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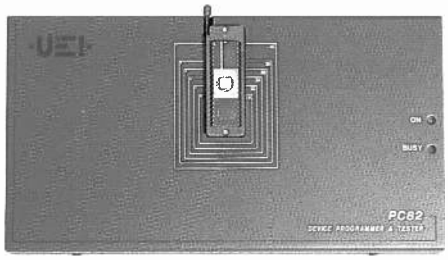

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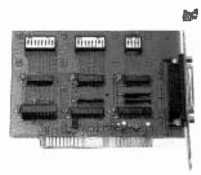

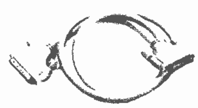

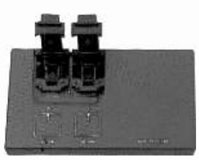

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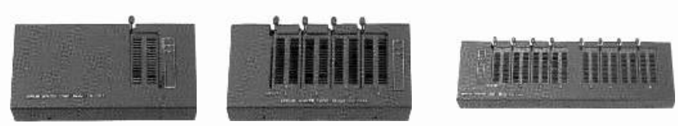

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CONTENTS

FEATURES

REGULARS

In next month's issue: Designing GPS systems. Philip Mattos begins a major new series on the ins and outs of GPS. Using a transputer powered PC card as a design model, he will cover every aspect of hardware and software for the satellite navigation system.

December issue on sale from NOVEMBER 26

Paying for the arts

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Why should the government fund higher educational activities which do not materially add to the nation's actual wealth? Isn't it about time that we applied market laws in such a way as to channel resources to those sectors of education which will eventually support manufacturing industry?

The collapse of the UK currency produced a real concern that this country's economy is, compared to that of France and Germany, very sick. Our politicians (of all parties) look stupid and inadequate, unable to comprehend the overwhelming economic forces. We wonder about our fate, looking with awe at Germany's ability to support both unification and the value of the deutchesmark.

There is an explanation and a solution. Simply put, the Germans make things, real things, widgets that people want to buy. They sell them to us and the rest of the world. If we want a strong economy, we too must make world class widgets and sell them to the Germans and the Japanese.

We kid ourselves if we think that the country can support itself in any other way, for instance by export earnings from our financial services sector. These bankers possess the loyalty and morality of alley cats. They have just ripped off this country for nearly £2bn and they will do the same thing again tomorrow unless we change the basis of our economy.

The UK Government must develop a long term strategy for British industry; this starved and underrated sector provides the only hope of salvation. It must recognise the need for an educated, motivated manufacturing workforce paid the salary which its fundamental position in the economy deserves. It must be the first choice for our brightest graduates, not the last.

Why is it that we price the value of our investment in transport, energy and health while singularly failing to evaluate the returns which public investment receives from education? A Thatcherite style assessment of the education service is long overdue.

Since engineering, science and technology graduates potentially contribute more to the core economy than the arts departments, then public funding should be switched massively to the sciences. Studying of arts subjects should be regarded as a personal luxury which the nation should not be asked to subsidise; a realistic course fee would shorten admission queues, concentrate thinking about the value of many arts courses and release funds for the economically useful science and technology departments. After all, what does the nation receive in return for providing lecturers, buildings and grants for three years to enable a handful of students to study the History of Art?

If people want to study these indulgences so that they can get a job in some creative agency, then that's fine. But they shouldn't presume an arts degree to be a passport to top jobs in the Civil Service and government. And they shouldn't expect the rest of the country to pay for them, especially if it is at the expense of industry.

If you feel as strongly about this as I do, please send a copy of this page to your M.P.

Frank Ogden

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REGULARS

UPDATE

IBM and Motorola produce first PowerPC risc chip

Just a year after announcing their technology tie-up to develop the next generation of desktop PC architecture, IBM has produced the first samples of the PowerPC microprocessor chip at its Burlington, Vermont, facility. The device was made using IBM's 0.6μm cmos process.

The two companies completed the design and first fabrication in just 12 months – a much shorter time than is common in the industry. The 601 processor chip incorporates 2.8 million transistors in a silicon area of $11mm^2$.

The chip includes the Motorola 88110 bus, which supports personal computers, workstations and multiprocessing systems. Products using the 601 are expected to be announced in the next 12-18 months from IBM, Apple Computer, and others, including Groupe Bull and Thomson-CSF, which have stated their attention to develop PowerPC-based systems.

The 601 is the first of four initial PowerPC RISC microprocessors that IBM and Motorola will design, produce and market to the industry. The firms are now developing the designs for the next three PowerPC parts at Somerset, a new facility in Austin, Texas opened in May of this year. The participating companies intend the new architecture to displace Intel's 486 and P5 successors from the world's desktop computers.

Automotive radar

GEC Plessey Semiconductors (GPS) has cracked the technical problems involved in producing radars sufficiently low-cost to allow their use in cars. The subject was presented to the International Microwave Symposium in a conference paper entitled 'Millimetre Wave Radars for Automotive Applications' given by GPS' David Williams.

Wiliams states that in order to get the cost down sufficiently it is necessary to reach a $500 selling price for a 77GHz sensor module with dc/digital interfaces to the vehicle. He concludes: "The radars described in this paper, together with the simple quasi optical antenna system, show that this is now a practical possibility".

Two types of radar are discussed in Wiliams' paper. The first is a linearised FMCW radar which measures range using the swept frequency technique. The frequency sweep must be linear for accurate ranging and the radar makes use of 'frequency feedback' to linearise the transmitter VCO.

The radar presents range information in terms of the intermediate frequency output of the transceiver mixer. A fast fourier transform (FFT) frequency analyser system is used to convert the frequency data to a digital word which is fed to the ICC management computer. The FFT is realised as a CMOS chip.

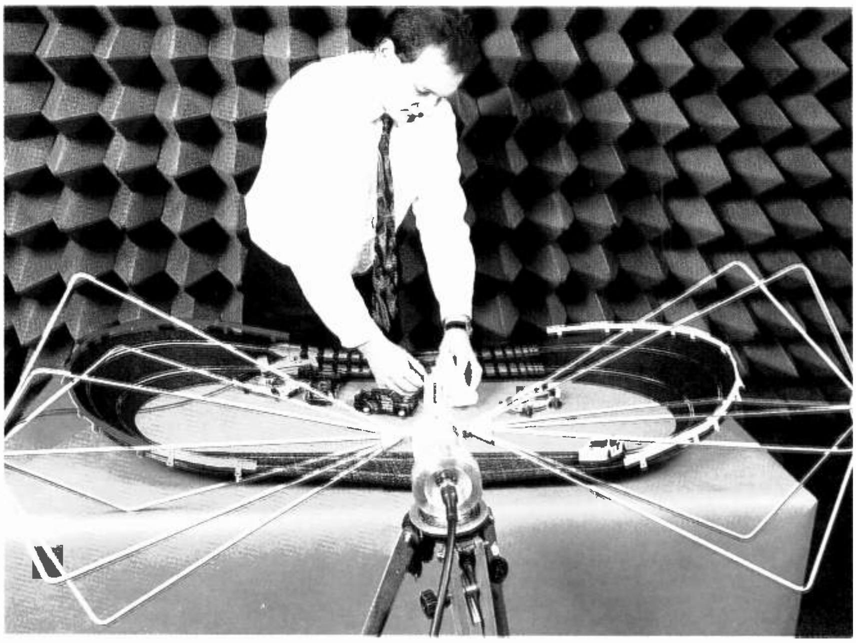
The second type of radar discussed by Williams is a pulse coded radar using pulsed frequency modulation to measure range. The oscillator frequency is pulsed from its rest value to a higher frequency for a very short time (around 20ns). Energy at the pulsed frequency is transmitted and reflected from a target.

This is a very simple type of radar to make and uses few millimetre wave components but is very inefficient since energy transmitted in the interpulse period is wasted. The power transmitted is also very low (about 10mW).

A more sensitive but more complex system uses phase coding. A millimetre wave oscillator is used to drive an upconverter mixer which is fed with a VHF signal that is bi-phase modulated by a pseudo random code generator. The resultant output from the upconverter is therefore also bi-phase modulated. This signal is amplified and fed to the transmit antenna.

Antennae have also to be low-cost and a beam switching antenna has been produced, says Williams, which uses quasi-optical principles. No machined metal parts are required, making the antenna suitable for high volume manufacture.

Racing to obtain EMC approval: Scalextric track and cars are prepared for EMC assessment against EC Directive.



Satellite network plans....

Motorola's decision to redesign its Iridium global pocket telephone network to use fewer satellites could save up to $500m in hardware and launch costs. It is a decision which has been made possible by the development of gallium arsenide microwave component technologies by the company's semiconductor division.

The number of beams and antennae on each satellite has been increased by almost a third, reducing the number of satellites from 77 to 66, orbiting in six low earth orbits.

In addition, Motorola believes it is now possible to conserve spectrum by using the single band of frequencies between 1610MHz and 1616MHz for bidirectional links. No other company has proposed anything like it.

Last year it invested $100m in a new GaAs fabrication plant in Phoenix. This produced its first engineering samples earlier this year. A first range of satellite and microwave transistors were introduced this summer in the 1660MHz frequency band, supporting output powers from 0.5W up to 35W.

As well as discrete MESFETs, Motorola is also designing a number of monolithic microwave integrated circuits (MMICs) using its patented dielectric isolation technology. This supports low capacitance and low insertion loss in low noise amplifiers (LNAs), mixers and oscillators using stripline interconnects and printed inductors.

GaAs is an important technology for new commercial satellite systems such as Iridium and global positioning system (GPS) products. But it is likely to find its first mass market application a lot sooner.

Mobile telephone manufacturers are recognising that GaAs has a power consumption advantage over silicon bipolar technology and high density emitter coupled logic (ECL) gate arrays.

Asic specialist Fujitsu is as close to volume production of GaAs arrays as anyone has ever been. It is now producing 4inch GaAs wafers with up to 30,000 gates from its new $200m plant at Yamanashi.

Fujitsu points out that a 3,000 GaAs gate array running at 600MHz will dissipate a fifth of the power of an equivalent emitter coupled logic (ECL) device.

Motorola believes the gains in radio front-end design will be even more dramatic. The RF power amplifier accounts for the largest power drain in analogue cellular telephones. John Powell of Motorola's RF products group predicts that a switch to GaAs front ends will increase handset battery life by up to 75 per cent.

By the end of the year Motorola will be sampling four 1.8GHz front-end components for the UK's DCS1800 standard and the European digital cordless telephone (DECT). These include an LNA with a gain of 25dB and a 4dB noise figure, and a transmit/receive switch with 20dB of isolation. **Richard Wilson**

Automatic TV tuning

A chip that automatically tunes a TV set, cutting out one of the most labour-intensive parts of TV production, has been developed jointly by Thomson Consumer Electronics of France and Sanyo of Japan. The chip, which sits inside the set, can tune 46 parameters, including brightness, colour and horizontal and vertical synchronisation. Tuning takes place when the set is first switched on. Thomson and Sanyo have already started putting the chip into TV sets although the device will not be available to other TV makers until the middle of next year.

... and NASA goes for GaAs

Vitesse Semiconductor, the Californian GaAs specialist, has first working prototypes of a 15,000 gate array designed for NASA. The GaAs telemetry frame synchroniser will be used in ground based data acquisition systems and will support data capture rates of 300Mbit/s. NASA chose a GaAs chip due to its combination of performance, high level integration and low power consumption compared to ECL alternatives. "The silicon alternatives we evaluated were either too slow or consumed too much power," said Jim Chesney of NASA. The Vitesse H-GaAs process can integrate over one million transistors on a single chip.

Inmarsat considers own GPS service

International satellite operator Inmarsat may be planning its own satellite navigation service to compete with the global positioning system (GPS) service run by the US military.

Inmarsat has yet to make a final decision, but there are plans to include a satellite navigation transponder on a new high power satellite due for launch in 1994.

At the moment, shipping, haulage and railway companies using Inmarsat satellite communications services must rely for high accuracy positioning on the GPS signals provided free of charge by US military satellites.

Satellite navigation is not new but its use is expected to boom as a result of new mass market and aeronautical applications. According to Bob Philips of Inmarsat, customers are uneasy that it is controlled by the US military.

Inmarsat may be forced to offer a free service, but Philips justifies the investment on strategic grounds. Inmarsat may also be planning to offer a new higher accuracy service for aeronautical navigation. Current GPS accuracy of 50m can be improved to under 5m using corrections signals broadcast by Inmarsat.

Richard Wilson, *Electronics Weekly*

The world's first demonstration of an in-flight facsimile service by an in-flight stereotype. BT Research at Martlesham has developed a fax link for use with its Immarsat based Skyphone service.

Superconductors from Du Pont ...

A breakthrough that brings high speed superconducting chips one step closer has been reported by US chemicals giant, Du Pont.

A high temperature thin film superconductor material has been manufactured in a one-step process by Du Pont scientists. This may eventually allow digital circuitry to be built up from layers of superconducting film laid down in a series of sputtering operations, according to Du Pont.

Du Pont researchers made a thallium-based thin film material that was superconductive after it emerged from a sputtering chamber. This is significant because the material did not require the subsequent treatment in a furnace normally needed to turn such a thin-film material into a superconductor.

Du Pont is now planning to use this process to develop a new family of thallium-based compounds that superconduct at about 125K (–148°C) - warm enough to allow components based on such materials to be used in suitably cooled electronic equipment.

Du Pont is currently working with US computer maker Hewlett-Packard and US nuclear weapons researchers at the Los Alamos National Laboratory to develop thin-film superconductors for high speed electronic components that may be used in advanced super-computer applications.

Thallium-based materials superconduct at relatively high temperatures (typically, warmer than -150°C) and are therefore ideal candidates for component applications. The trouble is that thallium evaporates at the kinds of temperatures — up to 850°C - typically needed to process thin-film superconductors which will form the basis of super conducting electronic devices. However, Du Pont researcher, Dean Face, from the firm's Experimental Station in Delaware, managed to grow a superconducting thallium-barium-calcium copper oxide film at relatively low temperatures - between 500 and 600°C — below thallium's boiling point.

Face reported this breakthrough last month at the Applied Superconductivity Conference in the US. The Du Pont research was conducted under a US Air Force research contract in conjunction with the Wright Laboratory at Wright Patterson Air Force Base in Ohio.

...and carbon from NEC

Japanese electronics giant NEC says it has developed a new manufacturing technique to produce a rare form of carbon which could lead to novel electronic products.

NEC has discovered a way of improving the yields of carbon nanotubes – a form of carbon in which carbon atoms are arranged in concentric sheets of hexagons organised in a helical pattern.

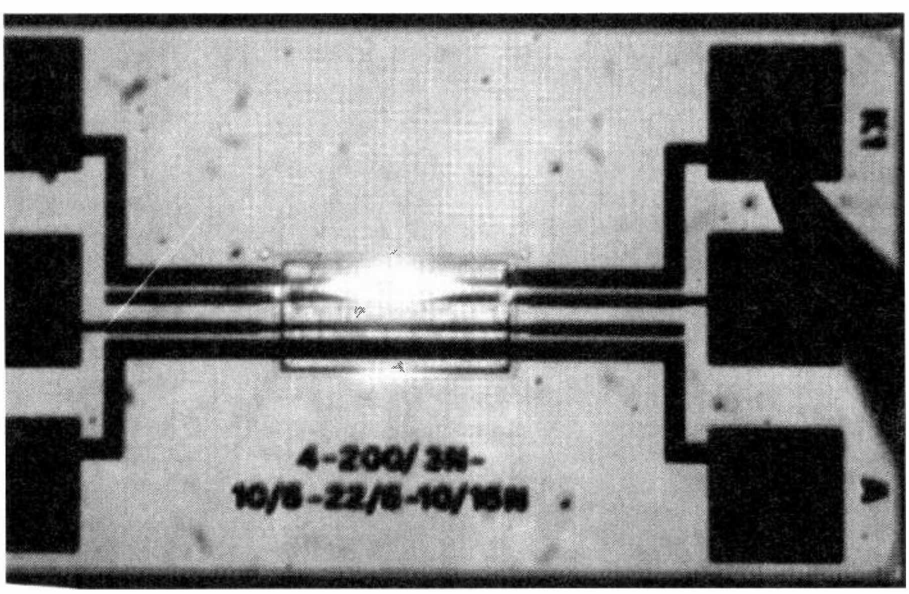
These structures are microscopic but they are as strong as diamonds combined with properties associated with graphite sheets. Researchers say that carbon nanotubes also have interesting electrical conduction properties.

They could become the basis for new types of semiconductors once their properties are better understood and production yields are improved.

NEC is making carbon nanotubes by allowing an arc of electricity to pass between two carbon electrodes in an atmosphere of inert gases at one atmosphere of pressure. NEC says the yield is thirty times that of the standard production method.

The next stage is to develop techniques that will allow control over the size of the carbon nanotubes, whose properties vary according to their dimensions.

Integrated silicon light bulb: Researchers from the University of California at Berkeley have produced a microscopic hot filament light bulb on a silicon chip using standard IC production techniques. These devices use heated filaments made of tungsten wire 0.7μm thick, 5μm wide and 200μm long. They produce up to 0.3 lumens of light visible at over 15 feet. Each filament requires between 50 to 100mW of input power. This picture, taken with a scanning electron microscope, shows an actual working hot filament chip.



Micron in flat panel success

Micron Technology, the dram company from Idaho, believes it has demonstrated the feasibility of a proprietary flat panel display technology which it calls field emitter display (fed).

According to Micron vice president Kipp Bedard, the company's fed technology has five advantages over other flat panel technologies: superior drive circuitry; lower power consumption; wider angle of view; higher brightness and wider temperature range.

Bedard said the company did not need to build a factory for the fed display because the product can be manufactured alongside its dram and sram lines.

At the moment, said Bedard, the largest panel the company can make is three by five inches "because that's the largest size that will fit on the wafers we currently produce". However that does not rule out producing larger panels. There are people who can supply 14in diameter wafers," said Bedard, "or we could get to larger panels by using several wafers per panel. "

For the time being, Micron expects the biggest market demand to be for one inch square flat panels which it can make on Its current semiconductor production lines.

Recently Micron set up an R&D subsidiary company called Micron Display Technology Inc devoted to flat panel technology. "We're still pursuing different technology options," said Bedard.

David Manners, *Electronics Weekly*

REGULARS

RESEARCH NOTES

Jupiter's aurora is cloud of uncertainty

Scientists are still undecided about the nature of Jupiter's aurora. This is despite the wealth of information obtained following the imaging by the Hubble space telescope of the aurora surrounding its North Pole.

The exposure, made with the faint object camera aboard the telescope earlier this year, must surely make the efforts of the royal press corps pale into insignificance: it was taken at a distance of 673 million km from the Earth.

Measurements of Jupiter's aurora have been made by various passing spacecraft, but this is the first time that atmospheric phenomena, other than the massive Great Red Spot, have been observed and monitored regularly from the vicinity of Earth.

The image was recorded in the far ultra-violet part of the spectrum to isolate the aurora which radiates at the Lyman-alpha line of atomic hydrogen – a technique that considerably enhances the visibility of the aurora against the optically bright background of the planet's surface.

The relative faintness of the aurora combined with the loss of sharpness due to the spherical aberration of the telescope mirror made it necessary to group pixels together (28 x 14 pixels) to improve the image quality. The emission zone appears as a patchy, non-homogeneous region, extending around the magnetic pole.

Although bright in the UV part of the spectrum, Jovian aurorae are not visible optically because there none of the ionised gases that colour up the earthly aurorae are present – but the mechanism is similar. It is thought that charged particles move along the planet's very strong magnetic field lines and interact with the hydrogen atmosphere, producing the UV radiation.

The precise origin of the charged particles is still the subject of considerable debate, some scientists believing that they originate from the solar wind outside the Jovian magnetosphere. Others think that they result from particle diffusion along the field lines crossing the plasma torus surrounding Jupiter near the orbit of the moon Io. The latest observations seem to favour the first explanation.

Is there anyone there?

About now, Nasa is due to start up its "Project Columbus", a search for extra-terrestrial intelligence expected to last ten years. It will involve two separate approaches: a high-sensitivity targeted search for signals from 800 solar-type stars – presumed likely sources of signals – and a less detailed all-sky survey conducted at lower sensitivity.

The possibility that intelligent life might exist somewhere (else) in the Universe has long fascinated scientists, philosophers, poets and theologians, but so far there has been no unequivocal evidence for its existence. Unless, that is, you believe in flying saucers.

But most serious ET watchers are convinced that Alpha Centaureans, if there are any, will adopt a more energy-efficient approach and try to communicate using radio. "Credit the aliens with some intelligence" says Professor David Blair, a radioastronomer from the University of Western Australia.

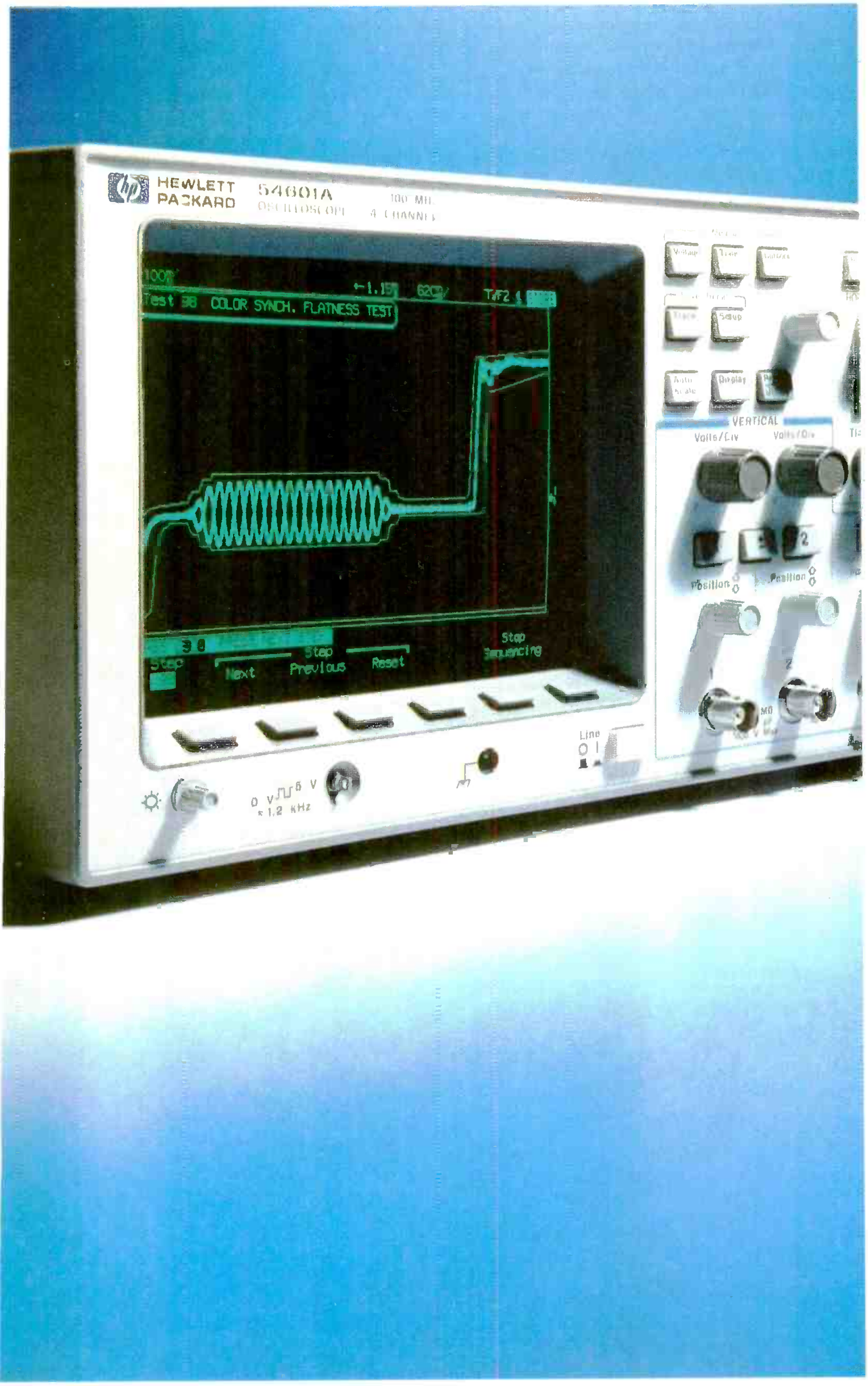
Radio searches of the sky have been going on in fits and starts ever since the 1960s when Frank Drake conducted the first formal search-for-extra-intelligence experiment at Greenbank in West Virginia. Then in 1970 Nasa started studies to establish the parameters that are now being used with Project Columbus.

The plan now is to scan more than ten million different radio frequencies in the range 1-3GHz. Specialised computer techniques will be used to distinguish between natural signals and those of artificial origin. Obvious points of distinction will be the source of whatever is received. Any signals of terrestrial origin or which are not fixed in space will be ignored. The receivers used in this project will include the Arecibo telescope in Puerto Rico and the Goldstone dish of Nasa's deep space network in California.

"EXTRA TERRESTRIAL INTELLIGENCE? – 'SOUNDS MORE LIKE AN ALIEN VERSION OF ELDORADO!"

Nasa scientist John Rummel says the team is convinced it can do good science and that the equipment will be able to give a definitive yes/no answer on whether there is any signal of interest within the bands and sky areas being covered. The biggest

Within budget. Without compromise.



The value of this 100 MHz digital scope is easy to see.

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No. of channels	2 or 4
Bandwidth	100 MHz
Timebase accuracy	±0.01%
Vertical accuracy	±1.5%

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HEWLETT PACKARD

*As at 1 September 1992

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problem, he says, is the question mark over funding because of what Nasa describes as the "snigger factor". It is difficult, says Rummel, for Congress to figure that anyone out there might be intelligent...

Meanwhile, down under, Professor Blair and his Australian group have been adopting a different strategy. Instead of using what they describe as Nasa's "sledgehammer approach", Blair and his colleagues are using the 64m Parkes dish in New South Wales to search a different band of frequencies, 3-10GHz, in a more selective way. They too have been looking at Sun-like stars in our own galaxy, but only on a number of special frequencies, plus or minus expected Doppler shifts.

Blair, in line with his hypothesis that any aliens out there are probably fairly intelligent, concludes that they would select what he describes as an "interstellar communication channel", or ICC. These ICCs are mathematical combinations of natural frequencies and universal constants. The most likely sign of intelligence, thinks Blair, would be to transmit on a frequency of *pi* multiplied by the natural hydrogen spectral line on 1.42 GHz. Finding someone transmitting on this frequency (4.462336275 GHz) would be what Blair calls a "signature of civilisation". He proposes to check out ten to twenty of these special frequencies.

Although it may be that none of the currently-proposed search experiments yields positive results, that thought doesn't really trouble the investigators. What the studies will do is test a number of hypotheses about life in space, the most basic of which is the assumption that life will evolve anywhere where conditions are suitable. If no contact is established over prolonged and detailed searches, this assumption – or at least some of the statistics on which it is based – may need radical revision.

Supercomputer key to cancer cure?

Using a Cray Y-MP machine at the North Carolina Supercomputing Center, Scott Clegg of the Duke University Medical Center is building what he believes is the most complete model yet of how microwave energy heats up the incredibly complex structure a cancer tumour and its surrounding tissue. It's all part of an attempt to exploit the fact that tumours tend to be more susceptible than normal body tissues to the destructive effects of overheating or hyperthermia.

At present, hyperthermia using microwave energy is seen as a promising form of cancer treatment, but at the present stage of

Running rings around superconductors

Los Alamos National Laboratory researchers report that a new engineering design for high-temperature superconducting wire results in a stronger, simpler wire that conducts electricity more reliably than other designs under investigation.

High-temperature superconductors carry electric current without any resistance, or loss of energy, when cooled with liquid nitrogen to 77K. Since their discovery in the late 1980s, researchers have sought ways of producing wires or tapes from this brittle ceramic material, for use in energy transmission and storage.

Dean Peterson of Los Alamos' Superconductivity Technology Centre and his colleagues have invented a "tube-within-a-tube" design that sandwiches a bismuth-based superconducting compound between concentric silver tubes. After depositing a layer of superconducting onto a silver tube's outer surface, another tube of slightly greater diameter is slid over the bismuth layer. The three-layered structure is then drawn and heated causing the powder and the silver to bond into a single tubular structure.

The "tube-within-a-tube" design is a sharp departure from previous experiments to produce lengths of superconducting wire using the so-called "powder-in-a-tube" method. In this approach, researchers pack a silver tube with superconducting powder, then draw it down and heat it until the material bonds into a single thread.

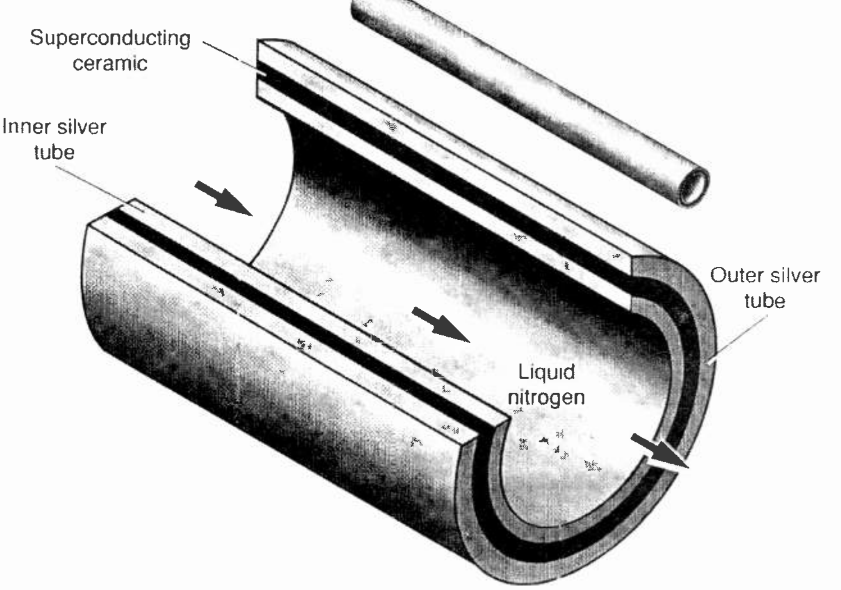
The new tubular structure is stronger mechanically, capable of conducting electricity even if the ceramic superconductor partially cracks, and potentially able to carry a heavier current.

The design also retains a hollow core which allows liquid nitrogen to be run down the middle to cool it. The researchers preserve the hollow core by filling the inside silver tube with lead and melting it off at the end of the fabrication process.

The team plans to enhance the current-carrying capacity of the new design by adding more layers of ceramic and more silver tubes. By increasing the wire's diameter one layer at a time – in the same way as growing trees add tree rings – the total surface area of superconducting material is increased, allowing the wire to carry more current. High-temperature superconducting materials have additional applications in medicine and transportation. Magnetic resonance imaging, a diagnostic tool, and the magnetic levitation used by high-speed trains, currently use superconducting materials cooled to near absolute zero by liquid helium. Since liquid nitrogen is cheaper and more abundant than liquid helium, the "tube-within-a-tube" concept could make high-temperature superconducting materials a practical and more economic alternative for both of these applications, Peterson says.

The Los Alamos researchers have filed for a patent on the design and plan to offer the invention for commercial development with an industry partner.

Los Alamos researchers have found that sandwiching a bismuth-based superconductor between two silver tubes produces a stronger



Computer models constructed by Scott T Clegg, assistant professor of radiation oncology and biomedical engineering, and his colleagues at Duke University will predict how microwave energy is deposited in tumours and surrounding tissues.

development it's as much an art as a science. Doctors have to rely on skill and judgement to select the right amount of energy and the right direction in which to beam it. Their precarious task is to raise the tumour's temperature enough to kill the diseased tissue without at the same time damaging normal tissue just a few millimetres away. It's a task which is complicated by the huge variability in size, shape, density and composition of tumours. Nor is it helped by the fact that tumours have highly variable water content, highly variable blood flow, and hence highly variable thermal properties.

Clegg and his colleagues have set about constructing computer models to predict how microwave energy is deposited in tumours and surrounding tissues. From "power deposition" calculations it's possible to work out how effectively microwave energy is distributed throughout a tumour and how this is offset by the tumour's ability to conduct heat away. Further calculations can then yield a "temperature map" of the entire tumour and surrounding tissues.

Clegg's model is based on finite element analysis in which the computer divides the tumour and its surroundings into a three-dimensional grid. Details for constructing this grid would be obtained from a patient by means of magnetic resonance imaging (MRI) or computerised tomography (CT) scans.

So far the system has only been tested on dogs whose tumours are being treated with hyperthermia. These animals have very thin thermocouples inserted into their cancers to check out the predicted temperature rise. What the North Carolina group have found is that the temperatures actually measured during microwave treatment are very close – within one degree Celsius – to the predictions of the computer model.

Eventually Clegg hopes that doctors will be able to use an advanced version of the model to plan treatment strategies for human patients. That will require better knowledge of the properties of human tumours, as well as the development of more powerful algorithms.

Meanwhile researchers at various other US universities are doing thermal modelling using ultrasound and different frequencies of electromagnetic energy as the power source. It's extremely complex work and the amount of computer power need to model heterogeneous tissue in three dimensions is massive. But, given the current advances in computer power, Clegg expects computerised hyperthermia to become a routine clinical practice in the not-too-distant future. ■

Battery that fits inside a blood cell

Chemists at the University of California, Irvine, have constructed a battery measuring only 70 nanometres along its largest dimension, one-hundredth the diameter of a red blood cell. It contains fewer than 500,000 atoms.

Reporting in the *Journal of Physical Chemistry*, Reginald Penner, assistant professor of chemistry, and his co-researchers describe a "nanometre-scale galvanic cell" consisting of tiny pillars of copper and silver deposited on a graphite surface using a scanning tunnelling microscope (STM).

When the surface containing the tiny metal structures is immersed in a dilute copper sulphate solution, atoms from the copper pillar spontaneously dissolve and copper ions plate onto the surface of the silver pillar, generating 20mV for 45 minutes. By comparison, a typical biological cell in the human body requires about 60mV to drive its metabolic processes.

Penner says the key to creating the battery using the STM was the ability to deposit atoms directly onto a desired site. Previous attempts had been foiled by metal atoms migrating to defects elsewhere on the surface. By adjusting the voltage of the STM, Penner essentially created his own defect, a tiny pit at the desired site, where atoms of metal accumulated and formed a pillar.

Other than its incredibly small size, the most remarkable property of the battery is that it works at all. A normal copper/silver battery operates in a solution of silver ions, not copper, and silver ions from the solution deposit onto the silver terminal at the expense of copper atoms dissolving from the copper terminal.

The force driving the nanometre battery appears to be an esoteric electrochemical phenomenon known as underpotential deposition (UPD). Electrons in the two metals have a slightly different work function. This difference drives copper ions to deposit on the silver terminal until the silver is coated with a layer of copper only two atoms thick, a process that takes 45 minutes. Once the silver terminal is coated with about 80,000 atoms of copper, the battery stops working.

To test the theory that UPD was driving the nanobattery, the scientists created a macroscopic version using copper and silver wires in a beaker of copper plating solution. Indeed, sensitive spectrometric measurements revealed that a two-atom thick layer of copper formed on the silver wire before UPD stopped.

Although the battery's life is limited, Penner says the device could conceivably be recharged by applying a positive voltage to the graphite surface and driving the copper coating off the silver terminal.

As a power source, the battery currently lacks any immediate application but in principle the constructional methods could be adapted to produce other types of nano-electronics, such as diodes and transistors made of a few hundred thousand atoms.

Penner envisages the first important applications to be in studies of corrosion, itself an electrochemical reaction. For example, a piece of rusting iron can be thought of as a very low-power oxygen/iron battery.

Very little is understood about corrosion at the atomic level and this technique makes it possible to look directly at what occurs during corrosion and to measure its rate and changes in the surface structure, all in real time.

Research Notes is written by John Wilson of the BBC World Service

GREG BECKER

Opening the gates to DIY LSI

Anyone undertaking serious electronic systems design must possess a working knowledge of programmable logic, just as they needed to know about TTL two decades ago. This series of three articles by Dave Nicklin* and Nick Sawyer* will cover its use and applications in electronic systems with emphasis on high density devices such as the FPGA and the complex EPLD families.

1: introducing programmable logic

Programmable devices have become the fastest growing segment of the entire semiconductor industry. It is now rare to find a designer who does not use programmable logic in one form or another. It is interesting to note that the ubiquitous microprocessor is just another form of programmable gate, but that is another story...

By the middle of the 1970s, TTL logic in its various forms (standard, Schottky, low-power Schottky, etc.) had become the de facto way to design electronic systems. A large range of MSI devices had been developed to try and meet the changing markets, and virtually all electronics systems were designed using them. However, discrete logic design using TTL had a number of shortcomings. Engineers didn't like the amount of work needed to modify designs: even a simple circuit change could mean another printed circuit board design or at the very least a number of cut-and-straps. It thus became a common practice to design with possible future modifications in mind. Circuit boards were designed to accommodate extra devices, and extra gates were deliberately left free for use if needed. Management accepted the need for this practice, but didn't like these hidden costs, nor the longer design cycle time. Buyers, trying to control their stock levels, didn't like the increasing range of devices specified by the design departments.

*Xilinx UK

Proms

At this stage proms were being used mainly in the computer industry to store micro-programs and look-up tables, though some creative designers had already started using proms in their general logic design. Although they were highly inefficient in terms of silicon usage, proms gave the designer the ability to write on silicon for the first time. In a matter of minutes people were able to program the prom to perform a Boolean transfer function. As an example a 16x8 device, which was common at the time, could be programmed to generate up to eight outputs, each of which was a function (any logic function) of the four inputs. It now became much easier to modify a design to correct or change that function. Proms were particularly useful for state-machine encoding. They allowed the designer to program the state tables directly without the need to perform the device count minimisation phase, something designers using TTL still needed to do.

There were, however, two main weaknesses: the devices were expensive and the fixed AND structure was too inflexible for efficient use of the silicon. The solution developed came in two flavours: the PLA (programmable logic array) and the pal (programmable array logic).

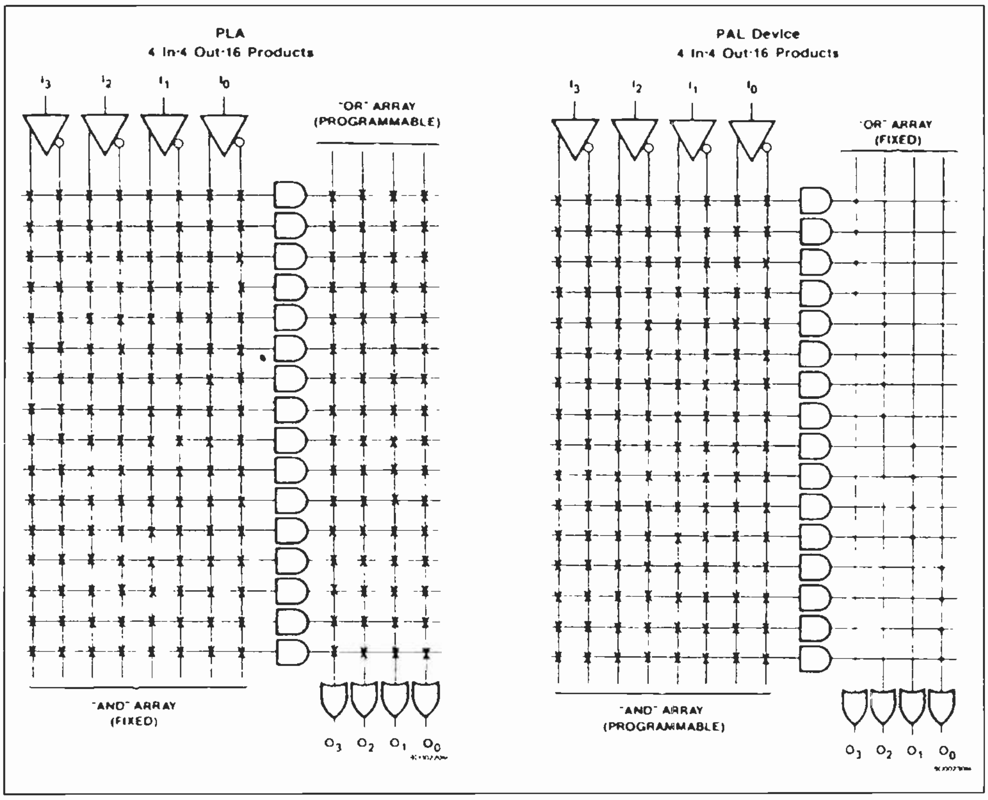


Fig. 1. Comparing PLA and PAL structures. The PLA is a PLD with two programmable arrays: an AND array and an OR array. Unlike PAL devices, the output OR array in a PLA is fully programmable.

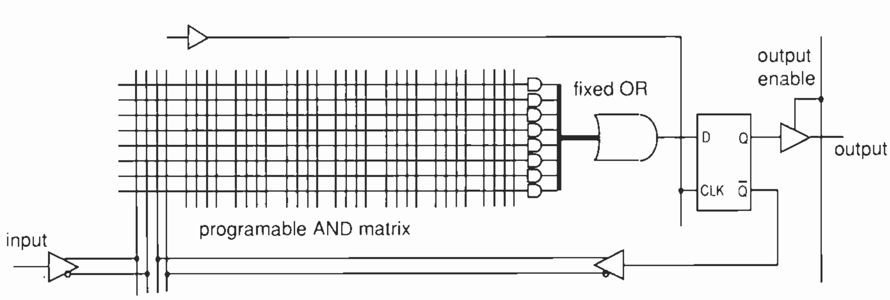


Fig. 2. One section (of eight identical ones) of a 16R8 state machine PAL device. It has 16 inputs, eight registered outputs with feedback available to the AND array structure.

The PLA

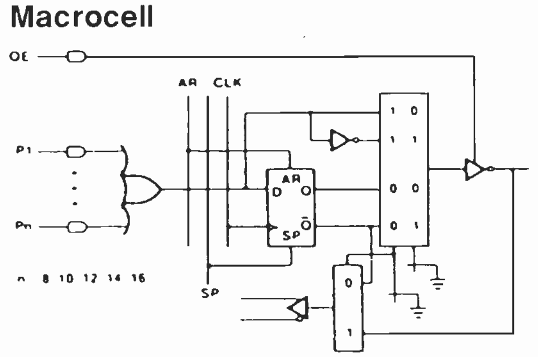
The PLA contains a programmable AND array (product terms) followed by a programmable OR array (sum terms). To put this another way, the designer could generate a number of intermediate product terms from some or all of the true/complement signals available from the inputs. He could then add any or all of these terms together in the OR array. Such an architecture was extremely flexible and also less expensive than a prom when performing a similar function. However, the presence of the programmable OR array made it larger in terms of die size, i.e. more expensive, and also lower in speed than the other alternative, the pal.

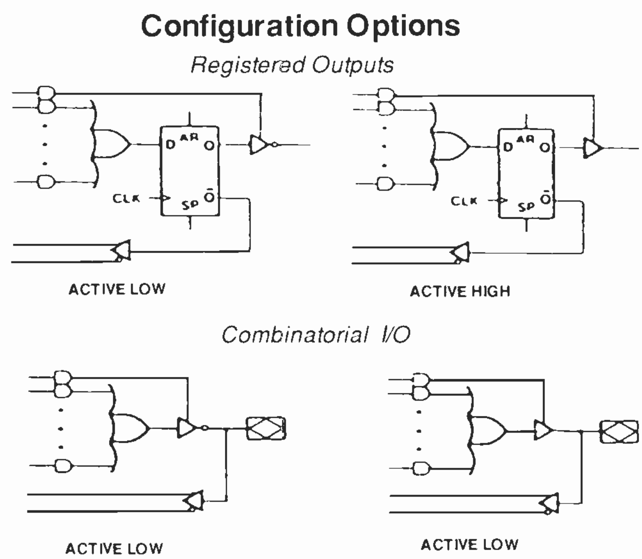
The PAL

The pal architecture was invented by Monolithic Memories and has proved over the years to be the most popular of the available small PLD architectures. The pal has a fixed, i.e. pre-defined OR (sum) structure and a programmable AND (product) structure. This meant that it had the same benefits as the PLA over the restrictive AND structure of the prom, but was slightly less flexible than the PLA in terms of its output structure. The fact that the OR array was fixed made the devices smaller (and therefore less expensive), and faster than the other PLD architectures. Designers found that the cost and speed benefits usually outweighed the slight loss of flexibility. A comparison of the basic PLA and the basic pal showing these differences is shown in **Fig. 1**.

The pal architecture began as a straight AND-OR structure, with products such as the *12L10* and *16L6*. Each available output (the second number, e.g. 10 or 6) was a straight sum-of-products of the available inputs (the first number, e.g. 12 or 16) and no more. Incidentally the *L* in the part number means that the outputs were active-low, and *H* would indicate active-high. Designers, however, began to ask for (and indeed require) more features, such as registers and it was not long before the basic pal structure was enhanced to incorporate them Perhaps the best known of these newer

Fig. 3. The 22V10 from AMD used a much more sophisticated I/O arrangement. The output structure of OR gate plus register could also act as an input increasing dramatically the versatility of the device.





Simple pal design

This design example is intended to illustrate the uses to which pals were (and indeed still are) put in the embedded controller world. The design (a buffered serial protocol converter) would have been typical seven or eight years ago, and at the time would have demonstrated a reasonable level of system integration and performance. The circuit shown) consists of a *Z80* running at 6MHz together with an 8kbyte eprom, 48k dram, and a serial communication controller. The 'glue' logic is provided by a *16V8* device from Lattice.

Consider the equations we need to generate to produce the required function:

1. The Eprom decode line ROM_CS is required to be active low for addresses in the range of 0000 to 1FFFH. This is easily achieved by just decoding the address lines (all low), and ensuring that MREQ is low, IORQ and RFSH are high, i.e. :

/ROM_CS = /A15 * /A14 * /A13 * /MREQ * IORQ * RFSH

2. The RAM_CS signals are used as the RAS (row address strobe) line for the three banks of dynamic rams are required to be active low for all memory addresses in the range of 4000H to 7FFFH (bank 1), 8000H to BFFFH (bank 2) and C000H to FFFFH (bank 3). The decodes are performed exactly as above, but with different address combinations.

In addition dynamic ram needs periodic refreshing to retain the memory contents. This is done by addressing each of the 128 rows in the device at least once every two milliseconds. The *Z80* is well suited to this, as it automatically generates a 7-bit refresh address at the end of each op-code. This situation is identified by MREQ and RFSH low together, and this decode is ORed in with the address decode. The CS_RAM lines will therefore become active so that the rams will be refreshed.

/RAM_CS1 = /A15 * A14 * /A13 * /MREQ * IORQ * RFSH
+ /A15 * A14 * A13 * /MREQ * IORQ * RFSH
+ /RFSH * /MREQ

/RAM_CS2 = A15 * /A14 * /A13 * /MREQ * IORQ * RFSH
+ A15 * /A14 * A13 * /MREQ * IORQ * RFSH
+ /RFSH * /MREQ

/RAM_CS3 = A15 * A14 * /A13 * /MREQ * IORQ * RFSH
+ A15 * A14 * A13 * /MREQ * IORQ * RFSH
+ /RFSH * /MREQ

3. The SCC is chip selected for any input/output access as it is the only peripheral in the system. If there were more then some address decoding could be performed as well. The decode is therefore active when MREQ and RFSH are high, and IORQ is low:

/SCC_CS = MREQ * M1 * /IORQ * RFSH

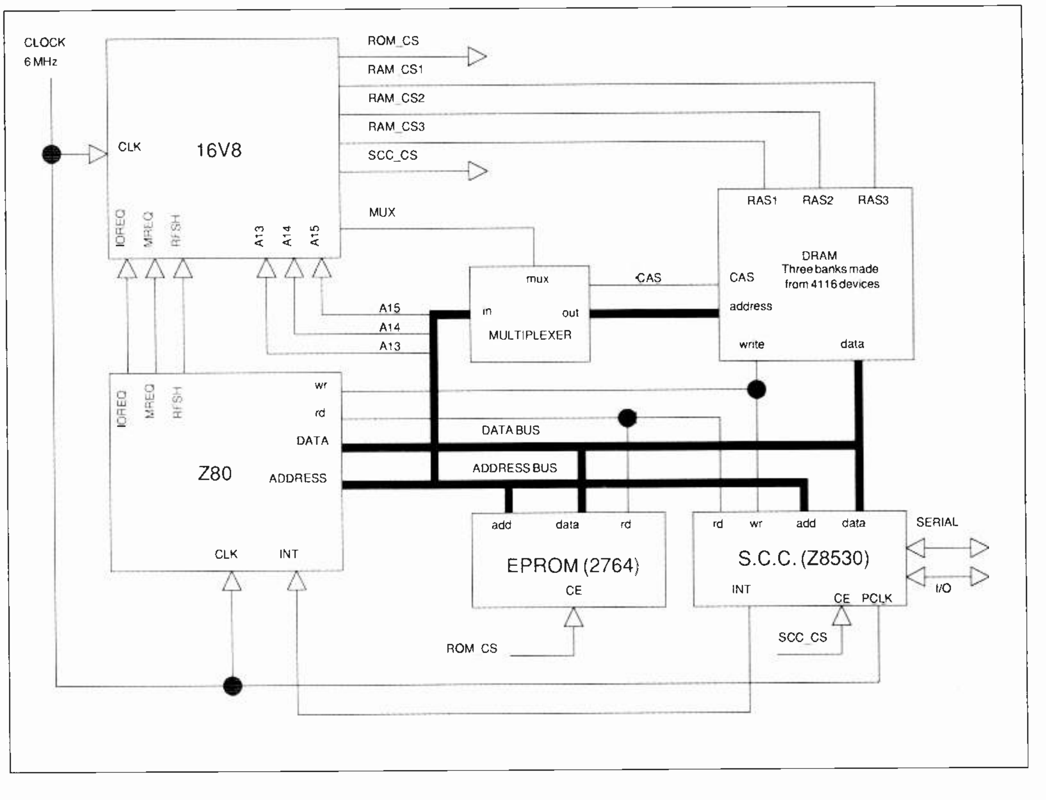
4. The signal to control the multiplexers is slightly more complicated in that the *Z80* has two different sets of memory timings. The one in use depends on whether it is reading the first op-code in a sequence or not. We need to use a registered output and a couple of tricks here! The registered output is used to produce a signal that is only used internally called DUMMY, which is just MREQ inverted and registered.

