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cover photo Robert Clifford

REGULARS

In next month's issue. Everything you ever wanted to know about Unix. How do its user interfaces compare with the dos world? Why is everyone talking about it? What are the new electronic engineering applications packaged in a Unix release? How much will they cost? Can you afford the hardware? Watch this space . . .

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Political fish (land based)

Not everyone is happy with Europe. The french snail farmers are outraged because the Commission isn't giving them a fair deal, ie, a subsidy.

Apparently Brussels considers — or considered — *les escargots* a different kettle of fish from *les moules*. One set of molluscs come from the sea and can thus be treated as fish, and the people who catch (?) them fishermen. Snails, on the other hand, come from the land and look nothing like cows, sheep, pigs, chicken or any other beast officially recognised by the EEC. The result? *Les escargots n'existent pas*.

Under the threat of hundreds of *escargotiers* driving their flocks of snails through the centre of Paris bringing traffic to a halt, the French Government went into immediate dialogue with the Commission. It didn't take long for the fisheries people in Brussels to reclassify snails as fish (land based).

An absurdly true tale, but neither it, nor the other euro-canards should mask the advantages which membership of the Community confers. Having just returned from a visit to Electronica, the massive German electronics exhibition held every other year in Munich, one couldn't help noticing the complete contrast between the high levels of business confidence and activity in mainland Europe and our own depressed economic state. Simply put, there isn't either recession or rampant inflation in Germany, a fact made even more surprising given the economic drag of unification.

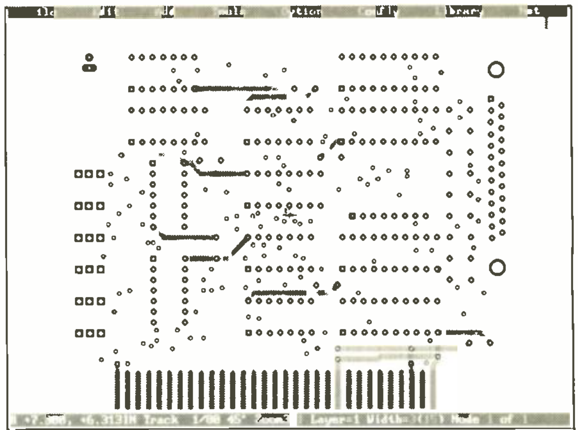
In many ways the UK is better placed to do world business than France or Germany. We speak English which means that our industry should be able to communicate effectively. The City of London is — for the moment — the capital of World Money. The current crisis of confidence in the UK economy appears almost incomprehensible although our inflation and interest rates are real enough.

The continental cousins fiercely defend their national interests through a mixture of talk, tactical inertia and opportunism in behind-the-scene diplomacy. The UK Government by contrast makes dissonant noises about sovereignty, dark plots for a federal Europe and common currency without materially adding to the debate. There is scarcely more enthusiasm for these things in the other countries of Europe; it is simply that the contributions from Thatcher and Delors add heat without light allowing the real issues of UK interest to get lost in the noise. Our industries, and the electronics industry in particular, require a strong lobby in Brussels. We will only achieve this through agreement and quiet diplomacy.

There are plenty of warts on Europe. Most are irritating but benign as in fish (land based). A few are malignant: the runaway CAP, state sponsored protectionism. The difference must be appreciated to ensure the health of the body.

Frank Ogden

Take the Sensible Route!



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

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

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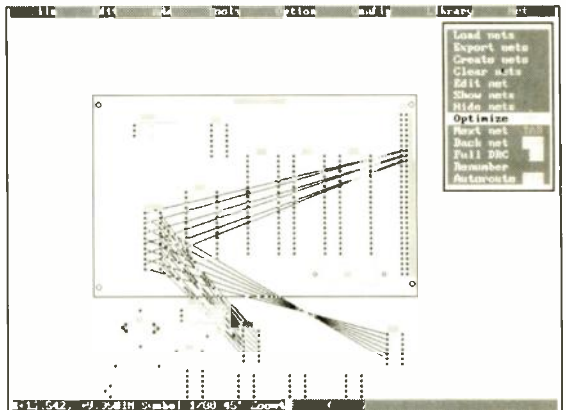
£495

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



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CIRCLE NO. 138 ON REPLY CARD

Large leds use plastic semiconductors

After last month's molecular junction boxes you would be forgiven for wondering if *EW + WW* had shares in the plastics industry. This month the same theme of conductive polymers is given a further boost by the publication (*Nature* Vol 347 No 6293) of some work on polymer leds at Cambridge.

JH Burroughes et al have demonstrated that films of poly (p-phenylene vinylene) can be made not only to conduct electricity but also, with suitable electrodes, to function as the active elements in large area light-emitting diodes.

Until now, reliable, stable leds have only been possible using inorganic semiconductors with suitable band gaps such as gallium arsenide, though these are not adaptable for large area displays. Attempts at making large displays using polycrystalline zinc sulphide or organic semiconductors have all been limited either by low efficiency, chemical instability or difficulty of manufacture.

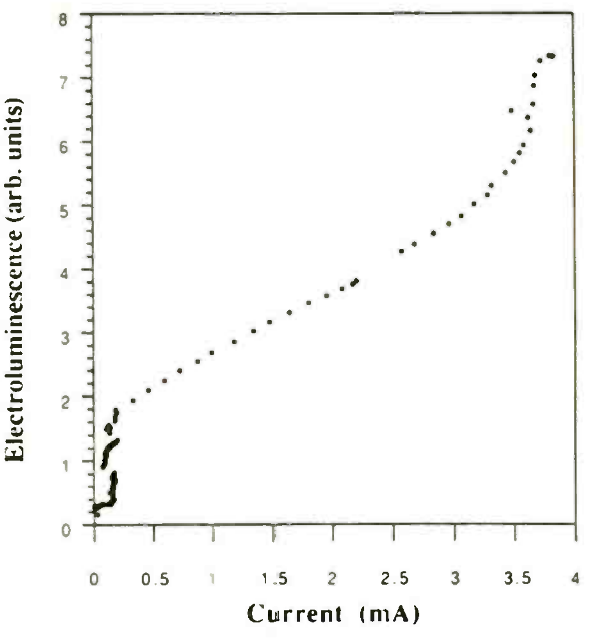
The Cambridge team decided to approach the challenge by looking at some very large organic molecules, notably conjugated polymers. Some of these, like doped polyacetylene, are very good electrical conductors and also very stable and relatively easy to make. Unfortunately polyacetylene shows little or no luminescence. Other compounds, however, such as poly (p-phenylene vinylene) or PPV, have larger band gaps and can in theory photoluminesce with high quantum efficiency. The only problem has been to develop a means of producing the stuff with high purity and in a form suitable for coating on a substrate.

The Cambridge method, in outline, consists of preparing a precursor polymer soluble in methanol. Spin-coated films of this mixture on suitable substrates are then heated at 250° for 10hr in vacuo, creating 100nm thick films of pure PPV.

As for fabrication of experimental large area leds, the method used is to deposit the PPV on a sheet of glass on which a bottom electrode has already been formed. A top electrode is then deposited by ion-beam or RF sputtering. The high stability of the PPV film makes this a simple process.

Obviously at least one of the electrodes needs to be transparent, since the whole idea is for light to emerge normal to the plane of the device. The graph shows light output characteristics of a polymer led in which PPV is sandwiched between a layer of indium oxide and a layer of aluminium.

Researchers at Cambridge have developed a method of producing high purity PPV on a suitable substrate for use as a large led. Devices emit a greenish yellow colour that can be seen under normal laboratory conditions.



Burroughes and his colleagues say that the devices emit a greenish yellow colour that can easily be seen under normal laboratory lighting. Reliability is obviously a question that will need addressing since some of these experimental devices failed at the polymer/metal interface, probably due to local heating.

Nevertheless these early experiments clearly show the promise of commercial applications ranging from simple indicators to alternatives for liquid crystal displays.

Superconducting sinters bring practical progress

It seems almost unbelievable that high temperature superconductors have been with us now for only a little over 3 years. So frantic was the research that followed the announcement by Paul Chu and Maw Kuen Wu in 1987 that one can be forgiven for thinking it was much further back in time. But in spite of the initial excitement at creating a ceramic material that would superconduct at 93K, practical applications have been few and far between because of two seemingly insuperable obstacles.

The first major problem was the discovery that all the ceramic high temperature superconductors lose their properties in the presence of strong magnetic fields. And because it is impossible to pass a large current without creating a strong field, many of the obvious applications were ruled out.

A year ago, however, research at AT+T Bell Labs in New Jersey (Nature Vol 342 No 6245) showed that if certain ceramic superconductors are irradiated with neutrons, tiny faults are introduced into the crystal structure which pin the magnetic fluxoids and greatly increase the permissible field before electrical resistance reappears. As a consequence of this work, materials are now available that can carry currents of $1MA/cm^2$.

The other serious difficulty is that

the high temperature superconductors have all the malleability and ductility of a china teacup, which makes coil-winding somewhat difficult. Attempts have therefore been made – not always successfully – to blend powdered superconductors with metals or conductive polymers. The latest work (Weizmann Research No 25) describes a fascinating approach by which Professor Shimon Reich has coated individual particles of ceramic superconductor with silver and then sintered them at high temperature. The resulting material not only has desirable mechanical properties but, since the silver entirely surrounds each ceramic particle, also gives good protection against moisture ingress.

The question which immediately arises is how material containing only "islands" of superconductor can function at all. How can current pass without loss through the silver honeycomb when silver itself does not superconduct at liquid nitrogen temperatures?

Reich and his colleagues at the Weizmann Institute in Rehovot, Israel, can only speculate that there is some "proximity effect" by which the superconducting ceramic bestows its properties on the non-superconducting metal. How this might operate remains a mystery and indeed just adds to the growing number of theoretical problems that already surround high temperature superconductivity.

From a practical point of view, however, there can be little doubt that the goal of commercially useful materials is getting slowly but steadily closer.

Killer debris filling up the sky

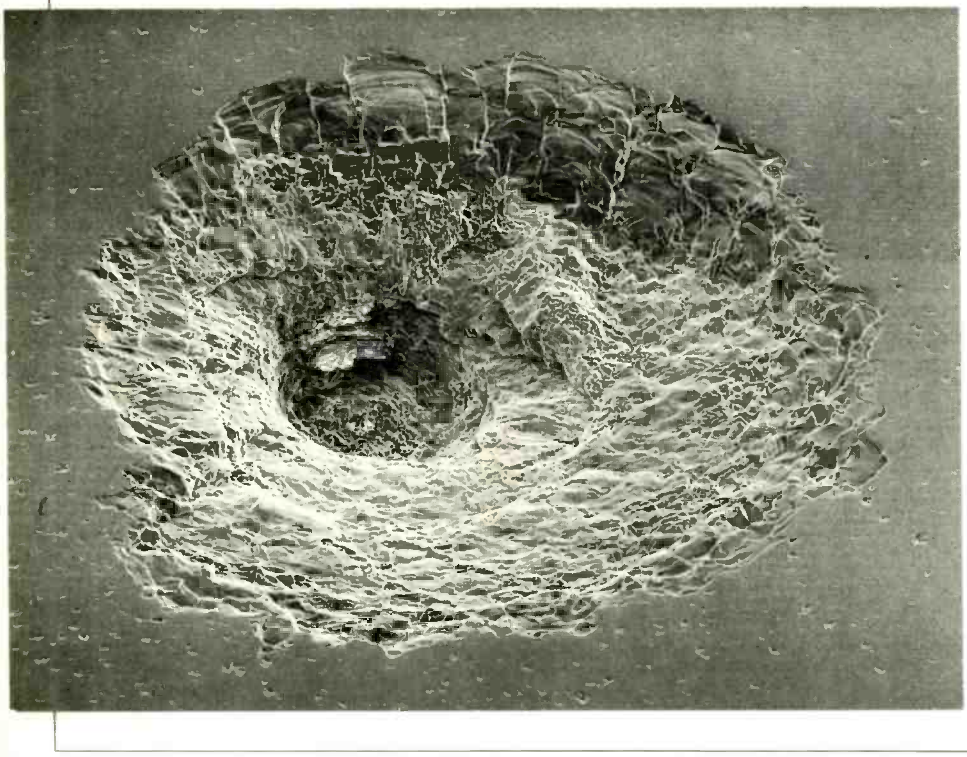
The danger of being hit by another car whizzing round the M25 may be as nothing compared with the risks of high-speed collisions in space. The US Office of Technology Assessment is now the latest in a series of agencies that have warned that unless something is done to curb the growing amount of junk in space, some well-used low-earth orbits could become too risky to use.

So cluttered are the skies above our heads that, according to Nasa calculations, there's a one-in-a-thousand chance that within the next decade an astronaut could be killed by one of the numerous objects orbiting at speeds of 27 000km/hr. The Hubble space telescope, already handicapped by optical aberrations stands a one-in-a-hundred chance of being irreparably damaged by space junk during its projected 17-year lifespan.

Where then does all the orbiting rubbish come from? Since the dawn of the space age in 1957, around 4000 satellites have been blasted into orbit by some 3500 multi-stage rockets or shuttles. Many satellites are deliberately designed to shed spent components; others are blown up or accidentally self-destruct. The result, according to computer predictions is a total of between 30 000 to 70 000 objects bigger than a 1cm cube. These include at least one screwdriver and a spanner.

US Space Command currently tracks over 6600 objects using ground radar, only a few hundred of which are actively functioning satellites. The rest are spent rocket stages, defunct satellites, power packs, hatch covers and virtually anything you might find in a Cape Canaveral scrapyard. The total weight runs into millions of tons and is expected to double within the next 30 years.

According to an ESA report a few years ago, it is not just a matter of the total tonnage of space junk. Lumps of debris regularly collide with each other and, because of the huge momentum, break up into what the agency describes as a self-propagating swarm



Even paint chips can be a deadly hazard to astronauts. The micrograph (left) of damage to a space shuttle window following a mission, shows a pit 640μm in diameter and 630μm deep, surrounded by a 2.4mm diameter spall. The pit contains titanium oxide – a pigment used in aircraft paint. (Above) Nasa estimates there are up to 70 000 objects bigger than 1cm cube orbiting the earth.

of ever-smaller pieces. Worse still the impacts inject pieces into orbits that were not previously occupied.

Already there have been a number of spacecraft damaged, seemingly by collisions in orbit. In some cases this has amounted to nothing worse than pitting, caused by impacts with very tiny objects or micro-meteorites the size of grains of sand. Much more serious, however, was the occasion when Soviet cosmonauts on board Salyut-7 heard a loud bang and discovered a 4mm crater in one of their windows. As for near-fatal accidents, the space Shuttle Columbia just missed a defunct Soviet rocket stage travelling at 11 000km/hr.

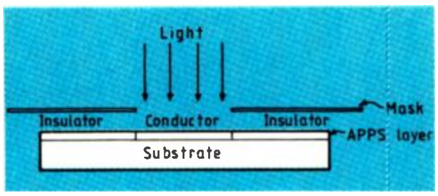
If nothing is done, some of this junk will eventually fall back to earth and burn up. An estimated 16 000 man-made objects have already done so. But much of what is now up there is parked in stable orbits that will not decay for decades, if ever. So while international agreements to curb space "litterbugs" will go some way to reducing the problem, the only way it seems to make space a much safer place is to put into orbit a giant vacuum cleaner.

Conductivity in a flash

A meeting of the American Chemical Society recently heard of a development that could greatly simplify the manufacture both of printed circuits and IC wafers.

Bruce Novak of the University of California at Berkeley told the meeting of a polymer called arylated poly (p-phenylene sulphide) — APPS for short. What's special is that APPS can be changed from an insulator to a moderate conductor merely by exposure to light. What's more, once the transformation has occurred, the APPS remains permanently conducting.

This combination of properties is not unique, although APPS does offer for the first time a material that is cheap and convenient enough for commercial fabrication processes. Furthermore, its conductivity, though not high, is within the range of what is useful in normal circuitry. As yet, the mechanism of conductivity is unknown but there's every chance that its existing performance could be improved by suitable dopants.



If APPS does prove suitable for commercial application, it could eliminate a number of stages from today's etch-based processes. Instead of depositing a conductor, adding a photo-resist, masking it, exposing it and then etching, a conductive path could be created simply by depositing the APPS on a substrate, masking it and exposing it to light. Wherever the light reached the surface, a conductor would form.

So far the system has been used to create conducting strips far finer than required for ordinary printed circuits, though compared with today's photolithography techniques for silicon wafers its 10μm capability is relatively modest.

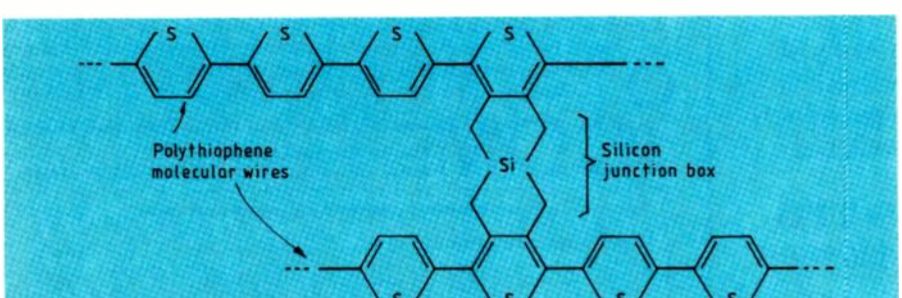
Lots of questions still remain unanswered, not least how much current the conductors will carry and whether or not the conductivity figures stay stable over long periods of time. Nevertheless, industry is said to be very interested.

Chemical junction box

In an attempt to avoid the size limitations even of X-ray and electron lithography, researchers have turned their attentions to the possibility of growing nanometre-sized molecular wire using chemical techniques (see *EW+WW*, October 1989). It involves the synthesis of long-chain molecules with free electrons that can hop along the molecule from one end to the other. Most of the materials so far investigated are polymers such as polypyrrole and polythiophene.

Molecular wire is an exciting idea in theory but suffers from one very serious difficulty: it can't easily be joined without some adverse reaction or without some geometrical constraint.

Early work suggested that the answer might lie in interposing some extra atom, such as carbon or silicon, in an arrangement that allows a totally flexible configuration. The difficulty, however, has been to do this without creating unwanted bonds or losing the conductive pathway.



Silicon supplies an atomic "spot-weld" for molecular wires.

Progress has now been reported [*Journal of the American Chemical Society*, 1990, Vol 12, 5662] by James Tour, Ruilian We and Jeffry Schumm at the University of South Carolina. What they've done is to join together two molecular wires of doped polythiophene using a single central silicon atom. The detailed chemistry is complex, involving a variety of reactive volatile intermediate compounds. The net effect, however, is to create what amounts to a molecular junction box — a sort of atom-sized spot weld — between a pair of polythiophene molecules.

The next step will be to grow longer chains of molecular wires and to characterise fully the performance of the molecular junction.

How to speak to an alien

Now that considerable effort is being expended in both hemispheres in the search for extra-terrestrial life, people are beginning to ask themselves the question of what to say when contact is eventually established. Apart from a polite "Good Morning!" (or G'day if you're working at Parkes or Tidbinbilla), what on earth (or in space) do you say?

Dr Jill Tarter of the California-based Search for Extraterrestrial Intelligence (SETI), bemoaning the fact that there are few international, let alone interstellar greeting cards available, says that the United Nations should adopt guidelines telling us humans how to approach our first alien. It's all very well, she believes, spending billions of dollars on sophisticated radio facilities if you have no idea how to handle success. Do you respond to signals from space with a burst of binary data, a cheery "Hello playmates", a hopeful "QRZ" or do you adopt that peculiar English habit of addressing foreigners as though they were half-wits?

Previous research in this area has concentrated on the idea of evolving a common language. Dutch mathematician Hans Freudenthal set out some guidelines in his book *Language for Cosmic Intercourse*. Others believe, however, that this would be much too slow and cumbersome. Professor Carl deVita of Arizona University thinks that one approach might be to seek common ground with whatever form of extraterrestrial being eventually turned up. And assuming it were possible to

transmit pictures or communicate face-to-face, deVita thinks the answer would be pictures with mathematical captions.

But what pictures? Not the naked people displayed on the Voyager space probe, thinks deVita. Ideally, he says, a picture showing an ocean, then an icefield, then an iceberg. Using this method, he believes, earthlings could build up a rapport with aliens that would eventually lead on to discussions about non-scientific matters.

But why, I wonder, does anyone think that the first thing aliens will want to talk about is science (or even engineering)? The laws of physics may be the same throughout the Universe but if I ever had the good fortune to meet an alien creature, I think I'd want to probe issues a good deal more fundamental than the Latent Heat of Fusion.

High Value for 1Ω resistor

CSIRO's National Measurement Laboratory in Australia has created a reproduceable 1Ω standard resistor that is probably better than anything else readily available. It ought to be at A$15,000 apiece!

The resistor is made from Evanohm S and is heat treated during manufacture so that the slope of its resistance vs temperature curve is zero at 22.5°C. This means that there is effectively no change of resistance as long as the ambient temperature does not depart too far from normal laboratory conditions. NML say that within a few degrees of this temperature the 1Ω resistor changes in value by less than $10^{-7}\Omega$. To achieve a similar performance using Manganin alloy the temperature, they say, would have to be controlled to within 0.04°C.

Other major advantages of the new resistor include a pressure coefficient ten times lower than that of Manganin and a lower thermal hysteresis. NML is currently negotiating with a scientific instrument maker to manufacture the resistors under licence. What I want to know is how much you would have to pay for a dozen at 10MΩ!

Chemical route to sub-micron LSI?

Some months ago (*EW + WW* July 1990) we reported, with graphic illustrations, the efforts of IBM to manipulate individual atoms and molecules using the scanning tunnelling microscope (STM). Now it seems as if an STM researcher at NTT in Japan has achieved a similarly spectacular result in the sphere of surface chemistry.

Reporting in *Nature* (Vol 347 No 6295) Yashushi Utsugi of NTT's LSI Laboratories describes his work using STM equipment to etch chemical modifications about 10nm wide on the surface of a film of silver selenide (approximately Ag_2Se). Silver selenide was chosen because it conducts electricity both ionically (as an electrolyte) and electronically (as a metal).

Utsugi prepared his material by silver-plating a $Ge_{0.1}Se_{0.9}$ film that had been deposited on a substrate by RF sputtering. (The purpose of the germanium was to prevent unwanted crystallisation of the resulting silver selenide compound.) What resulted was a 15nm thick film with the chemical composition $Ag_{1.9}Se$, not quite stoichiometric but with the same chemical properties as Ag_2Se.

After demonstrating the flatness of the sample, Utsugi went on to use his STM probe to etch a coarse pattern with 60nm grooves. Conscious of the publicity value, he then went on to etch the company name in letters only 3nm deep.

Utsugi believes the electric field segregates the ions comprising the silver selenide, exposing Se ions to the atmosphere. This in turn facilitates a chemical reaction with hydrogen atoms taken from the moisture in the air.

The etching of the Ag_xSe is thought to be the result of the selenium component flying off as hydrogen selenide gas.

Utsugi believes that this vertical chemical etching holds out great promise for fabricating nanometre-scale devices. The Ag_xSe/Ge-Sc system has already been suggested as a medium for storing X-ray holograms and for making sub-micron LSI chips.

Free energy for ever?

Eye-witness accounts suggest that US inventor Stanley Meyer has developed an electric cell which will split ordinary tap water into hydrogen and oxygen with far less energy than that required by a normal electrolytic cell.

In a demonstration made before Professor Michael Laughton, Dean of Engineering at Queen Mary College, London, Admiral Sir Anthony Griffin, a former controller of the British Navy, and Dr Keith Hindley, a UK research chemist, Meyer's cell, developed at the inventor's home in Grove City, Ohio, produced far more hydrogen/oxygen mixture than could have been expected by simple electrolysis.

A witness team of independent UK scientific observers testified that US inventor, Stanley Meyer, successfully decomposed ordinary tap water into constituent elements through a combination of high, pulsed voltage using an average current measured only in milliamps. Reported gas evolution was enough to sustain a hydrogen/oxygen flame which instantly melted steel.

In contrast with normal high current electrolysis, the witnesses report the lack of any heating within the cell. Meyer declines to release details which would allow scientists to duplicate and evaluate his "water fuel cell". However, he has supplied enough detail to the US Patents Office to persuade them that he can substantiate his 'power-from-water' claims.

The picture was taken by a member of the UK scientific team, Admiral Tony Griffin, and shows the inventor with a working cell.

Where normal water electrolysis requires the passage of current measured in amps, Meyer's cell achieves the same effect in milliamps. Furthermore ordinary tap water requires the addition of an electrolyte such as sulphuric acid to aid current conduction; Meyer's cell functions at greatest efficiency with pure water.

According to the witnesses, the most startling aspect of the Meyer cell was that it remained cold, even after hours of gas production.

Meyer's experiments, which he seems to be able to perform to order, have earned him a series of US patents granted under Section 101. The granting of a patent under this section is dependent on a successful demonstration of the invention to a Patent Review Board.

Meyer's cell seems to have many of the attributes of an electrolytic cell except that it functions at high voltage, low current rather than the other way about. Construction is unremarkable. The electrodes – referred to as "excitors" by Meyer – are made from parallel plates of stainless steel formed in either flat or concentric topography. Gas production seems to vary as the inverse of the distance between them; the patents suggest a spacing of 1.5mm produces satisfactory results.

The real differences occur in the power supply to the cell. Meyer uses an external inductance which appears to resonate with the capacitance of the cell – pure water apparently possesses a dielectric constant of about 5 – to produce a parallel resonant circuit. This is excited by a high power pulse generator which, together with the cell capacitance and a rectifier diode, forms a charge pump circuit. High frequency pulses build a rising staircase DC potential across the electrodes of the cell until a point is reached where the water breaks down and a momentary high current flows. A current measuring circuit in the supply detects this breakdown and removes the pulse drive for a few cycles allowing the water to "recover" (if that is what it does). Research chemist Keith Hindley offers this description of a Meyer cell demonstration: "After a day of presentations, the Griffin committee witnessed a number of important demonstration of the WFC (water fuel cell as named by the inventor).

"One demonstration cell was fitted with two parallel plate "excitors". Using tap water to fill the cell, the plates generated gas at very low current levels – no greater than a tenth of an amp on the ammeter, and claimed to be milliamps by Meyer – and this gas production increased steadily as the plates were moved closer together and decreased as they were separated. The DC voltage appeared to be pulsed at tens of thousands of volts.

"A second cell carried nine stainless steel double tube cell units and generated much more gas. A sequence of photographs was taken showing gas production at milliamp levels. When the voltage was turned up to its peak value, the gas then poured off at a very impressive level.

"We did notice that the water at the top of the cell slowly became discoloured with a pale cream and dark brown precipitate, almost certainly the effects of the chlorine in the heavily chlorinated tap water on the stainless steel tubes used as "excitors".

"Within seconds of splitting water in this novel way, Meyer lit a flame at a gas burner fed from the cell and, within seconds, was melting a steel bar amidst a shower of sparks – demonstrating hydrogen gas production at milliamp and kilovolt levels.

"The most remarkable observation is that the WFC and all its metal

continued on page 12

pipework remained quite cold to the touch, even after more than twenty minutes of operation. The splitting mechanism clearly evolves little heat in sharp contrast to electrolysis where the electrolyte warms up quickly.

"The results appear to suggest efficient and controllable gas production that responds rapidly to demand and yet is safe in operation. We clearly saw how increasing and decreasing the voltage is used to control gas production. We saw how gas generation ceased and then began again instantly as the voltage driving circuit was switched off and then on again.

"After hours of discussion between ourselves, we concluded that Steve Meyer did appear to have discovered an entirely new method for splitting water which showed few of the characteristics of classical electrolysis. Confirmation that his devices actually do work come from his collection of granted US patents on various parts of the WFC system. Since they were granted under Section 101 by the US Patent Office, the hardware involved in the patents has been examined experimentally by Patent Office experts and their seconded experts and all the claims have been established.

"The basic WFC was subjected to three years of testing. This raises the granted patents to the level of independent, critical, scientific and engineering confirmation that the devices actually perform as claimed."

The practical demonstration of the Meyer cell appears substantially more convincing than the para-scientific jargon which has been used to explain it. The inventor himself talks about a distortion and polarisation of the water molecule resulting in the H:OH bonding tearing itself apart under the electrostatic potential gradient, of a resonance within the molecule which amplifies the effect.

Apart from the copious hydrogen-oxygen gas evolution and the minimal temperature rise within the cell, witnesses also report that water within the cell disappears rapidly, presumably into its component parts and as an aerosol from the myriad of tiny bubbles breaking the surface of the cell.

There is plenty more that could be said about Meyer's invention, but it comes from the inventor himself rather than independent scientific opinion. Cells may be placed in series to increase the gas generating capacity. Meyer claims to have run a converted VW on hydrogen/oxygen mixture for the last four years using a chain of six cylindrical cells. He also claims that photon stimulation of the reactor space by optical fibre piped laser light increases gas production.

Regrettably, nearly all the obvious questions remain unanswered and the experimental technique has more holes in it than a sieve. First among these is this: what is the precise total cell energy input required to deliver a unit volume of dry gas mixture? Secondly, should the potential energy contained in the released gas mixture be greater than the total energy input, where does the extra energy come from?

There is a further subset of the last question. The water formed by the combustion of the gas mixture presumably equals the loss of water from the cell. If there is a net gain of energy to the system, where does it come from?

The inventor is a protegeé of the Advanced Energy Institute.

Frank Ogden

Instant C code for systems engineering

Systems development software producing instant program lines in C for DSP chip products, has been developed by Comdisco. Signal processing workSystem will turn a signal processing system, entered in block diagram form, into C code ready for compilation to advanced chips such as the Motorola 96002, AT&T DSP32C and TI TMS320C30. Since the generated code is standard, fully documented C, the system under development can compile to virtually any DSP system.

According to Comdisco technical director Robert Grossman, it should be possible to produce a target application of "instant bug free code in under five minutes" by describing the system to the computer as a simple signal flow diagram. Although the resulting code is universal, the software takes account of the target DSP chip by optimising the various calls for the specific architecture so that software emulation of hardware facilities, for instance register sets, can be kept to a minimum.

British company Loughborough Sound Images has co-operated with Comdisco to provide PC based DSP development boards which accept the compiled and downloaded code. The processed signals may then be returned to the SPW host system for analysis and review.

SPW, which runs under Unix and costs about £25 000, is primarily aimed at communications sytems development.

Comdisco technical director Dr Robert Grossman producing instant C code for DSP applications.

Navigating by Wogan

Cursor, invented by Dr Peter Duffett-Smith at Cambridge University, is a phase-difference system of radio-navigation that needs no dedicated radio beacons; it uses the signals from ordinary broadcast radio or television transmitters at any frequency from 10kHz to 10GHz.

Cursor measures the phase differences between signals received from several transmitters at two spaced receivers, one of which is borne by the moving vehicle (on land, sea or in the air), the other being a fixed base station. A narrow-band link passes information on the signal received by one station to the other, which uses both sets of information to calculate the position, the link being in either direction depending on whether the "rover" needs to navigate or the base station is to track it. In the former mode, the link can be shared by many vehicles, or the information modulated onto one or more of the broadcast transmitters.

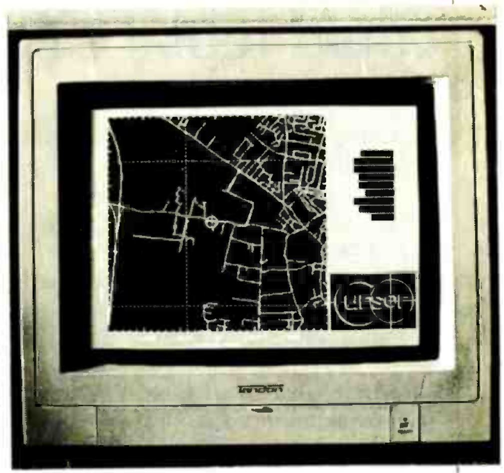
Any system using phase difference to determine position suffers from a degree of ambiguity, in that the same difference in phase is obtained for several positions, so the measurement gives a position which is not absolute but relative to a starting point. In effect, one must keep a running count of the "lanes" between lines of equal phase difference, which are hyperbolic.

In this case, however, the inventor says that this effect is unlikely to pose a problem in practice, since the unit is calibrated on installation. After that, the equipment "knows" its position and saves the information in ram even when, in a car for example, the ignition is off. Cursor will even survive a loss of signal for many kilometres, by virtue of the fact that many more transmitters are in use than in any of the established hyperbolic systems, the lanes being correspondingly wide and only one of the position-finding equations resulting from many measurements being a possible answer.

Signal propagation effects are less of a hazard to Cursor than to other systems, since wave-front distortion is alleviated by the large number of channels and the use of averaging and self-checking; and atmospheric disturbances, which can cause inaccuracies in many such systems, are reduced in importance by keeping a short base line between the two stations and by changing the transmitter selection as the rover moves. Since the system uses up to eight transmitters and needs only three to fix position, those giving results at odds with the majority can be discarded as a result of comparing signals between themselves. Additionally, since Cursor is differential in operation, propagation effects which are common to both stations do not seriously affect measurements.

In tests at the Cavendish Laboratory, a man walking outside the building was tracked to within 10cm, using broadcast FM transmissions, and current work involves the use of AM transmission to track a vehicle to within 5m at speeds of up to 70mile/h.

Low cost, the direct result of using existing transmissions, and high accuracy are the chief benefits of the system, which is being managed by a partnership between the Cambridge University company, Lynxvale Ltd and Cambridge Research and Innovation Ltd (CRIL)



Demonstration display of Cursor in action. Normal presentation is simply numerical position information; map is for illustration only.

Graphic changes in store for desktops

IBM is aiming to include graphics, video and audio processing on chips at the heart of its desktop computers, by the turn of the century – a step brought closer with launch of the second generation of Intel's i750 chips.

The new two-chip set, costing under £60 in volume quantities, will help turn desktop screens into something more like an animated film and allow the machines to produce sound quality more often associated with domestic hi-fi systems. One of the chips performs pixel processing, such as video compression/decompression interpolation, and colouring, while the other, the display processor, turns computer-type data into signals useable by a display.

Storing and displaying high-quality video using a computer involves processing lots of digital data, and standard algorithms for achieving this are in the final stages of preparation.

Different types of image (TV-style video, computer graphics, photographic stills) need different processing to achieve a visually acceptable result. So the pixel processor uses "soft microcoding", allowing the chip's instruction set to be changed.

The relevant instruction set is stored with the source material being displayed, so hardware will be able to match future algorithm developments. A single source program can also include several different sets of microcode, allowing the processor to reconfigure itself in real time, and adapt to different image types.

The processor's instructions are 48-bits wide, the minimum number of bits necessary for the tasks in hand.

Andy Gothard

Metal-hydride cells could replace NiCds

Nickel-metal-hydride batteries are beginning to take their place alongside nickel cadmium. The new batteries promise higher energy density than nickel cadmium and so could replace them in many applications.

Although several companies are developing nickel-metal-hydride batteries, only Sanyo Energy, San Diego, has released specifications on actual units, which are now undergoing beta site sampling. Sample quantities should be ready shortly.

Gates Energy of Gainesville, Florida, is also sampling nickel-metal-hydride batteries; the company plans early production, and Panasonic Industrial is in the market too.

Nickel-metal-hydride batteries are formed in a similar manner to nickel-cadmium batteries, except that energy density is at least 20–30% higher than nickel cadmium.

Higher energy densities mean nickel-metal-hydride batteries can have higher capacity in existing cell sizes or can have the same capacity in a smaller cell size. The newer batteries should fit into existing products without major modifications.

$5m bid to remedy packaging neglect

A five-year, $5million microelectronic-packaging research and development programme is to be conducted at Cornell University with the financial and technical support of several US corporations. The programme is in response to a shortage of efforts in this area of technology.

Cornell Electronic Packaging Alliance has received its first $250 000 from IBM — which is to contribute $1.25million — and other corporate participants are AMP, Carborundum, Digital Equipment, Rogers and Tektronix.

Cornell will develop courses at undergraduate and graduate levels where students will be able to work with corporate researchers.

Che-Yu Li, professor of materials science and engineering at Cornell, says the lack of funding for research in packaging at US universities has limited the number of graduate engineers and scientists who are experts in the field.

He says the Electronic Packaging Alliance will have its own research facilities and will also draw on the resources available at Cornell's National Nanofabrication Facility, Centre for Theory and Simulation in Science and Engineering, and the Materials Science Centre.

Li says the early commitment of IBM signals its recognition of the critical nature of electronic packaging to US competitiveness.

Negative resist

Negative resist for electron beam microlithography on semiconductors, sensitive to as little as 0.8μCi at 30kV, has been developed by Hiroshi Shiraishi of Hitachi, Tokyo. Shiraichi and his co-workers have blended a phenol-formaldehyde (novolac) resin with diphenylsilanediol and triphenylsulphonium trifluoromethanesulphonate. Electron bombardment decomposes the sulphonium salt and liberates protons which catalyse polymerisation of the silanediol to polydiphenylsiloxane.

The polysiloxane selectively enmeshes the novolac and impedes its dissolving during development with aqueous tetrabutylammonium hydroxide.

Because one proton catalyses formation of many resin bonds, such chemical amplification renders the resist particularly sensitive.

Totally uninspiring

Total Solutions electronics show held at Birmingham's NEC looks on paper to be a qualified success – nearly 13 000 people attended over the three days, slightly more than the previous year. But at the event itself it was too easy to feel that the show lacked the excitement expected from "Europe's focused showcase" for control, monitoring and power conversion.

Part of the problem must be because the exhibition sets out to do so much under an impossibly-broad banner. The idea is to combine six small shows under a wide-ranging heading linking various technologies and applications; from drives and motors through to telemetry and interfacing systems.

The aim is to retain the technology areas of the separate shows while generating the interest associated with a much bigger event. But as a result the identity of each individual show is submerged, and for the visitor the effect can too easily be of an exhibition without a heart.

Fears of a down-turn in business inevitably had their consequence. Though the exhibition was conceived when there was "every prospect of continued growth in the UK", the shadow of recession added only gloom. But was it fair to expect manufacturers to push the boat out in the UK so close to the holding of the much bigger Electronica in Germany, or Pronic in France?

As a result the razzle-dazzle and anticipation which should accompany such a show was lost.

Exhibition Director David Sturge said that indications were that exhibitors had obtained a "good quantity of high quality leads", and many visitors too will have gone away happy with the information they picked up.

But does information gathering have to be so dull?

The next Total Solutions show including Drives/motors/controls; Programmable controllers; Interfacing systems; Telemetry; Data acquisition and Sensors & systems will take place at the NEC, Birmingham, October 29-31. 0799 26699.

Continued on page 44

Talking confusion

Once again, technology is doing its best to blind the consumer with science — possibly to its own detriment. Steve Rogerson brings a little order to the chaos

In the beginning, there was Vodafone and Cellnet, two analogue-based cellular radio systems that have spread their grids around the United Kingdom.

Next in line was CT2, or telepoint. A handset operates only when in range of a receiving station signposted by one of the many gaudy notices springing up at railway stations and the like. Earlier this year the government licensed four companies to operate the different systems; three are already doing so and the other is due on line early in 1991. This uses digital technology and has a lower power requirement in the handset than cellular telephones. It is also taking a long time to get even a vaguely respectable number of customers.

Similar systems are about to start up in other European countries, but there is no fixed standard to which they have to adhere.

On the horizon is PCN, personal communications network. It will be cellular in construction but will be totally digital. The DTI is expected to announce four licences in 1991, of which at least two will use the group special mobile (GSM) method. These will be pan-European cellular systems.

To add further confusion, Motorola is toying with an idea of a satellite PCN system called Iridium, which will use low orbital satellites to pick up and transmit the signals. Keith Rose from Oftel is not impressed by Iridium. "Quite frankly, I can't see it working," he says.

And finally Ericsson has come up with CT3, an improved version of CT2, which it sees as a step between telepoint and PCN. It is a digital cordless system for use in offices, but may be used as a telepoint device and has potential residential use. The idea is that everybody in an office can carry their own handsets around with them — no more "I'm sorry, Mr Jones is away from his desk at the moment, would you like to leave a message?". Whether Mr Jones fancies taking the call in the lavatory is another matter.

CT3

CT3 works in the 800 to 1000MHz band and supports eight duplex channels on each 1MHz bandwidth. The first CT3 launch was the DCT900, designed as a peripheral to an existing PBX system operating in a similar way to an on-site paging set-up. To connect it, there is no need to modify the existing PBX — extension cabling for remote telephones can be diverted to the radio exchange or cordless extensions can be put in parallel to existing wired extensions. Both would share the same number.

Handsets weigh slightly more than 190g and use rechargeable NiCd batteries that offer 60h standby or 6h talk. They have a 12-digit LCD and a 20-number internal memory. The big problem is that they cost about twice as much as a hard-wired extension and Ericsson expects it will be a few years before it falls to even 40% more.

Its origins go back to 1985 when the Council of European PTTs (CEPT) called for technical proposals for a cordless telephone system that can be used in offices and in a telepoint environment. One of the two front-runners, put forward by mainly British manufacturers, has been developed into the CT2 products around today.

The other was jointly submitted by Ericsson and Televerket, the Swedish PTT. This was called Digital European Cordless Telecommunications (DECT). Final specifications for DECT should be available in the summer and products are likely to be out early in 1992.

CT3 is based on DECT standards and is functionally the same, the only real difference being the frequency — DECT will operate between 1.88 and 1.9GHz rather than 800 to 1000MHz for CT3.

Hans van der Hoek, product manager for Ericsson Radio Systems, said in a paper at the Comex exhibition in October, "In Europe, CT3 has been positioned as an opportunity for network operators and end users to familiarise themselves with the working of

Directional (sectored) Vodaphone base station. The network uses directional sites in urban areas and motorway corridors.

DECT in advance of the general availability of DECT systems. Outside Europe, where the DECT standard does not have any official status, CT3 has the opportunity to gain acceptance as a *de facto* standard for cordless communications".

Its ability to spread from the office to the street and the home has given Ericsson hope that it will be the winner with PCNs. The basic premise of a PCN is satisfied; that is, a telephone number is allocated to a person and not a telephone. Such a number would conceivably stay with a particular person for life.

It is also hoped that this will eventually genuinely replace the conventional telephone, with its appeal stretching to normal domestic use rather than just the business environment which makes up the bulk of the current cellular market.

Mercury

One of the likely winners of a PCN licence is Mercury Personal Communications which is planning a network of micro radio cells, which means that a low-power hand set could be used to receive and make calls.

Each cell will have a radius of between 0.4 and 6km, depending on whether it is a built-up or rural area; this compares with about 0.5 to 20km for current cellular systems. Even smaller cells may be fitted inside offices and other buildings operating in a similar way to CT3. Microwave links will connect radio base stations on PCN sites to switching centres. Handsets should be about 1W peak power and be about the same size as an 8oz bar of chocolate.

Unlike GSM systems, which will work at 900MHz, Mercury's PCN will be at 1800MHz, which will give it the advantage that it will be able to support four times the number of subscribers on a MHz/km^2 basis.

Nevertheless, some 22 European cellular operators, including Vodafone and Cellnet, have said they will launch a GSM system.

GSM

GSMs will be implemented on what are being called intelligent networks (INs), consisting of three components organised hierarchically. These are a service management system (SMS), a service control point (SCP) and a service switching point (SSP).

