useful calculations made.

More substantive evidence for the presence of chaos comes from reconstruction of the phase space portraits (see box on strange attractors) and from evaluation of such things as Hausdorff dimensions,

### CHAOTIC SOFTWARE

Not surprisingly, dynamics is a topic that benefits from visual images. Motion is explained better by pictures than text. The dynamics of chaotic systems can be studied directly with the aid of a PC, and Dynamical Systems Inc produce a range of programs to help. There are three packages. Two are simpler with an educational bias, whereas the larger package is a serious research tool.

*Chaos In The Classroom I & II* are packages designed to help users explore the visual mathematics of chaos and fractals. The illustrations of the bifurcation diagram of the logistic map are taken from the screen of CITC 001. I won't cover the fractal package here.

The chaos program is entirely menu driven. After selecting from the list of chaotic functions, there are a series of options, such as screen resolution (which has an impact on plotting speed) and what information the screen will show. The choice is between the bifurcation diagram alone, or the phase portrait, or a combination of these two plus a two-dimensional projection of the attractor.

Having completed a screen plot, the user can then selectively magnify parts of it, to reveal the fractal structure of the dynamics.

The program is very easy to use, and comes with a well written manual that covers much of the basic maths of chaos. This is a good starting point for getting to grips with the topic.

**Dynamical Software.** This is serious stuff. It comes in two parts. DS 1.4 provides the basics: a map driver and an integrator, facilities for two- and three- dimensional plotting with Poincaré sections, and programs to construct one dimensional maps and circle maps. DS 2.2 is more advanced, offering further programs for calculating eigenvalues and eigenvectors, power spectra, Lyapunov exponents and fractal dimensions. I only had access to DS 1.4.

A few of the programs require a fortran compiler, though only those that link to external sub-routines, such as for entering user-defined equations. The package will run on any IBM compatible, though with fairly substantial and intensive mathematics demanded of the machine, even a 286 is likely to appear lumbering. It benefits from co-processors and exotic video modes.

A collection of data files are included, generated from many standard chaotic equations. There is also a program called *Scanner*,

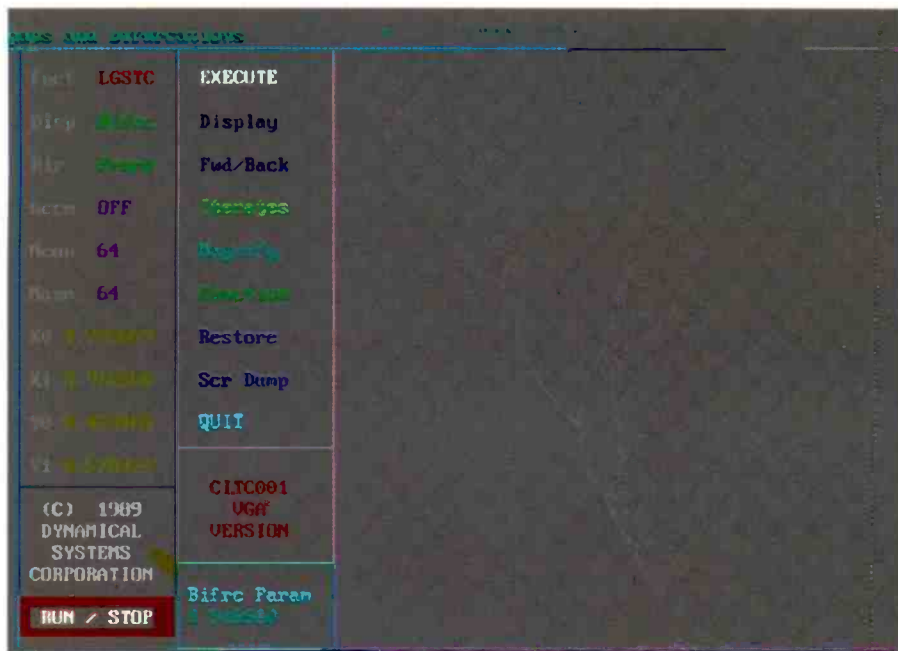
which parses equations entered at the keyboard to enable experiments with novel functions. Experimental time series data can also be used. A program, *Lagger*, is included to enable users to embed univariate time series data in up to ten dimensions.

The user interface can seem rather primitive at times. The *Chaos in the Classroom* packages are far easier to use. There are menus at certain points, but much of the option selection required is still via terse text entry requests, which are not very forthcoming if erroneous entries are made. The manual is likely to be needed on your lap for a good while. Nevertheless, this is a serious tool, and well worth the effort.

Producing 3-D images of attractors is easy, and the system allows images to be scaled, rotated and shifted to get the desired view of a particular part of an attractor. Screen dumps are in .PCX format, which makes importing them into other packages easy.

This is a highly recommended suite of programs for any maths or physics department with an interest in non-linear systems, or indeed for the adventurous amateur, who would like to join in the search for chaotic systems.

NB



Stable state wedged between two periods of chaos. Note the binary progression

Lyapunov exponents and Kolmogorov entropies. These indicators also measure the extent of chaos.

The Lyapunov exponents indicate the average rate at which nearby trajectories separate or converge. For a system to be chaotic, it must have at least one positive Lyapunov exponent. The Kolmogorov (or Kolmogorov-Sinai) entropy is the rate at which information is gained by observing a trajectory to a given precision. Alternatively, this is equal to the rate at which information on a system is lost with time. For one-dimensional systems (such as the logistic map) Kolmogorov entropy is equal to the Lyapunov exponent.

### Measuring Dimensionality

Dimensionality is measurable in many ways. One of the confusing features of non-linear dynamics is the number of different definitions of dimension-like quantities. Perhaps the best understood - and most widely used - is the Hausdorff-Besicovitch (or fractal) dimension. The basic idea is of a particular dimension at which the volume of a shape changes from zero to infinity. This number, not necessarily an integer, captures the irregularity of a shape or space. When applied to a time series, it measures the extent to which the attractor is irregular.

The Hausdorff (poor Besicovitch's name is often omitted) dimension,  $D$ , gives a clue as to the complexity of the trajectories within the attractor. The lower the value of  $D$ , the more coherent the dynamics. If  $D$  is greater than 2 and is non-integer, then the attractor is *strange*. In practice, it is more convenient to measure the correlation dimension,  $D_2$ , which gives the lower bound for  $D$ .

### The Meaning of Chaos?

Chaos has had such an impact on science that some people have suggested that we are in the midst of a paradigm shift - a period during which basic questions of science are redefined. Chaos has also been described as the end of determinism: the Butterfly Effect means that, in practice, the future can only be predicted rarely.

Chaos can also affect the view of randomness. Perhaps randomness is just high-dimensional chaos? The definition of randomness is often no better formed than the folk-meaning of chaos.

Science has for years been dominated by the notions of determinism and existence uniqueness. These notions are so pervasive that simple knowledge of the existence of a unique solution to an equation is sufficient to give scientists confidence in writing the exact solution. Precise science has even constructed a general equation to determine system dynamics:  $S(t) = f(S_0, t)$ , where  $S$  is the exact state of the system at time  $t$ , evolving from an initial state  $S_0$  via a functional rule (often unstated) defined through existence uniqueness. Physicists had assumed that, in principle, variables  $S$ ,  $S_0$  and  $t$  could be measured to arbitrary precision, and mathematicians had assumed that, in principle, that which exists can always be constructed. Chaos foils these efforts too, and joins the ranks of this century's many assaults on the comforts of certitude, such as the work of Heisenberg, Gödel and, latterly, Chaitin's algorithmic information theory contribution.

*The author is an information technology consultant in the health IT group at management consultants Price Waterhouse.*

### FURTHER READING

Ian Stewart. *Does God Play Dice?* Blackwell, 1989. Accessible, wide ranging, light on alarming equations, humorous and thorough. Recommended.

H G Schuster. *Deterministic Chaos*, Second Edition. VCH. Page after page of alarming equations! One of the definitive texts on the mathematics of chaos.

JP Crutchfield, JD Farmer, NH Packard, RS Shaw. *Chaos*. Scientific American, 254(12): 46-57. 1986. Beginning to date, but a readable and concise introduction to the topic.

YC Lee. *Evolution, Learning and Recognition*, World Scientific. A remarkable collection of papers on systems neural nets and genetic algorithms, with much discussion of the links to general non-linear dynamics.

GJ Chaitin *Information, Randomness and Incompleteness*, World Scientific 1990. A collection of papers on algorithmic information theory, looking at randomness in the some of the most unexpected places, such as the mathematics of number theory. A surprising and wide ranging book that covers introductory material through to advanced presentations. Excellent.

Michael Barnsley and Stephen Demko. *Chaotic Dynamics and Fractals*, Academic Press, 1986. A fascinating collection of papers from the (rather fractal) interface between fractals and chaos.

A. Babloyentz & A Destexhe. *Is the normal heart a periodic oscillator?* Biol. Cybern. 58, 203-211 (1988). Specialised topic, but with a good overview of the practicalities of chaos-spotting.

### SOFTWARE SUPPLIERS

Dynamical Systems Inc.  
PO Box 35241, Tucson,  
Arizona 85740. USA.  
Phone 602 292 1962

UK distributor:

Far Communications  
5 Harcourt Estate  
Kibworth  
Leicestershire LE8 0NE  
Phone 0533 796166

CITC 001 £40, CITC 002 £45  
DS 1.4 £199, DS 2.2 £249

**Editorial survey: use information card to evaluate this article. Item D.**

**E**lectronic engineers are used to dealing with devices which display various forms of electronic non-linearity. It is virtually impossible to find a radio or microwave system which does not contain a non-linear resistance (ie an ordinary diode). Varactor diodes are also widely used as capacitors whose value may be controlled by an applied voltage. Yet outside of a few well-defined applications such as frequency multiplication, non-linearity has generally been an unwelcome guest.

Engineers are frequently asked to suppress unwanted non-linear behaviour in electronic systems. Circuits displaying non-linearity or unpredictable oscillations are likely to be labelled as 'useless'.

It will probably be some time before we realise the full range of benefits arising from understanding chaotic systems. Mostly the obvious advantage is negative: know your enemy. If you can define just what produces chaotic behaviour in a given system then you are half-way to avoiding it! This can be valuable in preventing system failures. More positive results may be expected in the future although it is a bit soon to predict just what they might be.

At present, the most positive application seems to be in improving the performance of existing non-linear circuits: frequency multipliers, mixers, etc. Beyond that, there are few obviously new applications, although work is beginning on some ideas; for example, the use of non-linear systems to produce chaotic oscillators. These may prove useful as broadband sources, replacing noise sources for some applications, providing spread spectrum signals for communications or radar, and complex deterministic signals for signal encryption. Given these developments it is probably time for engineers to begin familiarising themselves with the new toolkit for chaos.

### Chaotic diode

A diode is the simplest form of non-linear device. In general, diodes have a conductivity and reactance that are voltage dependent. One could build virtually any sort of non-linear system from a suitable set of diodes along with passive linear components, and amplifiers to provide gain.

The main properties of an ordinary diode can be defined in terms of how the current

# Chaos in electronics

Chaos occurs in electronics. Its presence usually brings grief to design engineers in the form of unpredictable parasitics and distortions. Computers handle chaotic models badly. Simple analogue models do it rather better. They can even turn chaos to advantage. Jim Lesurf explains.

passing through the device depends upon the applied voltage. The non-linear properties of a varactor (the junction capacitance of a reversed biased diode which varies inversely with applied voltage) are less obvious, but can be explained by comparison with an ordinary capacitor.

The voltage,  $V$ , of a normal capacitor is proportional to the charge,  $Q$ , it holds. If we start with a discharged capacitor and add an amount of charge,  $Q$ , the capacitor acquires a voltage

$$V = Q/C \quad (1)$$

To change the voltage by a small amount,  $dV$ , we must add an extra amount of charge

$$dQ = C \cdot dV \quad (2)$$

We may now define the capacitance using expression 1 or 2. Either way we will get the same value, irrespective of our choice of  $V$ .

If we repeat the same process with a varactor we find that the voltage produced is not simply proportional to the charge. To change the diode voltage by  $dV$  we must now add a charge

$$dQ = C\{V\} \cdot dV \quad (3)$$

where  $C\{V\}$  depends upon the device voltage. To take a discharged varactor and charge it to a voltage,  $V$ , we need a charge

$$Q = C\{V\} \cdot V \quad (4)$$

where

$$C\{V\} = \left(\frac{1}{V}\right) \int_0^V C\{V\} \cdot dV \quad (5)$$

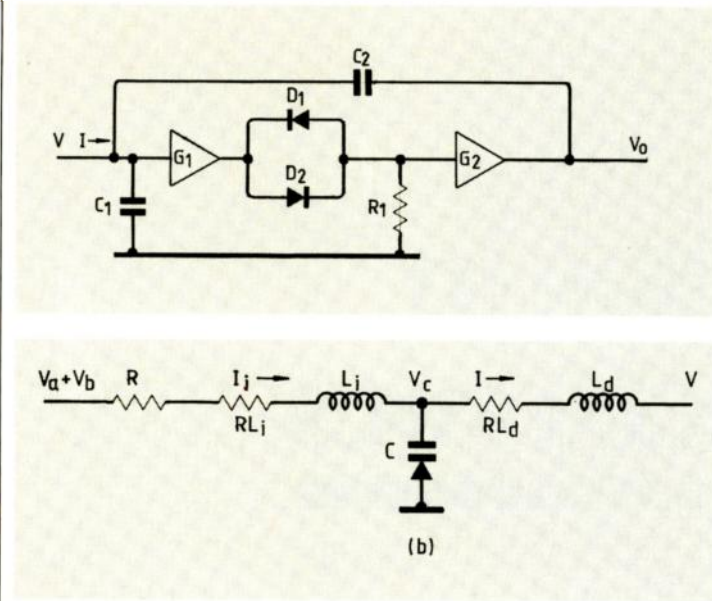
Unlike an ordinary capacitor, expressions 3 and 4 *won't* now provide the same capacitance value for any randomly chosen value of  $V$ .

This situation is analogous to the resistance of a normal diode which may be given either as a static value ( $R=V/I$ ) or as a dynamic or slope value ( $r=dV/dI$ ). Here we can define a static capacitance,  $C\{V\}$ , or a dynamic one,  $C\{V\}$ .

In general, these devices are used to carry out fairly basic functions like frequency conversion and tuning. Their analysis as presented in most textbooks seems straightforward. Yet, surprisingly, even quite simple arrangements containing these devices can behave in ways which are very complex — even chaotic.

One should be able to explore the behaviour by building circuits, experimenting with component values and watching what they do with applied signals. Unfortunately, this approach isn't

Fig. 1a. (top left) Circuit used to determine non-linear capacitance. It is connected to a T-network, Fig. 1b. (middle), to examine properties of the system as a function of the applied signal voltage.



Hence we can produce computer models where M is very large indeed — but it can never be infinite. This problem is made worse by the possibility that rounding errors during a calculation may force an accidental repeat of a set of values long before M model state updates. In short, as processes approach the chaotic, it becomes increasingly difficult to use a computer model. An analogue model of a non-linear device may be more useful and can also be used to cross-check the computer predictions.

Analogue of chaos

In general, we can define two basic types of non-linear device, a non-linear resistance and a non-linear reactance. These can then be treated as building blocks to assemble non-linear systems. To see how they can be used to explore the behaviour of complex or chaotic processes we can concentrate on just one type in the form of an artificial varactor. Figure 1a shows a circuit which behaves as a voltage dependent capacitance.

For simplicity, we can assume that the gains,  $G_1$  and  $G_2$ , of the two amplifiers are both unity i.e. they act as buffers. In practice these gains may be chosen to have some other value (they may also, of course, be voltage dependent). In this way the voltage dependence of the system may be controlled.

The diodes,  $D_1$  and  $D_2$ , are ordinary silicon signal diodes (eg 1N4148 or similar). When  $|V| < 0.5$  volts the diodes will have a high effective resistance and  $V_o$  will be held at about 0 volts. Any input current,  $I$ , must charge both  $C_1$  and  $C_2$  in order to alter the voltage,  $V$ . Hence the circuit behaves as if it were a capacitance

$$C\{V \approx 0\} \approx C_1 + C_2 \tag{6}$$

When  $|V| \gg 0.5$  volts any change in  $V_o$  will produce a corresponding alteration in  $V''$ , i.e. no charge need flow into or out of  $C_2$ . Hence the circuit behaves as a dynamic capacitance

$$C\{|V| \gg 0.5\} \approx C_1 \tag{7}$$

At intermediate voltages, the effective capacitance depends upon the behaviour of the diodes and the chosen value of  $R_1$ . As  $|V|$  increases from zero, through 0.5 volts, the effective capacitance tends to fall smoothly from  $(C_1 + C_2)$  to  $C_1$ .

To compare digital and analogue modelling, circuit Fig. 1a was built using a pair of TL081 operational amplifiers.  $D_1$  and  $D_2$  were a pair of 1N4148s,  $R_1 = 5k\Omega$ . The nominal capacitor values used were  $C_1 = 0.1\mu F$ , and  $C_2 = 1\mu F$ .

The  $C\{V\}$  behaviour of the circuit was determined by connecting it in series with

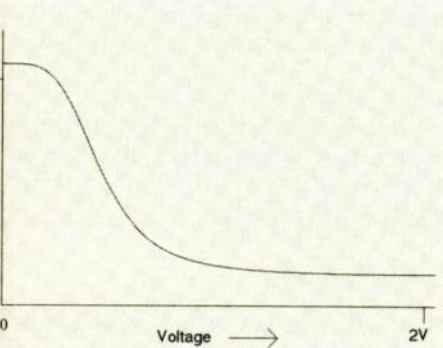
Fig. 1c. (left) shows variation of "dynamic" capacitance  $dQ/dV$  with  $V$  for Fig. 1a.

Imagine a non-linear circuit or system whose state at any moment can be defined by the values of, say, just four quantities (perhaps two voltages and two currents). The properties of the circuit will determine how these quantities change with time in response to some given input signal. If the process is periodic, the quantities will return to a previous set of values after some appropriate time. The process then repeats its behaviour over and over again. A chaotic process cannot, by definition, be periodic. Hence if the process is chaotic the quantities which describe the state of the circuit will never repeat any set of values.

Expanding the example further, a digital computer model of this circuit will store information about the state of the process in terms of four values. Each of these will be recorded in the computer as a finite number of bits. For standard IEEE floating point precision a number is recorded as four 8-bit bytes i.e. 32 bits. Hence a set of four variable values will be stored as  $4 \times 32 = 128$  bits.

A finite number of bits, N, can only have  $M = 2^N$  possible arrangements. So far as the computer is concerned, the simple digital representation we have described above must always be in one of the  $2^{128}$  states which the computer model can distinguish. As a result, any process whose state we represent in terms of N bits must repeat itself after — at most —  $2^N$  recalculations since the computer will have run out of fresh patterns of bits.

We can, of course, use extended precision values to increase N. Complex circuits and systems will also require more than four quantities to describe their state.



always practical. For example, millimetre-wave engineers have to deal with signals of 70 — 100GHz or more. At these frequencies it can be quite difficult to define the electrical properties of any circuit you have built. Measuring the details of output signals can — unless they are simple — also prove difficult and expensive.

In some cases we are also faced with the question, "What would this new sort of device do if we were to make one?". Solid state engineers can now manufacture a wide range of low dimensional structure devices which, although they only have two terminals like the humble 1N4148, can have complex electrical properties. Naturally, the people who develop them would like some advance idea of device characteristics.

When asked "what if" questions, engineers and scientists usually resort to a computer model, based upon a software algorithm running on a digital computer. This technique is a very powerful one, but it presents problems of its own. These can be roughly divided into three categories: is the program right? Is the computer fast enough? Is there a problem with computational error?

The problem of finite computer precision is particularly important when modelling circuits which may become chaotic.

a known inductor and then noting how the series resonance frequency varied with an applied DC voltage. From these measurements it was found that the capacitance behaviour was essentially of the form

$$C(V) = C_1 + C_2/(1+(\alpha V)^4) \quad (8)$$

where  $C_1 = 0.14\mu\text{F}$ ,  $C_2 = 0.94\mu\text{F}$ , and the coefficient,  $\alpha = 2.2/\text{volt}$ .

This artificial varactor was then connected to a T-network consisting of a pair of inductors and a capacitor (Fig 1b). The properties of this system could then be examined as a function of the applied signal voltage.

The actual network used consisted of two inductors whose values were  $L_1 = 3.24\text{ mH}$ , and  $L_d = 3.38\text{ mH}$ . The DC resistances of these were  $R(L_1)=6$  and  $R(L_d)=4\Omega$ . The shunt capacitor had the value,  $C_1 = 2.03\mu\text{F}$ . These particular components were chosen nearly at random; slight selection ensured that effects of interest would be likely to arise in the 100 Hz — 10 kHz frequency range and thus be easy to observe on a normal oscilloscope. An input sinewave,  $V_a$ , and nominal DC bias level were coupled into the circuit via a  $100\Omega$  series resistor.

A computer program was also produced to act as a comparative digital model. This was written in BBC Basic V and run on an

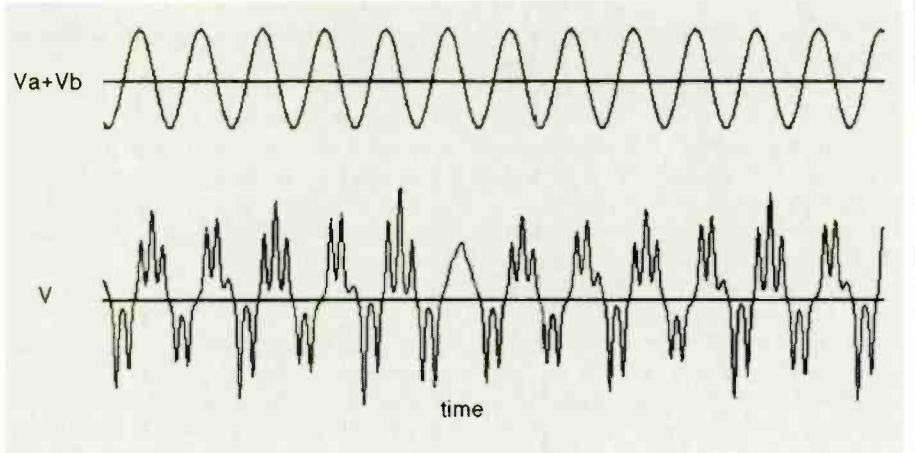


Fig. 2. Typical input and output waveforms for the system shown in Fig. 1;  $f=1300\text{Hz}$ ,  $V_a=3.5$ ,  $V_d=0.25$

Archimedes 410 with a 30Hz Am3 processor:

```

REPEAT
Vi=Va*SIN(W*t)+Vb
V+=l*dt/FNcap
Vc+=(li-l)*dt/C
I+=(Vc-RLd*I-V)*dt/Ld
li+=(Vi-li*(R+RLi)-Vc)*dt/Li
t+=dt
UNTIL FALSE
:
DEFFNcap =C1+C2/(1+(2.2*V)^4)
    
```

where  $V_a$  is the half-peak magnitude of a nominal input sinewave at the frequency,  $W$ .  $V_b$  is the DC bias level;  $dt$  is the time-step increment (here normally set to 1/256th of a cycle at the chosen input driving sinewave frequency).

The possible effects of finite precision and time-step value were tested by compiling a double precision (to IEEE standard) version using the ABC Basic compiler and running this with smaller  $dt$  values. This gave results visibly identical to the normal interpreted basic program, as viewed by plotting  $V_d$  against  $t$  on the computer display.

When plotting a useful output display, the computer program ran at an actual drive waveform rate of just a few cycles per second. The analogue system operated in real time and provided essentially identical behaviour with drive frequencies in the kHz range. Hence the analogue system operated around 1000 times faster than the computer program.

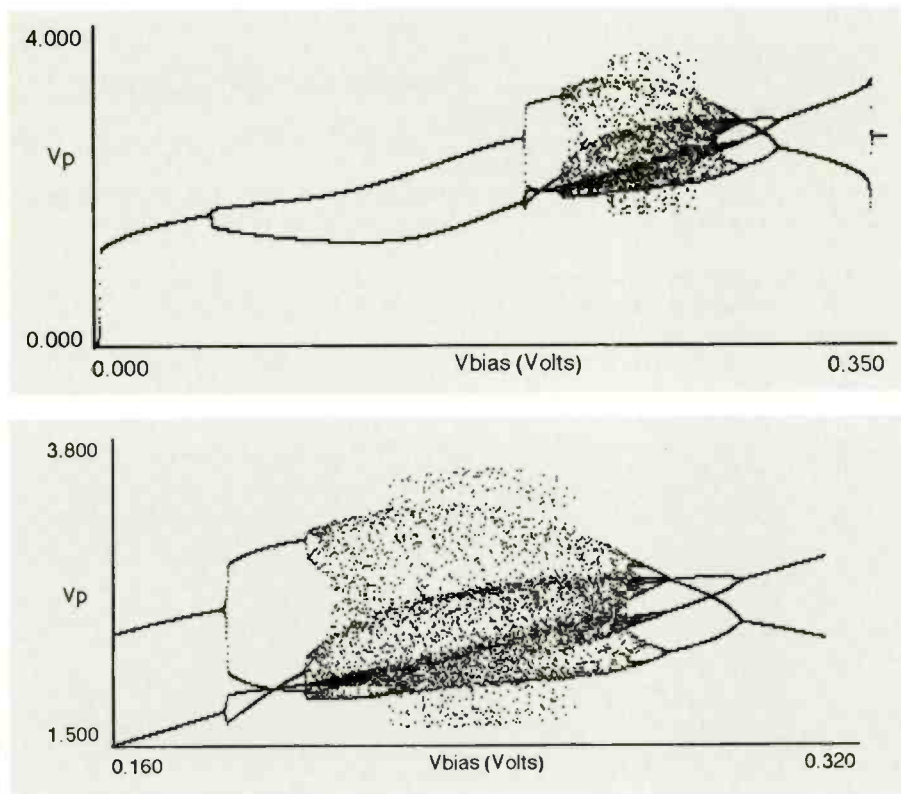
### Phase of chaos

The correspondence between analogue and digital models allowed a rapid exploration of the system behaviour using the analogue system. Detailed analysis of interesting regions of operation could then be carried out using the computer model without having to spend considerable time checking a wide range of conditions which produce less interesting results.

An example of interesting complexity was found, using the analogue system, to occur for a drive frequency of around 1300Hz at  $V_a=3.5$  volts (half-peak) combined with a DC bias level of around 0.25 volts. Figure 2 illustrates some typical results for the time variation of  $V$  in this region. This figure was obtained from the computer model, but identical results could be obtained using an oscilloscope connected to the analogue circuit.

We are accustomed to examining signal

Fig. 3a. Phase plot showing pattern of bifurcations and Fig. 3b. (bottom), close up of the pattern. Computer plots derived from model shown in Fig. 1.  $L_m=3.24$   $L_{dev}=3.38\text{mH}$   $RL_1=6.0$   $RL_d=4.0$   $C_1=0.14$   $C_2=.94$   $C_1=2.03\mu\text{F}$   $f=1300$   $R=100$   $V_{ac}=3.5$   $C\%=128$   $S\%=256$



variations on the screen of an oscilloscope, but in this case, such a display does not tell very much about what is happening. Fortunately, various methods have been developed for examining complex and chaotic processes. We can adopt one of these — a phase diagram — to explore the behaviour of a non-linear system.

The concept of a phase plot is simple: drive a non-linear arrangement with a periodic signal and note the value of its output at a particular phase of each drive cycle. Alter one of the system parameters and repeat the measurement.

In this case, we drive the system with a sine wave

$$V = V_a \sin\{\omega t\} \tag{9}$$

and note the output voltage (i.e. the voltage on the non-linear capacitor),  $V_p$ , at some chosen phase angle,  $\psi = \omega t \text{ mod } 2\pi$ , of each cycle. We can now plot how  $V_p$  varies with, say, the DC bias voltage.

Figures 3a and 3b show a typical phase plot for the circuit. At low DC bias levels, the output appears simply to be a distorted version of the input. Each cycle is identical to the next. If one were to look simply at the output it could be concluded that its period was identical with that of the input drive signal.

When the DC voltage reaches about 0.05 volts the situation suddenly changes. Now the output level alternates from input cycle to cycle, back and forth between two values. The output signal appears to have a period which is double that of the input. The phase plot shows a bifurcation, a place where one line splits into two. Another bifurcation occurs when the bias voltage reaches about 0.18 volts.  $V_p$  then cycles around four values and the basic period of the output appears to be four times that of the input. These bifurcations are also referred to as period doubling for obvious reasons.

As doubling continues, the bias increase required to produce extra bifurcations rapidly decreases and the circuit goes into a cascade of bifurcations. The basic period rises rapidly and, in principle, may go to infinity. If that occurs the system

becomes chaotic and the output waveform never produces any two cycles which are identical.

The number of bifurcations appears to reach a maximum value at a DC bias level around 0.25 volts. Any further increase in bias causes a reduction in the periodicity. Figure 3b shows an enlarged view of the complex pattern which occurs around a bias level of 0.25 volts.

### Model Gunn

We could continue to examine the behaviour of this system in more detail, exploring the effects of altering other variables, and applying other analytic methods. However, the purpose of looking at the complex behaviour of this circuit was to demonstrate the principle that an analogue system may replace a digital computer model easily and cheaply. To understand how the approach may be extended we can use the example of an artificial non-linear resistance shown in Fig. 4. This represents a rough approximation to a Gunn diode

Gunn diodes are widely used at microwave and millimetre-wave frequencies as oscillators and amplifiers. Although they are two-lead devices, they provide gain through the property of negative resistance. (Strictly speaking, this is more correctly termed negative differential conductance, but the label negative resistance is more commonly used.)

Imagine a potential divider made of two resistors,  $R_1$  and  $R_2$  connected in series. When we apply an overall voltage,  $V$ , the voltage across, say,  $R_2$ , will be

$$V_2 = V.R_2 / (R_1 + R_2) \tag{10}$$

Normally we will expect  $R_1 + R_2 \geq R_2$ , so  $V_2 \leq V$ . If, however,  $R_1$  or  $R_2$  is negative we may find that  $|R_1 + R_2| < R_2$ , which means that  $V_2 \geq V$ . The potential divider will then act as an amplifier.

Fig. 4a. (left). Artificial non-linear resistance representing a rough approximation to a Gunn diode. Fig. 4b. (right) is a typical I/V curve for this form of circuit.

But the power which is added to an amplified signal must come from somewhere. For a two-terminal device like a Gunn diode, static resistance must always be positive, but the dynamic (slope) resistance can be negative over some range of applied voltages. This means that an input bias signal must be applied to act as the source of power which can be added to amplify signal variations.

In Fig. 4 some extra components — zener diodes and resistors — have been added in between the amplifiers. These enable the circuit to mimic a Gunn device more reliably. Apart from these, however, the circuit illustrated in Fig. 4 is essentially the same as was previously used to make a non-linear capacitance except that the resistors,  $R_1$  and  $R_2$ , replace  $C_1$  and  $C_2$ .