The real MUX signal generated uses DUMMY, MREQ and RFSH to select the second set of eight addresses that the dynamic rams require, and in doing so also causes an active low CAS signal to be generated, by switching a mux whose inputs are just 1 and 0.

DUMMY := /MREQ (note the use of := to indicate a registered function)
MUX = DUMMY * /MREQ * RFSH

The *16V8* was chosen for the function, as only one registered signal is required, the rest are purely combinatorial, and the output macrocells are therefore programmed appropriately. The programmable device replaces a handful of MSI devices, but there is still the drawback that the interrupt acknowledge mechanism of the SCC is not handled in logic. Software polling is therefore used, and this slows down the system somewhat. Next month we will look at the improvements that were realised with the advent of the FPGA.

Design example of an embedded controller based on the Z80 chip. It illustrates the role of programmable logic and the derivation of the equations used to program the logic.



parts was the *16R8* pal structure (**Fig. 2**). It had 16 inputs, eight registered outputs, and each of the flip-flop outputs was fed back into the AND array structure. For the first time designers could implement a complex state-machine design on a single (programmable) chip, without the expense of designing a gate-array. This architecture and its numerous variants became immensely popular, and continued to replace discrete TTL solutions.

The cost of designing with pal followed the classic cost-reduction curve as the devices and their programmers became cheaper, and more importantly higher board densities were achieved. Designers had to become familiar with the textual form of design entry, followed by software processing, and found it more productive to design for pal architectures in this way. Thus, the growth and acceptance of the pal relied both on the pal architecture itself and the ease of design via textual entry tools. This two pronged concept of architecture and matched development tools set the scene for future generations of logic.

The next notable development was that of the hugely successful *22V10* device, invented by Advanced Micro Devices. This was more flexible in use due to further architecture enhancements, such as a varying number of product terms (eight to 16) for each output, and a programmable input/output or macro-cell structure (**Fig. 3**). The programmable macro-cell meant that each 'output' instead of having a fixed structure, was individually configurable as either an output, an input, a registered output with feedback, etc. This feature made the *22V10* the most generic of logic devices so far, and many companies started using them as their standard device for electronic design.

The alternatives to PLDs

Despite their flexibility and ease of use, PLDs have two main weaknesses which stopped them from competing effectively with the other types of custom logic design, namely gate-arrays, standard cell and full-custom. Firstly, they consumed a lot more power since they relied on a bipolar fuse link technology. Secondly, they could only replace a handful of TTL MSI devices, whereas a gate-array could replace hundreds. Small cmos pals utilising eprom technology were developed to reduce power consumption, as were the gals (generic array logic) developed by Lattice Semiconductor which utilise a cmos eeprom process. However, they still consumed more power than an equivalent gate-array and were still lower in density.

The main problem for designs using gate-arrays, standard cell and full-custom was that they only became economic as the number of pieces involved increased. They were also much harder to design, sometimes had a large overhead for the necessary test logic, and also required large capital outlay, both for software tools, and for mask charges. However attempts to increase integration in the user-programmable market, using bipolar devices with multiple pals on one piece of silicon, had proved less than successful.

The market was most recently addressed by EPLDs and FPGAs. The EPLDs relied on the development of high density cmos eprom technology, whereas the FPGA initially relied on the application of cmos sram technology.

Erasable Programmable Logic Devices (EPLDs)

It was the mid-1980s before cmos eprom technology had been developed to the extent where it could be applied to the logic market. Instead of bipolar fuse links blown permanently to break a connection, the eprom relies on an electrical charge to turn off a transistor. A new company called Altera, developed the *EP* range of devices using this technology. The smaller devices in the family are very similar to PALs and are used to replace them, mainly to reduce power consumption. The

Why sum-of-products ?

The sum-of-products method of defining logic is virtually universal for two main reasons. First, any possible function of *n* logic variables can be expressed in this form, and second it is easy to understand. This is one of the reasons that the programmable AND, fixed OR, i.e. sum-of-products structure of the pal was developed.

Consider the verbal expression *I want an output when A is high and B is high or when C is high and D is high.* This reduces to the simple expression X = A*B + C*D, which can be directly implemented in a pal without further manipulation, either by the designer or the software.

Real life is not so simple, and graphical methods have been developed to help with the data entry process. The most popular of these is the Karnaugh map, which is especially useful for expressions with a small number of input variables. Using this method, a matrix with a space for each possible input combination is filled in by the designer. The entry in each box can be a '1', i.e. an output required, a '0', i.e. no output required, or an 'X', i.e. a don't care situation. Groups of common output states are then selected, and the resulting equations are the sum-of-products expression of the logic function required.

An example which has three input variables (A, B, C) and an output Y might be:

A – Am I interested in this article ?
B – Does the lawn need mowing ?
C – Is it raining ?
Y (an output) – I should carry on reading.
Drawing the truth table, we might get :

A	B	C	Y	
0	0	0	0	Find something better to do
0	0	1	1	Well if it's raining...
0	1	0	0	May as well mow the lawn
0	1	1	0	Go sailing
1	0	0	1	No rain – read it in the garden
1	0	1	1	or read it indoors
1	1	0	0	Mow the lawn later
1	1	1	1	Who cares about the lawn anyway?

The completed Karnaugh Map will then look something like **Fig. 4** (we hope!)

Now we can 'associate' common output values. This is done by the grouping of common values as shown, and then reading off the product terms that are formed, and adding them together. To do this, we look at the groups and write down the variables that are not cancelled out. For example the vertical group of two is high when C is either low or high, so C is cancelled. In addition A is high and B is low, so the result is A*/B (the '/' indicates that B is to be inverted).

Doing this for all three groups and adding (ORing), the equation becomes :

Y = A*/B + A*C + B*C

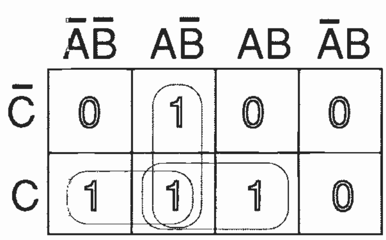


Fig. 4. Am I going to continue reading this article? A Karnaugh map graphically brings logical terms together to produce a Boolean logic expression.

This equation can then be directly entered into the appropriate software for the target device – note the sum of products format.

The example shown here is for purely combinatorial logic, but the principle can also be used for registered logic, where existing states (registered data) are used to determine future states (registered data after the clock edge occurs). This is the unremarkable reason that such designs are known as state machines, of which more next month.

larger members in the *EP* range could integrate multiple pal and TTL devices. They also use both graphical and Boolean forms of design entry, allowing the designer to integrate old TTL and pal designs very efficiently. Once again the combination of technology and ease-of-design (i.e. the software) made for a best seller, and paid for the development of the next generation of Altera EPLDs, the multiple array matrix (*MAX*) family.

Other companies also chose this technology to develop their products. AMD uses it in its *mach* range, and the Xilinx EPLD division (formerly Plus Logic) uses similar concepts, these will discussed in greater detail next month.

The Field Programmable Gate Array (FPGA)

The first FPGAs ever produced were the *XC2000* family of logic cell arrays (LCAs) from Xilinx. They were invented by Ross Freeman, while working for Zilog Corporation. His idea was to apply cmos sram technology, widely used in the microprocessor market, to the logic market. Even with the programmable solutions mentioned above, the density of programmable logic devices (as distinct from gate-arrays) was far below that of the other two main components of any digital system, i.e. the microprocessor and memories. Freeman also invented a radically new and flexible architecture to go with this technology, which broke away from the AND-OR structure of the PLDs, and had similarities to a sea-of-gates gate-array. The technology used rugged memory latches to control pass transistors. These transistors in turn controlled look-up tables for logic functions, and a programmable channelled interconnect for hooking the logic functions together. The devices could be manufactured on a relatively inexpensive standard cmos process.They were seen as flexible and efficient architectures for programmable logic. They also had the low power requirement, though this varies (in common with all cmos devices) with operating speed. Powerful new software had to be developed to help with the ease of design and exploit the opportunities the new architecture afforded the engineer. It was not long before they became accepted by designers, and became a phenomenal success.

Next month: the specific architectures and relative merits of both EPLDs and FPGAs will be covered next month. The third part will attempt to explain the importance of software developments such as synthesis that have occurred in parallel, and their role in increasing design productivity – in other words HOW.

We will also be announcing a competition that will challenge the ingenuity of the reader, and the prize in which will be a complete Xilinx development system and schematic entry package.

■

GLOSSARY

EPLD Erasable Programmable Logic Device. EPLDs are manufactured using a cmos eprom process, and are typically of higher density than conventional PLDs. They do have a basic AND-OR type structure although the specific number of product terms varies between competing architectures.

PLD Generic name for small density programmable logic devices. These are usually pals, gals and PLAs.

PAL Programmable Array Logic. (TM name MMI/AMD) This architecture has a programmable AND array and fixed OR array, as its basic structure.

PLA Programmable Logic Array. This architecture has a programmable AND array and a programmable OR array as its basic structure.

FPGA Field Programmable Gate Array. FPGAs have a basic structure in which an array of logic cells is connected via flexible programmable interconnect.

Eprom Erasable Programmable Read Only Memory. Technology used in EPLD devices. Electrons held on an insulated gate of a transistor during the programming phase, prevent the transistor from turning on. Strong UV light contains sufficient energy to release the electrons and erase the device ready for re-programming

LAB INSTRUMENTS – virtually redundant?

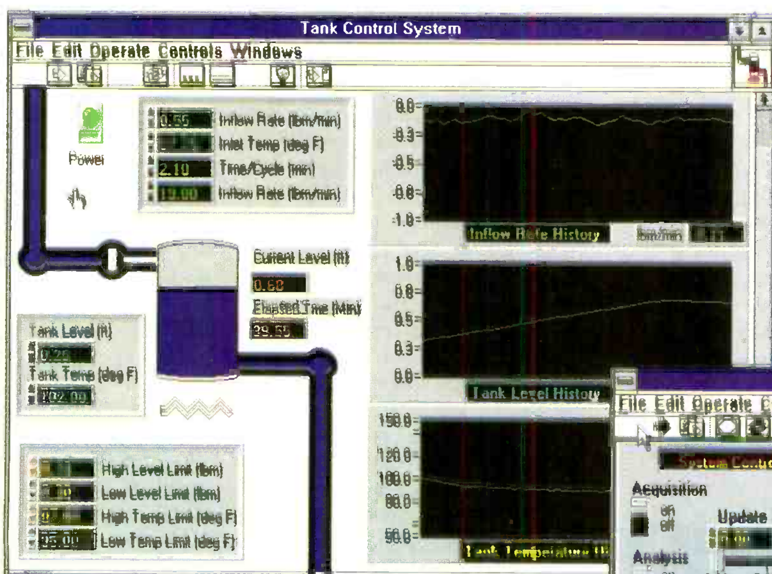
National Instruments' weighty Labview sets out to provide the complete solution to data acquisition. Allen Brown unwraps one of the major packages of its class on the market.

In data acquisition, process control and system simulation, the current generation of 386 and 486 PCs lead the way. Their preeminence is due in part to their large storage capability (hundreds of Mbyte), high performance (32-bit buses working at 33MHz) and a high resolution graphics front end – all at a reasonable capital outlay. Yet though the machines themselves have been around for a few years, very little commercial software has been available to exploit the 32-bit architecture.

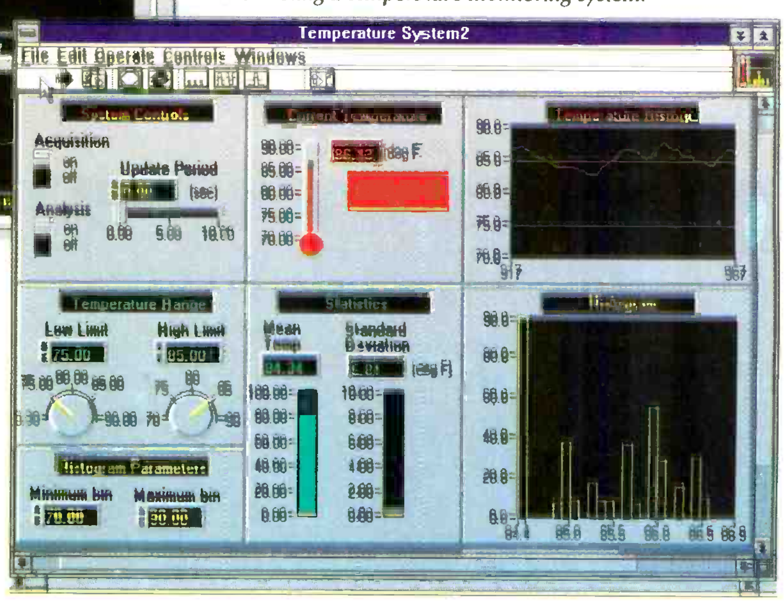
National Instruments' *Labview* has set out to change that, designed to make the most of today's high performance PCs. The aim is an impressive one – but perhaps the magnitude of the package can be gauged by looking at its size and system requirements: 10Mbyte hard disc space occupied; 8Mbyte ram (extended memory)plus the usual maths coprocessor to run.

Labview is a complete system for design, simulation and eventual control of a laboratory or an industrial process. Its role is to enable the PC to replace standard and custom laboratory instrumentation so that instead of having various discrete laboratory instruments (voltmeters, frequency meters and counters) each device can be created on the PC as a "virtual instrument" (VI) with its own switches, knobs and display features.

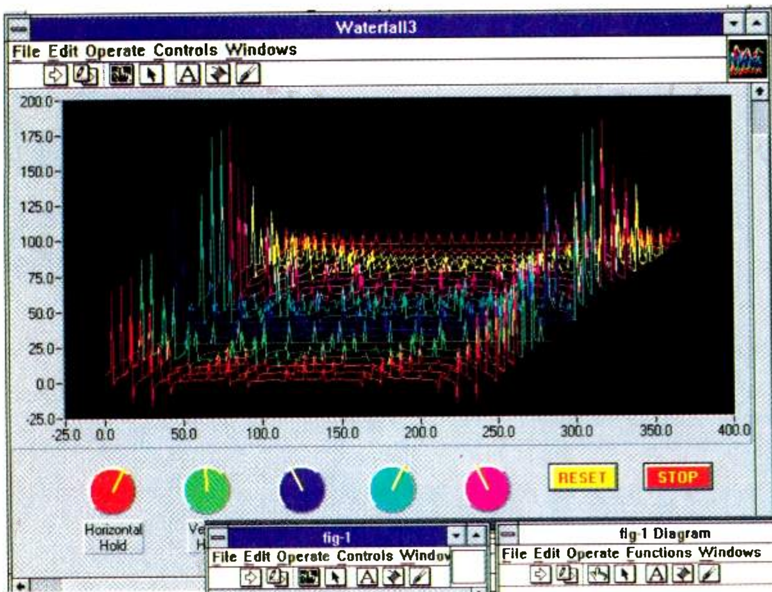
Each instrument (or group of instruments) occupies an individual window – with the multitasking ability of the 386/486 PC easily allowing each widows (instrument) to operate independently of each other. So once the design is up and running the VI front panel allows parameters to be controlled interactively in real-time. The various i/o signals are exercised through expansion cards compatible with *Labview* and are slotted into the expansion area of the PC.



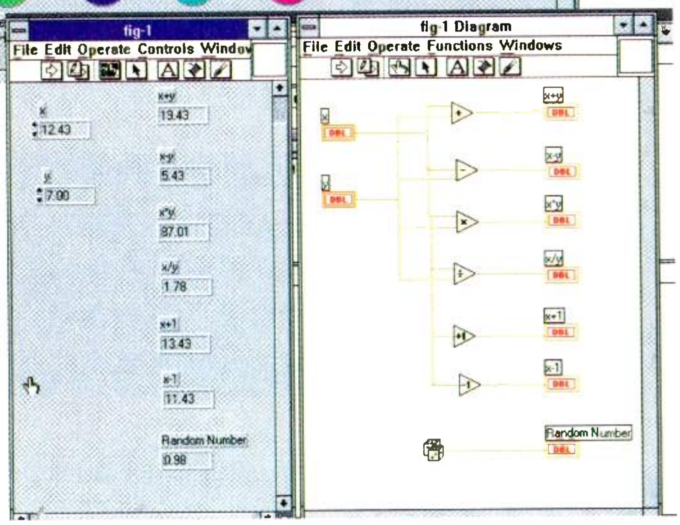
Using Labview to represent an industrial process, with the various input parameters adjusted interactively by the user.



Constructing a temperature monitoring system.



How to build your own virtual instrument waterfall spectrum analyser. The front panel knobs are controlled by the mouse and change the settings of the instrument.



Two views of a Labview design: front panel controls on the left and the actual icon design on the right.

Using Labview

Every VI has two views (each view within a window); front view and the inside view or system pictorial block diagram. For example when designing a VI to be displayed on the PC screen, one window would have the outward appearance of the instrument with its panel and display setting, while the other would contain the actual system design.

A system is constructed from icons selected from library sources, and the actual "programming" involves linking or wiring together the chosen icons making up the system design. In this way the designer works at a high level and uses a graphical programming language (referred to as *G* by National Instruments) as opposed to a usual text based language.

Labview's *G* language contains all the constructs of a conventional programming language. Program loops, conditional transfer, subroutines (referred to as subVIs) are all represented as icon events. For example, simple mathematical operations are performed with triangular icons/nodes. The front panel shows the inputs and output boxes – a dice icon represents a random number source – and the inputs can be changed dynamically by pointing and clicking the mouse on the direction arrows.

In the system diagram (*middle left*) the actual icons and links required to achieve the design are shown.

Icon libraries and other *Labview* facilities are accessed through the mouse click and drag technique from drop-down menus common to most windows-based software. The number of icons is vast; but the information required to use them is available only in the appropriate manual. There is no help file to give an insight into the operation and use of each icon. But this is where practice pays off and a proficient user soon learns the ins and outs of each icon.

As a viable programming language *G* has constructs common to conventional programming languages: the for loop, the while loop, the case structure (CS) and the sequence structure (SS).

In the WHILE and FOR loops sub diagrams are built inside each structure. The for loop has a count terminal *N*, set automatically or from a front panel icon, and an iteration terminal *I*, containing the number of completed iterations. Whatever operation is built inside the for loop remains executing until the exit condition (the defined number of iterations) is reached. The while loop has a condition terminal, and the operation inside the loop continues executing while that condition is true.

To add to design flexibility of the loops, shift registers can be added to the boundary of the structure – useful where a recursive-type operation is being performed in the loop and the result of the previous iteration is needed for the next iteration.

Case structures can be created as stacks. The value contained in the top panel (sub diagram display window) – the diagram identifier – can be a numerical value or TRUE or FALSE. The stack of CSs are parallel paths along which the programme can progress. The choice of the CS in the stack is determined by a condition test which is performed before entering the stack. The result of the decision can either TRUE or FALSE or a number.

The sequence structures (SSs or frames) on the other hand are also created in stacks except SSs are executed sequentially. Data can be passed from one frame to another using local terminals. In essence it is possible to construct a stack of frames, each fed with the same input data to process in parallel. However the output from the stack is only available when all the frames have finished processing the input data.

Formula node is an attractive feature of the *G* language and can contain a set of equation. The inputs and outputs are attached to the boundary of the node box and all variables are treated as floating point scalars. But since many computational tasks involve manipulation of matrices, it is disappointing that formula node cannot cope with matrix algebra directly.

Analysis and Signal Processing

Labview has many provisions for implementing signal processing operations – one of the user manuals is given over entirely to its analysis features – falling into roughly four groups: DSP, digital filters, numerical analysis and statistical operations. The various DSP virtual instruments for signal

Documentation

A library of seven spiral-bound reference manuals provide a considerable amount of information on operation and breadth of the product.

On the whole the manuals are well-written and, containing a useful number of illustrative diagrams.

The introductory tutorial is well thought out and a valuable introduction to the product.

Labview has been available for the Sun workstation for some time, and layout of the Reference Manuals shows it is obvious that National Instruments has benefited from the experience. But Labview still has a long and sometimes steep learning curve. Becoming familiar with the G language is one thing, but learning how to use it proficiently requires a lot of practice.

SYSTEM REQUIREMENTS
386 or 486
8Mbyte ram
80387 coprocessor if using 38
Mouse
VGA or SVGA monitor
IEEE-488 and/or suitable multifunction 16-bit i/o card(s)

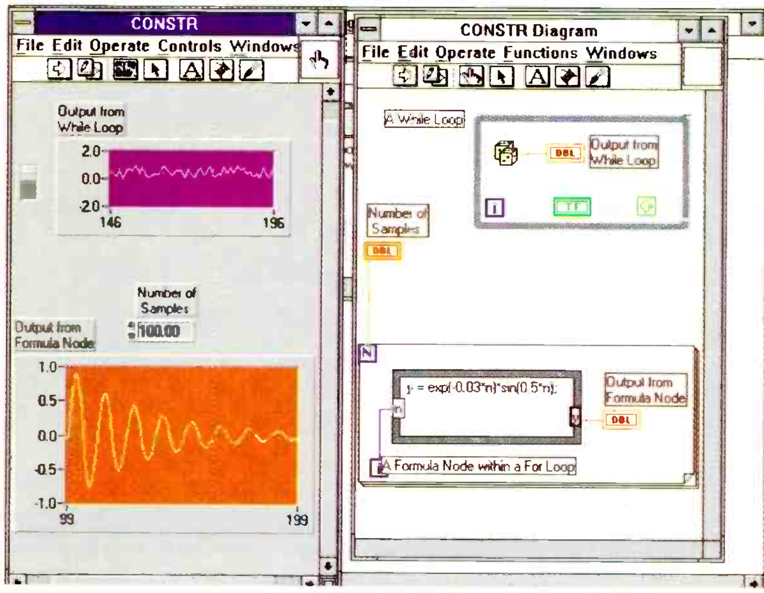
generation within *Labview* consist of impulse, pulse, square, ramp, triangular, sine, sinc and white noise (both Gaussian and uniform) for one or two dimensions. The ubiquitous Fast Fourier Transform (FFT) and its derivatives are well represented, and other transforms include the Fast Hartley Transform and the Fast Hilbert Transform – useful for generating the quadrature component of input signals. There is also a wide selection of window functions to choose from in order to improve the resolving nature of the FFT.

For infinite impulse response (IIR) or finite impulse response (FIR) filters there are a number of options. Customary IIR filters include Butterworth, Chebyshev (I & II), elliptical and Bessel designs, and the common FIR filter design techniques are also included (Window and Equi-ripple). Output can either be a transfer function or a set of filter design coefficients. The computation for calculating the coefficients for Equi-ripple is quite intense but proves to be remarkably fast on a 486 PC.

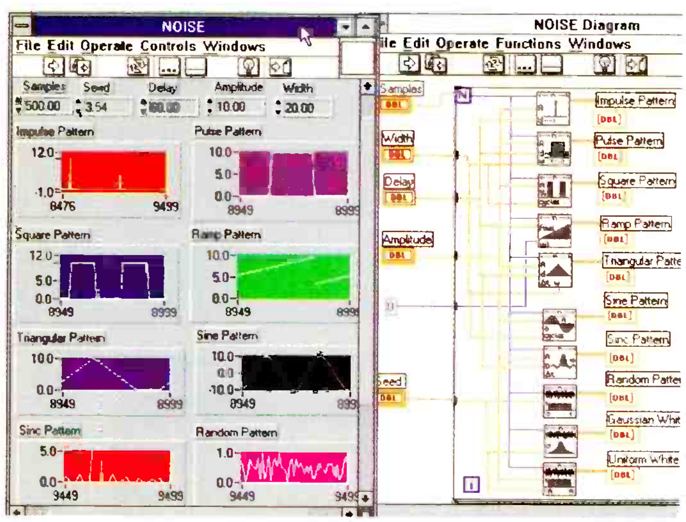
The analysis library also contains icons for performing statistical tasks on data arrays such as mean, variance, histogram, Chi square distribution, curve fitting and some options for statistical modelling/hypotheses testing. In fact the range of statistical options is impressive and exceeds that available on most applications of this type. The analysis library also has some attractive icons for manipulation of matrices – cross products, trace, inverse matrix, multiplication and the solution to linear equations are just a few. Understanding of the analysis features is helped by the examples given in the Analysis Reference Manual.

Code interface nodes

Occasionally code compiled from the icon design does not run fast enough, for example with a critical real-time system requiring a very fast response. But *Labview* can provide a framework which allows creation of code interface nodes or CINs. Applications which cannot be realised directly through the icon language *G* will also require the use of CINs, and an example of this is a device driver for an expansion board in the PC. CIN icons, once created, may be integrated into a *Labview* design with their various inputs and outputs. CINs can be written in *C* – though there are a few restrictions on the *C* compiler, and as yet only the Watcom *C* compiler is

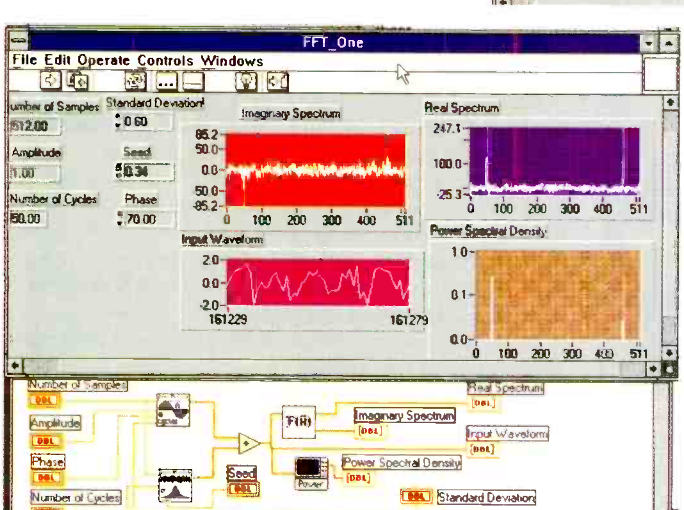


Representing For and While loops pictorially with embedded tasks.

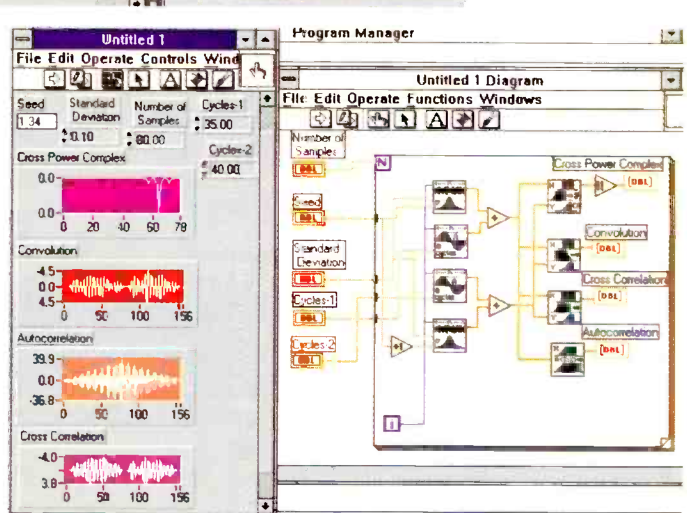


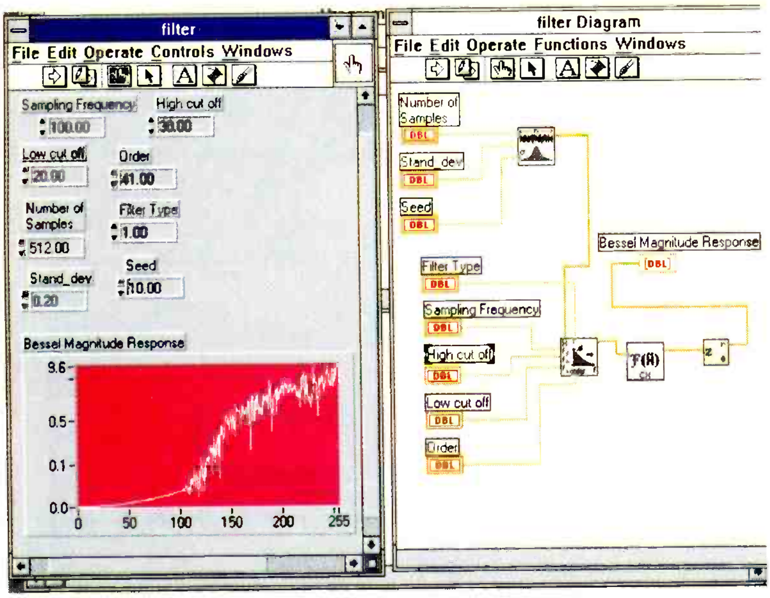
Generating waveforms from within Labview.

Below: Implementing the FFT using icons to generate a spectrum and the power spectral density of a waveform.



Below: Signal processing tasks are available as icons. There are also icons for performing cross power spectral density, convolution, deconvolution, autocorrelation and cross correlation.





Testing a Bessel high pass filter with random noise.

acceptable, producing 32-bit code specifically for the 80386 CPU. It is directly compatible with the *Labview* format.

Input/output functions

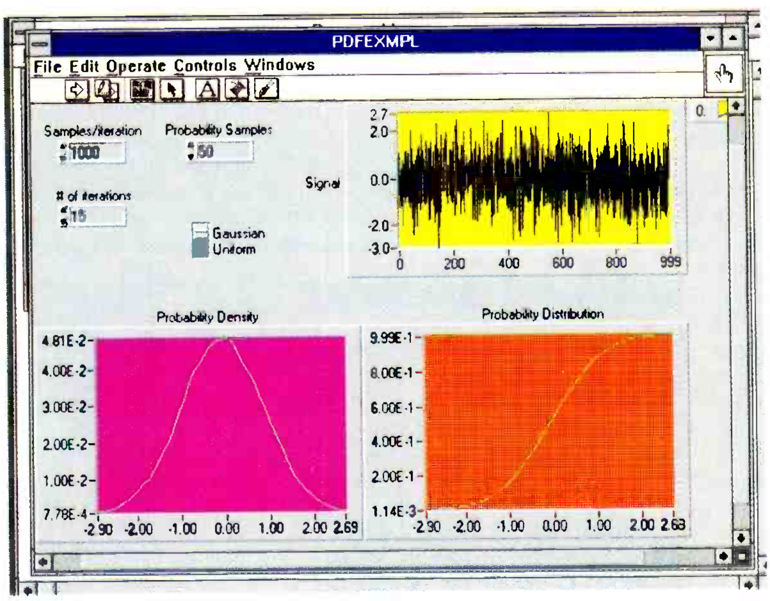
Transferring data to and from *Labview*, whether from an expansion card or a disc file, can be by accomplished by a variety of icons and data transfer methods.

For storage, retrieval and manipulation of disc files *Labview* has several icon choices. All computer operating systems have instruction relating to the operation of disc files and directories – creating directories, copying files, deleting files. In *Labview* these operations are represented as icons, and file tasks (or sets of tasks) can be implemented by stringing together the appropriate icons.

There are three other sources of data transfer: the IEEE-488.2 card (or gpib), the RS-232 serial ports and specific data acquisition expansion cards. Users familiar with the gpib will find *Labview*'s implementation of it quite convincing, and there are thirty one IEEE-488.2 icons available.

But for users new to gpib, a good grounding in its operation is necessary before attempts can be made to design a control and data acquisition system based on it. What is not given in the Gpib Reference Manual is a list of the commercially available IEEE-488 cards acceptable to *Labview*.

National Instruments is well-known for its PC i/o boards, such as the Multifunction I/O (MIO) family and Lab-PC expansion board, and there is plenty of guidance in the Data Acquisition Manual on interfacing the boards to *Labview*. Board-specific virtual instrument icons, required to configure the expansion boards and to perform calibration procedures, are contained in a library so the tedious task of writing device drivers is removed.



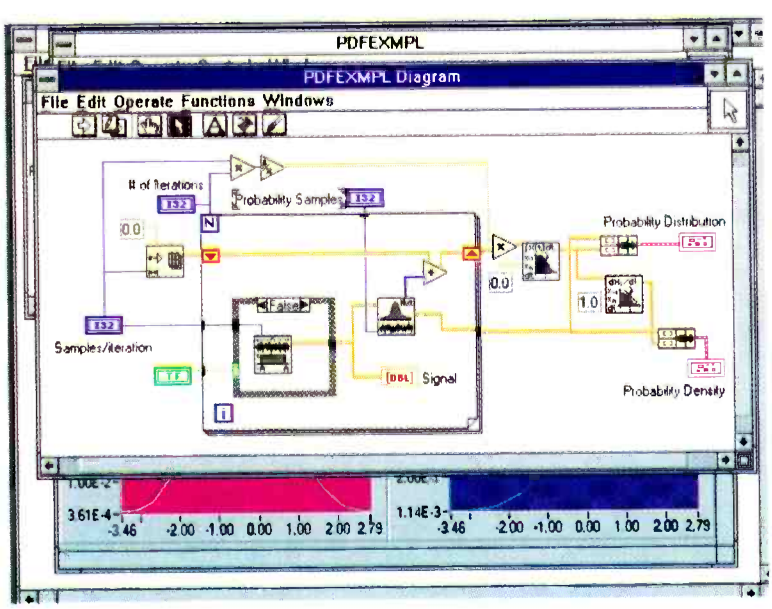
Labview has an armoury of statistical tools, such as the probability distribution function of Gaussian random noise.

Suitable for major projects

Labview is a professionally designed product with a great deal to offer the engineer embarking on a major project involving data acquisition, system design, simulation and eventual control. It represents one of the major packages of its class on the market, certainly exploiting the power of 80386/486 based PCs. But to run it on a IBM AT (80286 based) PC is really a non-starter and this combination should not be considered for any serious application.

Reliability of such a high level language becomes an important factor in critical real-time system design – though since it has been available for Sun workstations for some time high integrity can be assumed.

Labview uses Windows 3.1 as its operating platform, and though 3.1 is more robust than its predecessor, an open mind should be kept regarding its reliability. The occurrence of unexpected application error or UAE events is still not unknown in Windows 3.1 and while using *Labview* I have been confronted by *Application Error - Win386 caused a General Protection Fault* with the result that the program shut down. Apart from this reservation, which is applicable to every application package running under Windows, I feel that *Labview* is designed and will find numerous applications in the intended target areas. ■



Designing icons for use in the display above

SUPPLIER DETAILS

National Instruments, 21 Kingfisher Court, Newbury, Berkshire RG14 5SJ. Tel: 0635 523 545 Fax: 0635 523154.

TRACY MARTIN

You will search in vain for the word 'phrack' in the Oxford English Dictionary, but there again, you will not even find the word 'phreak' there. Before dismissing phracking as another asinine example of modern computer jargon, consider the suggestion that phrackers cost American telephone companies and their customers $2bn in a year. Moreover, according to telephone company officials, this may be only the beginning. Mark Nelson reports.

PHONE FRAUD: a high technology crimewave?

Phracking is the new combination of phreaking and hacking: the perpetrators combine computing skills and traditional phone phreaking to steal phone calls. What distinguishes this piracy from previous activity of this kind is the extent of the fraud and its technical ingenuity. Unlike earlier forms of phreaking, the telephone companies' exchanges and networks are no longer the object of the phrackers' attentions; individual customers' systems are the target. And whereas the phone phreaks of old justified their attacks on the phone companies, saying that no individual ever suffered as a result of their enterprise, the new breed of phrackers have no such scruples. Municipalities, large corporations, universities, even religious organisations have all been defrauded by these high-tech crooks. A large Seattle business was charged with $100,000 of fraudulent calls in just one weekend. Private individuals are not immune either: a single Seattle resident was charged with a similar burden last year.

The fact the phrackers get away with this so easily speaks volumes for the lack of security on modern user systems. Simply put, they tend to know more about the programming of modern call-connect systems than the official custodians. Which is how the former can manipulate them undetected to their own ends.

The information needed for phracking is not hard to find. In the USA there is a national underground movement of phrackers who, although not organised in any group, can obtain the information on a number of well-known computer bulletin board (BBS) systems. A hacker magazine called *2600* is now on sale openly in stores like Tower Records and is crammed full of articles and letters on topics like cellular eavesdropping, telephone system loopholes and magnetic card abuse. 'Share the information that others want to keep secret' is its motto.

An American disease?

Phracking is possible in the USA because company switchboards frequently provide a re-routing facility. This enables employees away from base to make a cheap or toll-free call into the switchboard and then dial their long distance and international calls through the PABX at their employer's expense. A password is required but this is liable to become common knowledge: its use allows free calls exploiting this re-routing facility, sometimes even using the company's international toll-free lines from Europe. Companies with voice-mail systems have also discovered advanced facilities set up for private purposes by the phrackers.

By exploiting these features in new-technology PABXs and the loopholes in their owners' security measures, the new phone pirates can place long-distance calls for nothing from any payphone (or private phone). And many more people 'not in the know' are willing to pay a modest sum to the 'brokers' who are happy to set up calls for a fee.

The result is that calls to worldwide destinations are being charged to unsuspecting corporations and organisations. Network operators charge the cost of these calls back to the victim customers, customers are blaming the phone company and their PABX supplier and, meanwhile, the law-breakers disappear without a trace. Nobody, it seems, is prepared to admit their system security was inadequate.

"The phone pirates' method is alarmingly simple and only works because people don't take the most basic security precautions," says Cardiff-based telecomms consultant Richard Cox. "Some observers are afraid the technique may catch on this side of the Atlantic and, while possible, it is less likely. Of course, if telecomms managers took proper precautions, PABX fraud would be impossible but we have seen in the States how lax people can be."

"Until recently, this system of re-routing calls was not generally permitted in Europe," says Cox, "but it is now perfectly legal in Britain and elsewhere, thanks to liberalisation and user demand. Remote programming of call-connect systems is also widespread now." This facility allows complex switchboard systems to have their software updated over the phone line. Hackers can also break in via the 'maintenance ports' and set up their own re-routing facilities on direct inward dialling lines. The hackers can do this because owners often do not change the password code from the default settings of 000 or 111; once logged on, they can make the changes they want and even change the passwords to lock out the legitimate system manager.

Cox explains that the maintenance ports are normal ex-directory phone lines and discovering these is not as difficult as it might seem. The likely exchange prefixes can be determined by logical survey, then the actual number obtained with the aid of a scanning program and a phone-connected PC. This dials every number on an exchange sequentially and drops the line after it answers, having first noted whether a modem tone is returned. Vast tracts of numbers can be scanned overnight (unlimited local calls are allowed in the USA), presenting the phracker with a shortlist of likely numbers to test further the next morning.

Armed with a system manual and some inside knowledge, the telephone hacker can set up new, more 'user-friendly' facilities at will. It can be prevented by proper password security and by dial-back operation, where the PABX rings back directly to an authorised number for re-programming."

Initially, the phrackers kept their secrets within their own fraternity, using their knowledge to cut the cost of their hobby – to call remote computer bulletin boards, for instance. They also used their free calls to dial premium-rate sex lines. Then they became more adventurous. According to US West Communications, one of the regional Bell telephone companies in the USA, voice-mail and credit bureaux are the new targets.

Credit card fraud

Phrackers allegedly deposited 300 messages to each other in a single voice mailbox of a large Seattle-based company. Their use of the box was not discovered until its assignment to a new employee. The hackers even sealed the mailbox with their own password, which they distributed throughout the underground network.

By connecting their computer to the telephone via a modem, the phrackers have been known to call credit bureau computers and enter a generic code with a name. They have obtained financial information, including credit card numbers.

According to *The European*, the United Nations is leading the list with $925,000 in disputed charges, followed closely by NASA and IBM, which were defrauded of half a million dollars each. *Business Week* reports that hacked calls – mainly to Pakistan, Egypt and the Dominican Republic – added $90,000 in one month to the phone bill of Philadelphia Newspapers Inc., nearly a quarter of their total charges.

Some phone customers refuse to pay: AT&T has sued at least 17 of its business customers for not paying bills run up by hackers and MCI Communications Corp. has filed suits against a few customers. Other customers cannot pay: the Christian Broadcasting Network was hit for $40,000 and has yet to pay.

Even though some customers claim they were never warned by the phone companies that PABX fraud was a problem, the Federal Communications Commission (FCC) has ruled that customers are liable for all charges.

A history of phone fiddling

Using deception to obtain phone calls in Britain dates back many decades when people used to kick the coinbox mechanism to rattle the gong which told the exchange operator you had deposited a coin. Dexterous individuals used to tap the switch-hook of the old "Button A/B" payphones or employed skilful "back-dialling" techniques to avoid paying for calls.

Long before the introduction of subscriber trunk dialling people made long-distance calls by "chaining" local dialling codes or by exploiting unadvertised codes to enter the trunk dialling network used by telephone operators. Nonetheless this was a minority sport until the late sixties, when enterprising students started collating all these codes on (mainframe) computers and built 'bleepers' to simulate the tones of the STD trunk network. With a general increase in anti-establishment feeling these codes and techniques began to achieved a wider circulation, culminating in a major criminal case in 1972, when the Post Office prosecuted 12 phone phreaks at the Old Bailey for conspiring to use electricity without authority.

In the USA phreaking was now widespread too, associated with the hippy fraternity and the yippy movement, also with organised crime. It was even alleged that the initial capital for founding a well-known personal computer corporation derived from the sale of blue boxes (used illegally for simulating operators' call-routing signals). In truth, though, the sheer technical virtuosity required to 'box' or make calls in this fashion meant that the problem was confined to relatively small numbers. For a while Ma Bell picked up the tab but better network security devices and some well-publicised custodial sentences both defeated and deterred all but the keenest of phreakers.

As the phreakers, like the hippies, grew older and followed more conventional pursuits, phone fraud declined in popularity and significance. As an intellectual pastime during the 1980s it lost respectability, being supplanted by computer hacking, and no doubt the phone companies thought this problem had finally gone away. But suddenly, at the beginning of the nineties phone fraud has been re-born and this time the problem is on a massive scale. It is remarkable how technological advance always brings problems along with its blessings.

Ban the bulletin boards?

Chief sources of information for phrackers remain the computer bulletin boards (BBSs) run by hobbyists, disseminating all manner of doubtful information. Information for defrauding phone companies is less openly displayed in Britain than in the USA, and you will search in vain on the BBS opening menus for phreaking and phracking options. The information is said to be there but as an unadvertised choice – presumably the precise means of access is spread by word of mouth.

It would be ludicrous to suggest that all BBSs are hotbeds of subversion. Many provide a genuine service to their users without any antisocial undertones. Even more, they generate valuable income for the telephone companies at the same time.

The innocence of their operators does concern network security chiefs, however, who perhaps paranoiacally see every BBS as a potential medium for the promulgation of dodgy information. Such people also find it difficult to see how anyone would wish to collate or pass on privileged inside information on the working of telephone systems unless for unlawful purposes. Yet, back in 1973, *New Scientist* suggested that phone phreaks were no more than telephone addicts. The previous year Judge McKinnon described the Old Bailey defendants as "rather similar to the small boy who liked to drive a train". They were, he said, fascinated by the machinery of the Post Office and "wanted to drive it themselves".

Times have changed and the stakes have increased. Whether publishing this kind of information electronically is an offence or whether it is even publishing is a vexed legal issue. That notwithstanding, the authorities in the USA have deemed that running a BBS containing other peoples' private codes is an offence. As a result, several individuals in the USA have been raided by the Secret Service and had their computer equipment confiscated. In a celebrated case, Craig Neidorf faces legal bills close to $50,000. The Electronic Frontier Foundation was set up to defend some of these BBS operators, but the claim of accused BBS operators that they are not responsible for what is posted on their boards is doing nothing to placate the victim organisations whose security has been breached and publicised by hackers and phrackers. A major test case seems inevitable.

It maintains that PABX users have the ability to control access to their systems and have merely failed to exercise this control.

Given the notoriety of the problem, which has been significant since 1987, it seems remarkable that corporations have allowed the situation escalate. PABX vendors, too, have advised their customers to change passwords frequently, monitor call-detail records daily and deactivate unused phone extensions and passwords. Rolm Corporation has introduced new software that lets users cut off callers who make more than a programmed number of password attempts and is enhancing security on the maintenance ports.

A crooked Europe?

Will the same mistakes be repeated in Europe, with the same consequences? Cox hopes not. "Initially I was reluctant even to discuss the subject in case people accused me of inciting hackers," he says. "But the industry must inject a level of responsibility and take the matter seriously before problems occur. It is particularly worrying that some PABXs which are reconfigurable by remote command have fixed passwords on the maintenance port, which cannot be changed by the comms manager. Users should press their suppliers to clarify this matter."

Another telecomms industry figure, who preferred not to be named, agreed that proper system security could prevent a repetition of the American nightmare in Britain. But *could* is the operative word in his opinion. He elaborates: "What worries me is that so few comms managers really understand how the equipment they control works. Most of them are just administrators with no technical background whatsoever, who couldn't tell an earth start from a busy peg. I must be careful describing a monster that doesn't exist yet nor create a self-fulfilling prophecy, but the potential for mischief appals me."

We asked BT and Mercury whether they believed fraudsters were at work in the UK and whether they had instituted counter-measures. Although BT prefers not to comment officially, sources close to the company indicate they are well aware of the extent of phone phreaking in Britain: while it occurs "on a reasonable scale", the situation is more or less under control.

Digital exchanges can be programmed to detect repetitive dialling and short holding time on calls which would betray someone searching for ex-directory access ports, while an expert system called LIMTEL has been developed by BT Research Labs to identify sudden surges in usage on individual phone lines.

The company says this will help alert users to possible misuse of their lines and also help BT combat large-scale telephone fraud and bad debts which cost the firm £179 million last financial year.

Mercury says that it has not come across any phracking or phreaking on its network. The GPT-manufactured ISTDX call connect system supplied to major customers does not permit 'in and out' through dialling and the ring-back system employed for remote programming means that these exchanges are extremely secure. So runs the official rubric. Unfortunately, it is admitted, quite a few users have insisted on a direct access (dial-in) link for reprogramming (albeit password-protected) and through-dialling is possible with a third-party enhancement supplied by Chesilvale Ltd. The tax on the use of mobile phones is making this 'in and out' dialling option look increasingly attractive to large users, moreover.

One item of cheer to British telephone customers is that without any announcement, BT has altered the wording of its customer agreement, releasing the customer from liability for calls made from his 'line' and restricting the liability to calls made from his 'telephone apparatus'. This was instituted after a television programme showed how easy it was for fraudsters to make illicit connections to customers' lines on wiring outside their premises. Whether this will also absolve business customers whose PABXs have been tapped into remains to be seen and may require testing in court.

Criminal hot line

Even with these reassurances, telephone subscribers may still have cause for concern. Earlier this year fifteen men were arrested for allegedly defrauding Mercury Communications of phone calls worth £500 million. They had achieved this by using authorisation codes which, it was suggested, had been issued illegally by the company's own staff. Cases of widespread fraudulent calling by BT staff have also been reported in the past, in one case to run a travel bureau business, and there have been repeated rumours of sales staff taking bribes to provide London businesses with unmetered lines. Although it was the telephone company and not innocent customers who were the victim in these last cases, the burden still falls on subscribers as a whole.

During June the US House of Representatives began consideration of a bill by Rep. Barney Frank of Massachusetts which would make phone companies and equipment suppliers, not consumers, liable for losses due to fraud.

Newsbytes reports that experts told the House telecommunications subcommittee of Rep. Edward Markey, which has jurisdiction on the bill, that consumers are losing $2.2bn to thieves, and the fraud will continue as long as the industry is able to say it is not responsible. But a spokesman for AT&T said his company has taken steps against the thieves, and maintained that since PBXs are on customer premises and only the customer knows who is an authorised caller, that the customers' security measures are the best defence. ■

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2 x LITHIUM BATTERIES 2.5V penlight size. Order Ref. 874.