The SSP is the part that works out which service a call is requesting and then setting up the call if it is possible. The SCP will validate call requests, being effectively a database of information on the different types of request that might be made.

At the top of the tree is the SMS, controlling the services active on the network. It will download software onto the network, collect data records about network performance, and manage traffic on the network. It will also register customers onto the network and record which services they have been authorised to use.

Central to a GSM network are four databases. First is the visitor location register (VLR), containing information about subscribers in a certain geographical area, whether they live there or are just passing through. The home location register (HLR) has the details of all the subscribers on a network and information needed to operate the network. Thirdly, the authentication centre (AC) will have information to validate a subscriber through means such as his or her entry code and finally, the equipment identification register will check if certain equipment is valid. For example, it will contain lists of stolen handsets which should not be used.

One way that, as far as the user is concerned, GSM will be different from other cellular-based systems is the smartcard, also called SIM card (subscriber identity module). It will be carried around by all subscribers and contain information relevant to the subscriber, who will be able to plug it into any GSM telephone and be able to use it as if it were his or her own.

The card comes in two sizes: one about the same size as a credit card to be carried by the user; and the second, smaller card to be left in the handset. This was conceived because of worry that the larger card may stop future generations of handset getting smaller. Both are functionally identical and contain a single IC with processing power and memory.

A plan for this future is that the card may become multifunctional, containing not only telephone but financial information, so that it can be used as a charge – and cheque-guarantee card.

Mike McIntyre from Orbitel Mobile Communications said in his paper at Comex, "The GSM subscriber card is an exciting concept which carries with it many significant benefits for the subscriber. These will provide important differentiation between GSM and analogue 'phones, which will encourage the rapid take-up of GSM throughout Europe".

It is hoped that CT3 will eventually replace the conventional telephone, with its appeal stretching to normal domestic use rather than just the business environment which makes up the bulk of the current cellular market.

Vodaphone's Brentford exchange control room, believed to be one of the busiest in the world.

Analogue

Despite this, operators of analogue systems are far from throwing in the towel.

Cellnet is still investing some £4million a week into improving its network and, up to October, had some 25000 available voice channels and expects to reach 30000 by March. From the end of 1989 to October 1990 the ratio of consumers to voice channels had fallen from 35 to 1 to 20 to 1.

There are also signs that the quality of service is improving. From March to May 1989, it was estimated that 80% of calls from a mobile to a fixed telephone were connected successfully. By August 1990, that had reached 87.7%. The coverage area reaches more than 97% of the UK population, including the Shetlands and Orkneys.

Two major players launched handsets which go some way to solving cellular telephone's major problem: that is, getting handsets that are small and light and do not consume power so quickly that you are lucky if you can make more than one call a day.

Hitachi's Flite weighs 310g and has 10h standby and 60min talk. But it does cost £1200. For £300 less is the Panasonic F series at 360g, 8h standby and 40min talk. A heavier battery increases that to 14h and 80min respectively.

Steve Davies of Hitachi said the Flite phone "offers more talk time per gram than any other unit in the world. We choose to maintain a high price and quality and sacrifice on volume".

Flite features include a retractable antenna, ten-digit viewing, and permanent battery-power and signal-strength indication. Programmable function keys guide the user through various sequences and it can store up to 99 numbers. It has a hands-free operation mode and accessories let it be used in a car; Panasonic's F series can also be used in the car with hands-free operation. Its number memory is about the same as the Flite and it has a noise-cancelling microphone to cut out other road noises.

Mitsubishi has just released a kit that will convert its MT-3 cellphone into a carphone that can be used in all types of vehicles. This is a much heavier unit at 520g, with 14h standby and 90min talk.

"It's like the Betamax-versus-VHS battle all over again. That is why manufacturers are going ahead with non-standard options to try to make them look better than the standard."

Ericsson's CT3 digital cordless telephone, for use in the home, in the office, at telepoints and, with GSM digital mobiles, in cars.

Testing time

With all the new systems about to arrive and the existing systems continuing to grow, it is providing a headache for makers of test equipment.

Chris Foreman from Marconi explained. "Test equipment is left until the last moment to define and purchase. But, when a new system comes on line, you need the test system up and running. Our problem is knowing which ones to back. We are not ignoring any system; we are keeping an eye on all of them. The cost in developing test emulators is excessive if you don't know how many you will sell. So we are are not ruling anything out. We are trying to keep everything ticking so that when there is a clear winner we will only be a short time from product."

He predicted that telepoint "will succeed if it is marketed correctly. Compared with cellular it has disadvantages but, compared to a kiosk, it has a lot of advantages".

Forum Phonepoint handset from Digital Mobile Communications.

Oftel's Rose added "I think, with GSM, manufacturers are jumping in to try and influence the standard and give themselves commercial advantage. It's like the Betamax-versus-VHS battle all over again. That is why manufacturers are going ahead with non-standard options to try to make them look better than the standard".

To confuse the situation even more, workers in the US are developing a code-division multiple-access (CDMA) system rather than European time-division multiple-access (TDMA). CDMA is similar to the military frequency-hopping radios and has a better spectrum capacity. Big players are Nynex in New York and Pactel on the west coast. Qualcomm make the handset.

Foreman warned: "The thing that may stop all the European developments is if the US steps in with its technology".

Whichever system wins, some firms will end up hanging on the line and others will be making collect calls till the cows come home. The consumer, though, may stay confused for some time to come. ■

Talking technology

The new digital cellular networks will present a significant technical challenge to the equipment and system designers. Nobody yet knows if they will better even the limited performance of the present analogue generation of cell phones. By Andy Gothard.

While CT-2 and GSM will sit at about 900MHz in the radio spectrum, the generation following them will be transmitted at around 2GHz. These so-called PCNs (personal communications networks) will use digital technology closely related to GSM. The idea is that PCNs will eventually replace even the fixed telephone networks, bringing together the car telephone, the domestic telephone, and the business telecomms and datacomms functions. Inside buildings, hard wiring will be replaced with "pico-cells"- computer local area networking, PABX functions, in fact all internal communications, will be run on-air, rather than down cables. And instead of sending information to a place, we will be able to send it to a specific person, because the network will be clever enough to track down a user's "personal communicator". This, when plugged into the right sort of output device, for instance a telephone handset or a fax printer, will be able to receive any type of transmission.

Beyond that lies Motorola's concept of an equivalent global network, with a girdle of over 70 satellites providing connection to the system from anywhere in the world be it city centre or sparsely populated desert. Project Iridium, as it has been dubbed, may sound like only a distant possibility, but the company says it could be in place by the turn of the century. That's the big idea. Realising it means lots of technology, and lots of investment. So the stakes are high -- with up to 300 million potential users across Europe, and similar systems in the US and Japan, it could hardly be otherwise.

Exacting GSM

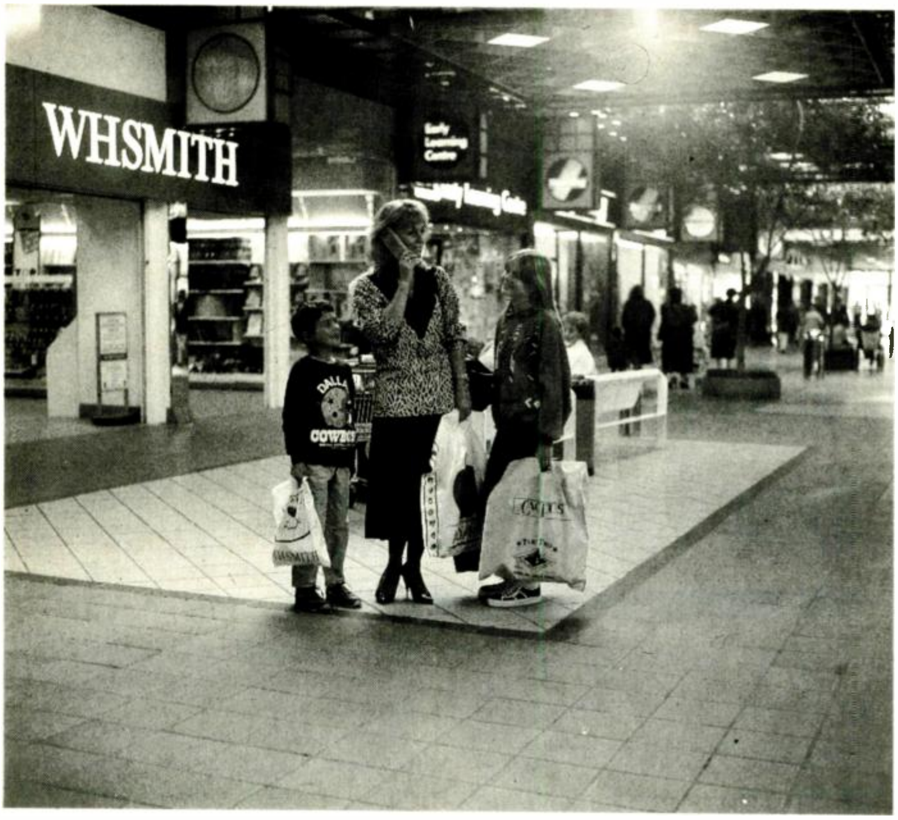
Although both Vodaphone and Cellnet have pledged support for GSM, doubts have been raised as to whether equipment will be available in time for the proposed launch next year. GSM is intended to replace the existing analogue cellular telephone system, and will run in the same frequency band. But, in the UK at least, there is only 5MHz of bandwidth available in this band, corresponding to 200 channels, or enough space to service about 250 000 subscribers. Beyond that, the operators will have to start eating into the frequencies presently used by the analogue services.

Part of the problem with GSM is that the original specification was fairly exacting. The decision to go digital was conditioned simply by the fact that doing so reduces the main problem of cellular systems, co-channel interference. This means that cells working on the same frequency do not have to be so widely spaced, and allows an estimated three-fold increase in the number of simultaneous conversations per megahertz of bandwidth per square kilometre.

From a technology point of view, however, it makes sense to be in GSM. The future PCNs will be based on the same digital coding technology so much of the development cost can be viewed as long-term. GSM provides a half-way house, with the digital coding problems, but without the headache of producing the mass-market microwave transmitters required by PCN.

The first of GSM's requirements was a speech coding technique which would produce acceptable quality, using the very minimum possible number of digital bits per second. Current silicon provides enough data compression to produce a "full rate" of 13kbit/second. By next year, the chip makers are promising a "half rate" coder, which will reduce telephone quality speech to 6.5kbit/second.

The basic technique used is called residually excited linear predictive coding (RELP). To this is added a long-term predictor which models the characteristics of the sounds picked up by the handset, and removes the "coarseness" produced by the coder. The initial sampling rate is 8ksamples/second, with 13-bit resolution, so the full-rate coder is producing a compression ratio of 8:1, the half-rate coder double



Shop talk: personal communications networks could replace conventional telephone lines for domestic as well as business use.

this. Developers working on implementing the algorithm have so far used dedicated DSP chips, for example Texas Instruments' C25 and C50 products, although late last year Motorola did announce a processor, the 56156, which can do at least part of the job in hardware.

The chip includes an analogue front end, A-to-Ds and D-to-As, comb and low pass filtering, tacked on to a 20mips processing core, which can implement the necessary antialiasing, and compensation filters in software. The clock rate will be upped next year, to produce a 40mips part capable of forming the basis of a two-chip (plus memory) GSM handset. If it works, this will be a formidable achievement - only 18 months ago some estimates put the chip count as high as seven custom devices plus microprocessors.

Dividing up time

After considerable initial debate, it was decided that the best transmission method for GSM would be time division multiple access (TDMA). This divides each radio channel into time slots, which can then be used for actual data, coding information, and network management functions. The system knows what kind of data it is dealing with (and its source and destination) by whereabouts in the time slot it arrives. Using TDMA means that several speech channels can be transmitted on the same radio channel. This has one very desirable consequence, in that the mobile unit is not constantly transmitting. This saves both power in the unit, and radio spectrum.

GSM uses 200kHz radio channels, TDMA organised into "frames" which last 4.62ms. Each frame is divided into eight time slots which carry the data itself. So transmission is going on for only one eighth of the call time. When the half-rate encoder is available, it will be possible to move to a figure of one sixteenth. The data from the speech coder is re-arranged and convolutionally coded so that the system can compensate if data arrives corrupted, the final result being data blocks of 456 bits.

GSM provides a half-way house, with the digital coding problems, but without the headache of producing the mass-market microwave transmitters required by PCN

Each time slot can accommodate 114 bits of data, so it would be possible to fit each block into four time slots. In practice, however, it is spread over eight by an interleaving process, once again to increase the chance of recovering speech data should a sequence of TDMA frames arrive corrupted.

In a flutter

If it seems unlikely that all of this complexity could find its way on to just a couple of silicon chips, then it will not be difficult to imagine why there is so much doubt as to the possibilities of success for GSM. The system's detractors say that for the foreseeable future the handsets are bound to be too bulky to satisfy users, and that the restricted bandwidth available will mean that coverage and capacity will both be inadequate. Its proponents counter that the system is inherently secure (at present anyone with the correct receiver equipment can listen in to cellular telephone transmissions) and provides the only sensible path to worldwide digital communications.

Nor is this the end of the complexity. Digital radio, particularly of the mobile kind, has a big problem with multipath distortion exacerbated by the higher operating frequencies. The receive path is also prone to disturbance by shadowing. The effect is for the same signal to arrive at spacings of several bit periods.

Moreover, GSM is supposed to cope with use in a vehicle moving at up to 250km/hour. To put it another way, the receiving antenna may move through an entire transmission wavelength in a single TDMA time slot. The way that this problem is solved is by transmitting a known "training sequence", some 20 bits in length, halfway through each time slot. The receiver compares what it receives with what it knows it should receive, estimates the likely impulse response of the transmission path, and calculates the transfer function of a filter which will perform the inverse transformation.

There is also a problem caused by the cell size, which can be a radius of up to 35km. Where many mobiles are broadcasting on the same channel, the base station needs to receive all the signals at exactly the correct time to prevent time slots from becoming confused. Providing a sufficiently long guard period to prevent this would be spectrally inefficient, so the mobile is made to transmit in advance of the base station's reference signal instead,

The restricted bandwidth available will mean that coverage and capacity will both be inadequate

the time of advance being constantly updated to compensate for changes in its location.

Corresponding with all of these mobile functions, there are a host of network management jobs which need to be performed including frequency hopping within cells, a process which can be done within a single TDMA timeframe, routing to the national trunk networks, user verification (which will be done using smartcards), and user location.

The infrastructure itself consists of the transmitting base stations, several of which can be controlled by a single base station controller which, in turn, talk to a mobile services switching centre (MSC). It is the MSC which organises communications with other networks.

RF technology

If the focus in GSM is on high speed digital signal processing, it looks as though the biggest problem for PCN and wireless in building networks (WINs) will be pushing the transmission frequency into the gigahertz range. In a speech last year, Wally Rhines, Texas Instruments' executive vice president in the semiconductor field, pointed to new products such as bipolar heterojunction transistors as the way forward in this field. These devices use a combination of different semiconductor materials to exploit the strange behaviour of electrons when they are very tightly confined. The effect is to make the electrons behave more like waves than particles, so that they do not take so much moving around. Commercialisation of such products is some years away yet, but with a need such as telecommunications driving development, they must surely become viable this decade. In its WIN proposals, announced last autumn, Motorola gave notice that gallium arsenide, so long a Cinderella waiting in the wings, could at last be set for centre stage.

The company is proposing the use of 18GHz channels in "pico-cells", to

Release from the physical and financial problems of cables for secure communications is the aim of much current progress in digital cellular networks

replace the final connection to office equipment. This is all far in the future, since present microwave transmitters are hardly either pocket sized or cheap. A GaAs monolithic microwave integrated circuit (MMIC), approximately the size of a pack of cards, lays at the centre of the proposals. The company has also come up with an antenna technology which brings the whole idea a little closer. This is a combination of six highly directional antennae, at both transmit and receive sites. Each element of the receiving antenna picks up transmissions from each element of the transmitter. The receiver itself then decides which of the 36 possibilities constitutes the "best" signal.

The advantages of WIN are similar to those quoted for FDDI (fibre distributed digital networks). It will, say its advocates, release companies from the physical, logistical and financial problems of using cables. It may also make it easier to get a telephone connected in a block of flats.

Digital radio, particularly of the mobile kind, has a big problem with multipath distortion

Globalising all of this is the subject of Motorola's other pet long-term project, Iridium. This is the idea that more than 70 satellites, in low earth orbit, could provide telephony for the entire world. The satellites themselves would perform the switching functions, and would use frequencies of 1.5-1.6GHz. Gateways in each country served would switch calls into public telephone networks, and perform the billing functions. Projected costs of the project are upwards of $2 billion, of which, at present estimates, around $50 million would go on launching the satellites.

Not surprisingly, the expectation is that the project would only get off the ground with a consortium effort between satellite companies, equipment makers, telephone operators and regulatory bodies. The great attraction is that the idea would bring the communications revolution to the large underdeveloped areas of the world, and would still be usable in the event of natural disaster; a company spokesman has cited the Armenian earthquake as one such event, in which lives were lost because of loss of contact with the outside world, as well as the immediate effects of the disaster.

These developments may seem far off and, perhaps, in this world where the telephone can be a hindrance as well as a help, a little frightening. But all communications professionals respond in the same way when asked: "Don't you ever want to be out of touch?". "You can," they promise, "always switch it off." ■

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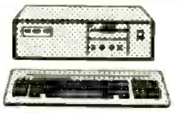

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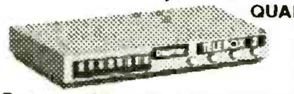

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Spread-spectrum for multiple access

Already well known in military circles, code-division possesses advantages over frequency and time division in multiple-access communication. Rex Lucas of LSI Logic describes the techniques involved.

Most wireless communication systems, regardless of application, have in common the complex handling of signals. Considerable signal processing is employed in modern equipment; for example, the channel equaliser in a digital cellular telephone carries out synchronisation with the base station and also eliminates unwanted signals reflected from hills and buildings. This section of the equipment alone typically has 50 000 gates of c-mos logic.

There are several possible approaches to realising a system. For the more complex equipment, such as digital cellular, the electronics can be incorporated into around 10 ICs, with discrete devices used in the RF output stages. Either SAW or ceramic devices are used for the filtering and are bulky and expensive, so zero-IF schemes are becoming increasingly popular, offering considerable advantages over the more conventional superhet type.

Spread-spectrum

A major concern for any multi-user communication system is multiple access without mutual interference and wireless communication is no exception to this; separation of user data by frequency slots or time slots (or both) is commonplace. These techniques are known as frequency-division multiple-access (FDMA) and time-division multiple-access (TDMA) and both approaches are used today in wired and wireless communications.

A recent development, which has advantages over both FDMA and TDMA for wireless communications, is known as code-division multiple-access (CDMA) and is based on the spread-spectrum technique. This has been used for many years in military radios for secure and covert communications, since it is highly immune to interference, carries a high level of inherent security and can be made to appear indistinguishable from ordinary broad-band noise.

With the spread-spectrum technique, the carrier is phase-modulated with a pseudo-random signal which is derived by multiplying the data to be transmitted with a pseudo-random code sequence. The effect is a frequency spectrum which appears as a uniform band of noise centred around the carrier frequency. Data is recovered in the receiver by correlation with the same pseudo-random code sequence.

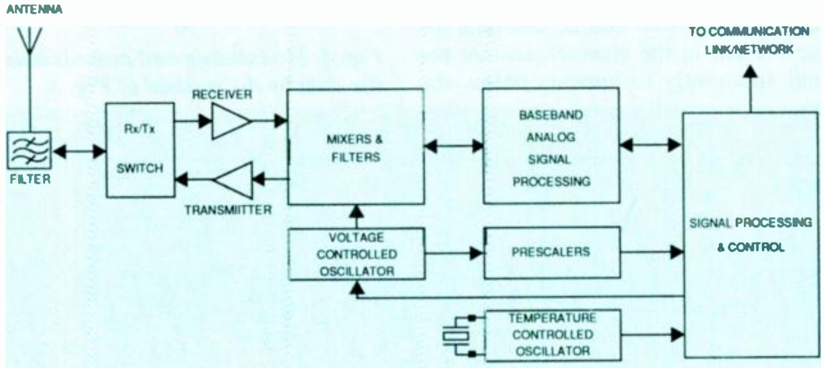
Figure 2 shows that if an interfering signal appears in-band, then after correlation in the receiver, it appears as a noise source well below the level of the required data. However, if the spread-spectrum signal is intercepted by an unauthorised receiver, it appears as a noise source and the data cannot be recovered without knowledge of the appropriate code.

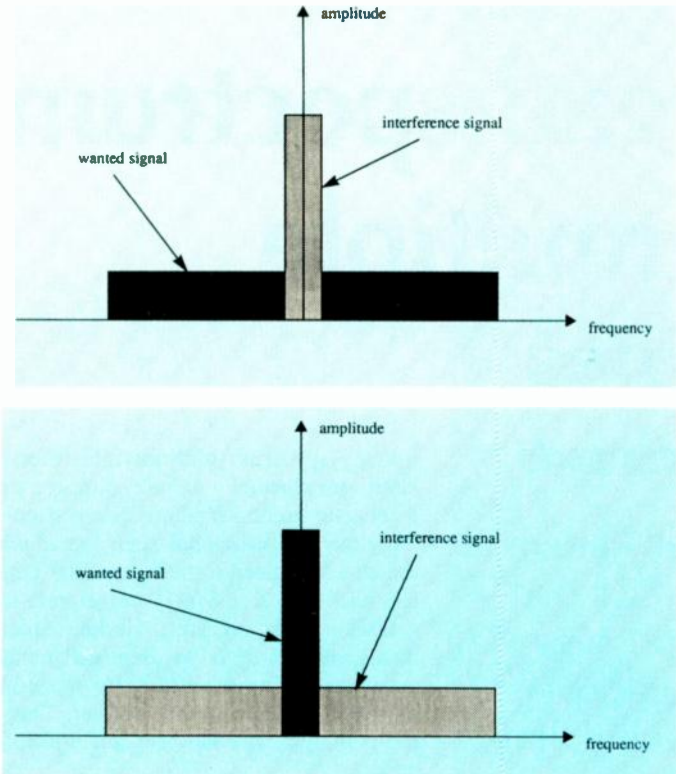
These properties of spread-spectrum enable several users to use the same frequency spectrum without interference. Each user channel will have allocated to it a separate pseudo-random code sequence. Only the data which has been spread with the code allocated to that particular channel will be successfully correlated and extracted at the receiver. All other spread data generated by other users will remain as wideband noise, adding to the other background noise in the receiver. This is the principle of code-division multiple-access.

Extending the information content of the signal over a wide frequency range is the aim of the spread-spectrum technique. In its most common form, spread-spectrum is known as "direct sequence", whereby the data bits are modulated by a pseudo-random noise code sequence to generate the spreading function, which then phase-modulates the carrier. Other techniques include frequency hopping, where the carrier frequency is changed in a pseudo-random fashion over the spread bandwidth, and time hopping, where rapid bursts of carrier are transmitted, each burst having a pseudo-random duration.

A technique known as chirp modulation is sometimes included in the spread-spectrum category; in this technique, the carrier is frequency-swept in a linear fashion over a wide frequency range. However, this is not strictly spread-spectrum, since there is no usage of random codes in the signal generation.

Fig. 1. Block diagram of a typical communications system, showing the amount of signal processing encountered in modern equipment.





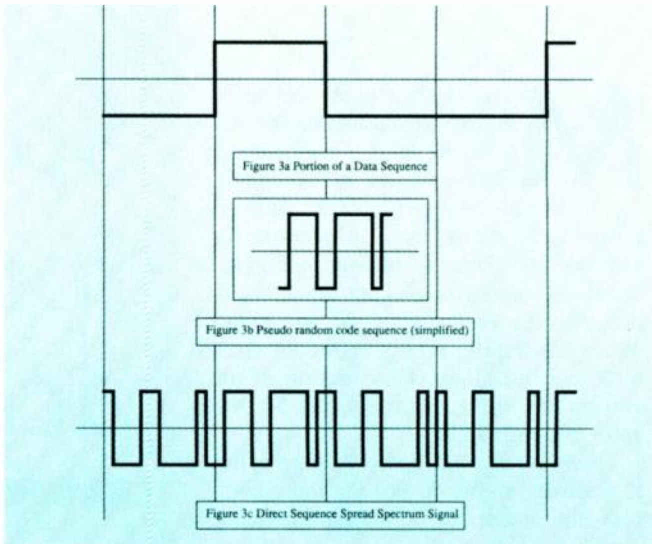


Fig. 3. Generating direct-sequence spread-spectrum signals by modulating the data with a pseudo-random code.

Fig. 2. (left) .The spread-spectrum technique. The wanted signal appears as a band of low-level noise until correlated with the code in the receiver. An interfering signal is not so correlated.

Figure 3 illustrates the principle of direct-sequence spread-spectrum (DS-SS): Fig. 3a shows a few bits of a data sequence. Figure 3b shows a code sequence, which has been shortened for clarity, and Fig. 3c shows the result of modulating (multiplying) the data bit with the code sequence. The resulting bit stream illustrated by Fig. 3c is commonly modulated onto the carrier by using 180° phase-shift keying (or binary phase-shift keying, BPSK), producing a wide-band, suppressed-carrier signal.

Within the code sequence, the smallest duration is known as a chip, and it can be seen from Fig. 3 that the chip duration is far smaller than that of the data bits and hence their spectral components cover a much wider frequency spectrum than the data bits, so the data is spread across a wide spectrum. Furthermore, the energy of the transmitted signal has been "smeared out" over a wide bandwidth and, as a result, has a very low spectral density. In fact, the transmitted signal spectral density may well be less than the noise present in the channel, so that the signal apparently disappears below the noise. Additionally, the spreading code has imparted a noise-like character to the signal, so that unauthorised detection can become extremely difficult.

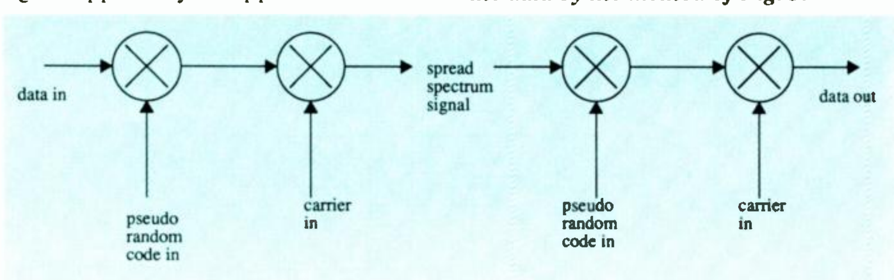
Data is recovered at the receiver by mixing the incoming signal with the same pseudo-random code sequence; the modulation and demodulation scheme being shown in **Fig. 4**. In principle, the sequence of modulation and demodulation does not matter, but the sequence shown is usually employed. Thus the received signal is mixed down to baseband after demodulation of the pseudo-random code.

If the carrier frequency is f_o, the chip duration is t_c and the code sequence length (in chips) is L, then the resulting transmitted signal spectrum is a distribution centred on f_o and comprises discrete spectral lines at frequency intervals of $1/Lt_c$.

The envelope of the distribution is given by

$$E(f) = \frac{t_c}{2}\left[\frac{\sin(\pi f t_c)}{\pi f t_c}\right]^2$$

Fig. 4. Modulating and demodulating the data by the method of Fig. 3.



Nearly all the transmitted power is contained within the frequency range (fo - fc) and $(f_o + f_c)$, where $f_c = 1/t_c$. Chip frequencies, f_c, of between 1 and 10MHz are typical for carriers, f_o, in the low gigahertz regions.

At the receiver, the spread signal is multiplied by the pseudo-random code, which is synchronised to the transmitter's code embedded in the received signal, removing the original spectrum- spreading modulation and collapsing the received signal power back into the original data bandwidth. Unwanted signals present at the receiver input, such as interfering carriers, will be spread by the multiplication of the pseudo-random code. As a result, the signal-to-noise ratio at the output of the receiver demodulator can be significantly higher than that at the input. In most cases, it can be shown that the ratio K of the signal-to-noise ratios, known as the "processing gain", is equal to the code sequence length L, for code sequences occupying a single data bit duration.

In all spread-spectrum transmission systems, the receiver has to identify and be able to lock onto and track the transmitted pseudo-random sequences. The simplest approach is to examine all possible phase relationships between the internally generated pseudo-random code and the received signal until a match is found. This is achieved by allowing the two signals to slip past each other, by offsetting their respective clock frequencies, while continuously correlating the two signals. Once a correlation peak is found, a code-tracking loop can be brought into action, which will synchronise and track the two signals. Synchronisation and tracking is one of the main areas of difficulty with spread-spectrum and where considerable work is being undertaken to establish, for example, optimal code sequences for rapid signal acquisition.

Applications of spread-spectrum

Military applications, making use of the covert and secure nature of spread-spectrum, have already been mentioned. CDMA and, hence spread-spectrum, is also being considered as an alternative to FDMA and TDMA, for the new Personal Communications Network (PCN).

Signalling over the electric mains is another area which offers amazing opportunities for data communications. The power supply network consists of large amounts of copper wiring, providing interconnections to every house, factory, and office in the country. This network is significantly under-used, in that its sole purpose is to deliver power at a single frequency.

The mains network suffers from high voltage noise sources such as switching spikes, but the inherent noise immunity of spread-spectrum makes it an ideal technique for transmission over this medium. Some companies have already developed spread-spectrum for applications such as automatic electricity metering. Typical data rates to date are 200bit/s with a spread bandwidth of 100kHz from 50kHz to 150kHz.

Spread-spectrum for GPS

Spread-spectrum will also find use in satellite communications systems, including the Global Positioning System (GPS), where immunity to interference and security are of paramount importance. In addition, the increased bandwidth occupied by the data means that critical timing measurements, crucial to accurate positioning systems, can be carried out with enhanced precision. Navtar GPS will use two pseudo-random noise codes: the C/A code, accessible by civilians, will permit fixing down to 100m accuracy and the military (P) code will allow fixes down to 10m. The C/A code length will be 1023 bits, repeated every 1ms; the P code is a 267-day-long code sequence at 10.23 MHz. Since there is a total of 21 satellites in the Navstar system, all transmitting on the same frequency, CDMA will be used to differentiate between the satellite signals at the receiver.

GPS receivers will make extensive use of asics for the analogue and digital processing functions. **Figure 5** shows the zero-IF asic which converts the 175MHz IF to baseband. This biCmos asic, developed by LSI Logic in the UK, meets the stringent noise requirements essential for spread-spectrum reception from a satellite.

Wireless lan

Ever-increasing costs of cable installation for old and new buildings and the explosive increase in portable computer usage are factors which point to a major need for wireless communications between computers. The spread-spectrum technique is ideal for such a wireless lan in an office or factory environment, since there is no danger of interference between equipments.

Wireless lan has been around in the United States for several years and is soon to take off in Europe. In the US, the FCC has allocated three frequency bands, around 900MHz, 2.4GHz and up to 6GHz, while in the UK the DTI is considering 2GHz for wireless lan.

Current implementations offer 200 kbit/s data rates and operate at a carrier frequency of 900MHz. Range indoors is typically 100m to 400m with a transmit power of 1W and a 3-in aerial.

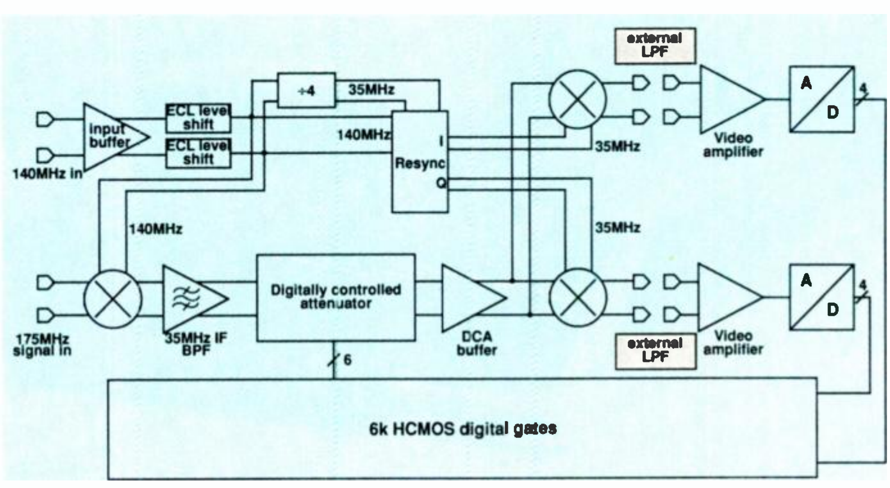
Apart from removing the need for wired connection, spread-spectrum has other advantages over conventional lan, such as Ethernet. Ethernet employs a carrier-sense mechanism on each node to detect the availability of the network. Once the network is free, node transmission is started. However, it is possible that, in this short time, another node has also started transmission and a data collision will occur. If a collision is detected, both nodes back down and restart transmission according to a prescribed precedence algorithm. In a heavily loaded network, collisions can dramatically slow up the message-transfer rate. Using spread-spectrum and CDMA, unrestricted access to the network is possible, and hence there is zero message delay under heavily loaded conditions.

Basic circuit blocks for wireless lan are again similar to the general system illustrated in Fig. 1. The main blocks are the wide-band RF front end for receiver and transmitter, the spread-spectrum circuit incorporating a tracking mixer and the correlator circuitry. Extraction of the data from the pseudo-random code modulated signal is achieved by correlation with the same random code signal generated in the receiver and synchronised to the transmitter. Correlation can be carried out using either analogue or digital techniques; analogue correlation techniques have the advantage of reduced power consumption (important for equipment associated with portable computers) and smaller silicon chip size to keep down cost.

Asics

An asic implemented in biCmos technology (i.e. bipolar and c-mos transistors on the same silicon substrate) permits the RF, IF mixer and other analogue circuitry to be integrated (in bipolar) alongside the complex digital signal processing circuitry (in c-mos). RF functions will normally be implemented in a custom solution with special consideration paid to packaging. The remaining functions can be implemented with a semi-custom approach using cells from a cell library. The GPS asic illustrated in Fig. 5 includes a 175MHz low-noise front-end amplifier, an IF filter, a 20MHz, 4-bit flash A-to-D converter, emitter-coupled logic operating in excess of 250MHz, and 6000 c-mos digital gates. This particular device is by LSI Logic and is based on the LAD series of arrays. ■

Fig. 5. LSI Logic LAD310 asic for Global Positioning System receiver, implemented in bipolar and cmos (bi-Cmos



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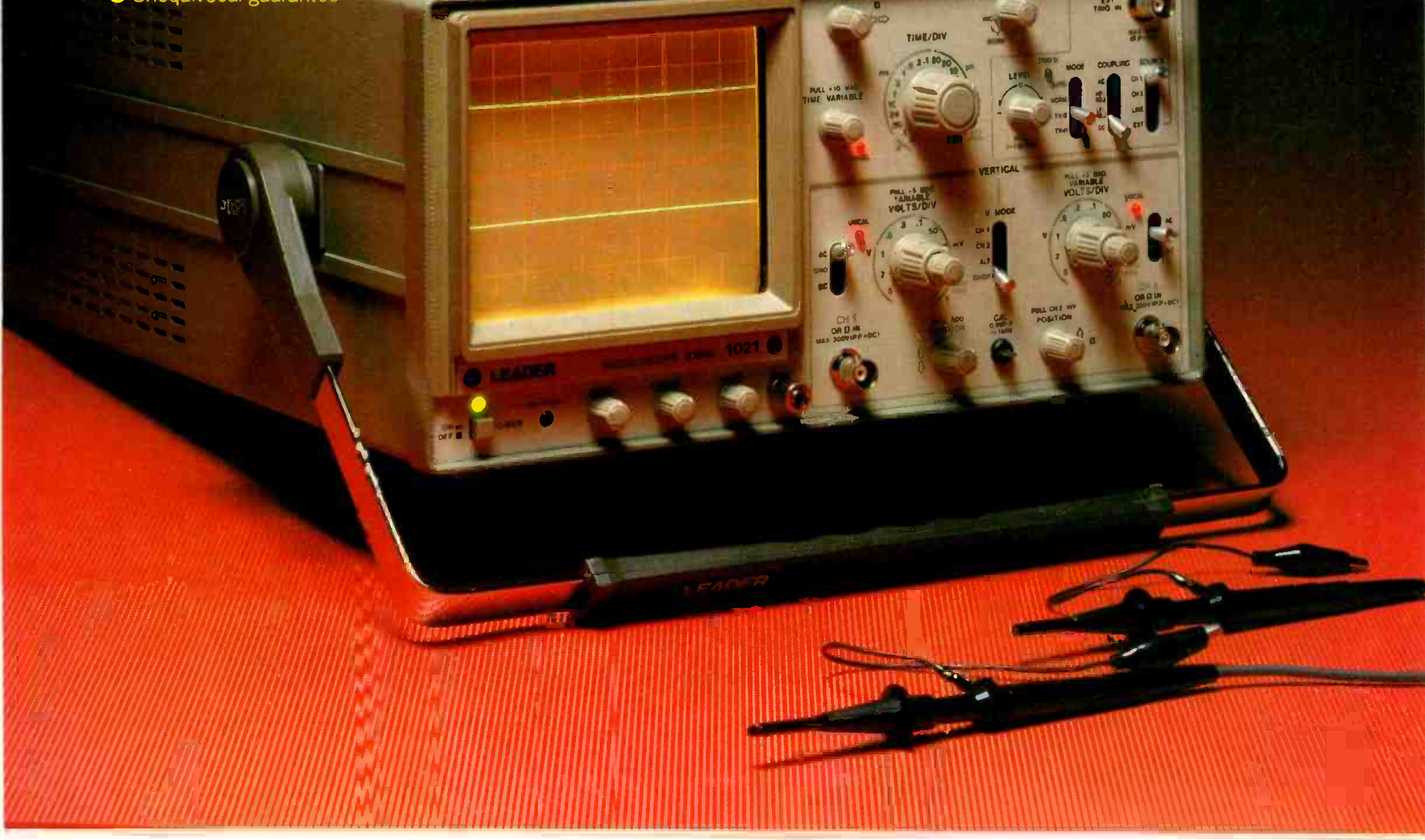
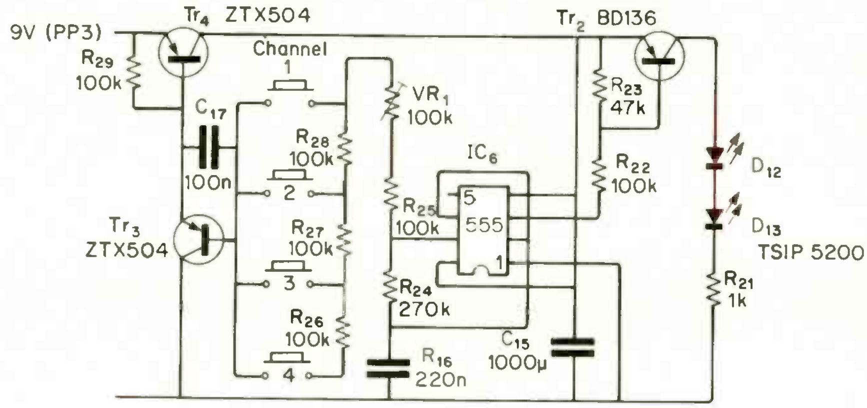




Infrared remote controller

Economical remote switching of up to eight circuits requires one c-mos 4013 and a few other components for each channel in the receiver and a simple 555 circuit in the transmitter.

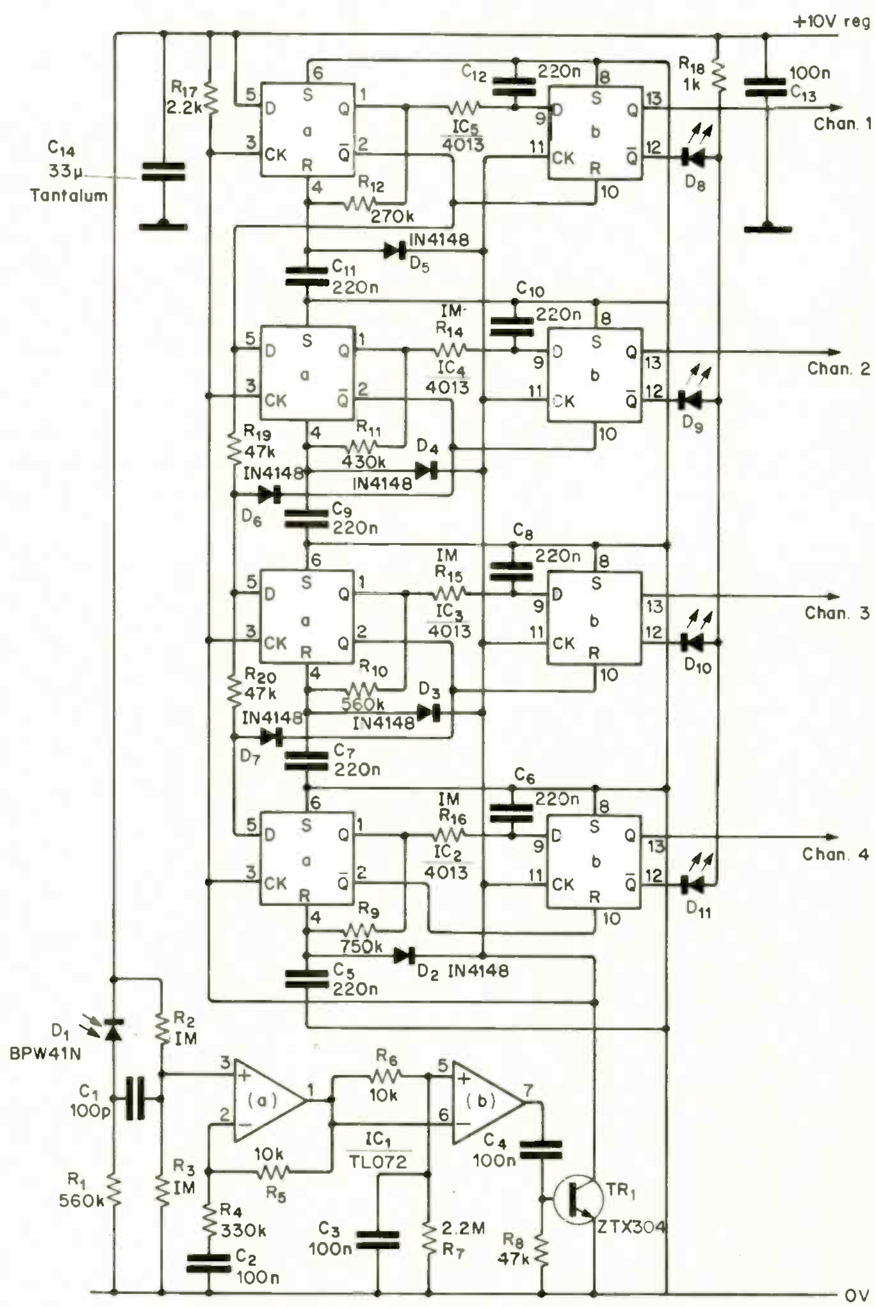
Top diagram is the transmitter, which uses a 555 timer running astably, $Tr_{3,4}$ automatically switching the transmitter on when any channel button is operated. The output pulse is about 45μs at 1.5A, its period being 125 to 35ms, depending on the channel switch and battery state; VR_1 is adjusted to obtain correct pulse period and therefore receiver decoding for 7–9.5V supply.