The behaviour of the circuit may be divided into three sections:

**Low voltage.**  $|V| \leq V_D/G_1$ , where  $V_D$  is the turn-on voltage of the diodes,  $D_1$  and  $D_2$ :

**Medium voltage.**  $[V_Z/(G_1A) - V_D/G_1] \leq |V| \leq V_D/G_1$ , where  $V_Z$  is the turn-on voltage of the zener diodes, and  $A = R_4/(R_3 + R_4)$ :

**High voltage.**  $|V| \geq [V_Z/(G_1) - V_D/G_1]$ . In the low voltage range the apparent dynamic input resistance,  $r(V)$ , will be

$$r(\text{low } V) = R_1.R_2 / (R_1 + R_2) \tag{11}$$

In the medium range, a change in input voltage,  $dV$ , will alter the current flowing through  $R_1$  by an amount

$$dl_1 = dV/R_1 \tag{12}$$

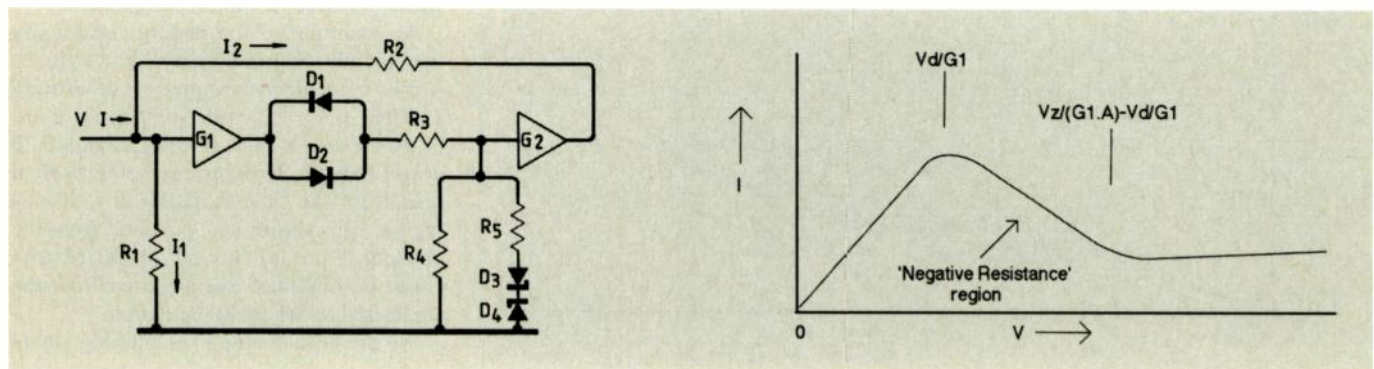
and that through  $R_2$  by an amount

$$dl_2 = (dV - G.dV)/R_2 \tag{13}$$

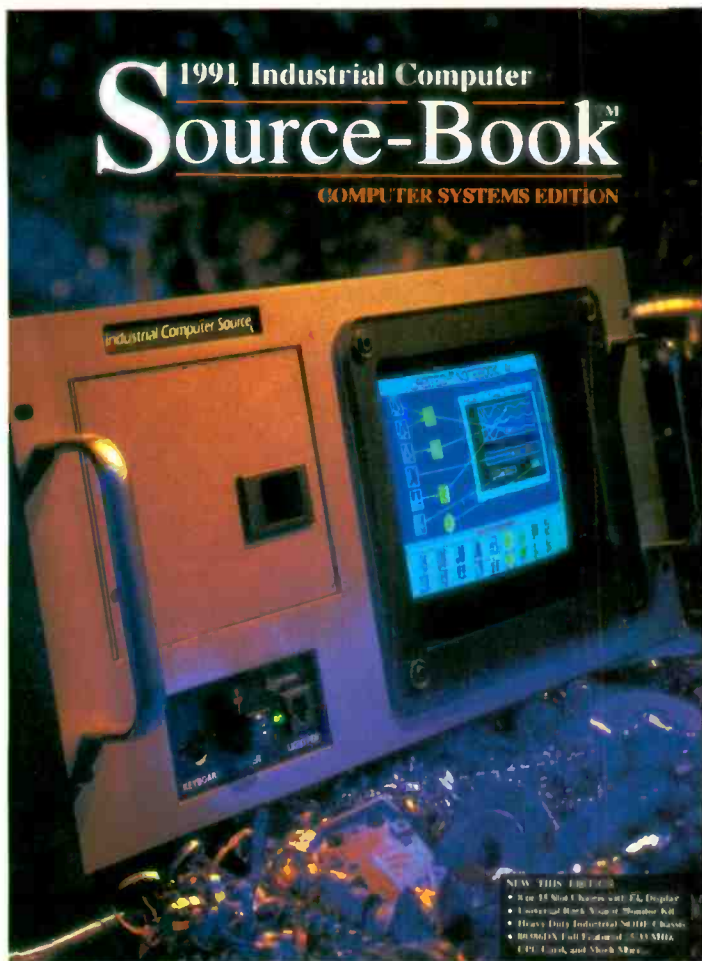
where  $G = G_1A/G_2$ . The dynamic resistance in this range will therefore be

$$r(\text{mid } V) = dV / (dl_1 + dl_2) = R_1.R_2 / [R_2 + (1-G)R_1] \tag{14}$$

Both the magnitude and sign of  $r$  depend upon the overall gain,  $G$ . If we choose a







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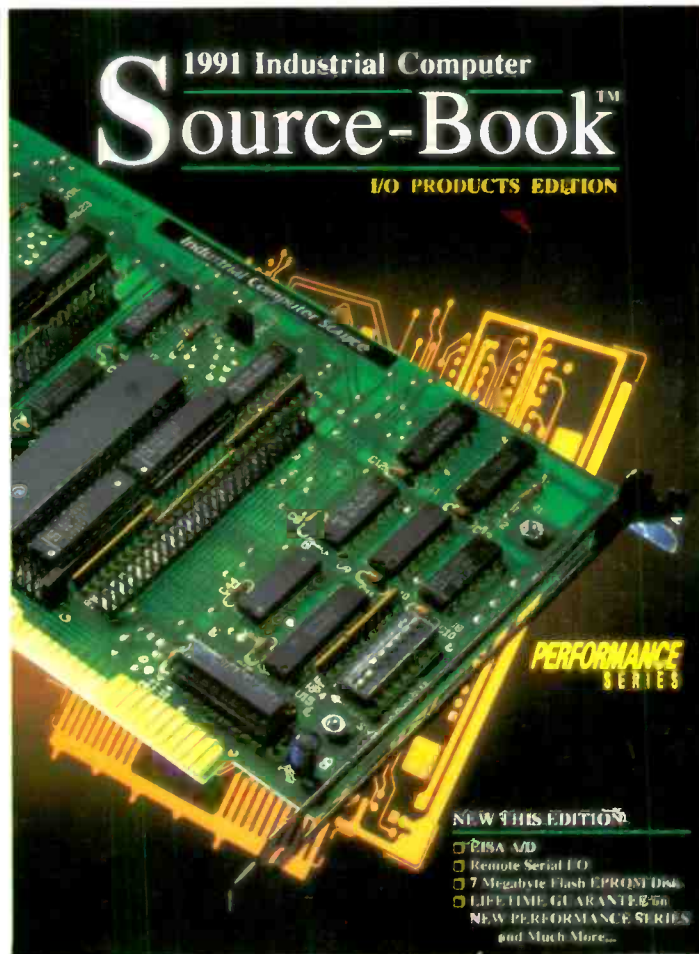
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CIRCLE NO. 128 ON REPLY CARD

# Channel 5:

## Interfering with business?

**R**aw data on the likely interference which will result from the new channel 5 television service suggests that the operators will face a large bill for retuning the nation's videos.

The findings, released by the Independent Television Commission, were from research carried out by National Transcommunications Limited, formerly the IBA's laboratory in Winchester.

NTL's brief was to try to quantify the interference which a new fifth TV service—transmitting either side of UHF channel 36—will cause to existing video recorders. Companies bidding for the Ch5 franchise need to know this because the Broadcasting Act 1990 says they must pay to retune or modify any equipment suffering interference from Ch5 transmissions.

Member companies of the British Radio and Electronic Equipment Manufacturers' Association (Brema) have warned that the cost of sending engineers to homes around the UK to retune or modify affected equipment to avoid interference will be astronomical — it could well reach several hundred million pounds.

The DTI has secretively given potential franchise holders bland reassurances that costs will be less than £20 million although it has refused to go public on this, fearing later claims for compensation. Worried potential applicants have been badgering the IBA, and ITC, for hard facts, warts and all. Ch5 will use two frequencies in the middle of the UHF band, identified as TV Ch35 and 37, the allocation being made because

The national bill for retuning videos following introduction of Channel 5 will far exceed current DTI predictions, says Barry Fox — with serious consequences for franchise holders

Ch35 is used for radio microphones in theatres and Ch37 for airport radar. The radars are moving to an existing radar frequency, Ch36, and the microphones will leave the TV band altogether.

Domestic video equipment such as recorders, satellite receivers, video games and budget computers have used these spare channels to connect with TV sets. When Ch5 starts broadcasting at high power on Ch35 and 37, it will inevitably cause interference to any domestic equipment which uses these frequencies; video recorders in particular suffer from a high level of feedthrough from aerial to TV even when operating in playback mode. This is likely to happen even though Ch5 signals will be vertically polarised.

The Broadcasting Act obliges any Ch5 broadcaster to pay for remedial service. The only loophole is that viewers will not

get free help if they have brought the problem on themselves by erecting a new aerial to receive Ch5. This could deter people from trying to receive Ch5, at least until after they have had their free service.

NTL noted that the nominal frequency to which most video recorders are set at the factory is Ch36. A few are tuned to Ch37. NTL then logged the actual frequencies used in three areas of the UK, each with different practical circumstances.

In Oxford there is no local radar using Ch36, so owners can leave their recorders tuned to the factory setting. Out of 127 recorders checked, nearly 30% were tuned to the frequency. But most of the remainder were tuned on or around Ch37.

In Slough, where Heathrow airport radar operates on Ch36, 149 recorders were checked and 25% were working on or near Ch36. The rest had been retuned to Ch37 or other frequencies which owners found to be free from radar interference.

In the Southampton area NTL looked at 147 recorders. Again most had been retuned away from Ch36 and onto channel 37 because the local TV transmitter, on the Isle of Wight, broadcasts on Ch27 and its harmonics (known as the image channel) interfere with Ch36.

The ITC has not yet drawn conclusions from the results. But it published the raw data to give potential Ch5 franchise applicants a chance to form their own opinions. The data clearly shows that several millions of video recorders are already tuned to frequencies (especially Ch37) which are likely to clash with Ch5 broadcasts. Surprisingly, NTL has not yet tested video games and satellite receivers, many of which will be tuned to frequencies other than Ch36 to allow the connection of both a recorder and game or satellite receiver to the same TV set.

There are already well over a million satellite receivers in the UK and likely to be several million more by the time Ch5 goes on air. There is a resurgence of interest in video games and the ITC is realising that the NTL must test these too.

The ITC will refuse any attempt to predict a retuning bill, on the grounds that no one knows what engineers will charge per visit to viewers' homes. It seems certain though that, by the time CH5 is on air, there will be several million pieces of video equipment in need of retuning. Engineers will be unlikely to charge less than £30 for a home visit. This puts the nationwide retuning bill for Ch5 far higher than the DTI's "under £20 million" predictions.

*Editorial survey: use the information card to evaluate this article. Item F.*





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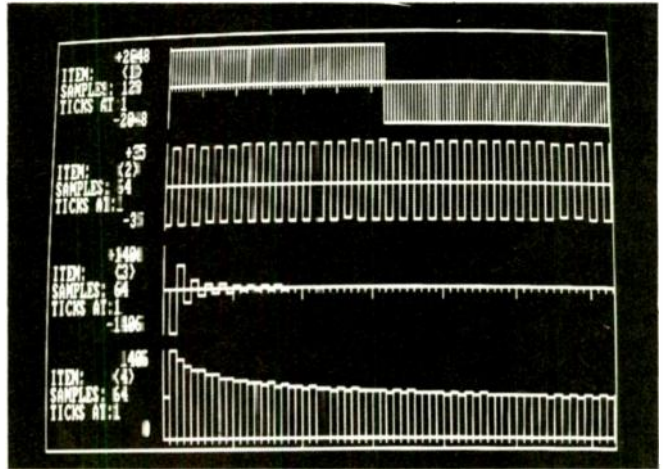
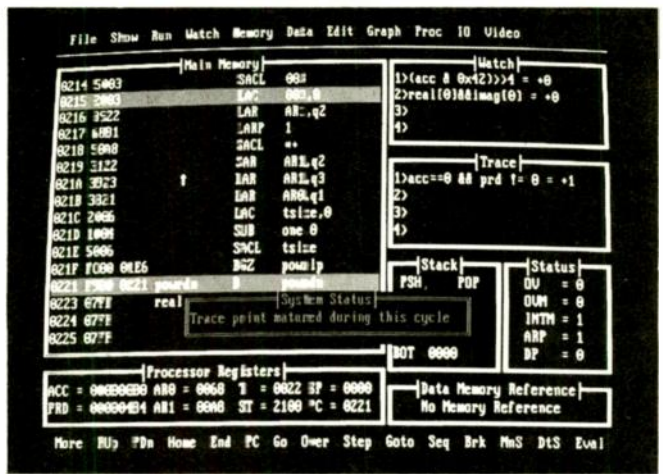
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## Pure vs applied science

Is it not reprehensible that a leading technical journal can reflect so shallow an appreciation of the vital role of technology in modern civilization ("Comment", *EW + WW*, April, p. 267), and of its debt to the honest, painstaking striving of scientists and philosophers against ignorance, superstition, prejudice and tyranny? Is this really less true now than in the past? It may be fashionable in some quarters to discount philosophy and, by virtue of its essential association, to include pure science in the process.

To recapitulate: "...an aspect of ersatz religion which, one suspects, big science has become". And again: "...the really useful things of life don't require obscure explanations of their worth". Well, what constitutes a really useful thing depends on the purposes of those who may adopt it, and, methods of scientific repression apart, we are surely now aware of the over-use and deleterious effects of quite a few really useful things.

It is also only fair to recognise the difference between what is big and what is pure science: the former would seem appropriate to the costly programmes of "ritualistic" ersatz research raised by the power of large-scale technologies in order to reaffirm accepted "truths", while the latter, applied to philosophical curiosity, may tend to make a reappraisal of these "truths" in its quest for deeper insights. The scientist/philosopher is informed by a venerable tradition set by his predecessors, questing beyond the acquisition of really useful things.

To argue for the flourishing of pure science, inspired by philosophy's honest, sometimes constraining yet always impelling ideas, perhaps the example of ancient China's science may serve as a warning. It failed to acquire the insight of nature as the font of rich resources to be explored, mapped, and systematically studied in a coordinated endeavour. When confronted with the scientifically liberated culture of the West, that of the Chinese collapsed into subservience.

Possibly the ancient Chinese culture was commendable, and *EW + WW* would champion its admiration; in which case its

readership ought to know of such an editorial policy. But there is a counter-argument, that modern civilization might rise to a greater challenge, if only to manage the dwindling resources of the planet and to tame the puerile passions of mankind. But even the really useful things would require examination and religion, ersatz or genuine, would be open to doubt; or is the vital exercise of thought, and its expression in research, to be decried if its ways are not immediately yielding to the creation of really useful things? Is the fate of our scientific heritage in jeopardy? Is our modern civilization going wobbly? Surely *EW + WW* could offer something better than a plea for the standards of commercialisation?

**C. Francksen**  
Farnborough  
Hants.

## Crossed field antenna

A clever man once remarked that when you have eliminated the impossible, then what remains, no matter how improbable, is the truth. The unfortunate (but perhaps not so improbable) truth in this case is that the electromagnetic radiation from a CFA can be calculated accurately using classical antenna theory. If the dimensions of the structure are made small compared with the wavelength, then either the radiation is inefficient, or the bandwidth is narrow, or both.

It is important to define here what we really mean by "small in relation to wavelength" and "inefficient radiation". One-twentieth of a wavelength is small and is a typical size for a "working" CFA including feeders. Five percent efficiency is low and yet quite enough to account for all the claims so far made for the CFA, including the large bandwidth.

I must admit to being impressed by the report of audible transmission at 90km in Egypt. And surely 25kW would make a bonfire of even the most indomitable ATU should the power not be radiated! However, the CFA in this location appears to have used a single, vertical (!) open wire feeder from the transmitter to the roof of the building, and I would venture to suggest that this, in conjunction with the "earthing"

arrangements from roof level to ground, formed a crude type of loop aerial which was responsible for the majority of radiation. CCIR curves show that 5% of 25kW (1.25kW) radiated would give a signal of about 48dB $\mu$ V/m, (0.25mV/m) at 90km range which is more than adequate for satisfactory daytime reception using a good quality portable radio.

There is a simple test, which is interesting to carry out and which really can prove to anyone's satisfaction, that crossing two E fields in space with the "correct" phase does not produce an electromagnetic wave. This is to construct a small CFA and to feed each plate in such a way that the phase of each can be varied. Now monitor both plate voltages simultaneously using a fast dual-trace scope (don't forget to use "chop" mode, not "alternate"). Also, keep all the feed wires short, and under the ground plane to minimise unwanted fields. Monitor the radiated field strength (or even the "near" field) as the relative phase of the voltages on the two plates is varied. The interesting point is that there is no sign of a sudden peak in radiation as the D plate goes through -90 degrees (or any other angle) relative to the E plate. My CFA was about one-hundredth of a wavelength high and proved quite easy to adjust, but was over 20dB down on a reference aerial at 500m range, implying an efficiency of less than 0.1% (the reference aerial itself was under 10% efficient). Best radiation and lowest return loss from the phasing unit were coincidental, but for this condition the two plates were virtually in-phase. Transmitter power is mostly dissipated in the phasing unit.

Incidentally, it may be of interest to D.A. Bell and others that a conductor one-twentieth of a wavelength long or even shorter makes a very efficient radiator as long as the RF power is fed into it and not dissipated in the matching unit or the immediate surroundings. Commercial aerials of this type achieve around 5-50% efficiency, depending on the efficiency of other design targets.

Prof. Bell makes a good point in stating that the current in the distant antenna wire is irrelevant to the propagating wave, but surely the current in the wire is directly

responsible for the generation of the wave, one cycle at a time. At the end of each cycle the lines of E and M field are closed loops which then expand without regard to anything that may happen subsequently in the aerial. My experience, such as it is, certainly leads me to believe that it is the current conduction current flow alone which causes the radiation. I disagree therefore with both his and Mr Hateley's description of how the dipole radiates. Some antennas have low RF voltage at all points and still work well.

The Crossed Field Dummy Load affair can only leave one staggered at how much we can achieve by manipulating electromagnetic waves, without understanding the basic forces involved. If anyone feels affronted by this statement, please write an article for *EW + WW* immediately: I am sure it will make fascinating reading  
**Martin Spencer**  
Evesham  
Worcs

Some time ago I purchased the advertised kit for a ground-plane crossed field antenna (described in *EW + WW*, December 1990), to use particularly on the 40 and 80m amateur bands: it sits in my loft over a shack, just above a cats cradle of house wiring, and behaves much as would be expected by a reader of the article. Since no other antenna is practicable here on 80m I could claim infinite gain! However, I continue to encounter quite widespread scepticism about it and a notion has gone abroad that the CFA only radiates a small fraction of the energy supplied to it. Being disconcerted by such aspersions upon my investment I conducted a simple test. I set up for the 80m band, on which there is little activity in daytime, and applied a 100W carrier on a clear frequency (3.742MHz) for 1 hour, with brief pauses for station identification and frequency monitoring. No heating could be felt in any part of the installation, but the air temperature in the phasing unit was measured at 22.6°C compared with an ambient temperature of 20.1°C. The presence of rf on the E and D plates could certainly be felt. It is possible to find

*Continued over page*

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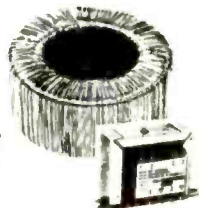
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"false" settings of the phasing unit switches at which power is accepted at a low standing wave ratio but little seems to be radiated. One of these was set up and the test repeated otherwise identically. The air temperature in the phasing unit rose to 44.4°C, and no rf could be felt on the antenna. It seems clear that almost all of the 100W was dissipated in the phasing unit in the second instance, and most of it went to the feeders in the first.

I cannot accept the idea that significant radiation takes place from the two 12ft feeders, twisted around each other, since that concept would imply effectively a short ( $\lambda/20$ ) end fed antenna, which firstly would have narrow bandwidth and secondly, as bitter experience with end fed wires has shown, would cause all sorts of trouble with rf in the shack, in the house, and next-door. So, most of the energy arrives at the D and E plates. If they do not radiate it what do they do with it?

Alexander Dick  
Dundee  
Scotland

## Research in crisis

Support for basic scientific research in Universities comes mainly from Government funds via two routes: the Universities Funding Council (UFC) and the Research Councils. Both sources seem to be drying up, with the UFC becoming less able to provide basic support, and the Research Councils facing a severe reduction in funding for 1991/92. The Science and Research Engineering Council (Serc) is constructing a programme with 10% cuts in all areas and must put them into effect immediately.

There is no sense in separating "big" and "small" science and preserving one at the expense of the other; modern research in all areas needs access to large facilities. In astronomy, for example, most researchers work on a small scale, in groups dispersed among at least half of our universities. They need access, however, to large telescopes sited overseas, and to large central computers.

All the major research tools needed for basic science are now available as part of international collaborations. Again, astronomy provides obvious examples, with international observatories in

Hawaii, the Canary Islands, Australia, and in space telescopes provided by the European Space Agency and other partnerships. These programmes have been remarkably successful, providing examples of international collaboration which should be the envy of all other social groups. "Big" science is now an essential part of our research; it is not so easily disposable to meet a sudden cut in resources.

Nuclear physics is especially under threat because of its heavy dependence on Cern, which takes two thirds of its Serc funds, but whose subscription costs cannot be reduced. The 10% cut falls on the remaining third, and forces a major economy at the Daresbury Laboratory. The Serc has decided to close the Nuclear Structure Facility, despite its recent successes and the research it promises to its many clients in the universities. The Serc also says it will, as far as possible, protect the jobs of the Daresbury staff. To the users of the NSF this is the wrong way round: there are too many staff anyway, and the cut should fall on them rather than on the NSF itself which could continue to provide a service at lower cost.

The real practical problem, however, is the need to make economies as a single drastic step. There is almost no possibility of smoothing the transition by carrying over funds or a deficit from year to year. No decent commercial enterprise would be expected to work like this. The result is the worst upset in UK science for decades, and the further erosion of our standing both as scientific leaders and as good international partners.

Sir Francis Graham-Smith  
University of Manchester

## Subectively batty view

A lesson from the humble bat. When it was first suggested that bats could "see" using sound, the idea was laughed at by the scientific establishment. Early sonar came along, and then bats were allowed to do the same. "Contours from sound? Piffle!". Then radar came along, and bats were graciously allowed the same facility. "3-D sound pictures? Poppycock!" Thankfully, someone finally invented holograms, much to

the bats' relief...

Even the most sophisticated audio analytical equipment operates over a very limited time frame. The ear analyses a signal over seconds, minutes, hours, even years, and (in conjunction with the brain) interprets it: a violinist would be amused to be termed "golden eared" simply because he could identify the rich intensity of a Stradivarius coming out of his pocket tranny at 10% THD. No signal analyser can manage this degree of discrimination (even with a perfect signal).

Colour vision is now understood as the eye identifying that quality of an object that remains constant regardless of ambient lighting or one's viewpoint, not a spectral wavelength. When dealing with the ear, therefore, is it so surprising that people consistently say that they can hear things that seem unmeasurable (eg. loudspeaker cable directions), or prefer things that some would argue are worse (eg. Haffler vs all comers)? The ear may be detecting differences in parameters we're not yet aware of, and therefore aren't even looking for.

The argument that people are merely "conned" into preferring things because they're told they're better, is, of course, a completely indiscriminate weapon applicable to anyone who disagrees with you on this subject. Perhaps it reflects that objectivity remains a theoretical concept only, when applied to people.

Stuart J. Leask  
Northampton

## Triple tone awareness

In his letter in the April issue about my article "Trial by three tones" (*EW + WW* February 91), Richard Black suggests, incorrectly, that I am unaware of the work of Paul Miller. His methods do use three or more signals to evaluate the performance of amplifiers, but there are important differences between our approaches.

Paul described his work in the July 88 issue of *Hi-Fi News and Record Review*. His signals are all sinusoids, either steady-state, or with swept amplitude or frequency. To show fine detail a narrow measurement bandwidth is necessary, so the sweeping has to be

done at a very slow rate. Effectively all the signals can be considered as steady-state. The method is a direct extension of harmonic and intermodulation distortion measurement. The result is an elegant, computer-generated, 3-D presentation giving information that would otherwise require many separate spectral graphs.

The differences as I see them are:

- my large low-frequency signal is gated to form tone burst, so placing considerable stress on the power supply, while assessing the behaviour of the amplifier to higher frequency signals;

- distortion signals about -120dB with respect to the peak signal can be revealed. The amplitude scale on the 3-D plots only goes down to -96dB. The triple-tone method is still being developed to make it more sensitive;

- apart from an audio spectrum analyser, not a cheap item I admit, the rest of the system is easily constructed or will be found in most electronics laboratories. This is in contrast to the need for an FFT analyser and low distortion bus controlled oscillators.

The methods measure similar, but by no means identical features of amplifier performance, and should be considered complementary rather than equivalent. Finally, I wonder if this is the same Richard Black who has reviewed some amplifiers in the April 1991 issue of *Hi-Fi News and Record Review*. If so, it is surprising that he has not included any 3-D plots. He does however mention that the crosstalk between channels of one of the amplifiers is rather large and distorted. The triple-tone method appears to be very suitable for assessing this feature of amplifier performance.

Ivor Brown  
Brunel University

## Nut note

So American cosmologists are puzzled by the galactic clustering disclosed by the Iras data (Is lumpy universe theory half-baked?, *EW + WW* April p.269). The clear reason for the inhomogeneity is that the universe is not composed of CDM (cold dark matter) but of a certain manufacturer's Fruit and Nut. This can be proved by examining

*Continued over page*

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the correspondence columns, and often editorial content, of some journals, particularly those concerned with "high quidility" (where the purchase price is far more important than the totally-discredited technical specification).

**John Woodgate**  
Essex

## Astro-mystics.

M.G Wellard's wry comment in the January issue of *EW + WW* that "...exact science was infiltrated by a school of mystics at the turn of the century" comes dangerously near the truth.

The infiltration began in 1905, when Einstein proposed his Special Theory of Relativity in an attempt to unify Newtonian mechanics and Maxwell's e-m wave theory of light. At that time, most of the optical experiments could best be described in terms of photons - which can be regarded as localised concentrations of energy. But the concept of photons could not be reconciled with e-m theory, so for the next 20 years the theory of light was in a state of confusion.

In 1927, Heisenberg proposed his "uncertainty principle", which allowed the theories of e-m waves, photons and relativity to be unified in the theory of quantum mechanics. So the latter theory was adopted as the new theory of light.

Scientific mysticism flourished for several decades, but even then a number of leading scientists had begun to suspect that relativity theory contained flaws.

Some years ago, while unaware of the controversy, I wrote to a learned society suggesting that a partial return to pre-relativistic physics might help to solve some of the problems then facing astronomers such as quasars, "black holes", anomalous red-shifts, etc.

As an alternative to "big bang" cosmology, I proposed a theory that systems of galaxies were circulating in vast orbits at high velocities. But a galaxy's velocity transverse to the line-of-sight can cause its appearance to be distorted. The reason is that while light from stars at the rear of the galaxy is crossing space towards us, the galaxy can move a large distance in its orbit.

So a globular-shaped galaxy with a high transverse velocity appears to us to be shaped like a rugby football. And a disc-shaped galaxy of diameter, say, 120,000 light-years,

appears to have "spiral arms" and a central "bar".

The theory can explain the shapes of all the galaxies, but it conflicts with Einstein's theory so it is regarded as "heretical"

In recent years the growing use of electro-optical devices - such as lasers, optical gyros, computers, etc - has created renewed interest in optical systems, and the more mystical theories are having to be re-assessed.

The policy of *EW + WW* has always been to publish new ideas, even the controversial ones. As an indirect result, the long-awaited updating of the theory of light is now being much more freely discussed by all concerned.

**John Ferguson**  
Camberley  
Surrey

## Enough is Enough

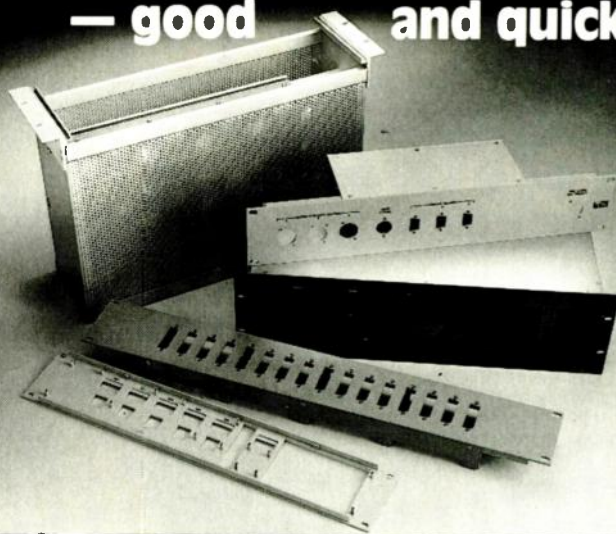
I've read with interest and utter dismay John W Ecklin's article regarding the laser Doppler effect in the March '91 issue. The last impression I want to give is one of a blind Einstein flag-waver, but enough is enough. I should think that over three quarters of a century would have been more than adequate time for most of us to absorb what Einstein was trying to tell us. When it comes to electromagnetic radiation (light), it makes no sense to talk about

$c' = c \pm v$  because empirically this phenomenon does not exist. Light does not obey the Newtonian principle of addition of velocities and what's more since frequency is inversely proportional to wavelength the product  $\lambda f$  is always equal to  $c$ , and therefore  $v \cdot v - c = \pm d = 0$ . The phenomenon described by Ecklin simply does not exist. The velocity of the wavefront is independent of both frequency and wavelength, and vice versa. Nobody ever said (Einstein included) that SR is intuitive or that it makes sense, and anyone making such an assertion is either mad or doesn't understand scientific methods. After all, if we don't learn from experiment, then what use is science or anything else.

**Frank La Tella**  
Sydney  
Australia

*Editorial survey: use the information card to evaluate this article. Item H.*

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**W**addington (pop 1100) is a picturesque, rather middle-class village in Lancashire's Ribble Valley, apparently inhabited by people with better things to do than watch TV. Ownership of VCRs in 1990 was less than half the regional average, and this time last year satellite dish penetration was less than one per cent - a quarter of the national figure.

Yet for five weeks in the spring of 1990, Waddington became the Television Village, bounced into a 21st century viewing experience of mega-multi-channel choice, including a soft-pom channel and a taste of wide screen viewing and even of HDTV. And, at the other end of the scale from pan-European satellite broadcasting, Waddington enjoyed its own community television, produced in the village Sunday School hall and transmitted from a mast in a nearby field.

The Scope of the project was devised by Granada Television and its aim was to give a small, self-contained community a taste of the future shape of television, and assess their reactions to it.

Thirty-two homes, 10 per cent of the village, were cabled-up to receive 25 channels. A further 14 were fitted with

# TELEVISION VILLAGE

The people of Waddington, Lancs, were cast in the role of couch potatoes to test the future impact of television and television technology. Peter Willis reports.

microwave (MVDS) receivers to pick up the five BSB channels, and one was issued with an HDTV receiver (though since this was an 18in monitor, it can hardly have done full justice to the transmission quality!). In addition, nearly all the homes in the village were able to pick up the village channel through their existing UHF TV aerials.

The channel - known as WVTV, Waddington Village Television - was originally a small part of the project, intended to reflect the plans of some cable companies and interest expressed by some local authorities. However, perhaps because it was the only part to involve the whole village, it ended up dominating the experiment, achieving a 97 per cent viewership.

This has been taken as an overwhelming argument for more local TV, though whether the homely mix of known faces, amateur presentation and parish-pump stories (some of which were censored anyway) would maintain interest once the novelty had worn off remains unproven. The channel went out, mostly live, for an hour each evening from an improvised studio in the Sunday School - loaned sofas and an old Granada backdrop (of Manhattan by night, hurriedly overpainted with Magnolia emulsion by a man who was redecorating the pub), using S-VHS cameras loaned by JVC. There were repeats the following morning, and a Saturday morning children's show, entirely made by the children.

### Alright on the night?

The channel developed through the enthusiasm of the village, assisted by journalism and media students from local colleges, and, to begin with, largely unnoticed by, and without help from, the Granada team, which was immersed in getting the rest of the project set up.

All that changed on the first night as soon as the first taped insert was reached. Two VCRs, left connected together in edit mode, produced corrupted sync references giving unviewable picture slip. The station closed immediately with the immortal line "What a cock-up" from one of the presenters. From then on, Granada engineers made proper technical checks and there were no more technical problems.

However, the channel gave the IBA's North West regional officer virtually a full-time job monitoring progress.

The IBA had taken responsibility for the channel, with assurances to the Home Office and the DTI that the Broadcasting Act and the IBA Guidelines would be followed.

Since the village steering committee had little idea of what these constraints involved, and made up much of its programming as it went along, this proved no easy task. One of the several instances about which the IBA felt less than happy was, oddly, the broadcasting of a public meeting with the Home Secretary himself (as it happened, eponymous local MP David Waddington). Another complication was the decision to carry advertising, which in theory put the channel in conflict with Granada itself as the local exclusive licence-holder.

### Local channel a hit.

On the whole the IBA was pleased with the project. The eagerness of the villagers to participate grew continuously through its lifetime, and people in surrounding villages were reported to be moving their TV aerials in order to pick it up.



*Command centre for the village channel was a Granada trailer surrounded by scaffolding to support aerials and with a tall tower for the MVDS transmitter.*

Transmitting the village channel was achieved by the simple expedient of erecting a temporary mast in-line with the local terrestrial transmitter, Winter Hill, and finding an available channel within the same group. Channel 67 was eventually selected. The transmitter, housed in an IBA cross-country vehicle, and with a single log-periodic aerial on a 17 metre telescopic mast, was sited in a field 1.5 km

*Eagerness of the villagers to participate grew continuously through its lifetime, and people in surrounding villages were reported to be moving their TV aerials in order to pick it up.*

south of the village. Mains power was provided from the farm. Signal levels in the village centre were about 75dBµV/m. Since this was some 20dB weaker than the existing Winter Hill signals, homes with poor aerials or badly-adjusted receivers found the pictures barely viewable. Engineers from Granada TV Rental, which provided all the cabled homes with identical, modern sets to ensure a uniform reception standard, also went round the other homes, tuning in channel 67. Where they came across poor installations ("salmon-pink pictures" was just one horror-story) they made improvements. So successful was this that at least one resident assumed he was now getting high-definition TV.