2 x 3M TELEPHONE LEADS with BT flat plug. Ideal for 'phone extensions, fax, etc. Order Ref. 552

1 x 12V SOLENOID has good ½" pull or could push if modified. Order Ref. 232.

4 x IN-FLEX SWITCHES with neon on/off lights, saves leaving things switched on. Order Ref. 7.

2 x 6V 1A MAINS TRANSFORMERS upright mounting with fixing clamps. Order Ref. 9.

12 x 30 WATT REED SWITCHES. It's surprising what you can make with these — burglar alarms, secret switches, relay, etc. Order Ref. 13.

2 x HUMIDITY SWITCHES, as the air becomes damper the membrane stretches and operates a micro switch. Order Ref. 32.

5 x 13A ROCKER SWITCH three tags so on/off, or changeover with centre off. Order Ref. 42.

2 x FLAT SOLENOIDS you could make your multi tester read AC amps with this. Order Ref. 79.

1 x SUCK OR BLOW OPERATED PRESSURE SWITCH or it can be operated by any low pressure variation such as water level in water tanks. Order Ref. 67

1 x 6V 750m A POWER SUPPLY, nicely cases with mains input and 6V output leads. Order Ref. 103A.

2 x STRIPPER BOARDS, each contains a 400V 2A bridge rectifier and 14 other diodes and rectifiers as well as dozens of condensers, etc. Order Ref. 120.

12 x VERY FINE DRILLS for pcb boards etc. Normal cost about 80p each. order Ref. 128.

5 x MOTORS FOR MODEL AEROPLANES, spin to start so needs no switch. Order Ref. 134.

6 x MICROPHONE INSERTS magnetic 400 ohm also act as speakers. Order Ref. 139.

6 x NEON INDICATORS in panel mounting holders with lens. Order Ref. 180.

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2 x (6"x4") SPEAKERS 16 ohm 5 watts so can be joined in parallel to make a high wattage column. Order Ref. 243.

1 x PANOSTAT controls output of boiling ring from simmer up to boil. Order Ref. 252.

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1 x 6 DIGIT MAINS OPERATED COUNTER standard size but counts in even numbers. Order Ref. 28.

2 x 6V OPERATED REED RELAYS one normally on, other normally closed. Order Ref. 48.

1 x CABINET LOCK with 2 keys. Order Ref. 55.

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1 x SHADED POLE MAINS MOTOR ¾" stack so quite powerful. Order Ref. 85.

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THIS MONTH'S SNIP is a Japanese-made 12v d.c. battery operated, brushless axial fan 93mm square, its optimum is 12v but it performs equally well at only 6v and its current then is only 100mA so it could be made into a hand-held dry battery-operated cooler. Or, on your desk operated by a P.S.U. or in the car using the lighter socket. Snip price only **£4**, Order Ref. 4P65. Mains power unit to operate this at variable speeds **£2**, Order Ref. 2P3

MOVEMENT ALARM GOES OFF, WITH THE SLIGHTEST TOUCH. Ideal to protect car, cycle, doorway, window, stairway, etc etc. Complete with Piezo shrieker, ready to use. Only **£2** (PP3 battery not supplied) Order Ref. 2P282

PROJECT BOX a first-class, Japanese two-part moulding size 95mm x 66mm x 23mm. Held together by 2 screws, this will hold a PP3 battery and a PCB and is ideal for many projects. To name just a few, the washer bottle described in September's issue of E.E. This is nicely finished and very substantial. You get 2 for **£1**, Order Ref. 876

HOLD IT MAGNETIC BASE embedded in a circular metal shallow disc, diameter approx 65mm (2½"), is the most powerful magnet. We have yet to find anyone who can remove this with his fingers. Ideal for adding extra shelves inside a metal case or to glass without drilling. Its uses, in fact, are innumerable. Price **£2** each. Order Ref 2P296

AM/FM RADIO CHASSIS with separate LCD module to display date and time. This is complete with loudspeaker and is mains-powered. Price **£3.50**, Order Ref. 3.5P5

2,3 AND 4 WAY TERMINAL BLOCKS the usual grub screwtypes. Parcel containing a mixture of the 3 types giving you 100 ways for **£1**, Order Ref. 875

12/24 DC SOLENOID The construction of this is such that it will push or pull as the plunger is a combined rod and piston. With 24v this is terrifically powerful but is still quite good at 12v and, of course, it can be operated by any intermediate voltage. Price **£1**, Order Ref. 877

2M 3-CORE LEAD terminating with flat pin instrument socket. **£1**, Order Ref. 879. ditto but with plug on the other end so that you could use this to extend an instrument lead. **£1.50**, Order Ref. 1.5P10

MULTI-CORE CABLES all with 8A 230v cores so suitable for disco and other special lighting effects. With earthable woven screen and thick pvc outer. 3 core **30p** per metre 16 core, **50p** per metre, 18 core **80p** per metre, 25 core **£1** per metre and 36 core **£1.50** per metre

20W 5" 4 OHM SPEAKER mounted on baffle with front grille. **£3**, Order Ref. 3P145. Matching 4 ohm 20W tweeter on separate baffle. **£1.50**, Order Ref. 1.5P9

135W POWER SUPPLY UNIT — ASTEC 230v in +12v at 4A, +5v at 16A and -12v at ½A out. Completely enclosed in plated steel case, brand new **£9.50**, Order Ref. 9.5P1

LOW PRICED FIELD TELEPHONES Ex-GPO mdoels, not quite so nice looking but quite efficient, and have the big advantage that the ringing is done by means of a hand operated internal generator. This saves a lot of batteries. These 'phones have the normal type of rotary dial built in and can still be connected into a normal B.T. system. Tested, guaranteed in good order, price only **£9.50** each. Order Ref. 9P5.

DRY BATTERIES CAN BE RECHARGED but not with a normal dc charger, it must be a periodic current reversal type. We can supply the kit, with data **£9.00**, Order Ref 9P10

SOLAR ENERGY EDUCATIONAL KIT — an ideal present for electronics students, it shows how to make solar circuits and electrical circuits, how to increase the voltage or current, how to use solar power to work a radio, calculator, cassette player and to charge nicad batteries. The kit comprises 8 solar cells, one solar motor, fan blades to fit motor and metal frame to hold it to complete a free-standing electric fan. A really well written instruction manual makes this a lovely little present. Price **£8.00**. Order Ref 8P42B.

HEAVY DUTY FLEX 3 core 15A, grey outer, 10m for **£2.50**, Order Ref. 2.5P3. 3 core 20A, white outer, 10m for **£3**, Order Ref. 3P109. 2 core 20A, 15m for **£3**, Order Ref. 3P110

HIGH POWER SWITCH MODE PSU normal mains input. 3 outputs - +12V at 4A, +5V at 16A and -12V at ½A. Completely enclosed in plated steel case. Brand new. Our special offer price of **£9.50** extended until 31st August. Order Ref. 9.5P1

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VARIAC an infinitely variable unit gives any voltage from 0-230 a.c. at ½A. Obviously an invaluable piece of equipment which should be in every workshop and probably would be except that the usual price for this is **£35** plus VAT. Now is your chance to buy one, brand new, at **£15** including VAT. Order Ref. 15P42B

ULTRA THIN DRILLS Actually 0.3mm. To buy these regular costs a fortune. However, these are packed in half dozens and the price to you is **£1** per pack. Order Ref. 797B.

YOU CAN STAND ON IT! Made to house GPO telephone equipment, this box is extremely tough and would be ideal for keeping your small tools. Internal size approx. 10½" x 4½" x 6" high. These are complete with snap closure lip and shoulder length carrying strap. Taken from used equipment but in good condition, price **£2** Order Ref. 2P283B

BUILD YOUR OWN NIGHT LIGHT, battery charger or any other gadget that you want to enclose in a plastic case and be able to plug into a 13A socket. We have two cases, one 3½" x 2¼" x 1¾" deep. **£1** each, Order Ref. 845. The other one is 2½" x 2¼" x 1¾" deep, 2 for **£1**. Order Ref. 565

SAFETY LEADS curly coil so they contract but don't hang down. Could easily save a child from being scalded. 2 core, 5A, extends to 3m. **£1** each. Order Ref. 846. 3 core, 13A, extends to 3m, **£2** each. Order Ref. 2P290

POWER SUPPLY WITH EXTRAS output 12v 1amp, mains input is fused and filtered and 12v output is voltage regulated, very well made on p.c.b. and also mounted on the board but easily removed are two 12v relays and a Piezo sounder. Made for expensive equipment but never installed, price **£3** order ref. 3P80B

ULTRA SONIC TRANSDUCERS 2 metal cased units, one transmits, one receives. Built to operate around 40kHz. Price **£1.50** the pair. Order Ref. 1.5P/4

100 WATT MAINS TRANSFORMERS normal primaries: 20-0-20 at 2.5A or 30V at 3.5A. **£4**, Order Ref. 4P24. 40V at 2.5A, **£4**, Order Ref. 4P59. 50 V at 2A. **£4** Order Ref. 4P60.

PHILIPS 9" HIGH RESOLUTION MONITOR black and white in metal frame for easy mounting, brand new still in makers packing, offered at less than price of tube alone, only **£15**+£5 post and packing. Order Ref. 15P1.

16 CHARACTER 2 LINE DISPLAY screen size 85mm × 36mm. Alpha-numeric LCD dot matrix module with integral micro processor made by Epson their ref 16027AR **£8**. Order Ref. 8P48

INSULATION TESTER WITH MULTIMETER internally generates voltages which enable you to read insulation directly in megohms. The multimeter has four ranges, AC DC volts, 3 ranges DC milliamps, 3 ranges resistance and 5 amp range. These instruments are EX British Telecom, but in very good condition, tested and gntd. OK, probably cost at least £50 each, yours for only **£7.50** with leads, carrying case £2.00 extra. Order Ref 7.5P/4.

MAINS 230V FAN best make "PAPST" 4½" square, metal blades, **£8**, Order Ref. 8P8

2MW LASER Helium Neon by PHILIPS, full spec, **£30**, Order ref 30P1. Power supply for this in kit form with case is **£15.00**, Order Ref. 15P16, or in larger case to house tube as well **£18**, Order Ref. 18P2. The larger unit, made up, tested and ready to use comple with laser tube **£69**, Order Ref. 69P1.

⅓HP 12V MOTOR — THE FAMOUS SINCLAIR C5 brand new, **£15**, Order Ref 15P8

SOLAR CHARGER holds 4 AA nicads and recharges these in 8 hrs., in very neat plastic case **£6.00**, Order Ref. 6P3.

FERRITE AERIAL ROD 8" long x ⅜" diameter, made by Mullard. Complete with 2 coil formers. 2 for **£1**. Order Ref. 832B

AIR SPACED TRIMMER CAPS 2 - 20 pf ideal for precision tuning uhf circuits 4 for **£1**. Order Ref. 818B

MAINS ISOLATION TRANSFORMER stops you getting "to earth" shocks. 230V in and 230V out. 150 watt upright mounting **£7.50**. Order Ref. 7.5P/5 and a 250W version is **£10**, Order Ref. 10P79

5 RPM 60W MAINS DRIVEN MOTOR AND GEARBOX this has a 3in square mounting plate and is 4in deep. It is a shaded pole motor. Price **£5**. Order Ref. 5P54.

POWER SUPPLY UNIT mains in, dc out, cased 4.5v 100mA **£1** Order Ref 104 6V 200mA **£1**, Order Ref. 103, 6V 700mA **£1**, Order Ref. 103A, 24V 200mA **£2**, Order Ref. 2P4, 12V 2A, **£6**, Order Ref. 6P23

AMSTRAD POWER UNIT 13.5v at 1.9A encased and with leads and output plug, normal mains input **£6**, Order Ref. 6P23

ATARI 64XE at 65K this is quite powerful so suitable for home or business, unused and in perfect order but less PSU, only **£19.50**, Order Ref. 19.5P/5B

80W MAINS TRANSFORMER two available, good quality, both with normal primaries and upright mounting, one is 20V 4A, Order Ref. 3P106 the other 40V 2A. Order Ref. 3P107, only **£3** each

PROJECT BOX size approx 8" × 4" × 4½" metal, sprayed grey, louvred ends for ventilation otherwise undrilled. Made for GPO so best quality, only **£3** each. Order Ref 3P74.

WATER VALVE 230V operated with hose connections, ideal for auto plant spray or would control air or gas into tanks etc. **£1** each. Order Ref. 370

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INFRA-RED RECEIVER CONTROLLERS Multi-way as used to channel switch, Thorn TV receivers, brand new **£2**.

500V BRIDGE MEGGER developed for G.P.O. technicians the Ohmeter 18B is the modern equivalent of the bridge megger. 9V battery operated it incorporates a 500V generation for insulation testing and a null balance bridge for very accurate resistance measurement. Ex B.T. in quite good condition with data & tested. Yours for a fraction of original cost **£45**, Order Ref. 45P2.

EXPERIMENTING WITH VALVES don't spend a fortune on a mains transformer we can supply one with standard mains input and secs. of 250-0-250V at 75mA and 6.3V at 3 A. **£5**, Order Ref. 5P167

15Watt 8ohm 8" SPEAKER & 3" TWEETER made for a discontinued high quality music centre, give real hi fi, and for only **£4** per pair. Order Ref. 4P57

WATER PUMP very powerful and with twin outlets, mains operated, **£10.00**, Order Ref. 10P74.

0-1MA FULL VISION PANEL METER 2¾" square, scaled 0-100 but scale easily removed for re-writing **£1** each, Order Ref. 756

Vu METER illuminate this from behind becomes on/off indicator as well, 1½" square **75p** each. Order Ref. 366.

EDGE-WISE PANEL METER ideal when short of panel space only 40 × 14mm, also have built-in led, 500 uA fsdd, scaled 0-5, **£1** each. Order Ref. 131

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CIRCLE NO. 180 ON REPLY CARD

POWER SUPPLY SENTINEL

Unsteady supplies and voltage glitches create havoc with microprocessor-based systems and other sensitive devices. Even powering up must be done in an orderly fashion. Philip Darrington shows how Dallas Semiconductor's new auto-reset device tackles both jobs automatically.

Depending on the precise role of a microprocessor, disturbances on its power supply line normally require a reset. A reset push-button is one answer, but requires several extra components and an awareness that something needs to be done in the first place.

The Dallas Semiconductor *DS1233* and *DS1233A EconoResets* do the job automatically for 5V and 3.3V circuits respectively.

The device continuously monitors the microprocessor's power supply voltage and compares it with a temperature-controlled reference. On detecting a departure from nominal voltage of more than 10% or 15%, depending on which version is in use, the device emits a 10mA minimum reset signal, which is maintained for 350ms after the power supply has regained its proper level.

The system application diagrams shows the /RST monitor line keeping a watch on the reset line, on the lookout for a manual reset applied by a push-button. If it detects a low-going edge from the switch, the edge is effectively de-bounced by the *EconoReset*'s pulling the reset line low. It continues to monitor the reset line after the delay has finished and, on finding that the button has been released, takes reset low for the 350ms. For proper operation with an external reset switch, a capacitor between 100pF and 0.01µF must be connected between /RST and ground. In applications where additional reset current is required, a minimum capacitance of 500pF should be used along with an external pull up resistor of 1kΩ minimum.

The upper timing diagram shows the button release (the hump in the middle) detected and followed by the 350ms active reset time.

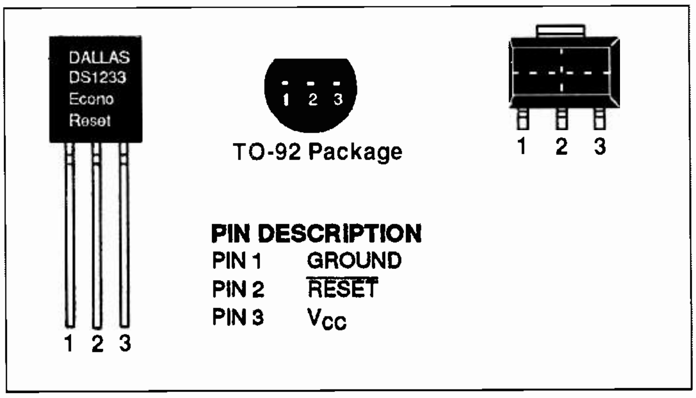
On power up, the device imposes a 350ms delay after it detects the power voltage rise to within operating tolerance before releasing the reset line (lower diagram). This provides time for the power supply to stabilise after switch-on. The *DS1233* draws 50µA in normal operation.

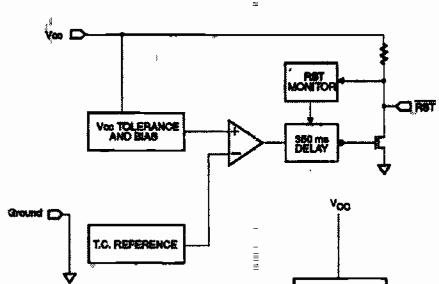
Clearly, the device may be used for purposes other than MPU power supply monitoring and reset. For instance switch debounce or power supply monitoring and protection. ■

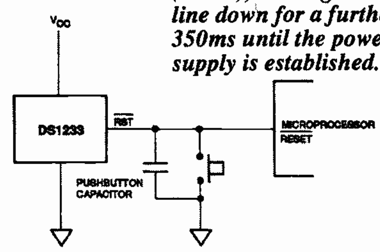
EW + WW professional services offer – FREE SAMPLE

If you would like a free sample of the DS1233/A, just fill in the special coupon located between pages 936 and 937. If your application is out of the ordinary, write and let us know about it. We will publish the more interesting ones.

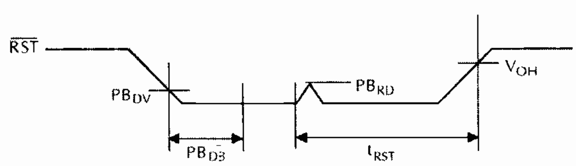
Note: issuing of samples and data as part of this offer is being handled directly by Dallas Semiconductor UK Ltd.



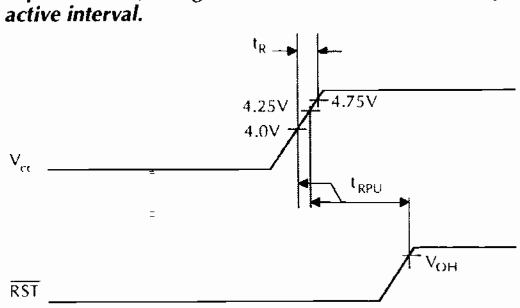




Dallas's DS1233 monitors micro's voltage supply and resets micro if voltage departs from nominal level. The device can work with a push-button reset (below), holding the reset line down for a further 350ms until the power supply is established.

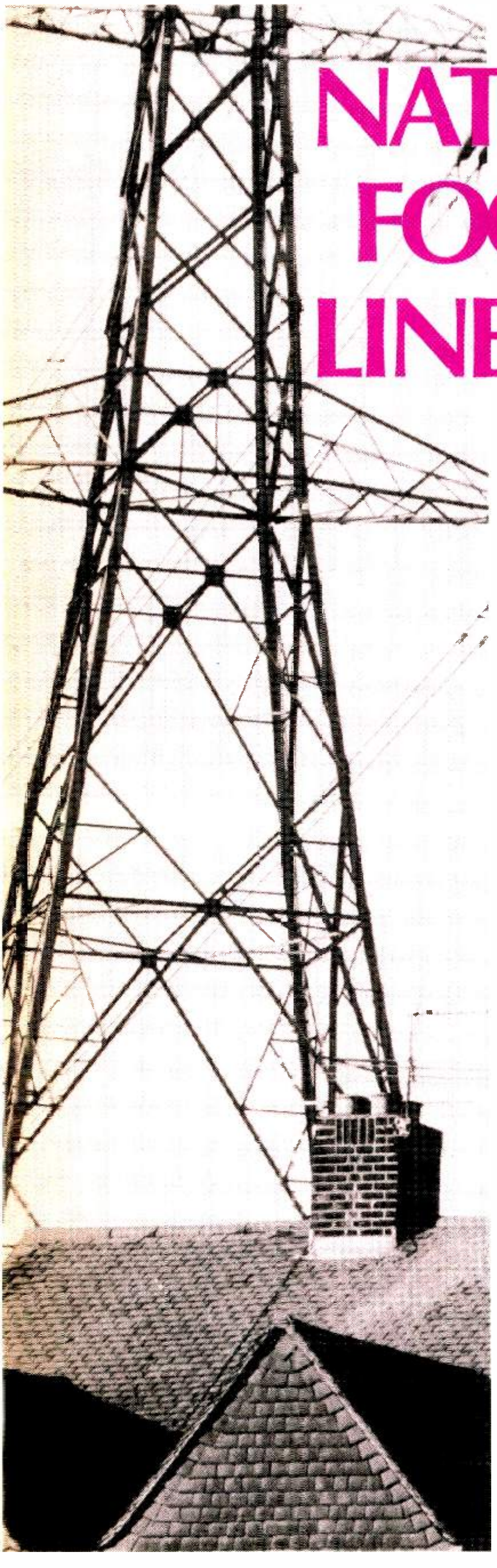


Timing in the device. When the DS1233 detects a falling edge, it first debounces the push-button, recognises the button release and imposes a 350ms reset active interval.



On power up, reset is active until power line is steady.

NATURAL RADIATION FOCUSED BY POWER LINES: NEW EVIDENCE



Cancer risks from radiation are well established. Anthony Hopwood turns the power line debate on its head with evidence showing power line fields can concentrate background radiation to damaging levels.

Scientists searching for a mechanism to explain increases in the incidence of cancer among those living in close proximity to power lines could have been looking in the wrong place. New evidence suggests that instead of trying to find an as yet unproven cellular reaction to the presence of the powerline's magnetic fields, researchers should investigate power lines as concentrators of potentially damaging natural sky radiation. If accepted, a clear link between a known biological cell damage mechanism and power lines will have been established, triggering a reassessment of the independent studies recording statistical increases in cancer incidence around power lines.

The evidence stems from recordings showing concentrations of background solar radiation under power lines – a direction of enquiry prompted by a chance observation made during a British Astronomical Association experiment.

The effect appears to have remained undiscovered because cosmic ray researchers have focused on ultra high energy particles, deliberately screening out the biologically destructive low energy particles. It has also escaped environmental monitoring agencies like the National Radiological Protection Board because they use carefully sited vertical axis Geiger tubes – an arrangement that could have fatal flaws for these type of measurements.

The worrying aspect is that overhead power lines could be concentrating the biologically most destructive lower energy particles along their length, exposing those living and working nearby to at least double the normal sky radiation dose. During periods of high solar activity, the situation is even worse, with whole body irradiation rates increasing many times during major solar flares.

Although the sky radiation levels near power lines are within current safety limits, the large population affected is likely to show a small but statistical increase in radiation-associated disease, because no lower level cut-off for radiation damage to human cells has been formulated.

Aurora clue

The first clue to the variability of low energy sky radiation came from work in the Aurora Section of the British Astronomical Association, which was at its most productive during the sunspot maximum of 1989-90. To help predict the magnetic storms which cause aurorae, a Geiger counter on a tall pole was set up to detect the solar eruptions that provide the particle blast that generates the aurora. The tube was initially oriented East West, with its long axis horizontal, in the mistaken belief that this would be the best way of detecting direct solar radiation.

First results from the detector in late 1990 were disappointing. For several months the rate stayed stable with a total background variation of less than 2% even though solar activity reached record levels.

In January 1991, the detector tube was turned to a geomagnetic North South axis. The effect was immediate, with variations in sky rate exceeding 50%. For the first time the count increased visibly as an active sun rose, and there were changes in rate caused by geomagnetic storms.

But other effects showed up too. Charged shower clouds caused a particle count transient as the electric field front passed over the detector, and during the aurora of 8/9 November 1991, the counter recorded a large sky particle peak as a direct auroral ray passed overhead. (**See Figs 2** and **3**).

It was this chance observation that confirmed that the geomagnetically aligned low energy secondary charged particles picked up by the detector might also be influenced by other artificial electric and magnetic fields. So a portable Geiger counter was built to find out how power lines affected incoming low energy particles

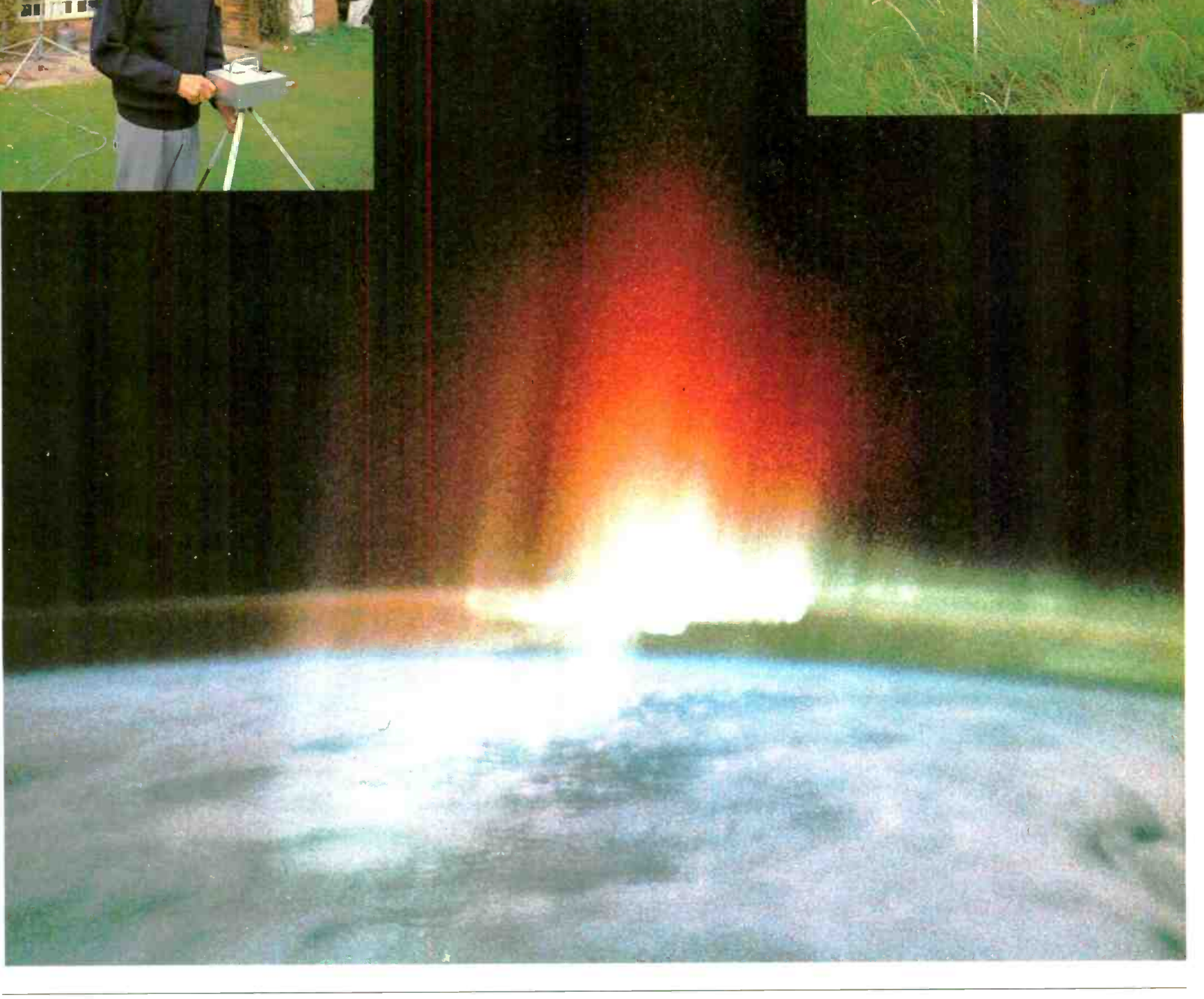
Measuring the power line effect

The instrument is conventional apart from the horizontal setting of the tube. As with the fixed installation previously mentioned, it takes advantage of the directional properties of a long thin Geiger tube set horizontally in an aluminium sleeve. The sleeve serves as an electrostatic screen and weather shield.

The method of measurement is very basic. The counter is placed on a tripod. Its axis and exact location are noted as well as the start time of the observation. The time taken for the instrument to count to 500 is recorded on a stopwatch, and this figure is later calculated as a count per minute. The result is also checked

Anthony Hopwood investigates the focusing effect of power lines.

The Earth's magnetic field bends low energy charged particles from the sun to produce aurorae. Magnetic fields from power lines bend and focus low energy particles – which make up much of our background radiation – in the same way. Picture shows the Aurora Australis (Southern Lights) as seen by the crew of Shuttle Discovery during Mission STS-39 28 April-6 May 1991 (NASA -SPL).



against the continuous count record for the same period to check for sky rate anomalies caused by solar flares

Hundreds of readings have been taken around power lines up to 33kV.

They show that power lines have a very strong effect on the secondary particle sky radiation under and near them. The width of the affected zone varies with line current: on one 3-phase 6kV line, the zone of maximum sky count moved from 8m from the centre line to 12m as local residents cooked their Sunday lunch!

8m up, even a domestic 240V line to an individual house will double the sky count, causing it to move up to 3m from its centre line. A tent or umbrella analogy is a reasonably accurate one, but the counter showed up two distinct particle deflection effects inside the zone of electrodynamic influence.

Although an overhead power line carries current and voltage waves which alternate 50 times per second, the effect is averaged because the particles travel so fast that they only respond to the instantaneous electric and magnetic field as they pass. This averaging is differentially detected by the directional properties of the long Geiger horizontal tube, and will not show clearly on the small portable vertical tube Geiger counters widely used for environmental monitoring.

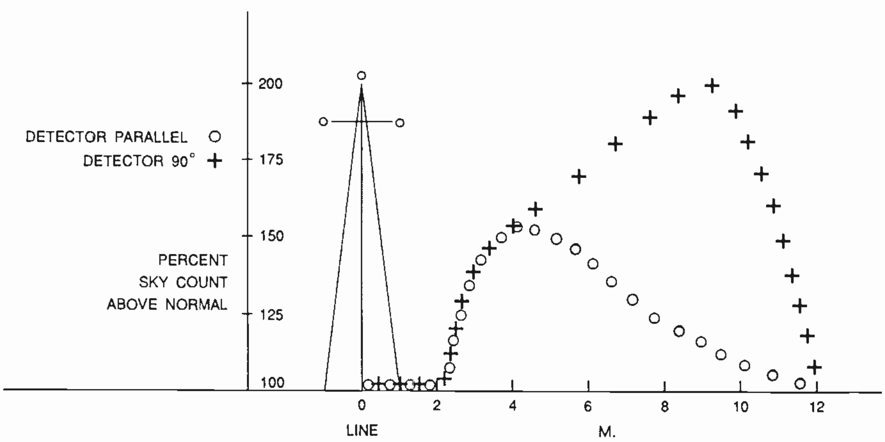


Fig 2. Graphic representation of typical 6kV 3-phase line effect on sky particle count. Note difference in detection rate between Geiger tube parallel to line O, and at right angles +. The + rate probably shows particles aligning to the instantaneous electrodynamic field like a linear motor. The O rate may show the mean deflection of particles when the current/voltage wave is weakest.

Directional differentiation

This directional discrimination makes it possible to examine the structure of the power line field effect by varying the position and alignment of the portable detector.

Directly under the centre of a typical 3 phase 6kV overhead line, it was discovered that there was a band about 4m wide where the sky count for all detector axes was normal background. At 4m from the centre on both sides, the sky count peaked at +50% for a detector set parallel to the line, tailing gradually down to normal background at 12m from the centre line.

When the detector axis was set at right angles to the line, a different effect was noted.

BACKGROUND OF CONCERN

The continuous particle bombardment to which we are all subjected – popularly known as background radiation – has four main sources. Most is from the ground and varies with geology. Areas of young granite containing uranium and thorium can show a background many times that of a "quiet" area, and buildings made from naturally radioactive materials can significantly irradiate those living in them.

The second major source is the Sun, a fusion reactor converting a million tons of hydrogen a second into light, heat, ionising radiation and fresh fuel. The Sun gives us about a third of our lifetime radiation dose but the actual dose rate varies widely during the 11 year sunspot cycle – which last peaked in 1989-90.

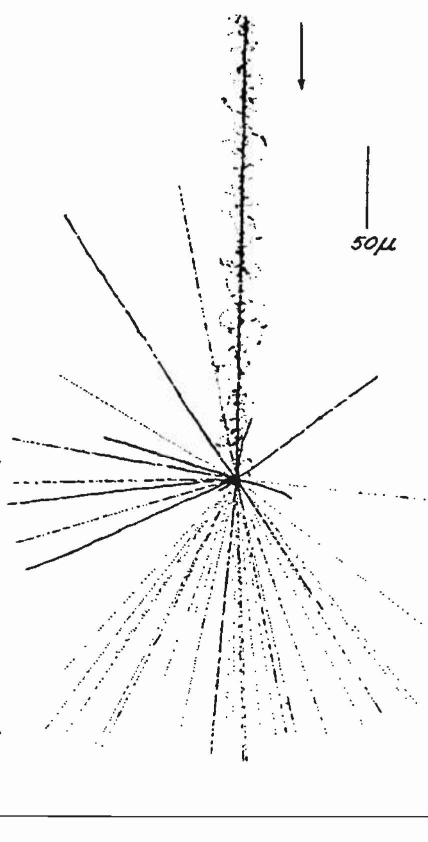
The rest of our dose of radiation is split between two other sources. The main one is the Galaxy. The cataclysmic process of star formation and destruction blasts the Earth with ultra high energy particles that may have come from a supernova or galactic collision that took place millions of years ago. These particles, and those that come from the Sun, are true primary cosmic rays and have so much energy that they shatter any nucleus they hit, generating a shower of nuclear fragments that can irradiate an area of several hundred square metres on the ground (**Fig 1**).

The remaining source of background radiation consists of artificial radio isotopes and X-rays encountered at work and in medicine, plus the residual legacy of contamination from atmospheric nuclear testing and Chernobyl. Despite popular belief, this now accounts for less than 1% of typical human lifetime exposure in the UK.

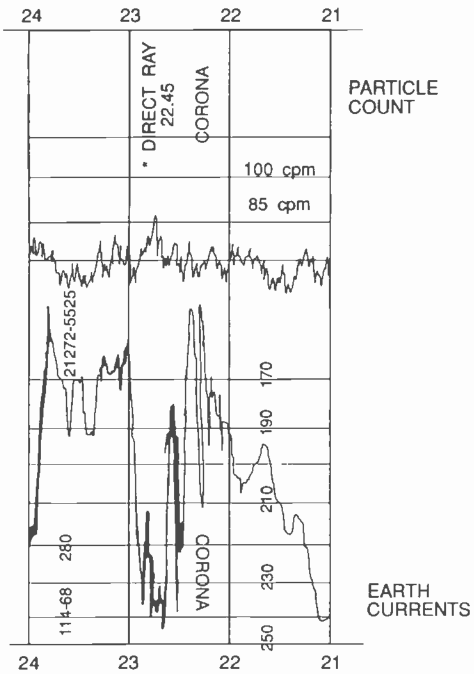
Solar and cosmic radiation – or sky radiation – can vary from about a third to many times typical background levels, depending on circumstances. It is generally agreed that the earth's electric and magnetic field causes a primary (over 2 x 10^{10} electron-volts) cosmic ray intensity variation of less than 2% between the Equator and the poles. This figure derives from cosmic ray research carried out on ultra high energy primary particles, which could not be generated artificially on earth.

For the main part, the lower energy secondary particles which reach the ground and contribute much of our background radiation dose have been ignored. However, the ground level variation in low energy sky radiation is much greater than the 2% figure given for high energy primary particles.

Fig 1. Tracing from an automicrograph of a high energy primary cosmic ray collision captured on a photographic plate. The primary particle was probably a silicon nucleus. The fragmentation products were not silicon chips! The light tracks would be energetic fast particles like mesons, protons and alpha particles. The heavy black tracks would be slower low energy particles created from the disruption of residual nuclei. The impact nucleus was probably silver or bromine in the photographic emulsion. Source: Intensity Variations in Cosmic Rays. D.C.Rose 1957.



COMBINED EARTH CURRENT AND LOW ENERGY PARTICLE COUNTER LOG FOR AURORA ON 3/9 NOVEMBER 1991



The sky count rose by 60% 5m from the line, peaking at double the normal count 8m from the line. The sky count then tailed off rapidly to reach normal at 12m from the line. The figures have been averaged from many hundreds of observations, and represent a a typical effect of a three phase line crossing open fields (see **Fig. 2**).

The effect for higher voltage lines has not been scaled due to problems with access. Since the affected zone for a 33kV line extends at least 25m from the line, it seems reasonable to extrapolate that there will be enhanced sky radiation at much greater distances for 300kV "supergrid" lines.

From the field measurements taken, it seems that line current is the significant variable parameter. The voltage effect will be significant, but constant, as will the height of the line. The most surprising result is that, from a sky radiation point of view, the best place to be is right under the wires!

Fig 3. Chart recording for the same event as that referred to in Fig. 2 from geomagnetically aligned Geiger tube. The plot shows background particle rate rise (top trace) and simultaneous geomagnetic earth current transient caused by local ionospheric particle beam effect.

Why the Geiger counts

A Geiger counter is the best known type of radiation detector. It does not detect all types of radiation, only those that can trigger an electrical discharge in the detector tube as they penetrate it. A convenient way of measuring nuclear radiation is to count the discharges in such a tube. This gives a direct measure of radiation intensity, from which an accurate dose rate can be calculated after applying various corrections.

Every day, millions of atomic particles pass through our bodies. A Geiger tube with a detector volume of a few millilitres generally detects about 20 sky particles every minute of the day or night.

More research required

More detailed research involving sophisticated equipment will be needed to fill in the fine detail of power line/sky radiation interaction, and to pinpoint locations where the effect is most marked and likely to irradiate large populations.

In the meantime, it seems reasonable to ask that no more supergrid lines be erected by the power companies close to houses, schools and factories. Instead, lines that can be shown to irradiate heavily populated areas should be installed underground. ■

REGULARS

LETTERS

Distorted proof

I am writing in response to Ben Duncan's article, "Proof for the Golden Ears Hypothesis", (*EW + WW*, June 1992). My first comment is about his choice of test frequency. It was really clever to get distortion spikes falling on grid lines so we cannot clearly determine their levels! Well, all is not lost.

In the last paragraph on p466 Mr. Duncan says that figure 2 clearly documents differences that corroborate the audible change, and odd harmonics – above the 9th – slope off monotonically with the modified circuit. I do not agree with either suggestion. It is because Duncan has chosen 1kHz as a test frequency that his harmonic spikes all lie on graph grid lines; hence it is virtually impossible to determine their amplitude accurately.

If the test frequency was shifted by a small amount, Δf from 1kHz, then the nth harmonic would be shifted by n times this amount, ie nΔf. As the 13th harmonic line is almost exactly on the 13kHz grid line we can tell the test frequency was probably within a few Hertz, less than 10Hz, of 1kHz. Since graph frequency resolution is only about 20Hz, it is not possible to read the amplitude of the harmonic spikes with any degree of accuracy. We see artefacts due to the non zero resolution bandwidth of the spectrum analyser.

Apparent differences in amplitudes of harmonics above the 9th, such as 11th, 13th and 15th, are considerably less than fluctuations due to noise. These harmonic spikes are only about 6dB above the grass, and variation in noise spikes between both graphs can be 10dB or more. Check it out around 9.3kHz, 10.3kHz, 12.4kHz and 13.2kHz. All one can reliably say, with regard to the odd harmonics above the 9th, is that some of them are visible above the noise, and Duncan's suggestion they "slope off monotonically" cannot be supported with the graphical evidence presented.

As for even harmonics, I agree there does seem to be a significant increase, borne out by figure 3.

So where does that leave us? Assuming the presented information is accurate, I think we would all agree using "reversible elcap" increases the amp's THD by about 50% (3dB). Not surprising, as most electronic equipment designers would tell you electrolytic capacitors do not have *V-I* characteristics which are symmetrical around zero, even at dc.

For this reason it is foolhardy to use electrolytic capacitors in situations where they may become reverse biased, and it is probably this mechanism of generating distortion which contributes to relatively poor performance from some amplifiers. It is an all too common mistake made by many designers of hi-fi gear. Duncan has introduced a non-linear component into the amp and its effect is to increase distortion, most notably even harmonic distortion, and therefore also intermodulation distortion.

It is widely known that even harmonic distortion is not altogether unpleasant. Not surprising since the second, fourth and eighth harmonics lie one, two and three octaves, respectively, above the fundamental (ie, are musically related to it). In many circumstances even the sixth may be as well, which is probably the main reason for some people finding valve amps sound more pleasant and "sweeter" than transistor amps.

It is hardly surprising some people would find modified *DVT-50*s more pleasant, assuming they really can detect a difference. If hi-fi power amps contributed no distortion whatsoever, the nature of the circuit and devices used would be irrelevant, and very nearly state of the art. Speaker distortion is far more significant in most hi-fi setups than amplifier distortion.

Duncan gives us no reason why increase in distortion should give us "sonic benefit", but expects us to simply believe it does. As outlined, there are well established reasons why modified amplifiers might sound *preferable* to some people, but this does not mean they have superior performance.

Duncan has failed to provide any evidence that the modified amplifier offers superior performance. If anything, the evidence suggests the opposite. He has provided us with evidence which shows that many subjectivists or "golden eared" ones like their music coloured with a little even harmonic distortion. Ironically it often seems to be the same crowd that berates us for using tone controls because they colour music.

Duncan says figure 3 shows how a traditional *THD+N* vs frequency measurement misses the point. Unfortunately it is Duncan who misses the point. Once again, supporters of the golden eared ones have failed to interpret data correctly and once again they have ignored the facts. Until they can come up with some real evidence, or accept evidence against them, the sooner they will be taken seriously.

In the mean time, some of us will have a good laugh, and I will continue to listen to my music with as little added distortion as possible.

Phil Denniss
University of Sydney
Australia

Crash solutions

I too suffered intermittent 'crashes' on my old Mitsubishi PC a few years ago, after re-siting it within the house. An attentive ear noticed the fridge/freezer switching off at the time of one of the crashes, and later, toaster 'popping' also froze the system. The PC's eventual demise was, I believe, due to the use of a vacuum cleaner on a nearby socket.

The lesson must be not to trust PSUs of older PCs and to site PCs' power points far away from sources of electrical noise. Use a capacitor/inductor filter to reduce line noise input to the PC and use filters on offending domestic appliances too, to prevent noise entering the mains.

Perhaps a suitable authority on the subject could produce an *EW + WW* article on the use of C_x, C_y capacitors and flux-cancelling inductors!

Mike Whittaker
Cumbria

Speakers in series

It is often suggested that audio speakers be connected in series (or in a parallel/series lattice) in order to present an acceptable load to the amplifier. But this can have disastrous effects on sound quality, as the following experiment demonstrates.

Speakers being linear motors, connect two small identical dc motors in series and apply a dc voltage. You will find the motors do not run at half-speed: only one motor actually works! In addition, you can 'flip-flop' the active motor by applying a small breaking force to it.

This instability makes it doubtful that speakers connected in series would reproduce sound evenly, unless they are exactly matched and have the same enclosure, damping material and room location!

Instead I would recommend using a step-down auto-transformer for each speaker, all connected in parallel at the amplifier; the secondary winding of the 70V line transformer carried by Radio Shack can be used for that purpose.

P C Meunier
Cambridge

Acro prob

Your editorial offering advice to authors intending to submit material for publication in your journal prompts me to raise a topic which has been in my mind for some time.

It has become fashionable in all forms of journalism, and particularly in its technical branches, to make extensive use of acronyms. There is, of course, nothing wrong with this per se: it provides a convenient form of shorthand which avoids tedious repetitive writing (and reading) but, unless the acronyms are made explicit, they can present an almost impenetrable barrier to anyone who is not familiar with them. It should be remembered that constructing acronyms is relatively easy but reverse processes are difficult and time consuming at the very least.

I would like, therefore, to suggest, that, in addition to the points mentioned in your editorial, authors should be urged to provide a glossary covering all acronyms used in their text. This could take the form of an appendix or a separate box for easy reference.

Alternatively, each acronym should be spelled out fully when it first appears - even if as often happens, this is in the title.

A few writers do help in this way but it would be useful if some consistent practice could be established.

E N Martin
Cleveland

Renaissance Science

Is Mr Ivall, (*EW + WW*, Letters, September 1992), seeking to clarify modern-day confusion over time, or merely to remark that there is nothing new under the sun? If the former, what little he says seems likely to deepen bewilderment, not disperse it!

The proposition that time exists only as a consequence of action in the physical domain raises many questions: does existence apply to an extension within the space of the universe, or to endurance outside it but in the realm of the mind?

Such a question is within the province of metaphysics, which engages philosophers' interest, but, I would suspect, practitioners of modern science and technology would rather "subversive" probing of philosophers be confined to the back waters of the humanities, lest a searing stab of moralistic illumination bring some discomfort to physicists cocooned by the cosy "fug" that now surrounds their discipline.

Suppressing all enquiry into relativity theory can hardly be defended as an act of piety and high principle, after all! Its viability as the paradigm of modern science is at stake should there be any doubt that time is an element of the physical universe, with definite characteristics including forming a continuum, when "combined" with space, which mediates in the functioning of material entities. Hence time's existence in consequence of action in the physical domain cannot be taken for granted by physicists, even if it is strictly beyond their province.

Philosophy requires examination of time which is not a component of the material domain but is absolutely a mental concept, albeit indispensable to life. To deny an entity all physical attributes is not to dispose of its existence: for instance my acutely felt heartache may manifest no definitive trace in the material universe, yet to me its existence is all too real!

Within metaphysics it is realised that our mental images have no extension in the space of the physical universe, but without the order allotted by temporal intuition, all meaning and intention is impossible. Under the impression of sensations given by an "unfolding" of the material world, which is an expression of its essential characteristic, we discover a means of relating physical action to mental operation, by means of synchronisation.

Failure of scientists to grapple with such metaphysical concerns leaves them vulnerable, not only to abuse by opportunist theoreticians like Professor Einstein, but also to the persuasive assertions of ambitious zealots of religion and superstition. Under the sway of mystics, rather than making a stand on philosophical principles, we have lost the way to our Brave New World; it protects us from the stimulation that would drive us to new endeavour towards a deeper appreciation of our world, both "outer" and "inner".

The stimulation which ultimately fires us is that of the moral challenge: scientific endeavour requires persistence, devotion and, above all, honesty. Beware of the subversion of honest philosophers, and prepare a draught of hemlock, you bringers of progress!

We would all do well to follow Ivall's example, and to study ideas of ancient philosophers: they belonged to societies who could at least contemplate the continuity of mankind!

C Francksen
Farnborough

Lipschutz's leap forward

With regards to Phil Darrington's article, "Pursuing A Lost Course" (*EW + WW*, May 1992) I would like to put the point of view of a member of a Main Force Bomber Command crew.

Bearing in mind the primitive navigation tools available at the outbreak of the war, "*GEE*" was an enormous step forward. But, in training around the British Isles and in early months of operation against the enemy, crews were soon shown the other side of the coin. Range was restricted and interference tried navigators' skills in reading the almost invisible Blips in a phalanx of "Railings" and the like. *GEE* continued in use until the late fifties with civil airlines and the military.

The same cannot be said of *H2S*. It was an excursion in a similar direction to that taken by Captain Lipschutz: a moving map display in the form of display tube and scanner. At its best, when crossing coasts, the display looked very much like an early type of weather radar. In my experience, service was not very good and the Germans were soon to turn radar transmission to their advantage.

Finally, despite the shortcomings of these aids, navigators kept within a relatively short distance of track whilst PFF target marking provided beacons visible for a hundred miles on a good night.

If Lipschutz's invention had been put into production alongside *GEE*, a great leap forward would have occurred.

G A Perrott
France

Not in competition!

Sir Edward Fennessey's reply (*EW + WW*, July 1992) to Philip Darrington's article, "Pursuing a Lost Course" (*EW + WW*, May 1992), on my air navigation work is of great interest, but he does slightly miss the point. As Darrington said, both *GEE* and *Oboe* were jammed quite quickly, in a matter of months and TRE was obliged to develop newer versions with a spread of frequencies, or centimetric wavelengths. Indeed, Germans captured an experimental *GEE* system even before it was officially in service, and were using our own *GEE* system against us by 1943. *H2S* was claimed by General Beppo Schmid to be a great mistake, since it had given away our bombers' position after his predecessor General Kammhuber's radar chain had been put out of action. These systems were a great improvement over earlier needs to rely on DR navigation. Yet, even as late as spring 1945, Albert Speer, the German armament minister (quoted in The Listener, April 6, 1978), believed we were "still not able to attack, for instance, the factories of the ball-bearing industry in night-time effectively".