The input to the receiver (bottom) consists of a detector and high-pass amplifier (D_1, IC_{1a}) and a threshold comparator/clock driver (IC_{1b}, Tr_1). Each channel uses a dual D-type flip-flop, the first half of each being wired as a monostable and the other as a resettable latch. All are clocked by IC_{1b} output, the periods being nominally 130, 100, 75 and 50ms.

For pulse periods longer than that of the slowest monostable, IC_{2a}, all monostable Q outputs are reset before the latches are clocked. If the input period is less than the monostable timeout, the monostable Q output remains high and is transferred to the latch. As each of the shorter-period monostables is over-ridden by the input pulses, it inhibits the longer-period ones by resetting their data inputs by R_{19}, D_6, etc., so that each intermediate channel acts as a window discriminator.

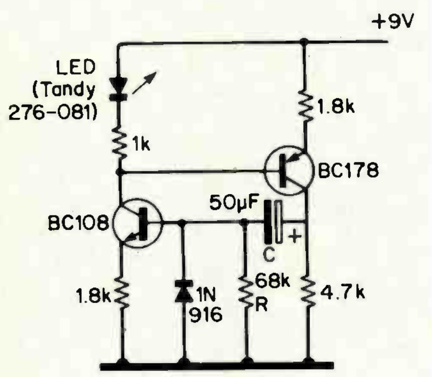
When the pulse train stops, the active latch is reset by the monostable Q output when the monostable times out, diodes D_{2-5} discharging the timing capacitors.

H. Maidment
Wilton
Salisbury
Wiltshire

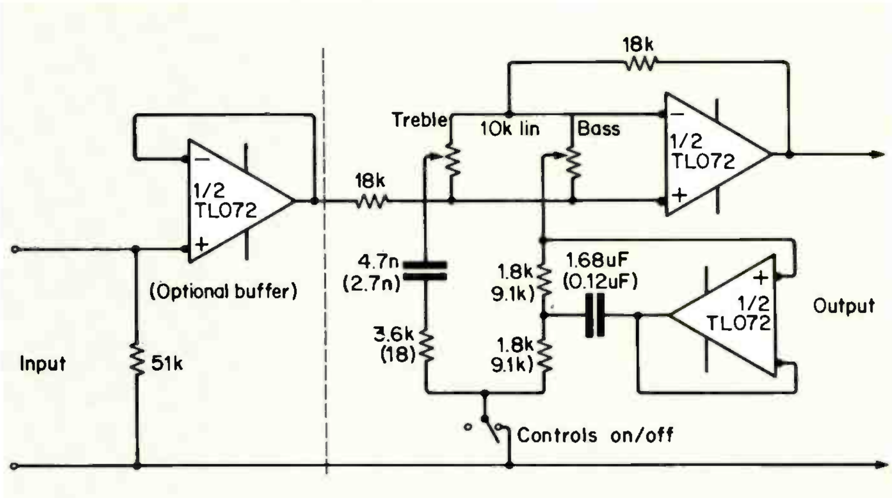


Complementary monostable

Timing in this simple flip-flop is due to CR, component values shown giving an on time of around 4s. The diode on the n-p-n base is a charge dumper to increase the possible re-triggering rate. When both transistors are saturated, the p-n-p collector voltage must be higher than that on the n-p-n collector. In the off state, the impedance seen by



the led is high, so the circuit may be triggered by the photovoltage generated by a light shone on it, the led then illuminating. No power is consumed during the off state.
W. Gray
Farnborough
Hampshire



Treble/bass or shelving tone control

To afford a choice of characteristics, this tone control circuit will take the form of either the traditional bass and treble adjustment or the shelving type, which is similar to a "tilt" control but with independent bass and treble. A gyrator is used in the bass section.

It possesses inherent symmetry in that the boost function is exactly complemented in the cut mode, at both bass and treble ends of the spectrum. Asymptotic slopes for both are about 4dB/octave, but begin to flatten out at 100Hz and 10kHz, reaching a maximum of ±15dB at the ends of the audio band.

Component values in parenthesis are those for the shelving type of control. In this case, the shelf begins at about 250Hz and 4kHz, flattening to a ±6dB maximum an octave above and below; the central point is 1kHz.

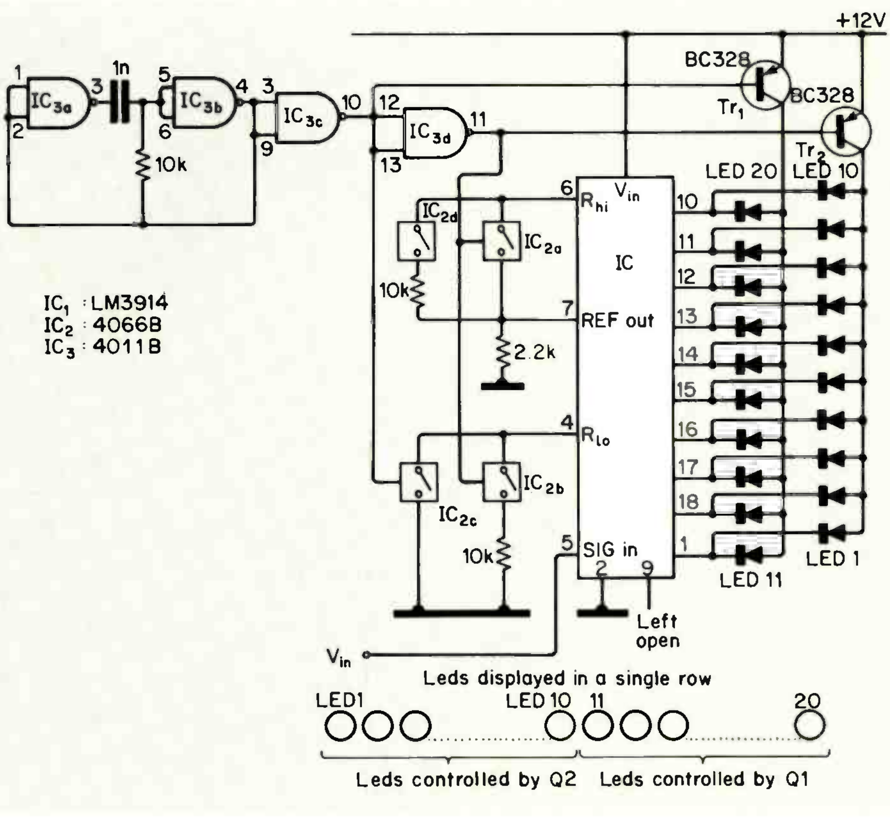
If the input comes from an impedance low compared to the 18kΩ input resistor, the input buffer is not essential.
Reg. Williamson
University of Keele

20-led display from a 10-led DVM

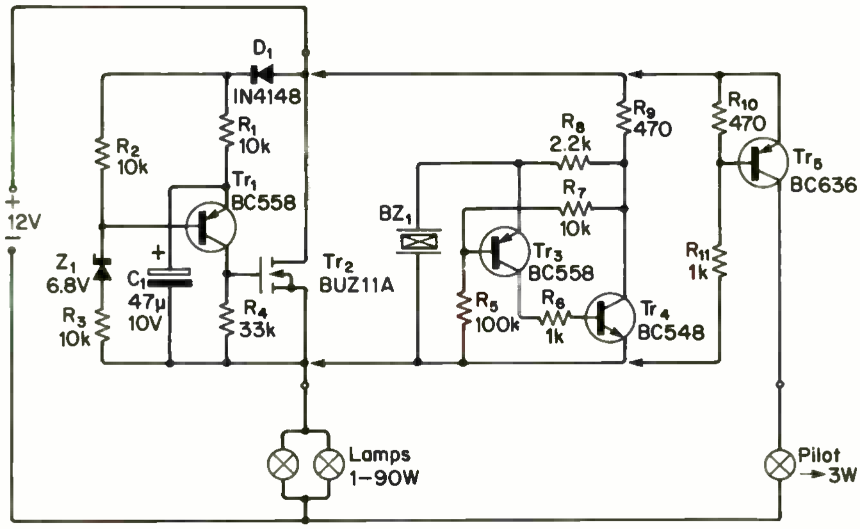
A single LM3914 DVM chip, which is designed to drive a 10-led display, is made to drive 20 leds and thereby double the display resolution.

The scale internal resistor string is controlled by switching 10 kΩ resistors into the top or bottom of the string, so that by selecting the correct set of leds the internal 1kΩ resistors "see" points from 1 to 10 or 11 to 20. Four c-mos analogue switches control the scale; IC_{2a} and IC_{2b} are controlled by the same clock phase as are IC_{2c} and IC_{2d}.

The two-phase clock from IC_3 which drives the switches also controls the two led switching transistors $Tr_{1,2}$. Clock speed should be around 100Hz, so that switching between sets of leds appears as a continuous 20-led display.
D. Yates
French's Forest
NSW
Australia



90W power flasher



Longer life and invulnerability to shock and vibration make this an attractive replacement for mechanical direction-indicator flashers.

It is essentially an astable multi-vibrator using a mos power transistor instead of an n-p-n bipolar type. When power is applied, 12V is placed across Tr_2 via the lamp bulbs. Since C_1 is discharged, Tr_1 receives no gate drive; in addition, positive voltage on Tr_1 gate further reverse-biases it. Capacitor C_1 charges through D_1R_1 until the voltage on Tr_1 emitter is sufficient to allow it to conduct, regenerative action then taking both devices into saturation. When C_1 discharges, Tr_1 comes out of saturation and the circuit reverts to its initial state. The zener provides an accurate threshold for Tr_1, to avoid variations due to load current and device differences, and to speed up transition.

Transistors Tr_3 and Tr_4 act as another multivibrator, using two bipolar types, to provide an audible signal. The piezoelectric buzzer (Murata PZKM 4201 EPP) does not operate at its resonant frequency, but must be capacitive to act as the timing capacitor.

L. Vlemincq
Tunisia

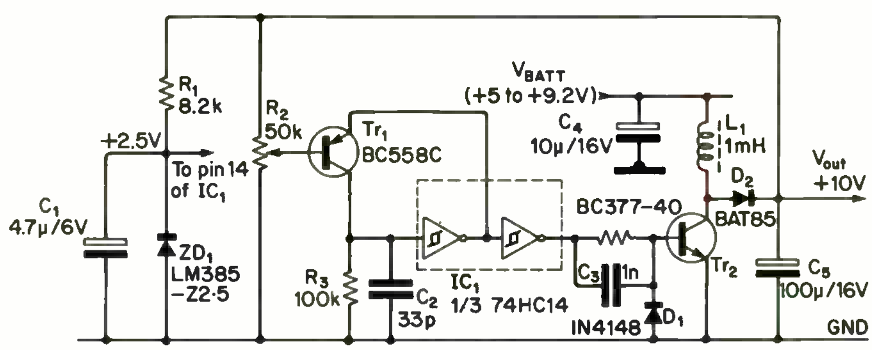
Battery-power regulator

This regulator gives a 10V output for battery voltages of 5–9V. Load regulation is better than 1% at currents of less than 20mA and line regulation is better than 2%. Output ripple is less than 30mVp–p.

The first inverter, with Tr_1 and associated componenents, forms a voltage-controlled oscillator. For a fixed period determined by R_3 and C_2 (about 3µs), the first inverter output is low, Tr_1 is off and Tr_2 is on. The output is high for a time set by current in Tr_1, which itself is determined by V_{out} and the output of the first inverter at 2.5V in its high state. Diode D_2 is a low-power Schottky type which withstands a peak current of 60mA.

Efficiency is about 85%, but partly made up for by the lower battery limit of 5V. The regulator starts even from the high impedance of a very low battery.

S. Theobald
Vrist
Harboore
Denmark



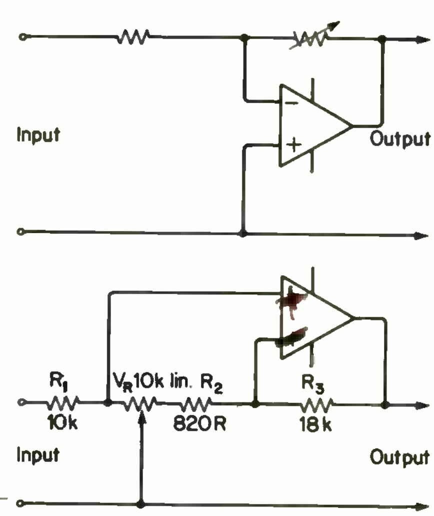
Unused I/P's of IC_1 must be tied to GND or +2.5V

Volume control attenuates to zero

Gain controls such as that shown (top) using a combination of negative feedback and passive attenuation, first used 20 years ago in the Cambridge P40 amplifier, possess certain disadvantages, not the least of which is its reliance on the virtual earth of a shunt-feedback amplifier for absolute attenuation to zero. This is not possible with conventional carbon-track potentiometers.

The lower diagram configured for a total gain of 20dB, suggests an alternative. While still using a linear potentiometer, it achieves a near audio taper; a computer simulation shows that the control function satisfies BRIC specification RIC/122, for a rotary control with a log. taper, in respect of both resistance and rotary setting. It gives zero attenuation with the input at a real ground and is non-inverting, should that be important. Maximum gain is calculated from $G=20\log(R_3/R_2)-20\log(R_1+V_r)/V_r)$. Input source Z much less than R_1 is necessary.

R. Williamson
Kidgrove
Staffordshire



Flat displays: a level appraisal

Flat-panel displays are getting bigger and sometimes better, but the CRT, says Steve Rogerson, still has its traditional place

There are two main fallacies about flat-panel displays. One is that the main thrust is to replace the cathode ray tube and the other, as a result of the first, is that everybody is putting all their efforts into making them as big as possible.

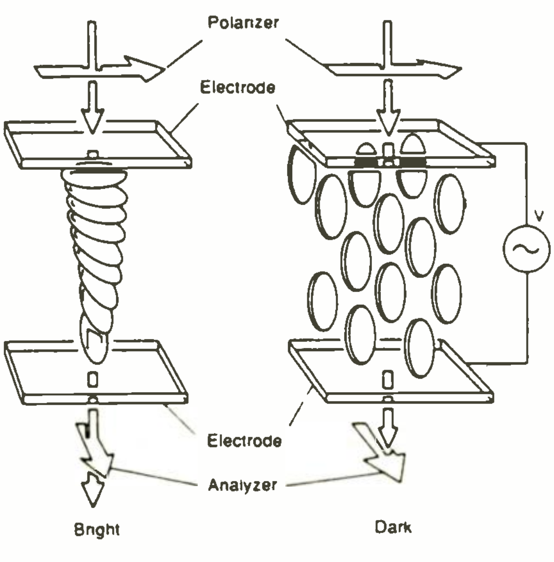
While it is true that they will replace CRTs in some applications, it is expected that their true forte will be in places that the CRT never visited. For example, some airlines are considering having them as screens in the backs of seats so that passengers can watch the film of their choice; the CRT is too bulky even to be considered for such a use. We will one day see wall-mounted, flat-panel television in the home, but not for some time.

The hype about size is media-driven; it makes nice headlines to say "Biggest ever" and so on. It is true that some companies have capitalised on the cheap publicity this brings by making one-off large laboratory displays. It is also true that production displays will get bigger as companies get to grips with the technologies involved. But, for most firms, this is something for the future; there are far more pressing problems in the present.

For a start, to manufacture displays in a cost-effective way means the very serious problems of low yield have to be tackled. And it is still not clear which of the many technologies will become the backbone of the standard flat-panel display of the future, though the clever money seems to be going on active-matrix liquid-crystal displays.

Liquid-crystal displays consist of a thin layer of a liquid crystal sandwiched between two pieces of glass. The thickness of the layer varies from 6μm for super-twist down to 1.5μm for ferroelectric displays. A liquid crystal is an organic material made of long organic molecules, with strange crystalline properties: at low temperatures it is like an ordinary solid and at high temperatures it is an isotropic liquid. But, unlike other materials, it goes through a phase in which it is a semi-ordered liquid. By applying an electric field you can control the way the molecules in this liquid line up.

Twisted-nematic liquid-crystal display. Varying the applied voltage changes the orientation to pass or block light.



Etched onto the surface of the glass is a transparent conductive material, arranged in vertical and horizontal lines to create an array of squares. By applying voltages to the lines you can create an electric field in any of the squares that they create on the surface. Active-matrix displays are more like conventional integrated circuits, with active devices at each crossover point.

The inside of the glass is treated with a thin surface coating of a plastic, usually polyimide. If this surface is rubbed with a material like velvet then it has an effect on the liquid crystals to make them line up in a certain way. Nobody is absolutely sure why.

As well as the glass, the liquid crystal is also sandwiched by two polarisers. The electric field supplied alters the crystal's optic axis compared with the absorption axis of the polarisers. This is what determines whether light is allowed to pass through or not.

Competing technologies

Before looking in more depth at active matrix, it is worth browsing through its competitors, some of which are already in production and have found markets.

Plasma or gas-discharge displays are easily the biggest in size, some being more than

30in in diameter. But size isn't everything; they are very expensive and come in any colour as long as it is orange. In fairness, NHK (Japan's equivalent to the BBC) did demonstrate a colour version five years ago, but it was very dim.

Firms like Matsushita and Hitachi have been working on improving the brightness, with only limited success; and, in the US, Photonics has done some work on plasma for the military. The basic display is a structured array of cells filled with a gas like neon — when a voltage is applied, the neon glows. But, short of a major breakthrough on brightness, plasma is unlikely to become a major contender.

Electroluminescent displays, on the other hand, work well for some applications, but the problem again is full colour. Their natural colour is yellow and it is possible to get red and green, but very difficult to obtain blue and a full grey scale. The structure is a phosphor material sandwiched between two electrodes; if you apply a large electric field, current flows between the electrodes and the phosphor glows. Its main use has been for small PCs, where it performs reasonably well.

Flat-panel CRTs have been made, primarily by Philips Research in Redhill. But the company stopped work on this two years ago after developing a 12in diagonal, 2in deep display, when it was decided that the cost of making the displays would be prohibitive. Such CRTs use a low-current, low-energy electron beam, which is deflected, folded and then amplified by a discrete dynode electron-multiplier made from a stack of perforated metal sheets.

Dr Alan Knapp from Philips said: "We could make a device that worked but it was expensive compared with traditional CRTs. It was technically possible but not economically attractive. It is like the plasma display, you can do it but it is not economically viable".

Arrays of leds have been the subject of some speculation and may be applicable in restricted application areas, but they are not very efficient and it is hard to get a blue colour.

Electrophoresis is unlikely to be applicable anywhere in the manufacture of displays. Applying a voltage to a liquid with charged particles suspended in it causes the particles to move about and scatter light in different ways. People have made little cells to demonstrate it, but it is not a viable technology in any sense.

Vacuum fluorescent displays work like a CRT, in that a phosphor is bombarded with electrons, but at a much lower voltage, say about 100 to 200V. Fine-wire cathodes run in a grid structure and are crossed by conductive strips with dollops of phosphor on them. This is an attractive display and one of its main uses is the large blue-green price displays on cash registers in supermarkets. Futaba in Japan has used the technology to make an 8 to 10in data graphics display that works well.

These displays are not very bright and it is not easy to get grey scales. Colour is also a problem; it is easy to get blue and green but red is harder. And it is a difficult structure to make with all those fine wires suspended in a vacuum.

Ferroelectric technology is similar to a conventional liquid-crystal display but uses a ferroelectric liquid crystal. In a conventional liquid-crystal display, the electric field is used to introduce a dipole. But ferroelectric material has a built-in dipole that is at an angle to the optical axis of the material. If a voltage is applied, the dipole lines up with the polarity of the field; if the polarity is changed, the molecules rotate round a cone angle to allow the dipole to flip over. The switch happens very quickly at what is known as the shutter speed. Once it has flipped, it will stay in the new state until an opposite voltage is applied.

It is difficult to maintain the necessary 2 or 1.5μm gap over a large area, which causes reliability problems when the display has to operate in an environment with vibration and shock. Firms like Canon, Thorn EMI and GEC have been active in this area and GEC claims to have developed a more robust structure by changing the cell architecture. Benefits include speed and stability.

Shutter speed has reached 50μs switching time, giving effectively flicker-free displays and the possibility of stereo images with different shuttering for the left and right eyes. Other advantages include a high contrast ratio, wide viewing angle and low power consumption. They are good for data graphics but there are problems with grey scales.

Because the dipole is bistable, it also retains the last image if the power is switched off, something airlines are looking into as a way round the problems encountered in investigating the recent M1 737 crash. Because all the displays went blank after the crash, it was impossible to tell exactly what information the pilots were receiving when they chose to shut down the wrong engine. Investigating the data bank only shows what image was meant to be displayed, which could be different to the actual display if there were faults in, say, the connections.

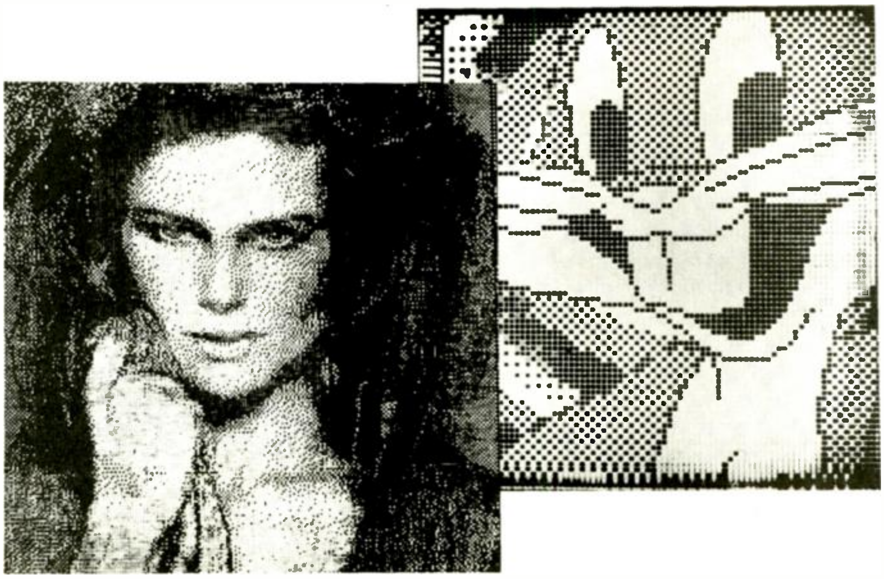
Supertwist display from GEC Hirst Research, which affords better contrast and does not suffer to the same extent as earlier types from excessive directionality.

Because of this, researchers at GEC's Hirst Research Centre in Wembley are working on a large-area ferroelectric, dot-matrix display as a replacement for supertwist LCDs in aircraft. So far, they have developed an A4-size ferroelectric shutter which they claim to be the biggest in the world.

Liquid-crystal displays continue to attract by far the largest effort in research. It is this technology, if any, that may eventually make a real challenge to the CRT, although the CRT has many advantages: it is a proven technology; it is an excellent display; and it is constantly getting better.

Knapp said: "All the other technologies are trying to catch this moving target The CRT will not be replaced in any reasonable time scale, because it is too good a display."

One of the problems with liquid-crystal displays is that they are very angle-dependent, which could cause problems if they ever are used for very large displays with many people watching. But generally, the side-to-side viewing angle has steadily improved over the years and is not really the problem it once was. Up and down,



Is polysilicon active-matrix display from GEC Hirst Research, which compensates for faulty cells. At right is ferroelectric LCD using thick-cell technology, also from GEC.

there is a serious variability in contrast, but it is hard to think of an application where this will be a major drawback.

Outside active-matrix displays, the main LCD thrust is with supertwist and its predecessor, twisted-nematic, which are becoming standard for data graphic applications.

Twisted-nematic was the first commercially viable LCD and most LCDs in use are of this type; it is well suited to the seven-segment displays found in watches, calculators and so on. A twisted-nematic cell consists of two glass polarising plates, set at 90° to each other, with the liquid crystal between them. Since the light path through the crystal is twisted and the polarising plates also twisted, light passes through the cell. Applying a voltage across the cell destroys the orderly twist and cuts off the light.

About ten years later, in 1982, it was found that a more tightly twisted configuration improved the quality. This was called supertwist and is similar to twisted-nematic but without the poor contrast and narrow angle of view. It is a monochrome display, but colour filters can be used.

On the negative side, it is expensive, it offers only a limited range of grey scales and it is not very fast, so moving objects smear on the screen.

At Hirst Research Centre, a supertwist has been developed with a full 270° twist to give a much greater viewing angle. The firm has achieved this using a proprietary technology that can't be patented, so it is keeping it under wraps, but it involves increasing the pretilt from about 2° to 15°. Without this pretilt the image has a tendency to blur.

Hirst Research Centre is mainly looking at cockpit application, which brings its own problems. For a start, there has to be a minimum change of colour when the green back light is switched on. Red must be avoided, because it may activate night-vision goggles, and the viewing angle must be such that both pilot and co-pilot can see the display.

Viewing angle could be improved if the display were operated in only one of transmission or reflection modes, but for cockpits, during the day it is in reflection mode and at night, when the light is turned on, in transmission mode. So the displays have to operate in both modes, which means some compromise on viewing angle.

Professor Michael Clark of GEC said that in cockpits "active-matrix will probably replace the CRT displays, but other displays will use supertwist or ferroelectric."

Active matrix

And so to active-matrix LCDs. This is really the only technology that looks like offering anything like the same quality as a CRT. It is full colour, has a good grey scale and copes with fast movement without smearing, and offers good brightness and contrast.

Displays are already available in some small consumer products such as hand-held televisions. There are also some top-end video recorders that use active-matrix as a display panel and it is the favourite technology in work on video telephones. So far, the commonly available displays are in the 3 to 5in range but, as they get bigger, their low weight will see them used more and more in aircraft.

Knapp said that the seat-back application is "important, because it is someone putting a display where they wouldn't have previously. You shouldn't think of flat panels as a replacement for CRTs but look for new places where they can be used".

Most of the work on active-matrix is concentrated on improving the yield and making displays easier to manufacture. Their base structure is an array of active devices, thin-film transistors and diodes, etched on to the glass that sandwiches the liquid crystal. This means that real electronic devices have to be fabricated over large areas on sheets of glass, and all of them have to be working; at least most of them, since in the majority of applications the odd missing pixel will not be crucial.

Knapp said: "I don't know what the real yield is, but it is small. It is a very young technology and we have not yet worked out the tolerance rates. We don't know how many pixels you can have not working before it is noticed. There will be quite a lot of learning done in the high-end data-graphics market which will let the industry learn about the technology and from that it should let us develop bigger screens in the future."

He predicted that there will be 30in LCD screens with colour, movement and grey scales early next century. They will find applications for public demonstrations like sporting events and advertising hoardings. With such large screens, the segments are likely to show, so quality will be a problem.

One method of improving the yield is redundancy, by using two layers instead of one. The most effective dielectric used is silicon nitride, but a small hole in this dielectric will cause the transistor to short. One way that is being considered to solve this is to use an extra insulator such as tantalum oxide.

Alternatively, two devices can be put in each picture element. This will mean a more complicated photomask, but once this is made the production will cost the same because no new steps are needed. It isn't the obvious solution because, while it halves the chance of some faults, it actually doubles the possibility of others. Some shorts are actually twice as likely to happen.

Another possibility is to use diodes instead of transistors. Transistors cross over on the same piece of glass, creating a danger of a short between column and row. This is the worst kind of short because you don't lose a pixel but a row and a column full of pixels, creating two lines on the screen, called line faults. With diodes you can have the rows on one sheet of glass and the columns on another.

The standard manufacturing technique is to use a large sheet of glass, say 12in, and from this cut a number of smaller displays. There is no physical or scientific reason why the displays cannot be much larger; the problem is technology. We are talking about tiny devices which have to be laid with an accuracy of a few microns. With a 6in silicon slice you can do this without much problem, but over a large area you need optical aligners with a very high degree of accuracy, which do not yet exist.

Opaque layers

Also, with a large display in colour, ambient lighting is not good enough. For a start, two-thirds of the light is absorbed in the colour filters. For example, all the blue and green is absorbed in the red, all the red and green in the blue and so on. The LCD effect also needs polarisers which, even if perfect, only let through half the light. So the best quality display will in theory only let through a sixth of the light. In practice, it is much worse, only about 6 or 7% of the light getting through.

So with ambient light you have a very dull and muddy display. The answer is obviously a back light, fluorescent lamps being the normal type used. These, though, consume power which, even for a 6in display, can be as high as 10W.

All this has led to a spin-off from the technology: an LCD can be used in a projector. From a small display, a projected image of some 40in diameter can be produced. These have already found professional applications such as conference videos and, in the US, 40in projectors for the home have started to take off, but so far not in Britain.

Another area of work is putting the drive circuits for the display on the display itself. This would mean that the display would only need a power supply to work. At the moment, one of the most costly areas is the drive circuits with connections being made to each row and column. If one of the connections is broken, there is a line fault on the display.

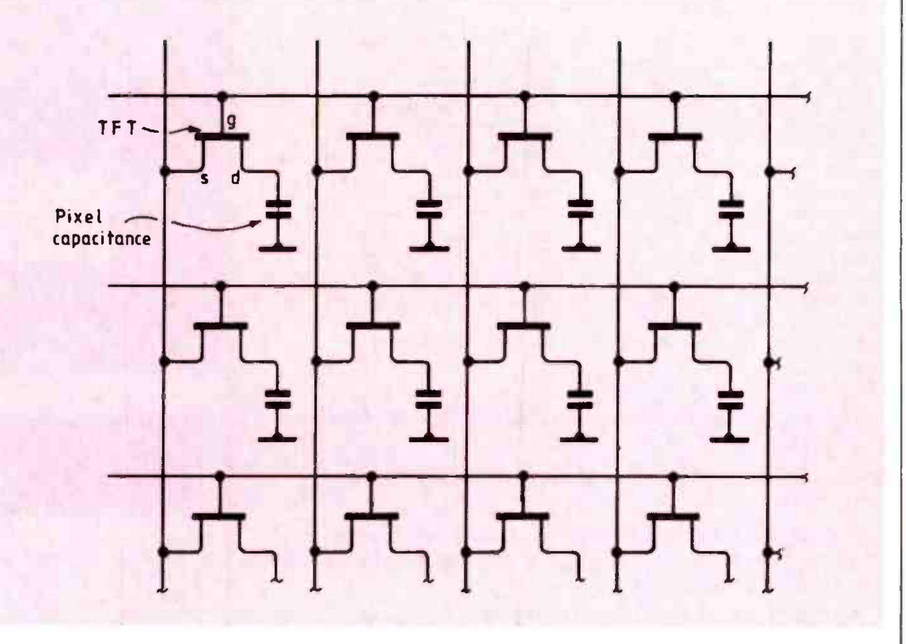
Drive circuits can be put round the edge of the glass, using polysilicon rather than amorphous silicon. With amorphous silicon, the current is too low, but the problem with polysilicon is that it needs a high-temperature process, which can cause the glass to change shape during processing, putting the alignment out.

First, it is totally insensitive to light, unlike amorphous silicon. This is important for some avionic applications where the displays have to withstand 100klux. Polysilicon is also more reliable. Amorphous silicon has hydrogen as a structural requirement; under electrical and thermal stress the hydrogen changes its shape, causing problems with the thin-film transistors.

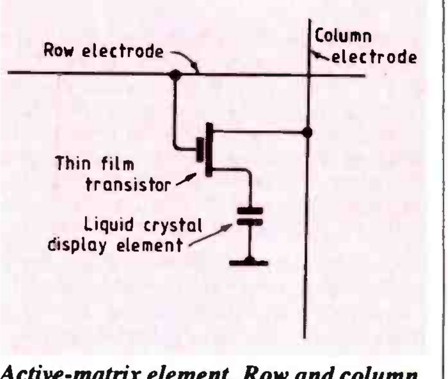
As to the temperature problem with glass, GEC is doing the processing at about 630°C and is trying to get the process below 600°C. This does mean using more expensive glass; it is possible to use quartz but this is too expensive. The more expensive glass does expand and contract at high temperatures but this expansion is predictable and optical aligners are designed to allow for it.

In conclusion, there is a future for flat-panel displays outside the traditional alphanumeric watch and calculator market where they are already well established. The recent developments mentioned such as pocket televisions and video telephones will provide new outlets, though why anyone would want a video telephone is a question in itself, especially with the telephone's annoying habit of ringing while you are in the bath. ■

5in diagonal, 256×85 colour active-matrix displays from GEC. Notice the line faults in the lower picture.



Electrical equivalent of thin-film transistor active-matrix display. Diagram by Philips.



Active-matrix element. Row and column electrodes are on glass substrates separated by 2 microns, with liquid crystal between them.

Universal-input power supply

Universal-input power supplies allow equipment to be used on any mains supply from 100V to 220V (nominal) without the use of switching or jumper connections. Application note AN90-8 from Siliconix describes the design of a universal, low-power unit which uses the Si9120 pulse-width modulation controller in a flyback circuit.

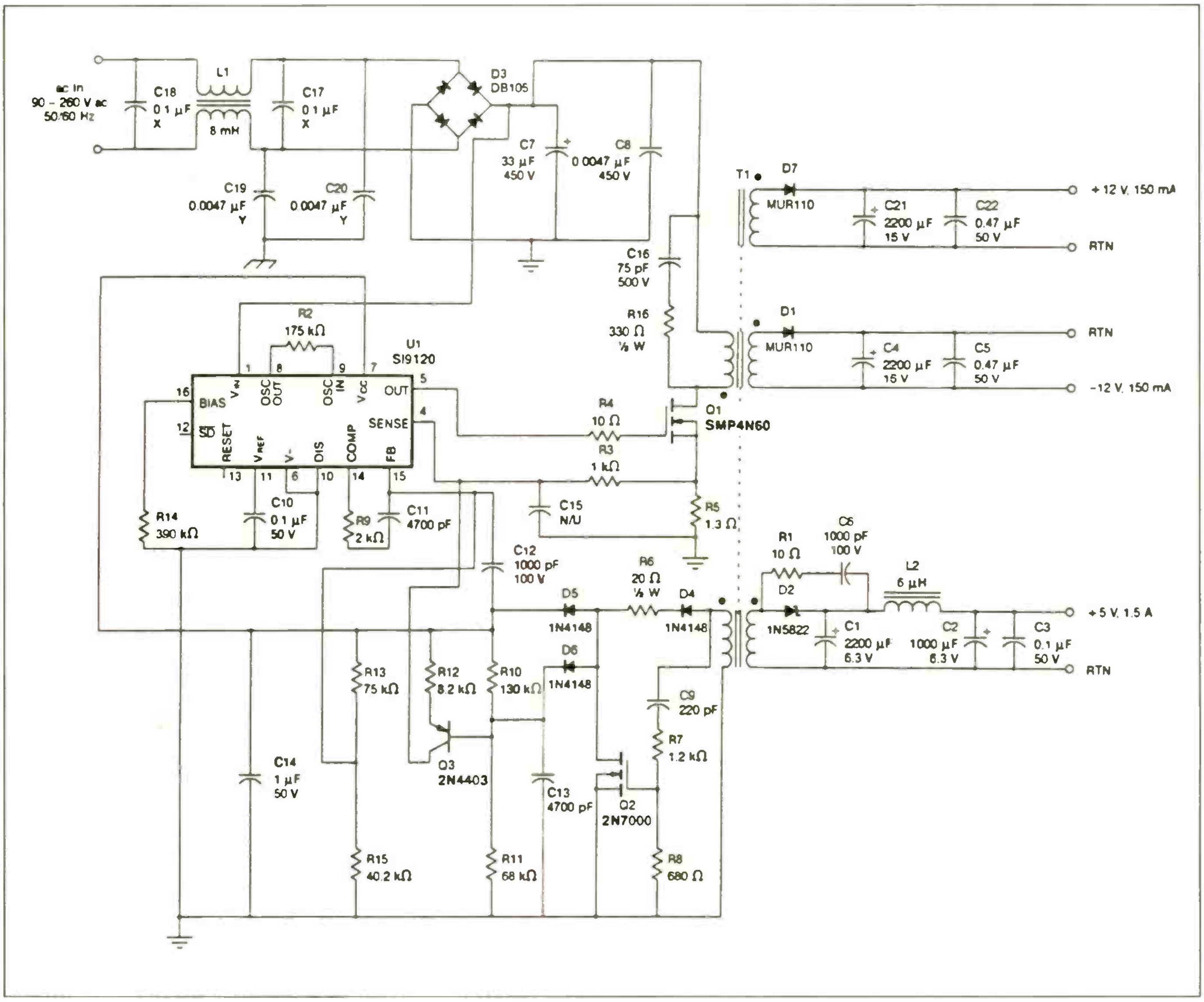
The diagram shows an 11.1W, three-output supply which accepts inputs of 90V to 260VAC. There is primary-side regulation, full mains isolation and fold-back current limiting. Switching frequency is 100kHz.

Transistor Q_3 provides foldback current limiting. Normally, C_{13} is charged to V_{cc} through D_6, biasing Q_3 off. A short on any output causes Q_1 to clamp all transformer voltages low, the voltage on C_{13} falling to a level set by R_{10} and R_{11}; V_{cc} is kept at 8.6V by the Si9120. Current set by R_{12} flows through Q_3 and R_3 and causes the voltage on pin 4 to rise and, since there is an internally set voltage of 1.2V on pin 4, the voltage across R_5 to terminate a pulse is reduced by the drop across R_3. Therefore, as I_{Q3} increases, I_D decreases.

Siliconix Europe, Weir House, Overbridge Square, Hambridge Lane, Newbury, Berkshire RG14 5UX

Table 1. Universal input supply test data. All data taken with DC input source to ensure stable readings.

FULL LOAD				
V_{in}(DC)	I_{in}(mA)	+5V	+12V	-12V
100V	143.9	4.974	12.64	12.50
200V	72.3	5.014	12.76	12.61
300V	48.9	5.027	12.79	12.65
385V	39.4	5.049	12.81	12.67
HALF LOAD				
100V	78.0	5.153	12.99	12.83
200V	40.3	5.205	13.10	12.96
300V	27.9	5.235	13.12	12.97
385	23.0	5.254	13.14	13.01
PK-PK OUTPUT RIPPLE VOLTAGES (SPIKES NOT INCLUDED)				
5V		+12V		-12V
60mV		45mV		40mV

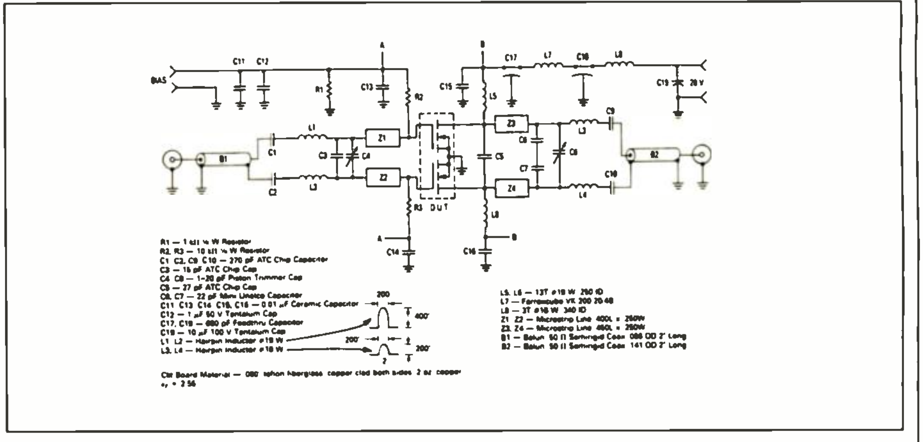


150W,400MHz mosfet

Motorola's MRF176GV/U transistors are intended for applications using push-pull circuits at frequencies up to 500MHz, such as FM or television broadcast transmitters. MRF176GV(U) offers an output power of 200W(150W), power gain of 17dB(14dB) and efficiency of 55%(50%) typical at 225MHz(400MHz).

The diagram shows an amplifier circuit providing 150W at 400MHz. Typical power gain is 14dB and drain efficiency is 50% typical.

Motorola Ltd, European Literature Center, 88 Tanners Drive, Blakelands, Milton Keynes MK14 5BP.



Internally trimmed IC multiplier

AD532 from Analog Devices is claimed to be the first pretrimmed, single-chip multiplier/divider. A maximum error of ±1 and ±10V output voltage are obtainable with no external trimming resistors or output op-amp.

Transfer functions possible with the AD532 include $(X_1-X_2)(Y_1-Y_2)/10V$ in four quadrants, two-quadrant division of $10VZ/(X_1-X_2)$ and square roots in one quadrant with a function of $\pm\sqrt{10VZ}$. Other functions exploiting the differential input configuration (CMRR is 75dB) are useful in both algebraic computation and transducer instrumentation.

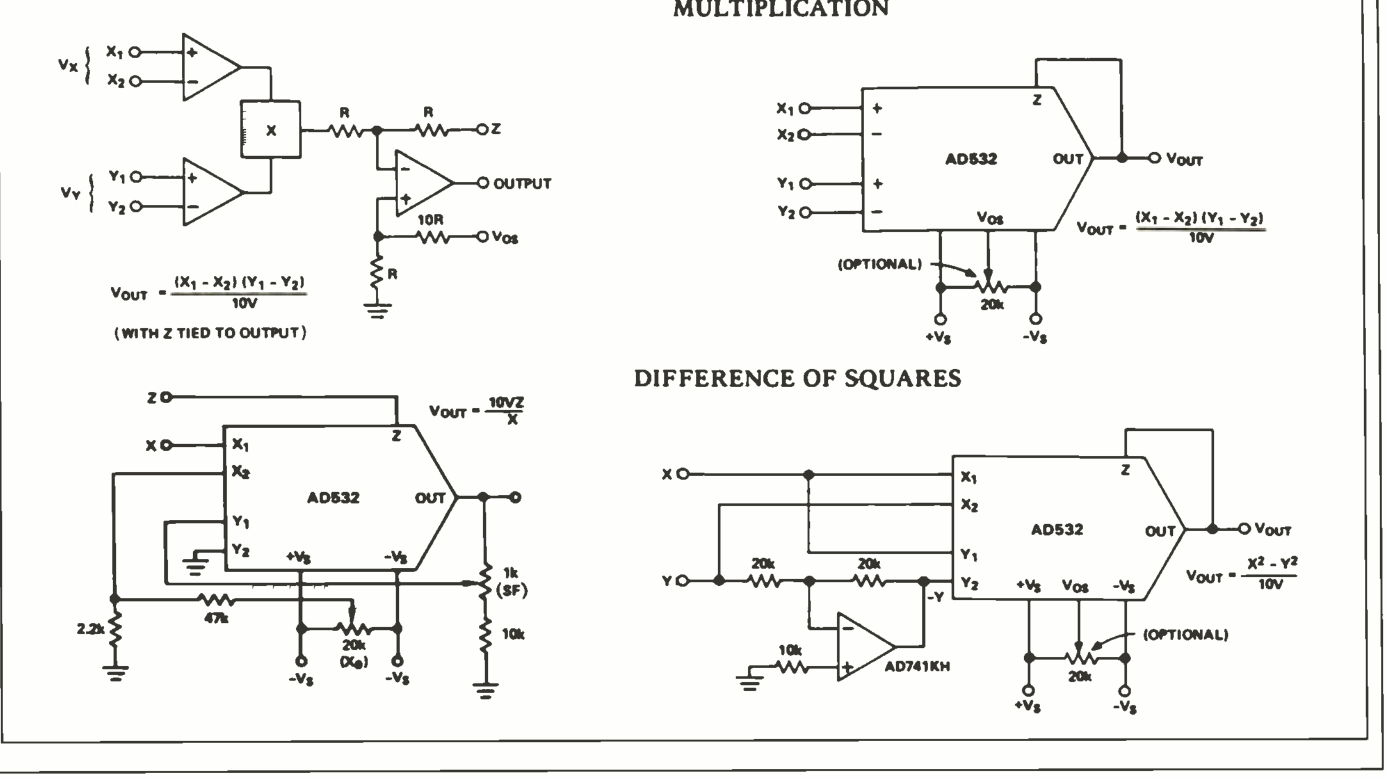
Figure 1 is the block diagram of the device. When in use for multiplication or squaring, Z goes to the output and completes a feedback loop, being used as an input terminal in division.