The village channel was fed to the transmitter by a 2.5GHz microwave link from the Command Centre. This, the hub of the project, was a Granada trailer around which was erected a scaffolding rig to support the satellite aerials, and a tall tower for the MVDS transmitters. Waddington is a T-shaped village, set on gently rising ground. The main pub, *The Higher Buck*, is on the crossbar of the T, looking straight down the main road which forms the upright. Since this is the

highest point of the village, the car park behind the pub suggested itself as a suitable location for the Command Centre. It was also handy for the village hall and the Sunday School. Satellites pulled in were: Astra (1A), Eutelsat (1. F4 and 1. F5), Intelsat VA Fil, DFS-1 Kopernicus, TDF-1A and BSB's Marcopolo 1, which started transmission during the experiment. Programmes provided included all Astra English-language channels, all BSB, plus CNN, Children's Channel and Discovery on Intelsat, Superchannel and Worldnet (US Government news) on Eutelsat, plus German, French, Italian and Dutch channels. Two channels were provided from tape: Vision, a Sundays-only religious channel, and Home Video Channel, "adult" films.

The Command Centre used Triple Crown modulators to convert the signals to VHF, with saw (surface acoustic wave) filters to provide adjacent channel performance. It was distributed on a wideband (50-550MHz) trunk. Cable losses were made up by 34dB gain bridging amplifiers, powered from cable-borne 55V AC, which overcame the problem of providing local power feeds.

Waddington is a strikingly pretty, and obsessively tidy village, and in laying the cable, Granada engineers used considerable ingenuity to minimise visual disruption. The main trunk was half-inch coaxial, with quarter-inch co-axial between the tap-offs and the chosen households.

*Everybody asked for the porn channel (it was a standing Cable Authority condition that this was only supplied on request) but only eight households watched it in any given week and nobody had much to say in its favour.*

An additional, reverse, run of cable had to be included to carry the monitoring data, collected from specially-adapted remote-control readers, back to computers in the Command Centre.

On initial tests, some patterning, due to intermodulation between T sets, VCRs and cable receivers, was found, and with a large number of signals present, proved a complex problem. Attenuating the terrestrial signal, with a pad in the aerial downlead, proved to be the solution though this gave rise to further problems in some cases because of the relative weakness of

the village channel. Richard Ellis, Granada's chief engineer, noted: "In retrospect, it might have been better to convert the four terrestrial UHF signals to VHF at the Command Centre and pass them down the cable with the 25 satellite channels."

One problem the team had not foreseen was loss of signal due to sheep chewing through the cable. It is this sort of difficulty, and others to do with way-leave and installation, that microwave distribution is so good at avoiding.

### MVDS system

For the MVDS (microwave video distribution system) part of the experiment, a fair amount of improvisation was necessary. Although government had indicated 12.5 and 40GHz as possible frequencies for future systems, the only available equipment (borrowed from BT's Racenet bookmakers' service) operated at 29GHz. The aerials were encased in plastic domes about 12in in diameter - larger than a 40GHz aerial would be, but reasonably unobtrusive and entirely acceptable to the householders. The aim was to provide a wide-bandwidth (27.5MHz) service capable of carrying PAL, MAC and W-MAC (16:9 screen ratio).

Since MVDS is a line-of-sight system, homes had to be selected with care. The five transmitters were mounted on the 30ft gantry at the Command Centre, which gave a clear view over the village. Once BSB started transmitting, the MVDS was

*Young TV reporters for Waddington TV interviewed their local MP at the time, David Waddington.*



used to carry its programmes - delivered to BSB receivers in the 14 homes. However, signal lock was lost in a number, due to the combined drift with temperature of the transmitter and local oscillator being, at 6MHz, outside the capture range of the BSB receiver.

One solution - offsetting the frequencies of the transmitters and the MVDS receivers - was rejected as impractical, since the latter were attached to the aeri-als, by then on the roofs and chimney pots of the houses.

Eventually, it was noticed that the BSB receiver circuits had an adjustment for the pull-in range of the AFC; once this was widened, the problem was solved. "A good example of experienced engineers finding a practical solution under extreme pressure and in a short time without resort to the research laboratories who would have had to come up with a solution to improve the oscillator circuits," commented Richard Ellis.

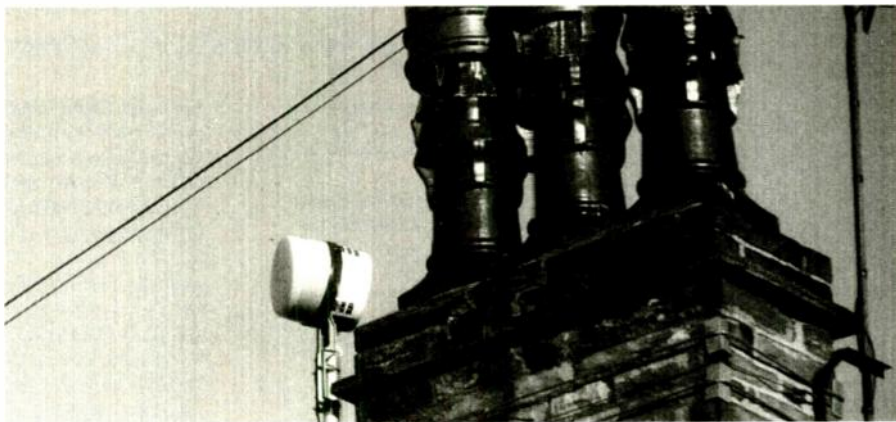
The 14 MVDS homes were therefore among the very first in the UK to experience D-MAC transmission standards (the cable homes had their BSB channels converted to PAL).

Questionnaires were issued, of which eleven were returned. Seven thought the picture quality better than normal television - more lifelike and with greater detail, clarity and brightness. However, only three were definitely interested in having MAC - two were prepared to pay £800; one would only pay £350.

### Widescreen television

Widescreen television (16:9 aspect ratio) was also demonstrated in Waddington - the Command Centre had its own D-MAC encoder, so was able to make its own programmes, including village material and converted HDTV footage. A bigger problem proved to be finding ways of getting it seen. Only two prototype proper dimen-

*What was striking about the project was the immense enthusiasm it generated, both among the villagers and the incoming professionals... particularly so of the village TV channel.*



*Microwave video distribution system aeri-als attached to roofs and chimney pots brought the first D-mac transmissions to UK homes*

sion HDTV sets were available in the country at the time - one went to Waddington, but had to be borrowed for a few days when the other, which was to be displayed at the London Cable & Satellite show, was dropped and put out of action.

For the other four homes which were favoured with widescreen reception, two had masked 4:3 33in CRT sets, and two had masked 46in rear-projection receivers. Viewer-response to the picture was overshadowed by reaction against the physical bulk of the sets. An urgent problem posed for broadcasters by widescreen is how best to display 16:9 format material on 4:3 sets. Twenty people in the cabled homes took part in an experiment, watching the same material displayed in three different ways: (1) Using the full 4:3 screen, and losing the side portions of the 16:9 picture; (2) Full 16:9 "letterbox", showing the whole picture, between two black, horizontal bands; (3) A compromise display (1.54:1) which more nearly fills the screen; it loses some of the sides of the picture, but reduces the thickness of the black bands top and bottom. Most viewers (74 per cent) preferred the full 4:3 display to the 16:9 letterbox; however they were divided 50-50 over whether they preferred 4:3 to the compromise, 1.54:1, picture.

### HDTV

To demonstrate HDTV, a closed-circuit system was set up, using a four metre screen and a Barco 1001 projector, plus two Philips 54in back-projection receivers in the village club (and the 18in monitor in a nearby house). Material shown included the ITV "Winchester" footage, some Eureka 95 material produced by RAI and showing "breathtaking" scenes of Italian architecture, football (1989 Cup Final) and Wimbledon tennis. In addition, ITV's HDTV vehicle visited the village; eight feature films were transferred from 35mm, using its telecine and colour grad-

ing facilities. Its HDTV cameras recorded scenes of the village. The villagers were undeniably impressed by HDTV, but, again, no-one would spend more than £800 on it, and the house with the monitor, although "very interested" in a set up to 36in, wouldn't be prepared to spend more than £350.

### Epilogue

Quite what the whole project proved is not immediately clear. The amount of viewing, in the cabled households, was nearly double the national average. The number of channels tuned in fluctuated wildly. Everybody asked for the porn channel (it was a standing Cable Authority condition that this channel be only supplied on specific request) but only eight households watched it in any given week and nobody had much to say in its favour.

Zapping was more prevalent among children than retired people. What was striking about the project was the immense enthusiasm it generated, both among the villagers and the incoming professionals.

This was true of all aspects, but particularly so of the village TV channel. Quite possibly the point was the taking part. More than anything else, it proved to ordinary people the adage of the chattering classes - that television is for being on, not watching.

A book on the project, *The Television Village*, published by Granada, is available, price £9.50, or £27.50 with a 10 minute VHS videotape, from: TV Village, PO Box 4000, London W3 6XJ; cheques payable to Granada Television.)

*Editorial survey: use the information card to evaluate this article. Item 1.*

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CIRCLE NO. 103 ON REPLY CARD

# PCB design on the cheap?

**B**oardmaker 2.30, latest PCB design product from Cambridge based Tsien (UK), is an integrated schematic capture and layout package with autorouting. Nothing new in that. But the price for the whole package is under £500. So what compromises have been made to provide such a comprehensive product at that low price?

Installation is straightforward and an install program moves the files — 1.4Mbytes of disc space including libraries — onto hard disc.

Operation is claimed to be possible on a dual floppy system, but with this amount of data speed must be seriously compromised.

## Starting up

Boardmaker starts up with a menu offering schematic, PCB or library editors. Selection leads to a working environment of standard banner and pull-down windows, and a data line across the bottom of the screen. Access to the functions at the banner is either by mouse clicking or by typing control with the key letter of that menu.

Windows are fast and responsive, though it is not possible to move directly from one to the next by simple cursor movement.

## Draw and redraw

Drawing speed of Boardmaker is excellent, handling quite complex PCBs in only a few seconds. A particular zoom level is chosen by pressing one of the number keys, 1 to 8 (seen this scheme somewhere before?) and its only weakness is that the program insists on completing the redraw even if a different zoom has been keyed. If the redraw speed had been slower, this slavish following of keystroke to action could have been tedious.

Auto pan across the PCB can be switched off and on, but unfortunately

John Anderson tests cost-conscious Boardmaker.

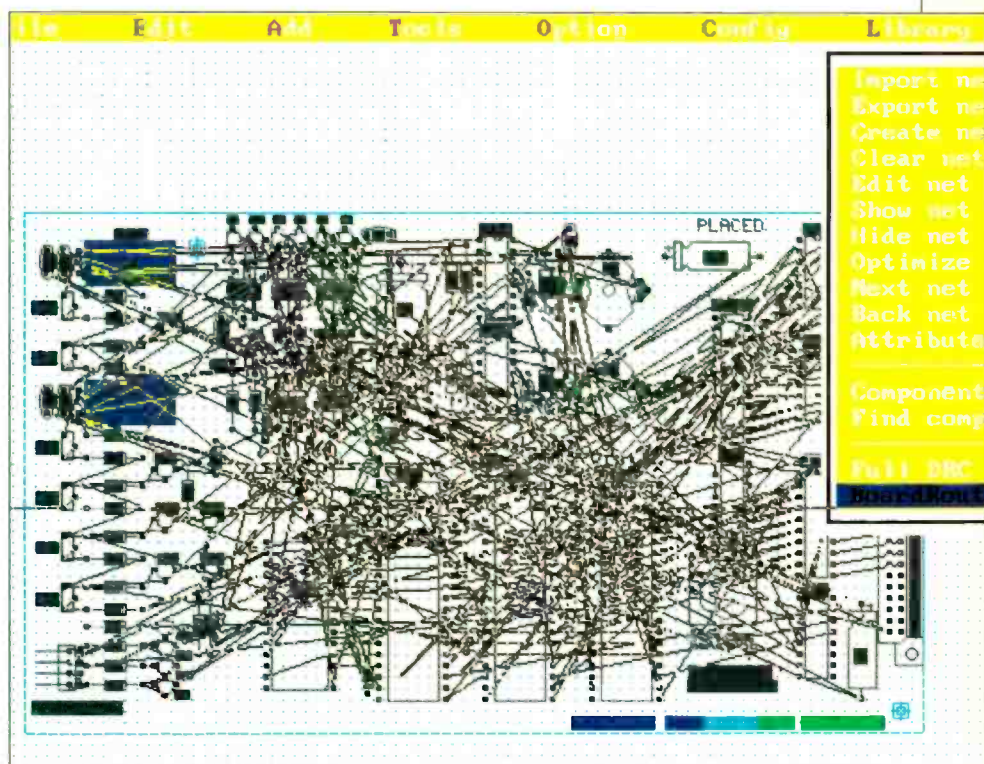
Does £500 really buy schematic entry, component placement and autorouting?

panning only responds to the cursor key and not to the mouse.

## Simple editing

Simple editing of, say, a PCB is fast and easy, with the cursor snapping to the pad, rubber banding as the track is laid, and the track identified by cracks as it changes direction. The command structure puts Boardmaker in particular mode, eg track laying, and continues in it until cancelled by a new mode. Text placement is initially on the silk screen layer. But text may subsequently be moved to another layer with text edit; boardmaker is smart in moving text and components between layers, mirroring both if they are transferred to the bottom layer.

Fig. 1. Rat's nest and net menu



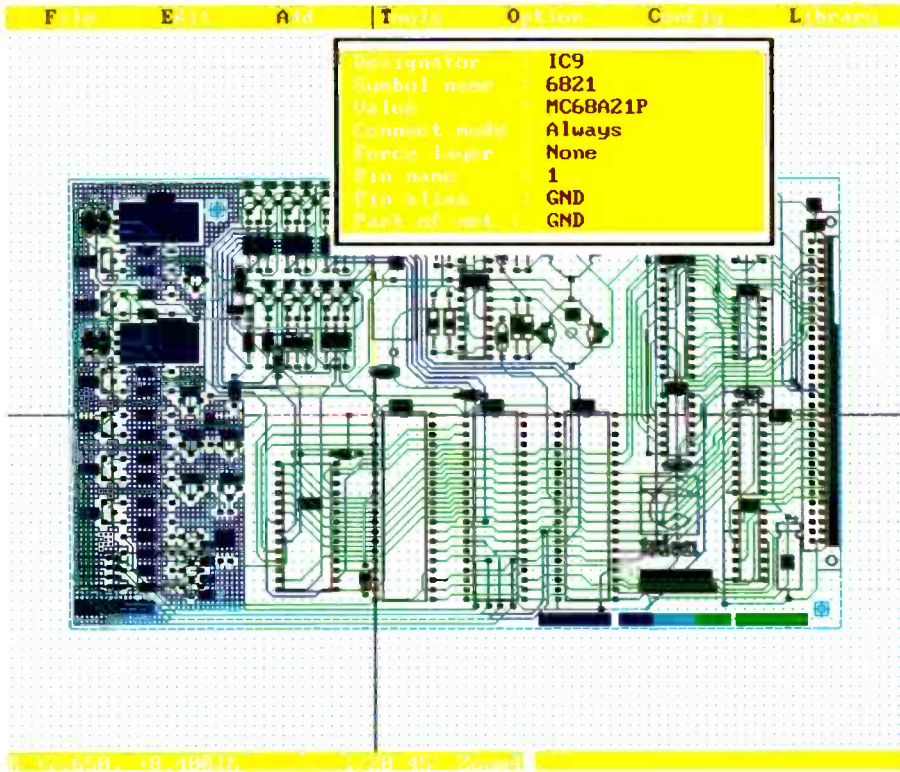


Fig. 2. Routed PCB with node view

A reservation is that it achieved only a 99% routing, when that last track would have been a simple matter with a shove router (where tracks already laid are shoved to one side).

To remove the rat's nest of nets for tracks already placed by the autorouter, a full DRC must be run and this means more wasted minutes while the program sorts out something it "knew" already.

Living with boardmakerSchematic capture looked and felt like a PCB editor. Not only were the lines tracks and the junctions pads, but any pad size could be used, including drill hole on the schematic.

No net labelling and capture functions available in this part of the program. Indeed the net pull-down menu announces "no net facilities available in schematic editor" and this is a serious shortcoming

Fig. 3 Edit track — note rubber banding and track codes

This smartness also extends into the block mode of operation.

A block, defined in the normal way by identifying one corner and dragging a box to the opposite corner, can be moved, deleted, repeated and mirrored. This latter command logically inverts all the layers so that, for example, a group of top surface mount devices will be moved to the bottom, and mirrored (as seen from the top), including any text.

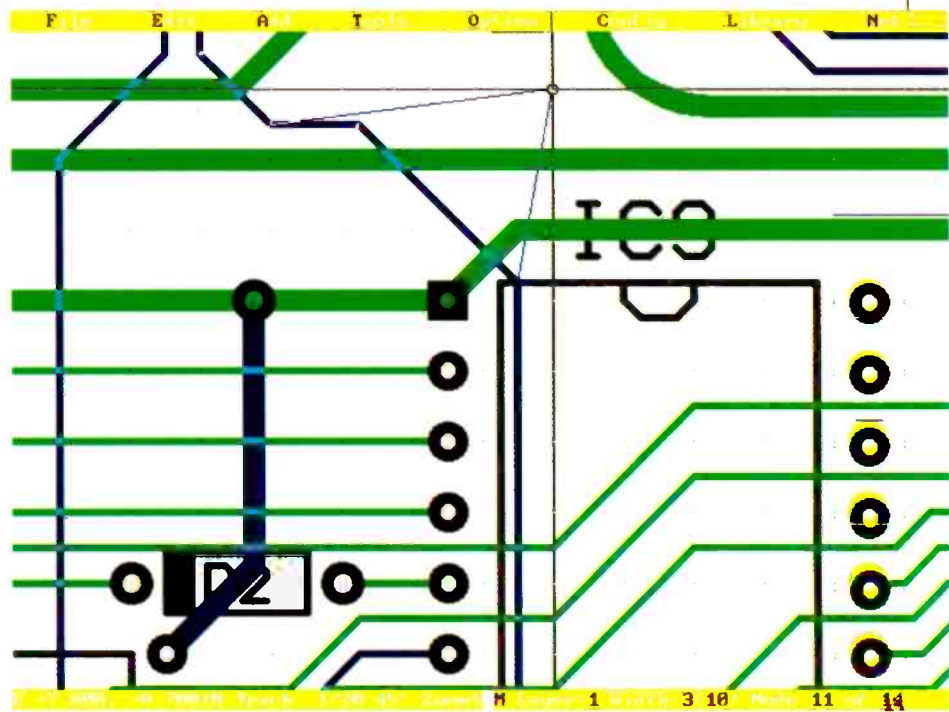
Boardmaker has a reasonable footprint library suitable for most simple designs, covering ICs — including surface mount — connectors and devices. Selection of the required device is assisted by a useful library browse facility.

### Autoroute and check

Design rule check (DRC), integrated into the program, means that before allowing autoroute to proceed, the checker reviews all the nets and this takes several minutes. Eventually the user is presented with the autoroute banner, and routing options can be selected.

Autorouting strategy is not specified, and the only set-up options available are select direction of routing on a particular layer and whether to route a net or the whole board.

The autorouter is completely re-entrant allowing the user to interrogate the system while routing is in progress. What advantage this gives is not clear as all that is required from an autorouter is a routed PCB. Watching an autorouter work is no better than watching paint dry, and actual



routing is painfully slow. On an 8MHz AT it took about 5s simply to route adjacent pins. Complex nets can take several minutes, and a complete board about 20min.

### Good results?

What about the results? Well they are really quite good: minimal backtracking, no stubs or complete loops — a very creditable performance.

as there seems little point in having an integrated schematic and PCB layout package if the components and connectivity which describes the job are not transported between integrated components of the program.

On the PCB side of the equation, Boardmaker looks very competent. The area fill — termed flood fill — is better handled by Boardmaker than competing packages with a much higher price tag.

Set-up allows selection of the type of



fill, then Boardmaker, with a degree of intelligence, fills the area following design rules, and missing already placed circuit elements.

Another nice touch is the power to point to a particular node and carry out interrogation, to determine relevant details about its net, pin number, pad size etc in a pop down window (Fig. 1).

PCB files are stored in Boardmaker's proprietary format, so that the only way to interrogate the database is through Boardmaker itself.

### Real weaknesses

Schematic capture does not build the netlist for the PCB for import at the PCB edit and route stage — the autorouter imports either from a text file generated by hand, or from a netlist generated by a schematic package such as Tango, OrCad or Protel. Thus one of the most important aspects of generation of a PCB, maintenance of connectivity between schematic and PCB layout, is lost.

Further, the PCB part of the package offers component renumber, which for an un-netted PCB will produce a very professional looking result.

But competitive products provide this sort of feature with back annotation to the schematic so that one to one correspondence is maintained.

Boardmaker does produce a file containing a list of old and new annotations, but implicit in this is manual update of the circuit diagram, and intervention of the operator in doing, by hand, what should be accomplished by computer.

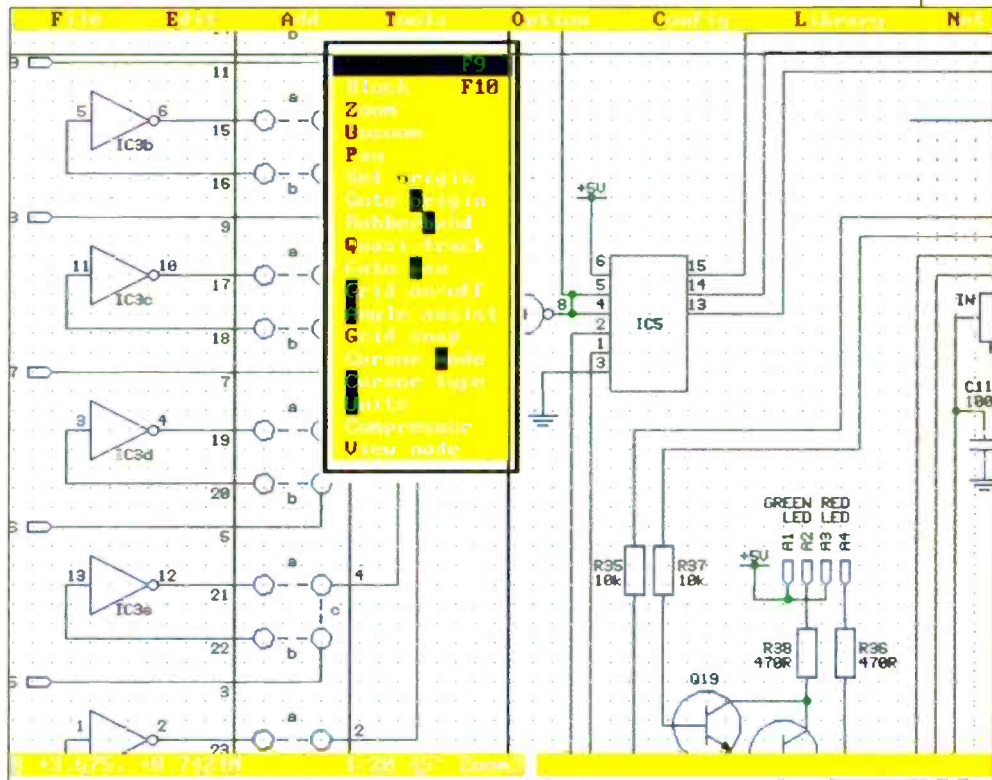


Fig. 4. Schematic capture with the tool menu

### Compromise, competition and conclusion

Working with this product gives a definite feeling of "double-take", as ideas under-pinning operation of the program are very similar to that of another British PCB package, Easy-PC — though the whole product does have a very much more professional feel. So it came as no surprise to find the two packages are writ-

ten by the same person, Lawrence Rao.

Certainly in some tasks the package was slow, particularly autorouting and design rule checks. But this is offset somewhat by the seemingly ever-increasing processing power of today's PCs, though I would not recommend the package for large boards on say an XT.

The DRC facility, though slow, is a very important part of any PCB cad. It is advent of this function that provides the quality assurance required, guaranteeing that it is possible to make the PCB and that it corresponds to the input netlist.

There have been compromises in attempting to combine the functionality of library editing, schematic capture and PCB edit all in, notionally, the same operating environment. Requirements of the three functions are rather different and I feel this has been missed, particularly with schematic capture. Better functionality would be achieved if the package were combined with a dedicated schematic capture package such as OrCad. But if you are forced into this; why use Boardmaker?

All in all this is a good product with a high functional specification supplied with an excellent manual, though the speed issue could force you to have a second cup of coffee while those larger PCBs are being routed.

### BOARD MAKER SPECIFICATION

- Requires: PC, XT or AT compatible computer
- At least 512K ram, running dos 2 or later.
- Parallel printer port (for the dongle)
- Graphics screen supported are: CGA, EGA, VGA and Hercules
- Options: Epson compatible printer, mouse, HP LaserJet II or compatible HPGL plotter
- Gerber photoplotter and Excellon NC drilling supported
- Boardmaker 2 and autorouter £495
- Boardmaker 2 only £295
- Boardmaker 1 entry level £95
- 5.25 and 3.5-in media with professionally printed manual and parallel port dongle.

Product support for Boardmaker is free for three months. Additional support is available for a further 12 months at £69.

**Supplier:** Tsien (UK) Ltd. Cambridge Research Labs, Huntingdon Road, Cambridge

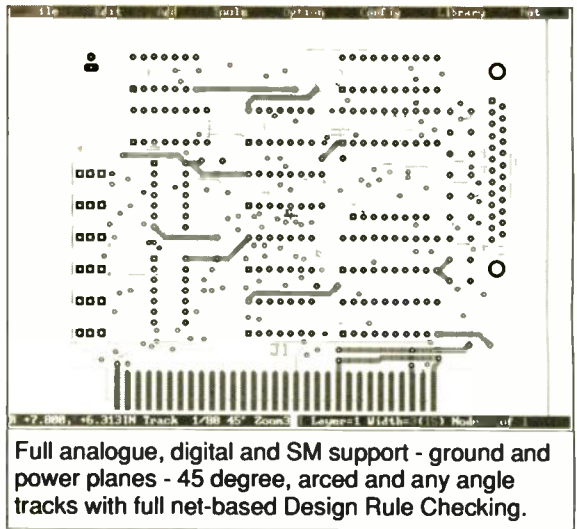
*Editorial survey: use the information card to evaluate this article. Item F.*

# Take the Sensible Route!

**B**oardMaker is a powerful software tool which provides a convenient and fast method of designing printed circuit boards. Engineers worldwide have discovered that it provides an unparalleled price performance advantage over other PC-based and dedicated design systems by integrating sophisticated graphical editors and CAM outputs at an affordable price.

## NEW VERSION

In the new version V2.23, full consideration has been given to allow designers to continue using their existing schematic capture package as a front end to BoardMaker. Even powerful facilities such as Top Down Modification, Component renumber and Back Annotation have been accommodated to provide overall design integrity between your schematic package and BoardMaker. Equally, powerful features are included to ensure that users who do not have schematic capture software can still take full advantage of BoardMaker's net capabilities.



**£295**

**BoardMaker V2.23 is still a remarkable £295.00 and includes 3 months FREE software updates and full telephone technical support.**

## NEW AUTOROUTER

BoardRouter is a new integrated gridless autoroute module which overcomes the limitations normally associated with autorouting. **YOU** specify the track width, via size and design rules for individual nets, BoardRouter then routes the board based on these settings in the same way you would route it yourself manually.

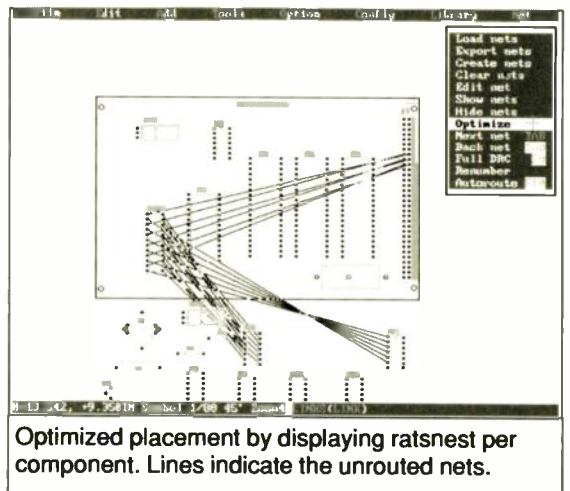
This ability allows you to autoroute mixed technology designs (SMD, analogue, digital, power switching etc) in **ONE PASS** while respecting **ALL** design rules.

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You can freely pre-route any tracks manually using BoardMaker prior to autorouting. Whilst autorouting you can pan and zoom to inspect the routes placed, interrupt it, manually modify the layout and resume autorouting.



**£495**

**BoardRouter is priced at £295.00, which includes 3 months free software updates and full telephone technical support. As a special introductory offer, BoardMaker and BoardRouter can be bought together for only £495.00.**

## HIGHLIGHTS

- Net list input from OrCAD, Schema etc.
- Top down modification
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CIRCLE NO. 104 ON REPLY CARD

# Digital potentiometers

New from Dallas is the DS1267 dual digital potentiometer IC, which contains two digitally controlled 256-position pots connectable in series for higher resolution. Resistance and resolution values of each section of the -10, -50 and -100 versions are 10kΩ/39Ω, 50kΩ/195Ω and 100kΩ/390Ω.

Figure 1 shows the arrangement of the DS1267, which is adjusted to the required value by selecting resistive elements digitally, tapping points accessible to the wiper being provided at each element junction; wiper position is set by an 8-bit register, which is read or written to by data bits at a three-wire serial port and which controls a 256:1 multiplexer to select the tapping point. If the resistors are to be in series for higher total resistance, a STACK SELECT bit determines which wiper is seen by the output.

Data is entered and read via a 17-bit I/O shift register, loaded by the three wires RST $\bar{N}$ , DQ and clock and updated by transferring all 17 bits, as in Fig. 2., serially at the DQ pin when RST $\bar{N}$  is high. To read the data, DQ floats and, when RST $\bar{N}$  is high, bits are fed back to DQ through an isolating resistor serially until they have all shifted back to the original state, being read at C $_{out}$ .

Wipers are taken straight to output pins, non-linearity being less than  $\pm 0.5$ LSB for all settings and -3dB points 40kHz for the -100 version, 250kHz for the -10.

Dallas Semiconductor Corporation, Unit 26, West Midlands Freeport, Birmingham B26 3QD. 782 2959.

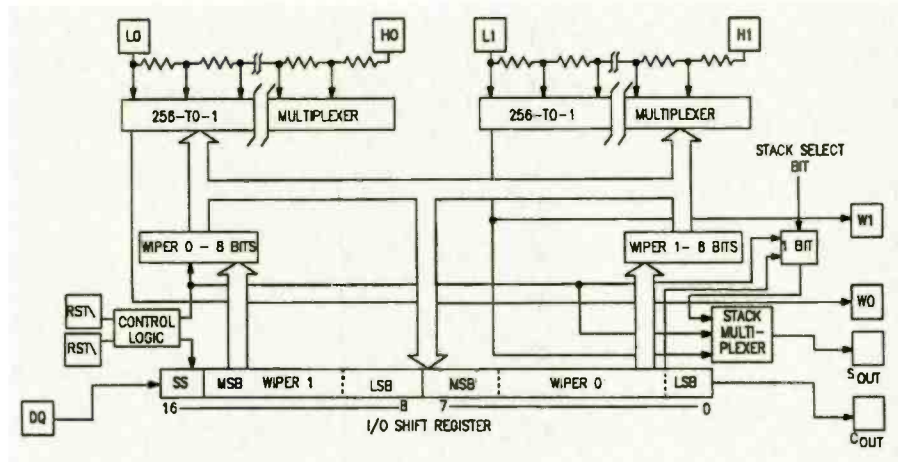


Fig. 1. Internal block diagram of Dallas's DS1267 dual digital potentiometer.

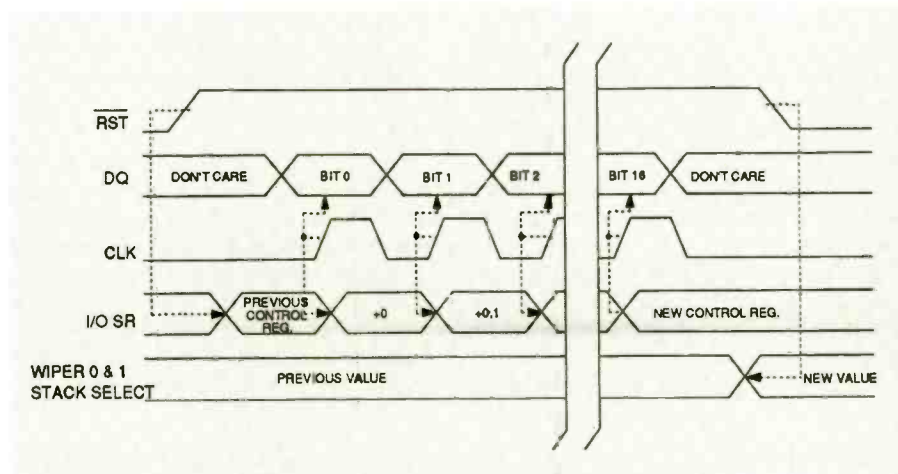


Fig. 2. Writing control data to the potentiometer. While RST $\bar{N}$  is high, the original state is preserved during data entry, changing to its new value when RST $\bar{N}$  goes low.