My offer of displaying an aircraft's position on a map was *not* in competition with either of these systems: it pre-dated both and could have been in service in 1939-40. Development time would have been short, since my own instrument took only two afternoons to construct. Methods of dealing with interference were also included in its design. As the article points out, my radio system was simply a 'taster' for a jam-proof inertial navigation system that I had designed some years previously.

My offer was declined without serious consideration at a time when such equipment was desperately needed. The dismissive way it was done caused me to hesitate in making additional offers of advanced technology such as design work on jet engines, and on internal combustion engines that would provide much greater power output than existing devices. Several of these engines were actually built in the RAF Met.Service workshop, arousing considerable interest. While enhancing my reputation, these did not result in any action towards helping the war effort - the incentive for my work in the first place.

Since nothing appears to have been learnt from my own experiences and those of people such as Sir Frank Whittle, who suffered roughly similar treatment, it seems certain British industry will continue to decline; the power of "not invented here" syndromes is so overwhelming it seems futile to disclose any discovery or invention of major importance. The more advanced it is, the louder doubt is expressed with regard to its feasibility; it is ignored, suppressed or, eventually, pirated.

Meanwhile, my 'U-Plane' patent (*EW + WW*, March 1988) has been taken up commercially abroad and by foreign naval designers. As Whittle found, you can take a horse to the water, but.......

Capt. Heinz Lipschutz
Rhoose

The plot thickens

Greg Ball (*EW + WW*, May 1992) asserts I have lost the plot regarding problems of *PSRR* and the contribution of injected distortion from power supplies caused by class AB output stage commutation. I do not believe this to be the case and concur with much in Ball's discussion. Many of the points raised are well understood by a number of designers.

For example, I agree that power supplies can be over-specified. Where using large value electrolytics connected by widely spaced conductors, the inductive component in the supply's source impedance is increased. More modest but "wider-bandwidth" capacitors in close proximity to critical circuitry may actually achieve a superior performance by achieving a better suppression of the injection of hf distortion resulting from class AB operation.

Why do amplifier designers often use separate or separately decoupled supplies for output and pre-output stages? Surely to reduce interstage coupling related to distorted waveforms appearing on supplies and non-linear circulating currents which can mutually couple to more sensitive circuitry via injection, transformer action and ground rail layout problems.

For many years I have held that the principal advantage of class A amplifier operation lies not in lower voltage and current transfer errors but rather in reduced distortion appearing on the power supply, together with mutual coupling from high-level current paths injecting less correlated distortion into sensitive input and pre-output stage circuitry. Using distortion reduction techniques[4], transfer distortion generated by class AB working can be controlled to more than acceptable proportions and sonically (I believe) is not a major issue. Once interface problems associated with class AB stages and power supply interaction are properly understood and accounted for, apparent advantages offered by class A biasing virtually disappear.

As a contentious point, I do not find it surprising that some of the best transistor audio amplifiers are rated between 50 and 100W, are of modest size and run in class AB. For high-performance domestic amplifiers, large size just multiplies electromagnetic problems.

Basic analysis presented[3] enabled the supply injection to be calculated for the primitive amplifier shown in Figure 10 (repeated here where system parameters are also defined), where the closed-loop expression describing output voltage V_0 as a function of both input signal V_{in} and the supply voltage variation v_s was given by equation 17 as:

$$V_o = \frac{mg_m R_g V_{in} + R_g\left[m / Z_{n1} + 1 / Z_{n2} + r_2 (Z_{n1} Z_{n2}\right] Vs}{(1 + r_2 / Z_{n1})(1 + R_g / Z_{n2}) + kmg_m R_g}$$

Providing R_g is large, its effect on closed-loop gain is small where supply injection is dependent on the slope impedances and system gain elements. Interestingly, if R_g is replaced by a capacitor, it can aid the reduction of supply distortion injection. After all, if $R_g=O$, there would be virtually no injection, and no signal either!

Important points to observe are that slope impedances are reactive and non-linear, especially where voltage swings are a significant fraction of their quiescent bias values and supply voltage variation V_s is a non-linear function of the input signal where related to output-stage design and even nonlinearity in reactive loudspeaker load.

Analysis was meant to show the ratio of gains $\partial=(V_o / V_s)/(V_o/V_{in})$ was independent of R_g, where:

$$\delta = \left[\frac{1}{Z_n 1} + \frac{1}{mZ_{n2}}(1 + \frac{r_2}{Z_{n1}})\right]\frac{1}{g_m}$$

A small value of ∂ implies that amplifier output depends more upon input voltage than supply voltage, although a large value of mirror current gain m only reduces the effect of Z_{n2} and not Z_{n1}. Although this analysis accounts for slope impedances, it does not address problems of inductive coupling and poor ground rail design.

Power supply related injection occurs from three main factors within an amplifier topology: finite semiconductor device slope impedance, electromagnetic coupling and ground-rail errors. All of these respond to distorted supply voltages and induction from non-linear currents, flowing for example in the output devices, exacerbated by supplies with finite, complex and non-linear output impedances.The well known solutions are to use proper supply regulation/decoupling with due regard to capacitor parasitics[5], separate power supplies (if within budget), appropriate physical circuit layout and a circuit topology that has an inherently high *PSRR*.

As a suggestion, where reservoir capacitors are remote from the main amplifier, connection should be via an interconnect with a low characteristic impedance so capacitive impedance dominates and connection is effectively an extension of capacitor plates (assuming hf distortion products represent only a small fraction of a wavelength along the connection). This can also achieve a low radiated magnetic field.

Some of the problems of power supply interaction are discussed in reference 2. Interested parties should be able to obtain a reprint from the Audio Engineering Society (*reprint 2247 A-14*, 78th AES Convention 1985), or I would be pleased to supply a copy if you enclose a SAE (*Dept ESE, University of Essex, Colchester,England C04 3SQ*).

A paper by J.F.Dawson,*"EMC on a PCB"*, Proc. Institute of Acoustics, vol. 13, part 7, November 1991 contains interesting and relevant material.

Dr Malcolm Omar Hawksford
University of Essex

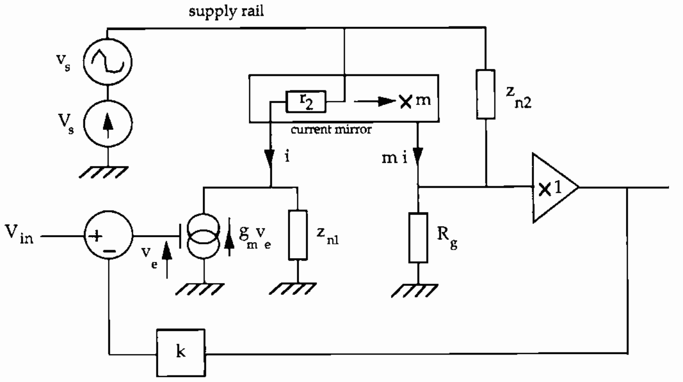


Figure taken from ref 3. Two-stage amplifier with Vs representing power supply voltage variation

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Filthy smear

As I write this, Granada TV is showing a programme called "Covington Cross". I see that it was made using the very latest (probably digital) 'smearvision' process. What an advance over VHS! I have noticed this peculiar 'softened' effect on several programmes lately, and if this is the quality we can expect from the very latest family of video production aids, then it makes a mockery of the (supposed) up-and-coming HDTV system. Just think - we'll be able to see those softened edges and smeary details in high resolution!

Seriously, can any broadcast engineer out there explain why TV pictures have got worse instead of better?

Andrew J Howlett
Cheshire

Not so dangerous!

With reference to David Goadby's letter (*EW + WW*, July 1992) regarding my article on PC Printer ports (*EW + WW*, May 1992). It is true that older models of PC add-ons used a hardwired printer port, but newer models use dedicated LSI devices like *82C11* which are fully compatible with the SSI version. I would like to emphasize that the *8255* has been used in my circuit to interface the printer port lines to the host microcomputer connected to the *8255* data/control bus.

If one looks at details of the PC printer port, use of open collector gates as output on lines STROBE, AUTO FEED, INIT and SLCT IN could easily be noticed. These lines can be put in the OFF state by software, and can be sensed through the *74LS244*, which is a facility made use of in my circuit. SLCT, PE, ACK, BUSY and ERROR lines are wired as pure input in the PC and hence there should be no problem in using them as input.

I do agree that the main output port at 378h is permanently enabled as an output and can be read back but not driven from external sources and if I correct the IC number, *LS374* is used as the output latch, not *LS240*. There are eight pure output lines, four bidirectional lines and five input lines in a PC printer port.

The reader has himself designed a system to transfer data through the PC printer port, albeit one bit a time. Mine just transfers 8 bit at a time instead. I don't think utilising PC ports' full facility can be dangerous.

R. Misra
Ahmedabad
India

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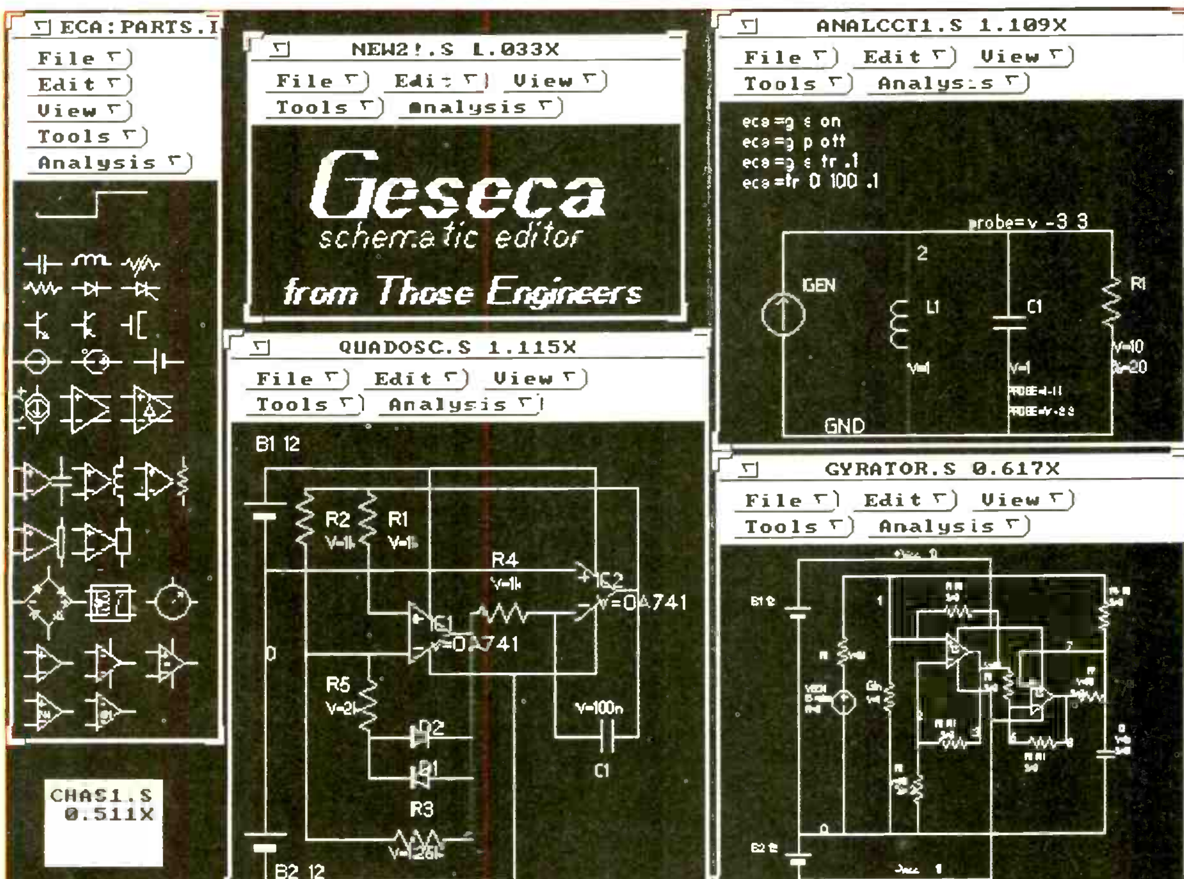

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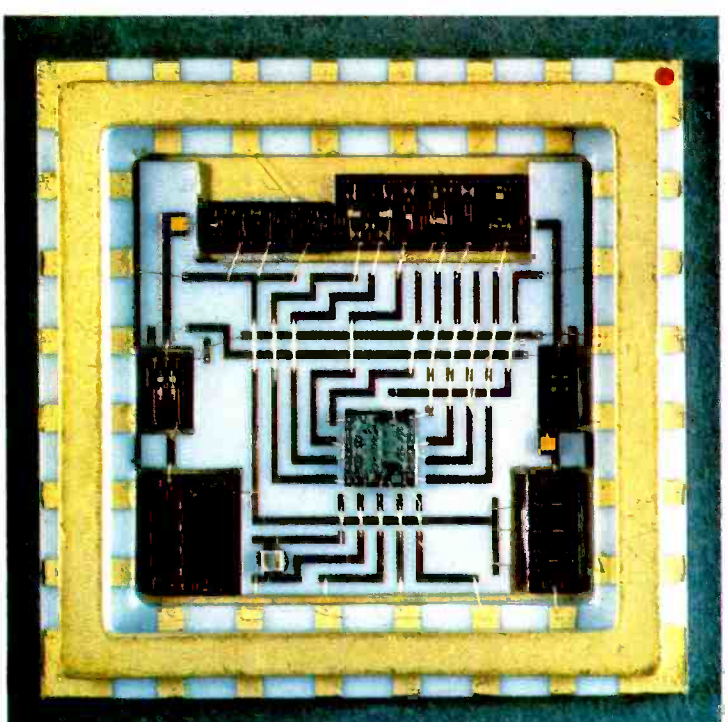
Receiver front ends traditionally use discrete components to maintain optimal noise performance. Integrated chips built on gallium arsenide are now replacing discrete components in RF amplifiers and mixers. LO functions may also be included. Tim Stanley reviews front end chips and their application circuitry.

DAVE BELL

THE RF DESIGN REVOLUTION 2: integrating the front end



Complete front end hybrid circuit module for phased array radar made with GaAs MMICs. Plessey Caswell Research

Development is focused, not surprisingly, in the microwave region. GaAs scores over Si for low-noise applications at tens of GHz offering better gain/noise performance and requires lower power. But designers must be aware of stability problems, particularly when using advanced semiconductors at lower frequencies.

Excess gain, which occurs when RF devices are operated well below their design frequency, might not seem like much of a problem. However, stray circuit reactances may adversely combine to form an oscillatory circuit at a much higher frequency than the design reactances. If the device has enough gain to sustain oscillation in the parasitic path, the result will be high frequency oscillation and generally rotten performance at the design frequency.

The difficulty for design engineers is to decide between Si or GaAs in the grey area around 1GHz – this has caused a good deal of debate over the most suitable technology for PCN handhelds.

The optimum front end

Arriving at the best solution for a specific application requires juggling with a number of conflicting but critical parameters.

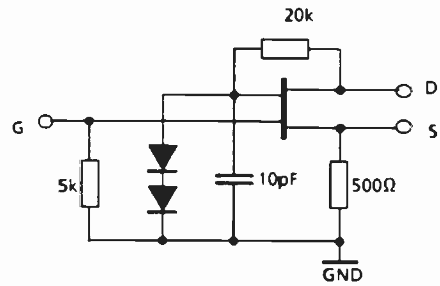
The obvious one is the noise performance of the early receiver stages, particularly the first. The associated gain is also important – the higher the gain, the less further contribution to overall noise will there be from the second and subsequent stages. Hence the noise figure/gain combination is important. However, strong signal handling is also an important consideration since the radio spectrum is increasingly cluttered with powerful adjacent frequency transmissions.

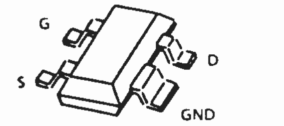
This hazard is prevalent at HF but may also be significant at higher frequencies where lower atmospheric noise allows the use of higher overall system gain. And strong signal handling varies inversely with overall system gain. Thus, high sensitivity can be achieved using low-noise devices, but this will usually be at the cost of the receiver dynamic range, i.e. its ability to receive weak signals in the presence of strong out-of-passband signals which cause receiver non-linearity and hence interference products within the passband.

Input filtering becomes important but, in general, the more effective the filtering the greater its insertion loss and the associated degradation of receiver sensitivity. (1dB loss adds 1dB to the noise figure by reducing the signal to noise ratio by 1dB at the receiver detector. The degradation can be worse in practice, as explained in the previous article). Noise figure, gain and dynamic range are difficult to reconcile with increasing device design frequency.

For small handheld battery operated equipment, the requirement for low power consumption becomes significant and dynamic range will be sacrificed for this.

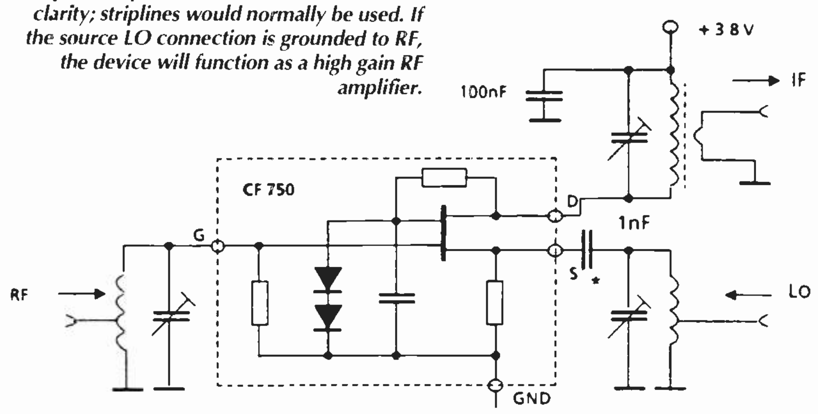
To aggravate the noise/gain issue, a GaAsfet's noise performance is affected by the impedance presented to its gate(s). Unfortunately, minimum noise does not coincide with maximum input power match, and hence for optimum signal-to-noise performance, the input matching network has to be designed carefully for the best trade-off. Also, special attention to stability has to be given when using GaAsfets towards the lower end of their useful frequency range (typically at VHF).





Siemens CF750 GaAs mixer chip and application circuits. This low cost device provides good conversion gain up to 3GHz

Fig. 1. CF750 mixer application circuit. The lumped component reactances are shown for clarity; striplines would normally be used. If the source LO connection is grounded to RF, the device will function as a high gain RF amplifier.



MMICS for DBS Satellite Receivers.

Already about four million Ku-band (roughly 11 to 14 GHz) receivers are in service, and it is estimated that the potential world market to 1994 is a further 16 million.

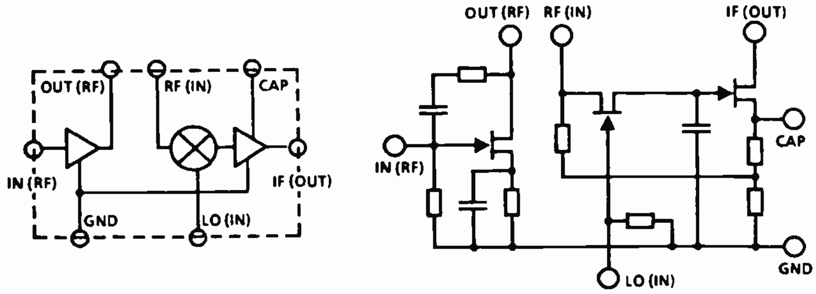
Development of MMICs doesn't appear to have reached the point of providing sufficient noise figure/gain combination to replace discrete modfets for the first stages of RF amplification. A Ku-band noise figure of 1.3dB or better is considered the minimum requirement for the complete low noise (converter) block. Best results for MMICs as an RF preamplifier appear to be 1.76dB noise figure with 28dB gain. Also, this required a chip area of $8mm^2$, thus being far more expensive in chip production than the $0.0625mm^2$ required for a discrete modfet.

MMICs for the LNB mixer and oscillator are more successful. A converter SSB noise figure of 8.5dB for conversion gain of 5.5dB has been achieved on a $0.45mm^2$ chip, together with a 10GHz oscillator with 16dBm output level and an SSB phase noise of –80 dBc/Hz at ±10kHz on a $0.81mm^2$ chip. Oscillators for these LNBs do not need to be tunable and therefore can be stabilised by external dielectric resonators. (Ku-band synthesisers have been realised in MMICs; these, and resonators, will be covered in later articles).

Table 1 Performance summary of some GaAs MMICs

Manufacturer	Type number	Noise dB	Gain dB	Test frequency GHz	Bandwidth GHz	1dB compression dBm	3rd order intercept dBm	Port impedance	Package	Supply mA/V
GaAs Low Noise Amplifiers										
Avantek	MGA 62100	2.5	14	4	2 - 14	+12.5	-	50	Chip	-
Hewlett-Packard	HMMC 5206	5.0	9.5	14	2 - 26	+21	-	50	Chip	-
Siemens*	CF 750	1.9	10	1.8	0.4 - 3	-	+9	-	SMD	2/3.8
Toshiba	TG 2000F	2.5	17	0.8	-	-	-	-	SMD	
GaAs Mixer										
Siemens*	CF 750	4.5	15	0.9	0.4 - 3.0		+10	-	SMD	2/3.8
GaAs Front-End (RF amp., Mixer and IF amp.)										
Siemens*	CMY 90	5.4	12	1.8	0.4 - 3.0		+6.5	-	SMD	2/3.8

*Preliminary data.



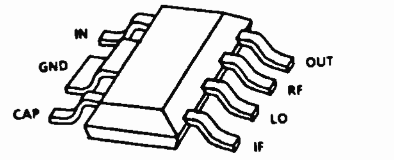
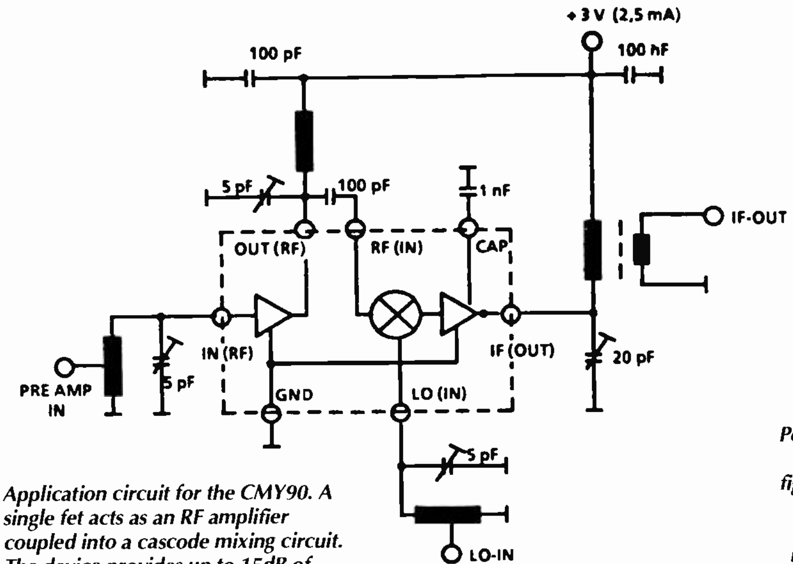
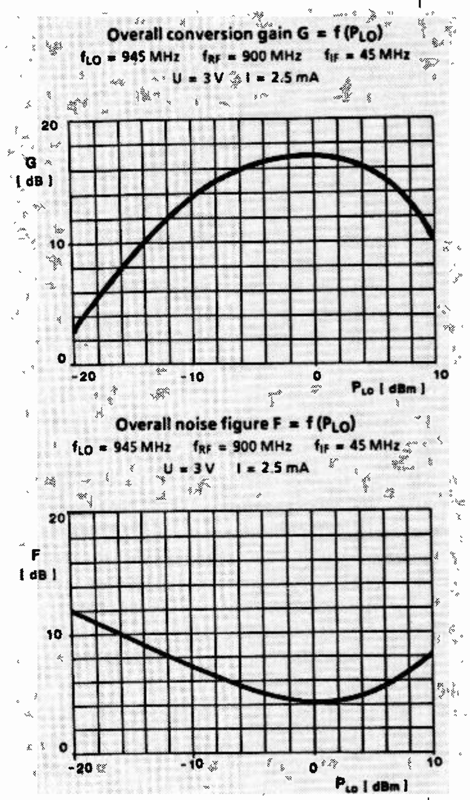


Fig. 2. CMY90 complete GaAs integrated front end.



Application circuit for the CMY90. A single fet acts as an RF amplifier coupled into a cascode mixing circuit. The device provides up to 15dB of conversion gain at 900MHz while drawing just 2.5mA from a 3V supply making it ideal for portable phones.



Power gain and noise figure plots for the CMY90 integrated front end.

Siemens GaAs Series

The Siemens GaAs range of front end devices may settle the GaAs/Si dilemma. Worthy of particular note are the *CF750* and *CMY90*. Supply requirements of 2.5mA at around 4V for the three stage front end chip together with good low noise performance should make them particularly attractive for hand-held/ battery operated equipment applications, e.g. PCN. The *CF750* is a single GaAs transistor with on-chip biasing in a surface mount package 4mm long. Input and output matching circuits are required. **Fig. 1** shows application circuits for mixer use.

The *CMY90* comprises input RF amplifier, mixer and IF amplifier, providing 15dB conversion gain at 900MHz with 4.5dB noise figure in a surface mount package less than 7mm long. Application details are given in **Fig. 2**.

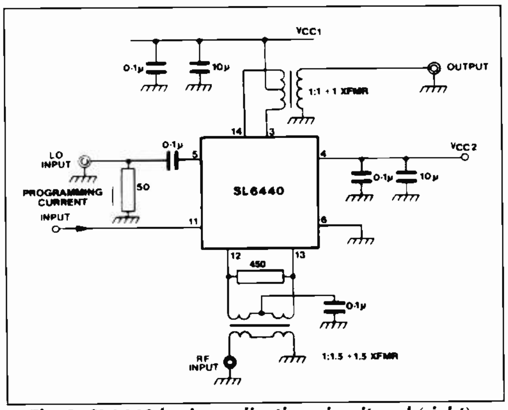
High-level Mixer – SL 6440

This device from GEC Plessey Semiconductors tilts the performance balance towards dynamic range. Comprising bipolar transistors, it offers a third order intercept point of +30dBm (1dB compression at +15dBm). Although only usable to 150MHz, strong signals tend to be increasingly prevalent with decreasing frequency: the device could be a powerful alternative to other transistor mixer configurations which, unlike the SL6440, rarely match ring-diode mixer linearity.

Conversion gain is quoted as –1dB when matched to a 50Ω load. LO drive requirement is typically 250mV into 1.5kΩ, and a 60mA supply current at 12V. DC operating point and hence linearity can be user-set by an external resistor. **Fig. 3** shows the recommended application circuit.

Chips for DBS

Anadigics (New Jersey, USA), offer a "fully integrated" downconverter MMIC, the *AKD12000*, comprising low noise amplifier, bandpass filter, mixer, low-pass filter, IF amplifier and LO, giving a noise figure of 5dB, conversion gain of 38dB and 1dB com-



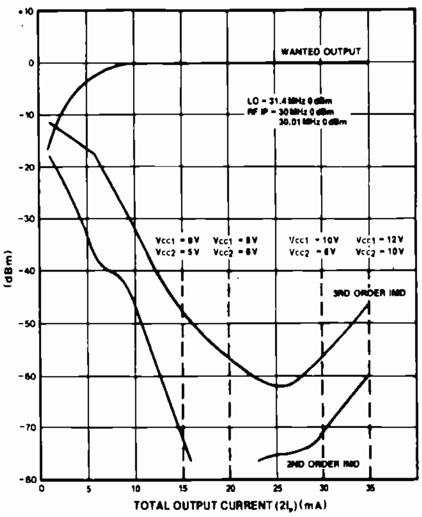


Fig. 3. SL6440 basic application circuit and (right) intercept graphs. The performance of this transistor tree device equals that of a diode ring mixer but without the gain loss.

Table 2. Performance summary of some Silicon MMICs

Manufacturer	Type number	Noise dB	Gain dB	Test frequency GHz	Bandwidth GHz	1dB compression dBm	3rd order intercept dBm	Port impedance	Package
Silicon Low Noise Amplifiers									
Avantek	INA01170	1.7	24	1.0	0 - 4	+10	-	-	stripline
H-P	HPMA0600	2.8	17.9	1.0	0 - 1	+2	-	50	Chip
H-P	HPMA0685	3.0	16.4	1.0	0 - 0.8	+2	-	50	SMD
Toshiba	TA4007F	1.3	28.0	0.2	VHF	-	-	-	SMD
Toshiba*	TA 4004F	3.0	9.0	0.5	UHF	0dBm	-	-	SMD
Toshiba*	HN 3C06F	2.0	7.5	1.0	VHF&UHF	0dBm	-	-	SMD
Silicon Mixers									
Siemens	PMB2330	8.0	10	1.0	0.001 - 2	-	+5	-	SMD
Toshiba*	TA4101F	9.5	–3.5	0.8	-	-	-	-	SMD
GPS	SL 6440	11	–1.0	-	0 - 0.15	+15	+30	-	DIL
Silicon Mixer and Oscillator									
Siemens	TBB204G	8.0	16	0.9	0.3 -1	+2.5	-	-	SMD

*Preliminary data.

pression at +5dBm output. Supplies of +6 V and –5V are required at 100mA and 3mA respectively. There are four variants of the device specific to each DBS band.

RF pre-amplification using discrete modfets is required together with input filtering. Anadigics emphasises the LNB manufacturing advantages with this level of integration, but admits that LO leakage from the RF input pin requires special attention in board circuit design. Input filtering might reduce the LO up-stream leakage to acceptable levels, but reflected energy will be fed back to the IC where it will be amplified by the first RF stage and re-appear at the mixer. The conversion gain of the device will be compromised if phase cancellation with the direct LO signal occurs. Hence the electrical path length between the external filter and the MMIC RF input pin needs to be carefully optimised, presumably on test.

Anadigics also offer an integrated DBS IF tuner IC (*AKD20010*) comprising LNA, mixer, and VCO with on-chip RF and IF filtering, and overall conversion gain of 8dB.

Thomson has developed complete on-chip downconverters which are pin compatible with the *AKD12000*, although it appears that external circuit design requirements are different. The company quotes a noise figure of 6dB, conversion gain of 35dB, and bare die or TO-5 packaging. It is working on integrating 0.25μm modfets directly onto the chip which could obviate external RF pre-amplification with discrete devices. Effort is also going into a downconverter requiring only a single supply rail.

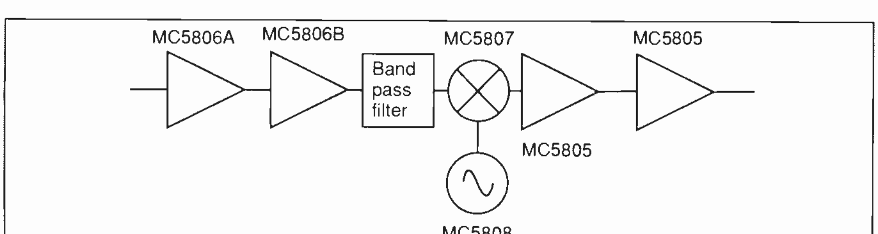
Major design parameters for Siemens consumer CF750 GaAs front end chip

CF750 DC characteristics

	min	typ	max	
Breakdown voltage V_{ds} I_d = 500μA V_{gs} = 4 V	8-	-	-	V
Drain current $I_{dss,p}$ V_{gnd} = 0V Vds = 3.8V S pin not connected	1.6	2.0	2.8	mA
Drain Current I_{dss} V_{gs} = 0V V_{ds} = 3.8V S pin connected to ground	-	50	-	mA
Transconductance G_m I_d = 10mA V_{ds} = 3 > 8V S pin connected to ground	-	25	-	mS

CF750 noise parameters
Bias conditions: V_d = 3.8V I_d = 2mA

Frequency	NF_{min}	r_{opt} MAG	r_{opt} ANG	Rn
900MHz	1.6	0.63	26°	49Ω
1800MHz	1.9	0.52	51°	36Ω

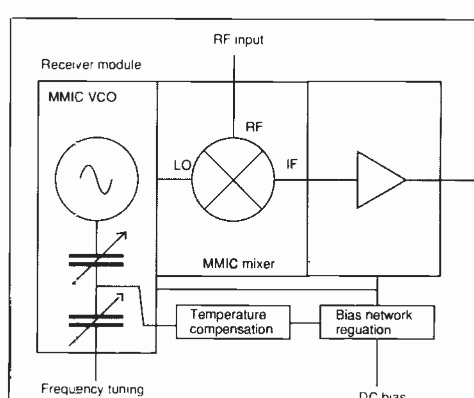


NEC's suggested GaAs MMIC LNB line-up and performance summary for the NEC DBS receiver head converter using GaAs MMIC devices: First amp MC5806A gain 16dB noise 2.2dB; second low noise amp MC5806B gain 16dB noise 3dB; mixer MC5807 conversion loss 6dB Oscillator MC 5808 output 15mW at 10.678GHz; IF Amp. MC5805 gain 16dB noise 4dB. On-chip IF amplification is of course an easier matter being typically at 1 to 2GHz, where GaAs or silicon bipolar devices are used. For indoor DBS receiver IF units: . uPC1659 gain 16dB noise 5.0dB bandwidth 1.8GHz; IF Amp. uPC 1652 gain 16 dB noise 4.0 dB Bandwidth 1.0GHz; AGC Amp uPC1476g gain 25dB, F_{max} 650MHz, AGC 40dB.

38GHz MMIC transceivers

These have been developed by Alpha industries in the USA for Ka-band European telemetry links. Quarter micron mesfets are

38GHz two chip receiver module architecture.



Manufacturers/suppliers address list:

Avantek Ltd, Unit 6, Frimley Business Park, Frimley, Camberley, Surrey, GU16 5SG. Phone: 0276 685753.

Hewlett Packard Ltd., Components Division, Cain Road, Bracknell, Berks, RG12 1HN. Phone: 0344 360000.

Siemens PLC, Semiconductors, Siemens House, Windmill Road, Sunbury-on-Thames, Middx, TW16 7HS. Phone: 0932 752615, Fax 0932 752632.

Toshiba Electronics (UK) Ltd, Semiconductor Div, Riverside Way, Camberley, Surrey, GU15 3YA. Phone: 0276 694600, Fax 0276 691583.

GEC Plessey Semiconductors, Cheney Manor, Swindon, Wilts, SN2 2QW. Phone: 0793 518000, Fax 0793 518411.

NEC Electronocs (UK) Ltd, Semiconductors, Cygnus House, Sunrise Parkway, Linford Wood Business Centre, Linford Wood, Milton Keynes, Bucks, MK14 6NP. Phone: 0908 691133, Fax 0908 670290.

Hitachi Europe Ltd, Electronic Components Div, Whitebrook Park, Lower Crookham Road, Maidenhead, Berks, SL6 8YA. Phone: 0628 585000, Fax 0628 778322.

Mitsubishi Semiconductors, Mitsubishi Electric (UK) Ltd, Travellers Lane, Hatfield, Herts, Al10 8XB. Phone: 0707 276100, Fax 0707 278695.

Fujitsu Microelectronics Ltd, Electronic Components Div, Hargrave House, Belmont Road, Maidenhead, Berks, SL6 6NE. Phone: 0628 76100, Fax 0628 781484.

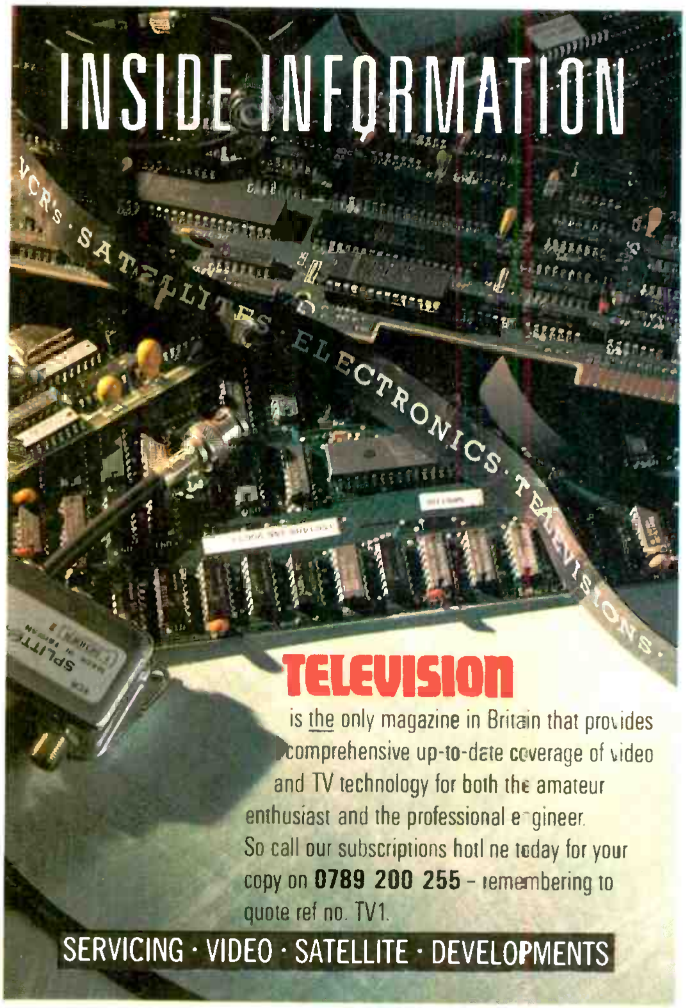
Thompson Electronic Components Ltd (also for Anadigics), Unit 4 Cartel Business Centre, Stroudley Road, Basingstoke Hants, RG24 0UG. Phone: 0256 843323, Fax 0256 23172.

Alpha Industries Ltd, 19/21 Chapel Street, Marlow, Bucks, SL7 3HN. Phone: 0628 475562, Fax 0628 474078.

used for the transmitter module which uses two MMICs in a module size of 26 x 15 x 13mm. It delivers +18dBm output from 38.0 to 39.5GHz, with the VCO tunable over 500MHz. It draws 60mA from an 8V supply. The temperature compensation loop gives better than 1MHz/°C stability.

The receiver architecture comprises a similar LO with a GaAs Schottky diode mixer; the IF output amplifier uses silicon devices and operates up to 1GHz. Supply requirement is 12V at 150mA. Information on these MMICs is sparse – some elements of the modules have been developed for US military programmes. These devices are expected to be available early next year. Development towards a vehicle collision avoidance radar is under way. ■

Next month: oscillator and synthesiser devices, including direct digital synthesisers.



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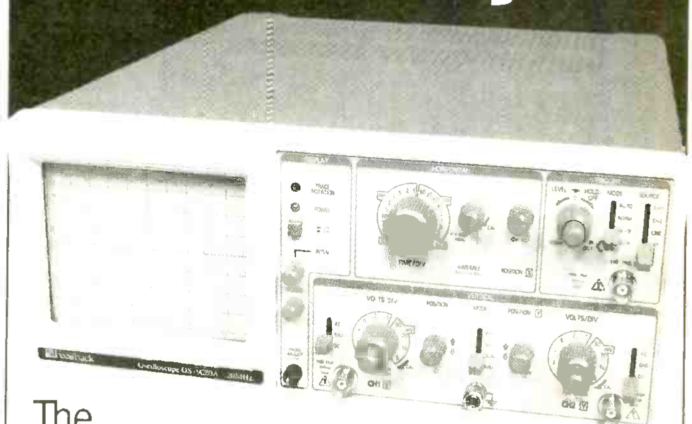

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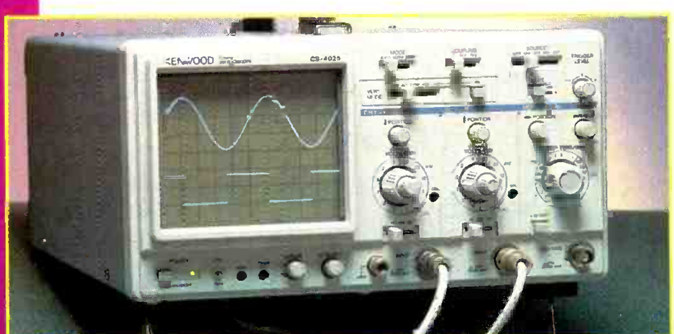

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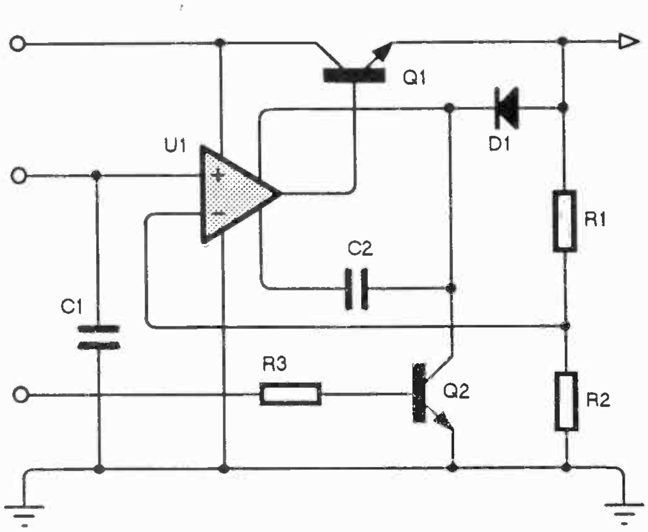

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Building better buffers

Although an effective symmetrical buffer can be built from slow bipolar junction output transistors, D.Danyuk and G.Pilko suggest ways of improving performance in a conventional circuit.

The unity-gain buffer forms the building block of many analogue electronic circuits. To the best of the authors' knowledge it was first commercially employed by Harris Semiconductor in *HA-2600* op-amp[1] as an output stage. Several National Semiconductor products - Bi-FET op-amp *LH4104* with short settling time and unity buffer IC *LH0002* - might serve as more recent examples. This buffer is at the heart of the latest current-feedback op-amps.

The unity-gain buffer shown in **Fig.1** consists of a two symmetrical halves. Each of them is an emitter follower with opposite polarity transistors, connected in series. Each half and the complete circuit have nearly zero dc offset voltage. The bases of input followers are connected together without any biasing network. The buffer input resistance is comparatively high, which, taken in conjunction with a low output impedance, leads to a high degree of isolation between input and output buffer nodes.

The emitter currents of input followers are set by current sources. The voltage drop on the input transistors' emitter junctions and R_1, R_2 serves as a bias voltage for output followers. A local current feedback through R_3, R_4 gives acceptable temperature stability of output transistors' quiescent current.

Two difficulties are inherent; the first is a low load capability. An output-transistor base current is limited by the value supplied by the current source, and the maximum output voltage (**Fig 2b**) can be expressed by:

$$V_{out}\max = I_{out}\max R_L = \left(h_{FQ_3}+1\right) I R_L \quad ..1$$

where I_{out} max is the maximum output current, h_{FQ3} is an output transistor (Q_3) dc current gain, I is the output current of a current source, R_L is a load resistivity. If the current sources are replaced with resistors R, equation [1] will be:

$$V_{out}\max = V_{cc} R_L \left(h_{FQ_3}+1\right) / \left(R + R_L\left(h_{FQ_3}+1\right)\right) \quad ..2$$

where V_{cc} is a supply voltage.

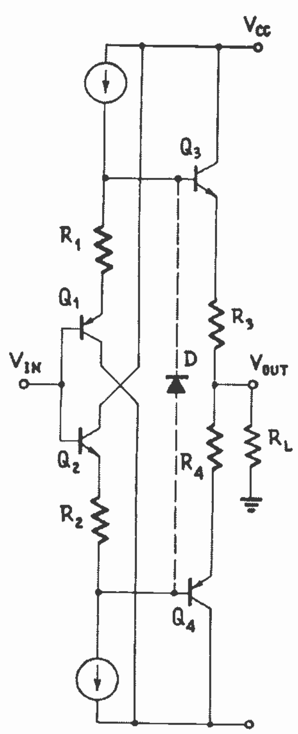


Fig. 1. The basic circuit of the unity-gain buffer.

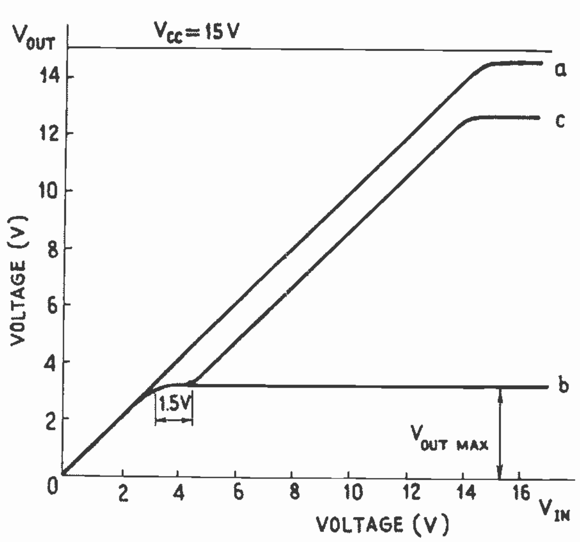


Fig. 2 Transfer characteristics of Fig 1 circuit, with (b) and without (a) load, with load and diode (c), as shown by the dotted lines on Fig. 1.

The second problem is that the buffer input followers drive capacitive loads – the output transistors' collector to-base junction capacities. The voltage step with small rise-time comes at the input, one of the input transistors cuts off and the output transistor collector-to-base capacitance charges slowly through the current source. This leads to slew-rate limiting and is shown clearly in **Fig. 3**. The output pulse edge breaks in two parts, when one output transistor turns off quickly and another turns on slowly. The output waveform becomes much worse with capacitive loads.

One of the simple methods is the diode placement between output transistor bases, as shown by dotted lines in Fig. 1. In this way a new path for an output transistor base current is open and base current value is no more restricted. The corresponding transfer characteristic Fig. 2c contains a pair of 1.5V dead zones. These features are hardly removed by feedback and cause a large amount of distortion.

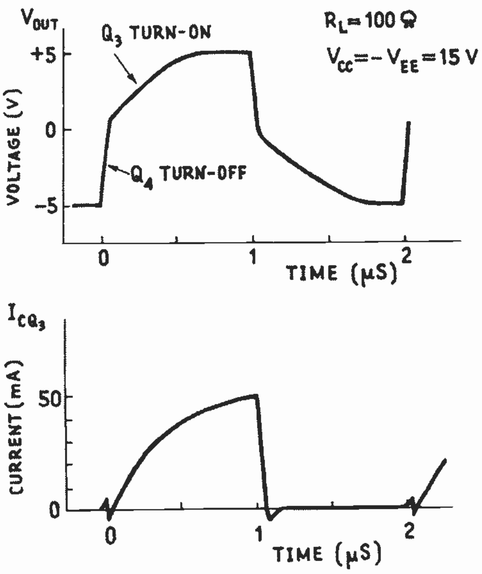


Fig.3 Transient responses of Fig 1 circuit driving a 50Ω load, output voltage (a) and Q^3 collector-current (b). Current sources are replaced with 5.1kΩ resistors.

Darlington-connected output stage

It is possible to improve the buffer performance by a more straightforward approach: increasing the output stage current gain. The possible circuit arrangements of Darlington-connected output transistors are shown in **Fig 4.**

Fig.4 The unity-gain buffer with Darlington-connected output transistors, with different paths for driver transistors (Q5, Q6) emitter current flow.

It is well known that if higher frequencies are fed into a push-pull output stage, the output transistors will both be partly on for a considerable portion of each cycle. This is like connecting the positive to negative supply by turning on both output transistors. The extra current conduction is referred to as 'mutual' or 'common-mode' conduction. The storage time effect in output transistors causes secondary crossover distortion, reduces high-frequency power efficiency and increases high-frequency distortion.

Three structures (Fig. 4) were tested for susceptibility to 'common-mode' conduction. One of them is an ordinary configuration with base-bleeder resistors (Fig 4b). Two others are without direct connection between output and driver transistor (Q_5, Q_6) emitters. The circuit shown in Fig 4a was offered by B N Locanthi[2] and the circuit shown in Fig 4c by J.M.Diamond[3]. Driver transistor quiescent currents were set equal for all configurations.

While it seems that available turn-off output transistor base-current is limited to the amount of a driver transistor quiescent current, the circuits shown in Fig.4 present a somewhat different performance.

The idle peak current values amounted to 100% of an output current with square-wave input. A typical collector current waveform for an output transistor is shown in **Fig. 6a**. The falling edge of an output transistor collector current for the circuit Fig.4a was one and a half times shorter than for the ordinary circuit (Fig. 4b) and twice as short as the circuit in Fig 4c.