The simplest circuit arrangement is a multiplier, shown in **Fig. 2.** Inputs are fed differentially or single-ended by grounding the unused input. Output is positive or negative, depending on X and Y inputs used.

For squaring, both inputs go to X_1Y_1 or X_2Y_2, depending on the output polarity needed, the other input pins being grounded. **Figure 3** shows a divider, obtained by placing the multiplier cell in the feedback loop of the op-amp, the Z pin being used as an input. In this connection, error is increased and bandwidth reduced and X must be negative to avoid positive feedback.

An example of an algebraic function is given in **Fig. 4**, in which the differential input is used to obtain the difference of squares X_2-Y_2/10V. This is effectively a squarer with a unity-gain inverter between a Y input and its inverting input.

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



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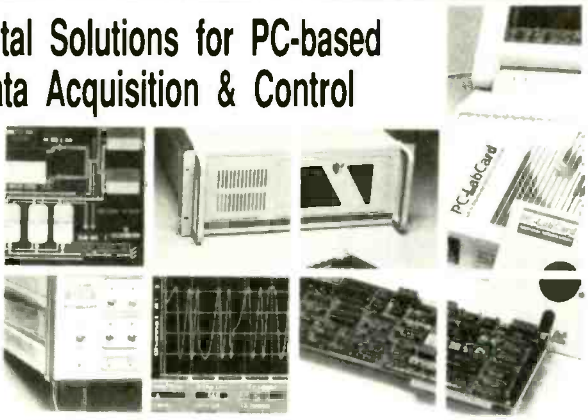

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Comecon on hold: do we answer?

Stoic acceptance of telephone installation delays and poor service are changing in the hunger for currency. Robert Farish reports

Eastern Europe has learned to live with hardship. Letters take weeks to arrive and waiting lists for telephones are measured in years. Regular break downs and unusable lines are accepted with a resigned shrug of the shoulders.

But now things are changing. These countries are in desperate need of the hard currency trade with the West can generate, and all over eastern Europe western multinationals are setting up offices. Prague, Budapest, Warsaw and Moscow are buzzing with business activity.

But the telecommunications infrastructure cannot keep pace. To grasp the opportunities, replacement of ageing telecommunications systems is now one of the most urgent tasks facing what used to be called the eastern bloc.

Across the whole of eastern Europe the telecommunications infrastructure has been deliberately neglected. In a centralised economy the state strictly regulates levels of investment in all industries. Communist ideology has always lauded the industrial worker and economies were skewed in favour of heavy industry. So-called "non productive activities", like telecomms, were of secondary importance.

The situation is not equally bad in all countries of the region. Pre war infrastructure in Czechoslovakia was good, so today the Czechs still have a reasonable network. In contrast Poland has a far less reliable backbone network and its problems have been accentuated by the enormous upheavals suffered in the past decade. Nevertheless a glance at the telephone densities in these countries puts into perspective the extent to which all lag behind their western European neighbours.

Anyone looking at eastern European technology feels as though they have somehow been transported back in time. "It's as if time has stood still since the war," says telecoms consultant John Walsh of Telecomms Plus who has been helping Western companies improve their telecomms facilities in the USSR and Poland. "When I discuss with a Soviet what I'm doing I go right back to basics. Quite often they look at me as if I have just stepped out of Star Trek."

Yet this situation is not just the result of chronic under investment. In many ways the industries of the region have stood still for the last 20 or 30 years. A lack of capital meant that once built, factories were rarely up-dated. For consumers this meant having one choice of car for three decades. (The East German Trabant first appeared in 1952 and its design has remained essentially unchanged ever since). In telecommunications this led to a situation where pre-war Strowger-type telephone exchanges were still being manufactured in the USSR in 1988.

Dated technology

The vast majority of telephones are connected to electro-mechanical exchanges with the oldest being the Strowger-type which is noisy, expensive and unreliable. In the mid 1980s about half the exchanges in use in the USSR were of this type. The rest are mostly second generation crossbar-type.

Major models in use are the MT-20 imported from France or manufactured in eastern Europe under a French licence, the Finnish EATS-200, and a Yugoslavian manufactured exchange – the Metaconta. In the late 1980s stored program control exchanges were just beginning to appear, refered to in eastern Europe as "quasi-electronic".

There is a big shortage of private branch exchanges. Though large state organisations do have PABXs most users do not. Even the largest hotel in the world, the Russia in Moscow, has not got its own exchange. Every one of its thousands of rooms has its own number connected to the local Moscow exchange.

Since the earliest days of the cold war eastern Europe was forced to be technologically self sufficient. Hence Comecon coordinated the manufacture and supply of telecommunications equipment across the whole region. Bulgaria, for example was a major manufacturer of telephone handsets and crossbar exchanges while the GDR was the main supplier of cables and telephones.

A system distorted to serve heavy industry and the military, woefully failed to serve domestic customers. In Hungary the waiting list for a telephone in the home is between eight and 14 years. Similarly in Poland the wait is 12 years. In Moscow 12 million families are on the waiting list for a telephone and it was heralded as a major civic achievement when the telephone waiting list was brought down to one year.

But as western business activity increases in the capitals of eastern Europe these already fragile ancient networks are approaching saturation point. There is now an urgent need for new cables and replacements for ageing network equipment.

"There are enormous opportunities and we have so much business it's ridiculous," says Walsh. "In the West there is nothing new coming along but here even to install a new telephone can be an enormous improvement." But he says patience is an absolute necessity for doing anything in the Soviet Union. "In the last eight months we have had three main projects and been successful in one – things move slowly here."

Walsh says as each month goes by it gets harder to get international lines, and in the last year maintenance breakdowns have become more and more common. He believes telephone users will never have an efficient service unless there is an emergency upgrade of existing cables.

"They have absolutely no chance of coping with the expansion without digitising their internal networks," he says. Considering it took BT over a decade, at considerable cost, to do so in the UK it remains to be seen how the hard-currency starved eastern Europe will manage.

Investment opportunities

All the countries of eastern Europe need new hard-wired networks – and they need the help of western companies to install it. The task, and the potential profits, are immense.

Telecommunications ministries are now besieged by western companies selling every conceivable telecomms product. However, all but the suppliers of analogue equipment and copper cable agree that the best solution is to construct a network using high capacity optical fibre. At a stroke these countries would be able to leap-frog several stages of telecomms development by installing a completely digital transmission system.

In June the US department of Commerce blocked a plan by a consortium headed by US West to lay an optical link across the entire length of the Soviet Union. The project is essential for the future development of the Soviet economy and according to a BT spokesman its construction is inevitable: "It's as if Great Britain were to be without a telephone link between London and Scotland," he says.

The affair brings into sharp focus how much the region is dependent on Western technology. In 1986 the Svetovod Research Institute in the USSR was formed to develop fibre optic

Satellites for sale

One of the many extraordinary paradoxes of the Soviet system is that though rural areas are still served by manual telephone exchanges the USSR has the biggest communications satellite industry in the world.

But isolated for so many years the Soviet Union's satellite network is not geared up to communicate with the West. Base stations face the wrong way, dishes do not have the right diameters, and the satellites themselves are positioned solely to serve Soviet users. Unlike Poland and Romania, the USSR has so far chosen not to join Eutelsat – the European communications satellite consortium and so the Soviet network remains a closed system.

In spite of the country's vast size surprisingly little use has been made of satellites for point to point communications.

Its Orbita base stations were deliberately designed for TV distribution rather than as an addition to the telephone network. Antenna diameter and satellite power were both optimised for broadcast and base stations are largely located in remote areas where there is little telephone activity – the biggest single brake on the development of a satellite system for two way traffic.

However new possibilities were hinted at by the Soviet minister for Posts and Telecommunications Dr Erien Pervyshin, when he said greater use should be made of satellites in providing telephone services to isolated rural communities where costs of hard-wired links would be too high.

The oldest range of Soviet communications satellites is the Molniya series first flown in 1965 and still being launched. The 77th Molniya satellite was put into orbit last April.

First generation Molniya-1 could not handle telephone communications, though the second and third generation Molniya-2 and 3 did have transponders able to take telephone traffic when they were not being used for TV broadcasts.

But this was a low priority, even after the introduction of several other satellite types during the 1970s. In 1980 the International Telecommunications Union recorded only 17 out of the hundreds of base stations were operating a space telecommunications service.

In this era of perestroika no sector of Soviet industry will be allowed to soak up investment without paying its way – even the prestigeous sputniks.

The Soviets are keen to attract Western users for their Energia space launcher and the geosynchronous Raduga, Ekran, and Gorizont satellites. At present customers can lease a transponder or use a Soviet satellite to carry their own transponder into orbit, and for the ambitious it is even possible to buy an entire Gorizont satellite.

More recent designs appear to promise much. Mayak, due to be launched in 1992, will cope with telephony and high quality digital data transmission. Similarly the Loutch, launched in 1985, is a ground to ground communications medium which the

Dr Erien Pervyshin, Soviet Minister for Posts and Telecommunications, says greater use is to be made of USSR's extensive satellite industry.

Soviets say permits organising of TV conferences and two-way exchange of video information.

Regular launches of large payloads are carried out using Energia – launcher for the Buran space shuttle. Speaking in London last September Dr Pervyshin said Energia would be used to launch a new generation of heavy platform satellites in 1993.

Heavy platform satellites can carry much greater on-board power than those currently in orbit. This will not only enable broadcast of high definition TV pictures but it could also be an "intelligent satellite" – performing tasks currently done on the ground. It could incorporate an on-board telephone exchange to ease current congestion in telephone traffic with the West.

Heavy platform satellites are also planned by Nasa but will not be on stream for at least another three years.

But Soviet pronouncements should always be balanced with a measure of scepticism. Grandiose economic plans have always involved grandiose overstatement of economic achievements; and old habits die hard.

technology. Inordinately long R&D lead times and the absence of modern manufacturing plant has meant that to date it has achieved little. So far it has only managed to manufacture cable with a transmission rate of 140Mbits/s. That the Soviets themselves might build a trans-Siberian optical fibre link with the proposed capacity of 565Mbits/s seems never to have been on the agenda.

But fibre optic cable is expensive and takes time to lay. Also, as the Soviets have discovered, the export of high grade cable to some eastern European countries is still classed as a strategically sensitive export and is restricted by the Coordinating Committee on Multilateral Export Controls (Cocom).

The Czech government has plans to lay inter regional fibre optic links in the next two or three years while Romania lists urban optical communications as "a priority". The former East German government had ambitious plans for its long distance transmission network but the development of the network is of course now in new hands.

Mobile solution

Laying of terrestrial cables is not the only answer. Some believe cellular radio and even satellites could play a much more significant role in eastern Europe than they do in the West.

Mobile communications could provide help in the short term. A cellular telephone network is quick to install and could be used to generate valuable hard currency since the main users would probably be foreign businessmen.

Tim Kelly of the OECD believes this technology could provide a telecomms lifeline for the region.

"The great advantage of mobile networks is that they can be installed quickly with a minimum infrastructure investment. In eastern Europe there exists the possibility that they could leap-frog the slow development pace of the traditional network," he says.

Kelly foresees the development of an extensive mobile network, primarily business orientated, which will grow in parallel with the fixed link network. The "peace dividend" would free frequencies now used by the military for cellular networks.

But the possibilities for mobile phones should not be overstated. Klaus Angermuller, general manager of the West German branch office of Orbitel Mobile Communications, a company which has some experience of cell phone installation in what used to be the GDR, points to the massive chunks of the radio spectrum which the Soviet military still occupy.

In Eastern Europe there exists the possibility that they could leap-frog the slow development pace of the traditional network.

"If radio channels are missing, eg for long distance calls, then signals from the radio path must be routed through the wire line network," he says. "Mobile communications can only be an add-on network." He adds that (as car phone users inside the M25 are well aware) the capacity of any mobile network within a city is also strictly finite.

Nevertheless mobile networks are already being established across the region. US West is collaborating with the Hungarian PTT to provide a network first in Budapest and then in the whole of Hungary. The Czech government has also chosen US West, this time in partnership with bell Atlantic, to help it establish a cellular network for the whole country.

Lumbered with a ramshackle telephone network for so long many users still rely heavily on the telegraph as a means of business communication, and the volume of traffic is huge. In the early 1980s there were over 500 million transmissions recorded in the Soviet Union – if correct that means there were more than in all the western industrialised countries added together.

Data networks are still in their infancy. BT has had access to the Soviet packet switching network for about 18 months and offers customers dial up facilities for the same cost as calls made to Europe. In September it launched its international package switching network service (IPSS) for Bulgaria and is linked up with networks in Hungary and Yugoslavia.

A spokeswoman for BT says most of the traffic so far is coming from capital cities: "The extent of our service depends entirely on how fast they develop their network," she says.

Electronic mail services are also in the early stages. Moscow-London electronic mail links have been available for about two years, the biggest provider being the Moscow Academy of Sciences. In Czechoslovakia and Hungary enthusiasts have been using mail boxes for several years but telecommunications ministries have yet to introduce a fully-fledged service. Because E-mail still depends on the hard-pressed telephone network western users usually send messages overnight to beat congestion.

Export checks

Blocking of the trans-Siberian link shows that even if a western supplier finds a buyer and a means of getting paid, export restrictions can still torpedo a deal.

Cocom governs all high tech exports to eastern Europe which might have potential dual uses. Ian Macdonald, head of the defence export services secretariat at the MoD, says though bans on exports to Poland, Hungary, and Czechoslovakia could soon be removed the government is still committed to the Cocom restrictions:

"This government's assessment is that the threat from Russia, though diminished, still exists. Unless there is a threat there is no justification for Cocom," he says.

The military are opposed to the sale of all advanced communications technology to the Soviet Union since the same equipment could be used to improve Soviet command and control structures.

Last July many telecommunications items were removed from banned lists for countries in eastern Europe but the USSR was largely excluded, and high capacity optical fibre is still banned. Controls remain on ISDN standard equipment, digital PABXs, packet switches and optical fibre transmission systems and digital cellular systems. A major revision of these regulations is due this month but the US and British governments are unlikely to agree to major relaxations. ■

A case-study of neglect

Peter Staric reports from Ljubljana on why more than just money is needed to revive the electronics industry in Yugoslavia.

Suppose a neglectful gardener, instead of tending the soil as good gardeners should, has preferred to study the books of Marx, Engels, and Lenin (who were not gardeners, as far as we know) seeking instruction on how plants should grow.

For 45 years he turns a deaf ear to all the good advice from his more competent assistants and stubbornly adheres to his own way until the garden lies forlorn with all the small and beautiful flower-beds lost to big fields.

He is finally removed (thank God!) and replaced by a better gardener, but what is left to be saved; a neglected wilderness, full of waste, weed, dead wood and poorly fertilised ground. This is the Yugoslav electronics industry and the neglectful gardener is the past system.

To be exact the system is only past in the two Northern Republics, Slovenia and Chroatia. Elsewhere there is progress though the situation is still far from rosy.

With only rare exceptions the Yugoslav electronics industry suffers from inadequate and out-of-date equipment, poor management, inefficient and poorly stimulated employees, overstaffing, needless bureaucracy, environmental pollution, and is heavily burdened with taxes and duties.

Equipment

In view of this situation and inadequate and out-of-date equipment it is amazing just what the Yugoslav electronics industry manages to produce.

Few plants have automatic component insertion and automated testing of printed circuit boards — pre-requisite for efficient large scale production.

One major manufacturer in PCB

Printed-circuit boards under test at Iskra.

automatic testing claims as few as 12 sets have been sold, mostly in the Eastern part of the state. Only a small number of the larger PCB production plants have automated and computer-controlled drilling and routing.

In production of mechanical components manufacture is, generally, automated, even so many of the machines are more or less worn-out.

There is also a shortage of modern electronic measuring instruments. It is surprising that the production line sometimes has access to more up-to-date measuring equipment than R&D departments.

Computer aided design is progressing slowly but is still at least some ten years behind the West. Overall, computer technology progresses faster in offices than in laboratories. Engineers are used to "thinking small" and appetites for badly-needed modern equipment are seldom completely fulfilled.

Scarcity of technical literature has also had an effect. In the late 70s, until relatively recently, access to technical literature was difficult. Yugoslavia was sinking in a sea of foreign debt amounting to some $22billion at its peak, so import of foreign technical literature was restricted and even libraries stopped subscribing to overseas electronics reviews.

This undoubtedly increased the already wide technology gap. Western books also ceased to appear in bookstores. The electronics enthusiast started to order books directly. But the purchaser had (and has still) to pay a special duty when the books arrive.

Importing books has now become much easier and even some software can be obtained. But the prices are so high in comparison with the average income of an electronics engineer, that access to the software is still mostly through illegal pirate copies.

Materials

By and large capacitors, resistors, potentiometers, wires, transformers, coils, small motors, switches, connectors, ferrites and some discrete transistors and simple integrated circuits are produced domestically and used in the home market. But there is no LSI production plant in Yugoslavia.

Delivery terms can look distinctly odd to outsiders. For example Fabrika Kablova Svetozarevo quotes two years delivery for their MS connectors. Since it is difficult to plan so far in advance, such parts tend to be imported.

Tantalum capacitors are also obtained abroad as are most integrated circuits and high-grade discrete components.

Yugoslavia does produce LCD displays, on a small scale, but led displays are imported along with most cathode-ray tubes particularly those with a high resolution.

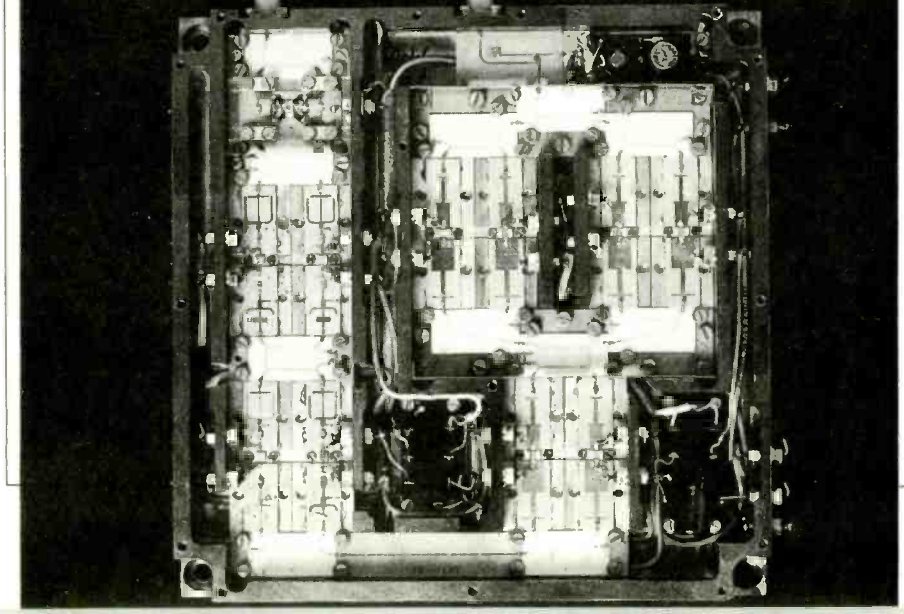
Mechanical parts such as knobs, BNC connectors, DIP IC sockets, screws, nuts, cabinets, etc are manufactured here — sometimes by very small "family enterprises" — and the quality of these components generally corresponds to Western standards.

But an additional problem is that import of components is extremely sluggish, requires numerous special permits from Belgrade and is heavily loaded with all sorts of taxes and duties. Up-to-date US equipment suffers from the extra delay caused by the requirement for End-User Certificates and approval of the US Board of Commerce.

Some foreign companies such as Motorola, RCA and Siemens hold stocks here but choice is poor. If an R&D engineer badly needs an item that is not in stock and has to be imported, the wait could take up to three months. This aspect alone makes design extremely sluggish and non-competitive.

Sometimes waiting times are so long that, in the interim, engineers find alternative solutions. By the time the components arrive the original reason for ordering them may even have been forgotten.

In an effort to beat the delays it is not unknown for R&D engineers to make personal purchases (with the secret blessing of their managers) of small quantities of badly needed components in Trieste, Klagenfurt, Graz or even Vienna or Munich, just to keep the ball rolling.



10W linear fet amplifier for the 1·7-2·3GHz band by Iskra.

Plants & Production

Two giants in electronics are Iskra in Slovenia and Elektronska Industrija (EI) in Serbia. These are followed by smaller operations like Gorenje and Elrad in Slovenia; Radio Industrija Zagreb (RIZ) and Nikola Tesla in Chroatia; and Rudi Cajavec Bosnia and Mihajlo Pupin in Serbia, to mention just a few.

The normal smooth gradation between biggest and smallest is practically non-existent in Yugoslavia. Fear of small privately-owned companies is an essential part of all communist systems.

Since progress to a market-oriented economy began at the end of 1989, some big companies have become ineffective and many are running into bankruptcy. Suddenly attention was focused on the excessive bureaucracy in these companies and about 30% of employees have faced redundancy.

Due to the cancellation of some projects, competent professional electronics engineers and technicians are also being laid off. They would undoubtedly find employment in smaller firms — if they existed.

Instead many engineers and technicians are becoming jobless. Some, especially those who have mastered English, German or Italian,(a good proportion), may find work in the West, but office employees are unlikely to be accepted abroad.

Iskra, with many sectors of activity, is best known for its electricity meters, instruments, communication systems, TV sets, electrical tools, small domestic appliances and component production. Production of TV sets and larger domestic appliances is handled by Gorenje, responsible for substantial exports, and Elektronska Industrija is known for its radio and TV sets, communication gear, electromedical equipment, discrete semiconductors, and components.

Western regions of the state export (mostly) to the West, while the Eastern part prefers the less-demanding Eastern market where payment is made by clearing — a system which underlies a big trade unbalance with the Eastern block, particularly the Soviet Union.

Under this arrangement, from the moment goods were exported the manufacturer became eligible for a full refund from the Yugoslav Bank. So clearing trade became responsible for a horrendous inflation rate (several thousand percent). This was stopped in 1989 by making the Yugoslav Dinar convertible (1Dm = 7 Din, fixed).

One curious fact is that Iskra telephone apparatus is world-renowned for its fine design. In fact its design was copied by an American manufacturer who got the embarassing but well-deserved "Plagiatus" award at the Hanover Fair.

Unfortunately since Iskra and Nikola Tesla opt for different telephone systems designs there is no unified approach in this sector on Yugoslav territory.

Slovenian productivity, a quarter of that achieved in Western Germany, is considered the highest in Yugoslavia and is 58% above the Yugoslav average.

The situation is worst in the South-East where Serbia, which finds use for little up-to-date production equipment, falls below Slovenia by 84% (figures are for industry in general since the particular figures for the electronics sector are not available).

Serbia's trade boycott of Slovenia, introduced in the last 12 months is expected to slightly affect Slovenian production output until new foreign markets are found.

A word about the environmental pollution: since investment funds are scarce and punishments for polluters are only symbolic, there is often not enough money left to spend on waste processing plants.

Although the electronics industry is not the main polluter it is still responsible for many dead fish where poorly processed waste from electroplating processes has been occasionally released into streams. A major producer of capacitors in Semic, Slovenia, was dumping dangerous PCB (polychlorinated biphenols) into the source of the river Krupa for years. This caused significant environmental pollution and, even today, several years after the practice has ceased, people from the area must undergo regular medical examinations and many are still seriously ill.

Managers are expected to be well-educated, competent, honest and members of the communist party – this last qualification being essential. Unfortunately, in too many cases at least one of these properties is missing.

Working conditions

Yugoslav industry works from 6am until 2pm, in a 42-hr week, with 40 working years necessary for a man (35 years for a woman) to earn a full pension. Some Saturdays must be worked too.

Although these hours might appear odd from a Western standpoint, average Yugoslav employees prefer them.

Low productivity means salaries are low, so to make ends meet many employees use the rest of the day for moonlighting. In effect this often results in employees saving themselves for the afternoon job, reducing their performance in their regular work.

A complete change of mentality will be needed to alter this situation, even if productivity and payments are improved.

Management and Professional Staff

Managers are expected to be well-educated, competent, honest and members of the communist party — this last qualification being essential. Unfortunately in too many cases at least one of these properties is missing.

Potential managers who should have been recruited from competent engineers have not been given the chance to develop their managerial skills unless they entered the party. As a result many good engineers have left the country to find stimulating and well paid employment in the West, particularly in Germany, Switzerland and the US. They grow roots in their new environment and few are eager to return, some not even after retirement.

There is a definite lack of engineers in Yugoslavia, yet paradoxically many engineers are unemployed.

In Serbia, for a single job opening in Belgrade, perhaps 100 engineers could be expected to apply. This is partly because no-one chooses without good reason to work away from Belgrade, as the surrounding area is considered so underdeveloped. Another problem is a shortage of apartments which greatly affects mobility of a work force. It is unlikely that this will be corrected in the near future.

Relative success of Yugoslav engineers abroad proves that most universities here have high standards despite their lack of equipment. However, the link between theory and practice should be given more emphasis in the future to make engineers better equipped for a prompt start in industry. This should follow with better equipped university laboratories.

So far it is solid fundamental knowledge which has somehow helped Yugoslav engineers overcome the diverse difficulties encountered in daily practice.

A View into Future

What are the priorities for change in the Yugoslav electronics industry?

First of all, competent management is needed and all dead wood should be chopped-off.

Small private companies are non-existent, so they must be established to absorb professionals made redundant from the bigger enterprises and to increase the capacity for small scale production. Most likely many large companies will split into smaller ones and foreign capital might play a substantial role in this change.

Like the neglected garden desperately needing fertilisation, foreign credits, technical aid and know-how are essential for our electronics industry.

New development programmes are not likely to be introduced and many existing projects might be cut if they bring no profit. It is also crucial that major foreign companies keep their stocks at a high level to make components swiftly available. At the same time Yugoslav legislation should be radically reformed to attract foreign companies and to make purchase easier.

With free democratic elections coming only slowly to Yugoslavia, foreign investors are delaying decisions while waiting to see what happens. This procrastination may have a severe effect on the national economy.

Yugoslavs can only hope that Serbia, the greatest Yugoslav republic, will start to mobilise soon and that engineers in the South-East, will realise that time is working against them.■

BSB: Murdoch, Mac and mistakes take their toll

Sam Chisholm, managing director of the newly-merged British Sky Broadcasting, used to have a notice on the wall of his office in Australia. It read: "To err is human, to forgive is not my policy."

BSB made many mistakes – some great, some trivial – in its short life, and Sky has proved an unforgiving partner.

Chisholm himself, who is generally regarded as a tough operator, was brought in by Rupert Murdoch to fill the then-vacant post of chief executive at Sky soon after the talks with BSB had begun. The only representative of BSB's management on the new board, deputy MD and former BSB finance director Ian Clubb, resigned within two weeks, on the same day as mass redundancies began at BSB.

What was announced as a 50-50 merger had already begun to look like a Sky takeover. Nobody seriously expected anything else. A partner with over 900 000 installed dishes will obviously be more equal than one with fewer than 120 000.

But BSB's biggest apparent mistake

Murdoch: "adroit timing"

– to adopt the D-Mac transmission system – was not in fact a mistake at all. It was a condition of its franchise from the IBA as Britain's DBS operator.

Nevertheless, it was development problems with the D-Mac receiver equipment that cost BSB valuable time and allowed Sky to build up such a commanding market-place lead. For the record, though the famous Squarial also proved harder to realise than expected, it was not this that held BSB back – the service could be, and was, received on small dish aerials as well.

It is the future of D-Mac, and with it, Europe's ambition to develop a home-grown HDTV system, which is now exercising minds both in the IBA and the Eureka 95 project.

The IBA (or ITC, as it became on January 1, 1991) had four main considerations to take into account: ownership, frequencies, the D-Mac system – but above all as the ITC itself likes to put it, "the interests of the viewer."

This latter consideration was behind the announcement that it was to take back the officially-assigned BSB frequencies from the new consortium – although probably not until BSkyB has decided it no longer wants them.

Astra, initially declared the "primary" satellite for the new five-channel service, quickly became the only satellite. Within days of the merger announcement, a notice went out to retailers that enablements of BSB receivers were being stopped almost immediately, ending any short-lived speculation that BSkyB might wish to continue its franchise as Britain's DBS broadcaster.

However, Astra will have to find an extra transponder, though this should not pose a problem once its second satellite, 1B (same frequency band, same orbital slot) becomes operational.

Adroit timing of the merger meant that bidding for space on the new satellite was still underway when the deal was signed and Sky, as a major customer, ought not to have any difficulty getting what it wants.

Until then, at least until April, a "transitional arrangement" using the Marco Polo satellite might be expected

Chisholm: to forgive is not my policy

to continue. This would give BSkyB time to make arrangements to exchange the 117 000 BSB receivers.

If BSkyB acknowledges a contractual obligation to owners, it could cost the new consortium well over £30million, plus another £8million or so for installing new aerials.

At present it is talking merely of an exchange "on favourable terms". But this will be little comfort to viewers who bought BSB because they did not have a clear line-of-sight to Astra, did not like the Sky programme package, or because they live in Scotland and baulk at erecting 80cm dishes.

The exchange receivers, incidentally, are likely to be Amstrads – a snub to Ferguson, ITT-Nokia and Tatung, who backed the BSB horse but also make Pal receivers (the fourth maufacturer, Philips, does not). Industry rumours are that Amstrad and its dish supplier were put onto increased production before the merger was announced.

Ownership limits

After the interests of viewers, the next consideration of the ITC seems to be the question of ownership. Under the new Broadcasting Act, a non-EC citizen (Mr Murdoch) cannot control a British DBS system, but is 50% ownership control?

Also the Act is intended to limit newspaper owners (Murdoch, again) to a 20% stake in British TV services, terrestrial or satellite – an aim enshrined in supplementary legislation.

Again, the timing is adroit – government has time to rewrite the rules, if it wishes, to suit the results.

In fact Sky, being on a foreign satellite, evades ownership controls. There may be moves to push its ground facilities abroad as well, but this would seem to be counter-productive.

The easiest way of satisfying, more or less, the regulations is to take back BSB's Warc-77-assigned frequencies and orbital position – and attempt to reassign them. In effect this would mean at some stage taking over the two co-located Marco Polo satellites, since they are tuned unalterably to the frequencies, and could not be easily moved from their orbital position.

The second satellite – which would have enabled BSB to transmit all five channels at full power – was being drifted into orbit at the time of the merger and, at the time of writing, was due to be in position by December.

Uncomfortably for Hughes, supplier of the satellite, BSB was not due to pay for it until it was on-station and transmitting.

Transmissions are handled by the ITC, which occupies a building at the uplink site at Chilworth, Hants. Management of the satellites is carried out by BSB in an adjacent building, so it would be up to BSB to switch the satellite on, but the ITC could at any time switch the programmes off.

The question is who, if anybody, would want them, as it is clear that at present there is not enough money in satellite TV for an additional five channels?

D-Mac requirement

With the frequencies would go the requirement to broadcast in D-Mac; BSB was to have been the flagship on the Mac route to European HDTV. Other satellite channels in Europe are using Mac (mostly D2-Mac), and high-power DBS satellites.

But the loss of BSB will be a severe setback, increasing the likelihood of the Japanese Hi-Vision system becoming the world standard. Biggest loser in the merger could eventually be the European consumer electronics industry.

Lobbying has started to see the channels offered to existing terrestrial broadcasters, BBC and ITV channels 3 and 4 – a solution which has much to commend it. It could offer a phased route to subscription broadcasting, while allowing the companies to dabble in high-tech transmission systems.

There would also be room for Channel 5, which at the moment will not cover significant areas of the country.

Chief problem is cost and it would be unrealistic to expect viewers to rush to buy receivers, or to pay for what they already see for free.

However costs of uplinking programmes to satellite are insignificant compared with costs of producing them.

The Eureka 35 project might provide some subsidy, if needed, but there is a strong possibility that the satellite could pay for itself.

An aspect of the merger which has so far escaped media attention is the fate of BSB's Datavision sideline, using spare transmission capacity to provide two business services.

One service is a closed user-group TV service in which, for instance, head offices can make secure broadcasts to branches. The other service is data transmission using spare capacity on the digital data stream carrying Nicam.

Both exploit aspects of D-Mac technology and may be why, as one BSB person put it; "Sky doesn't really know what it's got in Datavision." Estimates put the turnover that the services could be generating at £100million per year within ten years.

If the satellites were to be sold off, then it would make sense for the buyer to take Datavision too, or reinvent the service. It could be for this reason that D-Mac will get the best chance it's had so far.

Peter Willis

BBC subscription services need advanced electronics

Yet another box of electronics, containing some of the most advanced technology ever used in a home will be attached to the sets of the dedicated TV watcher from this September – a decoder to unscramble subscription programmes from the BBC.

BBC Select, as the venture will be known, could be broadcasting fifteen scrambled services through the night, when BBC transmitters are normally idle. Sectors such as professional training, community activities, education, leisure and other specialist areas will be the targets of the new service.

This is not the first time the BBC has tried subscription broadcasting: it has previously launched a service transmitting medical programmes for doctors. Apart from the scrambler proving too easy to crack, the service lacked appeal and failed commercially in February 1990.

BBC Select will transmit in conventional Pal TV with VideoCrypt scrambling – the system used by Murdoch's Sky Movie Channel, jointly developed by Thomson Consumer Electronics of France and News Datacom, a subsidiary of Murdoch's News International.

In scrambling, each horizontal scanning line of TV picture is cut into two uneven halves before transmission and then rejoined on reception. Cut positions are continually changed under control of secret codes with part of the code permanently stored in the decoder, part transmitted with the picture and part stored in a smart card (credit card with built-in computer memory and intelligence) which plugs into the decoder and must be changed every few months.

The services will be spread over the BBC's two channels. Because of the unsocial hours, most viewers will tape programmes and watch later. So the decoder will have to scan both channels continually and trigger a conventional domestic video recorder whenever it registers a subscription transmission.

This means the decoder must be combined with UHF tuning circuits similar to those found in a TV set. Like a video recorder, it must also have a modulator so that it can feed unscrambled signals into the aerial socket of a tv set or video recorder.

The decoder must unscramble only those services authorised by the card but must also be able to modify the card to authorise new services as extra subscriptions are paid. Updating instructions will be broadcast, along with the descrambling codes, as an 800 kbit/s digital data stream contained in the top scanning lines of the picture.

Because the decoder must work with existing video recorders, it will switch them on and off by mimicking signals from a conventional infra red remote control. BBC and Thomson have yet to solve the tricky problem of how to match the Select decoder to the viewer's recorder. One possibility is for the decoder to have a memory which "learns" the codes from any remote control briefly pointed at it.

Ferguson already makes satellite receivers and VideoCrypt decoders for receiving Sky. An integrated Sky satellite receiver and decoder, or IRD, (with aerial) costs around £350, with the manufacturing price of smart cards kept to under £1 by building in only erom.

The BBC system requires more versatile memory to store the broadcast information changes. All this points to a high cost for IRDs and smart cards on which BBC Select depends.

Both parties tacitly acknowledge the absurdity of asking people to pay, and find space, for two separate VideoCrypt decoders, one to unscramble Sky and the other for BBC Select. Ferguson's long term aim is to build a single unit which copes with both services.

But Ferguson, like the rest of the electronics industry, is currently waiting to see what the Disney Channel does. If, as widely expected, Disney signs to broadcast a subscription service in VideoCrypt from the second Astra satellite due to be launched, all the manufacturers can go ahead and build what they see as a "dream product"; a single box TV set or video recorder incorporating all the electronics needed for all VideoCrypt subscription services. **Barry Fox**

Current from light device powers ICs

GaAs monolithic devices converting light into electrical current at a voltage high enough to power ICs as well as sensors have been developed in California. When powered from light sources such as laser diodes, either directly or via fibre optic cable, the new converter is said to produce 1mW to 1W with voltages of ±1 to 12V.

Semiconductors that convert light into electrical power have been in production for some time but these devices are characterised by a low output voltage.

Compared with the old power-converter manufacturing process of manually wiring together discrete solar cells, the monolithic fabrication technique increases circuit reliability and decreases manufacturing costs.

Taking a 6V version of the converter as an example, the device has an active area diameter of 3mm divided into six (60°) equal sections. Each section is essentially a GaAs solar cell, operating as an independent photodiode with an output of 1V. These sections are electrically isolated by a trench measuring 20μm.

To overcome the problem of connecting sections in series an "air bridge" has been developed consisting of a metal strip spanning the trenches and producing a sum voltage of 6V between the first and the last cell. The output voltage can be increased by increasing the number of 1-V cells.

Used with fibre optic cable, the converters could find applications in avionics, process control, and medical electronics.

The device was developed by Varian Research Centre, Palo Alto, California.

Polymer circuits

Progress has been made toward creating "wires" of conducting polymers with lasers on plastic circuit boards, according to Bruce M Novak at the University of California, Berkeley. Conductivies are only 0.01/Ω.cm to date but may improve. Professor Novak and collaborators phenylated polyphenylene sulphide by reaction with diphenyliodonium salts, spin-coated films of the triphenylsulphonium resin onto glass plates, and exposed films at 248nm through masks.

Films changed from tan and insulating to grey-black and semiconducting in exposed regions. Films could be peeled undamaged from plates.

Person radiation monitor

Loral-Microwave Narda announce through its UK agents Rohde & Schwarz what it claims to be the first personal monitor for RF and microwave radiation.

The monitor, Nardalert 8840B, covers the ANSI recommended frequency range of 2 to 18GHz and gives an alarm signal by latching lamp or by earphone when a threshold of 1mW/cm^2 orm 5mW/cm^2 is exceeded — both versions are available. Detection is by thermocouple, providing continuous true RMS average field sensing and avoiding

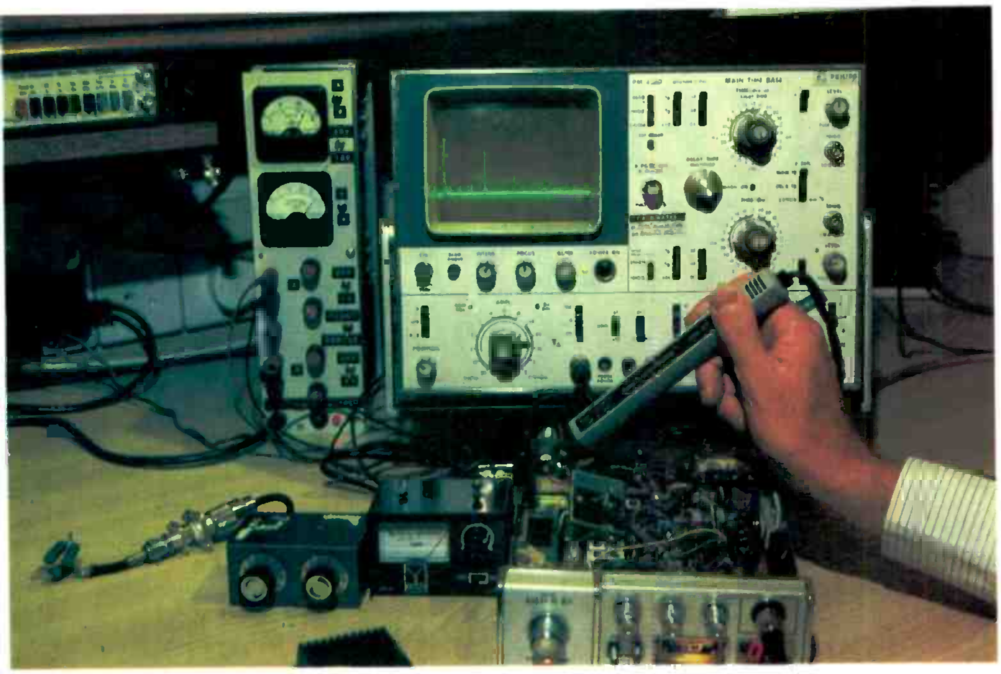
Loral-Narda personal non-ionising-radiation monitor, the 8840B.

errors caused by multiple signals or modulations. Measuring and display electronics are unaffected by RF fields.

Nardalert measures 1 *2.4*3.8in and is therefore easily pocketable, being completely "hands-free" in operation. There are built-in self-checks and a low-battery warning.

Narda makes a range of isotropic radiation monitors that cover the frequency range 10MHz to 40GHz and intend to push that to 100GHz as soon as it becomes possible to calibrate instruments at that frequency. Frequency characteristics of the instruments below 2GHz are a mirror image of the ANSI C95(1982) curve, which sets an exposure standard of 1mW/cm^2 from 30MHz to 300MHz, 5mW/cm^2 over 1500MHz and 900/f^2 mW/cm^2 below 30MHz.

USE YOUR SCOPE AS A SPECTRUM ANALYSER FOR JUST £295

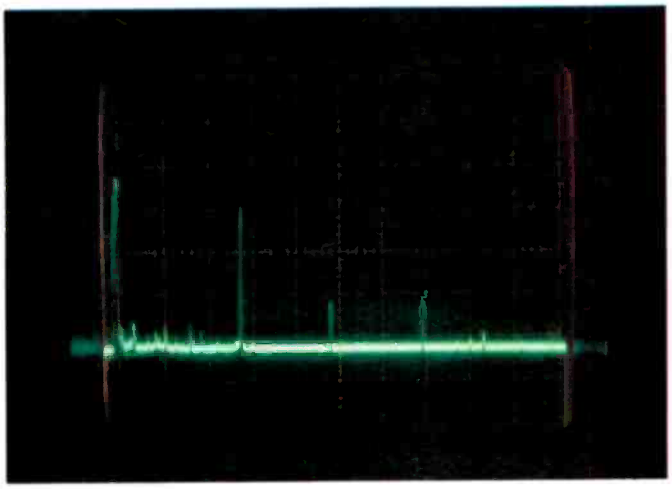


Imagine, if you will, an instrument which offers the power of a spectrum analyser combined with the ease of use of a conventional oscilloscope probe. Hard to imagine? Not any more. The Type 107 Spectrum Probe from Laplace Instruments provides these facilities at a mere fraction of the cost of a fully-fledged spectrum analyser.