# Microstepping drive circuits

A note from Analog Devices by John Wynne briefly reviews permanent-magnet stepper motors and discusses some of the problems involved in driving them: in particular, the errors introduced by D-to-A conversion and load torque are examined, as are the pros and cons of open and closed-loop control.

Two practical circuits illustrate the argument, one using fixed-frequency PWM and the other a frequency-modulated PWM technique. Both use dual 8-bit D-to-As for phase current control and an 8-bit A-to-D for closed-loop position control. It is assumed that an optical encoder on the motor shaft will produce quadra-

ture triangular outputs, although other types are also used with motors that provide velocity windings.

Figure 1 shows the fixed-frequency circuit which uses an AD7628 and an AD7820. Output power is provided by the Sprague UDN2998W, which is a dual H-bridge driver.

The NE555 gives 2.5µs low-level pulses at 45kHz, a high enough frequency to avoid audible noise while being low enough to reduce losses. The pulses reset the flip-flops and enable the phase currents through the output driver, their values being monitored by sense resistors R $_{SA}$  and R $_{SB}$ . Resulting voltages are noise

filtered, amplified in the first op-amps and compared with the D-to-A control voltages in the second pair of op-amps. If either amplified sense voltage exceeds the D-to-A control voltage, the comparator goes low, sets the flip-flop and turns the driver off. Phase current falls slowly until the next pulse resets the flip-flop.

Voltage switching is used in the 7628s. Reference is taken to out $_A$  and out $_B$ , the output coming from V $_{REFA}$  and V $_{REFB}$ . Positive reference gives a positive voltage (not a current) at constant impedance. This configuration exhibits virtually no gain error and output matching between D-to-As is better than 0.4%. The display in

**Fig. 1. Fixed-frequency PWM stepper motor drive, which gives 800 microsteps per revolution.**

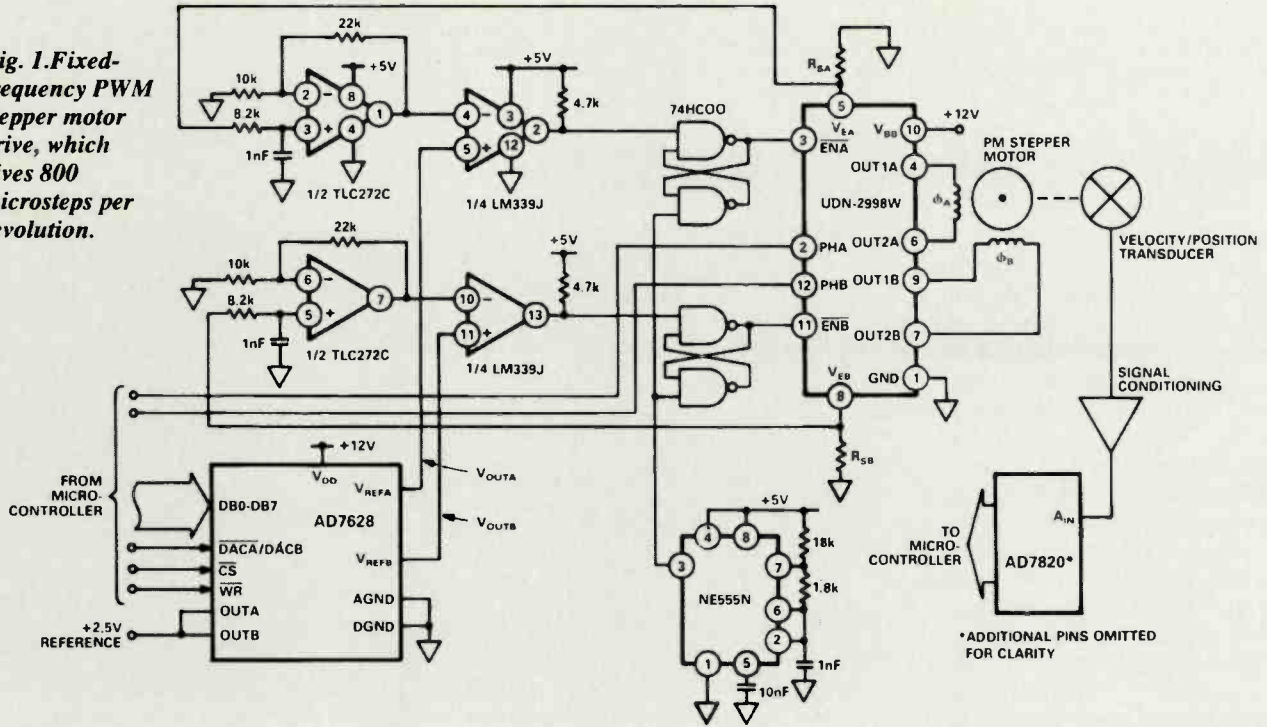


Fig. 2 shows the D-to-A output (bottom), covering two full steps with eight microsteps per full step. The top trace is the amplified sense voltage at 1V/div. Time for eight microsteps is 12.8ms so that, with the Portescap P530 motor used, which has a step size of 3.6°, microsteps are of 0.45° to give 800 microsteps per revolution.

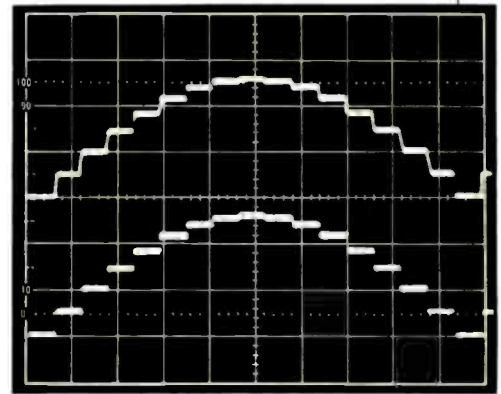
In the circuit of Fig. 3, a single IC contains both the dual D-to-A and the single A-to-D and the flip-flops are removed to produce an FM configuration.

In this case, after the phase current is turned off, the comparator output stays

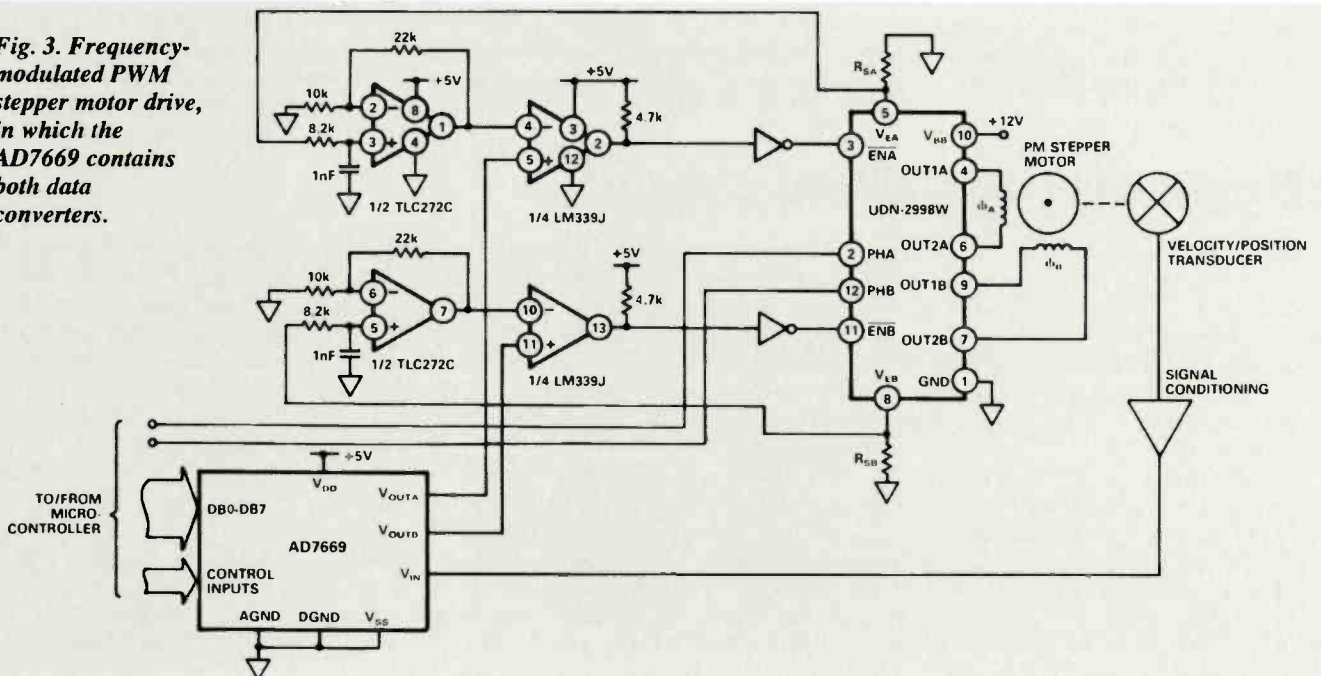
**Fig. 2. Amplified sense voltage (top) and D-to-A output at 1V/division, (right) showing eight microsteps for each full step.**

low until the decaying current is low enough to force the comparator output high again to restart the cycle. Both phases have separate loops, but it is found that the lock together in practice at about 25kHz and no beats are caused.

Analog Devices, Station Avenue, Walton-on-Thames, Surrey KT12 1PF. 932 253320.



**Fig. 3. Frequency-modulated PWM stepper motor drive, in which the AD7669 contains both data converters.**



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### COLOUR MONITORS

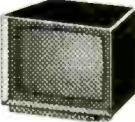
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CIRCLE NO. 113 ON REPLY CARD

# DC motor controller

MPM3004 from Motorola contains pairs of p-channel and n-channel mosfets in an H-bridge arrangement and is meant to drive stepper motors or the DC motors in disk drives and servos. The package is an ICePAK isolated to 2kV and will handle 25A peak with an ON resistance in the region of 0.2Ω.

Since the four complementary mosfets are integrated, the bridge IC offers a very simple motor controller, using two ICs and a pair of small-signal transistors.

In an arrangement referred to ground, as shown in the diagram, the lower pair of n-channel mosfets is easily driveable directly by ordinary cmos gates, when switching needs are not severe. In normal circumstances, this lower half of the bridge is pulse-width-modulated, the

capability of the driver gates determining switching speed. In the case illustrated, a MC1450B hex level shifter moves the 5V output of the gates to the required 15V level needed by the fet gate. Each mosfet uses the output of three gates in parallel to obtain a greater source/sink capability, the 100Ω gate resistors and the  $r_{DS(on)}$  of the p-channel and n-channel cmos gates limiting the current to ±70mA and allowing the power mosfets to switch efficiently at up to 15kHz. Higher speeds need higher currents.

To drive the upper pair of direction-steering power mosfets is also simple and

**DC motor controller using the Motorola MPM3004 power bridge. If the microcontroller is up to it, the small-signal**

fast switching is not needed. Since the microcontroller will probably produce positive-going steering pulses, a pair of small-signal n-p-n level-shifting transistors of the MPS ADS type will suffice — one for each direction control. A 60V rating is needed for these devices, because the bridge is to drive a 48V DC motor and is rated at 60V. The level translation is done by turning on the transistors, pulling down the p-channel gates to a level set by the 1kΩ and 2.7kΩ potential dividers — 13V in this case. If the microcontroller used has n-p-n open-collector output, the MPS ADS transistors need not be used.

Motorola Ltd, European Literature Centre, 88 Tanners Drive, Blakelands, Milton Keynes MK14 5BP. 0908 614614.

## Decoupling op-amps

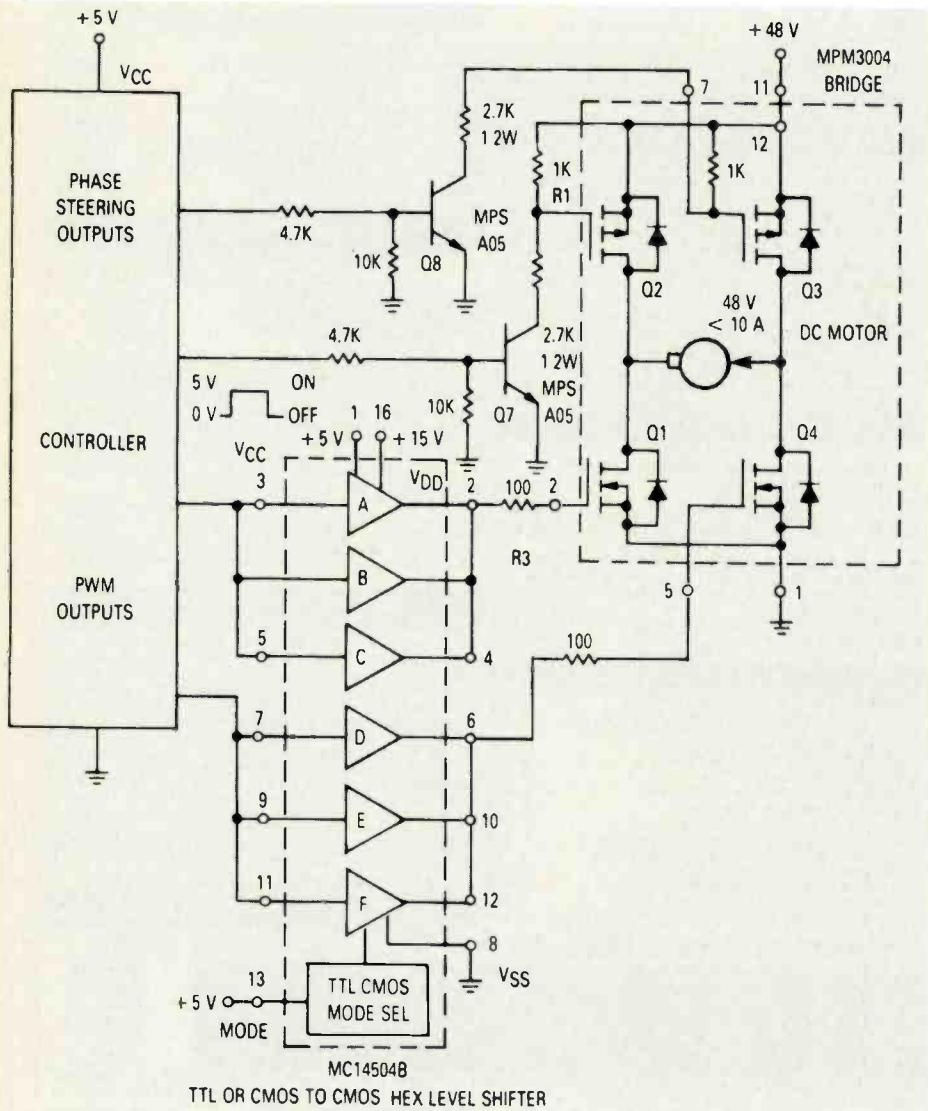
The tone of Analog Devices's application note on this subject may be seen from its far from succinct, but extremely pertinent title: *An IC amplifier users' guide to decoupling, grounding and making things go right for a change*, by Paul Brokaw.

Language in general use for this kind of publication is firmly cast aside and the note is clearly in the "Plain man's guide to..." class of writing — very refreshing indeed.

As the author points out, it is hardly possible to cover the whole subject in a general way, but he has quite obviously suffered himself from thinking that ground is exactly that, with no resistance or inductance, and is well placed to advise fellow sufferers on valid ways out of their problems.

The depth of his suffering can be gauged from the author's final comment: "...remember that you can always trust your mother, but..."

Analog Devices Ltd, Station Avenue, Walton-on-Thames, Surrey KT12 1PF. 932 253320.



**Editorial survey: use the information card to evaluate this article. Item G.**

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LOW STRAY FIELD  
LOW NOISE

### CONTROL GEAR

0-380-415V I/P  
24V RANGE  
110V RANGE  
240V RANGE  
100VA OUTPUT  
200VA OUTPUT  
400VA OUTPUT  
TO IEC 742  
TO BS 3535  
FLEXIBLE LEADS  
< 5% REG.

### LOW PROFILE

< 1U HIGH  
160VA RANGE  
225VA RANGE  
AUDIO GRADE  
TO BS 415  
TO IEC 65  
M6 x 25mm BUSH

SPLIT PRIMARIES  
120 + 120V I/P  
110 + 110V I/P

### RANGES

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TH LIGHTING ★  
100V LINE ★  
AUTOTRANSFORMER ★  
INVERTERS ★

STANDARD RANGE ★  
AUDIO GRADE ★  
FULLY POTTED ★  
160VA LOW PROFILE ★  
225VA LOW PROFILE ★

### TH LIGHTING

11.8V OUTPUTS  
TO IEC 742  
TO BS 3535  
220V RANGE  
240V RANGE  
THERMAL CUTOUT  
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DESIGN TO MOST STANDARDS  
FLEXIBLE LEADS

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CIRCLE NO. 105 ON REPLY CARD

**W**orkers in scientific disciplines often need to graph and publish data in ways which are simply not available in standard computer software such as the ubiquitous spreadsheet and its supplementary add-ons. But SigmaPlot from Jandel Scientific could help fill that gap.

In fact, among computer programs typically employed for data analysis and graphing, spreadsheets are the most ready comparison with SigmaPlot. Both bring a large data entry worksheet and various forms of numerical analysis and spreadsheets invariably provide sundry graphic outputs. But these are really needed in more universal activities such as general accounting and commercial computing.

Some of the latest spreadsheets also provide publishing facilities to improve document presentation and SigmaPlot's graphic output will inevitably be compared with these. But it is the style of graphic presentation that suggests suitability for more esoteric applications involving multiple regression analysis, curve fitting and data transformation.

Try to make an ordinary spreadsheet use split data axes with variable intervals in the two halves; or calculate confidence limits and plot them with customised quality control lines to a graph, fit a high order polynomial to the data, and use logarithmic or probability scales for the plot. In these, SigmaPlot excels.

Certain stand-alone programs and spreadsheet templates can also be used for data analysis and feature regression and general statistical analysis. A few also

# SigmaPlot: spreadsheet for scientists

Powerful graphing,  
multiple regression  
analysis, curve fitting,  
statistics and DTP;  
SigmaPlot can do the  
lot says Don  
Bradbury.

include automatic modes of data modelling for users uncertain of their ground.

But these can leave much to be desired in terms of user options and output quality, and automatic analyses risk inaccurate deductions when used by the inexperienced.

Jandel Scientific's program is aimed squarely at users needing specialist modes

of statistical analysis, powerful graphing and all the options for output manipulation. It is also for those who are prepared to devote time to mastering these options. General commercial forms of data presentation are not its aim. There are no three dimensional graph styles, nor hi-lo-close-open, filled line, bubble, or other common modes of representing that type of data. Instead the program's scatter, bar, stacked bar, box, and pie forms are geared more to types of graphing encountered in trend analysis and statistical applications.

## Data handling

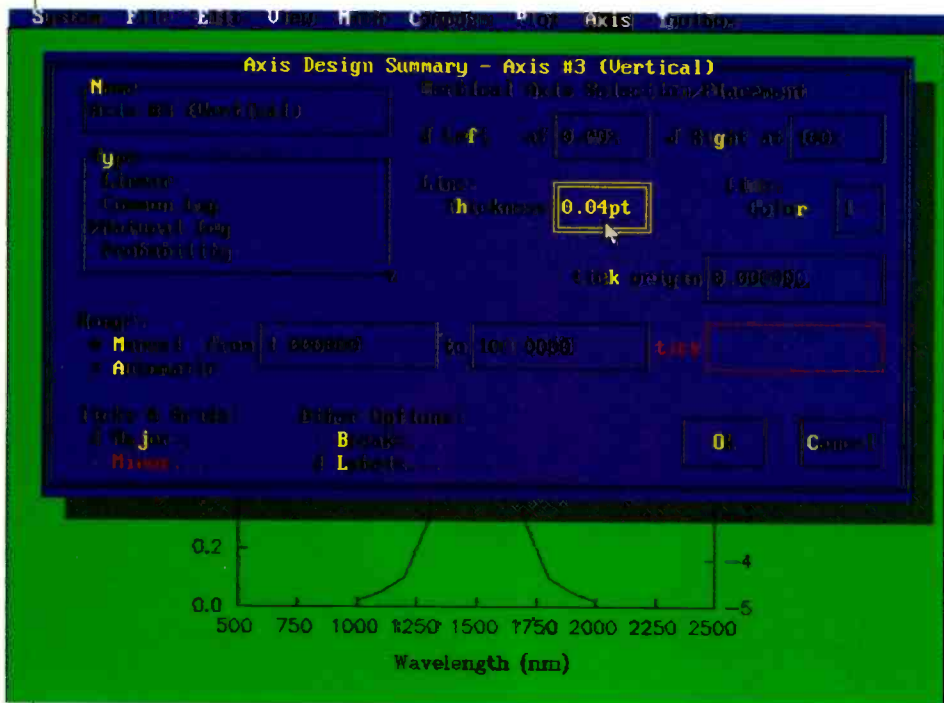
SigmaPlot's huge 16,000 column by 65,000 row data area is used like a spreadsheet. Both sets of axis labels are simple numeric progressions and can be used as data points in appropriate plots. "Cell" may not be the best description of the data points, because although use is made of the range principle for highlighting data, formula entries are not available, and a data block can not be named for reference.

But SigmaPlot does feature its own statistical functions which automatically summarise individual columns of data. These include the mean of the values, standard deviation (using the informal  $n-1$  divisor), standard error, 95 and 99% confidence limits, highest and lowest values, number of data points and total number of any missing values in the range.

Most users will probably switch from the default insert mode to the more familiar overwrite mode; then successive data entries need a down cursor movement or carriage return to enter values and move to the next lower row. Left and right cursor keys can not be used in this way.

When one column is complete, the cursor is used to locate the first entry point in the second column. The home key first

*Helpful setup: plotting a graph*





moves the cursor to the top of the current column; a second press places it in the true home position.

There is no range erase facility in the menus. Users must highlight the superfluous data and then press the del key. Cut and paste is available, and any data, or graphic plot, deleted in this way is not lost but is placed in a buffer to be replaced by the next pasted or deleted matter.

Deletions can be made with a mouse, or with the keyboard by holding down the shift key and highlighting the range with the cursor arrows.

Extensive use is made of dialogue screens containing default settings for every imaginable feature of graphic plots.

Certain user prompts are included too such as preferred colour settings, graph redraw mode, scientific notation on demand or in permanent use, and number of columns and decimal places shown in the data entry area.

But the multiple dialogue boxes do make demands on the memory if the user is to avoid constant references to the manual or on-line help system.

Many users will choose to switch off the novice user prompts at an early stage because the prompts or menu boxes obscure part of a graphic display, and clearing the overlay does not redisplay all the graph — that is if automatic screen refresh has been turned off for speedier operation. Screen redraws generally have to be forced to see results of amendments.

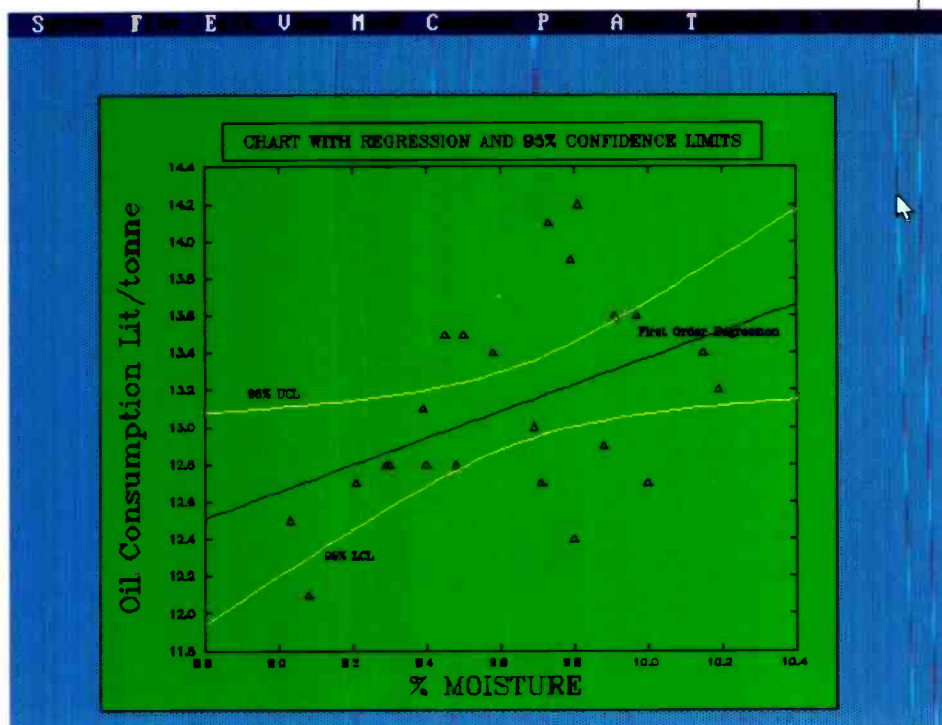
A second, rapidly learned, mode of operation is to avoid the menu system altogether (when possible) and use the keyboard shortcuts or mouse pointer. Most important of these shortcuts are function key F7 which redraws the current graph, and F4 which returns to the data entry worksheet. Other convenient hot keys include those for saving a file, and also graphic preference boxes.

Menus and dialogue screens are well laid out, as are the excellent, context-sensitive help screens, but dialogue boxes are operated in a "distinctive manner" and it takes a little time to remember that progressing with the cursor keys has to be followed by a carriage return to select the option box before an entry can be made.

After the entry, another carriage return confirms the change and closes the box before a move can be made to any other that needs to be changed.

In some cases the default or current entry must be deleted before making a change in the box; in other cases it can be overtyped, depending on cursor location.

Using a mouse is easier than the keyboard. Indeed, although the manual makes clear in a special section the alternative keyboard strokes, it is written with mouse control in mind.



*Not an ordinary spreadsheet: the contents of the cells do more in Sigmaplot*

Most dialogue boxes have a cancel option as well as an OK box which must be selected to confirm any changes because using the escape key leaves any intended changes inactive.

Clicking and dragging is used not only for menu operation and dialogue box navigation, but also graphic manipulation. For example, reshaping or resizing a graph is achieved by selecting pointing mode and dragging on handles which appear in the edges and corners.

Moving a graph, also in pointing mode, involves sliding the image to a different part of the screen and can be useful because SigmaPlot can accept several graphs on one page. For multiple graphs, a compose option allows additional plots to be included.

Zoom mode will toggle the size of the current graph, though a graph viewed in zoom-in mode is always centred, so zoom-out again to judge its size and position relative to the full page.

The compose menu can set the precise height and width of a graph in the design summary dialogue screen. Location for the graph can be entered within the page, if preferred, to see the actual coordinates rather than drag the image and place it by inspection.

Customising options in graphic displays include switch between portrait and landscape orientation, modify plot lines and symbols, alter line thickness for axes and lines (on individual objects or universally), choose between various axis scale types and ranges, and even select the colour of plot and axis lines.

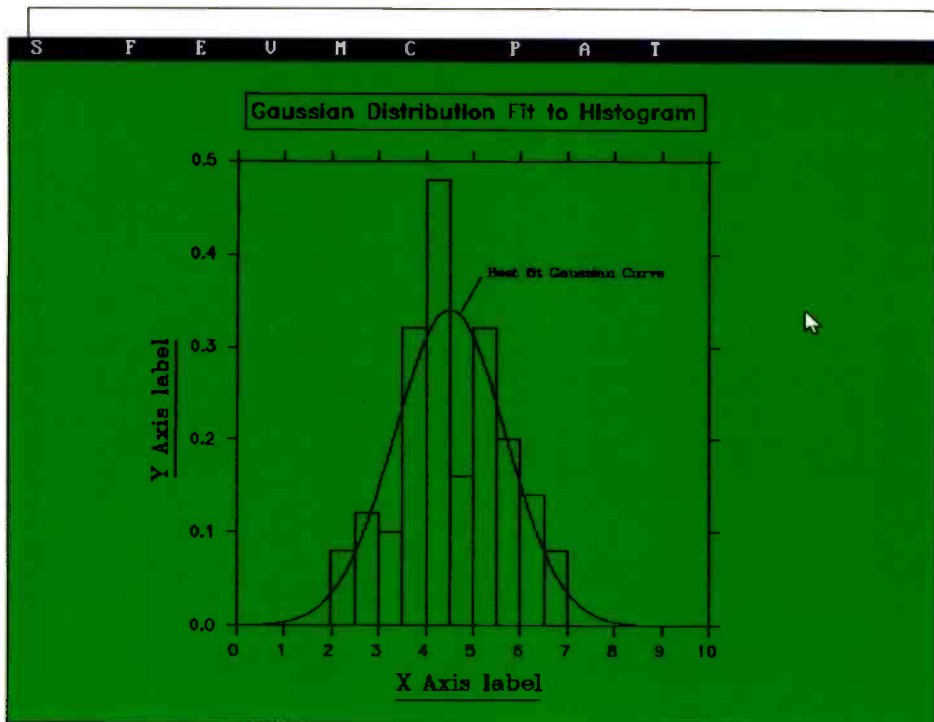
Of course labels and axis intervals can be selected ("tick marks" in Jandel parlance), or the default intervals and labels chosen. Axis titles can be generated automatically from the text in the name box of the axis design summary screen. An axis can be switched off, and it is possible to select minor (intermediate) tick marking from the ticks and grids option in the axis design summary screen.

Graphs can be copied and deleted with a deleted graph replacing the current contents of the clipboard. So apart from possible loss of previously pasted matter, copying many graphs via the clipboard involves multiple cutting and pasting.

But time can be saved because one graph might need to be presented in a simple mode, with a second building on this, perhaps with a multi-plot graph adding further dimensions of information. The basic graph style does not have to be reconstructed from scratch if it is copied first. There is also a template extraction option which can save time by recalling predetermined layouts. Finally, SigmaPlot can export to ascii and dif files for use with other programs such as DTP.

### Graph styles

The compose menu presents the most comprehensive dialogue for creating a new graph. Cartesian plots require the pick-XY-column-dialogue to indicate the columns of data to be used, with the axes option able to modify these if required. Range can be specified. The axis can also be split, with a choice of markers to be placed in the axis break.



*Scientific functions: automatic conversion from bar graph to Gaussian plot*

Design summary screen can be modified directly, as a dialogue box, to indicate the required height and width as well as the distance from the top and left of the page. Plot menu gives access to most of the graphing features of SigmaPlot, used to set the columns to plot, assign axes, set data point symbols and their size and fill, and select the type of plot from scatter/line, bar (of specific width), stacked bar, pie (with the usual options), and box plot. The latter shows information about the distribution of data, horizontal lines marking the 10th, 25th, 75th, and 90th percentile points of the data. The box encompasses the 25th to 75th percentiles, and can show the mean of the data outside the 10th and 90th percentiles.

Mixed plots are available for multi-range graphs, and datapoint sampling is possible, with only a stipulated range of data points in any column included in the plot. There is the option to select line only, symbol only, or both; insert any regression line between first and tenth order; add 95 or 99% confidence limits if required; include bad points; show vertical or horizontal error bars; set colours to highlight these (1 to 15 with an incrementing option); indicate a heavier line thickness for further emphasis, and select fill patterns for appropriate plots.

Quality control lines can be added, including upper and lower specifications, upper and lower control lines, and a mean line, each with calculation, line, label, and colour settings. The calculation can be according to various methods: fixed constant, standard deviation, standard error, or 95% or 99% confidence.

Labels can, of course, be added to these lines, and the line type, colour, thickness, and orientation can be set. Regression lines may be placed either through the data points alone, or be made to extend to the axes of the graph.

If coefficients of the regression equation need to be stored, the column number to house them can be indicated within the data worksheet. Eleven coefficients and R value are then written to the column.

A second order regression, for example, would show three coefficients followed by eight zeros and then the R value in the stipulated column. Coefficients are shown in increasing polynomial order. Axis scales can be linear, common log, natural log, probability, probit, or logit.

Probit is similar to the probability scale, graphing the Gaussian cumulative distribution function as a straight line, and the scale is linear.

Logit uses a  $\ln(y/a-y)$  transformation, and this is another scale that will straighten out a sigmoidally shaped curve. Axis tick marks can be given either a prefix or a suffix of up to five characters, and tick labels may be numeric, time series, or be generated from data worksheet column text. They may also be factored by a specified amount (default 1). Precision can be set automatically or manually, and the display may be in scientific notation either permanently or only when the data falls outside a specified range. Many other options are available for tick marks, including the font, size, colour, thickness, rotation, and just the exponent or both exponent and base in the case of natural and common logarithmic axes.

Axis breaks can be incorporated by specifying break datapoints and position of the break in terms of percentage along the axis. A different tick interval can follow a break if necessary, the break symbol itself can be specified, and the thickness, length, and colour set.