This occurs for two reasons. First, each base of the Fig.4a output transistors has a low-resistance path for the reverse base current to flow

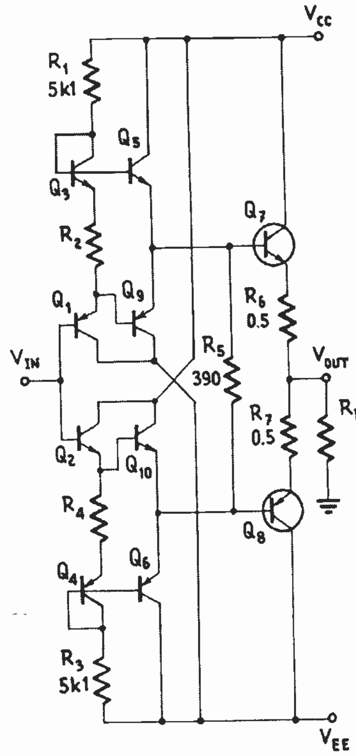
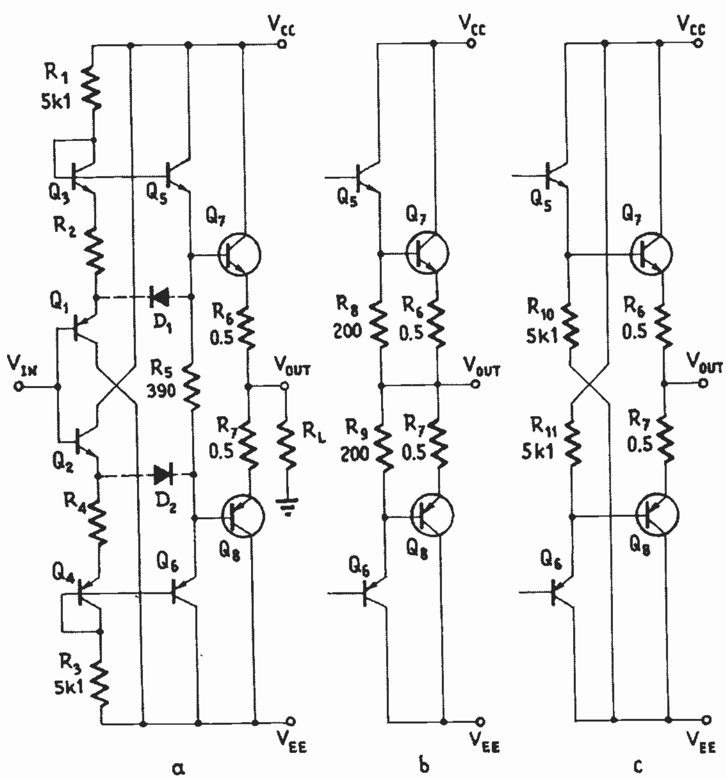
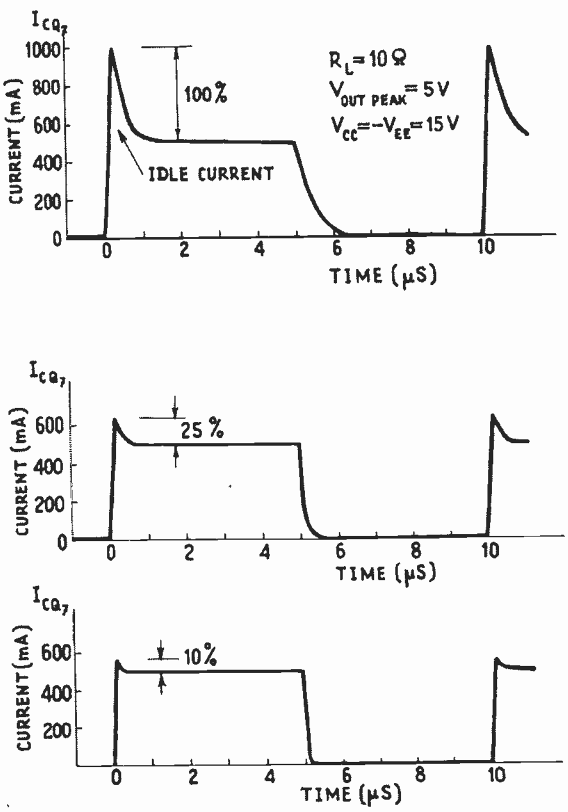


Fig. 5. Improved version of Fig. 4a circuit with additional emitter followers (Q_9, Q_{10}) for fast output transistor turn-off.

Fig. 6. Transient responses of Fig. 4, 5 circuits, n-p-n output transistor collector current for Darlington-connected version Fig. 4a (a), for Fig. 4a with diodes D_1, D_2 (b), for Fig. 5 circuit (c).





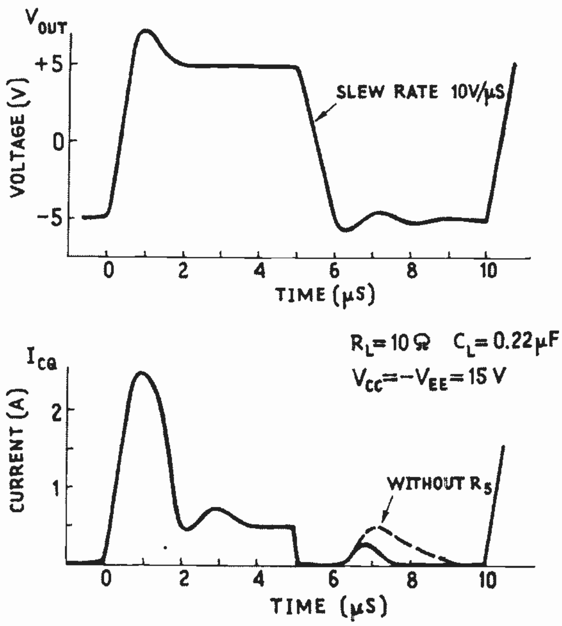


Fig. 7 Transient responses of Fig. 5 circuit driving a 10Ω load with 0.22μF in parallel, output voltage (a) and Q_7 collector current (b). Lower graph shows the effect of R_5 moving.

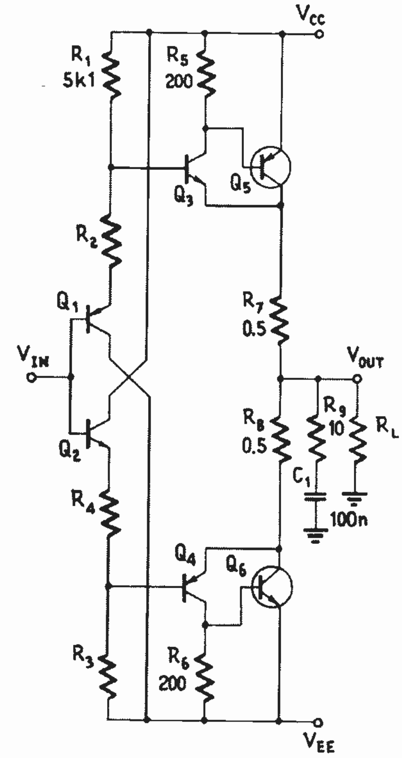


Fig. 8 The unity-gain buffer with a complementary compound output stage.

through its opposite emitter driver stage. Second, the driver transistors never cut off under load.

For high-speed transistor operation one should make use of L Hart's idea[4] and drive an n-p-n transistor from a current source with a special waveform. It envisages a positive spike for fast turn-on and a negative spike for fast turn-off as its components. Driving the output transistor from the low-impedance point gives nearly the same base current waveform and decreases the idle current to a negligible value. This can be realised by inserting the additional diodes D_1 D_2 as shown by dotted lines in Fig.4a or emitter followers Q_9, Q_{10} (**Fig 5**).

The low impedance aids in draining out the charge stored in the base region of the output transistors, thus speeding up their turn-off . The output square wave rise-time is improved by a factor factor of two, from 70 to 40ns. It should be noted that the first configuration (Fig. 4a, with D_1, D_2) operates satisfactorily with low and medium impedance input signal source only. **Figure 6** illustrates the output transistor collector current waveform for several of the topologies listed above.

A decrease in the output device turn-off time also gives an important improvement in effective safe operating area. The safe area of an output transistor is a region that is restricted by voltage, current, time and temperature limits which the device would stand without damage. The absolute current limit is set at low voltage by the fusing characteristics of the bonding wire, so the current spike after transistor turn-on should be considered.

At the falling edge of the collector current waveform, the device operates with rather high collector voltages near (or beyond) a secondary breakdown region. When an ordinary output stage operates with high capacitive loads, the falling edge of extra collector current is stretched in time, and the operating levels may exceed power dissipation and secondary breakdown boundaries.

Figure 7 shows the rather high load capability of the Fig 5 circuit. The output transistor collector current waveform (Fig 7b) is almost free from 'common-mode' conduction and has a sharp turn-off edge. R_5 helps to decrease the turn-off current residue. With a capacitive load an output follower has a negative input conductance that decreases with the transition frequency of the output device. These elements, with the output follower collector-to-base capacitance, form a parallel resonant circuit which causes peaking in the output waveform.

Compound output stage

The complementary compound output stage (**Fig. 8**) seems to be another solution to the increase in the output stage current gain. The circuit has a greater thermal stability due to the existence of current feedback loops. These loops contain Q_3, Q_5, R_7 and Q_4, Q_5, R_8 and the loop gain value can be expressed by:

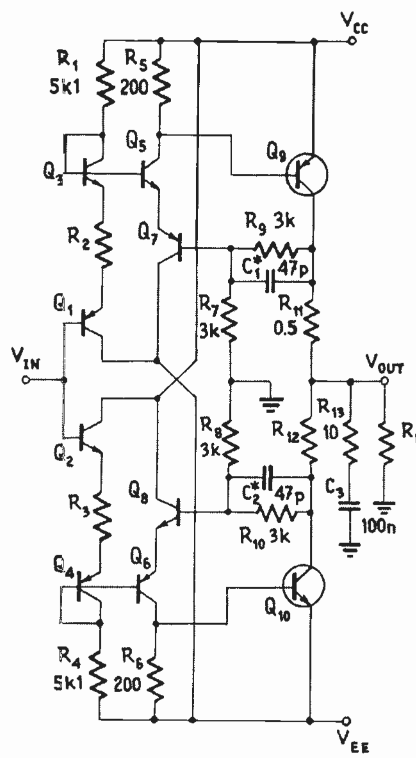
$$\beta A = 26mVR_7h_{FQ_5} / I_{EQ_3} \qquad ..3$$

where 26mV / I_{EQ3} is a driver transistor (Q_3) transconductance and h_{FQ5} is an output transistor (Q_5) dc current gain.

It appears to be convenient to have some gain in an output buffer to provide nearly a full output swing.

The presence of a feedback divider in the driver transistor emitter network decreases

Fig. 9 The output stage with improved thermal stability. Output transistors are driven with complementary versions of a balanced common-emitter stage.



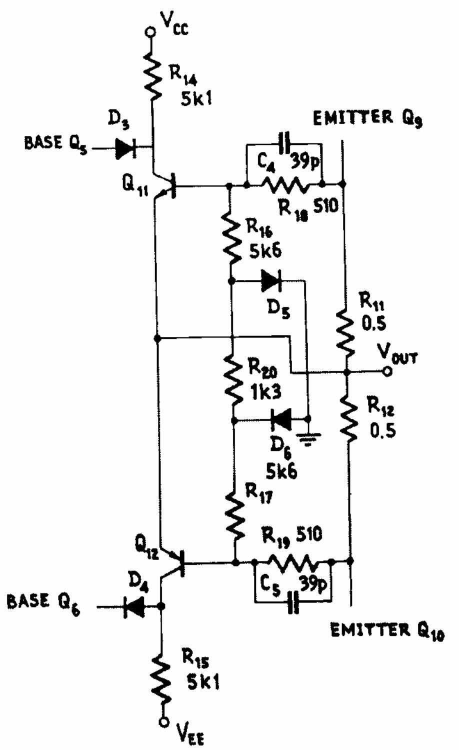


Fig.10. Suitable overload protection circuit with SOA control.

current loop gain βA to:

$$\beta A = \beta R_7 h_{FQ_5} / R_F \quad ..4$$

where β is a feedback divider attenuation ratio and R_F is a feedback network output resistance. A feedback network output resistance serves as a local feedback element. Current loop gain is decreased mainly due to driver transistor transconductance reduction by a local feedback and current loop gain βA is far lower than unity. Thus, the compound stage thermal stability becomes equal to a Darlington connected one.

One of the options for restoring current feedback loop gain and maintaining the thermal stability was employed by E M .Cherry[5]. In his circuit, the output transistors were driven by a pair of differential amplifier stages. An alternative solution is shown in **Fig 9.** The complementary versions of a balanced common emitter stage gives the same current loop gain value but eliminates a slew-rate limiting effects. These effects occur when the output transistor collector-to-base capacitance charges from the long-tail pair current source.

The modification is not that simple: a compound output stage is used to fasten the output transistors' turn-off at this stage. An output transistor collector current waveform is similar to the one shown in Fig. 6a, with the falling edge time interval one and a half times longer.

In the designs of Figs. 8 and 9, the 10Ω and 100nF Zobel network prevents the effective load from becoming too high and provides adequate stability in the feedback loop.

Figure 10 illustrates a suitable overload protection circuit with safe-operating area control. This circuit should be used with any of the configurations listed above.

Realisation

The circuits shown in Figs. 1-9 were realised with a pair of quad-transistor arrays and *BD233*/*BD234* output devices. Several units were manufactured in a hybrid IC form. Output transistor bias currents were set in the range of 10 to 30mA by the proper choice of the input follower emitter resistors. Their values varied from zero to 10Ω due to U_{BE} mismatching.

The paper discusses the practice of realising a symmetrical buffer topology using rather slow bipolar junction output transistors. The above analysis suggests some additional measures for improvement in a conventional circuit (Fig.1). The circuit shown in Fig. 5 would give the best performance in terms of speed and 'common-mode' conduction and seems to be suitable for high-speed operation with complex loads. The circuit shown in Fig. 9 is expected to give both higher linearity and thermal stability and appears to be acceptable for use with slower op-amps.

In passing, it should be noted that the results obtained are applicable to various output stages irrespective of power level or biasing network configuration. ■

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BOOK REVIEW

Fibre Optic Cabling, by Mike Gilmore, extends the understanding of optical fibres needed for practical application in telecommunications and data-comms to a more soundly based level, at which theory can confidently be applied to unfamiliar techniques. Nonetheless, this is essentially a practical treatment for engineers and laymen alike, which also covers the installation and commercial aspects of the technology.

Optical fibres in general terms and their use in communications form an initial chapter, as an introduction to more specific discussion. Five chapters cover fibres and connection practice, both theoretical and practical considerations being treated, and are followed by three more on cables, highways in general and design in particular. A final chapter on the hardware of optical fibres then presents the choices available in cables and assemblies, connectors, splicing and enclosures.

Specifying fibre systems appears to be an undeveloped art, its vagueness contrasting sharply with that commonly found in copper cabled systems; one chapter is therefore an attempt to introduce a little rigour into the process.

Acceptance testing, installation practice and final acceptance testing are all subject to contractual obligations and are therefore supremely important if reputations are to survive a contract; three chapters describe methods of ensuring survival of both reputations and systems. Documentation and maintenance form the two final chapters in the design and installation part of the book, but the penultimate section is illustrative of the author's experience with real systems — a case study. Future developments such as single-mode fibres and fixed, blown-fibre cables are then discussed in an end-piece.

This is no "penny-a-line" text cobbled together by a media man, but is the result of hard-won experience by a practitioner, the author not only being Managing Director of an optical-fibre cabling company, but also chairman of one of the BSI working groups in this area.

Butterworth Heinemann, 318 pp, hardback, £35. H M Howarth is the third volume in the Chapman and Hall series "Physics and its Applications", some of which are said to be suitable for final year degree courses and postgraduate work, although this particular one seems to be intended for slightly earlier work.

Widely used theorems are treated – Thevenin, Norton, Millman –and the book begins in a fairly peaceful way by covering DC and AC current theory, j notation and the complex-frequency s notation.

Mesh and nodal analysis take up a chapter, before the foregoing is used to explain the network theorems from Thevenin to star-delta, by way of superposition and reciprocity. Resonance and coupled circuits each have a chapter and the final section is on two-port networks, including transmission lines and artificial delay lines.

No great mathematical demands are made on the reader, who should find that simple calculus and a familiarity with matrices will be enough. This is a dead-pan, straightforward book, with no attempt at lightening the subject and, as such, is a workmanlike production. I saw no "It can be shown ..."s.

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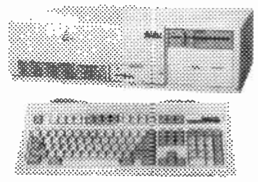

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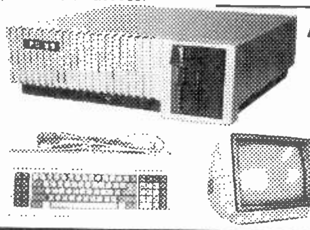

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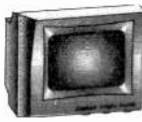

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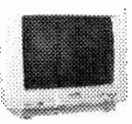

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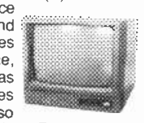

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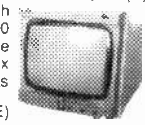

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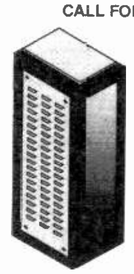

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Putting DDS to work

The final part of Ian Hickman's series on direct digital synthesis considers the design possibilities provided by this new branch of RF technology.

Direct digital synthesisers do far more than just offering a convenient method of generating an RF carrier wave. They can produce very rapid frequency changes, typically within a single clock cycle or less than 100ns. The output will also remain phase continuous at the point where the frequency changes – unless a step phase change is deliberately implemented at the same time; this is possible with those DDS chips that provide access to the output of the phase accumulator (see Fig. 2 of last month's article).

Phase continuous frequency changes are not possible in a direct (analogue) synthesiser, and in a PLL synthesiser they are only possible for very small frequency changes. This rapid frequency change capability makes DDS a natural choice for use in frequency hopping radios and also in ECM systems in a frequency-agile intelligent jammer. A DDS can also generate a super-linear chirp waveform, to a degree of accuracy not achievable by any other means.

This has obvious applications to radar, enabling both extended range and high resolution to be achieved simultaneously, by using a higher degree of pulse compression in the receiver. Another feature of some DDS chips (those with two independent phase accumulators where either can be routed to the sine look-up ROM) is phase memory or coherence.

This means that on switching to frequency f_2 (controlled by phase accumulator 2) and then back to frequency f_1 (controlled by phase accumulator 1), the phase of f_1 is the same as it would have been if the frequency change had never been effected. It is as if the output had been drawn by switching between two separate crystal oscillators. (Naturally, in these circumstances there will not in general be phase continuity between f_1 and f_2.) This feature is not usually important in over-the-air communications, since absolute phase is not preserved in such a link – which is why phase modulation systems use differential encoding – but it may well be a desirable feature in instrumentation systems.

Fixed frequency advantages

In addition to their convenience in variable frequency operating modes, DDSs can offer advantages when operating at a fixed frequency: there are models which by their con-

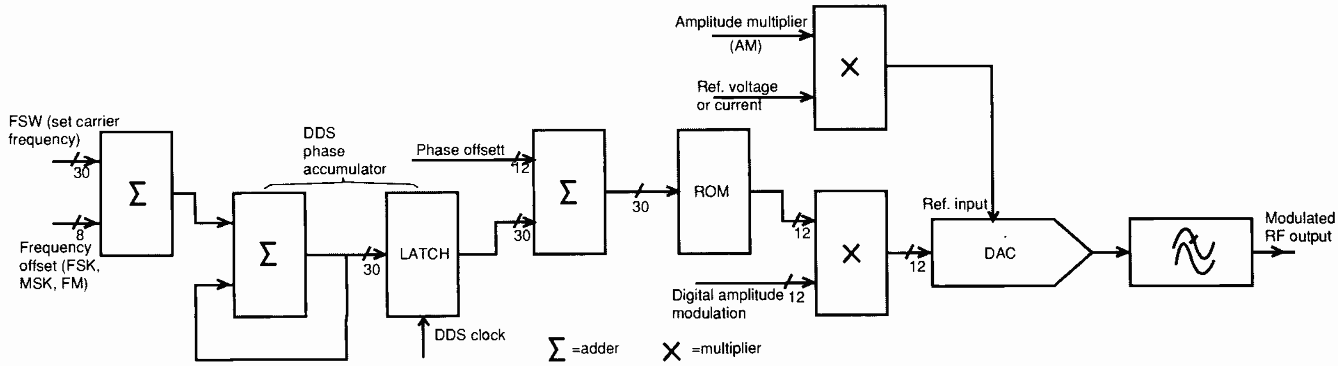


Fig. 1. A DDS system can produce various forms of amplitude, frequency and phase modulation.

struction can implement most if not all of the various types of modulation. They thus combine the function of carrier generator and modulator, which are usually separate stages when using a fixed frequency or PLL carrier source.

Figure 1 shows how AM, FM, the various types of PM, FSK, MSK, etc, can all be produced, with a degree of accuracy difficult to achieve with conventional analogue modulators. Adding a shift or offset to the FSW (frequency setting word) prior to the phase accumulator enables all the varieties of frequency modulation to be produced. Adding a phase shift or offset after the accumulator but before the sine look-up rom can produce all the varieties of phase modulation, while processing after the rom enables amplitude modulation to be provided.

This can be done in several ways. Digitally controlled AM can be produced by multiplying the rom output by a factor representing the instantaneous modulation amplitude between 0 and 100%. Alternatively, AM can be applied by modulating the reference supplied to the dac. The reference modulation can be effected either by linear circuitry such as multiplier module, variable gain amplifier or operational transconductance amplifier, or by digital means using another dac to supply the reference to the DDS's output dac.

By using two types of modulation simultaneously, complex modulation modes such 256QAM can be produced; this type of oper-

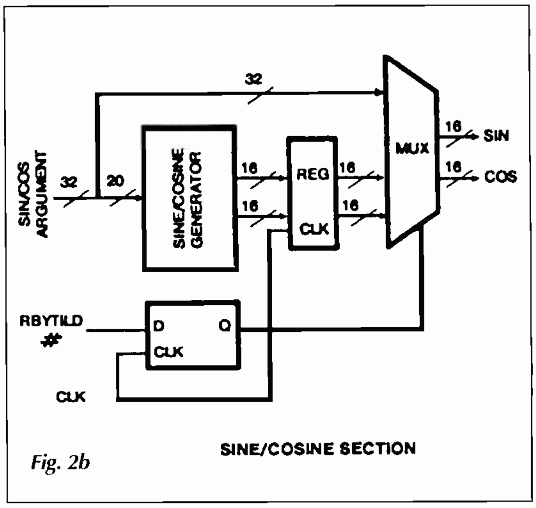


Fig. 2b

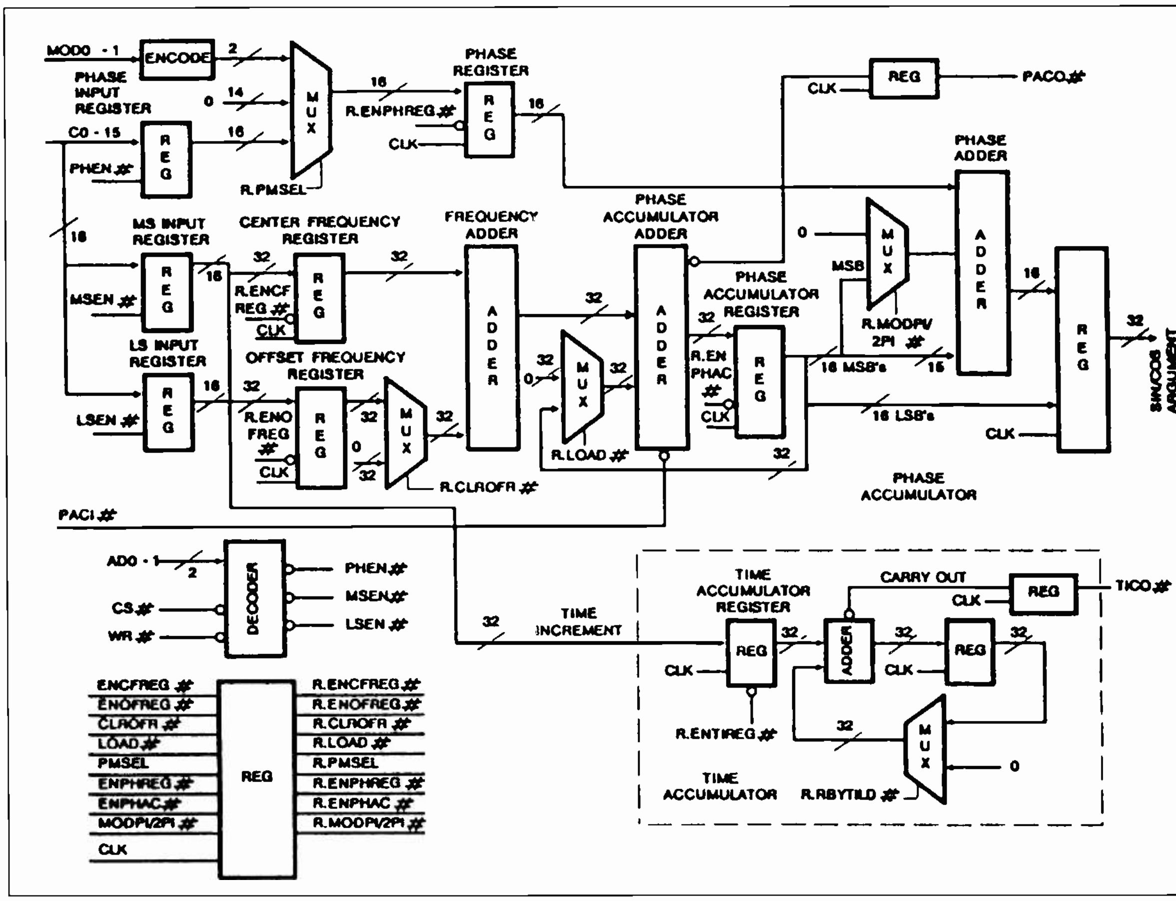


Fig. 2: The Harris HSP45116 NCOM (numerically controlled oscillator/ modulator. (a) (left) the PFCS (phase and frequency control section), (b) (above) the sine/cosine section, (c) (right) the CMAC (complex multiplier/ accumulator).

Fig. 2a

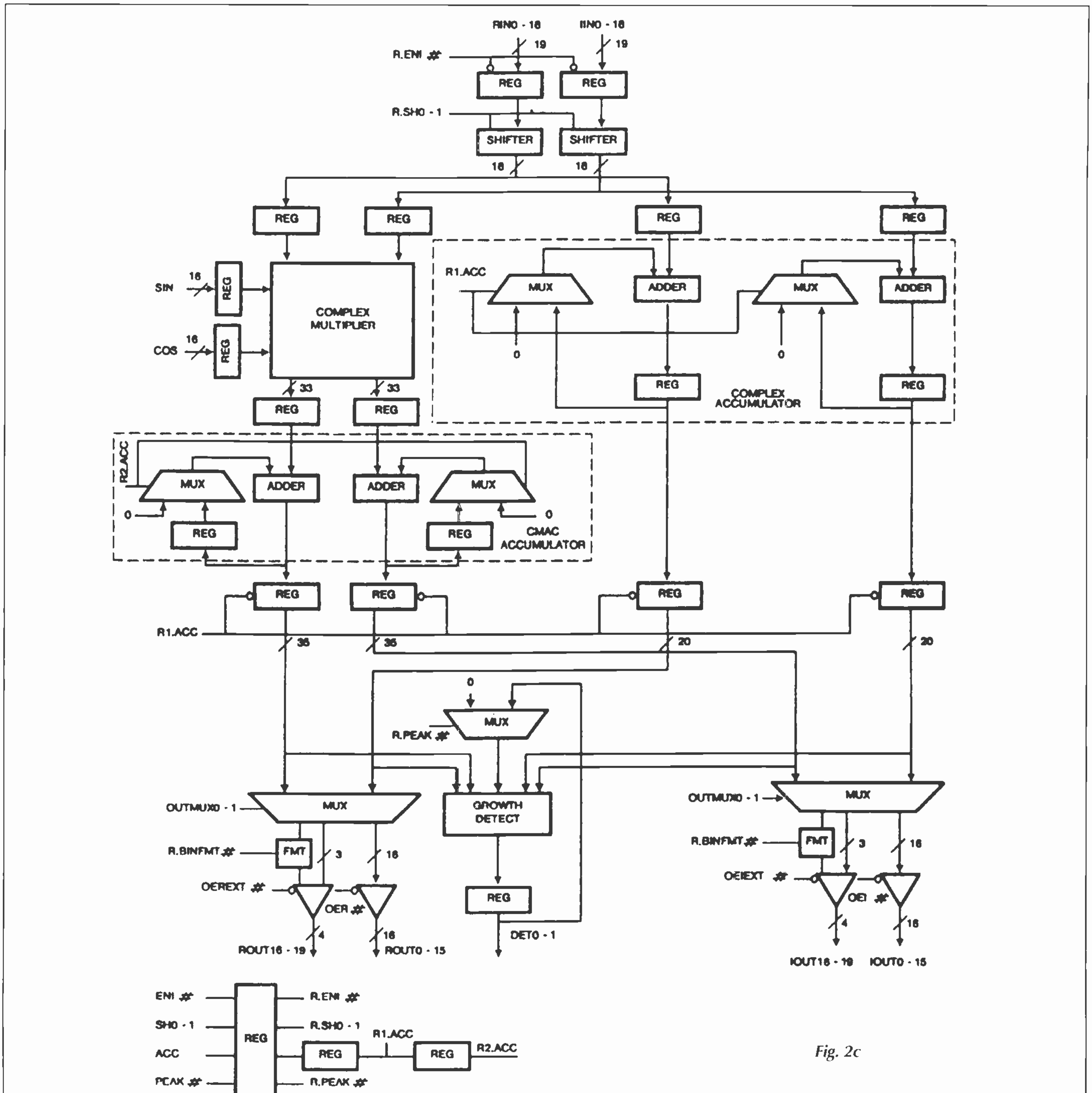


Fig. 2c

ation is more conveniently carried out in a DDS with separate paths for the real and imaginary parts of the complex modulation. **Figure 2** shows the block diagram of the Harris *HSP45116* NCOM (numerically controlled oscillator/modulator), a DDS not incorporating an on-chip dac.

Figure 2a shows the phase/frequency control section (PFCS), corresponding to the four left-most blocks in Figure 1, with its facilities for producing FM, PSK, FSK or MSK, while Figure 2b shows the sine (and cosine) look-up rom. This section takes the 20 MSBs of the 32 bit PFCS and produces 16-bit sine and cosine outputs. Computation is used to interpolate between rom values to reduce the size of rom needed.

The magnitude of the error in the computed value of the complex vector is less than –90.2dBm. The errors in the sine and cosine components are 2dB lower than this (these errors are much less than will be introduced by any current DAC operating in the MHz range). Finally, the sine and cosine values are passed to an output CMAC (complex multiplier/accumulator) which is particularly useful for the implementation of all types of AM and QAM.

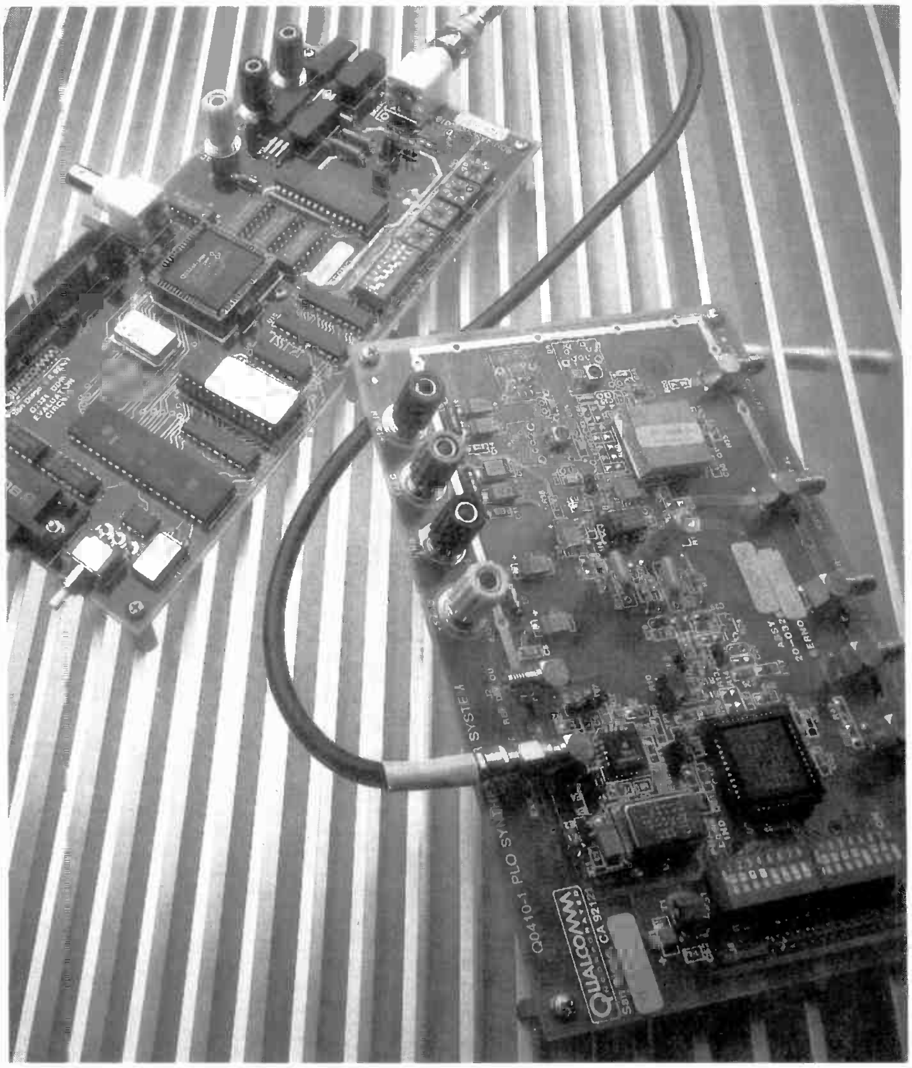
The CMAC multiplies the outputs of the sine/cosine section by two nineteen bit scalar quantities, $R_{in0}-18$ and $I_{in0}-18$, representing a general complex vector. It can thus produce all types of APSK and QAM and can also be used to perform the FFT butterfly operations required in calculating Discrete Fourier Transforms. The device, which clocks at up to 40MHz, is also available in a milspec/883 version.

As well as the *HSP45116* NCOM, the Harris range also includes the *HSP45106* which is generally similar but lacks the CMAC and the *HSP45102* which is like the *45106* but produces only a single 12-bit sine output. This last device is available in a 28 pin DIP or SOIC, the others being in pin-grid array packages.

Design-in success

DDSs would find much greater usage if engineers were more familiar with them. To assist familiarisation, various manufacturers have

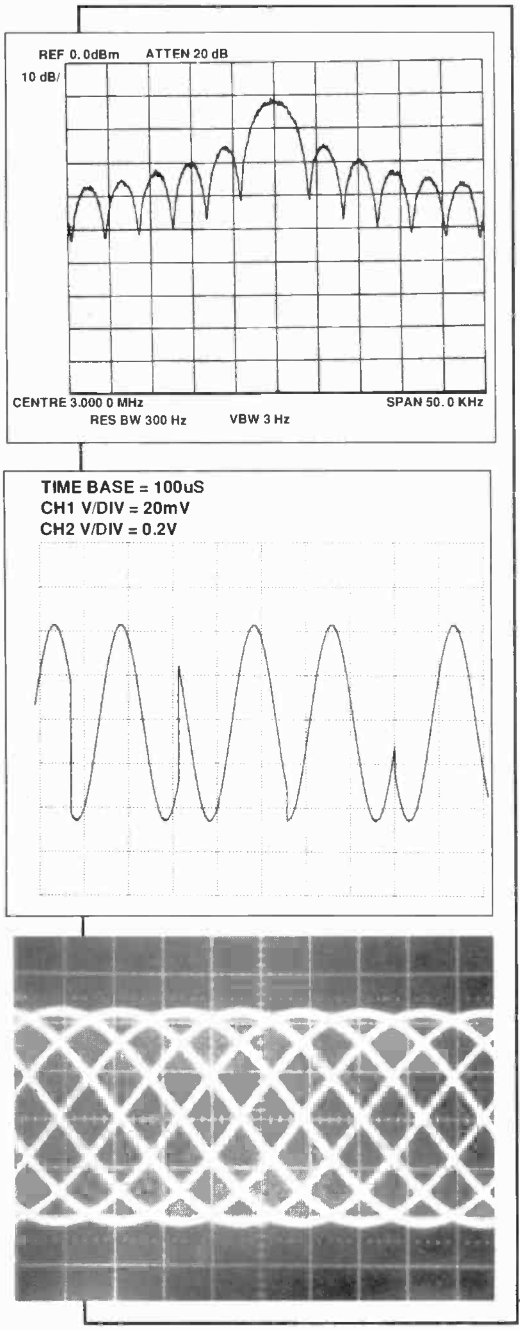
Figure 3 Qualcomm Q0310 DDS Evaluation Kit (incorporating the Q2334 DDS chip) (upper item), shown here connected to drive the Q0410 PLO Synthesiser System. The combination covers 900 – 1600MHz with output step sizes of approximately 1Hz.



evaluation kits which provide an instant way of getting hands-on experience without having to go through a board design stage.

Figure 3 shows the Qualcomm *Q0310* Evaluation Kit (upper item) incorporating the *Q2334 DSS* chip. This can either be controlled over an RS232 link from any PC or compatible, or by use of the onboard DIL and rotary switches. It enables many of the DDS chip's facilities to be demonstrated. For instance, **Fig. 4** shows the spectrum of the unit's output in FSK mode with tones at 2.000MHz and 2.100MHz, modulated with a pseudo random bitstream at a data rate of about 4kHz.

Figure 5a shows the spectrum when out-



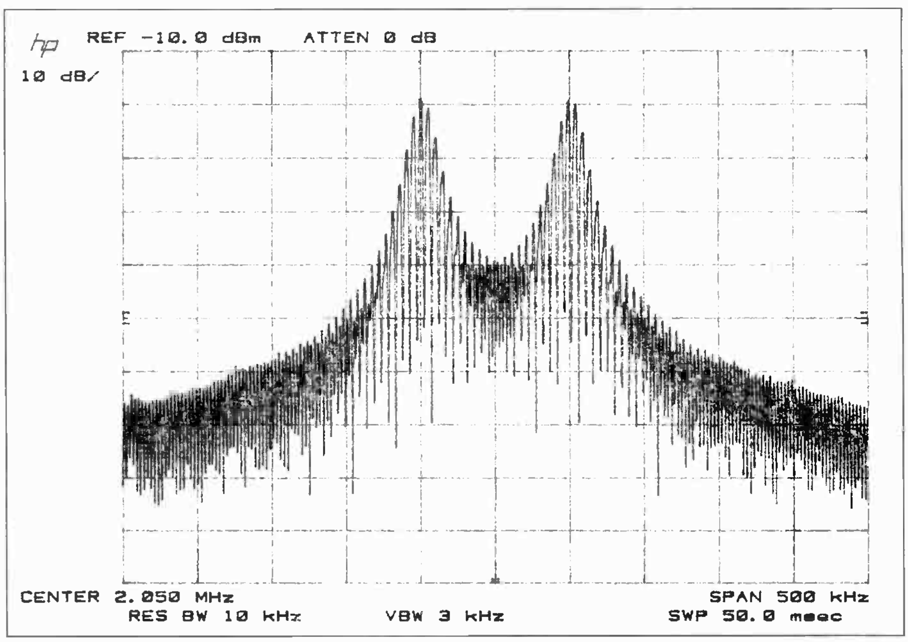


Fig. 4 Spectrum of FSK at 2.05MHz with a 100kHz shift and 4kbit/s data rate produced by the Q2334 DDS chip.

Fig. 5. 8-PSK produced by the Q2334 DDS chip operating at 4096baud (12.288kbit/s). a) spectrum. b) waveform showing phase changes modulo 45°. c) time exposure showing all eight phases.

putting 8-ary PSK: the (pseudo-random) data rate is 12.288kbit/s and because this modulation method encodes three bits at a time, the baud rate (signalling rate) is 4096baud (symbols/second). Each symbol has one of eight possible phases, so each phase change is an integral number x 45°. Figure 5b, where an unrealistically low "carrier" frequency of 5kHz has been set, shows the individual phase changes more clearly.

With a higher carrier frequency and a time exposure, all of the eight possible phases can be clearly seen, Fig. 5c. **Figure 6** shows MSK with its phase coherent frequency changes; the data rate is 8kbit/s. Again, for clarity an unrealistically low "carrier" frequency of 8kHz has been set, but in MSK ("Fast" or "Continuous Phase" FSK), whatever the carrier frequency, the shift is $\pm^1/_4$ of the bit rate.

Consequently, in any bit period, the phase of the signal advances or retards linearly by 90° relative to the phase of the unmodulated carrier, depending upon whether the transmitted bit is a one or a zero. (MSK can alternatively be considered as offset modulated QPSK with sinusoidal weighting of the symbols in the I and Q channels.)

With so many options built in, it is not surprising that where a one-off system is required, many firms opt simply to buy in an evaluation kit rather than design a bespoke board. The time to market advantage is obvious.

Future performance

Further advances and improvements in DDS performance can be expected in future, but for the most critical applications, the spurious outputs are likely to remain a stumbling block. As has been observed, the PM spurs are the most embarrassing; unlike the AM spurs, they cannot be eliminated by hard limiting (or designed around by using the DDS output as the high-level input to a double balanced mixer). However, this is an area where some lateral thinking might enable an engineer to produce a useful improvement in performance.

The bits of the accumulator output which are not passed to the DAC contain the instantaneous value of the spurious sawtooth phase modulation. These bits could be passed to an auxiliary DAC whose sawtooth output could be used to control a phase modulator which impressed upon the DDS output a cancelling phase modulation in the opposite sense.

For a narrow band design, a varactor controlled linear phase modulator could be used; this would also be suitable for a wideband design if the amplitude of the controlling sawtooth were suitably scaled, depending on the output frequency. Alternatively, a serrasoidal (sawtooth) modulator could be used, with the advantage that it provides a constant phase shift versus control voltage ratio, independent of frequency.

As the spurious phase modulation problem is eased, by further development of the basic DDS or by some other means, the application of direct digital synthesisers will steadily increase, providing designers with better, more compact and more flexible sources of RF carriers – with built in modulation facilities – for civil, military and space use. Military specified devices are available from Harris and space qualified devices from Stanford Research. These manufacturers will doubtless be joined by others in the near future, if they are not already on the path.

One area where DDSs can be expected to make an increasing impact is in instrumentation. With their facility for producing both sine and cosine outputs, in extremely accurate quadrature, these devices are a natural for many applications in measuring instruments. **Figure 7** shows an outline block diagram of a network analyser using DDS for both the test frequency and the local oscillator. In this application, there is only one wanted signal and it is always at the correct IF offset from the local oscillator. As a result, spurious components in the DDS outputs are of much less importance than in many other applications. Such a design of network analyser, working up to VHF, is entirely practicable right now, since circulators covering DC to VHF are readily realised. ■

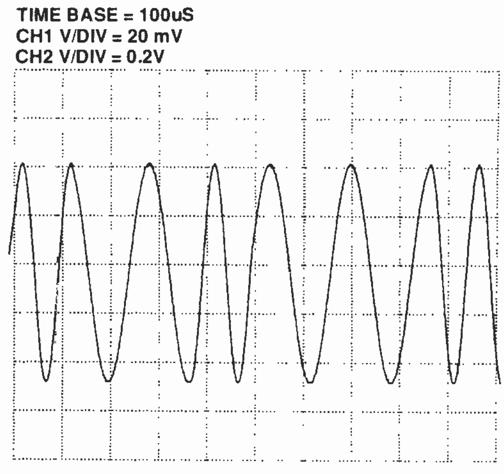


Fig. 6 MSK produced by the Q2334 DDS chip, showing the phase continuity at frequency changes.

Acknowledgements

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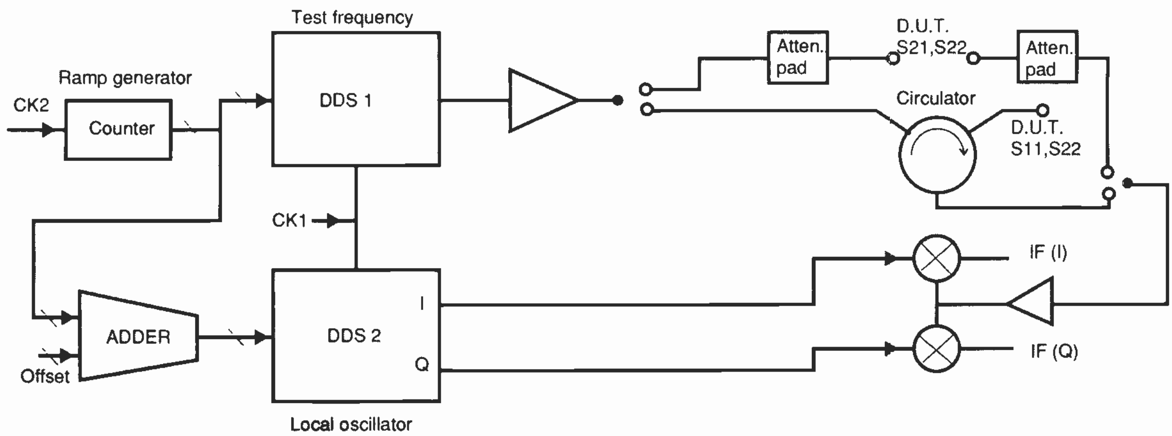

Fig. 7 Block diagram of the front end of a network analyser (up to the IF inputs) using two DDSs to provide parallel frequency ramps for the test frequency and the local oscillator. The adder provides an LO with an offset from the test frequency equal to the IF.