Specifications. Laplace Instruments quote the following specifications for the Type 107 Spectrum Probe

FREQUENCY RANGE: 100MHz
DYNAMIC RANGE: 50dB min.
VERTICAL OUTPUT: 5mV/dB typical
VERTICAL LOGARITHMIC LINEARITY: ±3dB
TANGENTIAL SENSITIVITY: 100µV ±3dB at 50MHz
FLATNESS: ±2dB, 5MHz to 100MHz
LF DEGRADATION: Approx. 5dB down below 1MHz
SPURIOUS RESPONSES: Generallly -40dB
IF BANDWIDTH: 180kHz at -3dB
MAX CW INPUT: +15dBm, 1V at 100MHz
SWEEP RATE: 6ms/100MHz typical
HORIZONTAL LINEARITY: ±10%
RADIATION (FROM PROBE TIP): -40dBm at 150MHz
POWER SOURCE: 220V ±10% 50Hz 4W max.
SIZE: 190 x 25mm diam. (probe)
WEIGHT: 56gm (probe) 260gm (power supply)

Spectrum Probe analysing transmitter RF output for harmonics



The Type 107 Spectrum Probe allows any standard oscilloscope to be used as a 100MHz spectrum analyser; the vertical deflection indicates amplitude (on a logarithmic scale) while the horizontal scale gives a (linear) indication of frequency. Mike Tooley reviewed the Laplace Instruments Spectrum Probe in the November 90 issue of Electronics World+Wireless World. This is what he had to say: "***The ability to display signals in the frequency domain on a conventional low-cost oscilloscope should not be underestimated. Indeed, it should be stressed that the Spectrum Probe can display signals at 100MHz far outside the bandwidth of, for example, a 10MHz oscilloscope.***"

Our magazine is pleased to be able to offer the Spectrum Probe to its readers for just £295, £45 off the normal price. To order yours, simply fill in the coupon below and return to Lindsey Gardner, Room L333, Quadrant House, The Quadrant, Sutton, Surrey.SM2 5AS. Alternatively phone in your order on 081-661 3614 (mornings only).

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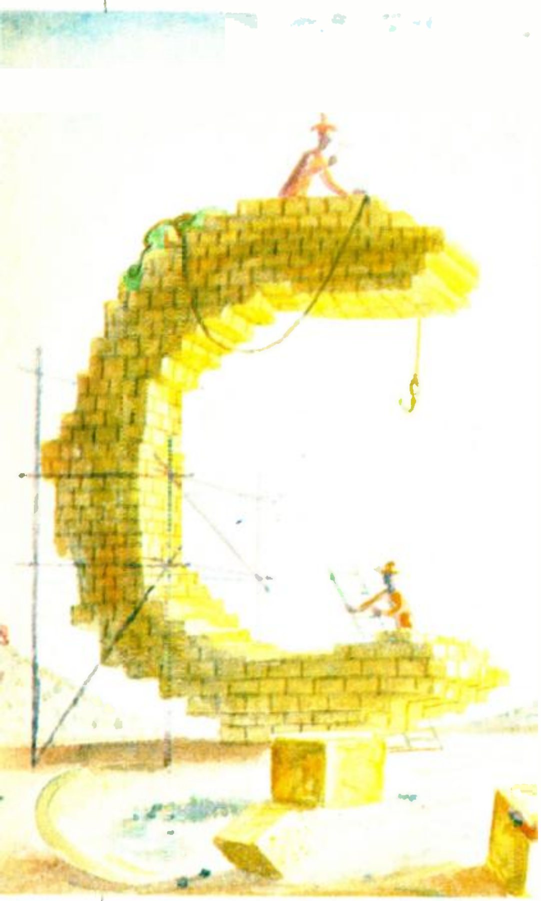


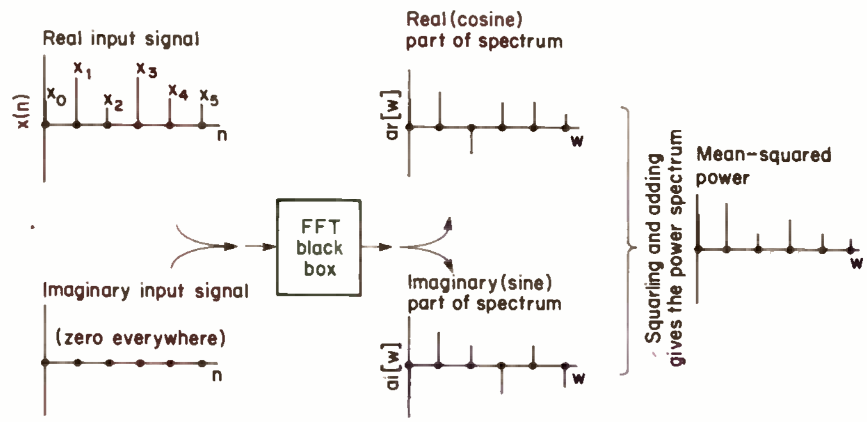
INTERFACING WITH C

PART 9

While running the discrete Fourier transform programs given last month is instructive, a large number of samples does take some time to process. Howard Hutchings continues the section on Fourier with listings for the fast Fourier transform, a method of data capture and ways of avoiding the effects of signal truncation.

The fast Fourier transform program, listing 6.12, is a translation into C of a Basic program found in Electronic Signals and Systems by P. A. Lynn, page 207 (published by Macmillan). This introductory program evaluates the FFT of 128 samples. The sampled data is generated synthetically within the program, making it ideal for demonstration purposes. As an easy-to-confirm confidence check, the program generates a ramp-function which makes it simple to check for software bugs. Changing the sign of the coefficient of the sine function allows the inverse transform to be computed by applying the FFT algorithm to its own output. This regenerates the original data and is a useful check.

Fig.6.15. Graphical description of fast Fourier transform



Listing 6.12

```
/ *********************************** /
/*  FAST FOURIER TRANSFORM AND        */
/*        INVERSE 128 POINTS          */
/ *********************************** /
#include<stdio.h>
#include<math.h>
#define PI 3.14159
main()
{
double ar[128], ai[128];
int n, n2, a, c, d, f, g, h, j;
double b, e, k, l, n1, co, si, mean_sq_power,
rms;
int m, p, q, r, s, t, u, w, z;
n = 128;
```

```
/*----------------------------------------------------------
                n = SIZE OF ARRAY
----------------------------------------------------------*/
n1 = log10(n) / log10(2);
/*----------------------------------------------------------
          n1 = LOG BASE 2 OF ARRAY,
CRITICAL PARAMETER CONTROLS No. OF
                ITERATIONS
----------------------------------------------------------*/
for(z = 1; z <= n; z++)
{
ar[z] = z;
ai[z] = 0;
}
/*----------------------------------------------------------
          SYNTHETIC RAMP FUNCTION
----------------------------------------------------------*/
start:printf("Choose transform or inverse(+1/
-1)\n");
scanf("%d", &n2);
a = n;
b = 2 * PI / n;
for(c = 1; c <= n1; c++)
{
d = a;
a = a / 2;
e = 0;
for(f = 1; f <= a; f++)
{
co = cos(e);
si = sin(e) * n2;
e = e + b;
u = 1;
for(g = d; g <= n; g = u * d)
{
u++;
h = g - d + f;
j = h + a;
k = ar[h] - ar[j];
l = ai[h] - ai[j];
ar[h] = ar[h] + ar[j];
ai[h] = ai[h] + ai[j];
ar[j] = co * k + si * l;
ai[j] = co * l - si * k;
}
}
b = 2 * b;
}
/*----------------------------------------------------------
          RE-ORDER SCRAMBLED DATA
----------------------------------------------------------*/
m = 1;
p = n / 2;
q = n - 1;
for(r = 1; r <= q; r++)
{
if(r > (m - 0.1)) goto label1;
k = ar[m];
l = ai[m];
ar[m] = ar[r];
ai[m] = ai[r];
ar[r] = k;
ai[r] = l;
label1:s = p;
label3:if(s > (m - 0.1)) goto label2;
m = m - s;
s = s / 2;
goto label3;
label2:m = m + s;
}
for(w = 1; w <=n; w++)
{
printf("%d\t%f\t%f\n", w - 1, ar[w] / n, ai[w] /
n);
/*----------------------------------------------------------
     PRINT: SAMPLE(m)  ar(m)  ai(m)
----------------------------------------------------------*/
}
goto start;
}
```

A rigorous explanation of the FFT algorithm is beyond the scope of this book and the interested reader is referred to the references at the end of this chapter. The aim of this book is to deal in plausible explanations and to present the program as a recursive form of the DFT, which accepts a sequence of numbers or time-domain samples as its input before processing the data into the required spectral coefficients. If you elect to modify the program and transform a different number of samples, the critical parameter is identified. This enables a change without disturbing the structure of the algorithm.

FFT with real-time data capture and graphics

Listing 6.13 uses the impressive computational power of the PC, together with the speed of C, to function as a real-time spectrum analyser. It will calculate and graphically display the Fourier transform of signals in the range 0–5V, with a sampling frequency of 40kHz. The number of data points are selectable up to a maximum of 1024. Do not be discouraged by the length of the program as the anatomy is straightforward. All the software-control of the peripheral board, data capture, video housekeeping, FFT algorithm, and graphics have already been tried and tested in previous programs.

listing 6.13

```
/ ************************************ /
/*  FAST FOURIER TRANSFORM WITH      */
/*    DATA CAPTURE (1024 SAMPLES     */
/*          MAX): Fs = 40kHz         */
/ ************************************ /
#include<stdio.h>
#include<math.h>
#include<conio.h>
#include<graph.h>
#define PI 3.14159
#define BASE 768
main()
{
struct videoconfig screen_size;
float ar[1024], ai[1024], window[1024];
int N, a, c, d, f, g, h, j, contents, x[1024];
/*----------------------------------------------------------
            N = No. OF SAMPLES
----------------------------------------------------------*/
double b, e, k, l, co, si, mean_sq_power,
average, n, time, rms;
/*----------------------------------------------------------
   n = LOG TO BASE 2 OF No. OF SAMPLES
----------------------------------------------------------*/
int m, p, q, r, s, t, u, w, z;
start: _settextposition(20, 20);
printf("Select No. of samples (1024max)");
scanf("%d", &N);
/*----------------------------------------------------------
          ENTER No. OF SAMPLES
----------------------------------------------------------*/
n = log10(N) / log10(2);
_setvideomode(_DEFAULTMODE);
_setvideomode(_HRES16COLOR);
_clearscreen(_GCLEARSCREEN);
_setbkcolor(_GRAY);
_getvideoconfig(&screen_size);
_setlogorg(screen_size.numxpixels/4,
screen_size.numypixels/2);
_moveto(0, 0);
_lineto(320, 0);
_moveto(0, 0);
_lineto(0, -90);
/*----------------------------------------------------------
   VIDEO HOUSEKEEPING AND AXES
            PLOTTING
----------------------------------------------------------*/
_settextcolor(3);
_settextposition(4, 6);
_outtext("r.m.s.");
_settextposition(14, 50);
_outtext("Frequency (Hz)");
/*----------------------------------------------------------
            ANNOTATE AXES
----------------------------------------------------------*/
outp(BASE, 1);
/*----------------------------------------------------------
          SELECT I/P CHANNEL
----------------------------------------------------------*/
for(z = 1; z <= N; z++)
{
outp(BASE + 2, 0);
/*----------------------------------------------------------
          START CONVERSION
----------------------------------------------------------*/
x[z] = inp(BASE + 2);
}
average = 0;
for(z = 1; z <= N; z++)
{
average += x[z] / (double)N;
ai[z] = 0;
}
for(z = 1; z <= N; z++)
{
window[z] = 0.5 * (1 - cos(2 * PI * (z - 1) /
N));
ar[z] = 5 * (x[z] - average) * window[z] / 255;
/*----------------------------------------------------------
 SUBTRACT d.c. COMPONENT, WEIGHT
 AND MULTIPLY BY HANNING WINDOW
----------------------------------------------------------*/
}
/*----------------------------------------------------------
            FFT ROUTINE
----------------------------------------------------------*/
a = N;
b = 2 * PI / N;
for(c = 1; c <= n; c++)
{
d = a;
a = a / 2;
e = 0;
for(f = 1; f <= a; f++)
{
co = cos(e);
si = sin(e);
e = e + b;
u = 1;
for(g = d; g <= N; g = u * d)
{
u++;
h = g - d + f;
j = h + a;
k = ar[h] - ar[j];
l = ai[h] - ai[j];
ar[h] = ar[h] + ar[j];
ai[h] = ai[h] + ai[j];
```

```
ar[j] = co * k + si * l;
ai[j] = co * l - si * k;
}
}
b = 2 * b;
}
/*-------------------------------------------------------
          RE-ORDER SCRAMBLED DATA
-------------------------------------------------------*/
m = 1;
p = N / 2;
q = N - 1;
for(r = 1; r <= q; r++)
{
if(r > (m - 0.1)) goto label1;
k = ar[m];
l = ai[m];
ar[m] = ar[r];
ai[m] = ai[r];
ar[r] = k;
ai[r] = l;
label1:s = p;
label3:if(s > (m - 0.1)) goto label2;
m = m - s;
s = s / 2;
goto label3;
label2:m = m + s;
}
for(w = 1; w <= N; w++)
{
mean_sq_power = pow(ar[w] / N, 2) +
pow(ai[w] / N, 2);
rms = sqrt(mean_sq_power);
/*-------------------------------------------------------
     COMPUTE AND PLOT FREQUENCY
              SPECTRUM
-------------------------------------------------------*/
_setcolor(14);
time = 320 * (double)(w - 1) / N;
_moveto(time, 0);
_moveto(time, -100 * rms);
}
goto start;
}
```

Control of the peripheral board and data capture

This program, listing 6.13, is designed to be run through the Blue Chip data acquisition card ACM-44. The peripheral board is link-configured to process uni-polar signals in the range 0–5V, using the Analog Devices AD7820 8-bit half-flash converter. As usual, the base address of the card is selectable, and the a-to-d is strobed by writing to the input data port. Conversion is completed in under 2μs.

The interactive program requests the number of samples to be processed (1024 maximum) before calculating the parameter $n = \log_2 N$ to control the structure of the iteration. Data capture is organised using a structured for() loop and the number of stored samples is determined by the parameter N. A high sampling rate is achieved by making the array x[z] as primitive as possible. To declare the array as the data type int requires only two bytes. To verify this statement, try declaring the array as a data type float. The sampling time will be approximately doubled.

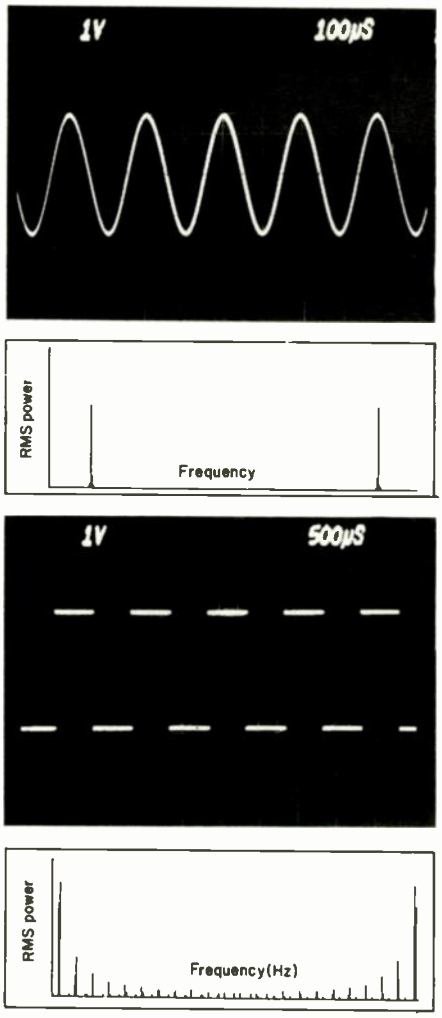


Fig.6.16. Effect of processing real signals using listing 6.13 (FFT with data capture). At (a) is a sine wave of 3Vpk–pk at 5kHz (1024 data points) while (b) shows a 3Vpk-pk square wave 1kHz (512 data points).

Fig. 6.17. Measuring sampling frequency using unique spectral component of sine wave and its alias.

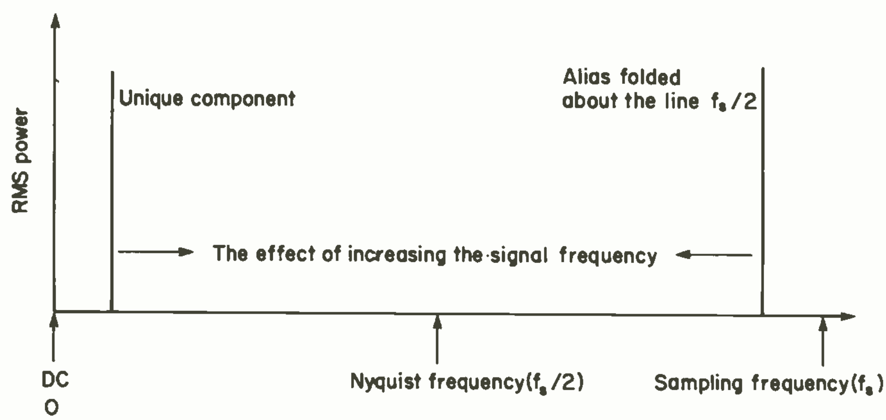


Fig 6.16a shows the results of taking the FFT of 1024 points of data, digitised at a sampling frequency of 40kHz. It is an effective test to process a sinewave through the algorithm, as this demonstrates the amount of spectral spreading. An interesting exercise is to run the program and progressively increase the number of samples from 16, 32, 64, . . . 1024 etc. Notice how the leakage is reduced. **Fig.16b** illustrates the FFT of a square wave, digitised into 512 points at a frequency of 40kHz.

I determined the sampling frequency of my system using a straightforward but indirect method, which avoided taking measurements inside the PC. The computed spectrum of the DFT is unique from d.c. to half the sampling frequency. Frequencies greater than half the sampling frequency are aliases or images folded around the line $f_s/2$. Simply apply a sinewave and observe the unique computed spectra, together with the symmetrical alias using the monitor graphics. Increasing the frequency of the signal generator results in the unique spectral ordinate and its alias moving towards the Nyquist frequency from opposite directions, as shown in **Fig. 6.17**. When these two ordinates are coincident at the Nyquist frequency (half the sampling frequency), the frequency of the applied sinewave is noted using the calibrated timebase of the oscilloscope. This gave a Nyquist frequency of 20kHz, so evidently the sampling frequency will be 40kHz.

Signal truncation and spectral leakage

Making practical measurements agree with theoretical predictions is often a problem in electronics. The very act of taking a measurement often distorts and disturbs the equilibrium conditions

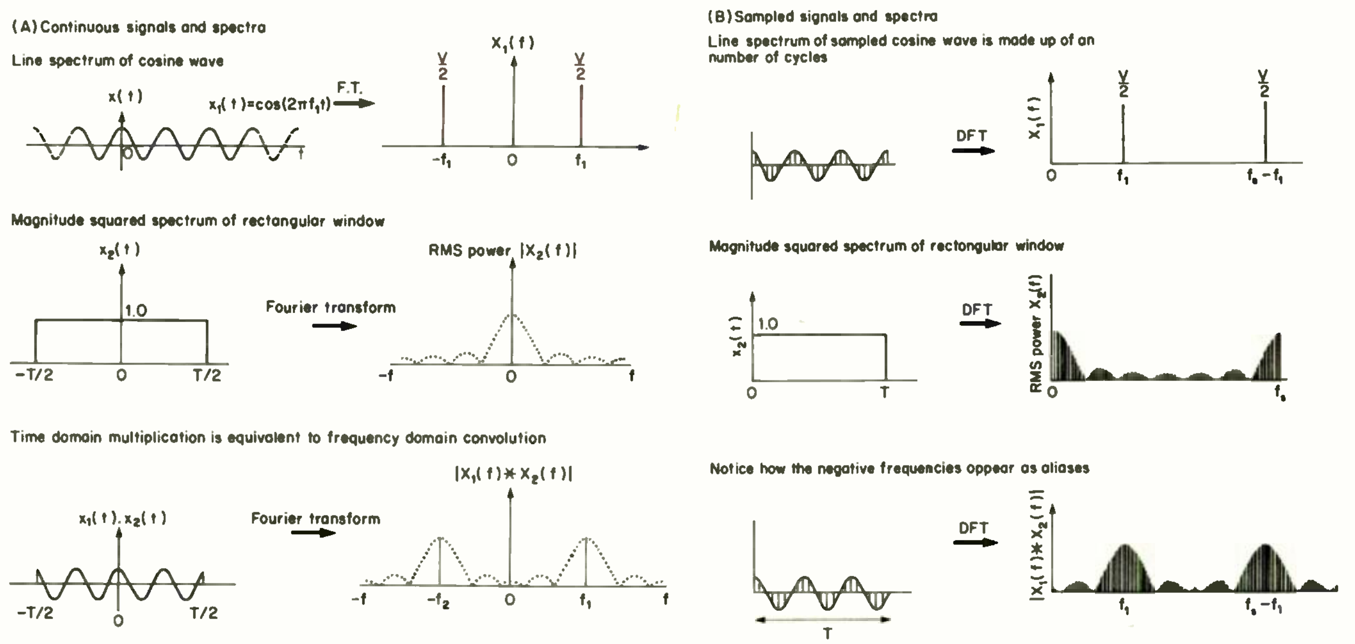


Fig. 6.18. Interpreting analogue and digital frequency spectra.

established by Ohm's law. Computing and displaying the Fourier transform using real data is no exception. The inherent problem is that of time-domain signal truncation, where the enforced discontinuity at the beginning and end of the sampled data set is treated as periodic by the Fourier transform. The effects really have to be observed to be believed — hence the emphasis on the deliberate generation of synthetic data composed of non-integer cycles (see listing 6.4). Tutors frequently resort to analogy when describing a hard-to-believe phenomenon. I like to refer to the probability of living a whole number of years, or to put it another way, dying on your birthday. Clearly, it is pretty unlikely. It is not right to assume that a sampled periodic signal will be composed of a whole number of cycles. It may be useful to compare and contrast the frequency spectra of the continuous and sampled data signals shown in **Fig. 6.18**. The intention is to highlight the effects of signal truncation and to show how the abstraction of negative frequencies — associated with the analysis of continuous signals — may be visualised as aliases in the frequency domain.

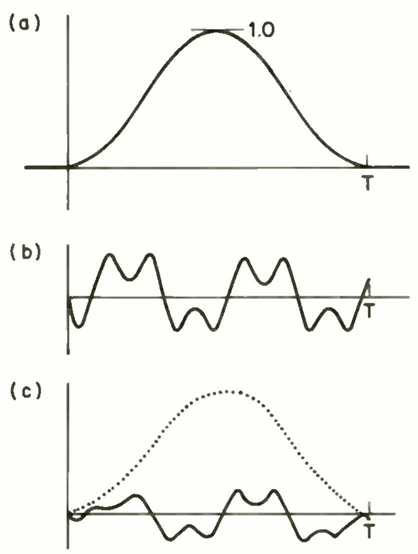


Fig. 6.19. Hanning window. At (a) raised-cosine function is generated using window[z]=0.5(1−cos(2*PI*z/N)), where z is sample point number and N number of samples. In (b) is truncated data set to be transformed and (c) shows effect of multiplying data set by Hanning window.*

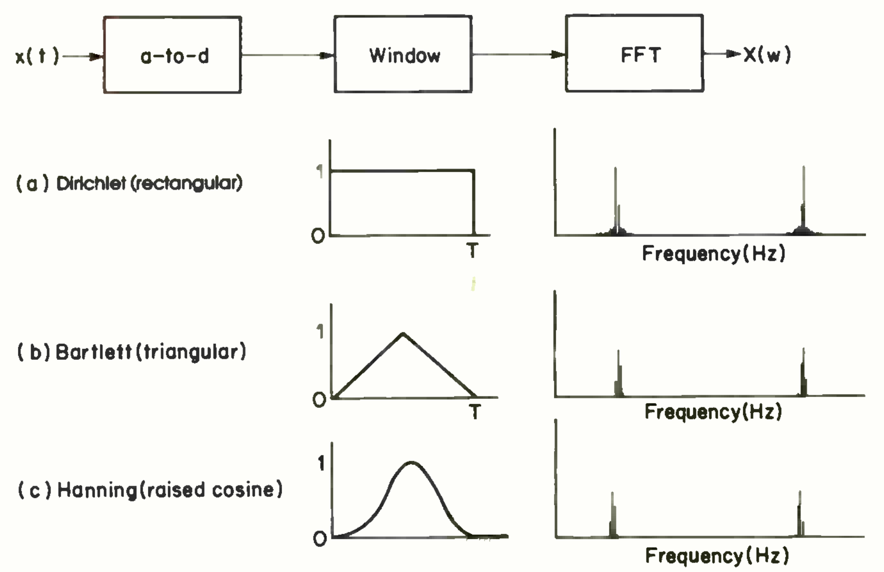


Fig. 6.20. Effects of signal truncation using (a) Dirichlet (rectangular) "do nothing" window, (b) Bartlett (triangular) window and (c) Hanning (raised-cosine) window.

Reducing spectral spreading with a Hanning window

Computing the Fourier transform of the raw captured data is equivalent to processing through a rectangular or Dirichlet window. The undesirable effects are illustrated in Fig. 6.18. A robust engineering solution is needed which will iron out the discontinuities at the beginning and end of the data set.

A popular and easy-to-use window, which provides zero padding, is the raised cosine function or Hanning window employed in listing 6.13. The window function, called window[z] in the program, is generated within a controlled for-loop. This construction was used as an opportunity to remove the substantial d.c. component from the captured data set, before multiplying by the Hanning window and weighting. The details are supported by comments in the program, together with **Fig. 6.19.** This method of signal conditioning — in other words, multiplication in the time domain — effectively convolutes the spectrum of the signal with the spectrum of the window. To fully appreciate the practical implications of window functions and spectral leakage, you should experiment. Listing 6.2 is a useful testbed. **Fig. 6.20** illustrates the effects of processing a pseudo-sampled sinewave — a strict test — through a rectangular "do nothing window", a triangular or Bartlett window, and a "bell shaped" or Hanning window. For further inspiration, or a more theoretical description, the paper by F. J. Harris is a useful source of ideas.

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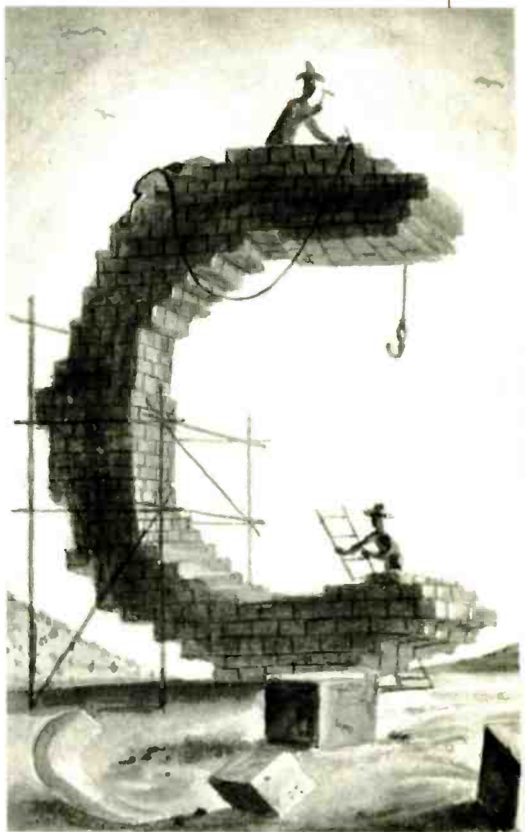


Audio Amplifier Bias Current

Two articles have recently appeared on the subject of audio amplifier bias current stability in Class B and AB amplifiers. These only serve to show that designers still appear not to learn from older but widely respected articles, some appearing in your periodical.

First, Michael McLoughlin, in the October issue, regards the "amplified diode" as all but deceased. Instead he chooses to operate an output stage in class-B mode, with high levels of negative feedback and high-impedance drive to minimise the distortion which arises. Secondly, we have had it asserted recently that the complementary Darlington output pair is as stable as the conventional Darlington pair, shown in **Figs. 1(a)** and **2(a)** respectively.

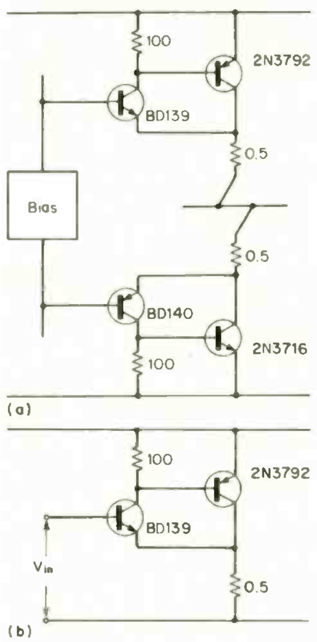


Fig. 1

Let us dismiss the second assertion first. Consider one half of each of the output stages, shown in **Figs. 1(b)** and **2(b)**. Let us apply a constant voltage to the inputs, V_{in}, referred to the centre rail. It takes but a moment's thought to realise that the quiescent current flow in the

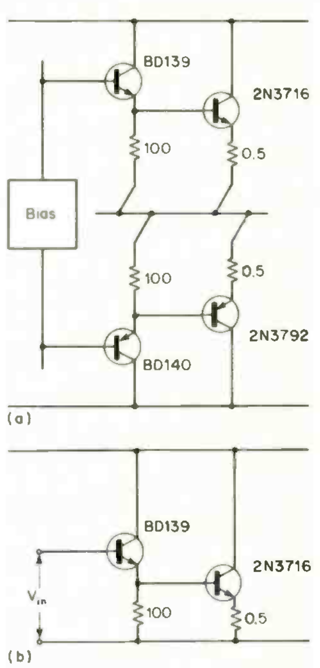


Fig. 2

0.5 Ω resistors will rise as the base-emitter voltages of the driver and output transistors fall with increasing temperature.

For the circuit of Fig. 1(b), one base-to-emitter diode voltage of Tr_1 causes approximately 4mA increase in emitter current of the pair per degree C rise. For Fig.2(b), two base-emitter diodes double the rate of quiescent current increase compared with Fig. 1(b), and the corresponding V_{in} will be about double also.

What the designer has to provide is a bias circuit, shown by the boxes in Figs. 1(a) and 2(a), such that the quiescent current in the output transistors is stable with temperature.

The problem with the conventional bias circuit, shown in **Fig. 3**, is that it is often unable

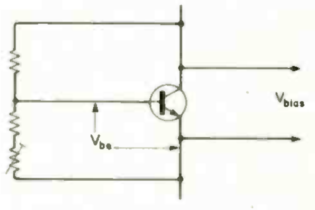


Fig. 3

to provide an exact multiple of the base-emitter voltages of the appropriate output stage, $4V_{be}$ in Fig. 2(a) and $2V_{be}$ in Fig. 1(a). The reason for this is easily seen in the case of the conventional Darlington circuit. Typically, the output transistor base resistors are 100Ω, the quiescent current 50mA and driver current about 6mA. At these values, the base to emitter voltage of the output transistors is about 0.55V and about 0.65V for the drivers at room temperature. This is the source of Michael McLoughlin's problem.

A bias stabiliser transistor may be operating at 10 to 15mA, and even for a device of the same type as the main driver transistors, it will have a base-to-emitter voltage higher than these main drivers as it is operating at a higher current. Now, the desired bias (at 20°C or thereabouts) is 2.4V. For the bias stabiliser, taken to be a similar type to a driver, it will be operating at about 20mV greater base-to-emitter voltage, as the current is, say, double the driver quiescent value. The ratio 2.4/.67 is only 3.58:1. A value of 4 is needed to be thermally stable.

One simple solution is to select a higher-power bias-stabiliser transistor. With a larger emitter area, the base to emitter voltage at the same emitter current will be lower. Another simple solution is to insert a bias resistor in the collector of the stabiliser, **Fig. 4**. This has the effect of increasing

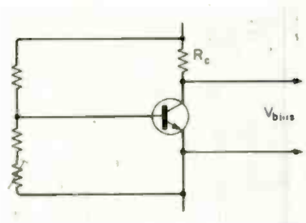
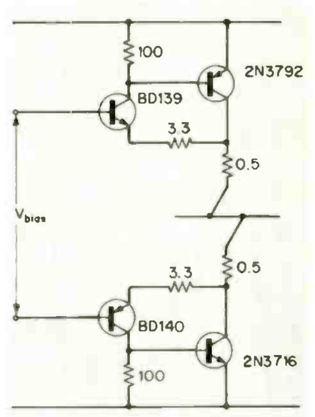


Fig. 4

the bias voltage needed, while at a constant collector current will tansfer the whole collector-to-emitter voltage drift of the stabiliser to the output stages.

In the example given, suppose the pre-driver current, equal to the bias stabiliser current, is 12mA. $4V_{be}$ gives 2.68V bias. The desired resistor is then obtained from the difference of this and the typical output stage bias. Here it would be (2.68-2.4)/12mA or 22 Ω. A larger value will begin to over-compensate the output stage which may in fact be needed to allow for a higher output transistor junction temperature than that of its heatsink.

In the complementary Darlington circuit, small resistors in series with the emitters of the drivers will push the bias voltage needed up, as shown in **Fig. 5**. When operating at about 6mA, resistors of only



3.3 Ω will suffice. The voltage lost at peak drive current is still acceptably small: only 0.66V at 200 mA, for example. As before, higher resistor values will increase the compensation.

Thermally coupling the driver transistors and the bias stabiliser is all that is necessary to prevent runaway. As the output-transistor base-to-emitter voltage falls with increasing temperature, the driver current reduces slightly while the output current increases slightly. This has to be taken into account when designing the bias circuit for maximum temperature range anticipated for the amplifier.

In the words of Reg Williamson, let us now consider this subject closed!

J.N. Ellis
Towcester
Northamptonshire

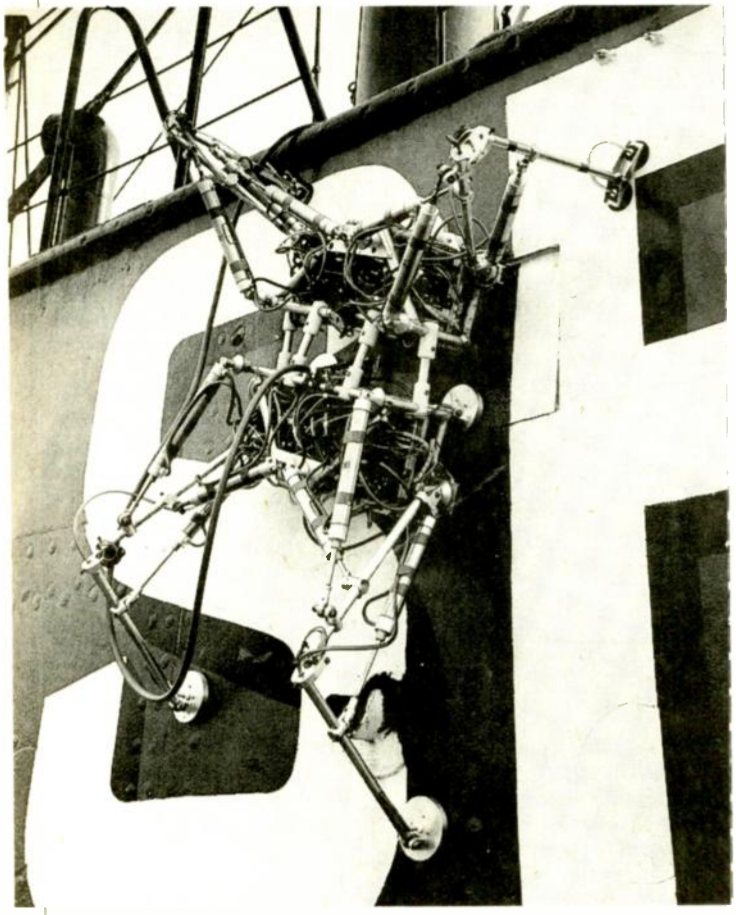
Driven up the wall

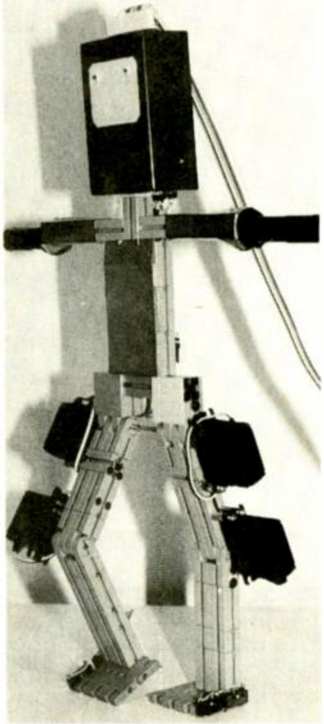
I am sorry to tell you that the Russian robot you featured last month (October Research Notes) is not the first climbing robot. There have been quite a number of similar climbing mechanisms produced over the last five years, mainly from Japan. However the first articulated-limb, wall-climbing, genuine robot is British. To be a genuine robot the mechanism must be able to modify its own behaviour in the light of the circumstances if finds.

Robug II, shown in the photograph, which was developed by Portech Ltd in conjunction with Portsmouth Polytechnic, is able to do this. It is pneumatically powered, but controlled by a separate 8/16 bit microprocessor for each leg. Instructions are sent as a string of high-level commands from a PC via a serial link, using a structured language. The robot is able to respond to general intentions such as REACH, HEAVE, etc, but the robot, with its on-board sensors, itself decides where to put its foot, searching for a good grip. When climbing buildings, it is able to step over obstacles and negotiate window ledges.

At the recent Robot Olympics another of our robots, Zig-Zag, won the gold medal for wall climbing, going about three times faster than its rival. Unfortunately, due to water in the air supply, Robug II developed an aberration, crossed out of its lane, stamped on the Russian machine and refused to let go till it was ignominiously disqualified for unsportsman-like behaviour and switched off. I hope that this is a lesson to all other robots who are reading this and preparing themselves for the next Olympics in 1992!

A.A. Collie
Portech Ltd
Portsmouth
Hampshire





Sporting (and unsporting) robots

I thought you might like to see pictures of some of the robots entered in the recent Robot Olympics held in Glasgow in September. Fifty entries came from 14 countries and entertained 1300 schoolchildren and other spectators by wall-climbing, pole-balancing, walking, staggering, shuffling and avoiding obstacles.

Paisley College's entry was a two-legged walking robot, built for less than £200, excluding the PS/2. Robots of this type were in two classes as far as motive power was concerned: pneumatics and radio-control servos, the latter being well suited to the latest generation of microcontrollers with PWM control on-chip. Our robot took second place behind a human-sized pair of legs that looked at times as though they might annihilate their competitors by simply falling over on top of them.

Ken MacFarlane
Paisley College of Technology
Renfrewshire

Spaceships or trains?

Einstein's problem, discussed in "Relativity" (translated in 1920), is restated in effect by John Ferguson in his letter in your November 1990 issue; in his book for "popular exposition", Einstein sought to show the difficulty of agreeing the simultaneity of spatially separated events when viewed from different frames of reference. He took for his example a train travelling along an embankment, suffering simultaneous lightning strikes at widely-spaced points along the railway-track, but analysis of his argument discloses a similar cause of confusion to that in the spaceship example. It is essential in both cases to determine the propagating medium that transports the light-signals; is it fixed to the train, or the ground, or indeed, to the electrically broken-down atmosphere; is it fixed to the earth, the travelling spaceships, or possibly is it flowing across the void?

Mr Ferguson suggests that we are all (including heretics) expected to imagine that radiated electromagnetic energy finds its own way across the void unregulated by any action of an "ethereal" medium; perhaps he was a little forgetful in not mentioning that, by Einstein's Second Postulate (given in his celebrated paper of 1905), it is implied that every receiver is hit by radiations at the universally constant rate c, so that we have to consider each receiver as embedded in its individual ether which it carries with it. Einstein himself had to admit that he had not created a consistent theory of electrodynamics which dispensed with the concept of medium, which had been the declared objective of his 1905 paper.

If we are to join with Mr Ferguson in commending Mr Harrowell's May 1990 call for a learned panel to further debate the creative speculations of Einstein, should we not be prepared, for the sake of an appearance of consistency and sanity, to abandon the methodology of scientific investigation? Should we not

ban all practical research which might produce rational explanations for Bradley's aberration, the Doppler effect, the Sagnac effect, and all else? Shall we then agree that the physical domain includes a "thing", the element time, which has properties which enable it to "combine" with space, to "dilate" itself, to act on material entities, moderating the regulation of the natural systems used as clocks?
C. Francksen
Farnborough
Hampshire

Cracking-up Cracker

The reviewer of Cracker 4 (November 1990) set forth only its good points; however, there are drawbacks. It is a quirky little program that shows its origins on a toy computer in several irritating ways and gives the impression that the features have been cobbled on to make it qualify as a "real" program. It will gobble up your data in several ways the moment you take your eyes off the screen and, as you contemplate its leisurely ways, it is easy to convince yourself that the damn thing is networking on the side for four other people. It takes fifty seconds to step across twenty five columns without entering any data, with messages saying "wait" or "rewriting the screen". If you miss these and type on, your data gets mangled and the program starts to interpret it as commands. The same happens when the program does its autosave. The cursor can be in text or number or neutral mode and if you move a text cursor over existing numbers, they disappear, and vice versa with the numbers cursor.

The drop down menus are clumsy to use – many needing ten or more strokes on four different keys to select an item. Two selections, the **Reference checking** and **Autocalc** can be on or off, but the menu does not say which state you are in. If you select one, the menu disappears instantly and you are in the opposite state – but you still don't know which it is.

There are three quick ways to get to line 255 but there is nothing there when you arrive. The **error** function displays as 0 and calculates as 0, which is not good. There is no x to power y, and no absolute cell-addressing. Fifty two columns are all you get. The first twenty six are labelled A to Z (upper-case) (shades of the toy computer) but the next twenty six are lower-case – there would be fewer keystrokes the other way round.

The sideways printing of wide spreadsheets is a nice idea but the printing on an Epson is NNLQ, ie nowhere near letter quality. There is no **table fill**, but you can set up a program with the **if then else** or **do while** features – see the example in the book.

I filled a spreadsheet A1 to Z27 with numbers and then used them to produce the result in A28 to Z55 but the program won't let me delete the first half or save just the second half, because as it says, B29 uses B2. I saved it all as a **txt** file, but it took two and a half minutes to save the 66kb to hard disk.

The graphs Mr Williams enthused about are quite good, but he forgot to mention there are no screen prompts to help – just use the book as a template. Where several lines are plotted, x values are required for each y value, which usually means duplicating the x list for each line – no time saving here The size of the standard graph is decided by the program, but the Cracker Plotting Language can (to quote) "be used to draw your own graphs". The scales log or lin can be any size and are easy to use, but the curves are made up of straight vectors with an x and y value each end, in millimetres from the edge of the paper! Five columns of calculations will change your data to suitable dimensions, but how to enter them all into the command **vector** (enter) x1,y1,x2,y2 (enter) is a mystery. There are no prompts on the screen, or in the book; you are on your own.

Yes there are lots of features, but for my hundred pounds I would have liked two more — speed and convenience
W. Robinson
Redcar

Crystal balls

The astronomers who recently subjected the images of Saturn's rings taken by Voyager 1 to mathematical analysis and used Fourier's transforms to reveal ". . . that the brightenings consisted of a complex of five periodic waves" (Research Notes, October), were anticipated by young Maxwell in 1857, without the aid of close-up images.