## Mathematical transformations

Math menu includes three options which can be used to carry out mathematical operations. Data can be generated or modified using transforms; non-linear curve fitting can be applied which can then be graphed along with own data, and Student's t-tests can be performed on any two columns of data.

Transforms involve entering an equation in the edit window of the transform dialogue, with many predefined functions available spanning arithmetic, statistical, trigonometric, and random number-generating. Further, functions can be defined, and supported operators include arithmetic, relational, and logical, with range, accumulation, precision, and area/distance functions as well.

Miscellaneous functions encompass histogram, interpolation, polynomial, "runavg", sort, factorial, and choose. Runavg produces a range of running averages from a window of predetermined size, and choose determines how several objects are selected from a larger group.

Curve fitting, or non-linear regression, determines an equation for a data series by selecting best fit values by applying a series of iterative passes through the data, using a least squares procedure. 25 parameters, 25 parameter constraints, and ten independent variables can be handled in equations, and the very important "if" statement can be included to allow different equations to be fitted to different ranges of the data series. Data for the resulting curve can be placed in the worksheet for comparison with the original.

Curve fitting options are explained by examples, and notes on possible pitfalls, weighting the fit, multiple independent variables and so on are in the manual.

## Toolbox options

Toolbox is available only in page mode and is used to add text and various graphic shapes to the page. Graphs can be customised with descriptive or explanatory text and symbols, arrows and a range of other symbols or non-standard characters placed or moved at will. Only the simplest graphs will make use of the defaults and while changes are being made it is best to switch off the automatic redraw of graphic screens if many modifications are

contemplated because screen redrawing is not rapid — though the particular video card employed — as well as central processor speed, will determine the rate of screen refresh. If screen redraw has been left on, a halt can be called at any time by a mouse click or entering ctrl/break.

To enter a label, toolbox is selected, then the text option chosen, with location of the text addition indicated by clicking on the mouse or striking enter. After typing, a further press of the return key concludes the label and drops the cursor down one line for the start of another line, classed as a separate label. When complete, the text cursor is switched off.

Added text can be edited, additions rotated through successive 90° steps (for Y axis labels, for instance), and label characters automatically resized by using numeric keypad + and - keys to increase or decrease them.

Labels are moved with the select object option, clicking and dragging the label to its new location with the pointer inside a box surrounding the label.

Text additions cannot be stretched or shrunk as with page objects, and their size remains fixed if the size of a graph is modified — though resizing of text characters is still available as a separate function. But the font of text additions can be changed as can orientation. Superscript or subscript fonts can be set in multiple stages within text additions, so that complex mathematical and chemical symbols can be constructed.

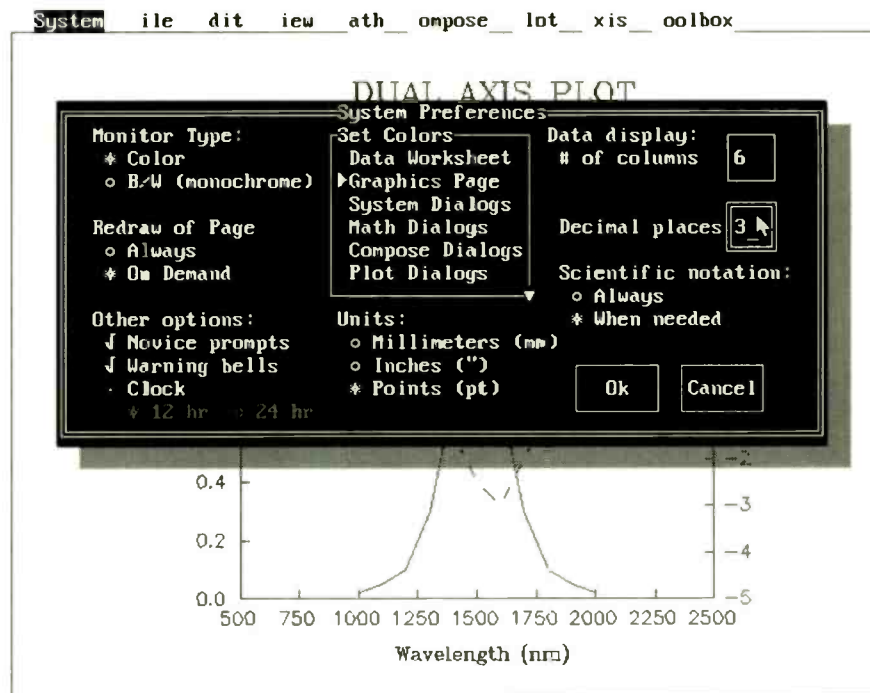
Possible global modifications of text additions means individual labels do not have to be reset separately — again reminiscent of DTP facilities — though not by a series of fixed descriptions; the appropriate dialogue box description has to be changed. Box, ellipse, or line addition options can be made via the toolbox and can be selected, pasted, relocated or deleted, either singly or in groups. Text additions can be simplex, duplex, complex, or triplex, and a text options dialogue box enables setting of point size, colour, and default orientation of the text.

Italic and Greek modifications can be superimposed, and special symbols and built-in fonts are available, the latter coming with support for Postscript printers.

The program runs on IBM PC, XT, AT, PS/2 and compatible computers, and supports VGA, EGA, CGA, Hercules monochrome, Hercules InColor, and AT&T 6300 or compatible video modes.

Owners of certain video cards such as the ATI Wonder EGA/VGA can select 800 x 560 or 800 x 600 display modes respectively, as can Genoa Super, Orchid Designer, Paradise Professional, and STB Systems board owners.

IBM 8514/A is supported in 1024 x 728



Old fashioned dos interface: the system preferences dialogue box.

mode. A list of supported digitising tablets is provided, together with some update information concerning these and other factors such as running the program under Desqview/QEMM and Windows 386, all in a disk 'readme' file.

Help is offered on importing graphs into word processors and PageMaker and Ventura DTP programs.

### Impeccable help

SigmaPlot's on-line help system is quite superb, making use of the hypertext principle where certain words are highlighted for optional cross-referencing. A good index section will guide the novice user through essential modes of operation, and backtracking is possible. screen by screen, to return to the index or to review previous material.

SigmaPlot help is the most comprehensive help system I have ever encountered in a program for the PC. Its use avoids the need for too frequent reference to the manual, though this also is excellent with a good reference section and a useful tutorial — recommended for newcomers.

The useful trouble-shooting section in the manual is usually only required when the program configuration has been set inappropriately or memory is insufficient.

### Well worth the study

A powerful program like SigmaPlot involves a certain amount of learning. But it is worthwhile study for anyone who has complex data to analyse and publish.

The degree of versatility on offer is out-

standing.

Preparation of papers and reports which need graphic illustrations is eased considerably, and researchers will value the powerful data analysis, curve fitting, transformation, and graphing options. The ability to have several curves within one plot, multiple plots in a graph, and a number of graphs on one page, gives excellent flexibility.

At £425, SigmaPlot will be a good buy for the type of potential user I have outlined.

More general commercial application might be appropriate where the current crop of data graphing programs is found wanting on the publishing front, or where they fail to offer the type of options which are the special forte of this program.

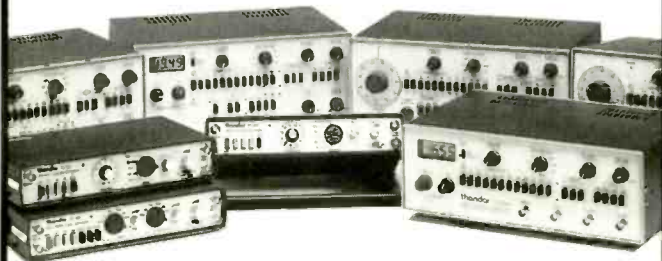
### REQUIREMENTS

PC, XT, AT, PS/2 and compatible computers, 540K. It will automatically use up to 64K of expanded memory. Display VGA, EGA, CGA, Hercules monochrome, Hercules InColor, and AT&T 6300 or compatible video modes.

UK agent for Jandel Scientific is The Core Store Ltd, The Studio, Hawthorn Cottage, Marbury Road, Comberbach, Northwich, Cheshire CW9 6AU. Tel 0606 891980.

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*Editorial survey: use the information card to evaluate this article. Item 11.*



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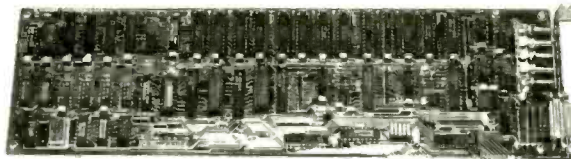
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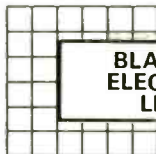
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# Understanding NiCds

An electro-chemical cell exhibits an EMF ( $E$ ) which depends on the energy of the chemical reaction of the cell and falls when the cell discharges. On discharge, the cell voltage ( $V$ ) is less than  $E$  by an amount called the polarisation voltage, which increases with discharge current. This is partly an ohmic voltage drop due to electrode resistance, and partly an EMF due to complex reactions on the surface of the electrodes. The amount of material involved in polarisation reactions must be rather small, since, when the current is stopped, the polarisation voltages soon disappear.

On charge, polarisation voltages are positive, and the cell voltage is higher than  $E$ . As the charging reaction approaches completion, the polarisation voltages rise if current is maintained. In the case of lead-acid accumulators this may amount to 20% of the total voltage providing a good indication that the cell is fully charged. It is easy to devise automatic chargers which switch off, or reduce the charging current, when the voltage of a 12V accumulator rises to, say, 14V.

If this is not done, the voltage may rise further, so allowing unwanted secondary reactions of higher  $E$  to occur. The decomposition of water to hydrogen and oxygen in the Lead-acid cell is an example: this reaction cannot occur at less than 2V per cell, and requires a rather large extra voltage (overvoltage) to take place at an appreciable rate.

## Nickel-cadmium cells

While, in principle, nickel-cadmium cells are similar to lead-acid cells, they involve chemical reactions which behave rather differently, and so require different charging methods.

An important practical difference is that polarisation is much less with nickel-cadmium and, for this reason, the voltage on charge cannot be used to control the charging current. Moreover, it is practically impossible to induce "gassing" in NiCd cells, since  $E$  is only 1.2V. Thus, in the

Why doesn't the terminal voltage determine the health of a NiCd cell? Roy Hill explains.

absence of a secondary chemical reaction, all the charging energy put into a fully charged cell appears as heat, which may damage the cell through an unacceptable rise in temperature. As a consequence, uncontrolled charging is usually kept to a low rate; about 10% of the ampere-hour capacity.

This practice carries the disadvantage that the performance of the cell may slowly deteriorate in service, particularly so if the charged cell is stored for an appreciable time, or if discharge is slow and intermittent. The reason for this is that the solid reagents of the cell have a tendency to crystallise into larger crystals and aggregates which, having a smaller surface area, become progressively more unreactive. Sometimes large crystal aggregates bridge the cell internally.

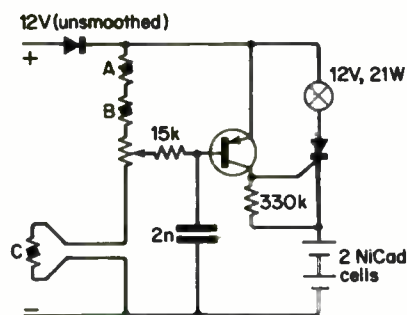
It is a general principle of solid-state chemical reactions, and of solid-state physical transformations, that rapid change promotes the formation of a highly reactive mass of small crystals, whereas slow change favours the growth of existing crystals with a corresponding loss of surface area. High current, high temperature electrolysis favours the formation of a finely divided electrode with good energy storage. It is therefore preferable to charge NiCd cells rapidly, at a rate of one or two times the ampere-hour capacity with charge termination controlled by cell temperature rise.

## A CHARGED SITUATION

In a fully charged NiCd cell excess charge appears as heat. The circuit shown, only one of many possibilities, is effective for charging two NiCd cells from a 12V charger.

Thermistor C is attached to one of the cells, conveniently with Bluetack, while thermistors A and B afford ambient temperature compensation. The two cells are placed in a battery holder and, after allowing a short time for the temperature to stabilise with the thermistor C is attached to one of them, the potentiometer is advanced until the required charging current is drawn.

When charge is complete, the cells warm up, and the charging current falls to a value which keeps the cell temperature about 12°C above ambient; it should not be allowed to rise above 35°C. This arrangement has been used for AA, C and D type cells, with an average charging current of 1A in each case



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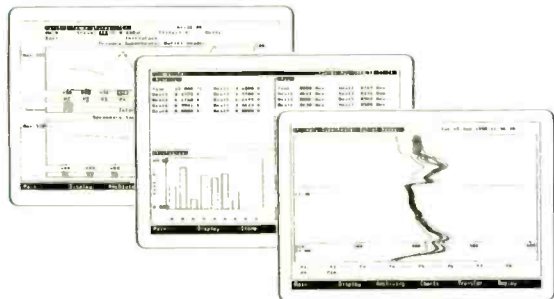
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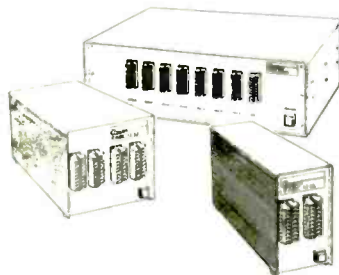
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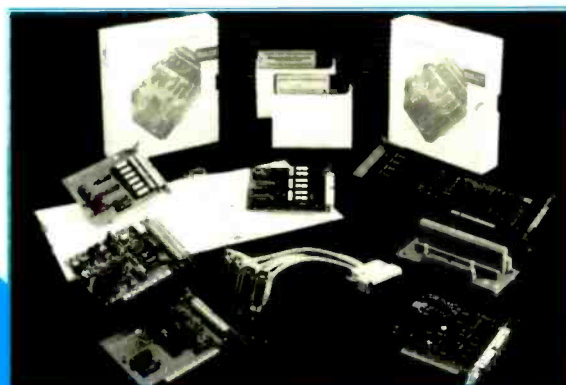
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# PC engineering

## Acquiring the capability

Before a PC can analyse the data, you need to capture it first. Andy Gothard investigates the data acquisition market.

**R**aw facts and figures can often be difficult to turn into useful information, with a context, a relevance, and usefulness.

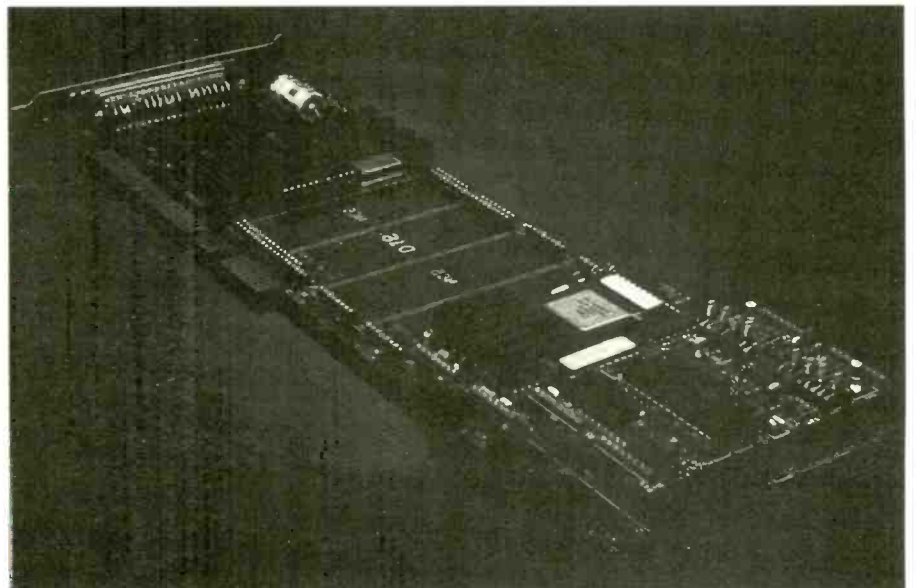
Fortunately, computers are very good at turning big chunks of data into something meaningful, and that explains why the familiar desktop PC now has so many extras available to enable it to collect data automatically. Data goes in; and — bingo! — out comes information, without anyone ever having to worry about all that troublesome data.

Or that's the theory. In practice, someone has to decide how the computer will do the conversion, and then produce relevant software: lesson one of data acquisition for personal computers - no matter how powerful your hardware, results will only be as good as the software which supports it.

This month's data acquisition buyer's guide surveys some 60 companies supplying hardware and software.

Representatives of all the common equipment types are there; from dedicated

*PC board with a miniature transputer module on the top from Sunnyside Systems, demonstrating some of the creative solutions now possible with PC plug-ins.*





## SUPERVISORY ROLE FOR THE PC

instrumentation to send data down an RS232 serial link; to equipment which the computer can control via the general purpose instrumentation bus (GPIB, or IEEE488) protocol; to PCbus and Nibus cards plugging directly into the computer and having circuitry to convert outside-world signals into computer data.

On the software side, packages can create an instrument front panel on the computer screen; collect data and produce statistics, trends and graphs; or are just basic code merely allowing the operating system to talk to installed hardware.

As computer expansion slots can incorporate the necessary acquisition hardware directly in the machine, it may seem irrelevant to look at systems which put the electronic signal conditioning circuitry in a separate unit.

But often a system will be dealing with data from several different physical locations, and so it makes sense to turn the data into something the computer can understand on site, and then transmit it over a link. Separate units may also be desirable to keep high voltage signals, or signals susceptible to external interference — such as spikes, out of the computer box itself, if only for safety's sake.

Remote data collection can be performed either by rack mounted data acquisition modules, or by traditional stand-alone instruments.

In the latter category, many counters, oscilloscopes and analysers include a GPIB or RS232 interface to receive commands, and send back data. Computers can be equipped with a GPIB controller card for less than £200, or an RS232 add-in for around £100.

Manufacturers such as Hitachi Denshi are now producing PC software to handle real-time and post acquisition processing. Packages allow the computer to display rise and fall times, and perform fast

The PC and its dos operating system were not designed for control applications, so it often makes little sense to give a PC ultimate control of a critical process.

Where the PC does come into its own is when data analysis and an operator interface are required, a role known as scada (supervisory control and data acquisition).

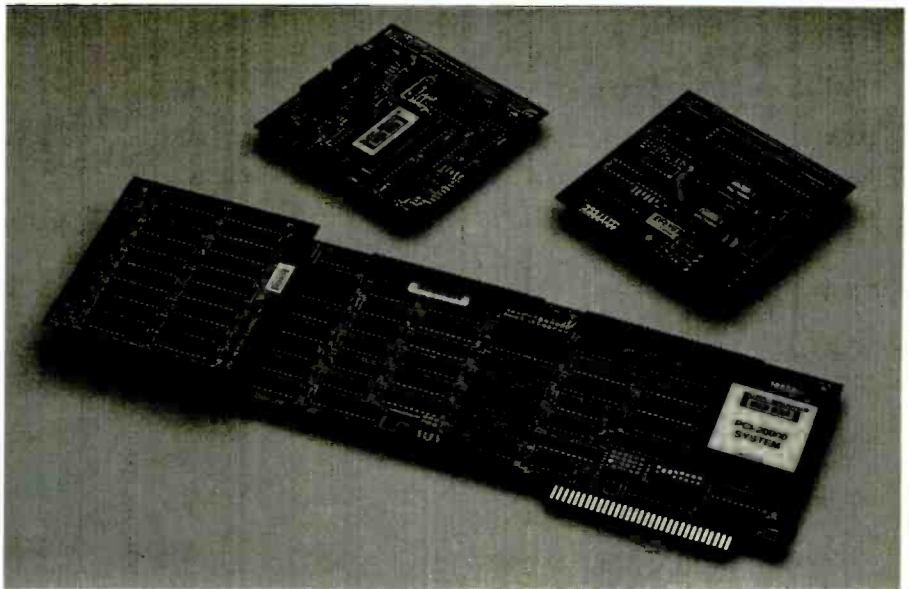
For example, a power station's furnaces might be controlled by some form of programmable logic — the PC would not be trusted to prevent the furnace running out of control when a fault develops.

But the control room might well be provided with PCs and screens, for collection

and display of data on the average temperature of the furnaces, for instance. This data could be used to make sure the station is using fuel efficiently, producing power when required, and so on.

The PC lends itself to these applications not only because it can provide an easily understood interface, but also because of the wealth of statistical analysis software available off the shelf.

Aside from dedicated scada software packages, many data acquisition programs will provide data in a form which can be passed to standard spreadsheets and databases for off-line analysis.



*In multi-channel applications, such as those served by Burr-Brown's PCI2000 system, the physical technique used to connect the card to the outside world is important if birds' nests of trailing wires are to be avoided.*

Fourier transforms and other mathematical tricks (such as summing, scaling, and trig functions) on data captured by a standard oscilloscope.

Hitachi says its experience in producing stand-alone instruments means that the

software itself is intuitively easier to understand, and more closely tuned to the data provided by the hardware.

Just as techniques vary, so do applications. Tasks can span single engineers trouble-shooting with a pair of probes; production testing of refrigerators, or control and monitoring of power stations.

There is also a growing market for cards which talk direct to the bus.

Digital I/O is about the simplest function to perform, and plug-in hardware is available to cope with anything between four and 200 lines of input/output. Incidentally, in high channel-count applications, the physical technique used to connect the card to the outside world is important as there is little point in choosing a neat, integrated solution which leaves hundreds of unidentified wires strewn about the place.

Hardware is cheap, so there is surprisingly little variation in prices.

Digital I/O cards cost from under £100 to £300, but most of the differences indicate different levels of support, rather than real function.

## DIGITAL SIGNAL PROCESSING

Digital signal processing is one of electronics' growth areas, and much of the post-acquisition work to be done on data falls into this broad category. Many processing packages can make use of a host's maths co-processor, but if the burden of coping with data acquisition becomes too heavy, the ordinary functions of the computer itself may suffer.

A dedicated application accelerator card can be used to ease the burden on the host, but these are relatively expensive, often costing over £1000. They contain their own processor chip, memory, and application code, leaving the host to deal with file management and the user interface. An extra DSP may also be included, for instance the Motorola 56K, designed to execute routines such as Fourier transforms with efficiency.

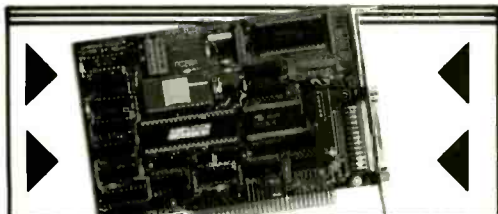
As with general purpose application accelerators, application code can be gener-

ated using C, Fortran, or Basic, and a set of library functions is often included. Aside from the more general-purpose application accelerators, boards for acquisition and processing will include analogue and digital inputs, and a smaller number of corresponding outputs.

Library functions include time-stamping, averaging, maximum and minimum detection, and digital filtering.

Amplicon's effort in this field also includes a set of display routines, allowing the production of bar and line graphs and scatter plots, as well as facilities for passing data to common analysis packages such as Lotus 1-2-3 and Labwindows.

Using application accelerators in this way can allow large amounts of real-time data to be handled in the same way that the host would cope with a data file, without degrading the PC's performance.



**LOW COST DATA ACQUISITION FOR IBM PC**

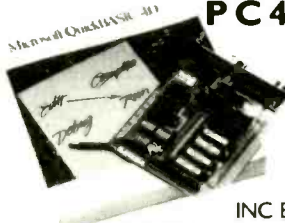
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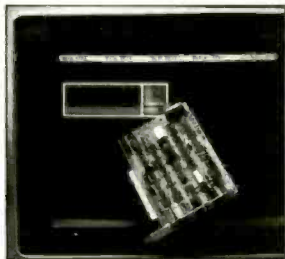
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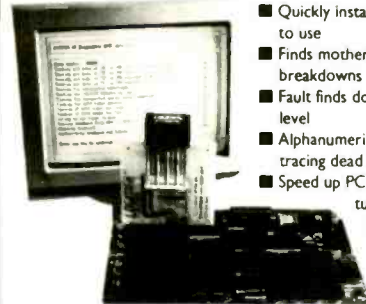
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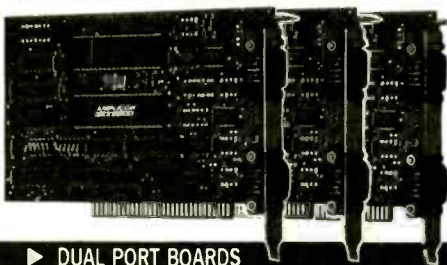
IoCalc is a specially written spreadsheet program with the ability to acquire, process and output data to and from analogue and digital input/output devices in real time.

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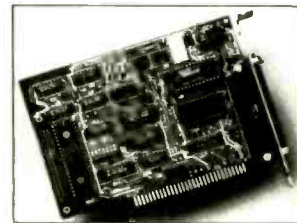
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*Continued on page 508*

## DATA ACQUISITION

upwards of £200, though some low cost versions could set the buyer back as little as £125.

Once again, software and support is the key.

Combination digital/analogue cards also carry a slight price premium and cards and software for the Macintosh tend to be considerably more expensive than their IBM PC equivalents. A common technical difficulty is when more than one card is installed in the same computer.

Neither the Mac nor PC are set up to act like an industrial bus system so compatibility problems can arise. This is particularly the case when using interrupts, and where the acquisition card needs to take over the bus to transfer large amounts of data to main memory using DMA.

The problem is a good argument for sticking to a single supplier if the system itself is to be any more than a convenient addendum to a single engineer's bench; if

two vendors' cards refuse to work in tandem, who solves the problem? Buyers who stick to one vendor then, at least in theory, know who to complain to when things go wrong.

In addition to various speed and channel count analogue and digital I/Os, specialist cards are available for functions such as pulse counting and timing, thermocouple input, and synchro-to-digital conversion.

Some hardware/software combinations aim to produce a virtual instrument, making the computer work as a digital multimeter, or storage oscilloscope; prices are extremely variable. Amplicon has oscilloscope software which sells at around £300; Blue Chip Technology offers a hardware/software DMM weighing in at below £500.

Software prices are similarly unpredictable. User interfaces which allow programming of a system, either via a text

editor or interconnecting icons on the screen, can cost anything between a few hundred and a couple of thousand pounds.

The application-specific nature of analysis software to process data means it is often supplied as a custom product, or offered in modular form.

Larger projects often rely on the services of a systems integration house to provide the custom software, or modules from a standard suite, and ensure all the component parts fall into a working system.

*Editorial survey: use the information card to evaluate this article. Item J.*

### USEFUL ADDRESSES

ERS 36-38 St Peter's Gate Stockport Cheshire SK1 1HD 061 476 5750 SCADA software	NE46 1SB 0434 605575 SCADA software, systems integration	Lee Dickens Rushton Road Desborough Kettering Northants NN14 2QW 0536 760156 Hardware, software	National Instruments Unit 21 Kingfisher Court Newbury Berks RG14 5SJ 0635 523545 Hardware, software	Rotork Activation Brassmill Lane Lower Weston Bath BA1 3JQ 0225 428451 SCADA software
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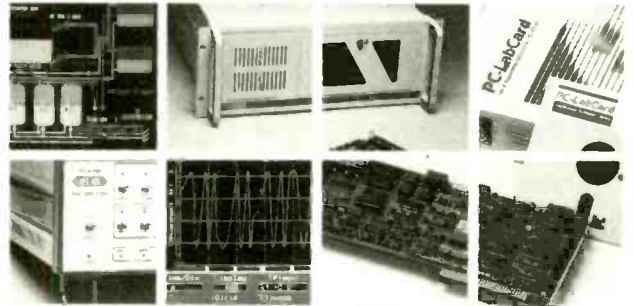
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# Cross-modulation in the sky?

If you have ever been irritated by hearing one radio station superimposed on top of another of a different frequency, you have been listening to cross modulation.

The effect is distinct from, and rarer than, overhearing one station on top of another on the same frequency. Two stations of the same frequency are always picked up simultaneously, but if broadcasting authorities are cooperating properly, one signal will be so strong in its area of intended reception that the ear generally cannot distinguish the other. Sometimes freak propagation effects cause the signal of the second to be channelled through the ionosphere to the receiver with much less attenuation, and it will be overheard.

But this is not cross-modulation, which

RF engineers are well aware that non-linearity breeds cross modulation. But Anthony Garrett suggests it can also occur in the ionosphere.

involves stations of different broadcasting frequencies. To tell the difference you need a radio ham's list of stations and fre-

quencies. To explain why cross modulation takes place we should first look at how the ionised plasma in the ionosphere interacts with electromagnetic waves.

Since charge is the source of electric fields, a plasma has a large effect on an electromagnetic wave propagating through it.

The ionospheric plasma is not uniform in density, because the sun's rays are more powerful higher up and there are more atoms available to be ionised lower down. The effect is to bend radio waves so that they eventually return to Earth and make long-distance radio transmission possible.

## IONOSPHERIC ACTIVITY

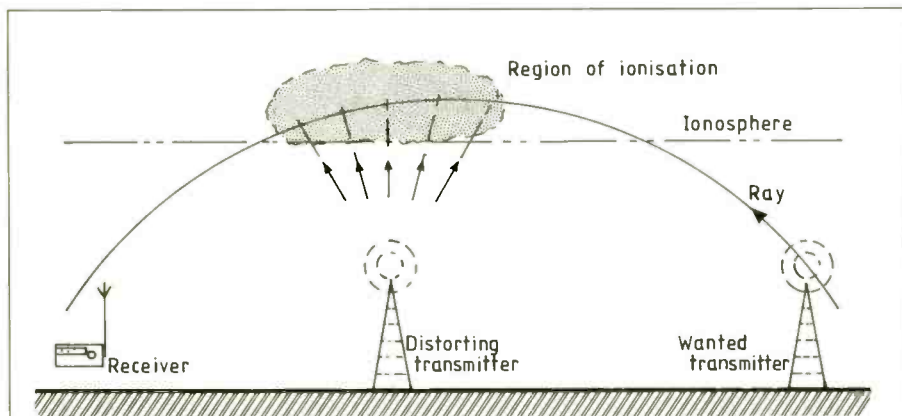
Above the stratosphere and the weather, from about thirty kilometres up, is the ionosphere where the sun's rays are powerful enough to strip negatively charged electrons away from the positively charged nuclei around which they orbit in an atom.

Energy is needed to pull the charges apart because they are of opposite sign, and opposite charges attract. The result is a free electron and a positively charged ion, and the process is called ionisation.

There is a balance between the number of electrons and ions pulled apart by the sun's rays and the number which spontaneously recombine under their own attraction.

A medium containing many charged particles is called a plasma, and it has very different properties from an un-ionised gas, because the forces between charges retain their strength over far greater distances than the forces between atoms having no net charge.

(Even the weak forces between atoms are due to forces between the charges within the atoms.)



*Non linear system?: the principle of ionospheric cross modulation can be explained by this illustration sent in to EW + WW by Anthony Hopwood. A powerful transmitter along the signal path varies reflectivity of the ionosphere causing cross modulation of incident radio waves. Hopwood first floated the idea of artificial ionospheric reflectors in a letter published in EW + WW last year.*

The clue to ionospheric cross-modulation is that the unwanted or disturbing transmitter always lies between the receiver and the wanted transmitter. This strongly suggests that it is an interaction between the signals which takes place within the part of the ionosphere where both waves co-exist.

Normally, a single wave propagating through the ionospheric plasma disturbs it to an amount proportional to the size of the wave. Two or more waves propagate independently, each disturbing the plasma as if the others were not there.

Total disturbance of the plasma is found by adding the disturbances caused by each wave separately. The waves deposit no net energy in the plasma, and the energy of the waves just passes through. But if a wave is powerful enough, it does now transfer energy to the electrons, which in turn pass it on to neutral atoms and molecules with which they collide.

This energy transfer modifies the plasma over and above the usual disturbances ("non-linearly"), and any other wave propagating through it feels this.

If the powerful disturbing wave is modulated, this modulation is imprinted on the rate at which energy is transferred to the electrons and so on to the fundamental properties of the plasma; and then on to any other wave passing through.

#### FIRST REPORTS

Cross-modulation was reported in 1933 by BDH Tellegen of the Philips Laboratories in Eindhoven, Holland, in a brief letter to the scientific journal *Nature* published on 10 June.

Tellegen had overheard the noise listening to several other stations whose transmitters, heard from Eindhoven, lay beyond Luxembourg.

Tellegen took pains to eliminate possible causes within the receiver used, and made a low-key suggestion that the effect had its origin somewhere between transmitter and receiver. His caution was because no interaction between radio waves propagating through the ionosphere had been observed before.

Almost simultaneously a report appeared in *World-Radio*, the weekly technical and overseas magazine of the British Broadcasting Company, then conveying very much a pioneer spirit and a stiff upper lip.

A subscriber called AG Butt, in Plymouth reported overhearing Radio Paris while tuned to Radio Luxembourg. Butt also listed some stations over which Paris could not be heard, most of them in very different directions from that of Paris. Unlike Tellegen, he made no attempt to eliminate effects from within the commercial receiver used.

#### THE SIGNS OF CROSS MODULATION

Intermodulation results when two discrete signals pass through a non-linear system such as a semiconductor junction, multiplier mixer circuit. The author hypothesises that the ionosphere may also operate as a non-linear system.