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HP Vector Voltmeter type 8405A – £400 to £600 – old or new colour.
HP Synthesiser/signal generator type 8672A – 2 to 18GHz £4000.
HP Oscillographic recorder type 7404A – 4 track – £350.
HP Plotter type 9872B – 4 pen – £300.
HP Sweep Oscillators type 8690 A & B + plug-ins from 10Mc/s to 18GHz also 18-40GHz. P.O.R.
HP Network Analyser type 8407A + 8412A + 8601A – 100Kc/s – 110Mc/s – £500–£1000.
HP Down Converter type 11710B – .01-11Mc/s – £450.
HP Pulse Modulator type 11720A – 2-18GHz – £1000.
HP Modulator type 8403A – £100-£200.
HP Pin Modulators for above-many different frequencies – £150.
HP Counter type 5342A – 18GHz – LED readout – £1500.
HP Signal Generator type 8640B – Opt001 + 003 – .5-512Mc/s AM/FM – £1000.
HP Amplifier type 8447A – .1-400Mc/s £200 – HP8447F .1-1300Mc/s £400.
HP Frequency Counter type 5340A – 18GHz £1000 – rear output £800.
HP 8410 – A – B – C Network Analyser 110Mc/s to 12GHz or 18GHz – plus most other units and displays used in this set-up – 8411A – 8412 – 8413 – 8414 – 8418 – 8740 – 8741 – 8742 – 8743 – 8746 – 8650. From £1000.
HP Signal Generator type 8660C – .1-2600Mc/s. AM/FM – £3000. 1300Mc/s £2000.
HP Signal Generator type 8656A – 0.1-990Mc/s. AM/FM – £2000.
HP 8699B Sweep PI – 0.1-4GHz £750 – HP8690B Mainframe £250.
Racal/Dana 9301A-9302 RF Millivoltmeter – 1.5-2GHz – £250-£400.
Racal/Dana Counters 9915M – 9916 – 9917 – 9921 – £150 to £450. Fitted FX standards.
Racal/Dana Modulation Meter type 9009 – 8Mc/s – 1.5GHz – £250.
Racal – SG Brown Comprehensive Headset Tester (with artificial head) Z1A200/1 – £350.
Marconi AF Power Meter type 893B – £200.
Marconi RCL Bridge type TF2700 – £150.
Marconi/Saunders Signal Sources type – 6058B – 6070A – 6055B – 6059A – 6057B – 6056 – £250–£350. 400Mc/s to 18GHz.
Marconi TF1245 Circuit magnification meter + 1246 & 1247 Oscillators – £100-£300.
Marconi microwave 6600A sweep osc., mainframe with 6650 PI – 18-26.5GHz or 6651 PI – 26.5-40GHz – £1000 or PI only £600.
Marconi distortion meter type TF2331 – £150, TF2331A – £200.
Microwave Systems MOS/3600 Microwave frequency stabilizer – 1GHz to 40GHz £1k.
Tektronix Plug-ins 7A13 – 7A14 – 7A18 – 7A24 – 7A26 – 7A11 – 7M11 – 7S11 – 7D10 – 7S12 – S1 – S2 – S6 – S52 – PG506 – SC504 – SG502 – SG503 – SG504 – DC503 – DC508 – DD501 – WR501 – DM501A – FG501A – TG501 – PG502 – DC505A – FG504 – P.O.R.
Alltech Stoddart receiver type 17/27A – .01–32Mc/s – £2500.
Alltech Stoddart receiver type 37/57 – 30-1000Mc/s – £2500.
Alltech Stoddart receiver type NM65T – 1 to 10GHz – £1500.
Gould J3B Test oscillator + manual – £200.
Infra-red Binoculars in fibre-glass carrying case – tested – £100. Infra-red AFV sights £100.
ACL Field intensity meter receiver type SR – 209 – 6. Plugs-ins from 5Mc/s to 4GHz – P.O.R.
Tektronix 491 spectrum analyser – 1.5GHz-40GHz – as new – £1000 or 10Mc/s 40GHz.
Tektronix Mainframes – 7603 – 7623A – 7633 – 7704A – 7844 – 7904 – TM501 – TM503 – TM506 – 7904 – 7834 – 7104.
Knott Polyskanner WM1001 + WM5001 + WM3002 + WM4001 – £500.
Alltech 136 Precision test RX + 13505 head 2 – 4GHz – £350.
SE Lab Eight Four – FM 4 Channel recorder – £200.
Alltech 757 Spectrum Analyser – 001 22GHz – Digital Storage + Readout – £3000.
Dranetz 606 Power line disturbance analyser – £250.
Precision Aneroid barometers– 900-1050Mb – mechanical digit readout with electronic indicator – battery powered. Housed in polished wood carrying box – tested – £100-£200-£250. 1, 2 or 3.
HP141T SPECTRUM ANALYSERS – ALL NEW COLOURS
TESTED WITH OPERATING MANUAL
HP141T+8552A or B IF-8553B RF – 1kHz–110Mc/s-A IF – £1300 or B IF – £1400.
HP141T+8552A or B IF-8554B RF – 100kHz–1250Mc/s-A IF – £1400 or B IF – £1500.
HP141T+8552A or B IF-8555A RF – 10Mc/s–18GHz-A IF – £2400 or B IF – £2500.
HP141T+8552A or B IF-8556A RF – 20Hz–300kHz-A IF-A IF – £1200 or B IF – £1300.
HP8443A tracking generator/counter – 100kHz–110Mc/s – £500.
HP8445B tracking pre-selector DC–18GHz – £750.
HP ANZ UNITS AVAILABLE SEPARATELY – NEW COLOURS – TESTED.
HP141T mainframe – £550 – 8552A IF – £450 – 8552B IF – £550 – 8553B RF – 1kHz–110Mc/s – £550 – 8554B-RF – 100kHz–1250Mc/s – £650 – 8555A-RF – 10Mc/s–18GHz – £1550.
HP 3580A LF-spectrum analyser – 5kHz to 50kHz – LED readout – digital storage – £1600 with instruction manual – internal rechargeable battery.
Tektronix 7D20 plug-in 2-channel programmable digitizer – 70 Mc/s – for 7000 mainframes – £500 – manual – £50.
Datron 1065 Auto Cal digital multimeter with instruction manual – £500.
Racal MA 259 FX standard. Output 100kc/s–1Mc/s–5Mc/s – internal NiCad battery – £150.
Aerial array on metal plate 9"×9" containing 4 aerials plus Narda detector – .100–11GHz. Using N type and SMA plugs & sockets – ex eqpt – £100.
EIP 451 microwave pulse counter 18GHz – £1000.
Marconi RF Power Amplifier TF2175 – 1.5Mc/s to 520Mc/s with book – £100.
Marconi 6155A Signal Source – 1 to 2 GHz – LED readout – £600.
Schlumberger 2741 Programmable Microwave Counter – 10Hz to 7.1GHz – £750.
Schlumberger 2720 Programmable Universal Counter 0 to 1250Mc/s – £600.
HP 2225CR Thinkjet Printer – £100.
TEK 576 Calibration Fixture – 067-0597-99 – £250.
HP 8006A Word Generator – £150.
HP 1645A Data Error Analyser – £150.
Texscan Rotary Attenuators – BNC/SMA 0-10-60-100DBS – £50-£150.
HP 809C Slotted Line Carriages – various frequencies to 18GHZ – £100 to £300.
HP 532-536-537 Frequency Meters – various frequencies – £150-£250.
Barr & Stroud variable filter EF3 0.1Hz–100kc/s + high pass + low pass – £150.
S.E. Lab SM215 Mk11 transfer standard voltmeter – 1000 volts.
Alltech Stoddart P7 programmer – £200.
H.P. 6941B multiprogrammer extender. £100.
Fluke Y2000 RTD selector + Fluke 1120A IEEE-488-translator + Fluke 2180 RTD digital thermometer + 9 probes. £350 all three items.
H.P. 6181 DC current source. £150.
H.P. 59501A – HP-IB isolated D/A/power supply programmer.
H.P. 3438A digital multimeter.
H.P. 6177C DC current source. £150.
H.P. 6207B DC power supply.
H.P. 741B AC/DC differential voltmeter standard (old colour) £100.
H.P. 6209B DC power unit.
Fluke 80 high voltage divider.
Fluke 431C high voltage DC supply.
Tektronix M2 gated delay calibration fixture. 067-0712-00.
Tektronix precision DC divider calibration fixture. 067-0503-00.
Tektronix overdrive recovery calibration fixture. 067-0608-00.
Avo VCM163 valve tester + book £300.
H.P. 5011T logic trouble shooting kit. £150.
Marconi TF2163S attenuator – 1GHz. £200.
PPM 8000 programmable scanner.
Fluke 730A DC transfer standard.
B&K 4815 calibrator head.
B&K 4812 calibrator head.
Farnell power unit H60/50 – £400 tested.
H.P. FX doubler 938A or 940A – £300.
Racal/Dana 9300 RMS voltmeter – £250.
H.P. sweeper plug-ins – 86240A – 2–8.4GHz – 86260A – 12.4–18GHz – 86260AH03 – 10–15GHz – 86290B – 2–18.6GHz. 86245A 5.9–12.4GHz.
Telequipment CT71 curve tracer – £200.
H.P. 461A amplifier – 1kc–150Mc/s – old colour – £100.
H.P. 8750A storage normalizer.
Tektronix oscilloscopes type 2215A – 60Mc/s – c/w book & probe – £400.
Tektronix monitor type 604 – £100.
Marconi TF2330 or TF2330A wave analysers – £100–£150.
HP5006A Signature Analyser £250 + book.
HP10783A numeric display. £150.
HP 3763A error detector. £250.
Racal/Dana signal generator 9082 – 1.5–520Mc/s – £800.
Racal/Dana signal generator 9082H – 1.5–520Mc/s – £900.
Claude Lyons Compuline – line condition monitor – in case – LMP1 + LCM1 £500.
Efratom Atomic FX standard FRT – FRK – .1–1–5–10Mc/s. £3K tested.
Racal 4D recorder – £350 – £450 in carrying bag as new.
HP8350A sweep oscillator mainframe + HP11869A RF PI adaptor – £1500.
Alltech – precision automatic noise figure indicator type 75 – £250.
Adret FX synthesizer 2230A – 1Mc/s. £250.
Tektronix – 7S12–7S14–7T11–7S11–S1–S52–S53.
Rotek 610 AC/DC calibrator. £2K + book.
Marconi TF2512 RF power meter – 10 or 30 watts – 50 ohms – £80.
Marconi multiplex tester type 2830.
Marconi digital simulator type 2828A.
Marconi channel access switch type 2831.
Marconi automatic distortion meter type TF2337A – £150.
Marconi mod meters type TF2304 – £250.
HP 5240A counter – 10Hz to 12.4GHz – £400.
HP 3763A error detector.
HP 8016A word generator.
HP 489A micro-wave amp – 1–2GHz.
HP 8565A spectrum analyser – .01–22GHz – £4k.
HP 5065A rubidium vapour FX standard – £5k.
Fluke 893A differential meters – £100 ea.
Systron Donner counter type 6054B – 20Mc/s–24GHz – LED readout – £1k.
Takeda Riken TR4120 tracking scope + TR1604P digital memory.
EG&G Parc model 4001 indicator + 4203 signal averager PI.
Systron Donner 6120 counter/timer A+B+C inputs – 18GHz – £1k.
Racal/Dana 9083 signal source – two tone – £250.
Systron Donner signal generator 1702 – synthesized lo 1GHz – AM/FM.
Systron Donner microwave counter 6057 – 18GHz – Nixey tube – £600.
Racal/Dana synthesized signal generator 9081 – 520Mc/s – AM–FM. £600.
Farnell SSG520 synthesized signal generator – 520Mc/s – £500.
Farnell TTS520 test set – £500 – both £900.
Tektronix plug-ins – AM503 – PG501 – PG508 – PS503A.
Tektronix TM515 mainframe + TM5006 mainframe.
Cole power line monitor T1085 – £250.
Claude Lyons LCM1P line condition monitor – £250.
Rhodes & Schwarz power signal generator SLRD-280 – 2750Mc/s. £250–£600.
Rhodes & Schwarz vector analyser – ZPV+E1+E3 tuners – .3–2000Mc/s.
Bell & Howell TMA3000 tape motion analyser – £250.
Ball Efratom PTB-100 rubidium standard mounted in Tek PI.,
Ball Efratom rubidium standard PT2568-FRKL.
Trend Data tester type 100 – £150.
Farnell electronic load type RB1030-35.
Fairchild interference analyser model EMC-25 – 14kc/s–1GHz.
Fluke 1720A instrument controller + keyboard.
Marconi 2442 – microwave counter – 26.5GHz – £1500.
Racal/Dana counters – 9904 – 9905 – 9906 – 9915 – 9916 – 9917 – 9921 – 50Mc/s – 3GHz – £100–£450 – all fitted with FX standards.
B&K 7003 tape recorder – £300.
B&K 2425 voltmeter – £150.
B&K 4921+4149 outdoor microphone.
Wiltron sweeper mainframe 610D – £500.
HP3200B VHF oscillator – 10–500Mc/s – £200.
HP3747A selective level measuring set.
HP3586A selective level meter.
HP5345A electronic counter.
HP4815A RF vector impedance meter c/w probe. £500–£600.
Marconi TF2092 noise receiver. A, B or C plus filters.
Marconi TF2091 noise generator. A, B or C plus filters.
Tektronix oscilloscope 485 – 350Mc/s – £500.
HP180TR, HP182T mainframes £300–£500.
Bell & Howell CSM2000B recorders.
HP5345A automatic frequency convertor – .015–4GHz.
Fluke 8506A thermal RMS digital multimeter.
HP3581A wave analyser.
Philips panoramic receiver type PM7800 – 1 to 20GHz.
Marconi 6700A sweep oscillator + 6730A – 1 to 2GHz.
Wiltron scaler network analyser 560+3 heads. £1k.
R&S signal generator SMS – 0.4–1040Mc/s – £1500.
HP8558B spectrum ANZ PI – .1–1500Mc/s – o/c – £1000. N/C – £1500 – To fit HP180 series mainframe available – £100 to £500.
HP8505A network ANZ + 8503A S parameter test set + 8501A normalizer – £4k.
HP8505A network ANZ + 8502A test set – £3k.
Racal/Dana 9087 signal generator – 1300Mc/s – £2k.
Racal/Dana VLF frequency standard equipment. Tracor receiver type 900A + difference meter type 527E+rubidium standard type 9475 – £2750.
Marconi 6960–6960A power meters with 6910 heads – 10Mc/s – 20GHz or 6912 – 30kHz–4.2GHz – £800–£1000.
HP8444A–HP8444A opt 59 tracking generator £1k–£2k.
B&K dual recorder type 2308.
HP8755A scaler ANZ with heads £1k.
Tektronix 475 – 200Mc/s oscilloscopes – £350 less attachments to £500 c/w manual, probes etc.
HP signal generators type 626 – 628 – frequency 10GHz–21GHz.
HP 432A–435A or B–436A – power meters+powerheads – 10Mc/s–40GHz – £200–£280.
HP3730B down convertor – £200.
Bradley oscilloscope calibrator type 192 – £600.
Spectrascope SD330A LF realtime ANZ – 20Hz–50kHz – LED readout – tested – £500.
HP8620A or 8620C sweep generators – £250 to £1k with IEEE.
Barr & Stroud variable filter EF3 0.1Hz–100kc/s+high pass+low pass – £150.
Tektronix 7L12 analyser – .1Mc/s–1.8GHz – £1500 – **7L14 ANZ** – £2k.
Marconi TF2370 spectrum ANZ – 110Mc/s – £1200–£2k.
Marconi TF2370 spectrum ANZ+TK2373 FX extender 1250Mc/s+trk gen – £2.5k–£3k.
Racal receivers – RA17L–RA1217–RA1218–RA1772–RA1792 – P.O.R.
Systron Donner microwave counter 6057 – 18GHz – nixey tube – £600.
HP8614A signal gen 800Mc/s–2.4GHz old colour £200. new colour £400.
HP8616A signal gen 1.8GHz–4.5GHz old colour £200. new colour £400.

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CIRCLE NO. 134 ON REPLY CARD

REGULARS

NEW PRODUCTS CLASSIFIED

ACTIVE

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

Small A-to-Ds. 12-bit, 5MHz sampling analogue-to-digital converters from Datel combine the converter and a fast S/H amplifier in a 24-pin DDIP; power requirement at ±15V and 5V is 1.8W. ADS118 has three-state outputs and the ADS118A offers direct adjustment of offset and gain. THD is -73dB at Nyquist. Outputs are compatible with cmos and TTL. Datel (UK) Ltd, 0256 880444.

Discrete active devices

Microwave transistors. Tekelec UK has gained the franchise for the products of Bipolarics Inc. of California, which possesses its own sub-micron wafer fabrication plant for low-noise bipolar devices up to a transition frequency of 15GHz. A typical Bipolarics transistor is the B12V114, which has a 10GHz transition at 25mA, with a noise figure of 1.7dB at 2GHz. Tekelec UK, 0753 548585.

High-current transistors. Eight new transistors from Zetex with continuous current ratings of up to 4A extend the ZTX850 range of n-p-n devices. At high voltages, the ZTX958 is a 400V type with a saturation voltage of 300mV at 0.5A and current gain of 20. A low-voltage device in the range handles 20A pulses at 20V with a gain of 40; saturation resistance of 50mΩ gives a continuous current rating of 4.5A at 1.5W dissipation and a gain of 200. Leakage of devices in this range is typically 1nA. Zetex plc, 061 627 4963.

Linear integrated circuits

Programmable-gain amplifiers. AD75062 and AD75068 from Analog contain two and eight programmable-gain amplifiers respectively, each amplifier including a gain-setting network and control latch. Bandwidth at -3dB is constant at 2MHz for all gains and phase shift 2.5degree from zero to 10kHz. Mos input circuits give input bias currents of 100pA or less. Gains are settable from 1 to 128 in powers of 2 and each amplifier has its own voltage regulator, giving 65dB power-line rejection and 73dB channel isolation Analog Devices, 0932 253320.

Switching regulator. For use in portable equipment, Linear's LT1432 switching regulator controller has a sleep mode for use with systems having sleep/resume facilities It controls the LT1170 and LT1270 family of regulators to make an efficient 5V step-down switching regulator with few external components. Only 60mV of sense voltage is needed and the sense resistor can be formed from the PCB copper. A burst mode affords high efficiency at light currents. Linear Technology (UK) Ltd, 0276 677676.

Y/C processor. Needing only a CCD delay line to form the core of a VCR system, Toshiba's TA8833N single-chip luminance/chrominace processor provides full amplification and AGC, together with sync. separation and identification of Pal, Secam and NTSC carriers and sub-carriers. All necessary filters are included. Toshiba Electronics (UK) Ltd, 0276 694600.

Memory chips

1Mbit drams. Organised as 64K by 16bit devices, new versions of the Toshiba TC511664/5 dynamic random-access memories are available in 80ns and 100ns grades, the fastest having an access time from column address strobe of 25ns. Toshiba points out that these devices are feasible replacements for hard-to-obtain 64K by 4bit types, particularly in VGA application, where two will replace eight. Toshiba Electronics (UK) Ltd, 0276 694600.

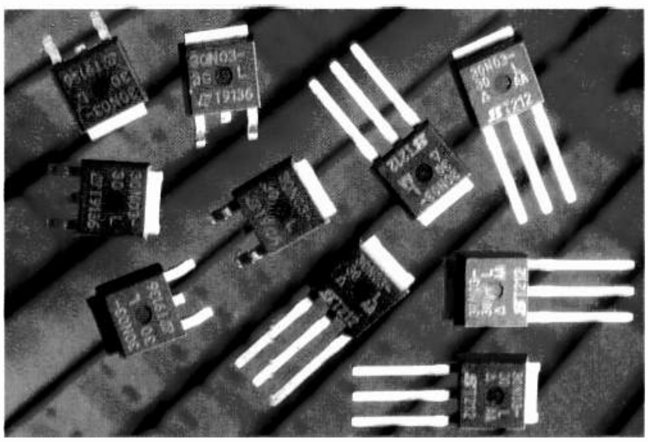
Video ram. "B" mask, third-generation, 1Mbit video rams from Toshiba, dual-port devices in both X4 and X8 configuration with 80ns access, are now in production. Features are write-per-bit, masked flash write and block write, with masked block write and persistent write-per-bit as options. Current consumption is reduced to 70mA maximum in standby. Toshiba Electronics (UK) Ltd. 0276 694600.

Mixed-signal ICs.

Motor driver. Intended to drive the motors used for head positioning in disk drives, the A8932CLW is a full-bridge device whose output current is a direct function of the applied voltage or current. Additional circuitry protects the head and disk during system failure or normal shutdown. Two 500mA mos drivers give low saturation voltage and a current sensor eliminates the need for an external sense resistor. Back-EMF closed-loop control of the motor is available. Allegro Microsystems, 0932 253355.

Direct digital synthesiser. Q2220 from Qualcomm generates digitised sinusoidal signals using phase accumulation and on-chip look-up. With a reference of 50MHz, it synthesises signals from zero to 20MHz at a resolution of 3Hz and with spurious components at a level of -60dBc, frequency setting and its rate of change being performed over a parallel digital interface or by simple dip switches. Chronos Technology Ltd, 0989 85471.

Audio interface for cellphones. Transmit PCM-to-linear encoding and receive linear-to-PCM decoding for cellular and cordless telephones is simplified by TI's TCM320AC36/7 voice-band audio processor, which uses a single 5V rail and dissipates less than 30mW in full operation (1.25mW in power-down). The units connect directly to electret microphones, piezo speakers and digital signal processors. Texas Instruments, 0234 223252.



Mosfet replaces schottkys. Siliconix's SMD30N03-30L n-channel logic-level mosfet has an on-resistance of 30mΩ, which enables its use as replacement for schottky diodes in synchronous rectification on the secondary side of power converters, giving an 8% increase in efficiency. Maximum continuous drain current is 6A, turn-on delay 9ns and operating junction temperature range -55 to 150deg. C. Siliconix Ltd, 0635 30905.

Power semiconductors

Power transistor. Primarily intended for use in avionics, Philips's MX0912B25OY comes in two frequency ranges: 0.96-1.215GHz; and 1.03-1.09GHz with 280W power rating. Gain and collector efficiency for the two versions are 7dB/42% and 8dB/48%. Collector voltage is 50V. Anglia Microwaves Ltd, 0277 630000.

Power rectifier. SDR953M-955M are 50A, 300-500V power rectifiers which have a recovery time of 35ns. Forward voltage at maximum current is 1.5V and reverse leakage at 500V is 100μA. Britcomp Sales Ltd, 0372 377779.

SM voltage regulator. SVR117AHV from Solid State Devices Inc. is a voltage regulator supplying over 10A at voltages between 1.2V and 57V; maximum input/output differential is 60V. Short-circuit and thermal overload protection are provided. Britcomp Sales Ltd, 0372 377779.

Switching diodes. A new diode from Zetex exhibits the forward voltage drop of a silicon diode many times larger, efficiency being similar to that of a silicon type but without the attendant capacitance. ZDX60 is packaged as an E-line device, the forward voltage being 0.8V at 1A, falling to 0.2V at 200deg. C. Recovery time is 20ns, but ssince the diode's capacitance is 150pF maximum, switching performance is similar to a silicon device. Leakage current is typically less than 1nA.. Zetex plc, 061 627 4963.

Please quote "Electronics World + Wireless World" when seeking further information

PASSIVE

Passive components

Low-profile capacitors. With values in the range 0.1μF to 10μF at 2-20V ratings, these new components from AVX are part of the TAJ range and have a maximum case height of 1.2mm. AVX Ltd, 0252 336868.

Miniature pot. In a 7.6mm diameter, 6.6mm high package — the usual size for a miniature single-turn potentiometr — Murata has fitted a four-turn type with a resistance range of 10Ω to 2MΩ, at a power rating of 0.5W. Temperature coefficient is ±100pp/deg.C. Surtech Interconnection, 0256 51221.

Thermistors. At temperatures of 135deg. C, Siemens's C811-C891 range of positive temperature coefficient line-overload protection thermistors cover the 30mA-690mA rated current range and switching currents of 65mA-1.43A. Siemens plc, 0932 752672.

Connectors and cabling

Interface connectors. Harting has a new range of high-density i/o systems interface connectors — the "har mik", which have contact pitches of 1.27mm in 20-100 ways of both pin/socket and bellows contact forms. Metal shells are provided and both male and female versions can be provided with straight or angled solder pins. Quick-Latch or Jackscrew locking versions are available. Harting Electronik Ltd, 0604 766686.

SM test point. Miniature surface-mounted test points from Oxley, Smox are based on the company's Snaplox series, using the same ball-and-socket coupling, but with smaller contacts. Insertion and removal forces are low, but contact is firm when components are aligned in place. Surface-mounted cups are also available, meant for bed-of-nails contacting or joining two boards together in piggy-back form. Smox connectors are gold-plated. Oxley Developments Co. Ltd. 0229 52621.

Toroid transformers. Toroids for use in hostile conditions are a speciality of Gardners, which offers design and manufacture of units in this class, taking into account humidity, temperature changes, acceleration and vibration. Gardners Ltd, 0202 470805.

Filters

EMI filters. Oxley's OX/PA planar capacitor filter arrays are made to fit standard or custom connectors, taking up less space than tubular or discoidal capacitors and allowing pin spacings of less than 2mm. Different capacitor values can be produced in the same array to cope with power lines or signal paths. Arrays are retained by spring clips, which avoids the need to solder and eliminates stress in the ceramic. Ferrite inductors can be incorporated. Oxley Developments Co. Ltd, 0229 52621.

Instrumentation

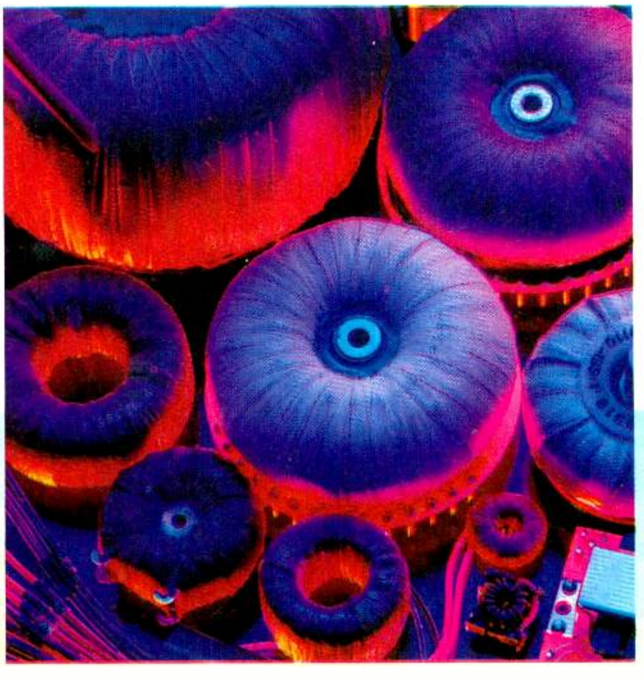
Current calibrator. Caltek 300 is a portable current calibrator with a range of 0-20mA. It is hand-held and battery-powered and operates as a current source, a current sink or as a monitor for the current in a process loop. Its 3.5-digit led display and front-panel control allow adjustment to within ±1% at a resolution of 10μA. Alpha Electronics plc, 0942 873434.

Sound-level analyser. B & K's Type 2146 analyser is an entry-level instrument, but nevertheless has the ability to perform real-time frequency analysis, allowing the measurement of pulsed signals. Spectra are stored automatically at preset intervals from milliseconds to hours, an internal disk drive being provided. Bruel & Kjaer (UK) Ltd, 081 954 2366.

Logic analyser. Thurlby-Thandar's TA4000 logic analysers offer 400MHz resolution and extended memory. In three versions, there is a choice of 32, 48 or 80 channels, with the 400MHz resolution on some of the channels. At 400MHz, timing resolution is 2.5ns and the memory depth is extendable to 8Kword. There is asynchronous sampling of 100MHz cn all channels and synchronous sampling across channels at external clock speeds of 50MHz. Disassembler support for 8, 16 and 32-bit microprocessors is provided. Feedback Instruments Ltd, 0892 653322.

Magnetic field-strength meter. HET1000 fro Redcliffe Magtronics is a digital Hall-effect meter to measure static, alternating or pulsed magnetic fields in the range 0.0ˉ-2000mT and is provided with a range of probes to suit virtually any application. It possesses a limits comparator for pass/fail testing, a one-touch zero facility and a zero-field chamber for calibration. The instrument is made to BS5750 standards. Redcliffe Magtronics Ltd, 0272 771404.

Function gen./counter. Saje's FG-506 and FG513 are each two instruments in one case — a function generator and a 100MHz counter. An LCD menu provides setup and frequency display. Output from the function generators at up to 6MHz (506) or 13MHz (513) is in response to a trigger, gate, internal or external clock, with duty cycle and symmetry adjustment and at a single frequency or linearly or logarithmically swept. Output is TTL or into 50Ω. Saje Electronics, 0223 425440.



Multi-standard TV analyser. SI7768, which is a video analyser by Schlumberger Technologies Communications Test, is intended for use by both installation technicians and R&D engineers; it is primarily meant to verify transmission quality during the change from existing standards to the digital format, providing automatic qualification of D2MAC digital/analogue signals and is ready for HDMAC. In essence, the instrument is a signal analyser, oscilloscope and printer, working on baseband signal and including measurement of all significant functions. Schlumberger Technologies, 0252 376666.

20MHz oscilloscope. At low cost, Kenwood's CS-4025 oscilloscope is relatively free of frills, but provides a sensible specification at the price. Bandwidth is 20MHz at 5mV/division (1mV up to 5MHz) and the sweep time is variable from 0.5μs/division to 0.5s/division, with a X10 magnifier; the usual chop and alternate sweep modes are included. XY display is provided and the vertical amplifier output comes out to the panel to give 50mV/division at 50Ω. Trio-Kenwood UK Ltd, 0923 816444.

Literature

Amplifier guide. In 56 pages, the 1992 "Amplifier Products Cross-reference Guide" from Analog gives information on ordering, device selection, cross-references, military devices, sales offices and distributors. Analog Devices, 0932 253320.

Data converters. DDC's 1992 catalogue presents details of MIL-Std data bus products, synchro and resolver converters and intelligent load management devices. There is also information on power hybrids including motor-drive circuitry and DC-to-DC converters. Data Device Corporation, 0635 40158.

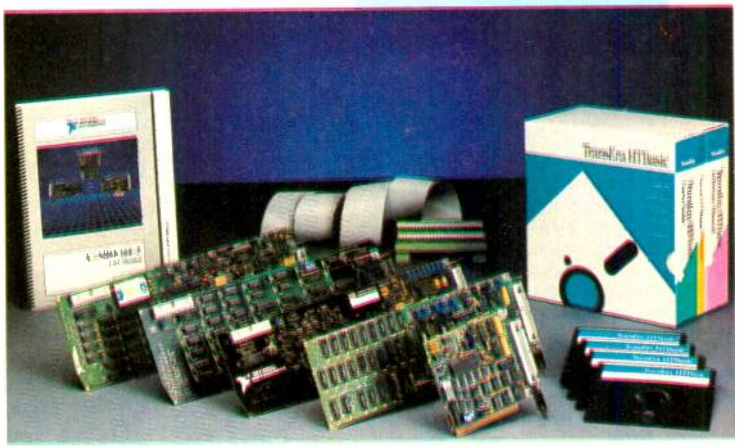
DSP products. In an 8-page brochure, National describes its range of digital signal-processing boards and software for PCs and Macintosh computers. Also briefly described are LabWindows and LabView applications software. National Instruments UK, 0635 523545.

PSU design. Motorola's new Switchmode guide is available, describing basic operation of switched-mode power supplies, with circuit design assistance. Numbers of device selection tables are provided. Switch-mode PSUs. 0908 614614.

Production equipment

PCB fault diagnoser PC link. ABI's BoardMaster 2400 is now linkable to a PC by means of the MasterLink-24 system to allow it to save the results of tests on known good boards and

Please quote "Electronics World + Wireless World" when seeking further information



Displays

Colour displays. ABA has a series of CRT display units for amusements and public information application, where high brightness aand readability are particularly important. CDT displays incorporate wide-band video amplifiers, a switched-mode power supply and a low-impedance EHT unit, with CRTs from 14in to 26in. The units operate from RGB or TTL input, have a 650-line resolution with 15-21kHz horizontal frequency and 40-75Hz vertical frequency, either interlaced or non-interlaced. They come in kit form, as chassis or in cases. ABA Electronics Ltd, 0264 335025.

compare them with boards under test, results being presented graphically under menu-driven control. BoardMaster combines 24 channels of in-circuit test with five bus-disabling outputs, diagnosing board and IC faults, including the intermittent variety. ABI Electronics Ltd, 0226 350145.

Power supplies

DC-to-DC converters. Needing no external components whatever, Calex's UW series of converters give 20mV pk-pk noise and 91% efficiency. Inputs of 12V and 24V are allowed, outputs being 5V, 12V and 15V at up to 5A. Although switching techniques are used, the circuitry provides linear-type performance in response to input changes, in particular during battery/backup change-overs. Calex Electronics Ltd, 0525 373178.

Compact switchers. Power General's range of switched-mode power supplies now includes the FLU2-20 series, 76 by 127 by 30mm open-frame types which provide 12V/1A, 15V/0.8A or 24V/0.5A and a 5V/3A primary output. Universal input is from 85V to 265V AC or 100-370V DC and there is an EMI/RFI filter. Protection includes indefinite short-circuits, overvoltage, soft start, 5.3kV input/output isolation and a power-limiting circuit. Dowty Power Electronics Ltd. 0722 413060.

Radio communications products

Microwave isolator. Murata's CE060 surface-mounted isolators weigh 75g and measure 7.3 by 7.3 by 4mm, which possibly makes them the world's smallest. They are designed for cordless telephones and interstage matching in microwave circuitry, working in five frequency ranges between 824MHz and 942MHz. Insertion loss is 1dB; isolation 12dB; VSWR 1.5:1 and power handling 2.5W forward and 0.75W reverse. Murata Electronics (UK) Ltd, 0252 811666.

Small UHF transmitter. The MT450 is an ultra-miniature (113 by 57 by 22mm) multi-channel simplex unit by Woods & Douglas and is meant for telemetry, signalling and data acquisition. It is optimised for use with the MR450 receiver; channels in the 450-470MHz band are remotely selected. Power output is high or low at 500mW and 5mW. Analogue and digital modulation is usable. Wood & Douglas, 0734 811444.

Switches and relays

Solid-state relays. FR's ZRA12 series of relays handles 1200V at up to 80A and is suitable for zero-voltage and zero-current switching. They are insensitive to shock, attitude or vibration and constant-current input circuitry reduces drive power. Isolation voltage is 5kV rated. VDE, UL and CSA approval is present. FR Electronics, 0202 897969.

Small, HF relay. Two change-over contacts rated at 30W, switching 300MHz with an isolation loss of 40dB, are contained in the Matsushita DX range of relays, which need only 60mW to activate. Action is monostable or latching, the latter having a thermovoltage characteristic of 1μV. The relays are shock-resistant up to 50g. Matsushita Automation Controls 0908 231555.

Transducers and sensors

Shaft encoder. CT80, a digital shaft encoder by Control Transducers, can be supplied with any type of fitting, so that no further mechanical design work is needed for any application. Line count per revolution is up to 2048, two quad outputs allowing direction sensing and a marker providing reset or zeroing. SM cmos circuitry reduces problems with noise and line drivers are available. Control Transducers, 0234 217704.

More HTBasic drivers. Version 3.2 of HTBasic has an expanded set of device drivers for NI data acquisition boards, including A-to-D-to-A, digital i/o and counter/timer capability for AT-MIO-16F-5, AT-MIO-16, AT-DIO-32F, Lab-PC and PC-LPM-16 boards. Normal HTBasic commands access the boards. National Instruments UK, 0635 523545.

COMPUTER

Computer board level products

PCTV. . Digithurst has thoughtfully provided yet another method of preventing anyone doing any actual work by offering the MicroEye TV2 card, which is a television tuner and all electronics to bring television from domestic aerial to the PC screen, the picture appearing in a window so that a pretence can still be kept up. Digithurst Ltd, 0763 242955.

Anti-alias filter. Laplace points out that aliased high-frequency components can appear at lower frequencies in an A-to-D converter with a sampling frequency that is not high enough to eliminate the aliased data, the aliased data being indistinguishable from the valid type. Laplace's AAF-1 anti-alias filter board reduces the problem by limiting input bandwidth sharply, eliminating the need for high-speed sampling that

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could present memory and PC processing speed problems. The Alligator Technologies AAF-1 contains as standard two brick-wall eighth-order elliptic low-pass filters, with Bessel and Butterworth types as options. Laplace Instruments Ltd, 0692 500777.

Speech development system. A PC-based development system for OKI's range of adaptive differential PCM ICs, the AR76 202 consists of a slot card, memory programmer, software and a manual. Speech is recorded in host memory, from which it is visible on screen and can be edited in a number of ways before being saved. Sampling frequencies up to 32kHz are available and speech synthesisers can be programmed directly. Manhattan Skyline Ltd, 0628 778686.

Iris Indigo interface. With National's GPIB interface kit, users of the Iris Indigo risc-based PC can control up to 14 GPIB-based graphics peripherals or instruments from the SCSI port. Included is the Irix multi-task software and the National GPIB-SCSI-A controller box, which is an 8-bit computer implementing the full range of GPIB functions and which has a 256K ram buffer. National Instruments UK, 0635 523545.

Data communications products

Digital-IEEE488 interface. IO Tech's DIGITAL488/32/OEM is a 32 i/o line interface board for transfers between IEEE488 buses and devices with up to 32-bit wide digital ports. The 32 TTL-level lines are programmable in 8-bit groups as inputs or outputs; the housekeeping is done by six handshake lines. A complete command set is in firmware. Keithley Instruments Ltd, 0734 596469.

Development and evaluation

68040 development system. Upgrades of BVM's BVME566/7 OS-9 systems are based on 68040 or 68EC040 processors. Systems use the BVME395 VMEbus CPU with 32byte of ram, dual serial ports, RS232, 422 or 485 and a printer port. The 68040 allows full bus snooping and cache memory burst filling, while still allowing an upgrade path for systems developed on earlier processors. A mass storage module provides Winchesters up to 200Mbyte and floppies to 4Mbyte. BVM Ltd, 0703 270770.

C compiler and 80C166 emulator. Kiel's C compiler is meant for use with high-end embedded risc systems, providing near-assembler efficiency and achieving over 5000Dhrystones at 40MHz. It forms a complete toolkit, which includes compiler, macro assembler, linker and simulator/debugger. Secondly, the T32/166 is the first real-time in-circuit emulator for the Siemens 80C166 risc microcontroller. Hitex (UK) Ltd, 0203 692066.

Graphic debugging. Debug monitors from LSI will now display memory contents graphically in a number of formats. Available in either dos or Windows 3.x versions, the new graphics facility enables display in both 1:1 pixel/point and min/max or data discard format, plots being from zero to the value or continuous line. Thw Windows version allows plot range to be set by mouse and provides zoom in and out. Refresh allows changing memory content to be followed. Loughborough Sound Images Ltd, 0509 231843.

Mitsubishi micro emulator. Described as a fully integrated development environment with full source debugging facilities, the TELL emulator by RCS is presently available for the Mitsubishi M50734/50747/37450/37410 microcomputers. Its needs are simply a PC XT/AT with 512K, an 8-bit slot and dos 3.0 or better. Editor, assembler and debug elements communicate with each other within the emulator and, since only one program is loaded, development time is reduced. RCS Microsystems Ltd, 081 979 2204.

Computer peripherals

LCD monitor. Citizen has a new LCD computer monitor, which offers a 640 by 480 display using Citizen's own panel. It incorporates a retardation control film and uses supertwist techniques, being suitable for text and graphics and being connected to the PC by a display controller card. A feature is its small size — only 40% that of a conventional CRT monitor; it can also be wall-mounted. Citizen Europe Ltd, 0895 272621.

488 for notebooks. Problems of using notebook PCs to control external devices are overcome by IOTech's Personal 488/NB interface, which plugs into the notebook's parallel port to allow control of up to 14 IEEE devices. Speed is comparable with interfaces for desk-top PCs, with which it can also be used. Personal 488/NB is compatible with Windows and dos and supports third-party data-acquisition software. Keithley Instruments Ltd, 0734 596469.

Software

BIOS maker. To allow embedded systems developers to make their own BIOS and tailor it to cope with special needs of the embedded 80X86 processor, GWI has brought out an adaptation kit including source code, 30 configuration options, rom building utilities, rom disk BIOS extension module, remote disk software and debugger. Embedded BIOS is meant to support AT-compatible BIOS functions in real time conditions with low interrupt latency of less than 10 instructions. Great Western Instruments Ltd, 0761 452116.

Schematic capture. Geseca (Jessica for those who have been introduced) is a schematic editor offering much simpler and faster schematic capture than is usual, with the intention of allowing engineers to concentrate on simulation rather than drawing pictures. Copying components from the library window to an edit window is simply a matter of using a two-button mouse and a couple of hot keys. All the features of earlier systems have been retained, but Geseca is meant to be intuitive to analogue simulator users, rather than PCB designers. Those Engineers Ltd, 081-906 0155.

LabWindows 2.2. The new version of LabWindows software development system for dos-based data acquisition and instrument control offers enhanced digital signal processing, more flexible user interface library and more drivers in the data acquisition library. Using the new analysis library, data can be simultaneously acquired and analysed in real time, and the UIL now incorporates interactive graph cursors. Seventeen new statistical functions have been added and the 40 new instrument drivers bring the total to 220, many of them for VXI instruments. National Instruments UK, 0635 523545.

AMSTRAD PORTABLE PC'S FROM £149 (PPC1512SD). £179 (PPC1512DD). £179 (PPC1640SD). £209 (PPC1640DD). MODEMS £30 EXTRA.NO MANUALS OR PSU.

HIGH POWER CAR SPEAKERS. Stereo pair output 100w each 4ohm impedance and consisting of 6 1/2" woofer 2" mid range and 1" tweeter. Ideal to work with the amplifier described above. Price per pair £30.00 Order ref 30P7R

MICROWAVE CONTROL PANEL. Mains operated, with touch switches. Complete with 4 digit display, digital clock, and 2 relay outputs one for power and one for pulsed power (programmable) Ideal for all sorts of precision timer applications etc. Now only £4.00 ref 4P151.

FIBRE OPTIC CABLE. Stranded optical fibres sheathed in black PVC. Five metre length £7.00 ref 7P29R

12V SOLAR CELL. 200mA output ideal for trickle charging etc. 300 mm square. Our price £15.00 ref 15P42R

PASSIVE INFRA-RED MOTION SENSOR. Complete with daylight sensor, adjustable lights on timer (8 secs -15 mins), 50' range with a 90 deg coverage. Manual override facility. Complete with wall brackets, bulb holders etc. Brand new and guaranteed. Now only £19.00 ref 19P29

Pack of two PAR38 bulbs for above unit £12.00 ref 12P43R

VIDEO SENDER UNIT Transmit both audio and video signals from either a video camera, video recorder or computer to any standard TV set within a 100' range! (tune TV to a spare channel) 12v DC op. £15.00 ref 15P39R Suitable mains adaptor £5.00 ref 5P191R

FM TRANSMITTER housed in a standard working 13A adapter (bug is mains driven). £26.00 ref 26P2R

MINATURE RADIO TRANSCEIVERS A pair of walkie talkies with a range of up to 2 kilometres. Units measure 22x52x155mm. Complete with cases £30.00 ref 30P12R

FM CORDLESS MICROPHONE. Small hand held unit with a 500' range! 2 transmit power levels reqs PP3 battery. Tuneable to any FM receiver. Our price £15 ref 15P42AR

12 BAND COMMUNICATIONS RECEIVER. 9 short bands, FM, AM and LW DX/local switch, tuning 'eye' mains or battery. Complete with shoulder strap and mains lead. **NOW ONLY £19.00!! REF 19P14R.**

CAR STEREO AND FM RADIO Low cost stereo system giving 5 watts per channel. Signal to noise ratio better than 45db, wow and flutter less than .35%. Neg earth. £19.00 ref 19P30

LOW COST WALIKIE TALKIES Pair of battery operated units with a range of about 200'. Our price £8.00 a pair ref 8P50R

7 CHANNEL GRAPHIC EQUALIZER plus a 60 watt power amp! 20-21KHZ 4-8R 12-14v DC negative earth. Cased. £25 ref 25P14R

NICAD BATTERIES. Brand new top quality. 4 x AA's £4.00 ref 4P44R. 2 x C's £4.00 ref 4P73R, 4 x D's £9.00 ref 9P12R, 1 x PP3 £6.00 ref 6P35R

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CABLE TIES. 142mm x 3.2mm white nylon pack of 100 £3.00 ref 3P104R. Bumper pack of 1,000 ties £14.00 ref 14P6R

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FM BUG KIT. New design with PCB embedded coil. Transmits to any FM radio. 9v battery req'd. £5.00 ref 5P158R

FM BUG Built and tested superior 9v operation £14.00 ref 14P3R

COMPOSITE VIDEO KITS. These convert composite video into separate H sync, V sync and video. 12v DC. £8.00 ref 8P39R.

SINCLAIR C5 MOTORS 12v 29A (full load) 3300 rpm 6"x4" 1/4" O/P shaft. New. £20.00 ref 20P22R.

As above but with fitted 4 to 1 inline reduction box (800rpm) and toothed nylon belt drive cog £40.00 ref 40P8R.

ELECTRONIC SPEED CONTROL KIT for c5 motor. PCB and all components to build a speed controller (0-95% of speed). Uses pulse width modulation. £17.00 ref 17P3R.

SOLAR POWERED NICAD CHARGER. Charges 4 AA nicads in 8 hours. Brand new and cased £6.00 ref 6P3R.

ACORN DATA RECORDER ALF503 Made for BBC computer but suitable for others. Includes mains adapter, leads and book. £15.00 ref 15P43R

VIDEO TAPES. Three hour superior quality tapes made under licence from the famous JVC company. Pack of 5 tapes **New low price £8.00 ref 8P161**

PHILIPS LASER. 2MW HELIUM NEON LASER TUBE. BRAND NEW FULL SPEC £40.00 REF 40P10R. MAINS POWER SUPPLY KIT £20.00 REF 20P33R READY BUILT AND TESTED LASER IN ONE CASE £75.00 REF 75P4R.

12 TO 220V INVERTER KIT As supplied it will handle up to about 15w at 220v but with a larger transformer it will handle 80 watts. Basic kit £12.00 ref 12P17R. Larger transformer £12.00 ref 12P41R.

VERO EASI WIRE PROTOTYPING SYSTEM Ideal for designing projects on etc. Complete with tools, wire and reusable board. **New low bargain price only £2.00 ref B2P1**

HIGH RESOLUTION 12" AMBER MONITOR 12v 1.5A Hercules compatible (TTL input) new and cased £22.00 ref 22P2R

VGA PAPER WHITE MONO monitors new and cased 240v AC. £59.00 ref 59P4R

25 WATT STEREO AMPLIFIER c. STK043. With the addition of a handful of components you can build a 25 watt amplifier. £4.00 ref 4P69R (Circuit dia included)

BARGAIN NICADS AAA SIZE 200MAH 1.2V PACK OF 10 £4.00 REF 4P92R, PACK OF 100 £30.00 REF 30P16R

FRESNEL MAGNIFYING LENS 83 x 52mm £1.00 ref BD827R

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

ULTRASONIC ALARM SYSTEM. Once again in stock these units consist of a detector that plugs into a 13A socket in the area to protect. The receiver plugs into a 13A socket anywhere else on the same supply. Ideal for protecting garages, sheds etc. Complete system £25.00 ref B25P1 additional detectors £11.00 ref B11P1

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

AMSTRAD MP3

UHF/VHF TV RECEIVER/CONVERTER

CONVERTS COLOUR MONITOR INTO A TV!

£9.00

286 MOTHER BOARDS. Brand new and tested complete with technical manual. £49.00 ref A49P1

UNIVERSAL BATTERY CHARGER. Takes AA's, C's, D's and PP3 nicads. Holds up to 5 batteries at once. New and cased, mains operated. £6.00 ref 6P36R

IN CAR POWER SUPPLY. Plugs into cigar socket and gives 3,4.5,6,7.5,9, and 12v outputs at 800mA. Complete with universal spider plug. £5.00 ref 5P167R

RESISTOR PACK. 10 x 50 values (500 resistors) all 1/4 watt 2% metal film. £5.00 ref 5P170R

CAPACITOR PACK 1. 100 assorted non electrolytic capacitors £2.00 ref 2P286R

CAPACITOR PACK 2. 40 assorted electrolytic capacitors £2.00 ref 2P287R

QUICK CUPPA? 12v immersion heater with lead and cigar lighter plug £3.00 ref 3P92R

LED PACK. 50 red leds, 50 green leds and 50 yellow leds all 5mm £8.00 ref 8P52R

AMSTRAD 1640DD BASE UNITS

BRAND NEW AND CASED

TWO BUILT IN 5 1/4" DRIVES

MOTHER BOARD WITH 640K MEMORY

KEYBOARD AND MOUSE

MANUAL

OUR PRICE JUST

£79!!!!

IBM PRINTER LEAD. (D25 to centronics plug) 2 metre parallel. £5.00 ref 5P186R

COPPER CLAD STRIP BOARD 17" x 4" of 1" pitch "vero" board. £4.00 a sheet ref 4P62R or 2 sheets for £7.00 ref 7P22R

STRIP BOARD CUTTING TOOL. £2.00 ref 2P352R

50 METRES OF MAINS CABLE £3.00 2 core black precut in convenient 2 m lengths. Ideal for repairs and projects. ref 3P91R

4 CORE SCREENED AUDIO CABLE 24 METRES £2.00 Precut into convenient 1.2 m lengths. Ref 2P365R

6 1/2" 20 WATT SPEAKER Built in tweeter 4 ohm £5.00 ref 5P205R

WINDUP SOLAR POWERED RADIO! FM/AM radio takes rechargeable batteries complete with hand charger and solar panel 14P200R

PC STYLE POWER SUPPLY Made by AZTEC 110v or 240v input +5@15A,+12@5A,-12@.5A,-5@.3A Fully cased with fan, on/off switch, IEC inlet and standard PC flyleads £15.00 ref F15P4

ALARM PIR SENSORS Standard 12v alarm type sensor will interface to most alarm panels £16.00 ref 16P200

MODEMS FOR THREE POUNDS!! Fully cased UK modems designed for dial up system (PSTN) no data or info but only £3.00 ref 3P145R

TELEPHONE HANDSETS Bargain pack of 10 brand new handsets with mic and speaker only £3.00 ref 3P146R

DATA RECORDERS Customer returned mains battery units built in mic ideal for Computer or general purpose audio use. Price is £4.00 ref 4P100R

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

ATARI JOYSTICKS Ok for use with the above interface, our price £4.00 ref 4P102R

BENCH POWER SUPPLIES Superbly made fully cased (metal) giving 12v at 2A plus a 6V supply. Fused and short circuit protected. For sale at less than the cost of the case! Our price is £4.00 ref 4P103R

SPEAKER WIRE Brown twin core insulated cable 100 feet for £2.00 REF 2P79R

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

MICROSCOPE 1200X MAGNIFICATION Brand new complete with shrimp hatchery, shrimps, prepared slides, light etc. £29.00 ref J29P4

LIGHT ALARM SYSTEM Small cased alarms that monitor a narrow beam area for sudden changes in light level. Complete with siren that sounds for a preset time when unit is triggered. £7.00 ref J7P1

JOYBALLS Back in stock popular Commodore/Atari equiv (replace standard joystick) £5.00 ref J5P8

720K 3 1/2" DISC DRIVE Brand new units made by JVC complete with tech info just £19.00!! ref J19P2

CAR BATTERY CHARGER Brand new units complete with panel meter and leads. 6 or 12v output £7.00 ref J7P2

CUSTOMER RETURNED SPECTRUM +2 Complete but sold as seen so may need attention £25.00 ref J25P1 or 2 for £40.00 ref J40P4

CUSTOMER RETURNED SPECTRUM +3 Complete but sold as seen so may need attention £25.00 ref J25P2 or 2 for £40.00 ref J40P5

HEX KEYBOARDS Brand new units approx 5" x 3" only £1.00 each ref CD42R

PROJECT BOX 5 1/2" x 3 1/2" x 1" black ABS with screw on lid. £1.00 ref CD43R

SCART TO SCART LEADS Bargain price leads at 2 for £3.00 ref 3P147R

SCART TO D TYPE LEADS Standard Scart on one end, Hi density D type on the other. Pack of ten leads only £7.00 ref 7P2R

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

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

VIEWDATA SYSTEMS Brand new units made by TANDATA complete with 1200/75 built in modem infra red remote controlled qwerty keyboard BT approved Prestel compatible. Centronics printer port RGB colour and composite output (works with ordinary television) complete with power supply and fully cased. Our price is only £20.00 ref 20P1R

AC STEPDOWN CONVERTOR Cased units that convert 240v to 110v 3" x 2" with mains input lead and 2 pin American output socket (suitable for resistive loads only) our price £2.00 ref 2P381R

CURLY CABLE Extends from 8" to 6 feet! D connector on one end spade connectors on the other ideal for joysticks etc (6 core) £1.00 each ref CD44R

COMPUTER JOYSTICK BARGAIN Pack of 2 joysticks only £2.00 ref 2P382R

BUGGING TAPE RECORDER Small hand held cassette recorders that only operate when there is sound then turn off 6 seconds after so you could leave it in a room all day and just record any thing that was said. Price is £20.00 ref 20P3R

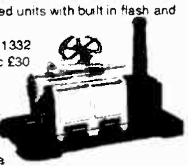
NEW SOLAR ENERGY KIT Contains 8 solar cells, motor, tools, fan etc plus educational booklet. Ideal for the budding enthusiast! Price is £12.00 ref 12P2R

286 AT PC
286 MOTHER BOARD WITH 640K RAM FULL SIZE METAL CASE, TECHNICAL MANUAL, KEYBOARD AND POWER SUPPLY £139 REF 139P1 (no i/o cards or drives included) Some metal work req'd phone for details.