His very long paper "On the stability of the motion of Saturn's Rings" secured the 1857 Adams Prize for solving the problem put by the examiners ". . . respecting the physical constitution of the rings. It may be supposed (1) that they are rigid: (2) that they are fluid or part aeroform: (3) that they consist of masses of matter not mutually coherent". Only three rings had been observed.

Maxwell used Fourier's transforms to predict that a ring of disconnected masses of matter would be affected by displacements propagated round each ring in the form of four free waves. Other forced waves would be gravitationally induced in each ring by the free waves of adjacent rings. He predicted ". . . that the only system of rings that can exist is one composed of an indefinite number of unconnected particles, revolving round the planet with different velocities according to their respective distances. These particles may be arranged in a series of narrow rings. . ." He also designed an ingenious mechanical model of a ring of waving satellites "made by Ramage of Aberdeen" to illustrate the predictions.

His paper is a typical example of Maxwell's virtuosity in many branches of exact science; an example of how the exact science of applied mathematics applied to the exact science of Newtonian laws of physics — unified in 1847 by Helmholtz's Law of the Conservation of Energy, followed in 1864 by Maxwell's major contribution to exact science with his Newtonian laws of the electromagnetic ether — were used in the last century to solve the problems of Nature, rather than the 20th-century-reliance on superlatives and the inexact mathematical laws of gaming or "uncertainty" to solve the problem created by human fallibility.

This abandonment of exact science is the inevitable consequence of the infiltration of exact science by a school of mystics at the turn of this century, activety encouraged by committees instructed to award Nobel Prizes in Physics "for *discoveries* conferring the greatest benefit on mankind", who unfortunately agreed that the verb "to find" was synonymous with the verb "to guess". Theorists' guesses have proved to be of no benefit or practical use whatever either to engineers who carry on working with the exact science of Newtonian laws of physics, or to our understanding of "electricity" – the Newtonian inverse square-law effect of mutual attraction or repulsion of matter at a distance, discovered by experiment several thousand years ago.

Fortunately, we can compare N. Heathcote's authentic history of 20th century physics (Nobel Prize Winners in Physics 1901-1950. Schuman. 1953.) with the totally demoralised engineer's equivalent, which certainly satisfies Alfred Noble's criterion, namely Dr Atherton's "Pioneer" series, dedicated primarily to discoverers. Discoveries are made by experiment and always precede theories. There were no theories of electricity before electricity was discovered. A close study of Heathcote's Establishment-approved book shows that we are living in a century of miracles, where theories precede discoveries claimed to be experimental proof of theories by a process of reasoning from self-evident principles, e.g. the rectified wave packet.

The quark theory, still awaiting experimental discovery, a mere detail, requires the existence of a third weightless particle, the gluon, to explain why the electron does not explode under the stress of the mutual electrostatic repulsion of its parts. It would seem the many optimistic schools of profound 20th century thought share the old school song "Another little particle won't do us any harm". In more ways than one!
M.G. Wellard
Kenley
Surrey

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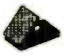

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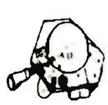

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CIRCLE NO. 107 ON REPLY CARD

Codas in control

The grind of plotting frequency, phase and time analyses for even a simple control system can easily take half an hour. John Anderson investigates Codas, which is claimed to do all that and more in 40 seconds.

Codas is an integrated suite of programs for simulating and, through this, designing single-input/single-output control systems. For those who are not familiar with control systems and the terminology, I would recommend one of the many texts available, but it is enough to say that control engineering is, in this context, a highly formal way of describing and analysing any system with feedback (or feed forward). Applications thus include the simple feedback operational amplifier and filters, and go on to cover complete systems.

Program installation

Software supplied is on a single disk, together with a slim, spiral-bound, but professionally printed manual, and consists of a single application file, an example and a few graphics files. The program cannot be run directly from the distribution floppy disk but must be installed on either a floppy or hard disk. Installation is, in principle, very simple: all you do is to set up your hard-disk directory and type **instal**. However, be warned; this software has a copy restriction facility built in, transferring copy protection and fixing up on your hard disk. This type of system is more prone to problems than the more conventional hardware dongle. As an indication of this, the first copy of the software refused to run on the day following installation; it could not be reinstalled and a new copy had to be obtained from the suppliers. For colour screens, there is an ASCII colour-definition file which you can edit to set colours to meet your particular needs, although there is no installation palette to assist in this task.

Running the software

Running the software brings up a message about a product called Metawindows before entry to the Codas program. The working screen comprises a number of distinct areas: a main graphics window, a supplementary graphics window, a command line along the bottom, a prompt for major functions in a banner at the top of the screen and various reporting areas. The program makes little allowance for the novice user, though each of the key sequences and their functions are listed in a series of small help windows. Codas is intended for knowledgeable users who, at the very least, understand Laplace transforms and frequency and time response representations. This is necessary because all input entry is in Laplace (or Z) transform format, which will require some effort on the part of the user in advance of running the software. As an example of this, to optimise an op-amp circuit you need to estimate the pole and zero locations, make decisions about what are the input and the output nodes and thus generate an explicit expression for the transfer function. Once that is entered and the type of graph and graph axes have been selected, the procedure is to press G (for GO). At this, the required graph is drawn. A comprehensive range of graphical presentations is available, which covers Bode magnitude and phase diagrams, direct Nyquist plots, inverse Nyquist plots, time-domain response, root locus and Nichols plot. It might have been useful to provide a magnitude plot in the complex plane, either as an oblique view or as a contour map.

Operating environment

Minimum hardware needed is a PC or PC-AT running dos, a CGA, EGA or VGA graphics card. The minimum memory is 380K and a maths coprocessor is recommended. A dot-matrix printer is optional

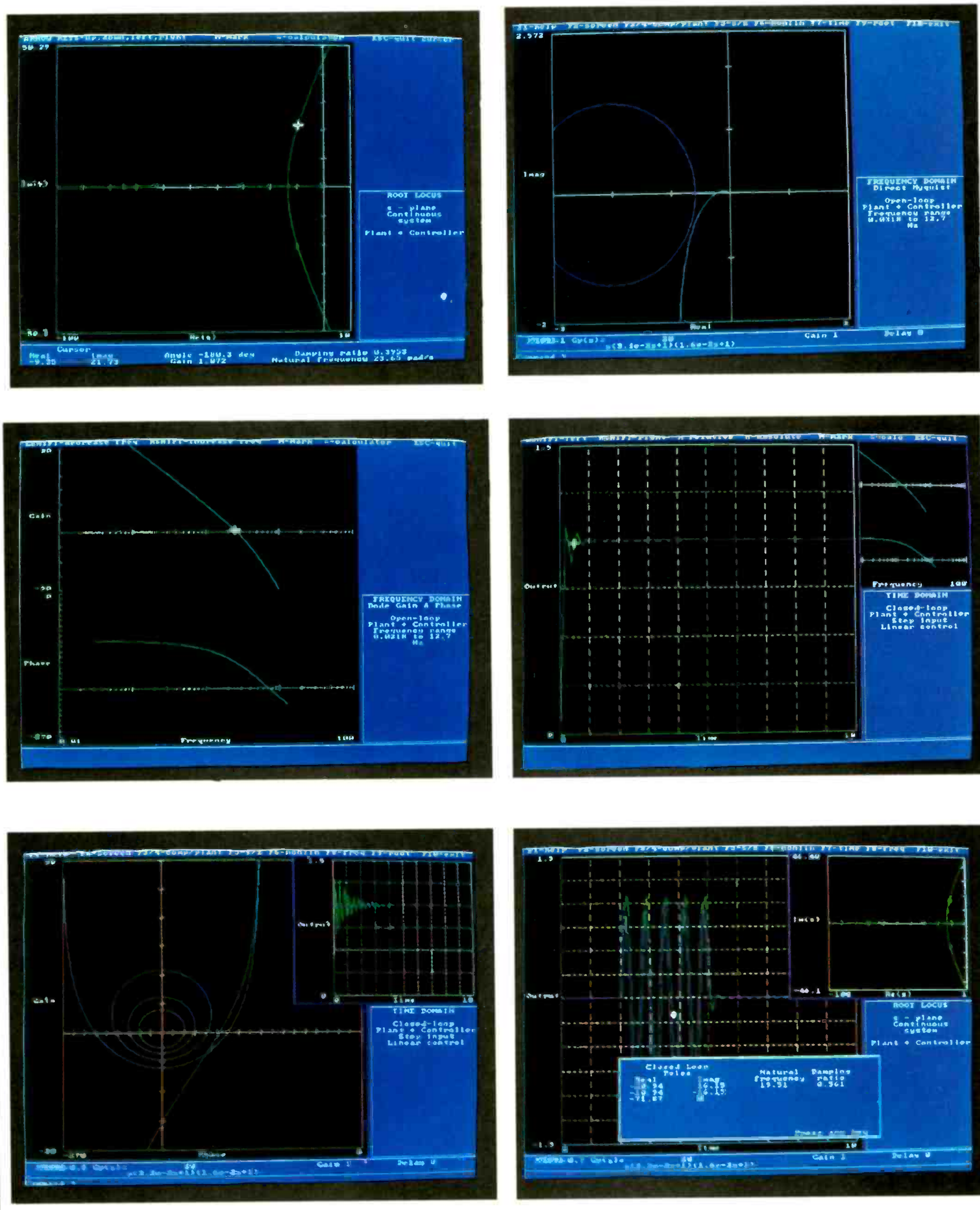
Entry of transfer function

Entering the transfer function is "free format": a series of simple or complex poles and zeros or a polynomial in s. The entry system is direct algebraic, i.e. (s+1)(s+2), the N key selecting the numerator and the D key the denominator. This is exactly as it would be written if you were expressing this on paper. At any time, there is access to a pop-up scientific calculator, with some novel facilities such as functions dB() and idB() (inverse dB). These facilities are used as part of the operation of the package, to specify a driving function, for example.

Examples and help

There is trouble in store for the novice user, who will find only limited help, which is not context-sensitive, and only a single prepared example on disk. This is mitigated by the three examples provided in the manual, but Codas is not a very good launch pad.

It is particularly infuriating that the help information on allowable keystrokes groups them as function keys or global keys, rather than by their contextual function. Consequently, it is



Top left. Root locus. This depicts movement of characteristic equation roots as system gain changes from zero to infinity. Note that their locus intersection of y axis indicates point of system instability. Top right. Nyquist plot for same system. Large circle indicates M=1.5 (M is magnification factor) ie locus for 50 per cent peaking in the frequency response. Middle left. Bode plot. Middle right. Time response with bode plot as inset at right side. Bottom left. Nicholas chart showing M-circle plots. Time response inset. Bottom right. Sine wave plot, a user defined input in purple, with the system response in green. Root locus and closed loop pole position shown inset.

something of a struggle to find out, for example, that pressing the V key (no mnemonics) in frequency-response mode brings up a pop-up window to select the type of frequency-response graph (Nyquist, Bode etc.).

Using Codas

This software has been written with great care; expressions can easily be evaluated at points where the denominator is zero which, if approached directly, will result in a division-by-zero error. It was evaluated with a number of different transfer functions and the only failures were to take the plot off-graph and the range-check problem, described in the panel. When the plot did go off-graph, it was reported, but there was no indication as to which way to alter the axes to bring it back into view. Analysis was fast, with the requested plot appearing after only a second or two on an 8MHz AT and all but instantly on a 33MHz 386. The graphical presentation is excellent, though I would think that a high-resolution screen is desirable, and provides a cursor facility which can be moved around the plots to interrogate for particular numerical values. Another use for this might be in the teaching environment, where salient aspects of the system's response could be pointed out and analysed in detail. Driving functions available include expected impulse, step and ramp, but also a very nice extension of the calculator to provide userdefinable inputs. **Bottom right** shows an example of how a complex input can be built up, a tone burst of 1kHz, lasting 3ms after a delay of 2ms, being synthesised simply with: sin(2*pi*1E3*t) * pulse(t,5E−3) * pulse(2E−3,t).

Non-linear systems

The program allows for the introduction of a single non-linear block, the non-linearity being defined by any combination of transcendentals, as well as the more often encountered practical non-linearities such as relay, sign, clip, deadzone and hysteresis.

Plotting

There is no plotter output and this might be regarded as a serious omission. However, there is a screen dump facility which can be set up to operate with a short list of printers. Point by point results of any graph can be exported to a file, which could subsequently be plotted, though this sort of thing should not be necessary.

Problem of control

Although many systems either are or can be approximated by a single-input, single-output arrangement, there are circumstances where this approach is not possible. For multivariable control systems, Codas would not be appropriate, though this type of problem is really the domain of the specialist control engineer. However, complex multipath filters, which are of more general use, would also be beyond the scope of the software. It is important to remember the amount of work that would be needed to replicate what Codas is able to do in a few seconds. Simply sketching a root locus plot can take several minutes, and in that time Codas could have performed frequency, time and root analysis, extracted gain and phase margins and probably rerun the system several times to investigate the sensitivity of a parameter! The question of complexity is worth mentioning. Hand tools for analysing feedback systems can become very cumbersome (or in the case of non-linear systems impossible) when the system being analysed is complex. How, other than using computer simulation, can one estimate the performance of a complex dynamic system with non-linearities and sampled-data-type microprocessor control?

Although a bit pricey, if you are designing control systems this is an excellent tool

As an example of this, only in recent years has it become known that such systems can exhibit chaotic behaviour.

Conclusions

This is a very professional single-loop control-system tool which can be used interactively to design any closed-loop controller. It does not synthesise the design for you, but the speed at which a design can be assessed allows the knowledgeable designer to focus on a good design quickly.

A lot of thought has gone into the user interface, which uses single (though rather difficult to learn) keystrokes and pop-up windows to give very fast access to the features of the package. On the debit side, the copy protection system proved troublesome and there is no mouse support, which would have been particularly useful with the cursor interrogation system. Graphics support on screen is excellent, but support of hard copy is very limited, with only a **print screen** facility and no plotter output. Functionally, the software provides all that is needed to analyse single-input, single-output systems, with the ability to switch to the sample domain for microprocessor controllers. Although a bit pricey, if you are designing control systems this is an excellent tool to remove the grind from the analysis. ■

Analysis of an op-amp circuit

The circuit is a simple non-inverting amplifier synthesised using an amplifier with a DC gain of 2E6 and poles at 10Hz, 5MHz and 10MHz. From this basis we have that: G =

$$\frac{2E6}{(1.6E{-}2s+1)(3.2E{-}8s+1)(1.6E{-}8s+1)}$$

With the simple attenuator feedback, $H = R_1/(R_1+R_2)$, a number of values for H were tried.

Initially, this formula was tried in the form g/(s+A)(s+B), but caused the program to crash catastrophically back to the operating system, presumably due to overrange. To pursue the performance of the amplifier, the gain expression was re-jigged, assuming that around the frequencies of interest (say 1 to 10MHz), the first pole position at 10Hz would appear as an open-loop integrator. Thus, rescaling all frequencies to MHz, gave the expression

$$G = \frac{2E6}{s(3.2E{-}2s+1)(1.6E{-}2s+1)}$$

This was successfully entered and run in Codas, producing excellent results, as the figures show.

Supplier

Golten & Verwer Partners, 33 Moseley Road, Cheadle Hume, Cheshire SK8 5HJ. Codas II Control System Design and Simulation for the PC costs £295 for a single copy, £600 for departmental use (eight users) and £45 for additional licences. All prices are exclusive of vat.

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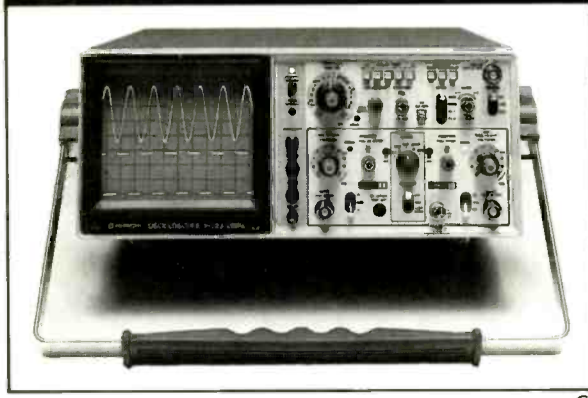

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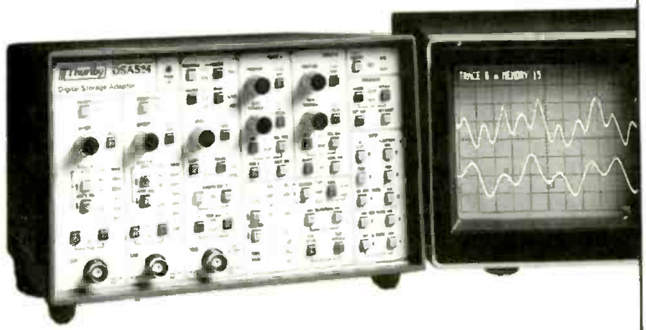

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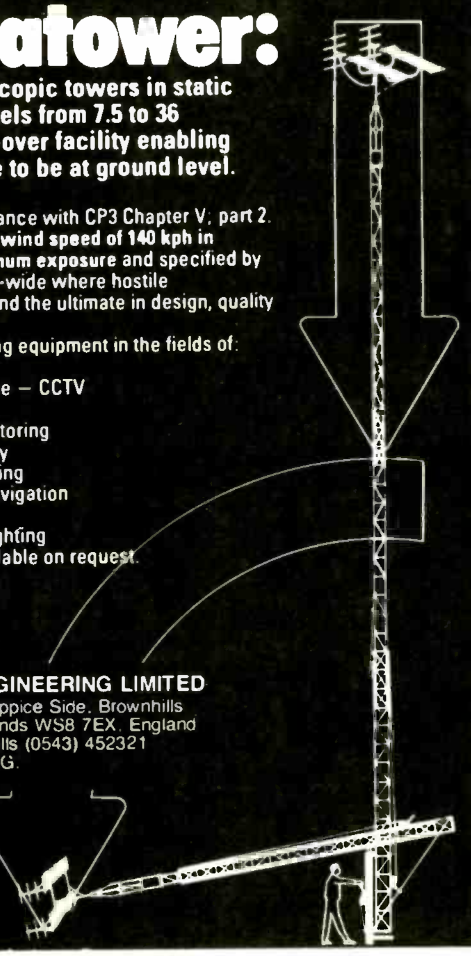

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CIRCLE NO. 105 ON REPLY CARD

Talking the language of development

Flexible and useful for advanced applications; but release 3.1 Asyst is not for the squeamish, says Allen Brown.

In broad terms Asyst can be described as a software development environment for the Asyst command language, designed for data acquisition, processing and system control.

It is well matched to the development needs of software for automatic test equipment systems, with its own constructs and conditional controls (if .. then .. else). Indeed the package's strength lies in versatility of its language, built from a large vocabulary of commands and operational words covering most needs for the acquisition, processing, display and storage of data derived from input signals.

The result is that Asyst has an inherent high degree of flexibility and users can produce customised signal processing and data manipulation programs to be used in turn-key systems for device testing and system monitoring.

But to make the most of the package the Asyst language must be learned — and this represents no mean feat, making it questionable whether it will appeal to the practising engineer whose time is at a premium.

Operation

The Asyst shell operates with a stack-like structure. As data or commands are entered (either from keyboard or program), the results reside on the stack (**Fig. 1.**). Command or data entry from the keyboard is sensitive to spaces — an annoying feature for the beginner.

Task execution is performed in reverse Polish so anyone familiar with a Hewlett Packard calculator should feel at home. But at a time when Windows rule the day, this aspect feels dated.

Space allocated for array storage is indicated on the overlay option list.

Installation is straight-forward, though to run the program a through-put dongle is required in the parallel printer port — an unnecessary irritation which extends the working length of the PC unit, intruding into a tight working space.

After the initial Asyst screen banner, the program again shows its age by displaying only "OK" in the top left hand corner of the screen — disappointing for such a costly software package where more of a visual impact could have been expected.

All data entries from this point onwards enter the stack. The keyed-in instruction stack. The keyed-in instruction stack display shows the depth and occupation of the stack, but when switching from graphics mode the stack display is lost and must be evoked afresh.

The Easy Coder option does go some way to remedy this kind of deficiency though menus really ought to be avail-

```
Current Stack Contents:   -.3000   (REAL)
                          -.0052   (REAL)
  Depth: 7                12.5430  (REAL)
                          34.6000  (REAL)

OK 256 ramp
OK 12 34.65 / 34 + 2 *
OK 12.3 34.6 .543 2.14
OK deg sin
OK 23.5
OK 65.8
OK 34.2
OK + + +
OK deg cos * 12.543
OK swap
OK 4.654
OK drop
OK deg sin
OK dup
OK asin
OK
```

Fig. 1. The Asyst shell has a stack structure, each data entry resides on the stack until processed

```
:                 :                     Asyst's quick guess
LOAD              ECHO.OFF
DEFER>            ABORT                 ACOSH
IMMEDIATE         MYSELF                ACOS
COMPILER.OFF      ENDOF                 ACOTH
."                WHILE                 ACOT
IF                REPEAT                ACSCH
UNTIL             [COMPILE]             ACSC
EXIT              THEN                  ASECH
QUIT              CLI.XEQ               ASINH
PROMPT.XEQ        TRACE.OFF             ABS
TRACE.DOES        RESUME                AXIS COLOR
{BRK}             ESCAPE
ONERR:            PAUSE                      R - remember
BELL              ?KEY                       H - help system
HEX               DECIMAL                 <cr> - to replace
INTEN.TOGGLE      HOME                   <esc> - to continue
INTEN.OFF         INTEN.ON
INVERSE.ON        INVERSE.TOGGLE
LEAVE             NOT                     XOR
OR                AND                     NOP
null

OK acoshz
```

Fig. 2. Help facility to access Asyst commands

able.

Commands

Asyst has an extensive range of instructions or commands, augmented by system overlays — entering ?words at the keyboard produces a bewildering flood of instructions.

Fortunately there are two useful help aids; an accompanying reference booklet, and well-thought-out help facilities. If the beginning of a command can be remembered then help can be evoked to suggest the possible full command **(Fig. 2)**. Extensive help is available as an overlay and can prove quite useful to the new user.

Several instructions can be linked together forming a command string:

```
: string.name
. command one
. command two
;
```

Every time string.name is entered, the instructions between : and ; are executed saving many key strokes. Unfortunately there is no obvious way of editing or viewing the command string once it has been generated, though it can be deleted.

Customising Asyst

An attractive feature of Asyst is its ability to customise. The substantial Asyst program is partitioned into its various facilities (stored as .sov files), each contained within an overlay.

F2 key evokes the configuration options **(Fig. 3.)**, and a number of overlay options also have sub-options **(Fig. 4.)**. A particular application will probably not require all the facilities of the program and Asyst allows selection of those overlays needed.

After selecting for a particular application, the system configuration can be saved as a .com file which can be used with the appropriate task. But having selected a set of overlays there appears to be no convenient way of deleting them from the list. F1 (the normal default help key) produces just a beep — a sound heard only too often during the steep learning phase of the product.

Data Acquisition

Asyst is primarily concerned with processing data derived from signals, and one area where the manufactures have focused a lot of attention is in design of data acquisition.

Input signals may originate from disc files, the IEEE-488 bus (GPIB) or from a sizeable variety of I/O expansion cards. To ease interfacing the PC with

```
            Available Overlays                       Selected Overlays

Editor                                        Array Editor
Help System                                   HP Plotter Driver
Array Editor                                  Statistics & Special Functions
RS-232
Algebraic Parser
Menu Tools
File Overlays
Graphics Overlays
Analysis Overlays
Data Acquisition
GPIB
External Interfaces

            Available Memory
Base Dictionary:        9668
Symbol Table:           6747
Overlay Memory:         10623                 Type:    O – for overlay description
String Segment:         6256                           W – to find a desired word
Array Memory:           16420                          &lt;esc&gt; – exit menu
```

Fig. 3. Available overlay menu and selected overlays thereby customising Asyst

```
            Available Overlays                       Selected Overlays

Editor                                        Array Editor
Help System                                   HP Plotter Driver
Array Editor                                  Statistics & Special Functions

   Statistics & Special Functions
   Bessel Functions
   3D Plotting
   Polynomial Operations
   Waveform Operations
   Matrix & Curve Fit Functions

            Available Memory
Base Dictionary:        9668
Symbol Table:           6747
Overlay Memory:         10623                 Type:    O – for overlay description
String Segment:         6256                           W – to find a desired word
Array Memory:           16420                          &lt;esc&gt; – exit menu
```

Fig. 4. Various overlay options provide sub-options which can be selected.

```
            Available Overlays                       Selected Overlays

E   Data Acquisition Master                   Editor
H   Data Translation 2800                     Help System
A   Data Translation 2820                     RS-232
R   Tecmar Lab Master                         Algebraic Parser
A   Tecmar Lab Tender                         HP Plotter Driver
M   Tecmar DADIO                              Statistics & Special Functions
F   Keithley Series 500                       Menu Tools
G   Cyborg Isaac 91
A   IBM DACA
D   Metrabyte DASH8
G   Metrabyte DASH16
E   Analog Devices RTI-800/815
    Analog Devices RTI-802
    Intel 8255 digital I/O
    General purpose I/O port
    External DAS Driver Support

Base Dictionary:        5883
Symbol Table:           5412
Overlay Memory:         10090                 Type:    O – for overlay description
String Segment:         5420                           W – to find a desired word
Array Memory:           10708                          &lt;esc&gt; – exit menu
```

Fig. 5. Sub-menu showing available overlays for commercial I/O cards.

the latter, Asyst is supplied with a selection of overlays for many well known products (**Fig. 5.**). In the event of an overlay not being available for an I/O card, an external driver can be used. Asyst has a number of device drivers for alternative I/O cards.

Each driver is accompanied by its own mini manual providing the information for linking Asyst to the expansion card. Extensive provision is also made for commercially available GPIB cards, again accessible through overlay options (**Fig. 6.**).

The user will still need to develop software drivers for instruments which hang on the GPIB, but the comprehensive nature of the Asyst programming language provides the necessary tools to achieve this. Complementing Asyst I/O is an extensive range of device-dependent direct-memory access allowing users to reach the low level operation of the I/O card/PC interface.

```
Available Overlays                                  Selected Overlays

Editor
Help System
Array Editor
RS-232
A
M
F    GPIB Master
G    Type 1 NEC GPIB driver
A    Type 2 NEC GPIB driver
D    Hewlett-Packard GPIB driver
G    TI TMS-9914 type driver
E    National AT-GPIB driver
     National GPIB-PCIII driver
     National MC-GPIB driver

            Available Memory
Base Dictionary:        11682
Symbol Table:           7665
Overlay Memory:         13286        Type:    O – for overlay description
String Segment:         6394                  W – to find a desired word
Array Memory:           16420               <esc> – exit menu
```

Fig. 6. Selection of GPIB cards which are recognised by Asyst.

```
CONFIG   FILE IO   GRAPHICS   ACQUIS   G   ANALYSIS   HELP
                        WAVEFORM OPERATIONS
          FAST FOURIER TRANSFORM

  Select an Array   BUFFER.A
  Return Results As . . .   SCALED MAGNITUDE AND PHASE
  Select Magnitude Result Buffer   BUFFER.C
  Select Phase Result Buffer       BUFFER.D
  Generate Code

          THE ARRAY YOU HAVE CHOSEN MUST BE ONE DIMENSIONAL
BUFFER.A
```

Fig. 7. Easy Coder is menu driven giving rise to sub-menus.

Tricky graphics

Make or break of an application program for data manipulation and processing is normally determined by graphics quality, after all it is graphics which give the greatest initial impact to a PC software product.

Asyst does not fare well in this respect and the effects of age are all too evident.

Although there is an option for the VGA standard, there is no option for Super VGA (screen resolution of 800 x 600 plus) which is a shame since many PCs have multisync monitors. To perform anything but the simplest plotting task is an involved operation, making learning difficult.

Even when copying examples from the manual, numerous problems can be encountered and the resulting display may be different to that shown. One more undesirable feature is the alphanumeric display on the left hand side of the screen; if a plot occupies that area, an entry on the command line causes a problem.

Display of any complex graphics is difficult and quite frankly the package is "user unfriendly" compared to graphics coding in C which is considerably easier. Plotting also has the peculiar quirk that after an array has been plotted, it vanishes from the stack and data is lost!

However, despite the reservations concerning ease of use of graphics, Asyst does have over 120 commands for graphics display purposes.

With the steep learning hurdle overcome, the product is able to offer quite clever features such as two dimensional- and contour-plotting. For the engineer who needs to pass information onto management personnel, the self contained commands for constructing bar graphs and pie plots and a Lotus 1-2-3 file link should be useful.

Easy Coder

A redeeming feature of the Asyst package is the Easy Coder which to some extent simplifies generation of Asyst code. Menu options make it more appealing to the user, with several main options giving rise to sub-menus (**Fig. 7**). A subset of the Asyst commands gives the feel for how the Asyst command language works.

As the options are worked through, the appropriate Asyst commands are compiled into a program file.

An example of an option is the set-up plot for graphics (**Fig.8**), where

```
        Graphics Setup

H. Axis          :  ON
H. Grid          :  ON
H. Plot type     :  LINEAR
H. Axis Size     :  .8000
H. Axis Point    :  .1500
H. Axis Divisions :  10
H. Tick Just.    :  .5000
H. Tick Size     :  .0200
V. Axis          :  ON
V. Grid          :  ON
V. Plot type     :  LOGARITHMIC
V. Axis Size     :  .8000
V. Axis Point    :  .1500
V. Axis Divisions :  10
V. Tick Just.    :  .5000
V. Tick Size     :  .0200
Plot style       :  SOLID
Plot color       :
Axis Color       :
Label Color      :
▶Vuport Color    :
Generate Code
```

Fig. 8. User selects graphics setting from Easy Coder option.

the user selects the various settings and colours. The last setting prompts Easy Coder to generate the appropriate Asyst code commands which are added to the program file. Once complete the file can be executed and modifications made through the editor.

A word of caution though: if not familiar with the Asyst commands when making changes to the program, it is very easy to fall foul of the system.

Signal analysis

A strong features of Asyst is the wealth of commands included for data analysis and processing, including two dimensional processes (2D-FFT and its inverse). But though there are all the normal commands for processing signals — such as convolution, correlation and power spectral density — there appears to be an absence of data windowing functions (Hanning, Kaiser, Blackman etc) which are essential for preprocessing data before using a FFT.

For users requiring statistical processing then Asyst will fulfil most needs. In addition to several distribution fits (Poisson, student-t etc), there are commands for curve fitting and even one for solving simultaneous equations.

A powerful set of commands for matrix or array manipulation includes a dedicated array editor overlay. Arrays can be real or complex and complex operations can be performed.

Additional Features

Having invested time and effort in constructing elaborate graphics displays, the screen image can be stored. Asyst has a PCX interface enabling the image to be converted into standard PCX image format and once converted it can be imported into various desktop publishing packages or stored for image processing.

Asyst programs can also be combined with Fortran or C programs and the Asyst Guide to New Feature Enhancements provides the necessary information for linking.

There is provision for ensuring that the printer matches the display, achieved with a "Baby Driver" editor. Recognising the popularity of menu driven displays, facilities enable users to design menu features and include them in the generated Asyst language code.

Documentation

Asyst is well provided with manuals; four major volumes (modules) and four smaller spring bound manuals help familiarise the user with the product. They are generally clearly written with lots of examples.

One of the smaller volumes, Quick Reference to Asyst Words is invaluable, as commands are listed under subject headings. The keyed-in instruction ?words gives all the commands in a jumbled up continuous stream, and is almost useless for reference purposes.

Conclusion

Asyst is in a very competitive market and though having considerable flexibility, it suffers from being difficult to use and generally quite unfriendly.

On a superficial level, it looks to have little more to offer than a pocket calculator, but for advanced uses it has a number of features to recommend it; the opportunity to reach the low level operation of the PC-I/O card interface enables maximum control to be exercised.

But proficiency at using Asyst is tempered by a steep learning curve and at this level Asyst will be competing with custom written C routines.

C is currently very popular amongst engineers and I feel that if the requirement is to get into low-level programming of a PC and interface, then C would be the natural choice.

If there is a requirement to develop a stand alone product for data acquisition and control then Asyst should be considered as a possible host environment. But now that software verification is a major aspect of a product's specification then Asyst should fair reasonably well. After all Asyst programs can be structured, commented and are easier to understand and follow than code written in C. ■

Asyst was among the first software packages designed for the PC to aid the engineer in processing signals. It was first issued in the mid eighties and after several upgrades later is available today as Version 3.1.

The package will run on IBM XT/AT and 386 machines and performance is improved by a maths coprocessor. Graphics options are available and it makes use of PC's LIM standard expanded memory (if available) for storing data arrays.

£995+VAT for analysis only, non-acquisition models; £1595+VAT for full package. Keithley Instruments Ltd, The Minster, 58 Portman Road, Reading, Berkshire RG3 1EA. Tel: 0734 575666.

BOOKS

Oscilloscopes, by Ian Hickman. This is an extended third edition of the book, which addresses the subject in a comprehensive manner. There have been many such texts in the past, most of them being written for the amateur; this one is at a much higher level and is intended not only for those with no knowledge of instruments, but also people coming into electronics from other disciplines. Oscilloscopes are, after the multimeter, basic instruments in most types of electronic design, development and service, and are also possibly the easiest to understand, which is why there have been so many books on the subject. Hickman takes his readers from a position of complete innocence, explaining the concepts involved, the various types of instrument and their characteristics and the circuitry used in their design. In a book of 248 pages, it is not possible to go deeply into any of the subjects, but there is sufficient detail to enable users of oscilloscopes to make an intelligent choice of instrument and to use it to its full potential. Unlike many of the other books referred to above, this text is completely in tune with current developments and covers both analogue and digital storage oscilloscopes. Appendices present information on types of screen phosphor and on manufacturers and their agents.

Butterworth Heinemann, 248 pages, paperback, £12.94.

Fibre optics — theory and applications, by Serge Ungar, translated from the French (the author is at Aerospatiale) by John Nelson. A good background in mathematics is the only requirement here, no previous knowledge of optics being needed.

The book is, in essence, in three parts: manufacture, interfacing and application of optical fibres. In the first part, the author presents the theory of fibres, of graded-index, multi-mode and monomode types. A chapter on fabrication follows and a further section describes the techniques of measurement used in fibre technology. The materials and design techniques of measurement used in fibre technology. The materials and design techniques employed in optical-fibre cables are the subject of the final chapter in this section. Third is a section on coupling lengths of fibre, excitation devices — leds and laser diodes — and receiving devices.

Finally, there is a chapter to the transducers used in interferometry, position, temperature and vibration sensing, and voltage and current measurement.

John Wiley, 228 pages, hardback, £34.95.

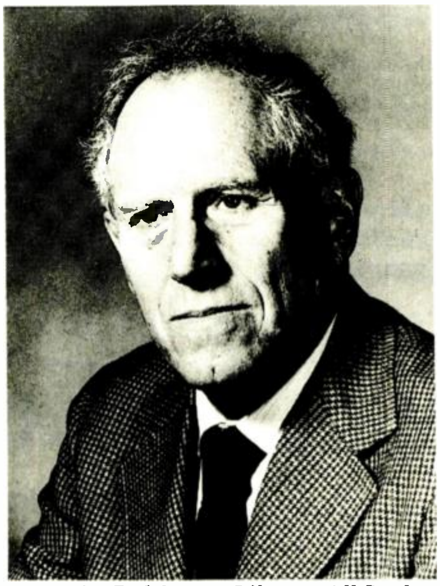
PIONEERS

Rudolph Kompfner (1909–1977)

"There is no harm in getting "expert" advice. But don't take it." W.A. Atherton

To have invented a twit does not appear to be the greatest of human accomplishments; at some time most parents feel they have done that. But when the twit turns out to be a friendly term for the travelling-wave tube (TWT) the event takes on real significance. TWTs have been used in a variety of electronic applications and are part of the farthest flung human machines, spacecraft, which are becoming mankind's first interstellar ambassadors.

The travelling-wave tube was invented by Kompfner in his spare time. Officially, he was working at the University of Birmingham as part of the war effort in World War II, trying to improve the klystron amplifier for use in radar receivers. It was in the same department that Randall and Boot invented the cavity magnetron. Whilst Kompfner's official work was leading nowhere, his evening hobby was heading for the jackpot. As Kompfner himself wrote, "I must emphasise again that all this work was carried on outside the laboratory; it was, so to speak, my spare-time amusement."[1] The story is reminiscent of Emile Baudot's spare-time invention of time-division multiplexing.



Portrait: Codrington Library, All Souls College, Oxford.

Architect

Kompfner was known as Rudi. "Few who knew him knew him as Kompfner or Dr Kompfner, and none as Rudolph," says J. R. Pierce, the American physicist who worked with him for many years[2]. Rudi was born on the 16th May, 1909 in Vienna, the elder child, and only son, of Bernhard Kömpfner and his wife Paula Grotte. Bernhard was an accountant, but also an accomplished musician who composed Viennese songs and waltzes. Rudi inherited a lifetime love of music.

World War I raged whilst Kompfner was a young boy and Vienna was blockaded. Suffering from malnutrition, he was evacuated by the Red Cross and put on a train to Sweden. His parents, apparently, did not know exactly where he was and it must have been a nightmare for them and for him[2]. World War II was also to have troubles in store, but before that there were happier times. He graduated in 1931 from the Technische Hochschule in Vienna with a degree in engineering (architecture). Two years later, in his mid twenties, he completed his studies of architecture in Vienna, becoming a Diplom-Ingenieur.

The 1930s were dangerous times for Jews in Austria, but Kompfner had a cousin in England. Her husband, Roy Franey, helped him to get to England in 1934 and then found him a job as an architectural apprentice. From 1936 to 1941, Rudi Kompfner was the managing director of Franey's building firm.

By that time, Kompfner's interest had been well and truly awakened in physics, as well as architecture. In fact, it would appear that architecture was never his first choice; it has been dictated by his father. His interest in physics, however, was self-generated and was sparked by the writings of the French physicist Arago, an early 19th century contemporary of Ampère.

One oft-repeated story of Kompfner's training as an architect is worth one more repetition because it has a lesson for anyone; not only that, but a lesson that others have discovered for themselves. Kompfner had been told to design a house and he sat and stared at his blank sheet for hours without drawing a stroke. "An infinity of possible solutions to the problem occurred to me, but I could not see why I should single out any particular one by starting with it.[1]" A senior draftsman came to help and simply drew a square. When Kompfner objected to the square as an unlikely shape for a house (he should be around today) it was changed. When the change was criticised it, too, was changed, and so on. Gradually an acceptable design evolved. "The secret of starting," he had learned, "is to start." "Starting means at least doing something."

Internment

Once in London, Kompfner pursued his love of physics by visiting the Patent Office library in the evenings and reading publications. In 1935 he started to keep notebooks in which he recorded his ideas and two years later he received his first patent for a television pickup device. He tried to market it, but without success. Also in 1935, another love of his life developed when he met Peggy Mason at the Westminster swimming club; Kompfner was a keen swimmer. They married on the 29th April, 1939 and subsequently had two children, a boy and a girl.

One day in June, 1940, Peggy returned hom from work to find that her husband had been taken to Brixton police station and interned as an enemy alien. His internment was spent on the Isle of Man where he shared quarters with Wolfgang Fuchs, the mathematician. Apparently, they talked about physics.

Kompfner's internment was thankfully short. Before he was detained he had sent a paper on magnetrons to the magazine *Wireless Engineer*, the editor of which had brought the paper to the attention of the Admiralty. Kompfner had meanwhile declared himself to be stateless and friends were petitioning for his freedom. He was duly released in December, 1940, after six months. Then, "I was more or less drafted to the physics department of the University of Birmingham," Kompfner wrote in 1964[1]. It was there, under the guidance of Professor Mark Oliphant, that the Admiralty had set up a secret research group with the task of making a practical centimetre radar system. Kompfner arrived in 1941 and within two years had invented the travelling-wave tube.

Travelling-wave tube

At Birmingham, Kompfner was assigned to work with researchers P.B. Moon and R.R. Nimmo. "I owe a lot to them," he wrote. They taught him physics and electronics, how to experiment and how to set up theoretical models. He learned well.

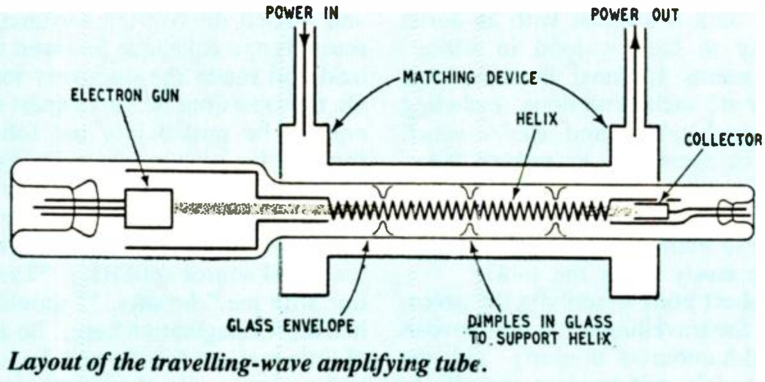
His task was to further develop the klystron amplifier and improve its noise figure. He followed the received wisdom of how to do this and "spent two years building klystrons along these lines and getting very discouraged with it in the process". "There is nothing like a goodly amount of dissatisfaction and unhappiness to bring on invention," he has remarked.

Outside work, he began to follow a quite different idea to that of the klystron: he would move the field with the electrons. His notebook for the 6th September 1940, records the idea of making the field move at the same velocity as the electrons. He needed to reduce this velocity and, after discussions with colleagues, the idea of using a helix as a transmission line was born. Kompfner then went to see the acknowledged expert on transmission lines at Birmingham. The expert thought it a poor idea but, when Kompfner tried it, he found that it did work. "I was tactful enough not to go back and tell the expert, but I did not conult him again," said Kompfner. "I might remark that there is no harm in getting expert advice. But don't take it."

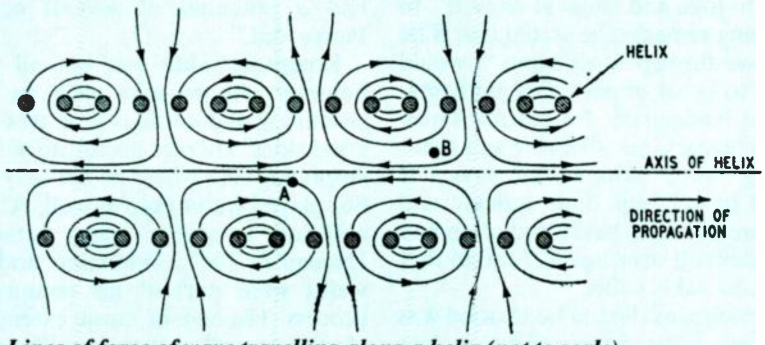
The story of the invention of the travelling-wave tube is too complex to describe fully here, and Kompfner himself has given a detailed account elsewhere[1]. Ideas changed, blind alleys were followed (six months were wasted down one), the helix was abandoned and then returned to and colleagues pointed out mistakes in his theories.

In August, 1943, the group at Birmingham broke up and half the staff were moved to Los Alamos to work on the atom bomb. With others, Kompfner decided to stay in England where he would now be allowed to work officially on his, now well known, homework. Despite setbacks, progress was made. Then in 1944 the group at Birmingham was dispersed and he was moved to the Clarendon Laboratory at Oxford University.