In the conventional sense, the ionosphere acts as a patchy, rather imperfect mirror of incident radio waves reflected by the electrically conductive plasma of which it is comprised. The characteristics of a reflected signal are frequent lapses into deep fading and envelope distortion, the result of multipath reflections and phase cancellations. A standard AM broadcast signal with sinusoid modulation typically degenerates into the envelope shape shown (right). There can be brief periods of total cancellation.

The author hypothesises that a second, high powered signal could cause the degree of ionisation to vary with its modulation envelope and thus cause a modulation of the path



loss suffered by a reflected low power signal. One would expect the interfering signal to have its greatest effect (as recorded at the receiving station) during periods of what would normally be a deep fade in the reflected signal path: any change at all in the composition of the ionosphere would have a disproportionate effect on the degree of cancellation. The interfering signal would be very much in the background at other times - if it can be heard at all.

Any form of non-linearity in the front end of the receiver system might cause two (or more) signals to be heard simultaneously. However, this effect is totally predictable and, one supposes, discountable. **FO**

This is the basis of the effect. Energy typically takes about one thousandth of a second to work its way from the wave to the molecules by collisions with electrons.

In 1959 David Layzer and Donald Menzel in the US worked out a kinetic theory of cross-modulation in the ionosphere — though their theory did not include the important effect of the Earth's magnetic field.

If a permanent magnetic field is present, electrons orbit round its direction at a definite frequency, and a wave whose fundamental frequency is close to this will kick the electrons in phase at each revolution and transfer much more energy than otherwise — resonance. Inclusion of the Earth's magnetic field is lengthy but is ultimately only a matter of detail. It is of course essential in order to compare with experiment.

Since the effect takes place in the ionosphere, there is no way of designing a transmitter and receiver to eliminate it. The

only good advice is not to broadcast really powerful signals on or near to the resonance, or gyro-frequency.

The news is not all bad, though: the effect has been used as a tool for learning more about electron collisions in the ionosphere, and this tells us more about radio wave attenuation, and how powerful a transmitter would be needed to reach given parts of the world.

*Dr Anthony JM Garrett is attached to the Department of Physics & Astronomy, University of Glasgow.*

**Editorial survey: use the information card to evaluate this article. Item K**

#### FIRST THEORIES

Victor Bailey, a physics professor at the University of Sydney, together with DF Martyn, a physicist with the Radio Research Board who worked in the University's Department of Electrical Engineering, applied JS Townsend's ideas on electrons in gases and explained what was happening in the ionospheric plasma to cause cross modulation.

Their joint paper was published in the *Philosophical Magazine*, a prestigious physics publication, in 1934 and the theory predicts that higher harmonics of the modulation frequencies, in particular the second harmonic at double a frequency, will also be overheard.

Later in the 1930s, Bailey refined his theory and enlisted the help of the BBC to test it.

It was what we call today a "fluid" theory,

meaning that it treats electrons as a continuous fluid with all the electrons near any one point moving in the same direction at the same speed.

But as with air molecules this is not so. Air molecules move around with speeds typically of some hundreds of metres per second, and so do electrons. We feel the motion of air molecules as air pressure, as molecules bounce off the skin. They move in all directions, and any net excess moving in one direction is perceived as the fluid motion — wind.

Fluid motion is therefore an average of molecular motion.

Kinetic theory, which takes the particle motion into account, is deeper and more accurate.



# INTERFACING WITH C

by

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To complement the published series, Howard Hutchings has written additional chapters on D-to-A and A-to-D conversion, waveform synthesis and audio special effects, including echo and reverberation. An appendix provides a "getting started" introduction to the running of the many programs scattered throughout the book.

This is a practical guide to real-time programming, the programs provided having been tested and proved. It is a distillation of the teaching of computer-assisted engineering at Humberside Polytechnic, at which Dr Hutchings is a senior lecturer.

Source code listings for the programs described in the book are available on disk.



## Switching oscillator

Two op-amps in a ring configuration, one used as a comparator and the other as a unity-gain buffer, and two RC lag networks form a very low-cost function generator. The circuit, shown in Fig. 1, generates three simultaneous waveforms — square, sine and triangle, as shown in the oscilloscope photographs.

The waveform at X approximates to a square wave, since the first op-amp operates as a zero-level switching comparator. Slew-rate limiting determines the switching times, amplitude being set by the supply voltages and op-amp saturation characteristics.

Lag network  $R_1C_1$  integrates the sine wave to produce the waveform at Y, which is an approximate triangular wave, while lag network  $R_2C_2$  filters the triangle to produce the sine wave at Z.

The square and triangular waves are at low impedance and the sine wave is not significantly affected by load capacitance less than  $C_2$ .

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Nottingham Polytechnic

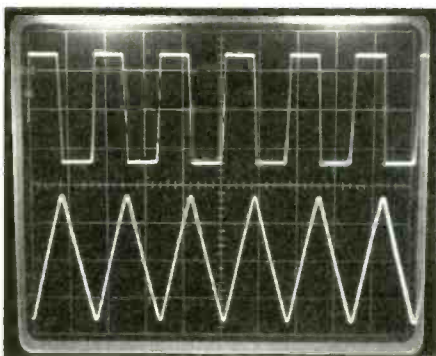


Fig. 2. Upper trace: vertical scale 10V/cm. Lower trace: 500mV/cm. Horizontal scale: 0.5ms/cm.

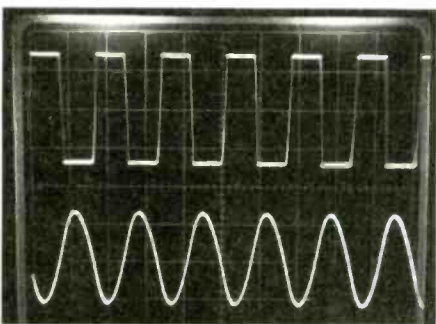


Fig. 3. Lower trace: 200mV/cm, 0.5ms/cm.

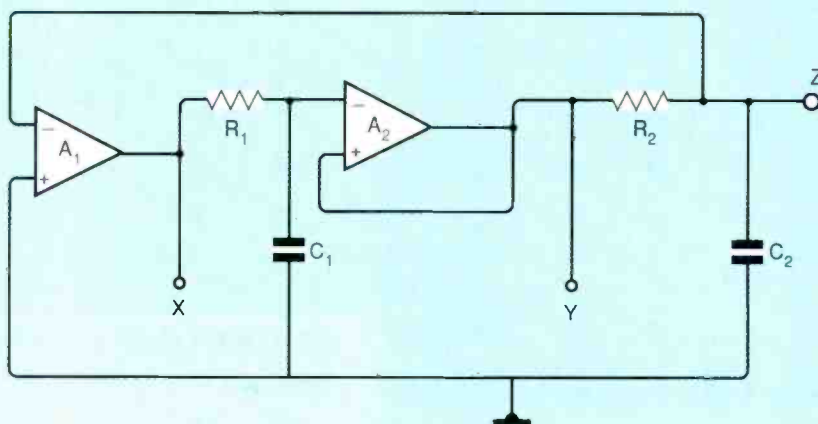


Fig. 1 shows the oscillator circuit. Components used to give results shown:  $A_{1,2}$  741;  $R_{1,2}$  33k;  $C_1$  100nF;  $C_2$  10nF. Supplies 15V.

## Linear current transfer

“Straight-line” input-output current transfer is provided by this arrangement.

It is sometimes necessary to transfer a control or measurement signal between two points in a circuit at different voltages. Optical methods offer good high-voltage isolation, but care is needed for precision transfer; the current transfer characteristics of standard opto-couplers are wildly non-linear, exhibiting a sag of around 50% at half-scale.

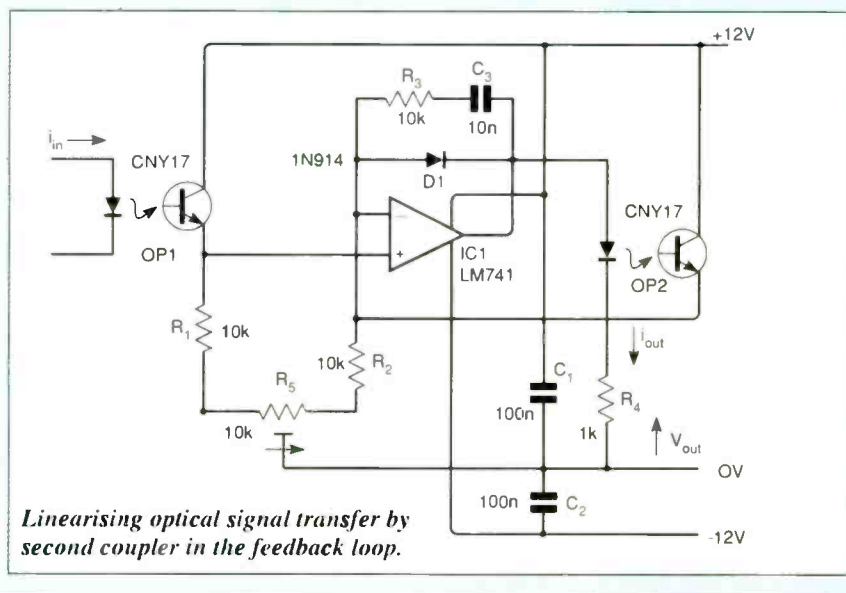
The circuit shown balances the non-linearity of the sender unit  $OP_1$  with the

non-linearity of a similar device  $OP_2$  in the op-amp feedback loop. Potentiometer  $R_5$  calibrates the circuit, compensating for the difference in gain of the two couplers. It is not difficult, using the inexpensive devices shown, to reduce non-linearity to 1% over 0.05 to 1mA.

The voltage across  $R_4$  will drive a chart recorder and the circuit has been used as a control element in multiple-output, switched-mode power supplies.

CJD Catto

Cambridge



Linearising optical signal transfer by second coupler in the feedback loop.



While we are not short of Circuit Ideas to publish, it would be agreeable to see some fresh input from the vast, untapped bank of talent that our thousands of readers represent. Please, don't be reticent; we would love to see your favourite circuit for a scratcher-converter, so send your ideas in. We pay a mod-

## Versatile VCO

A conventional free-running multivibrator, shown in Fig. 1, suffers from the disadvantage that its output waveform is asymmetrical, the rise time of the off transistor being much slower than its fall time at switch-on.

Figure 2 shows a method of counteracting this defect, using push-pull transistors

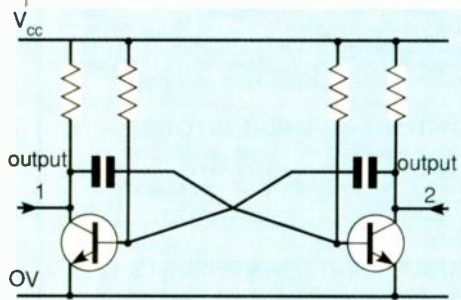


Fig. 1. Conventional multivibrator produces asymmetrical, distorted square waves.

to give a symmetrical output with unity mark/space ratio. The circuit works with a supply greater than 1V, current consumption being 100mA at 1.5V.

The circuit of Fig. 3 takes advantage of

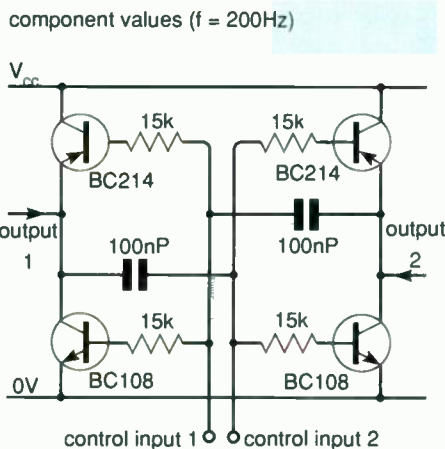


Fig. 2. Modification cleans up output wave shape and renders frequency control feasible.

this modification to produce voltage-controlled frequency. With the control voltage at mid-rail, the frequency is 200kHz, a variation of +5V yielding a 10:1 increase in frequency.

Applying different control voltages to  $R_1$  and  $R_2$  will control mark/space ratio.

component values ( $f = 200\text{Hz}$  to  $2\text{kHz}$ )

$$R_1 = R_2 = 100\text{k}$$

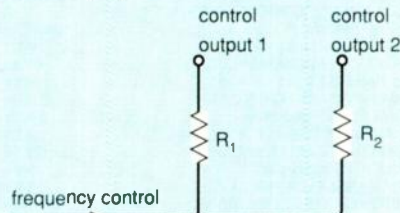


Fig. 3. Frequency control voltage can also be used to provide variable mark/space timing by feeding two resistors with differing voltages.

Applications envisaged for the circuit are phase-locked loops, function generators, switched-mode power supplies and musical effects generators.

Ian M Wiles

IPR Technology

Basingstoke

Hampshire

## Z80 peripheral interface

There are two varieties of microprocessor read/write logic: Intel and Zilog devices use separate READ and WRITE lines, where-

as Rockwell and Motorola provide a combined RD/WR line. This circuit will interface a Z80 to the latter type of peripheral.

The difference between the two types of equipment is that, with the Z80, it is unimportant in which order the chip-select and read/write controls are asserted; a combined line must be set up before the chip-select and held after it.

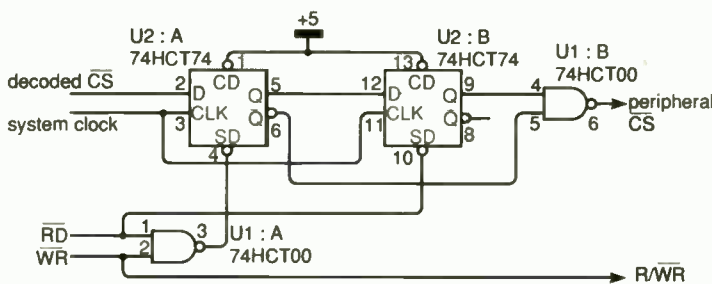
An easier solution to the problem than using an amount of combinational logic which would possibly present timing problems is to decode the address normally and to use one of the address lines as a peripheral RD/WR line. Although this arrangement meets the setup and hold requirements, it does mean that the peripheral has different addresses for reading and writing.

The circuit shown provides the answer. It uses the wait cycle which is automatically inserted by the Z80 processor in all I/O requests and is therefore not suitable for memory operations unless a wait cycle is inserted.

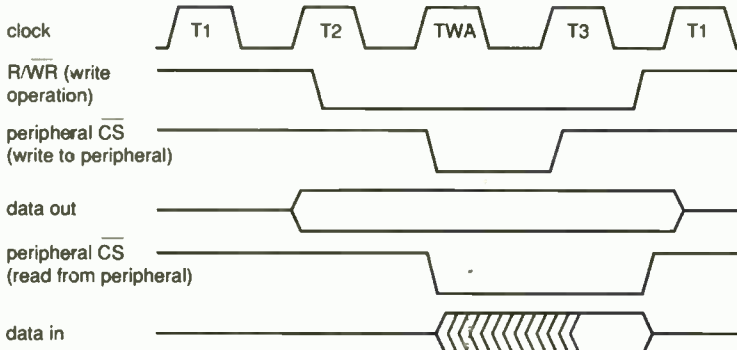
R.Townsend

Moston

Manchester



Interfacing a Z80 microprocessor to a peripheral with a combined read/write



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P8749H MICRO	£5
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R05 (50 milli-ohm) 1% 3W	4 for £1
W22 or sim 6W 7 OF ONE VALUE	£1
R47 R52 1R0 1R5 1R8 3R3 3R8 9R1 12R 20R 24R 27R 33R 51R 56R 62R 68R 100R 120R 180R 220R 390R 560R 620R 910R 1K0 1K2 1K5 1K8 2K2 2K7 3K3 3K9 4K7 8K2 15K 15K 16K 20K	
W23 or sim 9W 6 of one value	£1
R22 R47 100 1R1 56R 62R 100R 120R 180R 220R 390R 390R 680R 1K0 1K5 5K1 10K	
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# Colour-bar generator

This circuit will produce NTSC or, with slight modification, Pal colour bars with audio, video and RF outputs, using six ICs. Taking the NTSC case first, with its 15.75kHz line frequency, the clock oscillator is composed of IC<sub>3a</sub>, L<sub>1</sub> and C<sub>1,2</sub> and produces a 157.5kHz signal for IC<sub>1</sub>, a BCD counter; L<sub>1</sub> adjusts the frequency. Horizontal sync is available at point A and RGB at B, C and D; Fig.2 shows the relevant waveforms.

The horizontal sync. pulse drives 12-bit counter IC<sub>4</sub>, which is reset by IC<sub>2b</sub> when the count reaches 262, so that a vertical sync. pulse is formed at point E. A composite sync signal is produced by IC<sub>3b</sub> at point F.

Pal/NTSC encoder/modulator IC<sub>5</sub>, the MC1377, contains an encoder matrix, burst-pulse generator, subcarrier oscillator, 90 phase shifter, R-Y and B-Y modulators and one or two other functions. It merely needs 1V pk-pk RGB signals and a TTL-level composite sync to provide the composite video at pin nine.

MC1374 is an RF modulator, accepting video (pin 11) and audio (pin 14) inputs to give a 100mV pk-pk RF output. Audio comes from IC<sub>4</sub> in the form of a 1kHz signal from Q4. Tuned circuit L<sub>3</sub>C<sub>4</sub> sets the output frequency and the output filter reduces high-order harmonics.

In the case of Pal, L<sub>1</sub> must be adjusted to give 156.25kHz, the reset circuit of IC<sub>4</sub> must operate at a count of 312 and pin 20 of the MC1377 should be open-circuit. Adjust L<sub>2</sub> to the required audio IF.

**Yongping Xia**

West Virginia University  
Morgantown  
USA

Fig. 1. Complete circuit of simple and economical colour-bar generator.

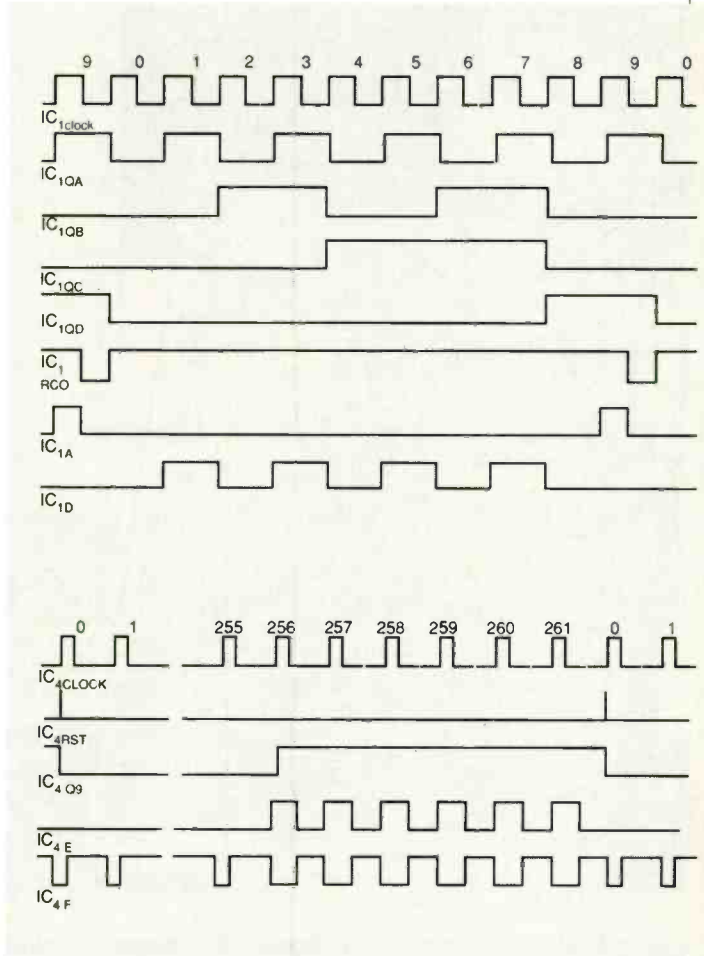
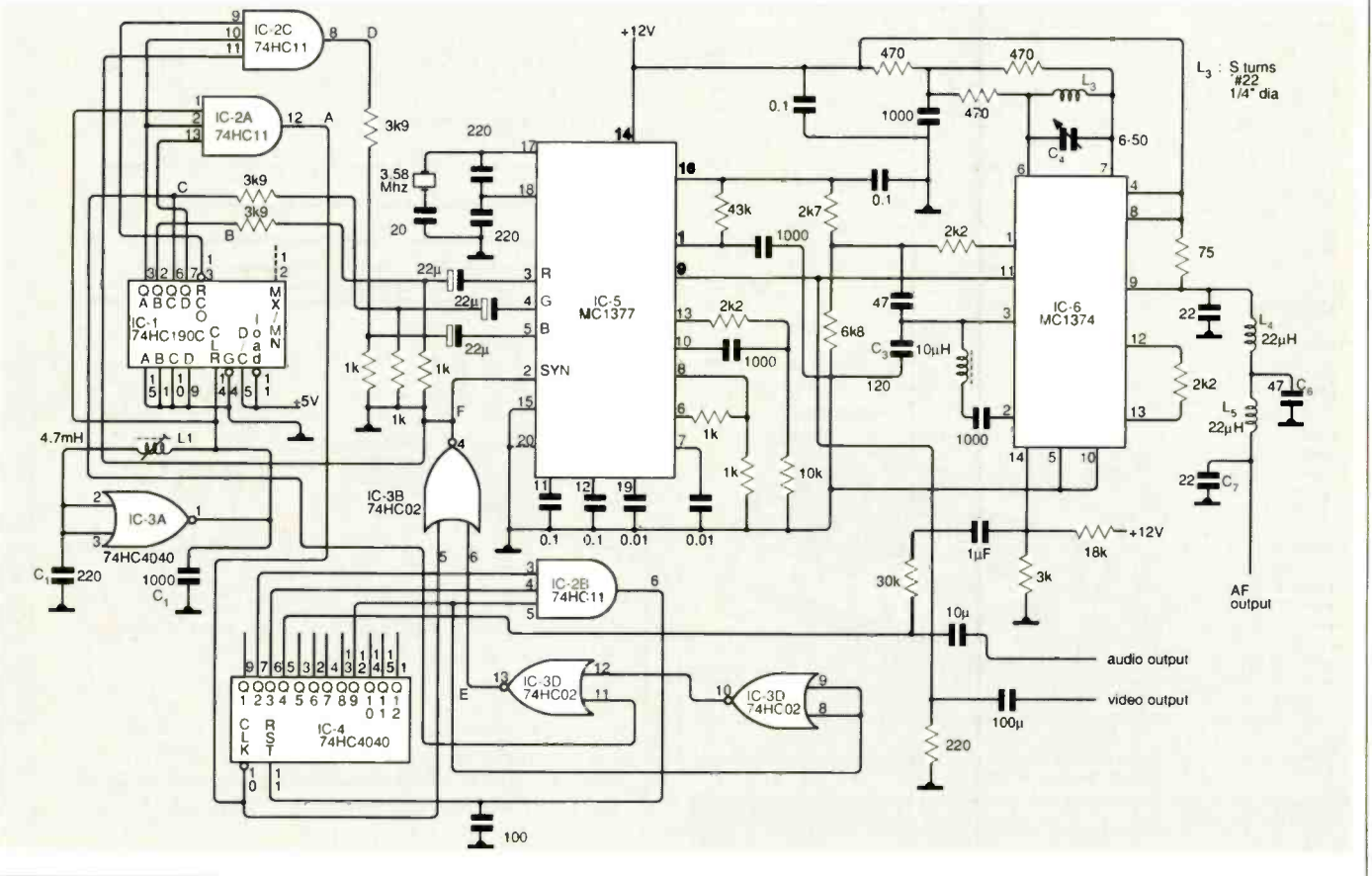
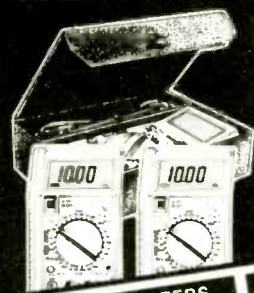


Fig. 2. Waveforms identified by letter in circuit diagram of Fig. 1 for the NTSC version.

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3610	30	0.3%		£35.35
3630	30	0.3%	Cap Test	£39.60
3630B	30	0.3%	with Bargraph	£49.00
3650	30	0.3%	Freq. Count & Cap	£42.45
3650B	30	0.3%	with Bargraph	£50.50
4600	30	0.05%	Data Hold	£53.85
4630	30	0.05%	Cap. Test. Data Hold	£59.20
4630B	30	0.05%	with Bargraph	£67.25
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MODEL	RANGES	BASIC	EXTRA FEATURES	PRICE
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3610	30	0.3%		£35.35
3630	30	0.3%	Cap Test	£39.60
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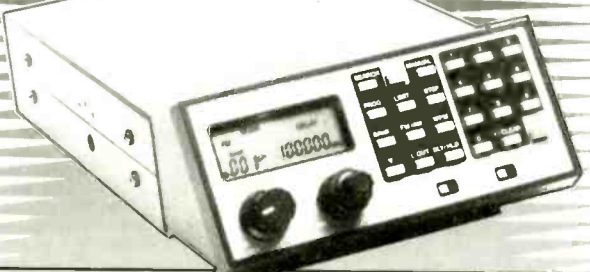
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# Satellites ride the solar wind

A satellite with solar sails, propelled through space by the force of solar light, could maintain its orbital position indefinitely argues Paul Birch

its elevation in the sky is about 10°. So big chunks of the globe, mostly in the arctic and antarctic, are not covered at all.

## Sailing by sunlight

Solar sailing makes use of the weak, but not insignificant, pressure of light from the Sun to push a vehicle through space.

Solar sails are simply mirrors, generating a force through photon impact perpendicular to the sail. By tilting the sails the direction of thrust can be controlled, and very interesting possibilities open up when this effect is combined with the idea of the geostationary satellite.

To exploit them I have devised a new kind of geostationary satellite — I call it a "sailsat" — which does not need to be situated directly over the equator, because a solar sail maintains its orbit away from the equatorial plane.

Take a solar sail in geosynchronous orbit, and tilt it to the Sun (Fig. 1.) — we can spin it on its axis to stiffen it and orient it relative to the direction of the Sun. Light pressure elevates it above the equatorial plane.

Ignore for the time being the nuisance sideways force away from the Sun, and ignore the effect of the Earth's axial tilt. Now, there is a force holding up the satellite against the component of gravity trying to pull it back into the equatorial plane; but the component acting inwards towards the Earth's axis remains and holds the satellite in this elevated orbit.

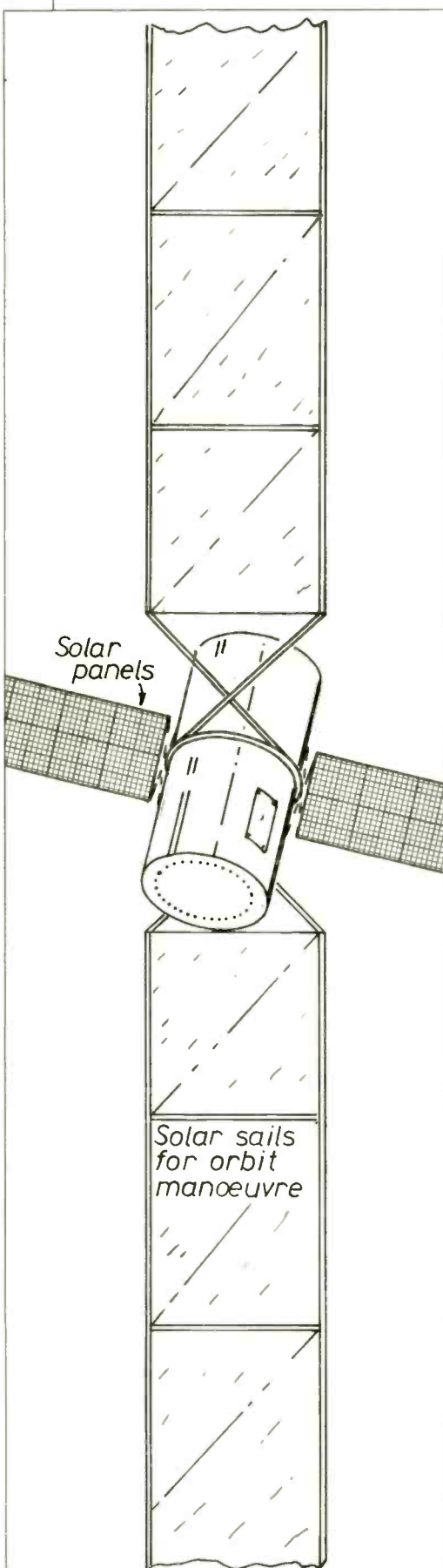
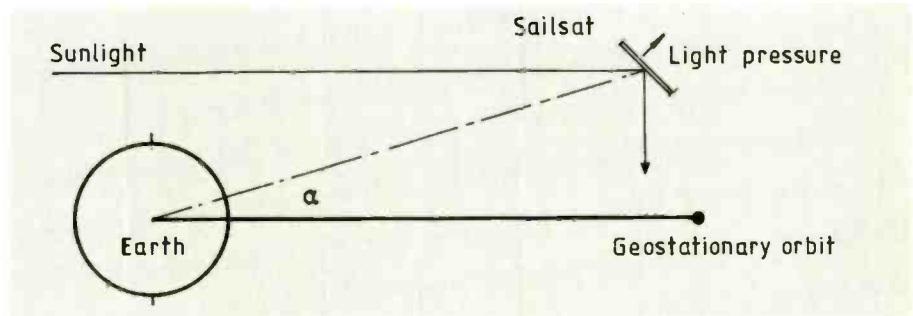
**A**bove our heads scores of geostationary satellites, civil and military, are going about their business — and the geostationary arc is getting crowded.

The problem is that all geostationary satellites have to slot into that thin line in the sky directly above the equator. It is not that the satellites are in any danger of bumping into one another. But they are close enough so that radio interference between neighbours on the arc can upset operation.

Bigger antennas, in space or on the ground, can help. But they are expensive, and when it comes to direct broadcasting television, the receiving antennas have to be small.

A further drawback is that a geostationary satellite can not be seen very well much above a latitude of about 70°, where

Fig. 1. Elevated geostationary orbit of Sailsat.



Solar panels

Solar sails for orbit manoeuvre

Could satellites fitted with solar sails combine built-in orbit-holding with a free flying capability — at no fuel cost?

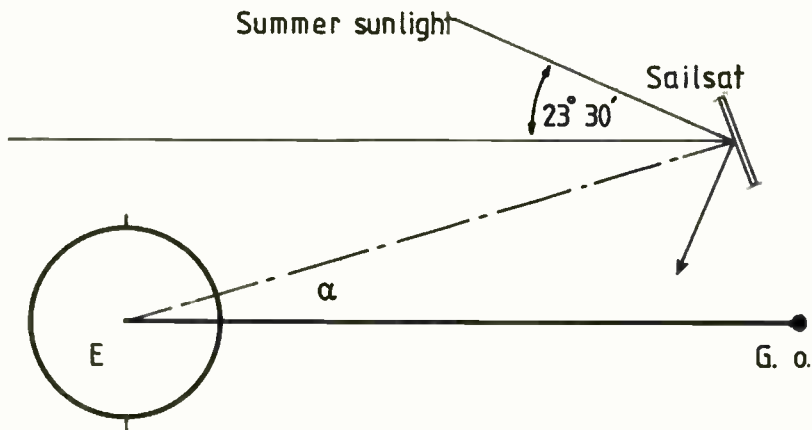


Fig. 2. Reduced lift at summer solstice.

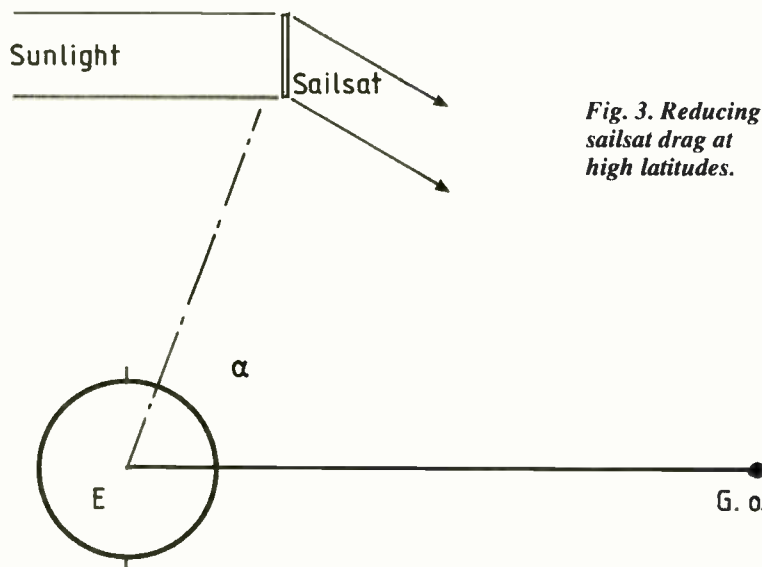


Fig. 3. Reducing sailsat drag at high latitudes.