35MM CAMERAS Customer returned units with built in flash and 28mm lens 2 for £8.00 ref 8P200

STEAM ENGINE Standard Mamod 1332 engine complete with boiler piston etc £30 ref 30P200

TALKING CLOCK LCD display, alarm, battery operated. Clock will announce the time at the push of a button and when the alarm is due. The alarm is switchable from voice to a cock crowing! £14.00 ref 14P200 R



HANDHELD TONE DIALLERS Small units that are designed to hold over the mouth piece of a telephone to send MF dialling tones. Ideal for the remote control of answer machines. £5.00 ref 5P209R

AMAZING TALKING COINBOX! Fully programmable talking, lockable coinbox BT approved, retail price is £79 ours is just £29! ref J29P2

ANSWER PHONES £15 Customer returned units with 2 faults one we tell you how to fix the other you do yourself! £18 ref J18P2 or 4 for £60 ref J60P3 BT approved (retail price £79.95!! each)

COMMODORE 64 MICRODRIVE SYSTEM Complete cased brand new drives with cartridge and software 10 times faster than tape machines works with any Commodore 64 setup. The orginal price for these was £49.00 but we can offer them to you at only £25.00! Ref 25P1R

90 WATT MAINS MOTORS Ex equipment but ok. Good general pupose unit £9.00 ref F9P1

HI FI SPEAKER BARGAIN Orginally made for TV sets they consist of a 4" 10 watt 4R speaker and a 2" 140R tweeter. If you want two of each plus 2 of our crossovers you can have the lot for £5.00 ref F5P2

VIDEO TAPES E180 FIFTY TAPES FOR £70.00 REF F70P1

360K 5 1/4" Brand new drives white front £20.00 Ref F20P1

EMERGENCY LIGHTING SYSTEM Fully cased complete with 2 adjustable flood lights. All you need is a standard 6v lead acid battery. Our price is just £10 ref J10P29

AMSTRAD 464 COMPUTERS Customer returned units complete with a monitor for just £35! These units are sold as faulty and are not returnable.

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REGULARS

APPLICATIONS

Using micropower op-amps

With its supply current of 16μA per amplifier from 4.5 to 15V single-ended, National's *LMC6062* dual op-amp is truly a micropower device, intended for use as a true instrumentation amplifier, in D-to-A converters or as a charge amplifier. Its voltage gain is 140dB, input bias current ten femtoamp ($10*10^{-15}$A) and input offset voltage 100μV. Transition frequency is about 100kHz, so the device is mainly for low-frequency application; a higher-frequency version, the *LMC6082*, is available.

Design is unusual in that the output is taken directly from the internal integrator for low output impedance and high gain — no push-pull output buffer is used — and feedforward compensation maintains stability over a range of conditions wider than is commonly found in this type of device. The technique allows rail-to-rail swing even when driving a large load.

The application note is mainly of interest in that it offers advice on the use of low input bias micropower op-amps in general, particularly in board layout. With a bias current of 10fA or less, it is essential to reduce the effect of surface leakage caused by humidity or dust, even though the board itself appears to be of high quality. For example, if the trace-to-pad resistance of the board is $10^{12}\Omega$, a 5V line next to the input pad would cause 5pA of leakage, or about 100 times degradation of performance. To avoid this kind of trouble, guard rings have to be used on both sides of

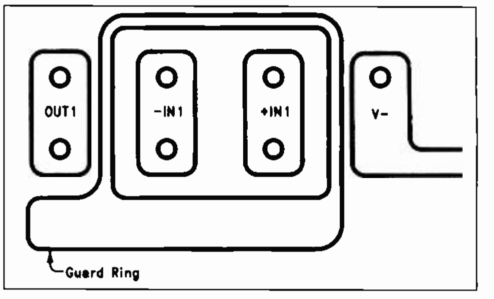

Fig.1. A guard ring will offset the effects of leakage on the surface of a PCB, which in an ultra-low input bias current device such as National's LMC6062 could degrade the performance by 100 times.

One-chip voice record and playback

Three ICs in the ISD1000A family from Information Storage Devices Inc. provide direct analogue storage for up to 10 years of 12, 16 or 20 seconds of audio, with no programming or development system requirement. The chips are compatible upgrades of the ISD1000 family and offer a better noise performance and 50mW of speaker power into 16Ω. ISD's DAST (Direct Analogue Storage Technology) offers eight times the storage capacity of digital devices, in this case its 128K cells being the equivalent of 1Mbit of digital storage.

As the block diagram of **Fig.1** shows, the device contains all the basic functions needed for an audio recording and playback system in the one chip, including a noise-cancelling analogue-in preamplifier with externally adjustable AGC, an anti-aliasing filter and timing oscillator.

Figure 2 is a typical application, in which an electret microphone input is amplified by the preamplifier, whose output is taken back to the analogue input for further gain. AGC

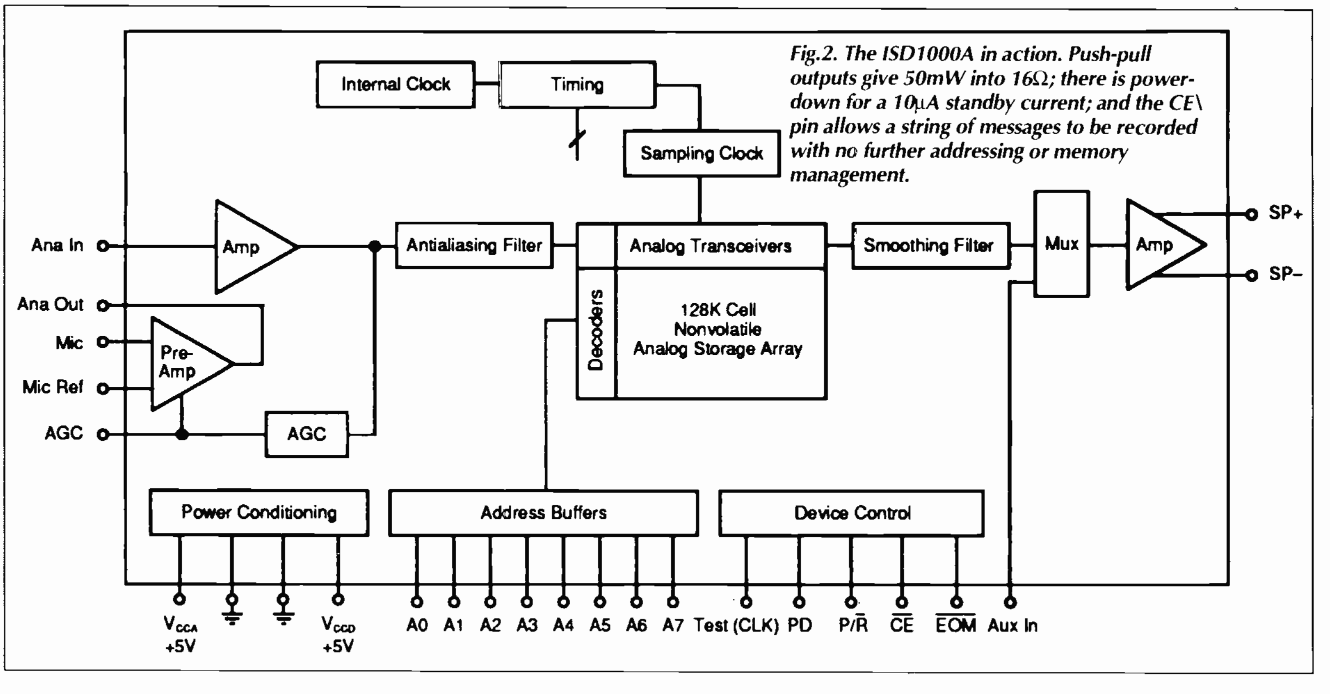

Fig.2. The ISD1000A in action. Push-pull outputs give 50mW into 16Ω; there is power-down for a 10μA standby current; and the CE\ pin allows a string of messages to be recorded with no further addressing or memory management.

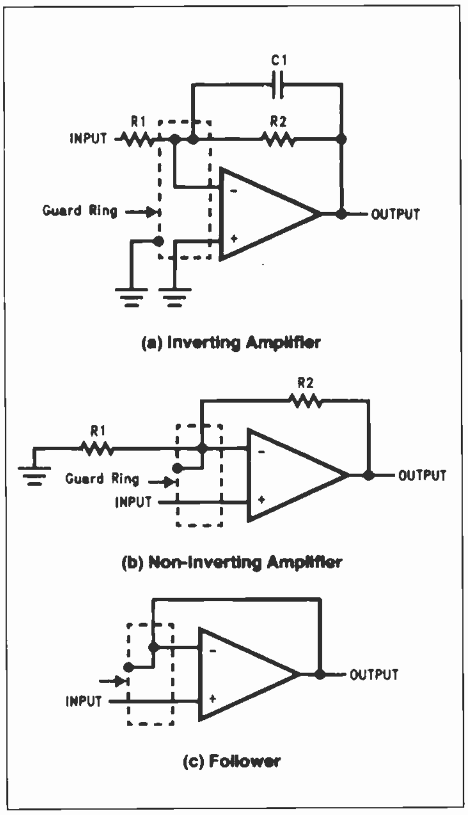

Fig.2. Guard rings applied to the standard op-amp circuits. These can bring the input current leakage down to 0.05pA from 5pA when a 5V line passes an input pad.

the board, as shown in **Fig. 1**, completely surrounding the op-amp inputs and component terminals and connected to the same voltage as that of the inputs. If the guard ring is kept within 5mV of the inputs, leakage is reduced by a factor of 100, even with one tenth the leakage resistance. **Figure 2** shows guard ring connections for the standard op-amp configurations.

On the other hand, as the note suggests, you could always use air as the insulator. It may be infra dig., but if the input pin is bent up in the air and the components made self-supporting, as in **Fig. 3**, the result is even less leakage than with a guard ring. **Figure 4** is an example of an instrumentation amplifier using three *LMC6062s*, which offers a voltage gain of 100, differential and common-mode input resistance of over $10^{14}\Omega$, input current of less than 100fA and an offset drift of less than 2.5μV/°C. Variable resistor R_2 adjusts gain without affecting CMRR and R_7 optimises CMRR to avoid the need to use precision matched resistors.

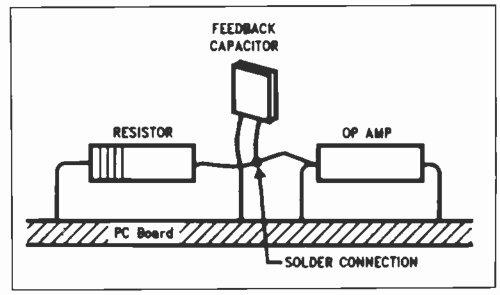

Fig.3. Alternative, but not pretty way of avoiding leakage. Air is a good insulator.

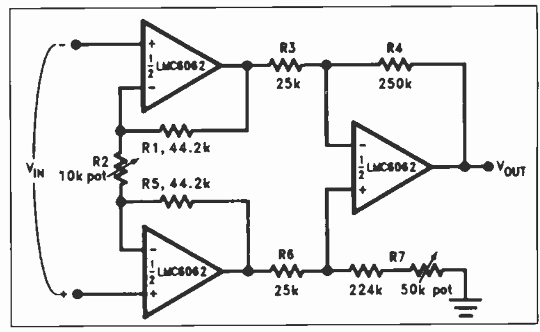

Fig.4. True instrumentation amplifier using the LMC6062.

***National Semiconductor (UK) Ltd**, The Maple, Kembrey Park, Swindon, Wiltshire SN2 6UT. Telephone 0793 614141.*

extends the dynamic range of signals by detecting peak levels with which to charge C_2. Attack time of the AGC is determined by the AGC internal resistance of 5kΩ and C_2, while release time is set by the values of R_2 and C_2. Below an AGC voltage of 1.5V, the preamplifier has its maximum gain of 24dB, this being reduced for AGC levels of more than 1.8V. A continuous, fifth-order Tchebyshev filter takes care of aliasing, its low cut-off being determined by the values of the capacitor on the analogue input pin and in the microphone connection.

One speaker output can be used on its own, but the push-pull connection gives 50mW into 16Ω, as against 12.5mW single-ended, and also avoids the need for a coupling capacitor.

***Sequoia Technology Ltd,** Unit 5, Bennet Place, Bennet Road, Reading, Berkshire RG2 0QX. Telephone 0734 311822.*

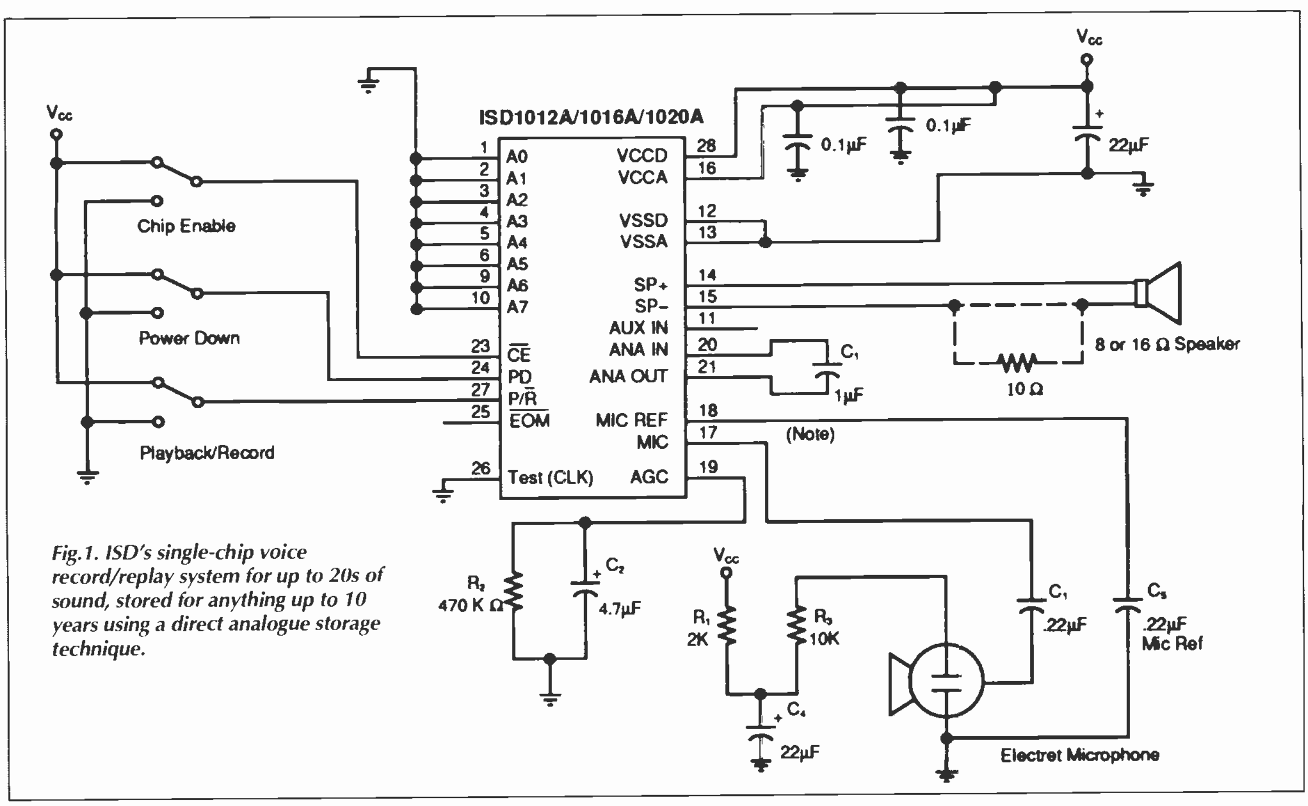

Fig.1. ISD's single-chip voice record/replay system for up to 20s of sound, stored for anything up to 10 years using a direct analogue storage technique.

Paralleling power modules

To prevent one of a number of power modules bearing more than its fair share of a common load, Unitrode's UC1/2/3907 family of ICs controls the power stage of each module to make it supply a current within 2.5% of that put out by an elected master module.

A voltage feedback amplifier whose reference is set by a common bus share voltage controls the power stage and each module's current is monitored to determine the master – the one that would normally give the most current output.

Figure 1 shows the block diagram of the device and **Fig. 2** a general application. The two sense inputs (pins 2 and 3) in Fig. 2 measure current through the resistor in series with the power stage of Fig. 1, the output from the associated buffer amplifier driving the current-share bus, which interconnects all the power modules. It can only source current and therefore ensures that the module taking the highest current acts as master and will drive the bus at low impedance; all other buffer amplifiers are inactive.

An adjust amplifier sets the power module's reference voltage to maintain equal current sharing; it compares its own module's output current to the current of the share bus, which is the highest current, and and forces the voltage amplifier reference to increase to match the share bus current. The output on pin 16 is open-collector and allows an indicator to show which module has taken over as master, since that adjust amplifier is in the low state.

A voltage amplifier on pin 11 is the feedback control stage for the power module's output voltage regulation, providing direct or opto-isolated drive via the drive amplifier to the device used to couple feedback to the power controller.

Unitrode (UK) Ltd, 6 Cresswell Park, Blackheath, London SE3 9RD. Telephone 081-318 1431/4.

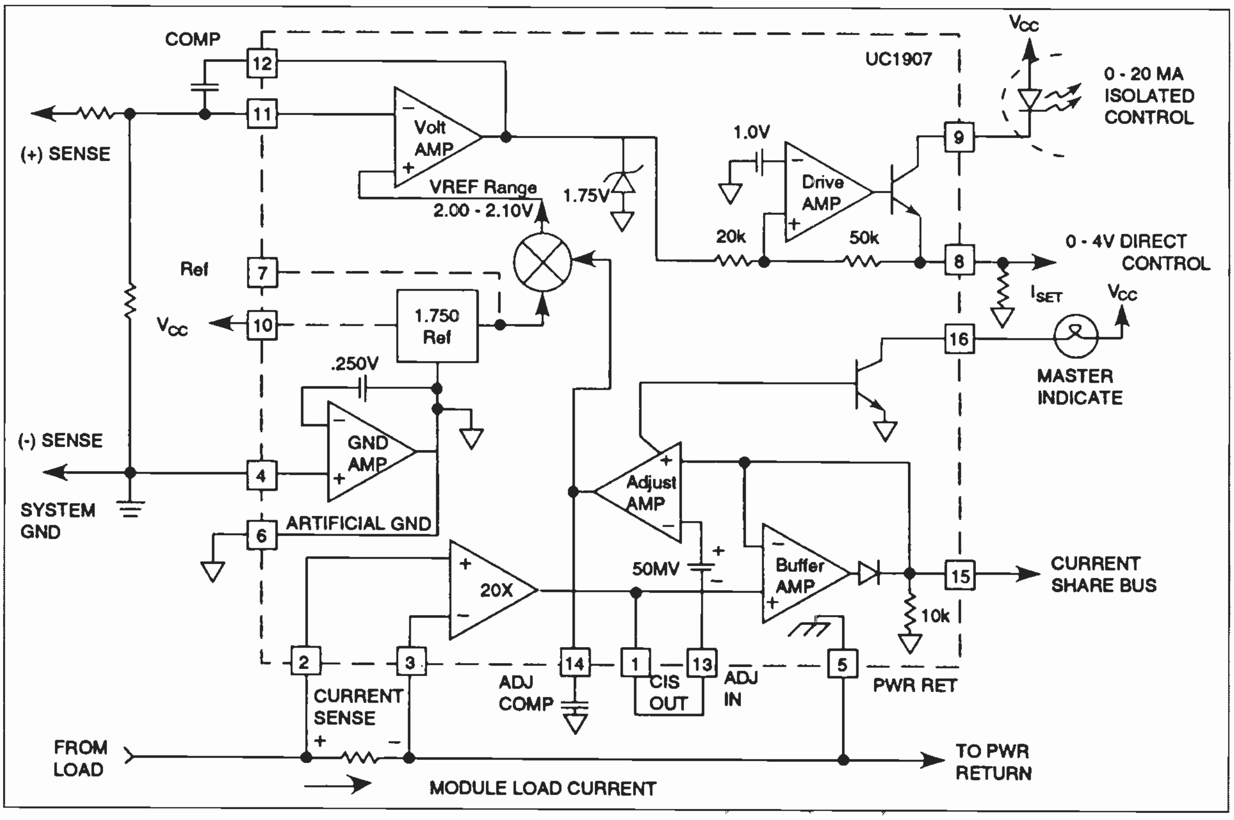

Fig. 1. Internal workings of Unitrode's UC1/2/3907 load-share regulator, which allows a number of independent power modules to work in parallel, each supplying its proportionate share to the total load current.

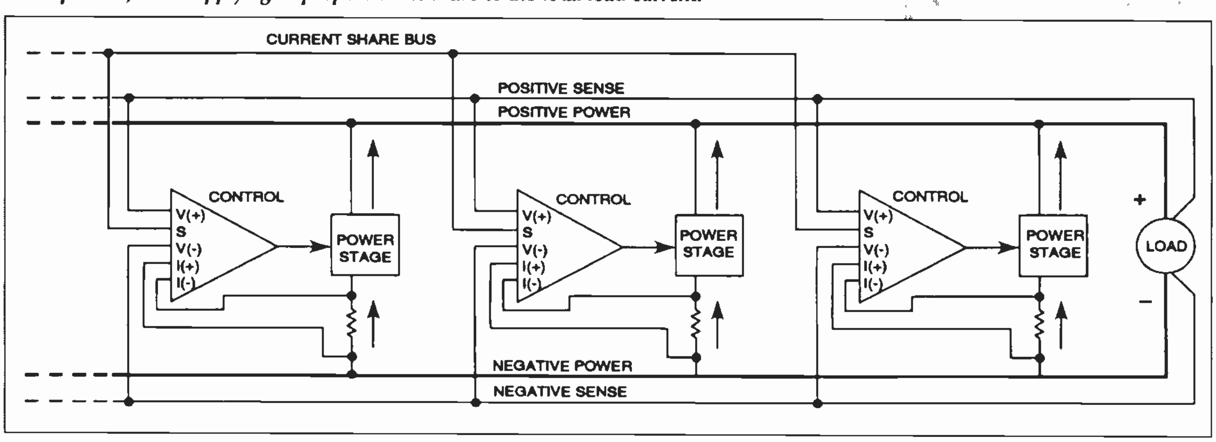

Fig. 2. Connection of the load-share regulator. V(+) and V(-) are on pins 11 and 4 of Fig.1, the current sense inputs being on pins 2 and 3. Output drive to the power module is either 0-20mA opto-isolated or 0-4V.

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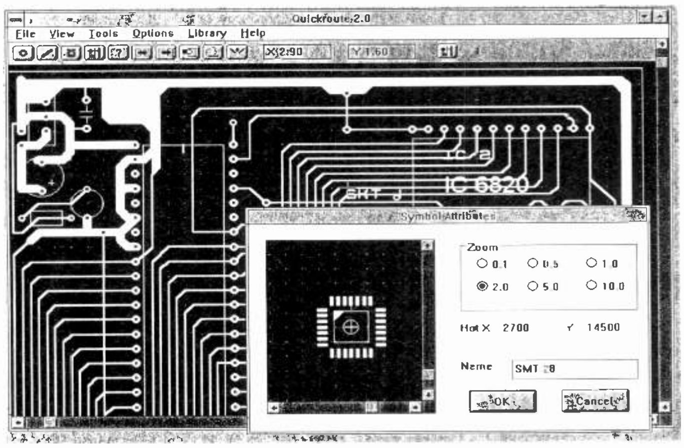

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Circuits, Systems & Standards

First published in the US magazine EDN and edited here by Ian Hickman

Amp provides 100 V common-mode range

Amplifier with large common mode range
By operating an op-amp at a gain of less than unity, both common-mode and the desired differential mode inputs are attenuated by the same amount. At the same time, the permissible input common-mode voltage is increased, as shown in this article.
IH

The unity-gain amplifier of **Fig. 1** can reject common mode voltages as high as 100V. For an application that does not require galvanic isolation, this circuit is an inexpensive alternative to the conventional isolation amplifier solution.

IC_1 is a monolithic gain-of-10 difference amplifier. By reversing normal connections to the on-chip resistor network, you place 100kΩ resistors (instead of the 10kΩ ones) at the amplifier's input, which attenuates the normal- and common-mode signals by a factor of 10. Then, resistors R_1, R_5, and R_6 form a T network in the feedback path that boosts the normal-mode gain to unity.

Because the addition of R_5 and R_6 degrades commonmode rejection by unbalancing the internal resistor ratios, you should restore the balance by adding

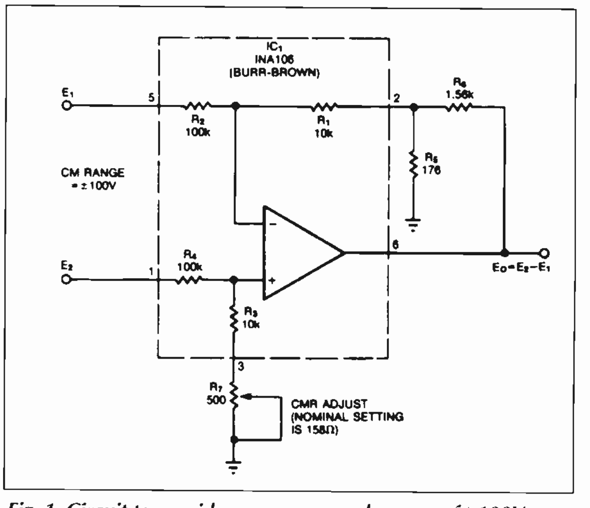


Fig. 1. Circuit to provide a common mode range of ±100V.

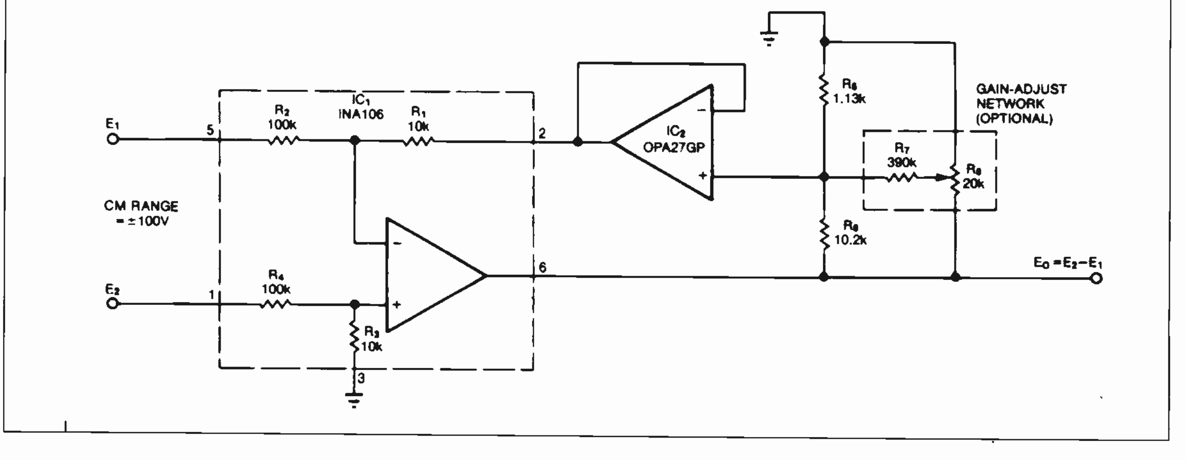


Fig. 2. Adding an op amp to the Fig. 1 circuit eliminates interaction between the gain-adjust potentiometer and the CMR-adjustment pot (not shown)

about 158Ω (R_7) in series with R_3. A fixed-value R_7 that differs by 2% from the T network's equivalent value degrades CMR by only a few dB, but note that IC_1's CMR is already 20dB below its specified value (100dB min) because the amplifier is operating at a gain of 0.1 instead of 10. You can improve the CMR by using a 500Ω potentiometer for R_7, as shown.

The differential-gain accuracy is within 2% if you use 1% resistors for R_5 and R_6. Adjusting the R_6/R_5 ratio can improve the gain accuracy, but calibration is difficult because the gain and CMR adjustments interact. You can eliminate this interaction and improve the gain accuracy by using the **Fig. 2** circuit.

In Fig. 2, IC_2 preserves IC_1's CMR by buffering the R_5/R_6 network. Again, IC_1's gain-of-0.1 connection reduces the guaranteed CMR by 20dB to 80dB min. (This CMR estimate is reliable because the IC_1 amplifier (distinct from its thin-film resistor network) contributes only -120dB of CMR error. Therefore, the resistor network is responsible for most of the residual CMR error that remains after laser trimming. This trim error affects CMR by about the same amount whether operating with a gain of 10 or a gain of 0.1.)

You can improve this circuit's CMR by adding 10Ω in series with *R1* (pin 2) and adding a 20Ω potentiometer in series with *R3* (pin 3). To adjust CMR, connect the inputs and drive them with a 1kHz square wave whose amplitude is in the range from ±10V to ±100V. (A sine wave will introduce unwelcome CMR-vs-frequency effects.) Adjust the 20Ω pot for a minimum-amplitude signal at E_o.

As before, $1+R_6/R_5$ sets the gain. The tolerance on this expression plus ±0.01% (contributed by IC_1) determines the overall gain accuracy. You can improve gain accuracy by using higher-precision resistors or by adding the optional gain-adjust network shown (R_7 and R_8). Gain and CMR adjustments don't interact in the Fig. 2 circuit.

One application for the circuit of Fig. 1 or Fig. 2 is in monitoring high-side load current in a regulator or power supply. By connecting the difference amplifier across a 1Ω resistor in series with the supply's output, you can interpret the difference amplifier's output as one ampere of load current per volt for supply voltages in the range from −100V to 100V.

Mark Stitt, Burr-Brown Corp, Tucson, Arizona

Intermittent converter saves power

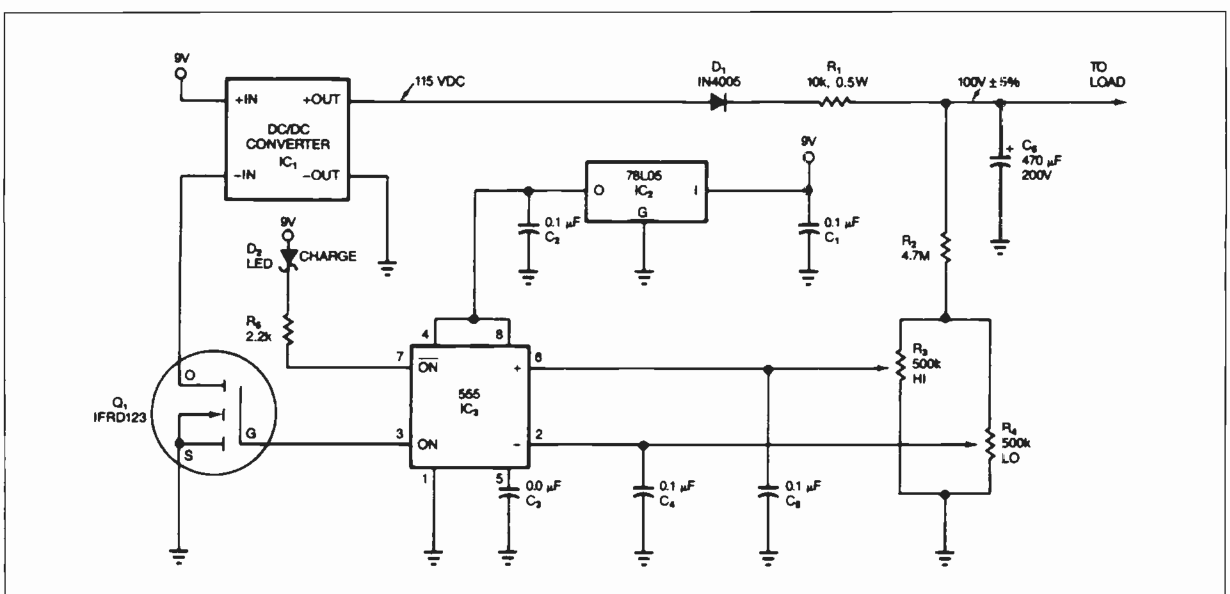
The circuit in **Fig. 1** switches its dc/dc converter, IC_1, off whenever the large filter capacitor, C_6, has sufficient charge to power the load. This scheme, which proves especially useful for battery-powered systems, saves power because virtually all DC/DC converters have poor efficiency at low and zero output-power levels.

Better battery economy
This brilliantly simple idea avoids the chronic low efficiency of converters running under light-load conditions. It features a novel application of the popular and widely second sourced 555 timer chip. **IH**

This particular circuit uses a DC/DC converter that produces 115V dc from a 9V DC input; you can tailor the circuit to suit other converters. The heart of the circuit is a 555 timer wired as a dual-limit comparator. An input of less than $^1/_3\ V_{cc}$ to pin 2 of the 555 turns the output, pin 3, on; an input of more than $^2/_3\ V_{cc}$ to pin 6 turns the output off. Thus, the 555 turns the converter on or off, depending on the voltage across C_6. The 555's complementary output lights the charge led when the fet is on.

Initially, the voltage on C_6 is zero, and the 555's output turns on the fet; Q_1- Q_1, in turn, enables the converter to run, which charges up C_6. When the voltage on the capacitor reaches the value set by R_3, the 555 turns off the converter. Then C_6 slowly discharges into the combined load of the voltage divider (R_2, R_3, and R_4) and the reverse-biased blocking diode, D_1.

When the voltage falls below $^1/_3\ V_{cc}$ the 555 restarts the DC/DC converter. If this circuit powers a load that



Employing a 555 timer acting as a dual-limit comparator, this circuit reduces low- and no-load power consumption by switching off the DC/DC converter when the filter capacitor is charged up.

periodically goes into a zero-power, shut-down mode, the *555* switches the dc/dc converter on full time whenever the load kicks in. The *78L05* voltage regulator stabilises the *555*'s internal resistive divider in the face of varying battery voltages. The regulator also enables the circuit to detect low battery voltage. When the supply voltage falls below 7.5V, the output of the converter is no longer high enough to charge the capacitor to the upper set point; hence, the charge led no longer lights.

The circuit uses 205mA when the converter is on and 10mA when the converter is off. The duty cycle comprises a 5s on-period and a 150s off-period and represents a 92% power reduction. You can further reduce power consumption by removing the charge led and using a cmos *555* and a cmos *78L05* regulator.

Paul D Gracie The Microdocters Inc, Palo Alto, CA

DESIGN BRIEF

Sensing the position

Economical ways of position sensing do exist. Ian Hickman examines one of them.

Position sensing is a common requirement in industry, especially with the advance of automation. Discrete photodetectors and vane switches will suffice for the simpler jobs. But for critical applications, a progressive rather than an on/off indication of position is required.

CCD imaging devices can be used for position sensing, though they require several different supplies and auxiliary ICs. The very small pixel pitch (typically 10 - 15µm) also requires use of good optics in most applications.

But the Texas Instruments *TSL214* is a 64 pixel addressed line array with a sensor pitch of 125µm, giving an active sensor length of 8mm and permitting the use of cheaper optics. In the *TSL214* (**Fig. 1**), the pixel charges are individually switched out sequentially under control of a 64 stage shift register which produces non-overlapping clocks to control this process, unlike a CCD array where all the pixel charges of an integration period are

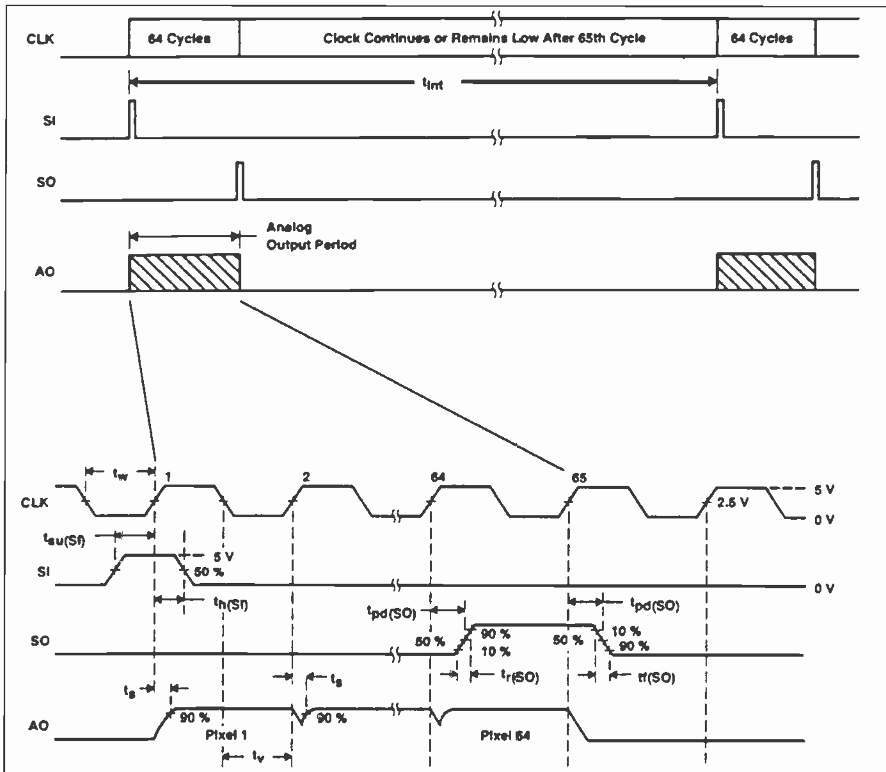


Fig. 2. The pixel outputs appear sequentially on the AO pin following the rising edges of the next 64 clock pulses that follow the assertion of the SI pulse, assuming its set-up and hold times are met. Following the sample time ts, the pixel analogue output data is valid for at least the period t_v.

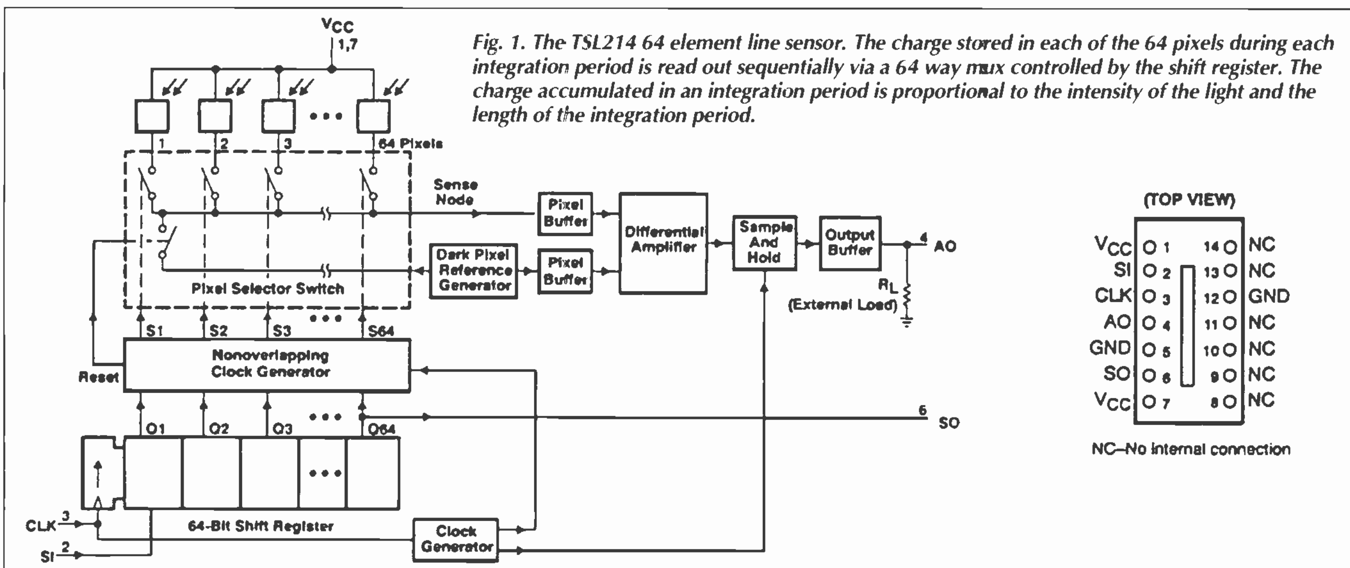


Fig. 1. The TSL214 64 element line sensor. The charge stored in each of the 64 pixels during each integration period is read out sequentially via a 64 way mux controlled by the shift register. The charge accumulated in an integration period is proportional to the intensity of the light and the length of the integration period.

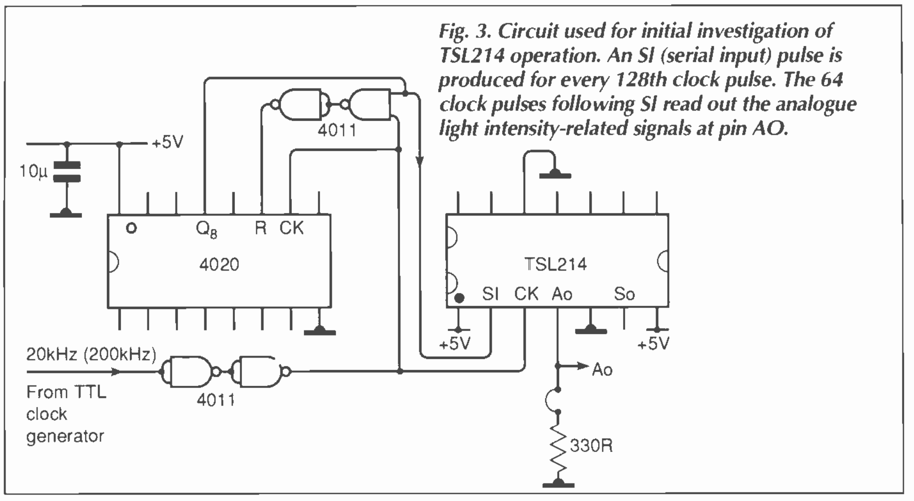


Fig. 3. Circuit used for initial investigation of TSL214 operation. An SI (serial input) pulse is produced for every 128th clock pulse. The 64 clock pulses following SI read out the analogue light intensity-related signals at pin AO.

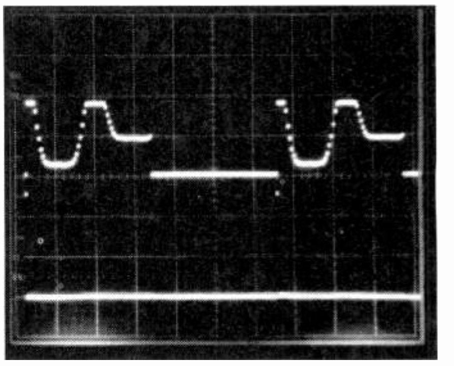


Fig. 4. Device operating in the circuit of Figure 3. Lower trace: SI pulses; upper trace: analogue output at AO with part of the line array covered.

clocked out together down transport registers.

The *TSL214* is mounted in an economical 14 pin DIL package with a transparent cover, and the low active pin count makes the production of 128 and 192 pixel devices (*TSL215, TSL216*) a relatively simple process. Operation of the device is controlled by a clock input (which may be between 10 and 500kHz) and an SI (serial input) signal which determines the integration time (see **Fig. 2**).

The integration period includes the 64 clock read-out period; each pixel recommences integration immediately after being read out. This means that the duration of the minimum integration period is 65 clock periods, though a longer interval between SI pulses (or a lower clock rate) may be used if operation at lower light levels is required.

To gain an insight into their operation, I made up the circuit shown in **Fig. 3**. When using the *TSL214*, beware: the end of the package with a semicircular notch is NOT the pin 1 end. The other end has two such notches, and a spot of silver paint over pin 1.

Having re-inserted the device into the circuit the right way round, I found that the output remained stuck at about +3.8V during the whole of each 64 clock output period, regardless of whether the sensor was covered or not. The obvious conclusion was that the device

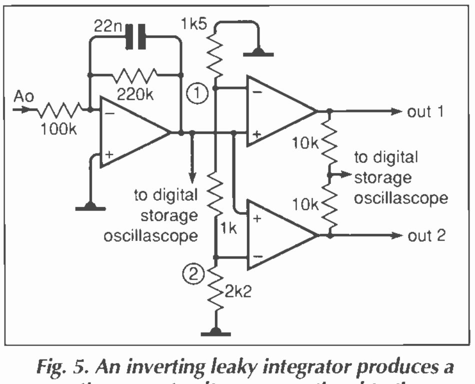


Fig. 5. An inverting leaky integrator produces a negative output voltage proportional to the number of pixels which are uncovered. Comparators indicate whether about half the device is illuminated, or more, or less.

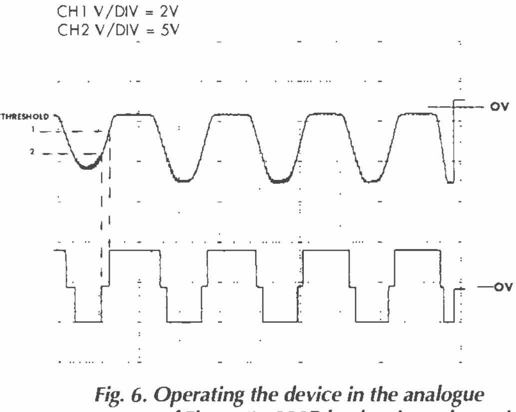


Fig. 6. Operating the device in the analogue system of Figure 5 - 330R load resistor shown in Figure 3 removed. Output as a piece of thick card waved back and forth across the sensor (upper trace); output of comparators (lower trace).