At Oxford, he was visited by Dr John Pierce from Bell Laboratories who had read some of the secret wartime memoranda which described his work. (Incidentally, the first British publication describing the TWT appeared in *Wireless World* in 1946.) Back in America, Pierce was able to develop the theory of the tube, but it was Kompfner who, virtually single handedly, conceived the idea and built working travelling-wave tubes. They were the first of a family of devices which came to be used in radar and space communications.



Layout of the travelling-wave amplifying tube.



Lines of force of wave travelling along a helix (not to scale).

After the war ended, Kompfner became a British subject (1947) and in 1951 he received a D.Phil. in physics from Oxford. Meanwhile, Pierce had persuaded him to move to Bell Laboratories in the USA. After a long wait for a visa he joined Bell on the 27th December 1951 and continued his research on microwave tubes. In 1955, he became Director of Electronics Research. By 1962 he was Associate Executive Director, Research, Communication Sciences Division and his influence was felt on research programmes as varied as masers, lasers, superconducting magnets and optical communications. Also, he had taken out American citizenship.

Satellites

In 1958 Kompfner and Pierce became interested in the idea of communication satellites. They wrote a paper exploring the possibilities for such satellites and Rudi's team designed the first one: Echo I. It was launched on the 12th August 1960. Pierce says the work was carried out under Kompfner's "inspiration and direction". Kompfner was also deeply involved with Telstar (1962), the first communications satellite to carry live television across the Atlantic.

Kompfner retired from Bell Labs in July 1973 and thereafter split his time between Stanford University (where he spent the winters) and All Souls College, Oxford (where he enjoyed the summers). At Oxford, his work centred on the use of fine lasers in scanning optical microscopes, whereas at Stanford he turned his attention to acoustical as well as optical microscopes. He left behind him a reputation as a generous and warm-hearted man who readily gave time and sound advice to his students. "No-one ever found him too busy to listen," wrote Pierce. No matter how many projects he had in hand, he always found time to discuss a new one.

Pierce has recounted many anecdotes about Kompfner. At one time Rudi conducted seminars for freshmen at his home and in his garage. He and the students suggested projects and one was chosen by vote. One year, he was very disappointed that his own favourite lost by one vote. It was to build a very small swimming pool in which one could swim long distances against a current without moving with respect to the pool. It still sounds like a great idea.

Another of his little inventions was a cat door which would prevent the entry of raccoons but still alow the cat in. An abandoned baby raccoon became a pet and he built it a house with an aerial tramway to take it food in winter. There seems to have been a large number of such diversions, including four-legged tables and chairs which would sit evenly on an uneven floor. Another, which Pierce describes as "unqualified success" was a mat or coaster to allow the port and madeira to slide easily along the table.

His short book describing the invention of the travelling-wave tube reveals a good-humoured modesty and the ability to joke and laugh at oneself[1]. In his closing remarks, he stated that if he could live through it all again "I would try not to be so stupid". His mathematics was inadequate, he did not know enough physics, his soldering and glass-blowing were sloppy, he says. "I wanted to get jobs done quickly and therefore did them badly and often had to do them all over again. I found that it pays to take pains."

A professional lesson he learned was not to get side-tracked; doing so cost him far too much time. Yet on one occasion he resisted being side-tracked and missed discovering ferromagnetic resonance; a colleague followed up the lead and made the discovery instead. On two occasions he took expert advice only to be misled into not following through his own convictions. Finally, he remarked, a research worker must have imagination. His travelling-wave tube worked over the entire range of his signal source (60MHz). "That was fine with me," he says. "I should have had more imagination here," he added. "I little realised that I had a device that had a potential of several octaves. Pierce did."

Kompfner's life was not all work, however. As we have seen, he loved swimming and music and he was also a good skier. He met his future wife at a swimming club where he not only swam but played water polo as well. After he suffered a severe heart attack in December 1967, swimming and long walks were part of his recuperation process. His love of music extended to playing as well as listening. Though he never mastered reading music he could play the piano well enough to accompany orchestral music from a record or the radio.

He was also something of a romantic, loving the ceremonial side of life at Oxford and delighting in having crossed the Atlantic in Concorde. Presumably he also enjoyed the collection of scientific medals and awards and honorary degrees he received. The latter came from both Oxford and Vienna, and the medals flowed from both sides of the Atlantic.

Late in 1977, Rudi suffered another heart attack. He was rushed from his home to Stanford hospital in California. Although he started to make a sustained recovery, it was not to be and he died on the 3rd December, 1977. He left a legacy of engineering achievements – and research scientists he had trained to listen to expert advice, but not necessarily take it.

References

1. R. Kompfner, "The Invention of the Travelling-Wave Tube," San Francisco Press, 1964.
2. J.R. Pierce, "Winning Ways: Kompfner's career," Memorial Lecture 5th May 1978.

Cúk: the best SMPS?

A properly designed Cúk converter allows DC to DC conversion at efficiencies of 90 per cent or higher, says T.S. Finnegan. Sophisticated design philosophy lies behind a minimal component count.

In 1978, the US Patent Office granted Dr S. Cúk (pronounced Chook) a patent for the design of a new power converter topology. This was the end of a search for a structure which combined the advantages of other known structures without any of the disadvantages in the minimum number of components.

Historically, many popular switching converter topologies were conceived more or less at random and often by accident. This new converter was the exception. The new topology comprised a combination of a boost converter followed by a buck converter, as the diagrams show.

Benefits of the Cúk converter include increased efficiency, low input and output current ripple, minimal RFI and small size and weight.

Basics

Figure 1a shows a boost converter followed by a buck converter. In **Fig.1b**, the two switch-and-diode sets are replaced by a single DPDT switch, operating with polarities as shown. Capacitor C_1 is the energy storage element, transferring power from the input to the output. As shown in **Fig.1c**, the DPDT switch and shunt capacitor can be replaced by a SPDT switch and series capacitor, if a polarity reversal of the output voltage is allowed. Finally, **Fig.1d** shows the practical realisation of this new converter.

The properties of the Cúk converter closely approach those of an adjustable ratio DC-to-DC transformer. The DC voltage transformation ratio M is $M=D/D'$, where D is the duty ratio (fractional on-time) of the transistor switch operated at a switching frequency $1/T_s$, and $D'=1-D$ is the complementary duty ratio (fractional off time). For a DC input voltage V_i, the output voltage is $V_o=M.V_i$. The converter thus has a step-down ratio for $D<0.5$ and a step-up ratio for $D>0.5$. The other principal feature is that both the input and output currents are non-pulsating, both being smoothed by the input and output inductors. These inductors also eliminate current surges in the transistor switch at power-on and power-off, which is often a difficult problem to solve.

Theoretically, the output capacitance C_2 is not needed, but it is usually included to absorb the load current fluctuations. The Cúk converter is unique because energy transfers capacitively from the input to the output, instead of inductively as in all previous converters.

A capacitor of 1µF charged to 50V has a stored energy of 1.25mJ, equal to an inductor of 2.5mH passing 1A. The size of a 1µF 50V capacitor, however, is considerably smaller than a 2.5mH 1A

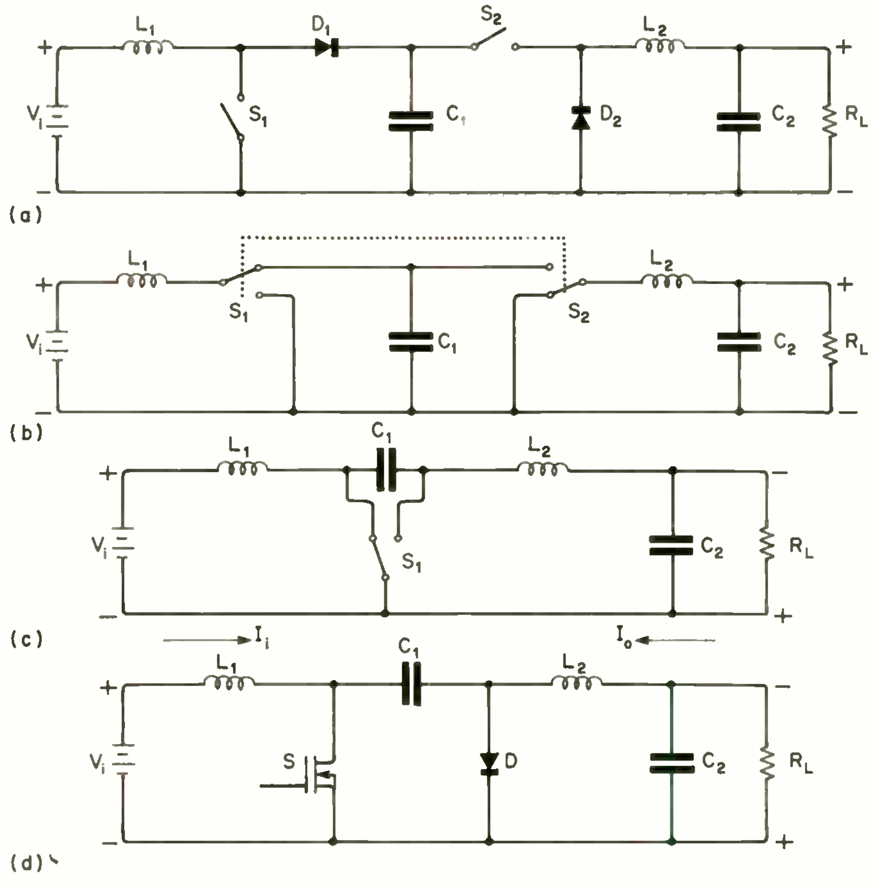


Fig.1. Cúk converters come in all shapes, sizes and switching arrangements with switching balance between input and output sides as the common feature. a) Boost/Buck Cúk converter b) DPDT switching converter c) SPDT switching and d) a practical circuit arrangement.

choke. Therefore capacitive energy transfer is more effective on a per unit size or weight basis than inductive energy transfer.

Because the input and output inductor currents are essentially constant, the switching current is confined entirely within the converter in the transistor-coupling capacitor-diode loop. With careful layout, this loop can be made physically small, which will reduce the radiated RFI from the magnetic field. In addition, the voltage and current waveforms in this converter are particularly clean, with very little ringing or overshoot; very little snubbing is needed.

Operation

The correct operation of the converter depends upon the inductor current remaining continuous throughout the cycle (neither inductor current falls to zero), and upon the capacitor C_1 being large enough to support the voltages across it throughout the cycle without appreciable decay. (Continuous capacitor voltage is the dual of continuous inductor current).

During the interval when switch S is open, the diode is forward biased and capacitance C_1 is charging in the positive direction through inductance L_1. During the interval when switch S is closed, capacitance C_1 is connected across the diode, which is therefore reverse-biased. Capacitor C_1 discharges through L_2 and load R_L, thus charging the output capacitance C_2 to a negative voltage. Finally, to close the complete cycle, when switch S is again open the diode conducts again and the output capacitance C_2 is charged positively, using the stored energy in L_2. **Figure 2** shows the voltages and currents during the cycle.

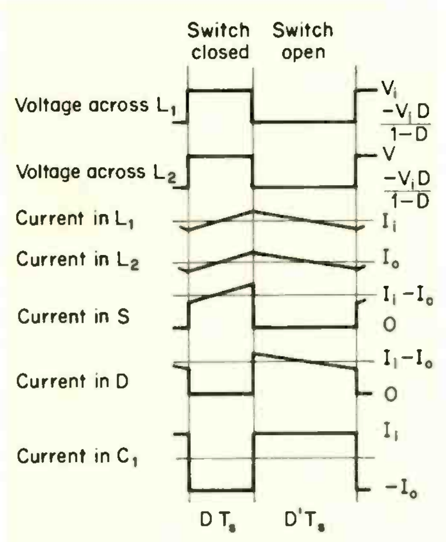


Fig. 2. Voltages and currents during the Ćuk cycle

Further research then showed that L_1 and L_2 could be wound together onto a common core, further simplifying the construction. If the inductors L_1 and L_2 are equal in value, then the voltage waveforms on each will have the same amplitude and phase as the waveforms in Fig.2 indicate. Hence the two inductors can be coupled together without affecting the basic DC conversion property, provided that the correct polarity is observed.

Circuit operation with coupled inductors is as follows. The switching action through the capacitance C_1 and switch S imposes internally some voltage waveforms on the inductors, while the transformer action imposes simultaneously another external requirement upon the same voltage waveforms. However, with a 1:1 ratio, the two conditions are consistent and the basic conversion property is not affected.

Notice, however, that there are now two paths for energy transfer. Energy transfers from the source to the load through the commutating capacitance C_1 (by the electric field) owing to the switching action, and directly through the transformer (by the magnetic field).

The total DC magnetising current in the core is the sum of the input and output currents, and the core cross-section must be chosen accordingly. The integrated magnetic element behaves essentially as two uncoupled inductors for DC current, but acts as a transformer for AC current.

Figure 3 shows the converter redrawn with L_1 and L_2 coupled together.

Zero ripple current

Further research into the operation of the integrated converter then revealed a surprising advantage: if the magnetic coupling and leakage reactances of L_1 and L_2 are properly considered, then a turns ratio and coupling coefficient can be chosen for L_1 and L_2 such that the AC current flow in either (but not both) is reduced to zero. Furthermore, this condition holds for all values of D. Usually the designer chooses to reduce the AC current in the output to zero, thus minimizing the output voltage ripple and further reducing the RFI. The analysis in the Appendix gives the conditions for zero ripple as

$$Le_1 = L_{11}\,[N_2/N_1 - 1]$$

for zero output current ripple

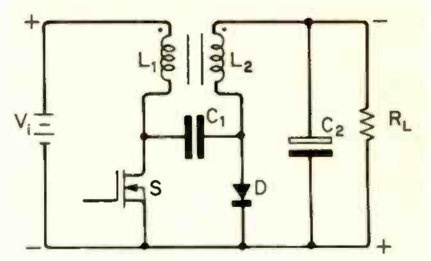


Fig. 3. The Ćuk circuit allows the integration of separate inductors into a single, close coupled transformer. DC currents in the core cancel out minimising the problems of core saturation.

$$Le_2 = L_{11}\,(N_2/N_1)^2[N_1/N_2 - 1]$$

for zero input current ripple

where

Le_1 is the leakage inductance of L_1
Le_2 is the leakage inductance of L_2
N_1 is the number of turns on L_1
N_2 is the number of turns on L_2
L_{11} is the self-inductance of L_1

This analysis assumes that L_1 and L_2 are perfectly coupled together on the core.

In practice, it is extremely difficult to design and consistently manufacture a transformer with the specific values of leakage inductance and tight coupling necessary to achieve and hold the balance condition specified above. One viable solution to this problem is to tightly wind L_1 and L_2 together (using a bifilar winding if possible) and then insert a small trimming inductor to simulate L_e. Furthermore, one extra turn on L_2 will guarantee that the term in the brackets for zero output current ripple is always positive and the small trimming inductor is then put in series with L_1. If the turns on the trimming inductor L_e are varied, then the current in L_2 will have either a positive or negative ramp, depending on the value of L_e. This indicates that the effective inductance of L_2 can be varied between a positive value and a negative value, and that at the balance point, the effective value of L_2 is infinite.

This zero ripple current phenomenon can be considered from a different viewpoint, by introducing two important quantities, the coefficient of coupling, k, and the effective turns ratio, n, as

$$k = \frac{L_m}{\sqrt{L_{11}.L_{22}}}$$

$$n = \sqrt{\frac{L_{11}}{L_{22}}}$$

The effective turns ratio defines the mismatch between the primary and secondary self-inductances L_{11} and L_{22}. By design, n will be very close to 1 because of the necessary 1:1 choice for the turns ratio. The coupling coefficient k, however, determines how tightly the two windings are magnetically coupled and can lie anywhere in the range from 0 to nearly 1. Using quantities k and n, the effective values of the input and output inductances can be expressed as

$$L_{1ef} = L_{11} \cdot \frac{1 - k^2}{1 - k.n}$$

$$L_{2ef} = L_{22} \cdot \frac{1 - k^2}{1 - k/n}$$

where L_{1ef} is the effective value of L_1 and L_{2ef} is the effective value of L_2.

These expressions show the physical conditions needed for zero input or output current ripple. There will be zero output current ripple with an exact 1:1 turns ratio if k equals n. A well constructed device with close coupling will approximate to this, so that some reduction in output current ripple can be expected to occur normally without the need for a trimming inductor. In contrast, however, zero input current ripple can only be achieved if both k and n equal 1, which is physically impossible. Hence if zero input current ripple is needed, L_1 will need an extra turn and a trimming inductor should be added into the output.

To acquire a feeling for the numbers involved, if n=0.99 and k=0.98, then $L_{2ef} = 4.L_{22}$, that is a fourfold increase in the effective value of the output inductance, as far as the ripple is concerned.

In practice, the minimum achievable ripple current is limited by the inter-winding capacitance, which introduces an error current in quadrature and thus Sod's Law raises its head again. The inter-winding capacitance must be reduced to the minimum practical value, consistent with close magnetic coupling. The bulk of this capacitance is due to the capacitance of one winding to the core and back to the other winding. This can be reduced by spacing the windings off from the core, using a tape with a low dielectric constant if a toroidal core is being used, or making up a cardboard bobbin to replace the standard nylon bobbin if E-cores are used. Cotton covered wire also helps.

Transformer extension

The converter in its basic form provides a single, polarity-inverted, non-isolated output. However many applications need DC isolation between input and output, and/or multiple outputs of different voltages and polarities.

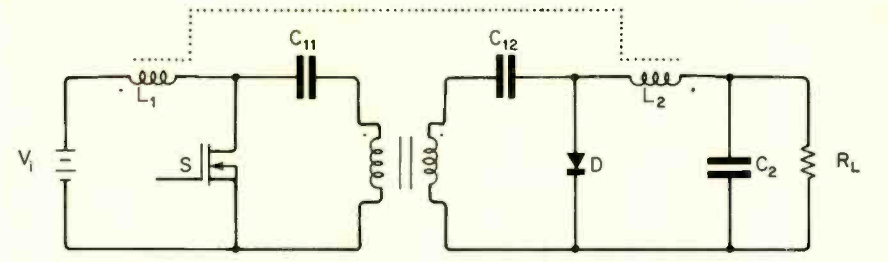


Fig. 4. Dividing the capacitance and the associated inductance allows supply isolation.

This can be elegantly achieved by dividing the coupling capacitance C_1 into two series capacitances and inserting a coupling transformer between them, as shown in **Fig. 4**. If the inductance of the transformer windings is large enough, the converter will operate as before. However, in this case, the turns ratio of the coupled inductors should be made equal to the transformer turns ratio, with the polarities as shown. This solution has a considerable advantage over other converter topologies: there is no direct current in either winding, enabling full use of the BH loop, and the core material can be ungapped, square-loop ferrite. This will give a smaller transformer, with lower losses than in the equivalent forward or flyback converter.

Cúk converters are very efficient and values greater than 90% are readily attainable. This can be directly attributed to the lower copper losses when compared to standard buck or boost converters and the improved operating duty ratio of the Cúk converter. The table below gives the effective primary and secondary copper losses, and the transistor and diode stress levels for the three types of converter, operating under identical conditions, for three different output voltages. The Cúk converter is more efficient and has lower stress levels in almost every respect.

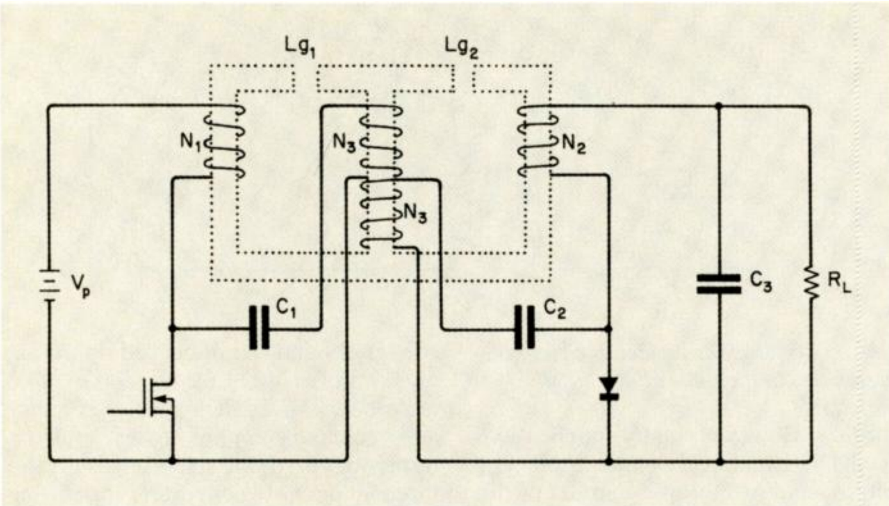
Transformer and Inductor Integration

Finally, the transformer and both inductor windings can be integrated onto a common magnetic structure, as shown in **Fig. 5**.

where
N_1 is the number of turns on L_1
N_2 is the number of turns on L_2
N_3 is the number of turns on the coupling transformer (assumed 1:1 ratio)
L_n is the transformer leakage inductance
L_{g1}, L_{g2} are the inductances associated with two air gaps, one in each side

In 1983 Cúk, in an extensive analysis of this structure, showed that the AC current ripple in both the input and output circuits could be reduced to

	$V_o = 0.5V_i$			$V_o = V_i$			$V_o = 1.5V_i$		
	Cúk	Forward	Flyback	Cúk	Forward	Flyback	Cúk	Forward	Flyback
D	0.33	0.25	0.33	0.5	0.5	0.5	0.6	0.75	0.6
Primary copper loss	$0.5I^2R$	I^2R	$0.75I^2R$	I^2R	$2I^2R$	$2I^2R$	$1.5I^2R$	$3I^2R$	$3.75I^2R$
Secondary copper loss	$0.5I^2R$	I^2R	$1.5I^2R$	I^2R	$2I^2R$	$2I^2R$	$1.5I^2R$	$3I^2R$	$2.5I^2R$
Transistor I_{ON}	1.5I	2I	1.5I	2I	2I	2I	2.5I	2I	2.5I
Transistor V_{OFF}	$1.5V_g$	$2V_g$	$1.5V_g$	$2V_g$	$2V_g$	$2V_g$	$2.5V_g$	$4V_g$	$2.5V_g$
Diode I_{ON}	1.5I	I	1.5I	2I	I	2I	2.5I	I	2.5I
Diode V_{OFF}	$1.5V_g$	$2V_g$	$1.5V_g$	$2V_g$	$2V_g$	$2V_g$	$2.5V_g$	$2V_g$	$2.5V_g$



zero, if the magnetic parameters were correctly chosen. Using some simplification of his solution, he gives the conditions for zero current ripple in both input and output circuits (assuming uniform core cross-section throughout) as

$$L_n/L_{g1} = N_1/N_3 - N_1/N_2 - 1$$

and

$$L_n/L_{g2} = N_2/N_3 - N_2/N_1 - 1$$

Once again we see that the leakage inductance is a critical element and it is necessary to stabilise this by the deliberate inclusion of a small balancing inductor as previously discussed, to generate an accurate value for L_n.

Operating characteristics

A full signal analysis of the Cúk converter is very complex and beyond the scope of the present article. Suffice it to say that, from the steady state model, the DC gain, which includes primary and secondary series loss resistances R_p and R_s, is obtained as

$$\frac{V_o}{Vi} = \frac{D}{D'} \cdot \frac{R_L}{R_L + R_s + R_p(D/D')^2}$$

From the AC model for the coupled inductor converter, there are poles and zeros at the following frequencies:

$$\text{An input pole at } f_{p1} = \frac{D'}{2\pi\sqrt{L_1C_1}}$$

$$\text{An output pole at } f_{p2} = \frac{1}{2\pi\sqrt{L_2C_2}}$$

$$\text{A complex zero at } f_z = \frac{\sqrt{D'}}{2\pi\sqrt{L_1C_1}}$$

Unfortunately, the complex zero is usually in the right-half plane. However, if R_p is deliberately increased so that $R_p > L_1/R_L.C_1.D'$,

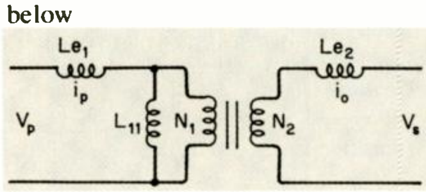
Fig. 5. Cúk converter with all windings integrated into a single magnetic structure. Magnetic balance is critical and leakage inductance may cause problems.

then the zero is transferred into the left-half plane in the case of uncoupled inductors.

When the inductors are coupled together, this condition does not apply and a complication of the frequency response is the penalty to be paid for coupling the inductors. Nevertheless, the potential stability problem arising from this complex right-half plane zero can be solved through standard current mode programming techniques.

APPENDIX
Conditions for zero current ripple

Key factors in achieving zero ripple current are the relationships of the voltage across the coupled inductors and the choice of leakage inductances associated with the windings. Given that a two-winding inductor is nothing more than a dual-winding transformer, proper modelling of this transformer can be used to determine what values of leakage inductances are relevant to producing the zero ripple conditions. Consider the case of a coupled-inductor Cúk converter with equal primary and secondary voltage waveforms. The coupled inductor can be modelled as a transformer as shown below

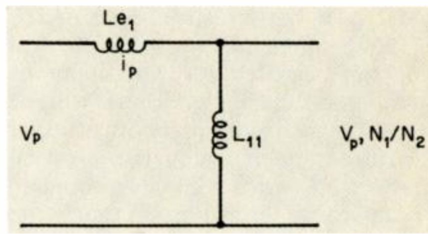


where

L_{11} is the self-inductance of L_1
Le_1 is the leakage inductance of L_1
N_1 is the number of turns on L_1
N_2 is the number of turns on L_2
L_{e2} is the leakage inductance of L_2

Both the input and output of this transformer model are excited with equal voltage sources of like frequency and phase, i.e. $V_p = V_s$.

Now assume that the value of i_0, the AC secondary current, is reduced to zero. If this is so, then the voltage across L_{e2} must also be zero and the voltage appearing across L_{11} must therefore be equal to that of the secondary voltage reflected through the ideal transformer. Also the current through L_{e1} and L_{11} must be equal to that produced by the primary voltage V_p. These conditions lead to the simplified model below:



Hence

$$V_p = (Le_1 + L_{11})di_p/dt$$

and

$$Vp.N_1/N_2 = L_{11}.di_p/dt$$

Combining these equations gives the conditions we are seeking ie

$$Le_1 = L_{11}[N_2/N_1 - 1]$$

Since this expression was developed on the basis of no output current ripple, then if this expression is satisfied, the no output current ripple condition must exist in practice.

Similar reasoning can be used to produce the condition for zero input current ripple ie,

$$L_{e2} = L_{11}(N_2/N_1)^2[N_1/N_2 - 1]$$

■

References

S. Cúk and R.D. Middlebrook, "A New Optimum Topology Switching dc-to-dc Converter", IEEE Power Electronics Specialist Conference 1977 pp 160–179

S Cúk and R.D. Middlebrook, Coupled-Inductor and Other Extensions of a New Optimum Topology Switching Converter, IEEE Industry Applications Society Annual Meeting, 1977 pp 1110–1126

S Cúk and W.M. Polivka, *Analysis of Integrated Magnetics to Eliminate Current Ripple in Switching Converters*, Power Conversion International Proceedings, 1983 pp 361–386

ACTIVE

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

High-speed A-to-D converter. The Sony CXA1296P high-speed 8-bit A-to-D converter offers a sampling rate of 20 Msamples/s, an 8MHz input band (-3 dB) and an input capacitance of 30pF. It will operate from a single or bipolar 5V supply. The device will operate in binary or two's complement mode, and a sample and hold amplifier is not required. Price £8.00. Hakuto International(UK) Ltd, 0992 769090.

BiCmos A-to-D converter. The MAX174 8μs 12-bit A-to-D converter has a 10-ppm/°C buried-zener reference, a clock oscillator, and a microprocessor interface. It is a BiCmos drop-in replacement for the 25μs 574A and the 15-μs 674A. Pin-strapped analogue input ranges include 10V or 20V unipolar, and +5V or +10V bipolar. Chip select, chip enable, and read/convert inputs control the three-state interface to an 8-, 12-, or 16-bit data bus: data-access time is 150ns max. Kudos Thame Ltd, 0734 351010.

True 16-bit A-to-D converter. MN6400 is a self-calibrating converter digitising analogue input signals at a 50kHz rate. Self-calibration upon power-up is all that is required to achieve specified performance. It has an inherent T/H amplifier function, analogue input buffer, reference, clock and control logic circuitry, and a parallel data bus driver. All are contained in a single, 28-pin double-wide side-brazed DIP. Micro Networks, 010 1 508 852 5400.

Discrete active devices

High breakdown voltage RF transistor. The cut-off frequency of the MPSH10/FMMTH10 chip is greater than 650MHz. Maximum collector-emitter voltage is 25V. Typical noise is 3dB. C_{ob} capacitance is 0.7pF. With a minimum static transfer ratio of 60, it handles a continuous collector current of 25mA or 50mA pulsed. Surface mount or through-hold assembly. Dissipates 350mW in SOT23 and 500mW in E-line. Zetex plc, 061 627 4963.

Linear integrated circuits

High performance variable gain. The NE5209 variable gain amplifier has a gain out to 1.5GHz, and a linear gain control range allowing precise AM modulation. Philips claim "near perfect linearity" and that "everything needed for wide bandwidth variable gain is in one package". Noise increases 0.6dB for each 1dB gain drop. At maximum gain, noise can be minimised to 7dB. $14.24 to $17.08 each. Philips Components-Signetics, 010 1 408 991 2000.

Fast fifo from Music (Mogul), with access time of 20ns.

Memory chips

Fastest 1Mbit cmos dram. Electronic Designs has introduced the fastest 1Mbit cmos dram, compliant to MIL-STD-883C, paragraph 1.2.1. It is available in two organisations; page-mode 256k x 4 (EDI44256C) or 1M x 1 (EDI411024C). Row access strobe access times for both parts are 70, 80, 100, 120 and 150ns. Maximum current draw for the 80ns versions is 70mA. When the ras and current access strobe pins are TTL high, standby current for 80ns versions is approximately 2mA; within 0.5V of VCC, standby current is 0.5mA. EDI, 0276 72637.

Monolithic substitute. Micro Call's EDI8M8512 four megabit 45-150ns sram is being touted as an "in advance" version of the monolithic device said by manufacturer EDI to be still some time away. Users will be able to do a plug-in pin-for-pin device-swap when the monolithic device becomes available. Functional equivalence is due to an on-board decoder that interprets the higher order addresses, A17 and A18, to select one of the 128k x 8 srams. Micro Call Ltd, 0844 261939.

20ns fifo. Fast fifo memory, the MU9C2903 from Music, has access time of 20ns. It is organised as 2k x 9bits allowing data transfer between systems while maintaining parity information. Asynchronous and simultaneous operation of read and write ports. Multiple devices can be used to expand depth and width with minimum external logic. Full, half-full and empty flags are provided. Retransmit capability. Mogul Electronics, 0732 741841.

Microprocessors and controllers

Fast transputer. Part of the Inmos IQ product range, IMS B426 is aimed at memory-hungry applications where space is tight. The 25MHz T800 transputer delivers a peak performance of 25Mips, 3.5Mflops. 4Mbyte one wait-state dram gives an external memory bandwidth of 25Mbyte/s. Up to 200Mips, 28Mflops peak performance and 32Mbyte capacity can be obtained on a single PC or VMEbus card. Barlec-Richfield Ltd, 0403 50111.

Vax accelerator i860. Hxi860 co-processing system for Dec computers provides 80Mflops and 40Mips accessible from within the VMS environment. It is capable of supporting multiple users and can be networked. Existing Vax-based applications can be accelerated by a factor of 40. Multiple HXi860s in parallel permit unlimited power to be added. The module contains a 40MHz i860, a 25MHz Inmos transputer, and up to 20Mb of memory. Caplin Cybernetics, 071 538 1716.

Lower cost 32-bit power. Motorola's 68331 is similar to its 68332, but with cost-saving changes that make 32-bit power available at lower cost. The modular design 331 has a CPU which is subset of the 68020. It is integrated with a queued serial module, a system integration module and a general-purpose timer. The smaller timer replaces the high-performance unit on the 332 and does not run independently. Price less than $40.00. Motorola Ltd, 0908 614614.

Faster 8-bit buses. The 68HC11K4 and 68HC711K4 8-bit devices operate at double the bus speed of Motorola's original 68HC11 and include memory configurations and on-chip peripherals. The K4 and 711K4 have 768bytes ram, 640bytes eeprom, 62 I/O lines, 16-bit timer, four 8-bit pulse width modulators, eight-channel 8-bit A-to-D and enhanced serial and peripheral and serial communication interfaces. Motorola Ltd, 0908 614614.

8-bit "compatible" 16-bit controller. Motorola's 68HC16 is the first 16-bit controller compatible with an industry-standard 8-bit product line. Its CPU is based on a 16-bit implementation of Motorola's 68HC11 microcontroller, making HC16 source code compatible with the 8-bit family. The HC16 also integrates control-oriented digital signal processing capability on chip. First in the range is the 68HC16Z1 with its CPU surrounded by on-chip peripherals integrated in modules. Motorola Ltd, 0908 614614.

V25/V35 with on-chip eprom. The V25/V35 single-chip microcomputer, available with a 16-kbyte on-chip eprom, means that for small memory applications, external memory can be omitted. Program code prepared for a V25 mask-rom version can be tested immediately under actual operating conditions. Maximum clock frequency is 8MHz. Voltage on an external pin configures the device as V25 or V35 compatible. NEC Electronics (UK) Ltd, 0908 691133.

Optical devices

Miniature photoelectric control. The smallest standard retroreflective photoelectric control could be the ultraminiature FE7B at 38 x 23 x 13mm. Sensing distance is 2m, with a Honeywell 50mm^2 reflector on both standard and polarised retroreflective types. Available in through- and diffuse-scan versions. Protected against short circuit, reverse polarity and false pulses during switch on. Honeywell Ltd, 0344 424555.

Lower cost data links. The TX5000S010 fibre-optic transmitter with the RX5237S010 receiver can provide secure low-cost digital data links, and are usable in hostile conditions. From a single voltage power supply, the units operate from -55 to +125°C. 24 pin DIP. 1.27 x 0.77in. Litton Precision Products, 0628 486060.

Power semiconductors

Intelligent power. TPIC2404 is Texas Instruments's first product for the intelligent power market. The TPIC2404KN is a quad high efficiency power switch, and each of its four 1A power outputs has been designed with over-voltage, over-temperature and current-limiting protection. Battery protection to -13V. Maximum positive supply clamp voltage is 45V. Independent thermal shutdown on each channel. Texas Instruments, 0234 223252.

PASSIVE

Passive components

Miniature surface-mount trimmer. Model 3363 surface-mount trimmer potentiometer is claimed to have the smallest outline dimensions of 3mm square, while meeting the EIA and EIAJ footprint standards. It is a single-turn, open-frame cermet device which can be wave- or reflow-soldered and is supplied in 8mm tape-and-reel packaging. 100Ω to 1MΩ tolerance of ±25%, contact resistance variation 5%. Bourns Electronics Ltd, 0276 692392.

Displays

"Brightest yellow" leds. Hewlett-Packard is claiming to have developed the "brightest yellow" led lamp, with a luminous efficiency of 20lm/A at 590nm —as bright as red AlGaAs leds. Typical on-axis luminous intensity is 5cd in a T-13/4 lamp, half power viewing angle of 6°, AlInGaP heterostructure on a GaAs substrate. Hewlett-Packard Ltd, 0344 369369.

50μA LCD. The MCM2000 is a 3.5 digit LCD panel meter module with current consumption of typically 50μA and a 9V battery life of around 8000 hours. It has 15mm high digits and a 199.99mV full scale digital selection. Resolution is 0.005%, accuracy 0.01% ±1 count, reading rate is 3/s. Input impedance is 1000MΩ. Input leakage current is 1pA. Bezel dimensions are 72 x 36mm. Rear-mounted version available. Martel Instruments Ltd, 0207 290266.

Dot matrix LCDs with CFL backlighting. Stanley's new range has CFL back illumination, driven by a 5V or 12V supply and low-cost inverter. The LCDs allow graphic, character, graphic/character display modes; automatic cursor shift facilities and scrolling. Blue background/white pixel or yellow background/green pixel. 256x 64 x 256 x 128 dot configurations. STC Mercator, 0493 844911.

Alphanumeric displays. Sharp's LM16X21A and B dot-matrix displays show two 16-character lines. The LM16X21A displays dark-blue characters against a greenish-yellow background; the LM16X21B greenish-yellow characters against a dark-blue background. Contrast ratio of the LM16X21A is up to 8:1; LM16X21B 10:1. 5 x 7-dot matrix —plus cursor. Basic matrix measures 2.96 x 5.56mm. STN technology. Led backlighting. Sharp Electronics (Europe) GmbH040 23 775 0.

Instrumentation

Mobile comms testing. Marconi 2955 aims to combine all instrumentation for transceiver testing in one unit for £3850 It will test all types of amplitude, frequency and phase-modulated mobile radio equipment. Versions available for testing NMT, AMPS, TACS, Radiocomm 2000, and Bank III systems. CRT displays all set-up, generated and measured information with hard-copy printout, or auto-ranging bar-chart. Carston Electronics, 081 977 0078.

90dB FFT analysers. Developed for FFT applications is the Advantest 9211 digital spectrum analyser with 16-bit resolution and a 90dB dynamic range. IBM/PC compatible floppy disk. Integral printer also available. Heading the range is 9211C with running zoom, integral signal generator, curve fitting and transfer function synthesis. The two-channel instruments have a frequency range of less than 1mHz to 100kHz and built in ICP accelerometer PSU. Chase Electronics, 01 878 7747.

Multi-channel data acquisition. Tektronix 2214 20MHz four-channel digital/analogue oscilloscope has 16k memory with 8-bit vertical resolution and full attenuation on each channel. Four digitisers allow 16Msamples/s concurrent sampling. Data captured can be expanded 50 times. 500μV/div vertical sensitivity. Any channel can be used as a trigger source. Timebase is continually variable. £3236. IR Group, 0753 580000.

High resolution 10 bit 'scope. Model 9430 dual-channel digital oscilloscope provides a bandwidth up to 150MHz, extra-high sensitivity up to 20μV/div and ±1% DC accuracy. Signals are captured with two independent 10-bit A-to-Ds which can sample repetitive phenomena at up to 4Gsample/s. Filtering and averaging techniques can increase resolution by up to eight times (or from 10 to 13-bits). Options allow FFT spectral analysis. 50k non-volatile memories for both input channels. Le Croy, 0235 33114.

200MS/s on two channels. Yokogawa DL2100A offers simultaneous sampling at 200Msample/s on each of its two channels. Memory capacity is 128kword/channel. It uses flash A-to-D converters with 8-bit resolution, and employs equivalent time-sampling to digitise repetitive signals with bandwidths of 300MHz. Enhanced trigger set (ETS) is used to capture complex high-speed waveforms. Martron Instruments, 0494 459200.

"Dual" logic analyser. Philips Test & Measurement's PM 3580 logic analysers are built on dual-analyser-per-pin architecture, so state and timing data can be acquired simultaneously, on up to 96 channels, using a single set of probes. The PM 3580/30 has 32 dual-analysis 100MHz channels, for timing and state measurements on 8-bit microprocessors. At the top end the PM 3585/90 has 96 dual-analyser 200MHz channels allowing it to handle 32-bit microprocessors. Philips Test & Measurement, 0923 240511.

DL2100A 200Msample/s oscilloscope from Yokogawa, distributed by Marton Instruments.

100MHz 'scope with cursor measurement. The PM3070 100MHz real-time 'scope has all the main functions of the PM3065 plus on-screen measurement cursor and zoom backup. Other features include triggering up to 150MHz; multiple display modes; auto set for instant display of signal; touch switch control of major functions; and a large LCD display for continuous read-outs of instrument status and selected settings. STC Instrument Services, 0279 641641.

2GHz optical-to-electrical converters. The OCP 5002 is a programmable plug-in model for use in Tektronix TM 5000 products. Tektronix says its combination of DC coupling and broad bandwidth is innovative. The converters provide a wavelength range of 1100 to 1650nm. Less than 15% P-P aberrations specified, with less than 5% to 10% typical. Noise floor is 1mW. While optical conversion is occurring, a power meter averages the result, displaying it on the front panel. Tektronix UK Ltd, 0628 486000.

Portable 'scope. The Trio-Kenwood CS3035 portable 'scope, 216mm wide x 89mm high x 298mm deep (4kg) can be powered from AC mains or 11.5-13.5V DC supply. Bandwidth is 20MHz (-3bD), with maximum sensitivity of 1mV per division using x5 magnification. A 90mm rectangular high-intensity CRT with inner graticule gives a viewing area of 8 x 10 divisions of 6.35mm each. Sweep time can be set between 0.2μs/division and 1s/ division. £995 including two probes and panel cover. Thurlby-Thandar Ltd, 0480 412451.

Interfaces

Multifunction I/O board. The C10-AD 16 analogue/digital I/O board, designed tc be compatible with DAS16, also has a P1012 compatible digital output providing 24 digital I/O lines. Two input multiplexers can be configured to provide 16 signal-ended or eight differential inputs. A 2μs sample and hold captures the signal, sampled by a 50kHz or 100kHz 12-bit A-to-D converter. Analogue voltage output is through two 12-bit multiplying D-to-A converters. Amplicon Liveline, 0273 570220.

40-channel I/O card. The Arcom PCIB40 separates digital I/O control in a PC chassis from signal conditioning modules outside, allowing greater I/O fan-out to configure bigger systems with modular, maintainable interconnection schemes. 40 TTL I/O lines are brought out by ribbon cable and individually configured under software control as either inputs or outputs—bit-by-bit. Dean Microsystems, 0734 845155.

Faster hard copy. Faster operation of hardcopy devices is possible with an Ikon 10097 card, supporting data transfer of 800k/s in an 8MHz PC/AT. Also usable with Sun 386i and Apollo workstations. Using one full-size AT slot, a standard 37 pin D connector cables to output devices, selected by an internal jumper cable. DMA transfers effected with the AT bus I/O channel DMA. Byte/word transfers. GMT Electronic Systems Ltd, 0372 373603.

Transputer network interface. IMS B422 SCSI Tram allows transputer networks to connect to Winchester and optical discs, printers, scanners, CD-rom and other peripherals via SCSI bus. It consists of a 20MHz T222 16-bit transputer and 64kbytes of two-cycle sram, credit card size. Local processing and control facilities. Four standard Inmos 20Mbits/s links allow direct SCSI bus connection to larger transputer networks. INMOS Ltd, 0454 616616.

Interface cards. SciTech MicroSystems' Blue series of intelligent data acquisition and control cards, manufactured by HuDe in Germany are designed for HP9000 Series 200/300 computers. Each card occupies one DIO interface slot and is a self-contained system of processor, operating system and GPIB interface. Control is by passing high level ascii commands over the GPIB so that each module is functionally independent of the host. SciTech Microsystems Ltd, 0734 772595.

Production equipment

Dil component cropping and forming. Cropelle and Formelle use a micrometer-type knob to obtain a precision of 0.001in on crop length or 0.01in on leg splay. With the Formelle, as well as adjusting the length and splay of the legs, additional preform is possible — a surface mount or positive engagement clip-in form. 0.3in and 0.6in dil components supported. Elite Engineering Ltd, 0329 231435.