Taking the radial distance of the satellite from the centre of Earth as 42,000km, if  $\alpha$  is the latitude or elevation angle of the orbit above the equatorial plane, the radius of orbital gyration is reduced by the factor  $\cos\alpha$ , the inwards gravity component by the same factor, and so too is the orbital velocity — since  $v^2 = rg$ .

The period of the orbit is thus unaltered.

It follows that geostationary orbits elevated above the equatorial plane lie along the lines of latitude of a sphere of radius 42,000km centred on the Earth.

Force elevating the sailsat is determined

by the angle of the sail to the Sun and the areal density of the sail material. But the force required to maintain an elevated orbit increases with the desired latitude, being zero on the equator.

Maximum achievable latitude obtains when:

$$\sin\alpha = (3/8)(P/rg).$$

where  $P$  is the available light pressure (9N/km<sup>2</sup> at the distance of Earth from the Sun),  $g$  is the acceleration due to gravity (0.22m/s<sup>2</sup> in geostationary orbit) and  $r$  is the areal density of the sail (values as low as 0.15kg/m<sup>2</sup> have currently been realised). Plugging in the numbers, we

find that with present technology the maximum latitude is about 5°—just beginning to be useful.

The Earth's axial tilt is an irritation. For part of the year the Sun lies above the plane, tending to push the sailsat back down. The worst case is at summer solstice (Fig. 2.), when the net lift of the sail is reduced by a factor of two.

So if we want a truly geostationary satellite all the year round our latitude of 5° is cut to about 2.5.

Future development of solar sail technology — including manufacture in space of unbacked perforated aluminium film — should squeeze down the minimum areal density, and may then enable geostationary satellites to be elevated to the higher latitudes. More modest improvements, say by a factor of four, would permit continuous global coverage to be achieved — including the north and south poles.

But what of the sideways component of the light pressure? For part of each orbit it pushes the sail towards the Earth; for part it pushes it away.

The net effect is an eccentricity in the orbit, which is displaced slightly away from the Earth, away from the Sun. Nevertheless, a geosynchronous orbit can still be maintained.

At low latitudes, the effect will be small. But at high latitudes we need to reduce the sideways component relative to the desired lift, to prevent the sailsat from being blown away (Fig. 3.). This is what prevents us positioning a simple sailsat directly above the pole throughout the year (there are ways round this).

Sailsats could be used in a variety of ways, greatly increasing the class of orbits available, not only about the Earth, but also throughout and beyond the Solar System. At one end, they start as satellites with built-in orbit-keeping capability; at the other, they are free-flying solar probes.

If a sailsat is launched into low Earth orbit (a few hundred kilometres high), then it can solar sail the rest of the way to its operational orbit, with considerable savings in launch costs.

Even a small sail would enable satellites to make orbital corrections without on-board rocket motors. This suggests that an economical way to prove and develop the sailsat concept and technology, prior to the deployment of fully elevated geostationary communications satellites, would be through the interim employment of solar sails for orbit-keeping, for orbital manoeuvring, and in use as integral upper stages.

### GEOSTATIONARY 50 YEARS ON

Almost half a century ago in an article in *Wireless World* (Nov 1945) Arthur C Clarke introduced the concept of the geostationary communications satellite. He pointed out that a satellite placed some 36,000km above the equator will orbit the Earth once every twenty-four hours (23h 56m 04s to be precise) and therefore remain above exactly the same spot on the globe.

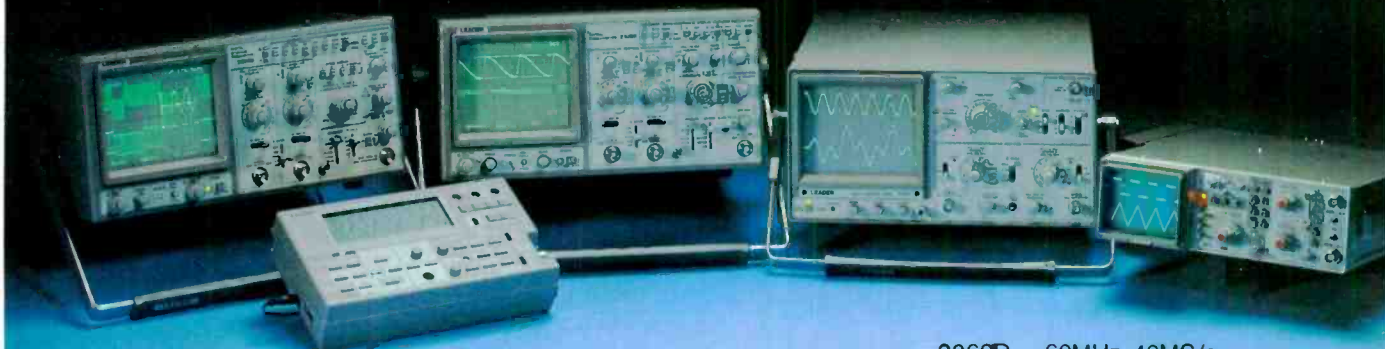
A communications antenna transmitting to—

or receiving from — such a geostationary satellite, can be anchored like a TV aerial, pointing at a fixed spot in the sky. This is a much cheaper option than using the tracking antennas used for low altitude satellites. Clarke is also a good source for more information on solar sails in which he has had an interest for many years. His classic story, 'The Wind From The Sun' is still the best introduction to the subject.

**Editorial survey: use the information card to evaluate this article. Item M.**



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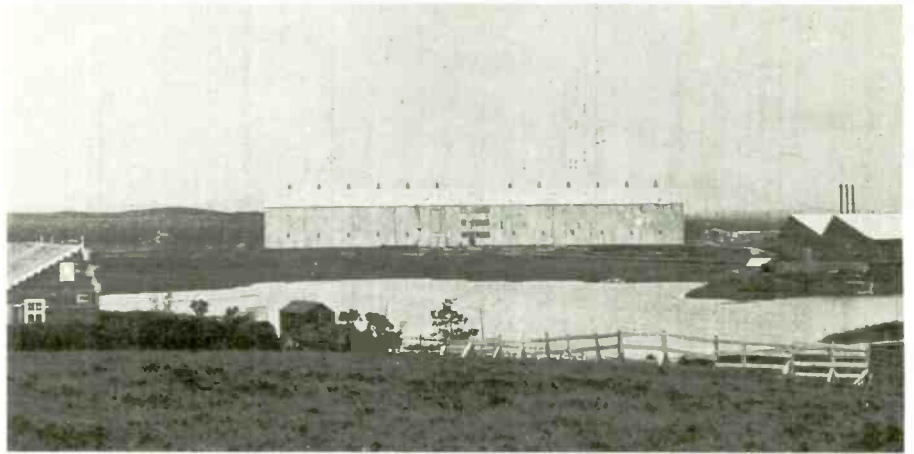
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CIRCLE NO. 145 ON REPLY CARD

This year marks our eightieth anniversary. Initially launched in 1911 as the *Marconigraph*, the magazine has faithfully mirrored the electronics industry over the intervening years. In this, the first of a series of historical articles, we open our archives to present a picture of the past.



*Clifden, the site of Marconi's historic transatlantic transmission pictures in 1907*

## Sparks over the Atlantic

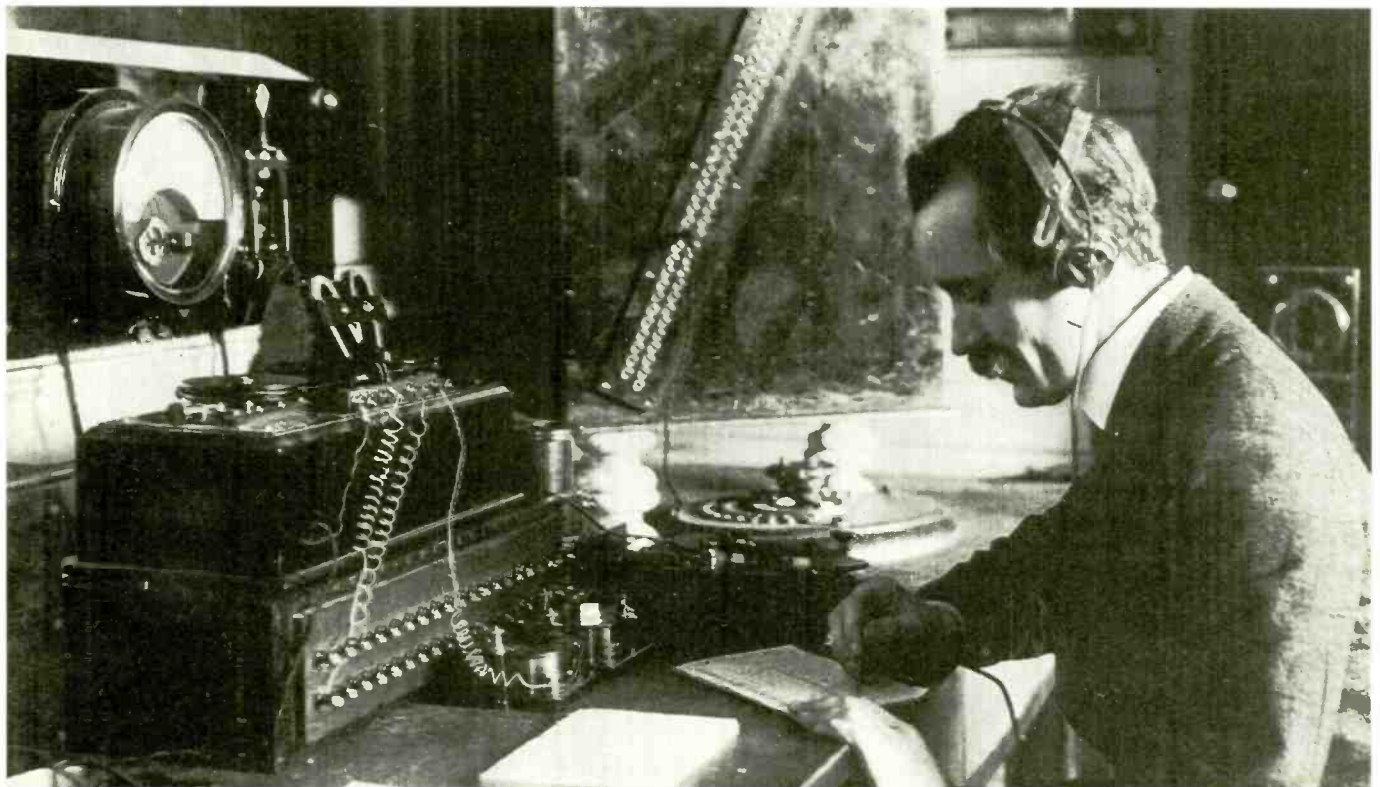
What appears to be some kind of aircraft hangar full of large objects drying out is in reality the air-dielectric capacitor (condenser, as it was then known) of the Clifden transatlantic spark transmitter of 1907. We have no record of its value, or of the inductance it tuned, but it cannot have been more than a few hundred picofarads, the plates being separated by one foot. It

is impossible to guess at what the man in roof is doing.

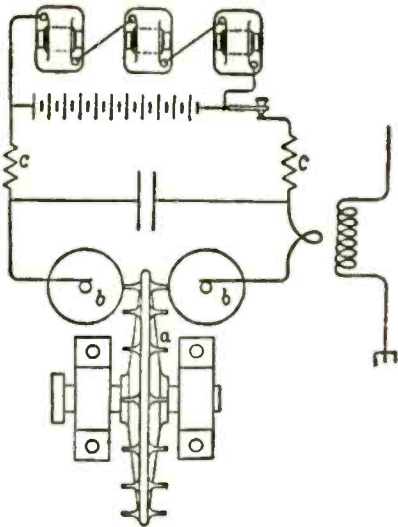
The Clifden spark station was regarded as one of the wonders of the world, being far and away in advance of anything possessed by Germany or the USA. The receiver, subsidised by the Canadian Government, was in Glace Bay in Nova Scotia and was of a comparable standard of design and performance.

Power was supplied at DC, the source being a huge battery of 6000 cells giving 15kV and supplying 300kW to the transmitter. Three, series-connected, high-voltage generators driven by a steam engine charged the batteries, which explains the picture of a railway: it is bringing peat for the boiler from a nearby peat bog.

Our third picture shows the station buildings, with the peat-burning power



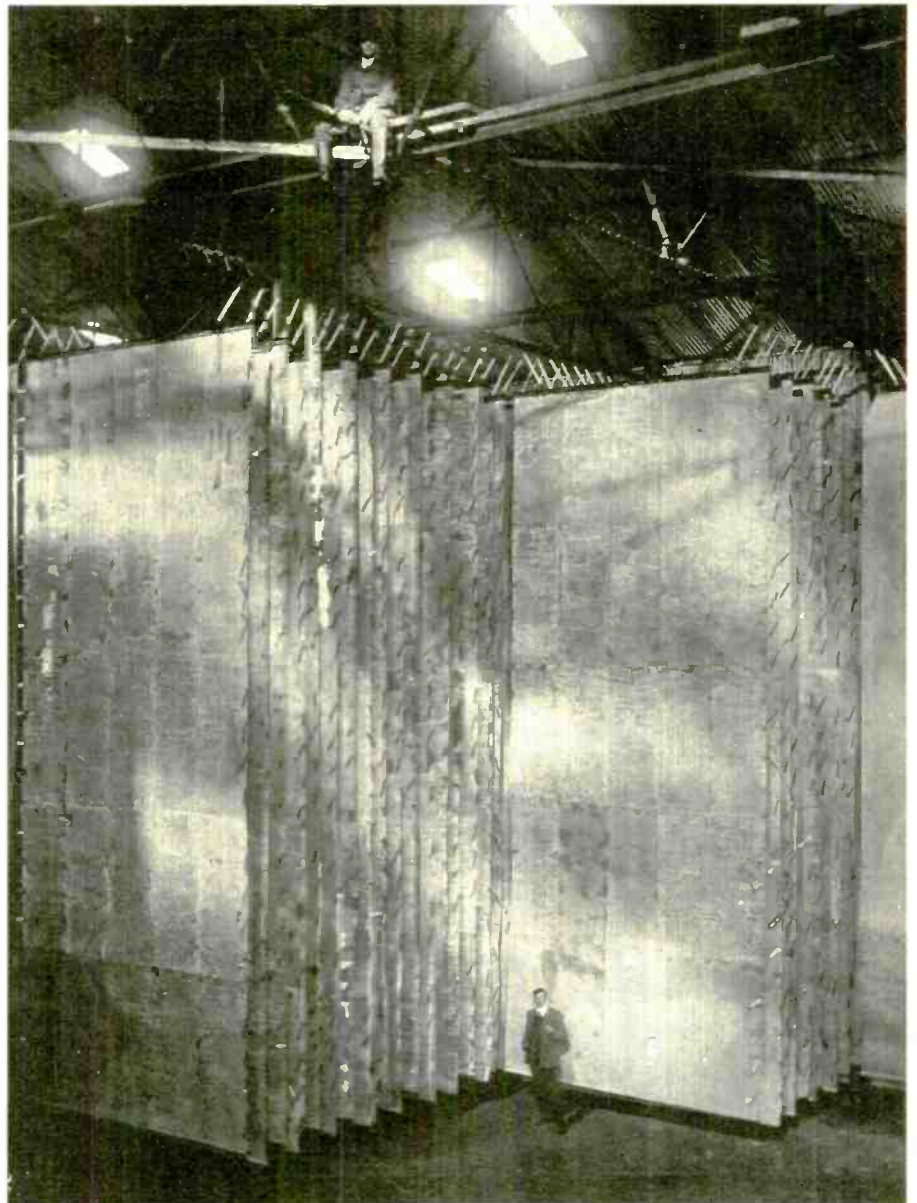
*At work in Clifden, Eire, 1907. The Marconi station successfully challenged the transatlantic cable operators in reliability*



*Circuit diagram of the Clifden transmitter. The power supply charged the condenser, which then discharged itself across the spark gap, the resulting current being taken straight to the aerial through the step-up transformer, or "jigger". Notes thus produced were harsh and very like ordinary noise, so the rotary discharger was used. Studs on a wheel passed through the spark gap, causing a spark for each stud at a higher, more constant rate and giving a musical tone.*

station on the right. The Irish "troubles" of 1922 saw the end of the Clifden station when it burnt down completely. Unlike the earlier (1901) site at Poldhu, Clifden has no memorial.

Lastly, the Clifden wireless operator is using a "Maggie" - the Marconi magnetic detector. A soft iron wire passed through a coil carrying the received signal, its hysteresis changing according to the signal. A pair of permanent magnets provided the field and a secondary on the signal coil fed a headset. This detector allowed traffic to flow at around 30 words per minute, which was much higher than the rate pos-



*Giant capacitor bank at Clifden. The hanging plates were separated by 12in of air*

sible with a coherer - the other popular detecting device.

Clifden's performance so alarmed the cable companies that there were rumours that they copied messages sent by the sta-

tion and published the interesting ones as advertisements in the US newspapers, in particular the messages that advised users that there was to be a break in transmission for bad conditions.

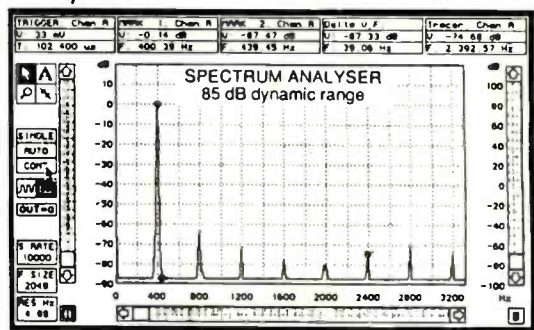
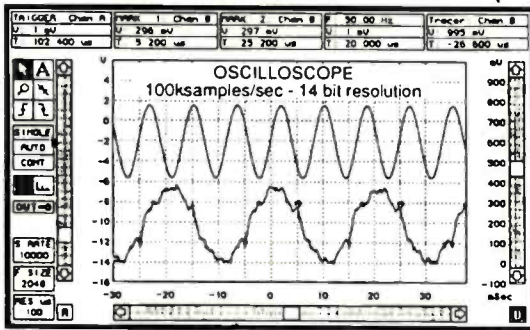


*Peat train for the generators. The Clifden station used a steam engine set to charge a 6000 cell battery.*

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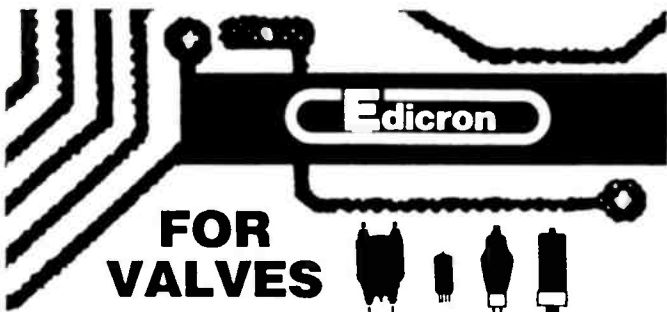
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## Asic

**Design generator.** An asic synthesiser has been introduced that can generate complete asic chips including the pad ring direct from the hardware definition language inputs. It implements optimised data path and memory as well as random and sequential logic letting full chips be produced instead of just netlists. It can run on Vax, DEC station, Apollo, HP9000 series 3, Sun-3 and Sun-4 computers. Compass Design Automation, 0908 667595.

**Cmos 1µm process.** ES2 has introduced its second 1µm process which gives a 31% increase in density over the previous process. An average density of 750gate/mm<sup>2</sup> for random logic or 2800bit/mm<sup>2</sup> for an Sram can be achieved using a standard place and route system. The ECPD10 process is supported by a full standard cell library.

**Gate array.** A field programmable gate array from Micro Call can achieve system clock rates in excess of 40MHz, 20% faster than earlier models in the same series. The Xilinx 2000-gate XC3020-125 is in production now and other members of the family are due out soon. Micro Call Ltd, 0844 261939.

**Bicmos gate arrays.** TI has introduced a family of seven submicron Bicmos gate arrays including a 150,000 gate device. The TGB1000 devices are made using a 0.8µm (drawn) Epic triple-level metal, sea-of-gates process. The firm claims 75% use of available gates. Dual and single port ram blocks can be integrated by metal customisation. A datapath compiler allows integration of elements such as adders, ALUs, multipliers and barrel shifters. Unloaded gate delays are typically 150ps and loaded 320ps. Texas Instruments, 0234 223252.

## A-to-D &amp; D-to-A converters

**20bit dac.** The PCM63 is a monolithic 20bit D-to-A converter for digital audio. It guarantees an idle channel signal-to-noise ratio of at least 116dB. A linear dual dac architecture is used to eliminate glitches and other nonlinearities around bipolar zero. The output has no glitch energy around zero. The design avoids signal-to-noise, channel separation and intermodulation distortion problems associated with sigma-delta and similar 1bit dac techniques. Burr-Brown International Ltd, 0923 33837.

**A-to-D converter.** Maxim's 8µs 12bit adc has the same pin configuration as

the industry standard 574A. The MAX174 uses the Bicmos process to keep power consumption to 150mW. It has an internal 10ppm/°C buried zener reference, an on-chip clock and a microprocessor interface. External components are limited to decoupling capacitors and fixed resistors. Dialogue, 0276 682001.

## Discrete active devices

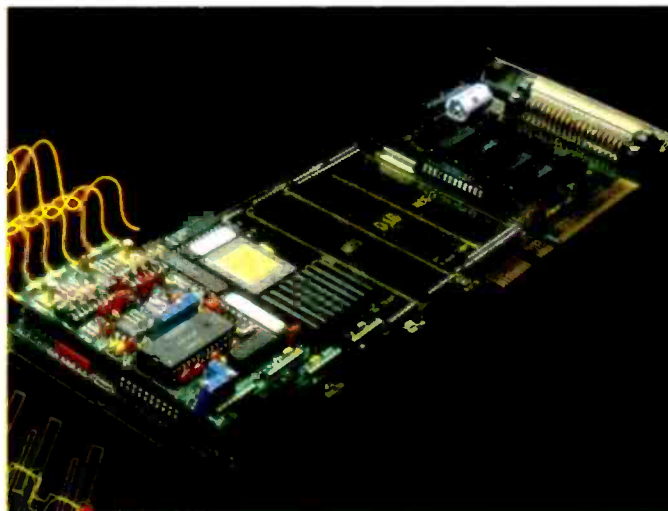
**Micropower precision references.** The GEC Plessey range of precision voltage references uses the bandgap principle to provide a precise stable reference voltage without the need for an external shaping capacitor. The 2.5V references include the REF25 in a two-pin TO18 metal can, the REF25Z in a plastic three-pin TO92, and the REF25D in an MP8 miniature surface mount package. Recommended operating current range is 60µA to 5mA. There is a similarly packaged 5V range. GEC Plessey Semiconductors, 0793 518000.

## Digital signal processor

**DSP modems.** DSP multimode terminal units from AEA have all the modem functions implemented in firmware. They have all the popular PK232 modem functions as well as satellite modems covering data rates up to 9600baud. They also include fax and SSTV modems. ICS Electronics Ltd, 0903 731101.

**Data acquisition module.** The adt156 A-to-D module provides a no glue logic high speed 16bit data acquisition interface for DSP devices from Motorola, AT&T, TI and Analog Devices. When combined with the spl156 Tram (transputer module) it can provide the basis of a data capture and analysis system for real time digital signal processing

*The adt156 A-to-D Module provides a no glue logic 16bit acquisition interface for popular DSP devices*



applications. Sunnyside Systems Ltd, 0506 460345.

## Linear integrated circuits

**Telephone circuit.** The AS2530 is a speech transmission circuit with LD/DTMF repertory dialler on a single chip. During on-hook the repertory number store is maintained by an on-chip low power voltage regulator which draws less than 30µA from the line. Standard operating range is 20 to 100mA but it can work down to 5mA with reduced performance. There is a 32 digit last number recall and an 18 digit repertory store for nine numbers. Austria Mikro Systeme, 0276 23399.

**PWM controller.** The Siliconix Si9120 is a current mode PWM controller IC with an input range of 50 to 450V that lets it work directly from rectified 110 or 220V AC power lines. Integrated in the chip are high voltage start-up circuitry, oscillator, error amplifier, voltage reference and noninverted cmos output driver for the external mosfet. Quiescent current is 1.5mA. Frequency capability is 500kHz. It comes in a 16-pin plastic DIP. Barlec-Richfield Ltd, 0403 50111.

**Instrumentation amp.** The INA120 monolithic instrumentation amp has a maximum nonlinearity of 0.005% (gain = 1) of full scale and, with ±15V supplies, a current requirement of only 2.7mA typical or 4mA maximum. Internal gain-setting resistors let precise gains of 1, 10, 100 or 1000 be set by pin strapping. Burr-Brown International Ltd, 0923 33837.

**Bus driver and receiver.** Cherry is developing a bus driver and receiver IC for analogue class A multiplex bus networks that can withstand short circuit, thermal overloads, reverse

battery voltages and various voltage transients that are found in hostile automotive applications. The CS8425 interfaces between the system microprocessor and sensors and control elements to provide information or functions on command. Cherry Semiconductor Corp, 0101 401 823 3995.

**Frequency synthesiser.** The Qualcomm Q3036 is a single chip solution for phase locked loop frequency synthesiser applications for RF designers. It needs a single +5V supply and has all the needed elements, except for the VCO and loop filter components, to build a PLL frequency synthesiser which will operate from DC through to the L band. The 44-pin unit is available in a PLCC or CLCC package. Chronos Technology Ltd, 0989 85471.

**Quad video op amp.** The HA2444 four-channel switched-input video op amp has a unity gain bandwidth of 45MHz and differential phase. Gain is 0.03° and 0.03%, respectively. It incorporates four differential op amp type input stages, digital selection logic, and output buffer with enable function. It comes in 16-pin SOIC and plastic/ceramic DIPs. Harris Semiconductor, 0276 686886.

**Power drivers.** Harris has introduced the SP600 series of high voltage half-bridge driver ICs for driving power MOS devices in half-bridge topologies. They can interface direct to n-channel power mosfets or IGBT devices. They are rated at 500V DC and can work directly from standard rectified 240V AC mains. Harris Semiconductor, 0276 686886.

**Linear amplifiers.** Motorola has introduced two wideband 10MHz to 1.2GHz high linearity amplifiers, the CA5900 and 5915. They are thin film hybrid amps that use an all gold metallisation system and are for operation in 50Ω units. Gain is 15dB and output power is typically 1W at 1dB compression point. Typical third order intercept is 41dBm. Motorola Ltd, 0908 614614.

**Frequency generator.** The SC11410 is a programmable frequency generator. The chip contains a set of eight mask programmed frequencies used in PC graphics adaptor boards. The user can either select a frequency from the mask programmed set or program another frequency on the fly by entering an 18bit word through the serial interface. No external voltage regulator is needed and frequency jitter is kept to less than 150ps. Sierra Semiconductor Ltd, 0793 618492.

**Bus line drivers.** A series of high output drive devices from TI have a specified drive capability of  $I_{OH} = 188mA$  and  $I_{OH} = 80mA$ . The series

comprises 16 drivers, transceivers and transceivers with registers. The first two released are the BCT25245 octal transceiver and the BCT25642 octal transceiver with open collector outputs. Texas Instruments, 0234 223252.

**Drive and transmitter duo.** The UC3725 and 3724 provide all the needed features to drive an isolated mosfet from a TTL input signal. A modulation scheme is used to transmit power and signals across an isolation boundary with a minimum of external components. They are suitable for driving the high-side devices on a high-voltage H bridge. The 3724 transmits drive logic and drive power and the 3725 receives power and signal across the isolation boundary and provides a pulsed output of 2A. Unitrode (UK) Ltd, 081 318 1431.

**Interface and FIFO IC.** A single IC from VLSI has on board four PC/AT compatible serial data I/O interfaces including data FIFO and associated logic. The VL16C554 has four NS16550 serial ports each with its own 16byte FIFO to reduce CPU interrupts. It can accommodate 5, 6, 7 or 8bit characters with 1, 1.5 or 2 stop-bits and even, odd or no parity. VLSI Technology Ltd, 0908 667595.

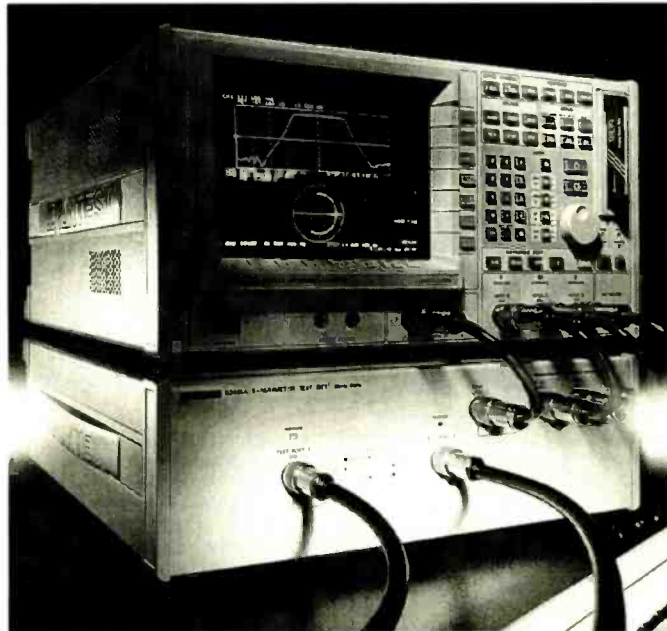
**Memory chips**

**4Mbit EPROM.** Dialogue has expanded its range of Hitachi UV-erasable EPROMs with the introduction of the 4Mbit HN27C4096 configured as 256K x 16bit. Programming time is 3.5s and access time 100ns. The cmos device has a write pulse width of 50µs which, when combined with a page programming mode that lets 64bit be written in a single write mode, cuts the programming time to a quarter. It works from a 5V supply with a typical operating current of 40mA at 10MHz and standby current of 20µA maximum. Dialogue, 0276 682001.

**Ferroelectric ram.** Ramtron's ferroelectric ram can use storage capacitor techniques to let it work like a conventional Dram. But, when high voltage pulses are applied, the ferroelectric films can be polarised to form long-lasting bistable storage elements preserving data when system power is lost. The first of these nonvolatile Drams is the FMX1208 512 x 8bit chip. Read/write cycles are 200ns. Mogul Electronics, 0732 741841.

**Microprocessors and controllers**

**Colour look up table.** Inmos has available the IMS G177 power down colour look up table. In standby mode it is totally powered down and consumes 200µA. In review mode the



A network analyser from chase includes a full 5 parameter measurement capability

clut can be accessed through the microport while the rest of the device is powered down. In this mode it consumes 500µA. In normal mode it works like the G176 VGA clut providing a VGA output for driving a monitor. The device has anti-sparkle circuitry which reduces snow or sparkle effects on screen generated when some software reads or writes operations to the palette during active video. Inmos Ltd, 0454 616616.

**Video decoder.** A single-chip moving pictures experts group (MPEG) video decoder and processor from C-Cube can decompress digital video in real time. This can be done at four times the pixel resolution specified by the base-level MPEG mode. Kudos Thame Ltd, 0734 351010.

**Graphics display chip.** Music Semiconductors and Avasem are jointly developing a graphics display chip which they hope will be the industry's first combination colour palette and frequency generator to fully support super VGA and other common graphics standards. The product is scheduled for sampling in August. Music Semiconductors Inc, 0101 719 570 1550.

**Low power microprocessors.** Two high speed microprocessors from NEC can work at any clock speed from DC to 16MHz with a current demand of a few microamps. The V20HL and V30HL have a 6mA/MHz maximum power consumption. These cmos chips are for mobile instruments, industrial control, telecomms and office automation. They come in 40-pin DIL, 52-pin QFP

and 44-pin PLCC packages. NEC Electronics (UK) Ltd, 0908 691133.

**Optical devices**

**Surface emitting LEDs.** GCA has introduced two surface emitting LEDs for analogue video transmission over fibre. The 1A184 is a linear high-speed LED for modulated carrier-wave video. The high linearity is expressed by the second and third harmonics which are suppressed by 40 and 45dB, respectively, at 10MHz. Bandwidth is 140MHz. It couples 35mW into a 50/125mm fibre at 100mA. A high power 45mA coupling version is also available. The 1A255 is a highly linear LED for base-band video. It works linearly even in the low-frequency range which minimises signal distortion. It couples 80µW into a 62.5/125µm fibre at 80mA and has a bandwidth of 55MHz. GCA Electronics Ltd, 0993 82 2252.

**Programmable logic arrays**

**Timing generator.** Altera has introduced a function-specific erasable programmable logic device, the EPS464 synchronous timing generator for use in the imaging and display market. The 50MHz unit integrates control logic needed by CCD image sensors, video cameras and various graphic display devices. The 660mW device has 64 programmable macrocells for waveform generation, 32 programmable I/O pins, and noise immune inputs with 250mV hysteresis and quiet output buffers. Altera Corp, 0844 275285.