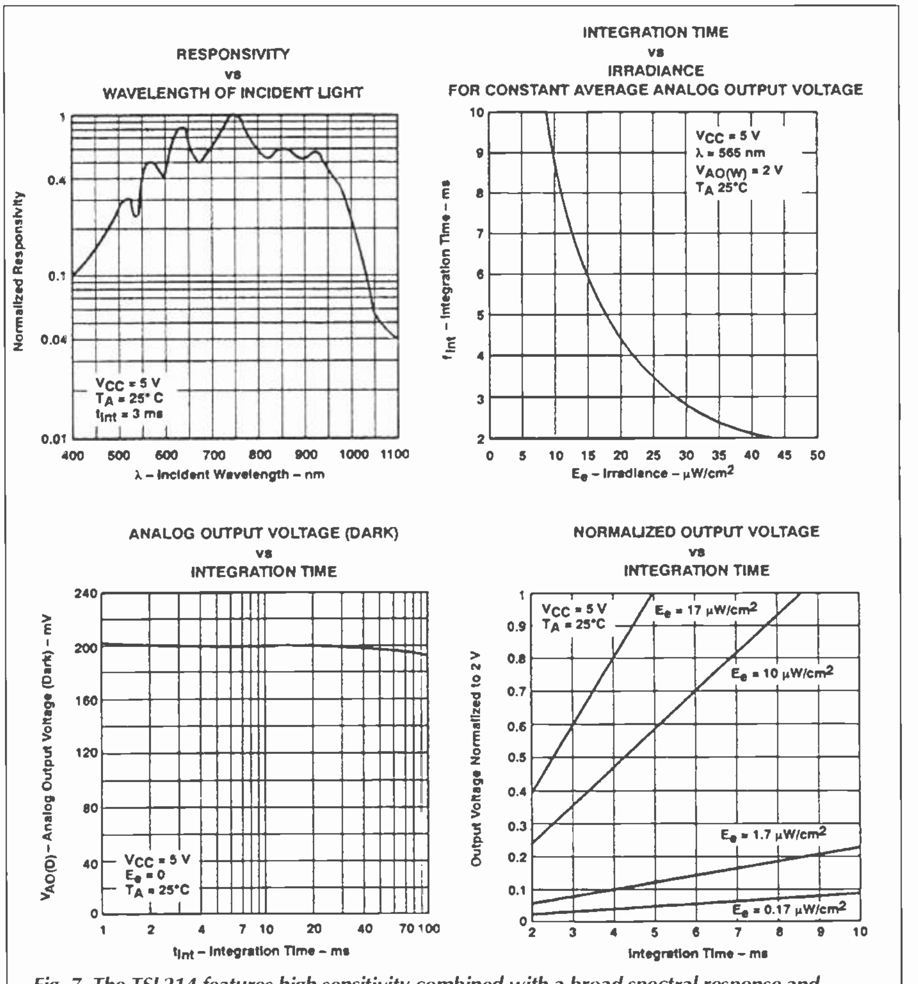


Fig. 7. The TSL214 features high sensitivity combined with a broad spectral response and low dark current which is almost totally independent of the integration time used.

had been damaged by being inserted back to front. However, there are no internal device connections on the pin 8 - 14 side except pin 12 (ground); the corresponding pin on the other side (pin 5) is also ground, rendering the device goof-proof.

The problem proved to be the low clock rate of 20kHz which resulted in a sensitivity so great that the device could still "see" the lights over the lab bench through my thumb. Switching the lights off, increasing the clock rate or using a strip of metal to cover the device were all equally effective.

Figure 4 illustrates the analogue nature of the output. A narrow strip of metal was laid across the device just left-of-centre whilst the right hand end was covered with a piece of deep green gel of the type used with theatre spotlights. The lower trace shows SI pulses and these are immediately followed (upper trace) by 64 analogue output samples. Where not covered, the samples are at the maximum output level of just under 4V; where covered by metal, at the dark level of around 0.2V and where covered by gel, at an intermediate level. With no optics, the light reaching the device was not collimated but diffuse: consequently light leakage under the edges of the metal strip is clearly apparent in the photograph.

The last stage of the shift register produces an output pulse, SO, which can be used to initiate readout from another similar device. To enable device outputs AO to be bussed up, the AO output becomes high impedance (tri-state) when not outputting samples: clearly this is most useful if the second sensor element is in the same package so that the active area becomes a continuous line, hence the *TSL215* and *216*.

This tristate aspect has another use. Besides using the device with a microcontroller it can also be used in edge-detection and similar applications in a purely analogue system. This is illustrated by the circuit of **Fig. 5**, where a negative output voltage is produced, proportional (under conditions of constant incident illumination) to the number cells illuminated. **Figure 6** shows this voltage varying as a card is waved back and forth, covering and uncovering the sensor.

The voltage could be used to drive a meter.

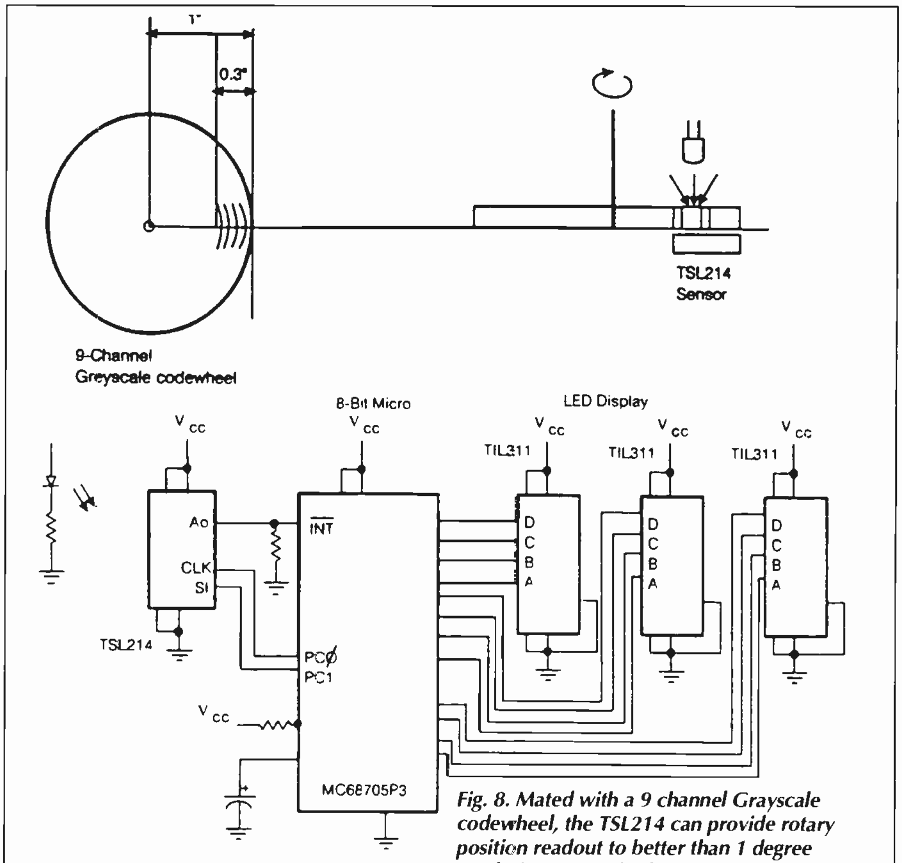


Fig. 8. Mated with a 9 channel Grayscale codewheel, the TSL214 can provide rotary position readout to better than 1 degree resolution (a), or display shaft position in degrees (b).

If the meter-movement carried a vane which moved across in front of the sensor so as to cover more of it as the output voltage increased, a rather complicated lightmeter would result, but a possibly useful pseudo-logarithmic sensitivity characteristic would give the greatest resolution at the lowest light levels.

Alternatively, the output voltage could be processed as shown by two comparators to indicate that substantially more (or less) than half the array is illuminated. (To show the operation of both comparators on a single trace, their outputs have been combined via 10K resistors: this is a useful dodge for showing two or more simple signals of pre-determined format on a single trace.) The comparators could provide steer-left and steer-right commands for a factory robot following the edge of a white line painted on the shop floor. This would provide a bang-bang servo type of control, so it might be better to use the analogue voltage directly for steering control: small deviations would cause only small corrections, resulting in smoother operation.

The *TSL214* features high sensitivity combined with a broad spectral response and low dark current which is almost totally independent of the integration time used (**Fig. 7**). It is thus eminently suitable for use in a host of applications, for example a rotary encoder with 1 degree resolution (**Fig. 8a**). The output can be simply be routed to a microcontroller to provide rotary position information to the host system, or to a display (Figure 8b).

To assist potential users with initial evaluation of the device, the *PC404* Evaluation Kit is available, **Fig. 9**. This consists of a *TSL214*, a circuit board with drive and output circuitry, and a detachable 10 x magnification lens in a housing. The circuity of the *PC404* comprises an oscillator, a counter/divider, a one-shot pulse generator and a comparator. The oscillator is built around a *555* timer and generates a 500kHz output data clock pulse.

The clock output of the oscillator is also routed to a *74HC4040* divider. This has a set of jumper terminals to four of the outputs, and 1, 2, 4 or 8ms integration time may be selected. The selected output is connected to the *74HC123* one-shot pulse generator, which provides the *TSL214* with an SI pulse. ■

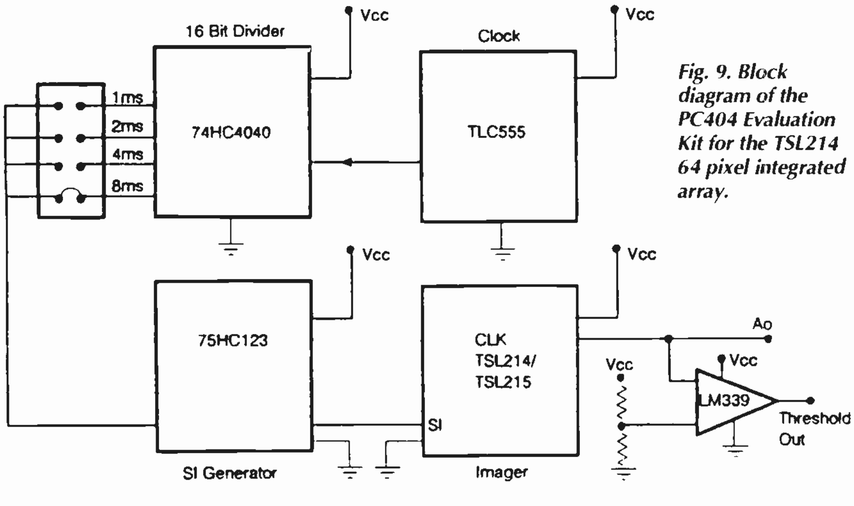


Fig. 9. Block diagram of the PC404 Evaluation Kit for the TSL214 64 pixel integrated array.

Switched-mode security

This circuit arrangement rapidly protects switched-mode power supplies against overload, while eliminating the usual protection loop and current-sensing resistor.

It hinges on the fact that the width of the PWM output pulse is voltage-dependent, as shown in **Fig. 1**. Pulses from the pulse-width modulator arrive at the D input of a flip-flop and also trigger a monostable, which puts out pulses that are somewhat shorter than those from the PWM. The result is that the flip-flop's Q output is continuously high, maintaining the PWM in operation.

If an overload occurs, t_p is reduced to become narrower than the monostable pulses and the flip-flop is clocked, disabling the PWM. To restart, the circuit must be switched off and on again, whereupon the flip-flop is set by the level at S, only to retrigger if the overload is still present.

Figure 2 shows the practical circuit, using a Motorola *SG1526* pulse-width modulator with R_3 to set the power supply output voltage. Potentiometer R_4 sets the width of the monostable's pulse.

G Mirsky and A Khokhlov
Academtekh R&D Centre
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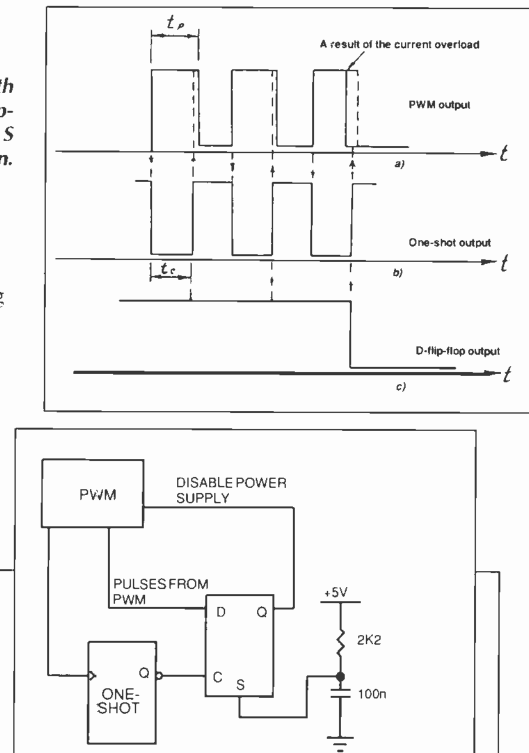


Fig.1. As the PWM's output pulse narrows with overload (a), the monostable (b) triggers the flip-flop (c), disabling the PWM. The network on S restarts the PWM at switch-on.

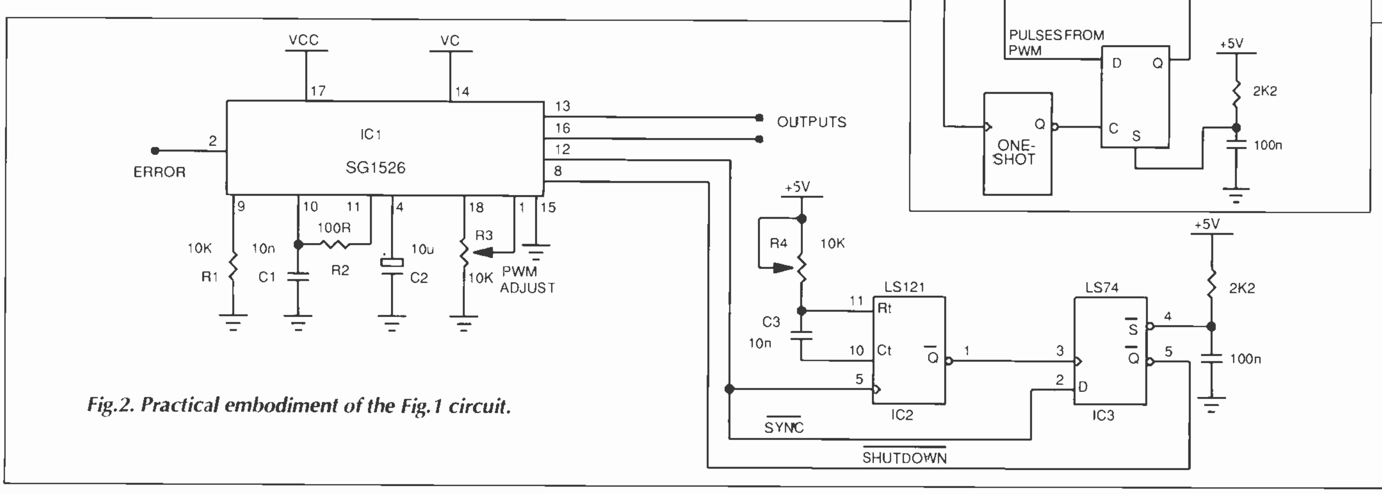


Fig.2. Practical embodiment of the Fig.1 circuit.

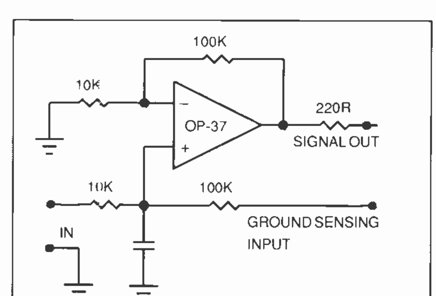
No grounds for interference

If you connect a small signal to a single-ended-input instrument and the ground potentials differ, this circuit cuts out the resulting mains interference and avoids ground loops.

A separate wire in the output cable of the signal source senses the ground potential at the instrument end, being connected to the cable shield there (inside the BNC connector with no mods needed). An op-amp adds the difference between the two grounds to the signal.

This technique can also be a useful way of preventing ground loops in audio equipment, since the 5µs filter confers a bandwidth of 34kHz; input impedance is over 100kΩ at signal frequencies. Using 1% resistors, signal-to-noise ratio improvement is, in theory, 60dB; in practice, interference simply vanished.

P C Meunier
Department of Biochemistry
University of Cambridge



Simple circuit to virtually eliminate mains-frequency interference on small signals between a source and an instrument. Difference in ground potentials is sensed and added to signal by the op-amp. Improvement is 60dB.

Resistance multiplier

To get long RC time constants without using large capacitors, use this circuit to multiply resistance values by a factor of up to 10^4. For example, a 10kΩ resistor can be made to behave like a 100MΩ component. Even the few ICs needed for the job take up less board space than a large, low-leakage capacitor.

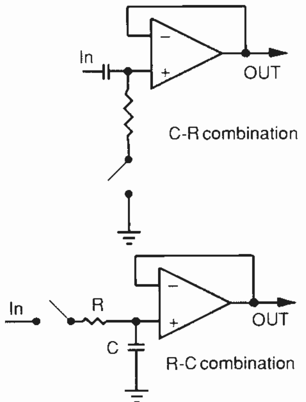


Fig. 1. Switching discharge current on and off in the CR circuit effectively multiplies value of R.

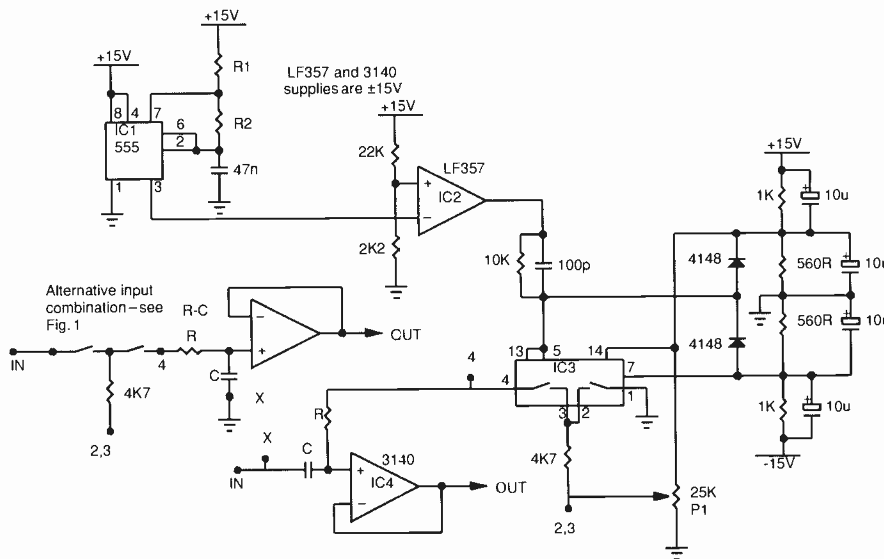


Fig. 3. Full circuit diagram of the R multiplier in a CR configuration; the RC equivalent is shown below.

The principle is indicated by **Figs 1** and **2**. Figure 1 shows a CR coupling circuit with a time constant CR when the switch is closed, voltage across the resistor falling exponentially when a negative-going step is applied at the input. If, however, the switch is open, no discharge occurs during that interval, only resuming when the switch closes; average discharge current is determined by the ratio of P_w, the time during which the switch is closed, to T, so the CR is effectively increased. The smaller pulse width in relation to the cycle time, the larger R appears.

Distortion caused by the steps in the discharge curve are minimised in practice by making the PRF high enough, in this case at least twice the lower cut-off frequency, which is 1/2πRC. If the positions of R and C are reversed, then the PRF must be at least twice the upper cut-off frequency.

Figure 3 is the circuit diagram. A 555 timer produces switch pulses, R_1 lying in the range 10kΩ-22MΩ for a period of 350μs-4ms and R_2 between 100Ω and 100kΩ for a P_w of 4μs-4ms. Amplified output from the 555 forms the switch control, which is over-voltage-protected by the diodes; the resistor chain provides ±5V from ±15V for the *CD4066B* cmos switch IC. The *3140* is a bi-mos op-amp connected as a follower to provide a very high impedance to avoid discharging the C. Potentiometer P_1 zeroes the output. A CR circuit would be connected as in the smaller diagram.

Figure 4 shows the result: with an on pulse width if 4μs, varying the PRF gives an R multiplication of between about 200 and 2000.

D A Kohl
Osseo Minnesota
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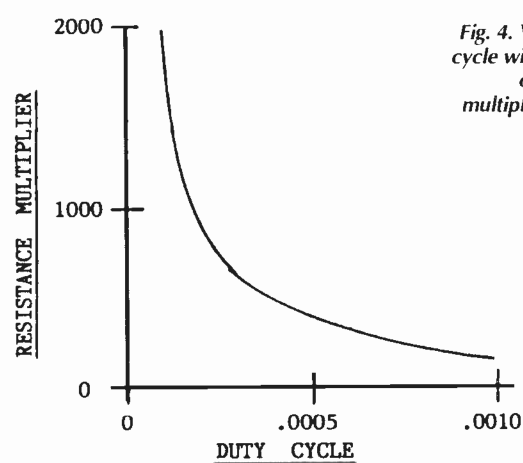


Fig. 2. The normal (lower) exponential discharge curve is replaced by a stepped curve, discharging current only flowing when R is switched to ground.

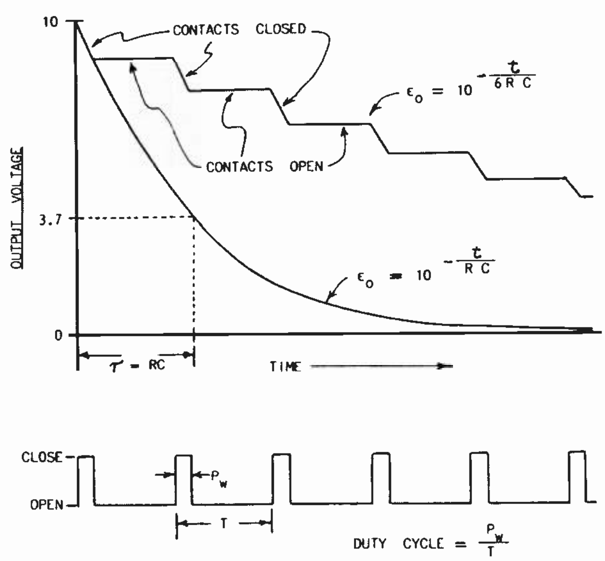


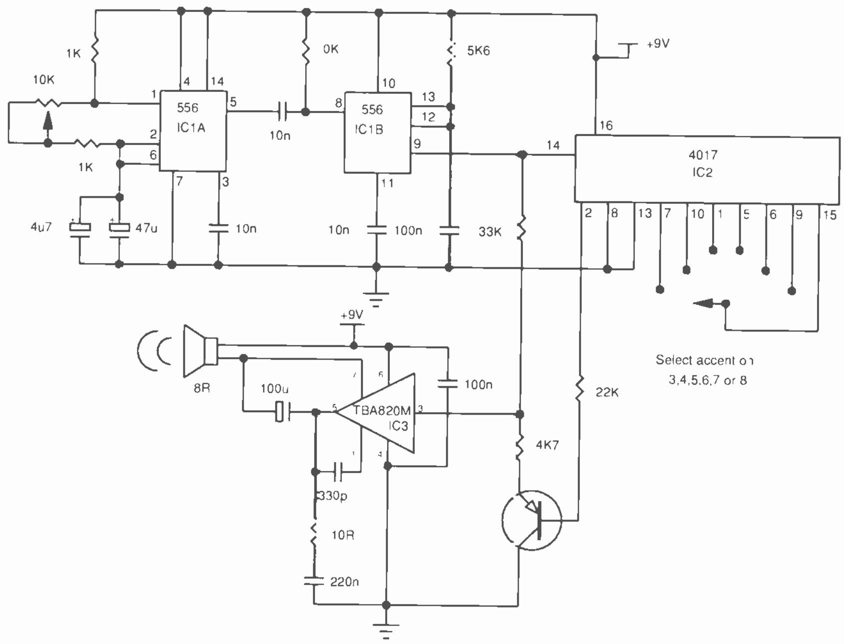
Fig. 4. Varying the duty cycle with a pulse width of 4μs gives an R multiplication factor of 200-2000.

Accented metronome

For a metronome with an accented beat on counts 3,4,5,6,7 or 8, three chips suffice.

Half the 555 timer, $IC_{1(a)}$, produces pulses with frequency set by the 10kΩ variable resistor and which drive the second half of the timer to give a variable-frequency, constant-width pulse train at pin 9 for the Johnson counter IC_2. The pulse train also goes to the unity-gain op-amp, attenuated when the transistor is on and directly when it is off, which happens once every count cycle as determined by which Q output is switched to reset the counter. The result is an attenuated beat, followed by an accentuated count and a reset to start the count again.

D M Bridgen
Racal Radio Ltd
Reading
Berkshire.



MOBILE SATELLITE SERVICES – STAR PERFORMERS

The past decade has brought obvious successes in the maritime satellite services operated by Inmarsat (in which BT has the second largest share). As a result, many major organisations have been encouraged to enter the costly but potentially highly-rewarding race to provide speech, data and even video links to compact mobile – and later hand-portable – terminals. The trend is despite the difficult propagation conditions faced by land mobiles resulting from urban and road-side-foliage screening.

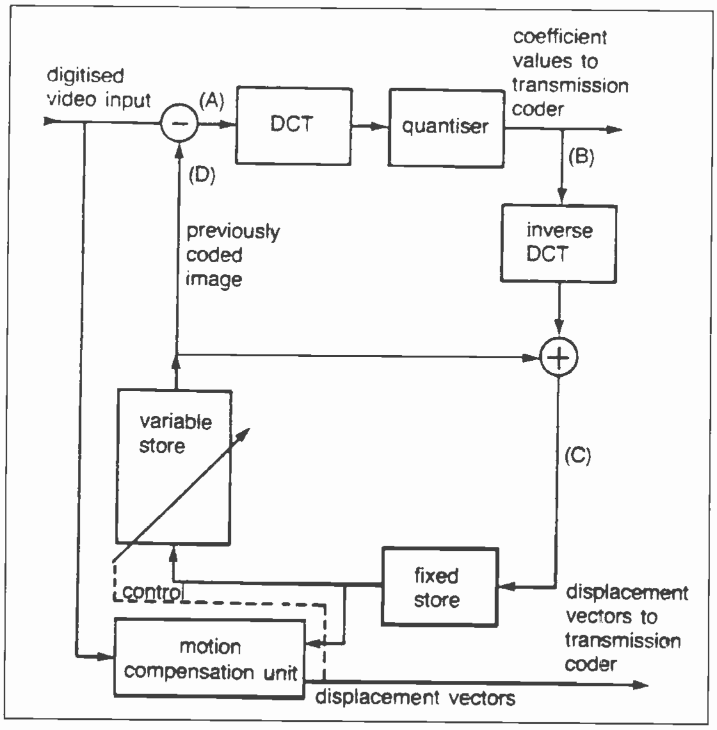
Ultimately the aim is to provide fully compatible digital services linking aircraft, ships and vehicles into the terrestrial telecommunications networks and/or to provide the equivalent of PMR (private mobile radio) company-operated facilities.

Currently, the operational land mobile systems of Inmarsat-C and Eutelsat provide only low-rate, store-and-forward data services. But numerous two-way speech and higher data rate systems based on geostationary satellites are under development. Systems based on highly elliptical orbits (heo) and low earth orbits (leo) have been proposed, and many of these systems will utilise advanced systems of digital bit-rate reduction to provide communications or even toll quality speech at data rates of less than 5Gbit/s.

Progress to digital networks

Pioneering use is to be made of near-broadcast-quality video store-and-forward transmission through 64Kbit/s-circuits via Inmarsat-C satellites from yachts in the 1993-94 Whitbread round-the-world yacht race (see box). According to Graham Mills, manager portfolio & business development of BT's visual & broadcast services the project is an important step for the company in its plan to see widespread use of digital transmission of video and high-quality audio over the expanding network of terrestrial and satellite ISDN telecommunication circuits – both for broadcast news gathering and for video conferencing either real time or on a store-and-forward basis.

BT is pioneering use of near-broadcast-quality video store-and-forward transmission from yachts in the 1993-94 Whitbread race



Hybrid DPCM/DCT encoding scheme of the CCITT H261 recommendation. British Telecom Technology Journal.

Live transmission of 128Kbit/s video using two ISDN 64Kbit/s circuits is claimed to provide "surprisingly good" pictures using H261 data compression, and the standard channel can support one video and two audio channels.

Although ISDN digital networks have been slow in coming, a major effort is currently being made by BT and the German and French PTTs to bring the benefits of broadband fibre optics into the PSTN subscriber networks. The extension of digits into local networks particularly to business premises has reached the stage where BT can claim that 86% of UK business premises could now opt for 64Kbit/s data and digital voice (actually 128Kbit/s two-way circuits) which can be carried over existing copper wires with a digital switch at the exchange and cards at the subscriber's plug. The 2048Kbit/s ISDN hierarchy requires the copper wires to be replaced by fibres or local area networks (lans) etc.

Putting on the squeeze

The CCITT recommendation of H261 for audiovisual services at bit rates between 6kbit/s and 2Mbit/s emerged from five years of international collaboration and was finally agreed in July 1990. Many different coding algorithms were explored including those based on differential pulse code modulation (DPCM), vector quantisation, hierarchical techniques, discrete cosine transform (DCT) and hybrid DPCM/DCT techniques. After much debate, a coding system based on the hybrid DPCM/DCT with motion compensation has been selected. A detailed description by MD Carr of BTRL of H261 can be found in British Telecom Technology Journal , July 1990, pp. 28-35 ("Video codec hardware to realise a new world standard").

H261 uses a common intermediate format (cif) approach to cope with different line and picture rate standards such as pal and NTSC. Both 625/25 and 525/30 codecs include pre- and post-processing modules which convert to and from a cif, based on 288 non-interlaced lines per picture at 30 pictures per second. Since there are 288 active lines per field in standard 625 line television: 625/25 codecs only need to perform rate conversion to meet the 30Hz requirement, while 525/30 codecs have only to convert the number of active lines from 240.

H261 was developed primarily for professional video picture phone and video conferencing applications, and would seem to offer broadcasters a cost-effective form of news gathering from remote locations not served by a high-capacity link without requiring the availability of a satellite news gathering uplink terminal. The Whitbread Race will thus be watched carefully by broadcasters generally – not only those interested in round-the-world yacht races. Yachts of the 80 and 60ft classes on storm-tossed seas will provide a severe test of both codecs and satellite transmission systems. One of several hazards would be destruction of solid-state devices by a lightning strike and it will not only be the yachtsmen who will be hoping that lightning keeps its distance.

Land mobile satellite systems poised?

At a recent IEE Colloquium on "Land Mobile Satellite Systems", chair Roger Fudge pointed out that for several years it has often been claimed that LMS is poised ready for acceptance and implementation, but there remain technical and political difficulties due to the fact that LMS systems are difficult to constrain within national boundaries and pose problems on who will own the system, who carries the traffic and who governs and regulates the system. While in the past the drive to LMS has been technology-led it now requires customer pull .

At the same Colloquium Paul Britten (Racal Research) described some of the technical constraints on LMS. Signal shadowing and

Whitbread race technology

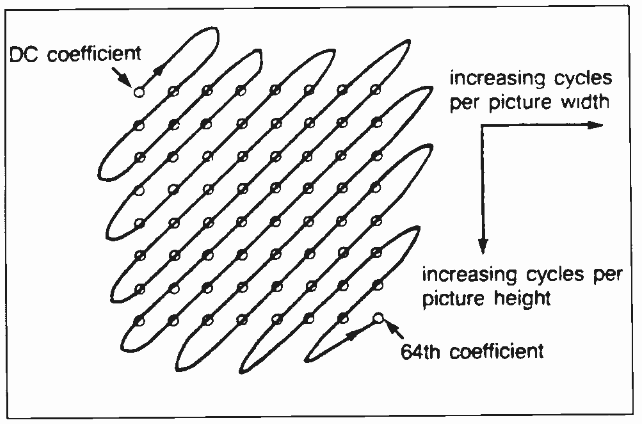
BT is offering to provide, on free loan, ten specially developed terminals for installation on competing yachts. At the BT Tower in London PC-software will process the incoming digital signals for distribution world-wide as standard 625/50 or 525/60 video.

The encoding will be to the CCITT H.261 video-conferencing standard, with the original video digitally compressed to 768 or 384Kbit/s making it possible to transmit on a store-and-forward basis either one-minute or two-minutes of programme material in 12 minutes of relatively low-cost satellite time. The system is also capable of transmitting jerky and degraded "live" pictures in real-time from the yachts (as demonstrated in a BBC Tomorrow's World programme). Computer simulations show that the 768 and even the 384kbit/s store-and-forward video provides pictures of very reasonable "TV News" quality.

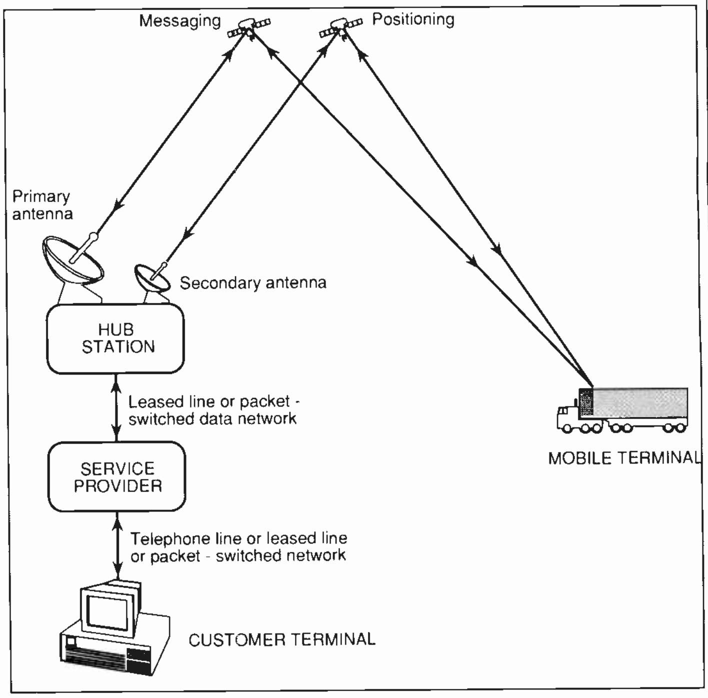
Edward Scott, BT's Head of International Promotional Projects, told EW + WW that IPP was set up to identify publicity vehicles which would benefit from a BT involvement by providing a visible presence of its advanced technology. The Whitbread race is seen as especially relevant. BT involvement is more than just providing some funding. Viewers want to see news-worthy incidents on board the yachts while they still at sea, and in 1990 BT agreed to develop a system for transmission of pictures from yachts. Since 1991, Inmarsat-C, serving both maritime and land mobile terminals, has had the capability to handle data at 56-64Kbit/s.

People also wish to know where the yachts are. The BT race system incorporates the American Global Positioning System (GPS) in conjunction with an Inmarsat-C file. GPS can determine positions of the yachts on a global basis with an accuracy of about 50m (as a military system, GPS can determine positional accuracy to within a few centimetres). The yacht terminal calculates its position from observations on three of the GPS satellites and then transmits it to up-date the Inmarsat-C file.

Complete yacht terminal and encoder weighs about 50kg and is mounted below deck, including the stabilised small dish. The RF terminal is being provided by STC, and is manufactured in the USA by MTI, a subsidiary of Comsat. This terminal is currently the only compact terminal suitable for 64Kbit/s transmission.



Coefficient scanning sequence for each 8 x 8 block in H261.



Euteltracs network architecture provides messaging and positioning information with a combination of Immarsat and GPS.

multipath effects result in large signal variations and: "The use of fixed fading margins of ten or more decibels remains impractical."

The degree of fading is strongly dependent on topography of the immediate surroundings of the mobile, the elevation angle of the path, the type of antenna used by the mobile and the frequency used. Gain of an antenna on a car or lorry is limited and for geostationary orbits there is a need for antenna steering and tracking systems that add to its size and complexity.

As Barts & Stutzman (IEEE Trans on Ant & Prop, April 1992) have pointed out, terrestrial mobile systems are often able to exploit strong multipath signals but the LMS service will be power limited and dependent on the direct line-of-sight signal, with shadowing from roadside vegetation the dominant fading mechanism.

Nevertheless, the introduction of smaller and smaller spot beams on the satellites could eventually provide high capacity systems using solely omni-directional antennae. Feasibility of telephony systems with small antennas has been greatly enhanced by progress in voice coding, with presently proposed systems based on coding rates of about 5kbit/s, with code excited linear predictive coding (celp) and improved multi-band excitation (IMBE) favoured.

Britten also noted that the current low data rate store-and-forward LMS systems are supported by Inmarsat-C and by the Qualcomm Omnitracs Ku-band systems (in Europe by Eutelsat and its Euteltracs operators) with Eutelsat operating the qualcomm automatic satellite position reporting system (QASPR). Some 20 types of mobile terminals have been approved for use by Inmarsat and some 2-3000 terminals are in use. For Omnitracks there are believed to be more than 20,000 users worldwide, with some 1250 terminals delivered in Europe of which about 800 are now operational, according to Geoffrey Hall (consultant).

HC Haugli, Inmarsat land mobile engineering manager, reported that among future LMS systems that will be based on geostationary satellites is the Inmarsat-M system for global telephony and data. This is expected to become operational by the end of this year, with a voice coding rate of 4.12kbit/s IMBE which with forward error correction coding brings the bit rate to 6.4kbit/s.

Inmarsat-B is expected to start commercial operation next year, using equipment similar in size to Inmarsat-A but using all-digital transmission to make more efficient use of the spectrum and expected eventually to be cheaper. It will support PSTN voice data at 9.6kbit/s including Group three fax and will have a 64kbit/s data capability.

Inmarsat is currently developing a high-penetration paging system which is expected to work even inside buildings. It is also investigating the best way to provide an Intersat-P voice service to personal handheld terminals with a dual cellular-satellite capability for use as an extension and gap filler to the cellular service. It is planned that the equipment should be similar in size to early handheld phones and aimed at opening new mass markets. An equipment price of about $1500 for a dual-mode unit with a utilisation cost target below $2/min is predicted. Currently detailed price and service-quality studies are being made for leo, meo and geo satellites.

Proposed systems

The European Satellite Agency is promoting and developing a European land mobile system with a piggy back payload currently being manufactured to fly on Italsat 2 for Prodat 2 data services plus closed-user group telephony for the mobile satellite network for business services (MSBNS) system.

Proposed "big" leo systems include Iridium, Globalstar and Aries plus a meo system called Odyssey. "Little" leo proposals for low-cost store-and-forward message services include Orbcomm (proposed by Orbital Science Corp) which would, according to Britten, use 20 small satellites in an inclined orbit launched by the Pegasus low-cost launcher and be capable of supporting data rates of about 2.4kbit/s.

John Norbury (Rutherford Appleton Laboratory has been studying propagation and spectrum-usage considerations for leo systems working between 20-30GHz. He has concluded that their development would: "provide both a considerable technical challenge and a creative approach to satellite systems architecture if they are to be realised in practice. However they do offer the intriguing possibilities of both spectrum efficiencies and power requirements approaching those of terrestrial mobile systems." But he agrees that attenuation from trees would be even more serious than at 1.6GHz.

AD Craig (British Aerospace) has described a digital signal processing payload concept for LMS communications. This has been studied with emphasis on use of digital beamforming techniques. He has described a payload configuration that offers significant potential advantages in terms of power efficiency – through peak mobile link gain and on-board level control; bandwidth efficiency – by decreasing the separation constraints on co-frequency beams and the use of active interference suppression; and traffic flexibility through the use of agile beams steerable anywhere within the service zone.

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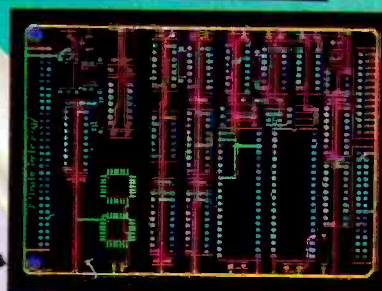
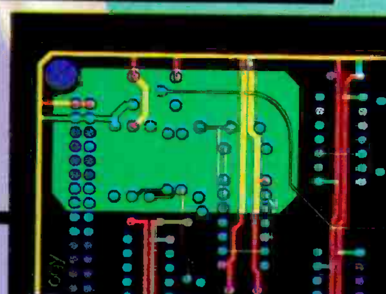
FROM CONCEPT TO ARTWORK IN 1 DAY

Your design ideas are quickly captured using the ULTIcap schematic design Tool. ULTIcap uses REAL-TIME checks to prevent logic errors. Schematic editing is painless; simply click your start and end points and ULTIcap automatically wires them for you. ULTIcap's auto snap to pin and auto junction features ensure your netlist is complete, thereby relieving you of tedious netlist checking.

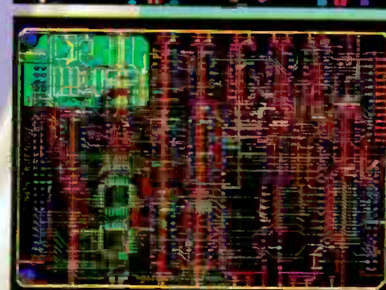
ULTIshell, the integrated user interface, makes sure all your design information is transferred correctly from ULTIcap to ULTIboard. Good manual placement tools are vital to the progress of your design, therefore ULTIboard gives you a powerful suite of REAL-TIME functions such as, FORCE VECTORS, RATS NEST RECONNECT and DENSITY HISTOGRAMS. Pin and gate swapping allows you to further optimise your layout.



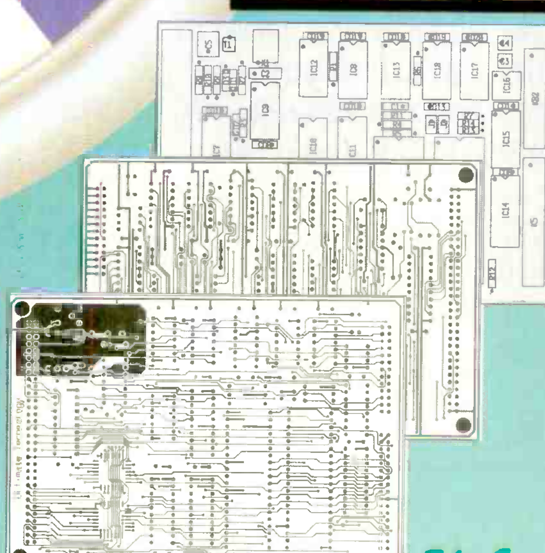
Now you can quickly route your critical tracks. ULTIboard's REAL-TIME DESIGN RULE CHECK will not allow you to make illegal connections or violate your design rules. ULTIboard's powerful TRACE SHOVE, and REROUTE-WHILE-MOVE algorithms guarantee that any manual track editing is flawless. Blind and buried vias and surface mount designs are fully supported.



If you need partial ground planes, then with the Dos extended board systems you can automatically create copper polygons simply by drawing the outline. The polygon is then filled with copper of the desired net, all correct pins are connected to the polygon with thermal relief connections and user defined gaps are respected around all other pads and tracks.



ULTIboard's autorouter allows you to control which parts of your board are autorouted, either selected nets, or a component, or a window of the board, or the whole board. ULTIboard's intelligent router uses copper sharing techniques to minimise route lengths. Automatic via minimisation reduces the number of vias to decrease production costs. The autorouter will handle up to 32 layers, as well as single sided routing.



ULTIboard's backannotation automatically updates your ULTIcap schematic with any pin and gate swaps or component renumbering. Finally, your design is post processed to generate pen / photo plots, dot matrix/laser or postscript prints and custom drill files.

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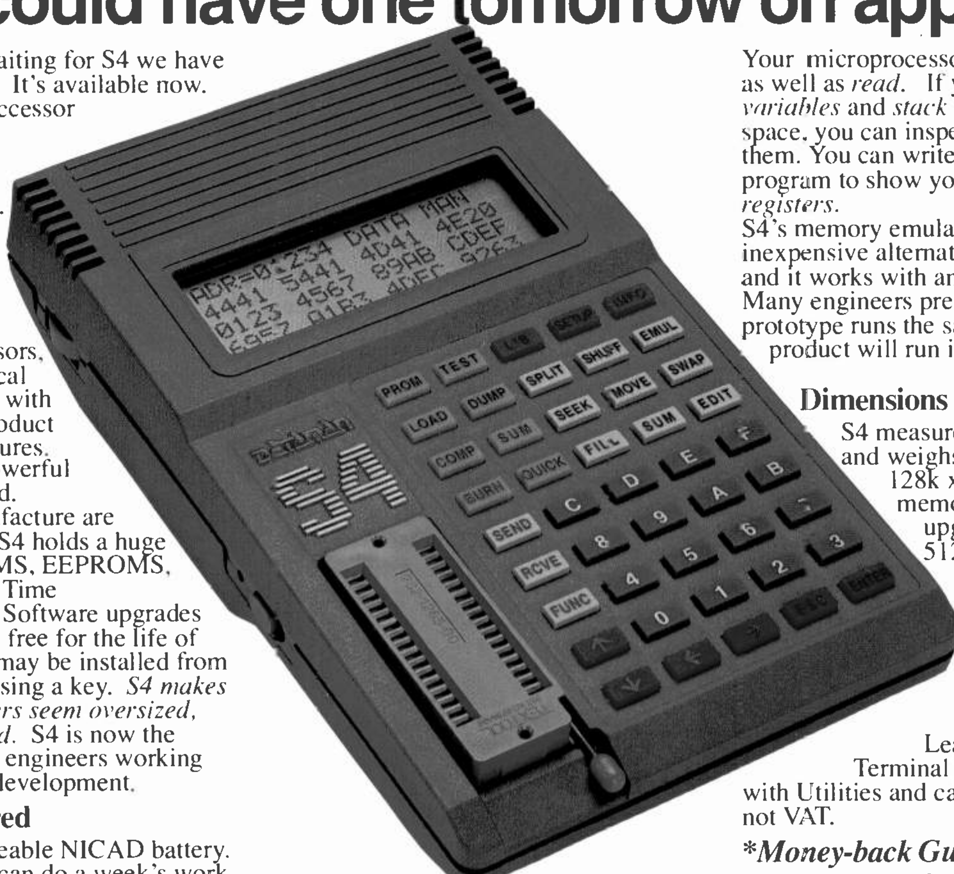
Dataman's new S4 programmer costs £495 You could have one tomorrow on approval*



If you've been waiting for S4 we have some good news. It's available now. S4 is the 1992 successor to Dataman's S3 programmer, which was launched in 1987. The range goes back through S2, in 1982, to the original Softy created in 1978. Like its predecessors, Softy4 is a practical and versatile tool with emulation and product development features. S4 is portable, powerful and self-contained. Design and manufacture are State of the Art. S4 holds a huge library of EPROMS, EEPROMS, FLASH and One Time Programmables. Software upgrades to the Library are free for the life of the product, and may be installed from a PROM by pressing a key. *S4 makes other programmers seem oversized, slow and outdated.* S4 is now the preferred tool for engineers working on microsystem development.

Battery Powered

S4 has a rechargeable NICAD battery. On average, you can do a week's work without recharging. On a single charge, up to a thousand PROMS can be programmed – and charging is fast: it only takes an hour. Normal operation can continue during the charging process.

Continuous Memory

Continuous Memory means never losing your Data, Configuration or Device Library. You can pick up S4 and carry on where you left off, even after a year on the shelf. If the NICAD battery loses all of its charge, RAM contents are preserved by the LITHIUM backup battery.

Remote Control

S4 can be operated via it's RS232 Serial Port. The standard D25 socket connects to your computer. Using batch files or a terminal program, all functions are available from your PC keyboard and screen.

Free Terminal Program

You could use any communications software to talk to S4. But the Terminal Driver program, which we include free, is the best choice. It has Help Screens to explain S4's functions and it sends and receives at up to 115200 baud – that's twelve times as fast as 9600 baud. At this speed a 64 kilobyte file downloads in 9 seconds. There is a memory resident (TSR) option too, which uses only 6k of your precious memory, and lets you "hot key" a file to S4. Standard *upload* and *download* formats include: ASCII, BINARY, INTELHEX, MOTOROLA and TEKHEX.

S4 loads its Library of programmables from a PROM in its socket, like a computer loads data from disk. Software upgrades are available free. Download the latest Device Library from our Bulletin Board.

Microsystem Development

With S4 you can develop and debug microsystems using Memory Emulation. This is an extension of ROM emulation, used for prototype development, especially useful for single-chip "piggy back" micros. When you unpack your S4 you will find an Emulator Lead with a 24/28/32 pin DIL plug and a Write Lead with a microhook. Plug the EMULead in place of your ROM. Hook the Write-Lead to your microprocessor's write-line. Download your assembled code into S4. Press the EMULate key and your prototype runs the program. S4 can look like ROM or RAM, up to 512K bytes, to your target system. Access-time depends on S4's RAM. We are currently shipping 85ns parts.

CIRCLE NO. 101 ON REPLY CARD

Your microprocessor can *write* to S4 as well as *read*. If you put your *variables* and *stack* in S4's memory space, you can inspect and edit them. You can write a short monitor program to show your *internal registers*. S4's memory emulation is an inexpensive alternative to a full MDS and it works with any microprocessor. Many engineers prefer it because their prototype runs the same code that their product will run in the real world.

Dimensions & Options

S4 measures 18 x 11 x 4 cm and weighs 520 grams. 128k x 8 (1MB) of user memory is standard, but upgrading to 512k x 8 is as easy as plugging in a 4MB low-power static CMOS RAM. The stated price includes Charger, EMUlead, Write Lead, Library ROM, Terminal Driver Software with Utilities and carriage in U.K. but not VAT.

**Money-back Guarantee*

We want you to buy an S4 and use it for up to 30 days. If it doesn't meet with your complete approval you will get your money back, immediately, no questions asked.

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Call us with your credit card details. Stock permitting, we are willing send goods on 30 days sale-or-return to established U.K. companies on sight of a legitimate order.

Customer Support

Dataman's customer list reads like Who's Who In Electronics. Dataman provides support, information interchange, utilities and latest software for S4, S3, Omni-Pro and SDE Editor-Assembler on our Bulletin Board which can be reached at any time, day or night.

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