Power supplies

Universal input switcher. Computer Products' NFS42 40W triple output switch mode power supplies have universal input design and eliminate an external 110/220 V AC system switch and cable assembly. Continuous input from 85 to 264V AC. For 220V AC users, hold-up time is 75ms. Triple output models can maintain voltages within limits down to zero load. Computer Products, 0234 273838.

Multiple-output switcher. A multiple-output switching power supply providing 1200W from a fan-cooled 3.2 x 5.5 x 11.4in package (power density of 6W/in^3) is available from Powerline. The StakPak switcher offers eight isolated and regulated outputs. Four outputs on any number of StakPaks can be paralleled, with current sharing. Input options include 110/220V AC, three-phase and 46V DC. Efficiency typically 80%. Powerline Electronics Ltd, 0734 868567.

Miniature SMPS. Zenith's switched mode power supply, ZPS-45, is a 45W miniature unit operating from inputs between 85 and 265V AC (or 120 to 346V DC) with no-jumpers change. Outputs are +5.0V at 5A max (7A peak), with a ripple of 50mV P-P. Secondary outputs are +12.0V max (3A peak) and -12.0V at 0.5A (max), both with a ripple of 120mV (max). Regulation of main output is ±3% (secondary outputs ±5%). 127 x 76 x 32mm. Zenith Components, 0306 76730.

Production test equipment

500V harness tester. X-Checker is a two-wire harness tester designed to offer a 500V capability for less than £3000. It has a 64 test point capability at a speed of 50 points/s. Up to 1024 points are supported in one chassis. Adjustable hardware. Hartley Measurements, 0752 344606.

Radio communications products

Automatic link for HF radio. Harris is offering a plug-in option adding automatic link establishment (ALE) to the RF-3200 and Hawk series HF/SSB radios allowing automatic selection of channel for best performance. It will support communications networks of up to 100 individual radios, with three-digit speed dialling. It mounts into the transceiver. Harris Corporation, 0101 (716) 244 5830.

Programmers

Low cost programmer. Nohau's ALL-03 universal programmer combines a £550 price with high specification (4Mbit eproms/microcontrollers/pals/EPLDs/40 pin sockets) and a fast PC-based design; 4Mbit file downloaded in seconds. A four-way gang adaptor is available. It comes with menu-driven software, eprom editor, IC tester software and memory tester software Nohau, 0962 733140.

Transducers and sensors

Thermocouple to 4/20mA converter. Series 6 converter, 6mm wide, is designed for mounting on standard TS32 and TS35 Din rails and uses standard Type K thermocouples. Output is loop powered; 12-32V DC, and resistance 0-1000Ω. Thermocouple open circuit is typically 25mA; non-linearity is 0.05% max. Cold junction compensation with an error level of ±1°C for an ambient change over the range 0 to 40°C. Klippon Micro-Systems Ltd, 0732 460066.

Vision systems

PC-based visual inspection. The Inspector PC-based visual inspection and measurement system accepts all normal video inputs, and has real-time threshold compensation. Full length board. Simple software generates C source code. Inputs accepted from a vidicon or CCD camera or other video sources and two software selectable inputs are available. 512 x 512 binary image. Amplicon Liveline Ltd, 0273 608331.

Digital TV chip. VSP 2860 is an IC designed to cover DSP functions in the video and sync sections of a digital television receiver. It is mainly intended for the second video channel in digital television receivers equipped with a picture-in-picture facility. N-channel mos technology and a 44 pin PLCC plastic housing make it compatible with the Digit2000 digital signal processing system. ITT Semiconductors, 0932 336116.

Full-motion video compression. LSI Logic's family of image and video compression chips meet performance levels applicable to still-image and full-motion video requirements. Comprising a seven-chip set, the L647000 processors offer a building-block approach to compression and decompression algorithms. In full-motion applications, these chips adhere to the P*64 (CCITT H.261) standard. They also track the emerging Motion Picture Experts Group (MPEG) standard. LSI Logic Europe plc, 071 353 8807.

Wideband video switch. Siliconix's wideband video switch integrated circuit, DG894, promises performance and integration benefits within TV switching systems based on the Philips I^{2}C bus and the international Scart interface. It includes the ability to switch analogue or digital signals with a bandwidth of up to 100MHz, combined with low crosstalk of -70dB at 5MHz. Siliconix, 0635 30905.

COMPUTER

Computer board level products

Embedded speech. VM series I/O products are small self contained modules which replay up to 128 different "real voice" messages from eprom. The DM series modules use dynamic ram to record and replay sounds "on the fly". Modules include amplifiers and TTL level trigger inputs which makes them simple to install. A PC speech development system is available. Small batch speech-to-eprom service offered. Fairchild Ltd, 042121 6527.

Flash memory card for laptops. Intel's flash memory-based IC card is available in 1Mbyte and 4Mbyte densities. The card with filing software is the highest capacity nonvolatile reprogrammable IC card available. Read/write capability and non-volatility of the flash memory card promises longer lasting, more reliable storage medium than mechanical disk drives. 1Mbyte iMC001FLKA—£176.40 (1000); 4Mbyte iMC004FLKA —£714.00 (1000). Intel Corporation (UK) Ltd, 0793 696000.

Digital output board for Workhorse. WH-DIO-16 is an optically isolated, 16-channel, digital output board for use with Metrabyte's Workhorse PC-based system. It has 16 individual optically isolated outputs arranged in two groups of eight, user circuitry areas for configuring outputs, TTL drive levels and a 45mA option. Optically coupled n-p-n phototransistors provide 500V of channel-to-channel and channel-to-ground isolation. Keithley Instruments Ltd, 0734 575666.

Development and evaluation

Test Sun workstation at 25MHz. High speed 68020 emulation personality pod, available with the MST 16/32 microprocessor system tester supports the Motorola 68020 processor, and is capable of testing target boards at 25MHz. By using the intelligent personality pods the MST 16/32 stand alone system can be configured to test the most widely used microprocessor based systems. Antron Electronics Ltd, 0252 737171.

Real-time debugging. Microtec Research's Xray/monitor in-circuit debugger (MHM68K) offers real-time in-target features of in-circuit emulators without their limitations on processor speed and at cheaper cost. It supports the Motorola 68000 family and is used with Microtec Research's C compiler and assembler. Risc processors are supported. Microtec Research Ltd, 0256 57551.

32-bit development. CDS32 is a compact in-circuit emulator, bus state analyser and control station unit for debugging the hardware and software during the development of 68332 and 68331 systems. It provides real-time capabilities, integrated emulation and a bus state analyser for fast debugging and product development. Software supports target system emulation. Under $10 000. Motorola Ltd, 0908 614614.

Software development system. Costing £1895, the ProfOS-922 package, comprises the professional OS-9 operating system implemented on Syntel's 68020 based CPU card, plus all ribbon cables and manuals. VM022 comes with 1Mbyte of 32-bit wide dram, full eprom set, four serial ports, battery-backed clock, and on-board SCSI interface for floppy, hard disk and tape. An on-board dual-bus interface allows the card to be expanded. Syntel Microsystems, 0484 535101.

Mass storage devices

125Gbyte mass memory. 125Gbytes of data can be accessed by the Magnus JBL-125 JukeBoxLibrary, manufactured by Summus Computer Systems. Two 8mm helical-scan tape drives and a 54-cartridge carousel are supplied in a standard 19-in rack mount. On-line capacity is equivalent to 900 nine-trace tapes. Transfer rate is 1.25Mbytes/s (burst), 246kbytes/s (sustained); maximum cartridge seek time is 3.5s. Harrier Computer Systems Ltd, 0734 328282.

2.55Gbyte 4mm dat. TurboDat uses advanced hardware and data compression techniques to pack more than double the data capacity of many other data drivers. In addition to more than doubling the storage capacity of 4mm dat, the TurboDat achieves a faster data transfer rate and thus faster backup restore time. Compared to 8mm's 2.2Gbyte capacity, TurboDat offers 300 more Mbytes of capacity using digital recording methods with 60 second file access time. Westec Ltd, 0258 456165.

Turbo Dat data driver by Westec, giving 2.5 Gbyte capacity.

Right UPS for the right job

Exactly how "uninterruptible" is that UPS you are considering? Frantisek Michele shows would-be purchasers what to look for.

An uninterruptible power supply (UPS) is a device that maintains quality power to a connected load, enabling sensitive equipment (computers, etc.) to operate at designed specifications. There are basically two types; the reverse transfer (on-line system) and the forward transfer (off-line system). Since the former system is the most common, because it completely separates operating load from utility power, this article will concentrate on the criteria for choosing the right type of on-line static UPS.

In a typical on-line static UPS (**Fig. 1**), utility AC power applied to the rectifier/battery charger is converted into a direct voltage.

The rectifier performs two specific functions: in normal operation it provides DC power to the inverter; if the batteries require charging, it also provides DC power to the battery bank.

Some manufacturers offer the battery bank as an integral component of the UPS, especially for data processing applications, but most provide it as a stand-alone or attached component. Either way, without the battery bank, the UPS becomes a glorified power conditioner.

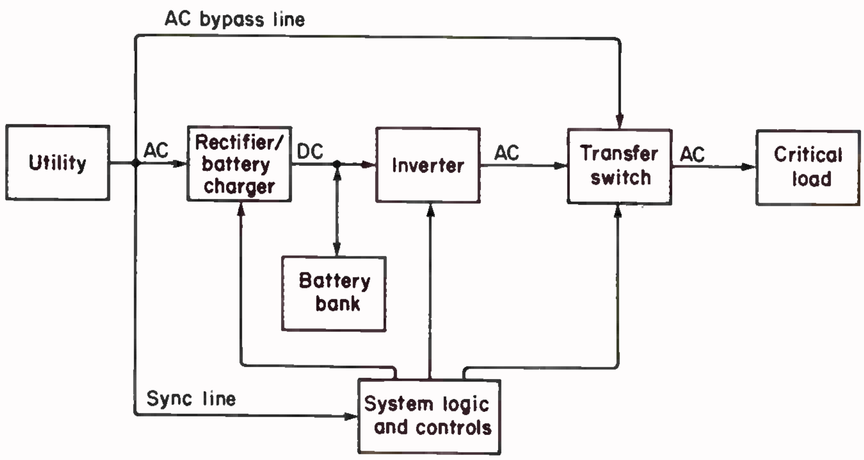
The inverter is probably the key component of the UPS, converting DC voltage from the rectifier or battery bank into a sinusoidal AC voltage. A transfer switch protects the critical load from inverter failure so that if it cannot supply for some reason (overload is a typical example) the transfer switch selects the utility line to supply the load.

After a power outage, the rectifier/battery charger must also provide current to charge the batteries. Depending on the amount of discharge, it may have to provide up to 120% of the inverter's full load rating for a short time during initial recharging.

It is not enough for the rectifier/battery charger to provide current at different load levels. It must also be capable of sustaining different charge rates. In addition, it must be capable of protecting itself by current limiting on startup or when AC power is returned after an outage.

Another form of charger protection is referred to as soft start or walk-in.

Fig. 1. In a typical on-line static UPS the rectifier/battery charger converts AC to DC which supplies the inverter and charges the battery bank if necessary. This type isolates the load from utility power.



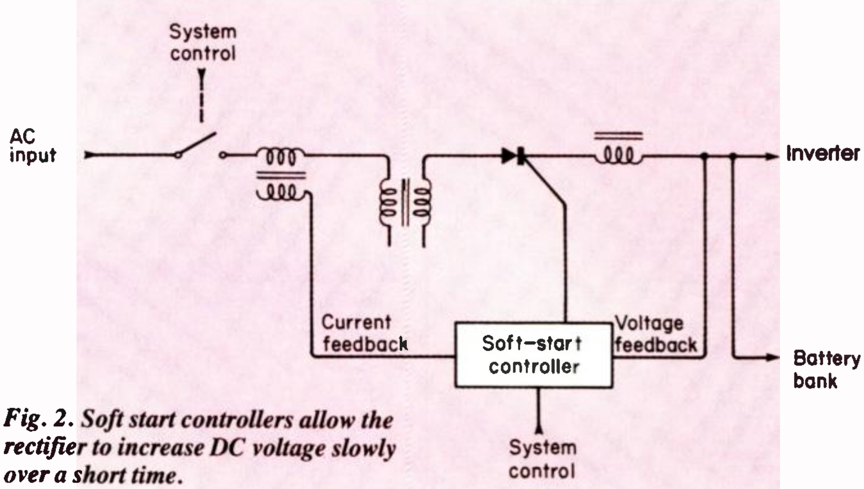


Fig. 2. Soft start controllers allow the rectifier to increase DC voltage slowly over a short time.

Soft start (**Fig. 2**) is simply a circuit that allows the rectifier/battery charger to increase the DC bus voltage slowly, over about 15 seconds.

The battery bank provides stored DC power to the inverter in the event of input AC power failure.

Batteries come in all shapes and sizes from wet cells to sealed maintenance-free models – and selecting a battery system is almost a separate issue because of the complexity of options.

Wet cell batteries require maintenance (watering, hydrometer checks) and ventilation but offer excellent recharge capabilities with long life.

Sealed maintenance-free batteries do not require positive ventilation but do require longer re-charge cycles and have shorter life.

Between those extremes there is the low maintenance battery, requiring less maintenance than the wet cell, and the maintenance-free battery which is not sealed and so requires positive ventilation. Size of battery bank is a function of UPS DC bus voltage and the critical load's backup requirement (time and power level). When a battery system is designed, load power factor and specific gravity should be specified.

Inverter

Inverters can be categorised into four basic technologies: ferroresonant, quasi-square wave, pulse-width modulation (PWM), and synthesised (step wave).

Ferroresonant inverter (Fig. 3) is simply an SCR bridge with a tuned resonant transformer in its output. The bridge produces a square wave, which is regulated and current limited by the ferroresonant transformer. Because the transformer is operated in saturation, it provides inherent voltage regulation and the sinusoidal output can be attributed to its resonant characteristics.

Quasi-square-wave inverter (Fig. 4) like the ferroresonant inverter, uses an SCR bridge to produce square waves, but here regulation is performed electronically rather than magnetically. By altering the relationship between square wave SW_1 and square wave SW_2, the DC voltage pulse width can be varied, regulating the RMS value of the output sinusoidal AC waveform. This change of pulse width also compensates for changes in DC bus voltage.

Filtering of the third and higher harmonics is achieved by a series/parallel LC filter. To control the duty

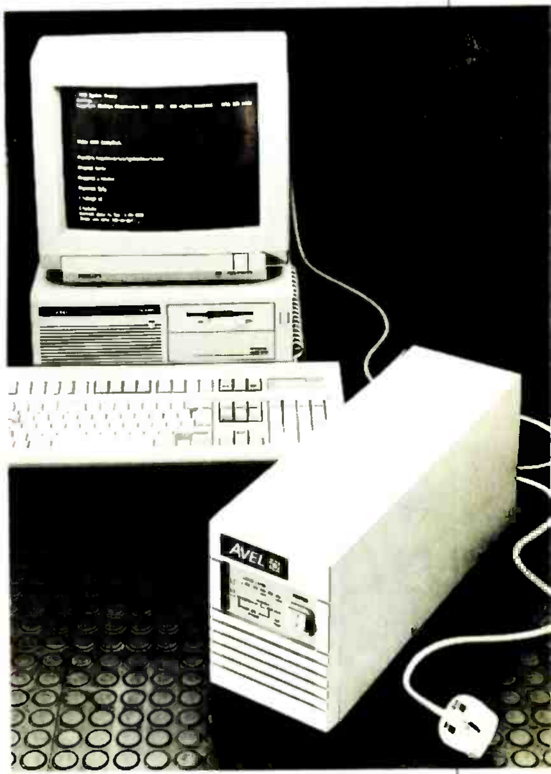
POINTS TO WATCH

● Selecting an on-line static UPS is not a simple task. There are several that do not fall into a specific category, of these hybrid technologies, the hybrid synthesised PWM (step wave) is the most common.

● The heart of a UPS – the inverter – is available in different types. If a category is disappointing, consider other options. Take reliability, for example. The addition of a static transfer switch can do wonders for MTBF, and the availability of a recommended spare parts kit may be the answer to MTTR problems.

● If physical characteristics are a problem, consider moving the unit away from the critical load. As long as the batteries are close to the UPS, the system can be moved a considerable distance away because AC line voltage drops are not nearly as significant as DC line voltage drops. Why not use your UPS to heat the basement?

As in any decision making process, the final decision is only as good as the original research.



The need for UPS: UK computer operators can expect six power failures totalling 90 minutes in a year (source DTI/Avel-Lindberg)

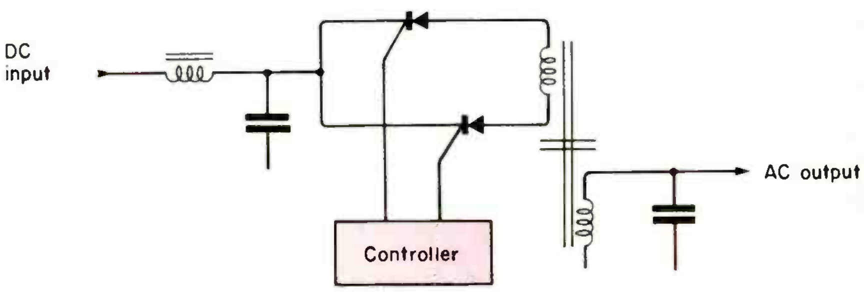


Fig. 3. The ferroresonant inverter is an SCR bridge with a tuned resonant transformer in its output.

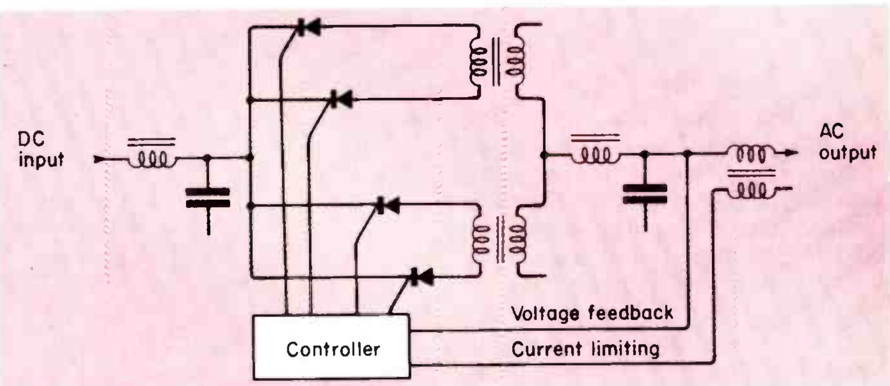


Fig. 4. Quasi-square-wave inverters use an SCR bridge to produce square waves, but regulation is provided electronically rather than magnetically.

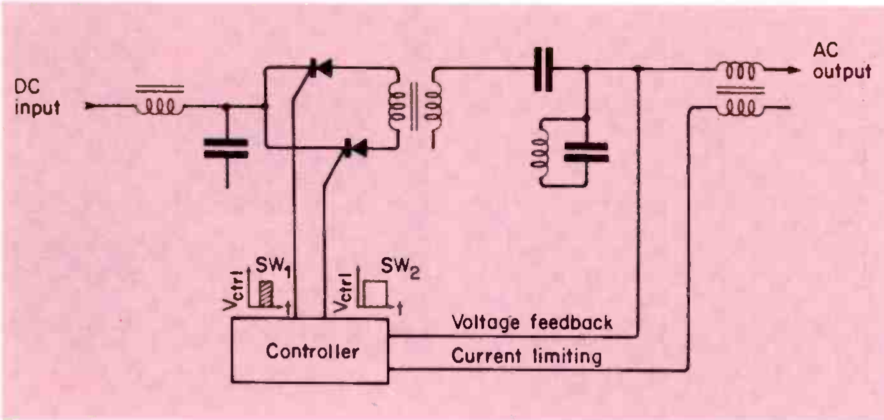


Fig. 5. A pulse width modulated inverter is a higher frequency version of the quasi-square-wave circuit.

cycle of the square waves, additional control circuitry is added.

PWM inverter (Fig. 5) is essentially a quasi-square inverter operated at a much higher frequency – from 1.5 to 20kHz. The object is to vary the duty cycle of the pulsating DC voltage so that the square wave is on for a very short time at the zero crossover point of the sinusoidal AC waveform, and on for a longer time at the waveform's peaks.

Higher switching frequency means more pulses and a simpler filtering task.

Synthesised or step wave inverter (Fig. 6) is a combination of between three and 12 or more inverters, typically found in large, three-phase power applications. Each inverter is controlled by a common oscillator and, when the inverter out-puts are combined, harmonics are eliminated. Filtering can be accomplished with just a low-pass output filter.

Obviously, each type of inverter will have both advantages and disadvantages. One inverter might be weak in performance but be the most reliable because of its simplicity. The converse is also true of the "state-of-the-art" inverter: More components implies a higher probability of failure.

Transfer switch

If the UPS is overloaded the transfer switch will transfer the critical load from inverter output to bypass or alternative AC input. It should not be confused with the transfer switch in an off-line UPS which transfers the critical load from the AC input to inverter output in the event of loss of input. It is also different from a maintenance bypass switch, which electrically isolates the UPS for maintenance.

Some loads – such as emergency lighting and security systems – can tolerate a momentary loss of AC, so a transfer switch with some amount of delay is not a significant factor. An electromechanical switch with a typical transfer time of about 30ms would probably be quite adequate.

But for extremely sensitive loads, the 30ms transfer rate is completely unacceptable. This type of application would require a static transfer switch, which incorporates SCRs in single-pole, double-throw configuration. If the load is powered from the inverter output and an inverter failure occurs, a make-before-break transfer is usually initiated. After overload, the transfer switch should be capable of transferring the critical load from bypass or alternative AC input to the inverter output when the load is stabilised to 100%.

Fig. 6. The synthesised step wave inverter is actually a combination of three to 12 or more inverters, each driven by a common controller.

Performance

There are four major areas of concern when selecting an on-line static UPS:

- performance
- physical characteristics
- reliability
- cost

and each will be weighted differently, depending on application.

Looking at performance first, this can itself be broken down into inverter efficiency and overall UPS efficiency.

Efficiency is expressed as a percentage of the ratio of output to input kW. If the inverter is 80% efficient, 1kW of battery power will supply 800W to the load or lower inverter efficiencies require larger battery banks.

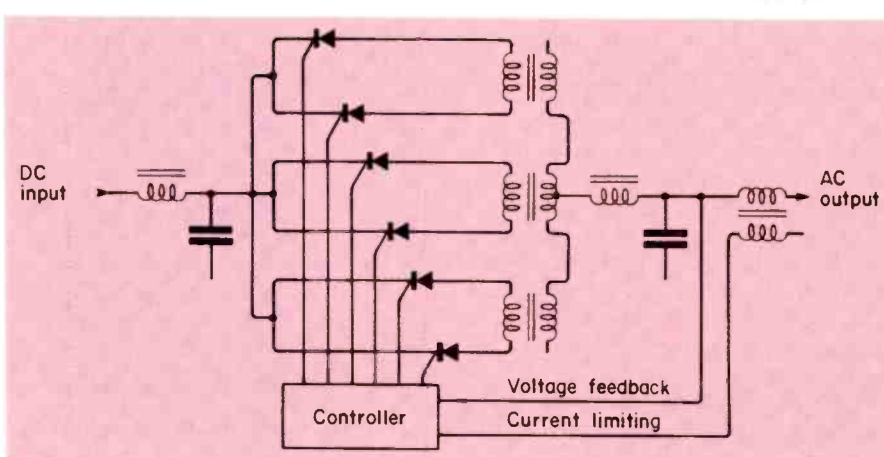
Inverters are typically rated at full load with a unity power factor, which is ideal or resistive. As the power factor decreases, true power decreases and apparent power increases. However, a UPS is rarely operated at full load; in most cases, the UPS is sized larger than the load requirement to provide for future expansion. UPSs are also often derated for increased reliabilty.

The ferroresonant inverter is typically larger than the nominal load requirement to compensate for its poor voltage regulation during high inrush currents; at approximately 150% of full load on a ferroresonant transformer, the output voltage will drop to zero.

Overall UPS efficiency is a function of the rectifier/battery charger and inverter. If UPS-A is 80% efficient overall and UPS-B is 85%, then 40kW from UPS-A requires 50kW from the utility, whereas UPS-B only requires 47kW.

One of the advantages of an on-line UPS is that it provides voltage regulation so that a large voltage fluctuation on input is reduced to a small band of fluctuation on output.

Commonly ±10% on input produces



±0.25% on output, or ±2% for a 0 . . . 100% load change over line and temperature extremes.

Input current distortion is normally specified as the maximum percentage distortion the rectifier/battery charger generates on the input line. If the supply is standard utility power, this is not usually a critical specification. But if other sensitive equipment has the same input source as the UPS or if a standby generator is being utilised for alternate power, input current distortion can be a problem because it tends to cause voltage waveform distortion on the common input voltage bus.

As a rule, input current distortion should not exceed 15% on three-phase supplies. Some manufacturers offer UPSs with special input transformers and circuitry to accommodate users with stringent input current distortion requirements.

Transient response – often neglected and widely misunderstood – is the inverter's instantaneous output voltage regulation capability during the cycling of stepped loads or changes in DC bus voltage.

Almost all loads are composed of a variety of smaller independent loads. For example, in typical data processing applications the critical load probably includes a CPU, some disk drives, a tape drive, several terminals and a telecommunications module.

As devices are cycled on and off, they represent step load to the UPS. If it is unable to respond instantly to the disk drive's spinning and stopping, the UPS could allow an output voltage outside the tolerance of the central processor.

Most UPS manufacturers specify transient response as a percentage of output peak-to-peak voltage deviation for loss or return of input AC and 50% load change.

Another good check is to determine the maximum step load change the UPS will allow while maintaining the ±10% voltage regulation band; 10% is the typical threshold for sensitive equipment.

Harmonic distortion of the fundamental sine wave frequency is generated when the pulsating DC waveform is created. This adds or subtracts from the fundamental frequency to produce distortion of the voltage waveform. Percentage distortion is expressed as a ratio of the amplitude of the harmonic(s) to the amplitude of the fundamental.

Usually, two different worst-case ratios will be offered: the ratio of all harmonics to the fundamental and the ratio of any single harmonic to the fundamental. For most critical loads, figures of 5% for all harmonics and 3% for any single harmonic should be more than adequate.

Frequency stability ensures the load will not be subjected to phase shifts during transfer from inverter output to bypass AC input and vice versa. More complicated units offer a multitude of input frequency windows with oscillator-controlled outputs. Some also offer tracking circuitry so that the UPS will synchronise automatically to the bypass AC input. A few offer slow slew of the tracking frequency synchronisation – 1Hz/s maximum is common.

The ferroresonant inverter has a major drawback in this area because the transformer is extremely frequency-sensitive. The slightest change in input frequency will cause it to operate out of the limits of its tuned tank circuit, causing distortion and voltage fluctuation.

Physical characteristics

Manufacturers tend to use one cabinet enclosure for several different power ratings. Small single-phase units are usually available in various configurations: rack-mountable for test and measurement; mounted with matching battery enclosures in a cabinet to maximise variations in battery backup for general purposes, or with one set backup period in a single enclosure for data processing systems.

Larger units, single and three-phase, tend to be offered with either attached or separate batteries in cabinets or racks. In this case, to extend life, batteries are often separate because of heat dissipation from the UPS.

Since the ferroresonant UPS is about 90% transformer, weight is directly proportional to power rating.

The physical footprint is not the only consideration; it is necessary to consider such items as where the I/O (back entry, bottom entry etc.), will be connected, what clearance is required for maintenance, the location of the ventilation ducts or fan intakes, and whether the unit has castors or a forklift base.

Options can add costs rapidly and little things like circuit breakers, metering, static switches, alarms, and remote indicators can affect a UPS budget significantly as power rating increases.

Power down alert: this UPS from Quadshield will provide remote signalling of mains and battery status.

Other criteria

Reliability can be expressed by three methods; calculation, historical, and availability. Calculation is simply a prediction of mean time between failure (MTBF) and mean time to repair (MTTR) by using statistical formulas and tables. Unless a manufacturer is a supplier to the military, calculated MTBF and MTTR will probably not be available.

But there is no guaranteed way to determine reliability, so a manufacturer's design approach should play an important part in user selection criteria. A UPS designed with significant margins for operating voltages and stress levels is far more likely to be reliable than a UPS taken to the limits.

Power semiconductors should be examined as a clue to reliability. These devices have the highest failure rates, so should be sized at 150% or more of maximum rated current and voltage.

Efficiency is not a linear function of load level for all UPS types. Efficiency of ferroresonant technology tends to drop off significantly when the load is reduced. Also, because the ferroresonant transformer core is designed to saturate with magnetic flux, it dissipates large amounts of energy. As a result, the ferroresonant transformer is typically only about 65% efficient at half load.

Probably the largest additional technological expense incurred over time, found in all UPS types, is waste energy dissipated as heat.

In the earlier example, where UPS-A was 80% efficient and UPS-B was 85% efficient, the 5% difference accounts for 3.0kW/hr = 25, 696kW/year. ■

RF Connections is by Pat. Hawker

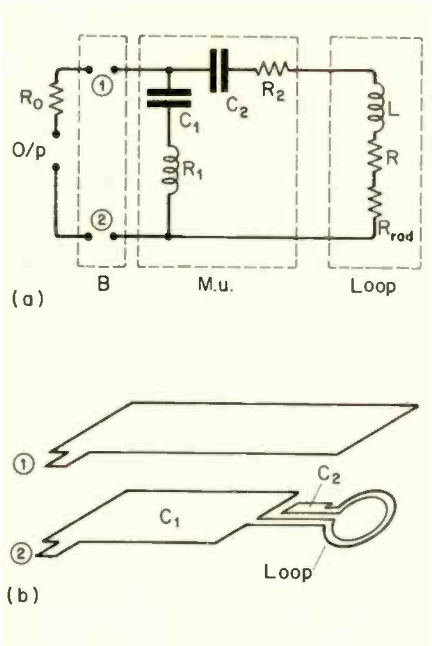
Supercool compact antennas and the CFA debate

Since the discovery by Bednorz and Miller of IBM Zurich that some copper-oxide materials exhibit superconductivity at temperatures above that of liquid nitrogen (77K), available as a coolant at a fraction of the cost of liquid helium (4K), much attention has been given to the application of these "high-temperature" superconductors to passive antenna systems. Unfortunately, the copper-oxide ceramics have mechanical and electrical characteristics that complicate their use in practical systems and much effort has and still is being directed towards the improvement of the material processing, including the growth of large-area superconducting samples, and to increase the maximum current density in the superconducting state.

UK work in this field formed the subject of several papers at a recent IEE colloquium on electrically small antennas under the chairmanship of Dr Brian Austin (University of Liverpool). Professor J.R. James (RMCS Shrivenham) reported current work, in conjunction with ARE Portsdown and ARE Holton Heath, on the design of a small UHF loop receiving antenna using a matching capacitor formed from superconducting plates. At a frequency of 500MHz, loop radius is 7.5mm for an application demanding near 100% efficiency, no added circuit noise and a very narrow bandwidth. Practical difficulties include the large size of the matching unit relative to the antenna loop, the very small capacitor plate separation (100 microns), the additional size and complexity of the cyrogenic housing and its accommodation of the ground plane. A planar integral structure is being investigated, including the use of a superconductive capacitor (C_2) of about 3.52pF with a conventional form of capacitor for C_1 (518pF).

Dr Y.J. Guo (University of Bradford) described a mathematical study of small helical antennas realized with superconductors, electrically-excited by a coupling loop at frequencies of the order of 35.5MHz.

Dr Z. Wu of the Birmingham Superconductive Research Group and ICI Advanced Materials, Runcorn, compared experimental results at 440MHz of a thick-film, printed high-T_c superconducting loop antenna fabricated on alumina substrate with those of an identical silver antenna. The Birmingham ceramic superconducting loop antenna has evolved from wire to thick-film form and is claimed to open the way towards practical superconducting antennas and superdirective arrays. While the experimental YBCO system at 77K shows a modest improvement on a similarly cooled silver system – silver (300K) OdB; silver (77K) 7.4dB; YBCO (77K) 10.9dB – it is considered that if the YBCO thick film material had better surface resistance, the superconducting antenna would have much improved power gain. Material with much higher crossover frequencies is currently being investigated.



Experimental 500MHz loop receiving antenna using superconducting capacitor (C_2).
(a) Loop antenna, matching unit and balun (B)
(b) Exploded view, (not to scale) of the superconducting planar matching unit and loop. (Royal Military College of Science.)

For superdirective arrays based on small loop elements, the very low radiation resistance contributes to low efficiency of conventional arrays. Superconductors could increase the efficiency of each element, and when used in conjunction with superconducting feed and matching networks, the array efficiency could be much improved, although this could result in unacceptably narrow bandwidth.

The IEE colloquium also featured five papers on other aspects of electrically small antennas including aircraft HF antennas (J.W.R. Cox, RAE); MF body loop antennas for use underground (B.A. Austin); the Phase Track segmented active receiving loop antenna covering 50kHz to 30MHz (E.C. Foster); and the still highly-controversial cross field (transmitting) antenna (CFA) described in *EW + WW* (March 1989) by M.C. Hately, F.M. Kabbary and B.G. Stewart.

The CFA, with electrically-small dimensions, is claimed to provide both high efficiency and broad bandwidth, in spite of the long-accepted fundamental limitations of small antennas with their very low radiation resistance and high-Q characteristics. At the colloquium, Maurice Hately admitted that, so far, it has not been possible to obtain equivalent results with scaled-down models at VHF and hence to subject the design to model tests that might establish once and for all the overall efficiency of these intriguing antennas. Meanwhile he sticks to his claim that at MF/HF, the CFA has an efficiency comparable with that of a full-size dipole or monopole, while exhibiting broadband characteristics.

He believes that at ELF/VLF it should be possible to radiate waves with good efficiency from structures no more than 1/1000th or possibly 1/10,000th lambda. Recent developments have included 300kHz beacon experiments with the CAA using a ground-plane CFA only 3m high and 3m diameter in a city centre – although no detailed results of these tests, or those conducted at the School of Signals ("with promising results") were given.

His associate, F.M. Kabbary, has reported radiating 25kW MF from a CFA 2.5m high and with the ground mat 4m in diameter in Cairo; with a 100kW antenna currently under construction. If, as many professional antenna designers continue to believe, the actual radiation efficiency is much lower (possibly by as much as 20dB) than the CFA advocates believe, the power dissipated as heat will presumably show up clearly at such high power. If it doesn't, we may be forced to take the claims for CFA efficiency more seriously than at present.

Few doubt the sincerity or integrity of the CFA team, but the large disparity in efficiency could arise from taking field strength measurements at ground level in the far field, a radiation node for vertically-polarised antennas but a null for horizontally-polarised antennas. Then again, as an engineer suggested at the colloquium, the measured broadband characteristics could indicate that there could be radiation from the outer skin of the two coaxial cable feeders, due to common-mode currents, in the absence of a balun.

The debate continues . . .

Sun power for rural radio systems

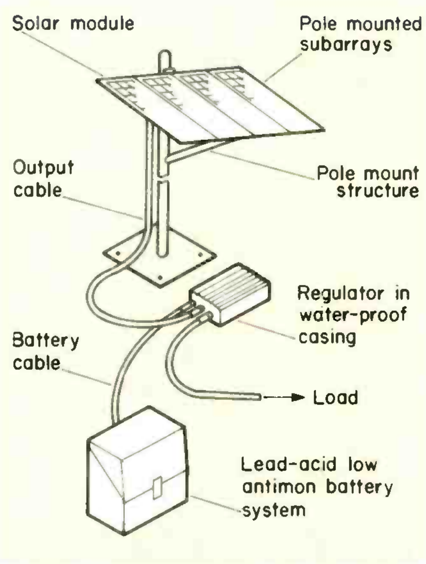
Some 15% of the world's population uses 85% of the world's telecommunications services; two-thirds have no access to a telephone; some 300-million people live in places where, despite the significant socio-economic benefits shown to result from rural telecoms, their availability is poor or non-existent. This disparity, emphasised at the IEE's 2nd International Conference on Rural Telecommunications, represents an enormous challenge in both economics and technology to governments and industry.

The ITU Centre for Telecommunications Development (CTD), resulting from the Maitland Commission, became operational in April 1987 and has projects underway in Tanzania, Gambia, Egypt and Nepal, but is faced with a gigantic task if substantial progress is to be made. The density of telephone lines in many regions seems destined to remain extremely low for the foreseeable future.

At the IEE conference, engineers from the Canadian International Development agency, one of the more active agencies working in this field, presented papers stressing that, with the introduction of highly complex radio technology at relatively low cost, "there is no question in our minds that radio is the answer to the challenge of the Maitland Commission in the provision of service to rural areas of the developing world".

CIDA has concentrated so far on TDMA microwave links in L-band (1.5 to 2.5GHz) but is also exploring other radio options in satellite, HF and VHF/UHF systems. One of the key factors in the provision of radio systems in rural areas is electric power generation based on solar-cell arrays in conjunction with storage batteries. In sunny countries, such systems already show better cost-effectiveness than, for example, diesel generators, despite their rather higher initial costs which continue to fall in respect of the solar modules.

P. Wolfe (Solapak Ltd) pointed out that lead-calcium storage batteries were widely used because of their low self-discharge rate, but are being superseded by lead-acid/low antimony tubular plate (sealed maintenance-free) batteries, despite their adding up to 15% to overall system cost. Amorphous silicon cells result in about 6% module efficiency – compared with the 9 to 12% of polycrystalline cells or the 12.5 to 15% efficiency of square-cell monocrystalline modules – but are considered to offer greater future cost-reduction potential.



Typical solar generator system (up to 200w load) as supplied by Solapak Ltd.

CIDA speakers, however, stressed that, although the advantages of photovoltaic power plants are impressive, their performance in the field has not fully met expectations. It is proving difficult to optimise system design "because of the lack of specific insolation data, the conflicting claims and varying data provided by the suppliers, a lack of standards and the difficulty of understanding different computer-aided designs submitted by suppliers".

A CIDA paper by T. Zeiton and H. Chamberlain noted that "experience has shown that the performance of solar modules has been fully satisfactory . . . controllers or regulators used on smaller systems have generally performed well. The same is not true for the controllers used with larger, higher-voltage systems where extensive modifications and replacements have been necessary because of inefficiency and heat problems . . . . The most important component is the battery. Their performance is difficult to monitor and many cells are exhibiting low specific gravity, which may be due to inadequate charging and may be an indication that short life is to be expected . . . . The overall performance of both large and small solar plants has not met expectations due to the large number of low battery-voltage alarms and service outages during periods of poor weather . . . this may be due to a tendency to provide minimum sizing in order to make solar plants cost-competitive".

Nevertheless, CIDA stress that, in spite of performance problems, "It is recognized that photovoltaic power plants are providing far superior service to what was experienced with other types of stand-alone supplies. The freedom from the need to provide fuel is greatly appreciated". CIDA believes that solar power plants will soon become almost the only type of plant used to power telecom equipment at remote sites in developing countries where there is generally lots of sun and the equipment buildings seldom require heating. Their experience of solar systems includes their use at 144 sites in ten countries in Africa, Asia and South America.

For space satellites, a major improvement in storage batteries for use with large solar arrays stems from the trend towards the use of nickel/hydrogen (NiH_2 batteries instead of nickel cadmium (NiCd batteries, which permit greater depth of discharge (70%) and suffer less damage through overcharging, are already being used in some of the larger communications satellites. The latest development is the use of NiH_2 batteries in a single common pressure vehicle (CPV) to increase the capacity per unit mass. Such NiH_2 CPV batteries can deliver 42watt/house per kilogram weight; over twice that of conventional NiCd satellite batteries.

To improve efficiency and reduce the rate of damage from high-energy particle radiation from the sun, silicon solar cells may increasingly be superseded by GaAs or InP cells.

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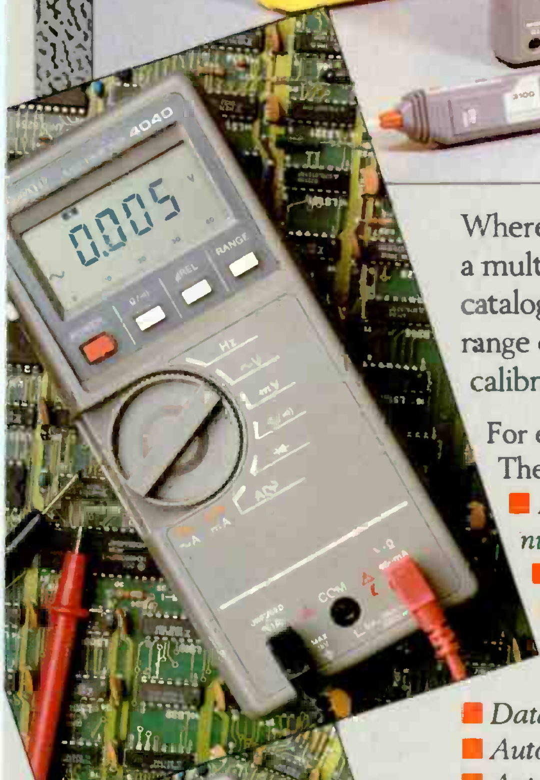

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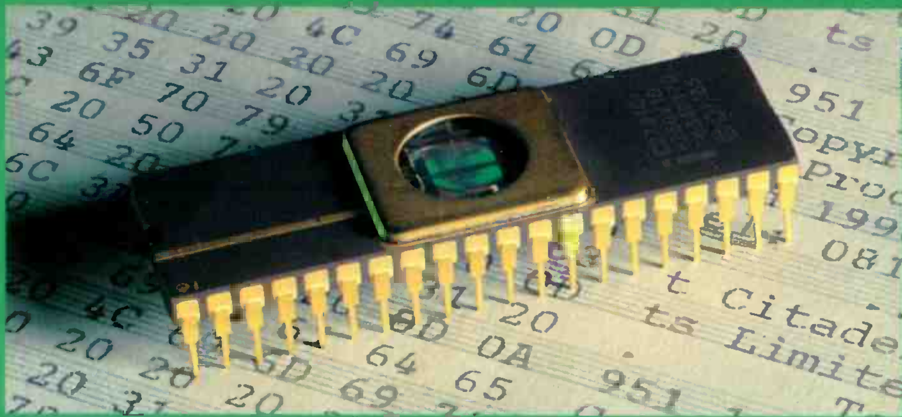

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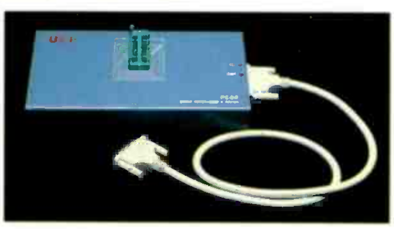

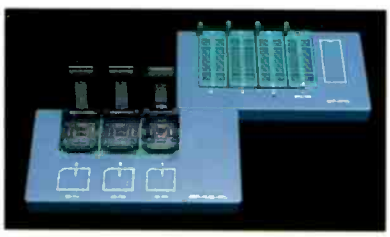

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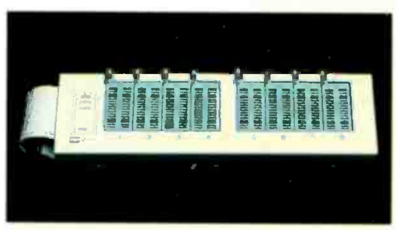

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