**PASSIVE**

**Connectors and cabling**

**Cable equalisers.** A series of negative slope equalisers from Inmet have a frequency range of 2 to 18GHz and are for in-line equalisation of long coaxial cable runs. They can exhibit a characteristic from 5 to 20dB attenuation at 2GHz and an insertion loss of 1.5dB maximum at 18GHz. Linearity of ±0.5dB over the entire frequency band is achievable and a low VSWR of 1.4:1 is guaranteed. Pascall Electronics Ltd, 081-979 0123.

**Displays**

**Miniature lamps.** Three types of miniature lamps for electronics equipment are available from Electroustic. First are single filament lamps with a range of 6 to 70V and current from 20 to 200mA. Secondly, single neon and green fluorescent lamps have a range of 60 to 220V and a current from 0.3 to 3.5mA. The third range comprises multi LED lamps which have four or six high luminosity chips available in red, green or yellow with a rating of 6 to 48V DC and a current of 10 to 35mA. Electroustic Ltd, 0264 333664.

**LCD module.** Toshiba has introduced the TLX1741-C3M 240 x 128 LCD module for EPOS and instrumentation applications. The black and white display uses a compensation film approach which with thin light guide technology keeps the thickness to 14mm. A cold cathode fluorescent lamp is used for back lighting. The on-board T6963C controller chip can store graphics screens, characters and full European fonts. Toshiba Electronics (UK) Ltd, 0276 694600.

**LCD module.** Trident claims its TRMod-34 is the smallest 16 x 2 LCD module available at 74 x 30 x 8mm. Viewing area is 45 x 14mm and the two lines of 16 are five by seven dot matrix characters each measuring 4.9 x 2.1mm. Supertwist and twisted nematic types are available and it can be supplied with an EL backlight. An optional panel mounting kit is available with scratch resistant window. It is suitable for hand held instruments. Trident Microsystems Ltd, 0737 765900.

**Filters**

**Interference suppression.** The Microslim range of RFI/EMI interference suppression filters from Oxley is claimed to save 40% space compared with similar units. The body is threaded for either tapped hole or

Continued on page 528

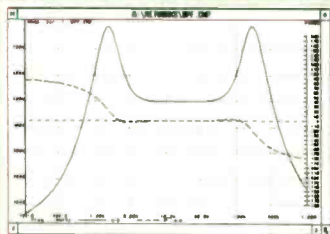
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### 1 Frequency response

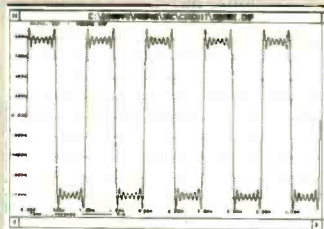
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Node	DC Volt	Node	DC Volt	Node	DC Volt
0	0.000000	1	1.200000	2	7.700000
3	1.414141	4	0.271212	5	7.678585
6	1.414141	7	7.678585		

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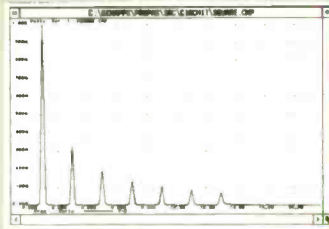
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LM339	0.25	0.14	ICL7660CPA	1.00	0.80
ILO-74	1.20	0.85	8085A	1.80	1.30
ULN2803A	0.55	0.35	80C85	2.20	1.60
6502P	2.20	1.56	8155	2.20	1.60
6522P	2.20	1.56	82C43	1.70	1.25
65C02P2	3.60	3.00	8251A	1.10	0.80
65C21P2	3.00	2.60	8253-5	1.40	0.95
65C22P2	3.10	2.66	8255-5	1.40	0.95
ICM75551PA	0.42	0.34	82C55A	1.40	0.95
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nut retention. It comes in C, L-C and Pi configurations and has capacitances from 330 to 22,000pF with insertion loss at 10GHz. Working voltage is up to 200V and maximum current rating is 10A. Oxley Developments Ltd, 0229 52621.

**Instrumentation**

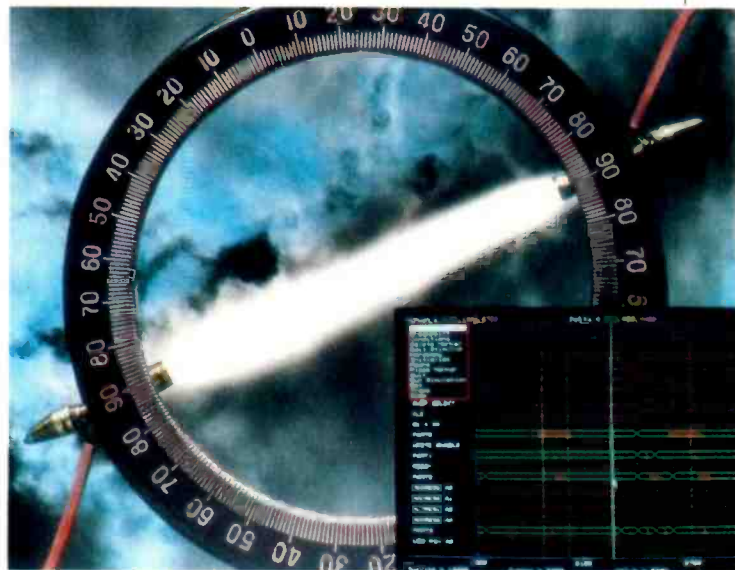
**Network analyser.** A network analyser with a full S parameter measurement capability is available from Chase. Menu driven software prompts the user through a full two-port calibration procedure using simple on-screen messages. All four S parameters can be measured without disturbing the connections to the device under test. Results can be used for CAD, quality assurance and archiving. Chase Electronics Ltd, 081-878 7747.

**LCR meter.** The LCR815 meter has selectable test frequencies of 120Hz and 1kHz. Features include autoranging, autoparallel and series circuit mode selection. Information is shown on two four-digit seven-segment LED displays. Basic accuracy is 0.2%. Inductance ranges are 190µH to 1900H, resistance from 1900mΩ to 19MΩ, and capacitance from 190pF to 19mF. Flight Electronics Ltd, 0703 227721.

storage capability. The 6023 has a real-time bandwidth and repetitive signal storage bandwidth of 20MHz and the 6024 50MHz. Both have sampling rates of 20Msample/s (two channel alternate) or 100Ksample/s (two channel chopping). Memory capacity is 2Kword (x2 channel) at 50ns/div to 2µs/div. Hitachi Denshi (UK) Ltd, 081-202 4311.

**Current calibrator.** A portable current calibrator with a range from 0 to 20mA is available from Intek. The TEK300 is for process control use and as a general purpose signal injector. This hand-held battery powered unit can work as a current source, current sink or monitor for the current in a process loop. It has a 3.5 digit LCD with LEDs to show battery state and operational error. Intek Instruments Ltd, 0942 227735.

**DC energy meter.** The DC101 is a DC power transducer and energy meter with an accuracy of ±1% which is not affected by ripple and noise on the supplies. It is for use with DC drives, DC systems and variable speed AC drives. It comes in an IP54 enclosure and gives measurements in kWh, MWh or J with a volt free pulse output per energy unit. An optional 4 to 20mA output is available. Display is via a seven digit electromechanical counter. Northern Design Ltd, 0274



*Orcad/VST release 4 digital simulation tool from ARS is easily accessible from the ESP desktop.*

oscilloscope with digital CRT readout. Control settings for on-screen readout include sweep time and vertical sensitivity. A cursor measurement facility comprises four horizontal and vertical cursors supported by two extra cursors for further measurement. Thurlby-Thandar Ltd, 0480 412451.

**Literature**

**ICs and discretes.** The Allegro Databook gives details of the firm's range of mixed signal ICs and discrete semiconductor devices. It also contains applications information covering their use in computer peripheral, industrial control, military, automotive, consumer and aerospace applications. Allegro Microsystems, 0932 253355.

**Production equipment**

**Cold light of day.** The Schott electronic cold light source provides controllable shadow free illumination of subjects with multiple light outputs. The electronic control system protects the halogen lamp from surges at switch on and during operation. It comes with one, two or three light output swan-neck guides which are self supporting. Flexible guides are also available which may be clamped to equipment for fixed illumination. It can be used with zoom type microscopes for inspecting small components and assemblies. A vacuum adaptor is available for clean room use. Hunter Equipment Sales Ltd, 0420 473723.

**Desoldering wick.** A desoldering wick is available for the capillary removal of solder from conventional and surface mount circuit boards. Its pure copper fine braid construction provides a large surface area to improve absorption and retention of excess solder. The rosin flux is mild, noncorrosive, non-hygroscopic and

non-activated. Tech Spray EC Ltd, 0423 520699.

**Power supplies**

**DC/DC converters.** The 2PKV series of 2.5 to 3W DC/DC converters are made using thick-film hybrid technology and boast an efficiency of 85%. Input range is either 9 to 36V DC or 18 to 72V DC. Input current is 3 to 5mA at nominal input voltage. Standard outputs are 5, 12 and 15V DC. Ericsson Components AB, 0203 553647.

**Bench supply.** The AX321 and 322 bench power supplies from ITT have digital display of voltage and current output. The dual output 322 has output voltage tracking up to ±30V as well as series and parallel outputs. Total power output is 140W. The single output 321 has an output range of 0 to 30V at up to 2.5A with adjustable current limit and a total power rating of 70W. ITT Instruments, 0753 511799.

**Uninterruptible supply.** The Accupower UPS range is claimed to provide off-line and standby power at 50p to £1 per VA. There are five units in the range from 150VA to 1400VA, the low power unit being enough to protect most XT type computers with the high power unit for network file servers and multiple PCs. Backup at full load is 8 to 10 min. Thame Power Ltd, 0844 261300.

**Programmable supply.** Thurlby has introduced a fully programmable quad-mode power supply with active discharge circuit. The TSP322H has two 0-32V 0-2A dual-tracking outputs which can be used in parallel to give 0-32V 0-4A or in series for 0-64V 0-2A. A nonvolatile memory can store 25 set-ups and user-definable overvoltage protection is included. It comes in stand-alone or rack mount formats. Thurlby-Thandar Ltd, 0480 412451.



*The LCR815 LCR meter from Flight has selectable test frequencies of 120Hz and 1kHz*

**Chart recorder.** The Easygraf oscillographic recorder from Gould is a portable unit for shop floor or field use. It has high-frequency thermal-array recording, extensive annotation capabilities, plug-in signal conditioning, and 18 chart speeds from 0.01 to 100mm/s. It can monitor up to four analogue inputs and six event channels. It measures 19.4 x 38.1 x 38.1mm and weighs 10kg. It comes in two and four channel versions. Gould Electronics Ltd, 081-500 1000

**Real-time scopes.** The VC6023 and 6024 are real-time oscilloscopes aimed at engineers who need a

729533

**Modulation analyser.** The FMA modulation analyser from R&S covers 50kHz to 5.2GHz. It includes RF measurements to 0.1Hz, AM/FM and phase measurements with an error less than 0.5%, balanced and unbalanced AF voltage and frequency measurements, and a precision power meter with an accuracy of <0.5dB. Various psophometric weighting filters are provided as standard with special filters available as an option. Rohde & Schwarz UK Ltd, 0252 811377.

**100MHz scope.** The Leader 2100AR is a 100MHz three-channel six-trace



## Production test equipment

**Appliance tester.** Seaward has launched a dual voltage portable appliance tester for batch testing electrical and electronic equipment on production lines. The PAT2000 needs a 240V supply for testing 110 and 240V appliances. A repeat function lets the user repeat a test function without a continuous input of information. A bar code reading facility allows the user to input serial numbers of test codes by a bar code wand. It can record up to 1000 test results. Seaward Electronic Ltd, 091-586 3511.

## Radiocomms

**Synthesiser.** The VDS100 from Sciteq is a phase-lock-loop synthesiser for use as a crystal replacement source for satellite communications systems. Phase noise is -20dBc/Hz at 1kHz offset and -150dBc/Hz at 300kHz, and spurious -95dBc (100kHz to 1MHz). The unit can be offered for any 15% span in the 50 to 150MHz range. Resolution is about 2.6kHz to provide 125kHz steps after multiplication by 48 to C band. Lyons Instruments Ltd, 0992 467161.

## Transducers and sensors

**Pressure transmitter.** From Control Transducers is the XPRO pressure transmitter for OEM use in refrigeration, process control, flow measurement and liquid level management systems. It has a 4 to 20mA output and an accuracy of 1%. The pressure ranges are from 0-0.4 to 0-3.5bar vented gauge and from 0-6.9 to 0-34.5bar sealed gauge. Control Transducers, 0234 217704.

**Piezo transducers.** The HPE range of piezo transducers from JPR Electronics comprises three compact audible annunciators in three-lead chassis mounting or three-pin PCB version. Each provides a feedback output. They have a self drive capability so they only need one external circuit and a DC power supply of 4.5 to 20V at between 10 and 20mA. Audible outputs at 30cm with a 9V DC input are 75dB at 6.6kHz, 80dB at 4.7kHz and 85dB at 2.8kHz. JPR Electronics, 0582 410055.

**Multi-transducer.** The Yokogawa 2479 power-line multi-transducer from Martron Instruments has the six measuring functions needed for power line testing - voltage, current, power, reactive power, phase, and frequency in a unit measuring 176 x 127 x 95mm. It works on single and three phase systems. Accuracy is said to be 0.5% and frequency range is between 45 and 400Hz. Outputs are 0-5V, 0-1mA and 4-20mA. Martron Instruments Ltd, 0494 459200.

# COMPUTER

## Computer board level products

**PC-AT board.** The PC12/14 is an analogue input board for PC use in industrial or scientific data acquisition, process control and factory automation. It will accept 32 single ended and 16 differential inputs with a common mode voltage range of  $\pm 11V$  to analogue ground. Analogue ranges are selectable from  $\pm 5$  and  $\pm 10V$  bipolar, +5 and +10V unipolar. There are three A-to-D converter options - 200kHz 12bit, 1MHz 12bit and 300kHz 14bit. Datel (UK) Ltd, 0256 469085.

**VMEbus CPU board.** The HK68/V3F 68030-based VMEbus CPU board from Diamond Point can be easily upgraded to a 68040 board. It also uses Heurikon's Corebus architecture which allows movement to Futurebus+ without a major redesign. It works at up to 50MHz and there is the option of a 68881 or 68882 floating point coprocessor. Standard memory support includes 2 or 8Mbyte 70ns dual-access Dram (optional parity), up to 1Mbyte EPROM, and 512byte non-volatile ram. Diamond Point International, 0634 722390.

**AT bus card.** Flash has designed a PC plug-in card to control up to four emulator pods allowing real time emulation and program/data trace for any 8, 16 or 32bit microprocessors via the memory sockets of the target system. By combining Flash emulators with existing third party universal integrated cross assemblers such as ECAL or from MPE, users can set up to two hardware breakpoints and trace program/data flow in real time. Flash Designs Ltd, 0293 551229.

**Tram subassembly.** The IMS B428 Tram subassembly (combining transputers, memory and peripheral devices) from Inmos has a processing power of 25MIPS and 3.5MFLOPS. This credit card sized module has separate address and data buses. It uses the IMS T801 25MHz 32bit transputer with four 20Mbit/s communication links. The Tram integrates 2Mbyte of zero wait state Dram at 80ns cycle time and 50Mbyte/s memory interface bandwidth. Inmos Ltd, 0454 616616.

**DSP board.** The DPV30 dual processor VME board provides a general purpose digital signal processing system for the VMEbus. It has a 66MFLOPS processing engine using two TI TMS320C30 processors. Standard global memory is 128K x 32word Sram but the user can specify either 512K x 32word Sram 1M x 32word Dram or 4M x 32word Dram.

Software support includes Assembler/Linker, C compiler tools, Spox DSP operating system, debug monitors and interface libraries. Applications can be developed in Dos or Unix. Loughborough Sound Images Ltd, 0509 231843.

**PC chipset.** METL has available full design details for UMC's 486 chipset, the UM82C480 for use with Intel's 50MHz 486 processor. The three-chip unit delivers 22.4MIPS with a landmark speed of more than 200MHz. The set has a built in cache controller with write back operation. Up to 256Kbyte of cache is supported with 16 byte line size for the 80486. The built-in maskable cache controller supports burst read for the 486 and hidden refresh to boost system performance. There is up to 64Mbyte of on-board Dram arranged in four banks. Microelectronics Technology, 0844 278781.

**PC instrument card.** A plug-in card and software package from Blue Chip can turn a PC into an intelligent DMM, chart recorder and data logger. The VIP gives 4.5 digit resolution, 0 to 2A AC/DC, 0 to 20M $\Omega$  resistance, 0 to 2 $\mu$ F capacitance and  $\pm 55$ dB functions. It is for quality assurance, automatic testing, data recording and proof testing applications. STC Instrument Services, 0279 641641.

## Computer systems

**Industrial PC.** Burr-Brown has introduced an 80386SX based version of its industrial PC, the VIPc which lets users specify internal circuitry, mechanical form and interfacing options. The core is an 80386SX based PC with a clock speed of 16MHz. It supports VGA and EGA graphics and an optional 80387SX maths coprocessor. An internal bay can accommodate an EMI-shielded card cage for standard boards, custom circuitry, small printer or magnetic card reader. Burr-Brown International Ltd, 0923 33837.

## Computer peripherals

**PC expansion box.** The EXT12 expansion box from Blue Chip adds 11 PC/AT slots to any IBM PC compatible system. Two versions are available which add either 8bit PC slots or 16bit AT slots. It is packed in a steel 19in rack mounting chassis with neoprene seals and a front panel sealed to IP54. Inside is a 150W power supply and fan. Blue Chip Technology, 0244 520222.

**3.5in floppy drive.** The Mitsumi 4Mbyte D352T2 3.5in floppy disc

drive is 1in high and powered from a single 5V supply. It measures 101.6 x 150 x 25.4mm and weighs 410g. The 160 track design has a 135track/in density which, with a disc speed of 300rev/min, provides a data transfer rate of 1000Kbit/s in 4Mbyte mode. Track to track access time is 3ms and average access time is 94ms with a settling time of 15ms. Southern Peripherals, 0256 819221.

## Computer security

**cmos lock IC.** The UA3730 made by UMC is a single chip cmos electronic lock which can accept 12-digit passwords. If an incorrect password is entered an external alarm or security system can be alerted. It has a 60s pulse output and a direct drive 4kHz buzzer output. It works in the 3 to 6V range and consumes 4mA operating or 5 $\mu$ A standby. Microelectronics Technology, 0844 278781.

## Software

**Logic device tool.** A programmable logic device tool, Orcad/PLD release IV, is available from ARS. Improvements over the previous release include integration of PLD into the ESP framework, an open architecture output from PLD, a new compiler with greater capacity, and the ability for tri-stated outputs to be tested as inputs. It supports 32bit signal sets for the compiler and Vectors tool. It runs on any IBM PC, XT, AT, PS/2 or compatible. ARS Microsystems, 0276 685005.

**Digital simulation tool.** The Orcad/VST release 4 is an upgraded version of ARS' digital simulation tool. It is accessible from the ESP desktop. It also benefits from the port of the code to Modula 2. Error handling has been improved including trapping mechanisms. It identifies the device, gate or pin where the problem occurred and is reported when the error message is displayed. Other improvements include better netlisting, increased capacity, browse command and integration with input from the schematic. ARS Microsystems, 0276 685005.

**High level debugger.** The DB30 high level language debugger is for system and processor boards which use TI's TMS320C30. It lets engineers debug digital signal processing applications at either the C source or assembly level. It has a user configurable graphical user interface with data or command input via keyboard or mouse. It allows multiple windows to be opened simultaneously displaying C source, program disassembly, data memory and internal register contents. Loughborough Sound Images Ltd, 0509 231843.

**Editorial survey; use the information card to evaluate this article. Item O.**

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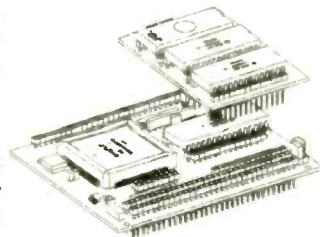
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Marconi/Saunders signal sources types - 6058B - 6070A - 6055B - 6059A - 400 to 18GHz/s. P.O.R.  
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H.P. 8640B opt 001-003 signal generator - .5-512Mc/s AM/FM - £1200.  
Phillips 3217 - 50Mc/s oscilloscope with probes & book - £300.  
Marconi microwave 6600A sweep osc mainframe with 6650 PI - 18-26.5GHz or 6651 PI - 26.5-40GHz -  
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Marconi TF2331 distortion meter - £150.  
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Gould K105 log dc amp with twin disc - £250.  
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Marconi 6700B sweep mainframe - PI 6790A .01-2GHz or 6738A 1.7-4.3GHz or 6766A 8-12.4GHz - £500.  
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Tektronix tracking generator TR502 - TR503 - 10-1800 mc/s P.O.R.  
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# Digital systems set timetable for HDTV

NHK in Japan is now transmitting regular, if limited, 1125-line analogue HDTV broadcasts through its BS-2 direct-to-home satellite. The system uses *muse* digitally-processed bandwidth reduction.

But the number of HDTV receivers is still small, virtually limited to public-viewing sites. Only recently have *muse*-to-NTSC converters become available enabling some viewers with NTSC receivers to view these programmes, though not as HDTV.

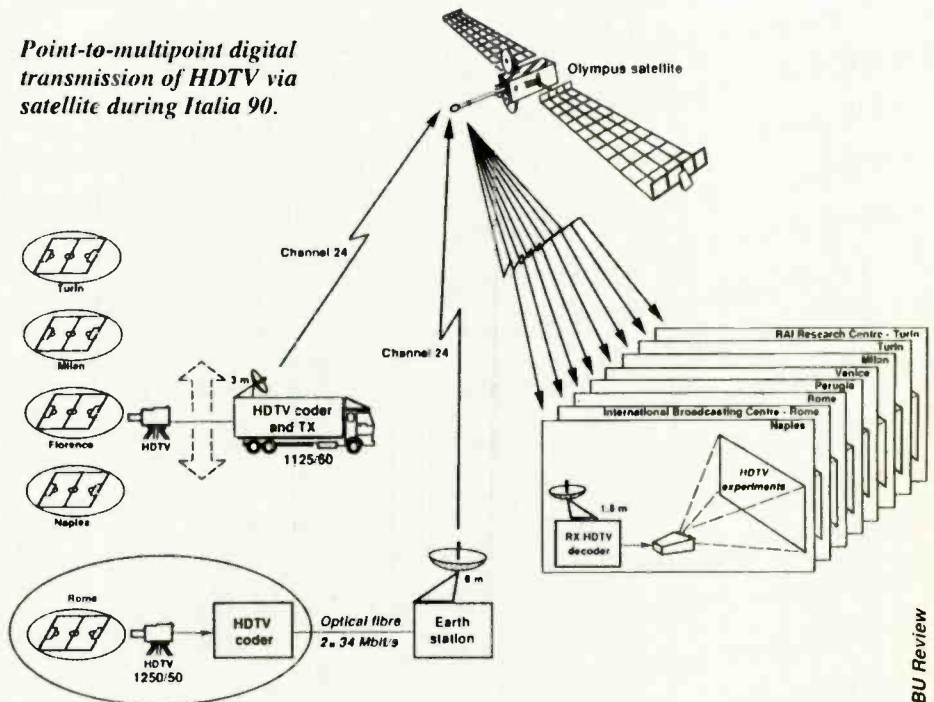
Despite the research effort being put into HDTV in Japan, Europe and North America, there is a growing feeling that HDTV transmission standards are evolving with increasing emphasis on digital rather than analogue transmission to homes.

We have already seen the future of D-mac, based on analogue-components, following on from mac and then wide-screen enhanced-mac thrown into doubt, at least in the UK, by the debacle of BSB. However after ITC persuasion BSKyB will fund part of the NTL continuing research on D-mac for the European EU-95 project.

European broadcasters still hope to register HD-mac as a CCIR HDTV transmission standard, compatible with the mac/packet-family of standards (C-mac, D-mac, D2-mac). But that does not imply that it will come to be widely used for operational HDTV DBS. George Waters, EBU Technical Director, has stated that Europe will probably adopt D-mac as an emission standard, "provided it meets appropriate quality targets".

*Continues over...*

## Point-to-multipoint digital transmission of HDTV via satellite during Italia 90.



## HOME TEAM CHALLENGES...

RAI's HDTV coverage of the World Football Cup included not only HD-mac transmissions but also experimental point-to-multipoint digital HDTV transmission with both 1250/50 and 1125/60 picture origination.

HDTV signals were digitally-encoded at 70Mbit/s and transmitted with QPSE modulation through channel 24 of the high-power Olympus satellite to a number of large-screen projection receivers with digital decoders in eight Italian cities.

Key element was the digital HDTV codec developed for Eureka project EU256 (supported by the governments of Italy and Spain) and built by Telettra SA. This codec is intended primarily for point-to-point transmission at 140Mbit/s contribution circuits but is capable of reducing an HDTV signal from about 1.2Gbit/s to 70Mbit/s, using redundancy-reduction techniques in space and time domains, with error protection. The Olympus satellite can handle 70Mbit/s through its transponders.

## ...GERMANY HITS BACK

A more advanced digital HDTV system than that used for the RAI World Cup project is under development by the German broadcasting R&D centre IRT. This is seen as a means of conveying to some viewers full studio-quality HDTV signals at a bit rate of about 125Mbit/s which with housekeeping, error protection and up to eight channels of musicam-encoded digital sound, can fit into the ISDN 140Mbit/s hierarchy.

Additional forward error correction might be used in the satellite sector at an overall bit-rate of 160Mbit/s. This would require satellite channel spacing of from 50MHz (16-qam), 87.5MHz (C8-PSK) to 100MHz (4-PSE etc).

"Hybrid DCT" (discrete cosine transformation) picture coding has been implemented by IRT in close collaboration with Siemens AG who have provided most of the coder software. The prediction values of a DPCM loop are subjected to DCT with the resulting coefficients coded in Huffman variable-length code. Hybrid DCT uses interfield coding with motion compensation, with the motion vectors transmitted.

The 27MHz channels of the 12GHz DBS band are too narrow to carry 140 or 160Mbit/s signals and IRT is currently contracting a demonstration unit operating in real time with the aim of convincing Warc-92 of

the need for a broadcast satellite service (BSS) frequency band in the region of 20GHz for Region 1 (21.4 to 22GHz is already available in North America (Region 2)).

IRT believes that the results so far of its studies show that a digital HDTV satellite and cable transmission system is technically feasible despite the difficult propagation conditions at 20GHz, but unlikely to be operational until about the year 2005. There is still need to develop such hardware as high-power TWTs for 20GHz satellites and fast Viterbi decoders for DTV receivers.

emission standard, "provided it meets appropriate quality targets". The system was demonstrated during the 1990 Football World Cup and further experimental broadcasts are planned.

Original marketing strategy relied on mac being firmly established as a DBS standard by the time of the first HDTV

broadcast services. Delays in satellite launches, transponder allocations and receiver availability, have meant the assumed timescale has not materialised, undoubtedly affecting momentum and the time when regular HDTV programme services will be available to the public.

In the meantime digital technology will

play an increasingly important role in broadcasting. In the US and Europe all-digital transmission systems for HDTV have been demonstrated and we can surely look ahead to the next century being an age of HDTV cameras, large flat domestic displays, and an all-digital environment from studio to the home.

## Brief-case terminals carry satellite news

Demand for up to the minute news during the Gulf war underlined broadcasting value of "portable" satellite terminals able to send video and sound from remote locations. It also focused attention on recent developments by CBS News to perfect a briefcase-sized go-anywhere system.

Air-transportable TV satellite-news-gathering (SNG) terminals have been used operationally for more than a decade, but they still remain bulky, with terminal and associated equipment often carried in about 20 bulky carrying cases and dependent on local power supplies and access to a satellite.

This led CBS, back in 1986, to start development of a briefcase terminal, complete with antennas, weighing about 14.5kg and capable of delivering good-quality speech and data (and later still-picture facilities) into the public-switched telephone network (PSTN) over satellite channels from most areas of the globe.

A proof-of-concept prototype was ordered from SkyWave Electronics Ltd in 1988 and provided simplex operation.

But subsequent appearance of lightweight duplexers has allowed the terminal to be upgraded to full duplex operation.

Communication is via Inmarsat satellites with portable links (up and down) in the 1.5 to 1.6GHz band and the hub earth-station links using 4 and 6GHz. Teleglobe Canada (signatory to Inmarsat) has submitted the system as a non-standard land-based satellite communications service.

Dimensions of the terminal and case are about 46 by 33 by 11cm. Antennas, two flat patch array microstrip units (gain 17dBi), are fixed to the top lid of the case, which is oriented in azimuth and elevation with a hinge locking device, using the satellite beacon signal as a guide. Antennas are circularly polarised.

Amplitude-companded single-side-

band (ACSSB) modulation is used with a 20W power amplifier, giving an EIRP of some 27dBW in a 5kHz bandwidth of the 25kHz Inmarsat channel (permitting use of two terminals simultaneously through the same channel). Data is transmitted at 2400 bit/s using differential minimum-shift keying. Power is from 110/230V 50/60Hz supplies or from internal 12V nicad batteries.

The hub-station (typically with an 18m dish) can patch the terminal's handset directly into a public telephone system. Once set up, the terminal can receive calls, with a distant operator dialling first the hub terminal's number followed by the briefcase terminal's code.

CBS News are currently developing even smaller and lighter terminals for use with higher-power satellites, including the use of Quixpix (Eastman Kodak Company) for transmission of pictures taken with an electronic still-picture video camera.

## Where low-cost TV stops culture shock

Very small television companies can find great difficulty in financing the making of their own local programmes. Smallest of the ITV regions is Channel Television. Yet serving as it does rather more than 100,000 residents, plus a substantial number of holiday visitors in an affluent society, puts the problems faced by Cook Islands Broadcasting Corporation (population 10,000) firmly in perspective. But Cook Islands too has now found a way to provide its own off-air service, with local origination for at least part of the time

The system adopted, based on low-cost technology, is being attempted in a number of Pacific Island territories supported by a sustaining service provided by Television New Zealand (TVNZ) with live events using satellite delivery.

Such an approach could meet the desire of many Pacific communities to protect and preserve their own cultures and values at a time when reception of international

or domestic US channels threatens their own cultures. The fear is that cultures can change or even disappear as a result of indigenous populations coming to depend on television for information and entertainment.

Jon Blomfield (TVNZ) in *Combroad* describes how TVNZ has devised and put into operation the concept that currently provides assistance and participation in cost-effective services in Nieu (population 2000) and Cook Islands.

He explains that the client-country manages programming and scheduling, exercising full control over what is shown. International programmes are acquired through TVNZ, with news bulletins and some sports programmes transmitted via satellite.

But local production is encouraged — particularly local news, news magazines and current affairs — using low-cost video equipment such as camcorders, S-

VHS tape formats and TVRO receivers derived, at least partly, from the consumer market, and with second-hand professional antennas for the TVROs.

There is also an unconventional solution to transmitter coverage. On Rarotonga (Cook Islands), for example, there are seven low-power, roadside translators around the island at sea level, avoiding "daunting costs" associated with high-altitude site development.

The arrangement allows the Cook Islands Broadcasting Corporation to operate both a local radio station and the TV service with a total staff (radio and TV) of about 15. Islanders can receive a daily local cultural entertainment for TV and a daily local news programme in Cook Island Maori and English.

**Editorial survey: use the information card to evaluate this article. Item P**

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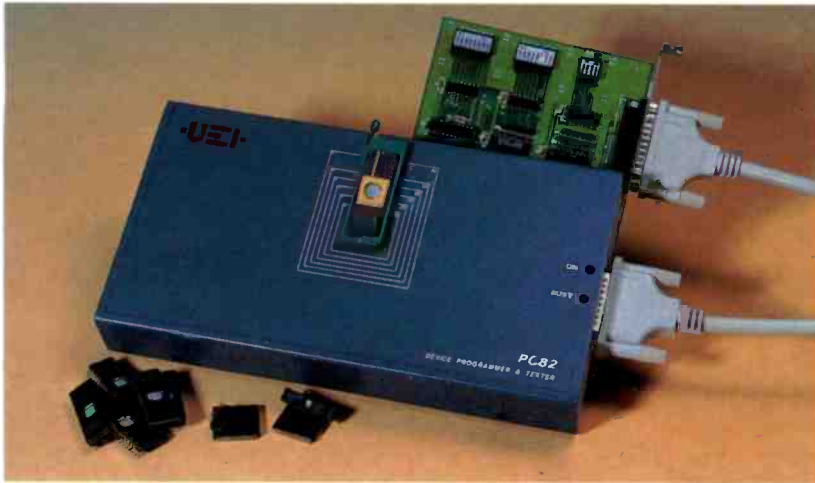
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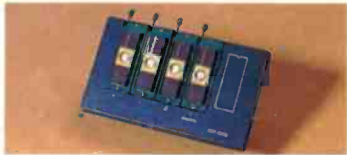
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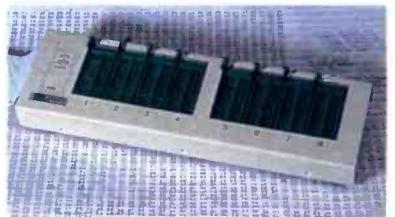
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